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**FEDERAL MINISTRY OF ENVIRONMENT AND TOURISM**

**Overview and state of biological and landscapes diversity in Bosnia and Herzegovina**

# BOSNIA AND HERZEGOVINA —LAND OF DIVERSITY

**First national Report of Bosnia and Herzegovina for the Convention on biological Diversity**

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Sarajevo, 2009.

# *INTRODUCTION*

Bosnia and Herzegovina, the land that is situated on the Balkan Peninsula, has been carrying high diversity of culture strongly attached to diversity of all environmental components since ever.

Biodiversity and landscape's diversity of B&H are characterized by high level of uniqueness, endemism and singularity, making our territory important at regional and global scale.

Richness of our country in terms of its flora, fauna and fungia is reflected not only in great number of occuring forms, but also in high level of differentiation from kindred species, which witnesses for sure on very specific genesis of life in the area. Diversity of ecosystems placed within mediterranean, supra-mediterranean, mediterraneo-montane, upland, high-mountainous, montane, peripannonian and pannonian landscapes creates vivid image of Bosnia and Herzegovina, as a country that was born in diversity. Moreover, as a country that fulfills its existance right through the diversity, and as such is being recognizable in a wide range.

Respecting the richness of life as whole, and heterogeneity of its forms on our territory, through the document *Strategy of B&H with Action Plan for protection of biological and landscape's diversity (2008-2015)*, based upon the study "*B&H – Land of diversity*", we endeavour to determine the sustainable development direction for our society, which shall ensure high quality of life in the preserved environment for both us and generations to come.

For it has been a signatory of the Convention on biological Diversity since 2002, Bosnia and Herzegovina follows the world trend regarding protection and sustainable use of biodiversity. Assigning our forces to the activities undertaken as a contribution to Targets 2010, we endeavoured to recognize, emphasize and re-direct all pressures araising upon biodiveristy and landscapes in B&H, in order to minimize the identified and possible threats of biodiversity loss to sustainable level.

The establishment of Strategy and Action Plan for protection of biological and landscape's diversity was based on scientific results obtained by a large team of experts from all over the country. This shall be considered as a deal in actions and attempts of Bosnia and Herzegovina to take an appropriate position within the process of the European integration, enforced by its changed attitude toward the environment.

Members of the Project's expert team, fully aware of significance and importance that designing of the Strategy posseses, have prepared encompassing study, which has, for the first time, brought a complete overview of biological and landscape's diversity in B&H. The study was applied as a qualitative base for projection of targets, whose accomplishment would provide more developmental options for a local community, leaving natural values preserved in their current state.

Traditional values contained in old knowledge and practices which were underlined in the study, and whose loss became obvious on global scale, represent today a potential that could open completely new development direction for Bosnia and Herzegovina and help it to find

its place on the world market of healthy food, phytopharmaceutics and ecotourism. By afore mentioned documents, Bosnia and Herzegovina sets a clear route for actions in the field of nature management which is, on one hand, independent on short-termed socio-political events, while on the other, it is firmly attached to sustainable progress in existing economic sectors of our society.

The Federal Ministry of Environment and Tourism bears the responsibility of present moment toward the B&H's future quality, in terms of nature protection, for it is a focal point for the implementation of the Convention on biological Diversity in Bosnia and Herzegovina. In the course of project's realization, preparation of study and set up of the strategy, the department of Federal Ministry has undergone number of changes in its structure and organization. However, the significance of project hasn't allowed a single delays in the project's realization to occur because of these changes. This speaks for our commitment to undertake responsibility for the implementation of Strategy, too.

We are aware of the fact that future of this country is tightly attached to its quality and wealth. Major proportion of that wealth is contained within natural beauties and rarities, whose significance on global scale is much greater than the one on local scale. Hence, as a country, we accept to be responsible for their protection and sustainabilty.

Nevenko Herceg, PhD.

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| Dubravka Šoljan, PhD.<br>full-time professor | Faculty of Science at Sarajevo University | Diversity of vascular flora |
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| Čedomil Šilić, PhD.<br>Scientific adviser, retired | National Museum of B&H | Diversity of vascular flora |
| Dubravka Hafner, PhD.<br>assistant professor | Faculty of Pedagogics at Mostar University | Diversity of cyanobacteria and alges |
| Branislav Nedović, PhD.<br>full-time professor | Faculty of Science at Banja Luka University | Diversity of ferns |
| Nada Šumatić, PhD.<br>part-time professor | Faculty of Forestry at Banja Luka University | Diversity of vascular flora |
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| WG's associates: | | |
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| Petar Grgić, PhD.<br>full-time professor | Faculty of Science at Banja Luka University | Diversity of mooses |
| Željka Bjelčić, PhD.<br>Scientific adviser, retired | National Museum of B&H | Diversity of vascular flora |
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| Working Group (WG): Diversity of fauna in B&H | | |
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| WG's leader: | | |
| Milenko Radević, PhD.<br>part-time professor | Faculty of Science at Banja Luka University | Diversity of vertebrates |
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| WG's members: | | |
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| Boro Pavlović, PhD.<br>full-time professor | Faculty of Science at Banja Luka University | Diversity of invertebrates |
| Rifat Škrijelj, PhD.<br>part-time professor | Faculty of Science at Sarajevo University | Diversity of invertebrates and vertebrates (fishes) |
| Suvad Lelo, PhD.<br>assistant professor | Faculty of Science at Sarajevo University | Diversity of invertebrates |
| Sadbera Trožić-Borovac, PhD.<br>assistant professor | Faculty of Science at Sarajevo University | Diversity of invertebrates |
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| WG's associates: | | |
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| Samir Đug, PhD.<br>assistant professor | Faculty of Science at Sarajevo University | Diversity of vertebrates |
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| WG's leader: | | |
| Mithat Usčuplić, PhD.<br>professor emeritus, corresponding member of ANU B&H | ANU B&H | Diversity of fungi |
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| WG's members: | | |
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| Sulejman Redžić, PhD.<br>full-time professor | Faculty of Science at Sarajevo University | Diversity of lichens |
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| Working Group (WG): Diversity of ecosystems and landscapes in Bosnia and Herzegovina | | |
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| WG'sleader: | | |
| Sulejman Redžić, PhD.<br>Full-time professor | Faculty of Science at Sarajevo University | Diversity and assessment of ecosystem's state of woods, wetlands and dry habitats; refugio-relict ecosystems, alpine ecosystems |
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| WG's members: | | |
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| Boro Pavlović, PhD.<br>full-time professor | Faculty of Science at Banja Luka University | Zoological component in refugial ecosystems, zoocoenoses in Adriatic and Black Sea basin |
| Jakov Pehar, PhD.<br>professor emeritus | Faculty of Agronomy at Mostar University | Diversity of agro-phytocoenoses |
| Đuro Marić, PhD.<br>full-time professor | Faculty of Science at Banja Luka University | Demography and Space Economy |
| Zoran Maunaga, PhD.<br>full-time professor | Faculty of Forestry at Banja Luka University | Strucutre and state's assessment of mesophilous and hygrophilous wooded ecosystems |
| Nevenka Pavlović, PhD.<br>part-time professor | Faculty of Science at Banja Luka University | Diversity of dry habitats with state of zoocoenoses, paleozoološki nalazi u BiH |
| Nada Šumatić, PhD. | Faculty of Forestry at Banja Luka University | Diversity of arable land |
| Mihajlo Marković, PhD.<br>part-time professor | Faculty of Agriculture at Banja Luka University | Diversity of soil in B&H |
| Dubravka Hafner, PhD.<br>assistant professor | Faculty of Pedagogigcs at Mostar University | Phytobenthos in streams |
| Milenko Radević, PhD.<br>part-time professor | Faculty of Science at Banja Luka University | Diversity of zoocoenoses in wetlands |
| Branislav Nedović, PhD.<br>full-time professor | Faculty of Science at Banja Luka University | Diversity of hydrophilous meadows in B&H |
| Muris Spahić, PhD.<br>full-time professor | Faculty of Science at Sarajevo University | Geosystems in B&H |
| Senka Barudanović, PhD.<br>assistant professor | Faculty of Science at Sarajevo University | Diversity of beech woods in B&H |

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| Ljiljana Topalić-Trivunović, PhD.<br>assistant professor | Faculty of Technology at Banja Luka University | Diversity of mesophilous meadows and ruderal vegetation |
| Sadbera Trožić-Borovac, PhD.<br>assistant professor | Faculty of Science at Sarajevo University | Zoobenthos |
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| WG's associates: | | |
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| WG's leader: | | |
| Rifat Hadžiselimović, PhD.<br>full-time professor | Faculty of Science at Sarajevo University | Genetic diversity and biotechnology |
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| WG's members: | | |
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| Milan Mataruga, PhD.<br>assistant professor | Faculty of Forestry at Banja Luka University | Genetic diversity and biotechnology |
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| Working Group (WG): Invasive species | | |
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| WG's leader: | | |
| Jakov Pehar, PhD.<br>full-time professor | Faculty of Agronomy at Mostar University | Invasive plants |
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| WG's members: | | |
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| Mihajlo Marković, PhD. | Faculty of Agriculture at Banja Luka University | Invasive plants |
| Dragan Mikavica, PhD.<br>full-time professor | Faculty of Science at Banja Luka University | Invasive fishes |
| Ljiljana Topalić-Trivunović, PhD.<br>assistant professor | Faculty of Technology at Banja Luka University | Invasive plants |
| Vojislav Trkulja, PhD.<br>assistant professor | Agricultural Institute of RS | Invasive fungi |

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| Edina Muratović, PhD.<br>higher assistant | Faculty of Science at Sarajevo University | Invasive plants |
| Sabaheta Abadžić, adviser in the Museum | National Museum of B&H | Invasive plants |
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| WG's leaders: | | |
| Proko Dragosavljević, PhD. | Ministry for physical planning, urbanism, construction and ecology of RS | Concept of ecological education |
| Zdravko Begović | Ministry for physical planning, urbanism, construction and ecology of RS | |
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| WG's members: | | |
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| Sulejman Redžić, PhD.<br>full-time professor | Faculty of Science at Sarajevo University | Management of ecologically valuable areas |
| Milenko Radević, PhD.<br>part-time professor | Faculty of Science at Banja Luka University | Eestablishment possibilities for ecological network in B&H |
| Senka Barudanović, PhD.<br>assistant professor | Faculty of Science at Sarajevo University | Models of nature management |
| Mehmed Cero, M.Sci. | Ministry of environment and tourism FB&H | International documents of importance for biodiversity management in B&H |
| Alojz Dunđer | Ministry of agriculture, water management and forestry FB&H | Position and role of biodiversity within institutional framework; current modes of managment in protected areas in B&H |
| Azra Korać-Mehmedović | Ministry of environment and tourism FB&H | Traditional knowledge and public awareness; protected areas; cross-sector implementation of CBD |
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# *EXECUTIVE SUMMARY*

Based on the Article 6a of the Convention on Biological Diversity, Bosnia and Herzegovina has realized a project which is to be considered as preparation for the *Strategy and Action Plan for Protection of biological and landscape's Diversity in Bosnia and Herzegovina (2008-2015)*. The Strategy was built upon study of biological and landscape's diversity under name "Bosnia and Herzegovina – the land of diversity", which is in the same time the First national Report of our country toward the Convention.

The project was initialized by the Federal Ministry of physical Planning and Environment in January 2006, and continued later on through the Federal Ministry of Environment and Tourism. The national sub-comettee for biodiversity has made decision on experts from all over the country which should have participated in the project as an expert team members, separated in seven working groups. The activities of expert team members were realized in three reporting periods, through attendance at four workshops, numerous meetings and continuous communication. The final output was an imposing text on biological and landscape's diversity of B&H, its state at level of genes, species and ecosystems, causes and degree of pressures upon biodiversity, in the text was also elaborated nature management both today and in future.

The project has resulted in following facts:

1. Flora of cyanobacteria and alges in Bosnia and Herzegovina is comprised of 1457 species, differentiated in 217 genera within divisions of Cyanobacteria, Rhodophyta, Heterokontophyta, Dinophyta, Euglenophyta and Chlorophyta. This is a part of B&H's flora that is characterized by extremely high diversity of species belonging to class Bacillariophyceae.
2. Flora of vascular plants in B&H contains 565 mooses, 71 ferns and 4498 spermatophytes. There has been recognized high level of endemism in each vascular plant division, whereas the highest diversity of species is reached within the families: compositae, leguminosae, grasses, rose family, mustard family, carrot family, mint family, sedges, figwort family, pink family, lily family and family of buttercups.
3. Fauna of vertebrates in Bosnia and Herzegovina includes 119 fish species, 20 amphibians, 38 reptiles, 326 birds and 85 (+2?) mammals, of which 39 species are endemic ones, with highest level of endemism reached among fishes and amphibians.
4. Fauna of avertebrates is highly diverse, but still poorly investigated in Bosnia and Herzegovina. Most diverse is the group of insects, with high diversity of Colembolla, Heteroptera, Lepidoptera and Hymenoptera. The underlined endemism characterizes limnofauna of Bosnia and Herzegovina, too.
5. Realm of fungi in Bosnia and Herzegovina is diverse, but also unsufficiently explored, which is to be confirmed by fact that within Ascomycota and Basidiomycota detected were only 552 species. The expected number of fungi is far greater than that, whereby many of the occuring species are threatened through habitat loss and other kinds of pressures. Unsufficiently explored, as well as both diverse and threatened group of organisms represent lichens, of which were recorded 300 in B&H till now.

6. There is a long tradition of ecosystem approach being applied in the investigation of Bosnia and Herzegovina. Hence, diversity of ecosystems in Bosnia and Herzegovina, from Adriatic Sea to Sava river, composed of mediterranean, supramediterranean, mediterraneo-montane, upland, subalpine, alpine, peri-pannonian and pannonian landscapes, has been well known. Group of specific landscapes, which are sensitive, mainly endemic ecosystem types, includes: high-mountainous and refugio-relict ecosystems, wetlands and karst fields. There have been identified numerous pressures on ecosystem diversity so far. Besides, landscapes reflect the diversity of culture and tradition of people in B&H.
7. To the diversity of genes and genetic resources of Bosnia and Herzegovina should be payed more attention than it was the case till now. Traditional biotechnologies should be placed in service of the country's development in the way that both old knowledge and practice and autochtonous gen pool of B&H remain preserved.
8. The indigenous biodiversity of B&H is under sever pressure arising from the identified invasive plants and animals. Through the establishment of first database on invasive species became obvious that it is needed to find out systematic solutions for further actions in that respect.
9. In order to ensure the management of highly complex biological and landscape's diversity of Bosnia and Herzegovina, it is required to define clear and efficient institutional framework. Therefore, analized were intra- and cross-sector capacities for management and use of natural values that already exist. It was stressed that current mode of nature management doesn't suit to known and re-identified attributes of biological and landscape's diversity in B&H.
10. In order to establish an appropriate relationship with diversity of life in B&H, determined were strategic directions and targets that should reflect our need after maintenance and sustainable use of biodiversity. Targets were elaborated all the way down to task level by expert team, and are to be implemented according to the forseen action plan.

# MAIN FACTS ABOUT BOSNIA AND HERZEGOVINA

## General facts

Bosnia and Herzegovina is situated in the southeastern Europe taking a central position of the Balkan peninsula. Its total surface is 51.129 km$^2$. Border length amounts 1.537 km, of which land border is 762,5 km, river 751 km and sea 23,5 km. Bosnia and Herzegovina shares its border with the Republic of Croatia (931 km), Serbia (375 km) and Montenegro (249 km). Northern parts of Bosnia and Herzegovina face the Sava river, while its southern parts reach the Adriatic Sea at Neum city. Land of Bosnia and Herzegovina is extremely hilly-mountainous, with average altitude of 500 m. From country's total 5% is lowland, 24% are hills, 42% mountains, and 29% is covered with karst (NEAP, 2003). Forests and forest type of soils in Bosnia and Herzegovina cover 2.709.769 ha (which is about 53% of its territory), of which woods cover 2.209.732 ha (about 43%), while barren land covers 500.037 ha (about 10%). Bosnia and Herzegovina has been arranged by Dayton Agreement, according to whome it is constituted of Federation of B&H (10 cantons), Republic of Srpska and Brčko District.

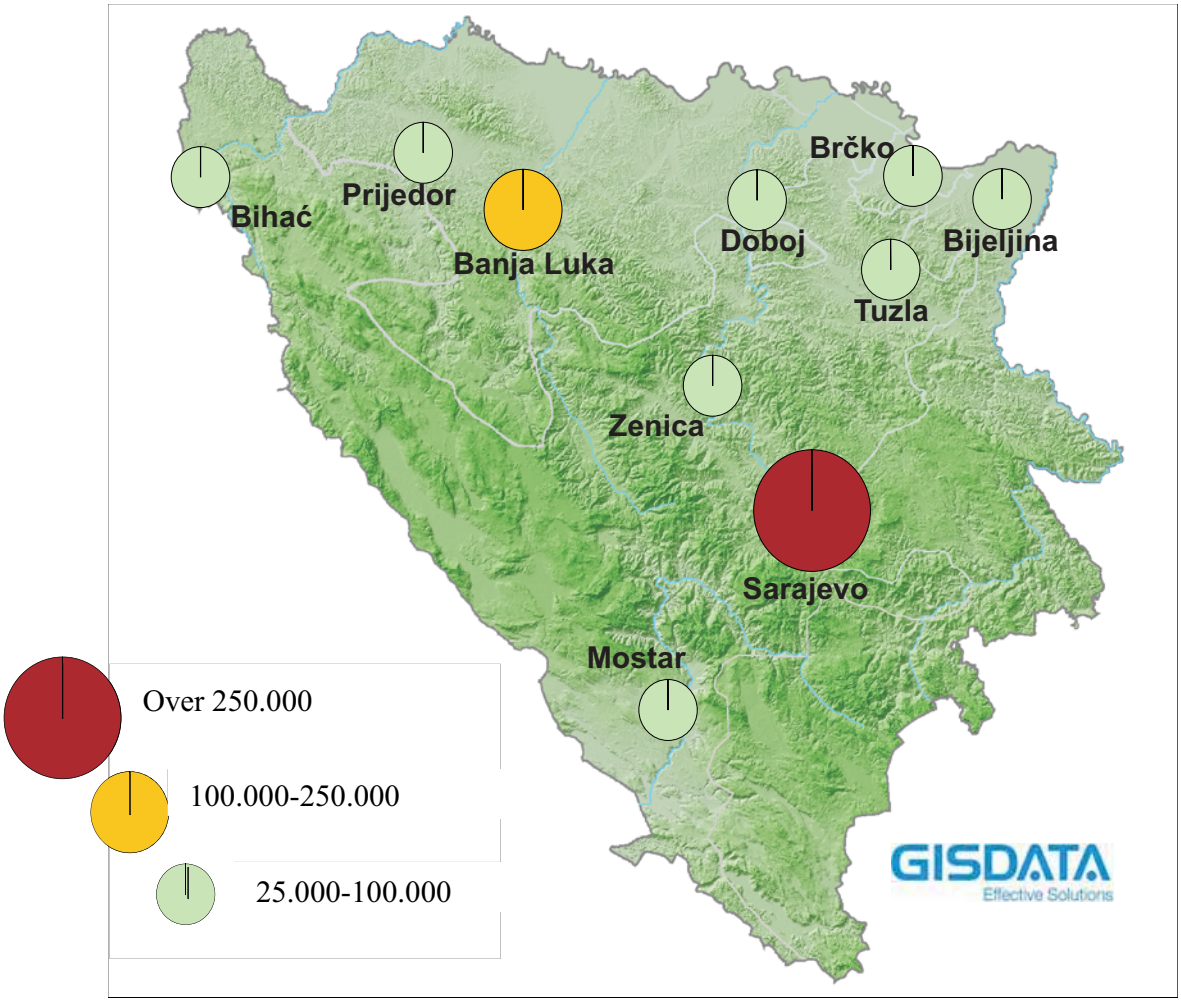



Fig. 1. – Bosnia and Herzegovina: Municipalities with more than 25.000 inhabitans (according to population cenzus in 1991)

## Physical-geographic position of Bosnia and Herzegovina

Bosnia and Herzegovina is positioned between coordinates N 420 26' and 450 15' and E 150 45' and 190 41'. It is placed in western part of the southeastern Europe, exposed to exchanging influences from southern part of the North temperate belt and northern part of the North suptropic belt. Most of young mountain chains (western part), the Dinaric Alps, is situated on our territory. Chains of the Dinaric Alps descend gradually in the northern direction toward Sava river, while in the southern direction they descend suddenly, directly into the lowland of Herzegovina and Adriatic coastline.

Bosnia and Herzegovina ows its mainly mountainous character to the western part of mediterranean mountain chains.

In terms of hydrology, Bosnia and Herzegovina belongs to the Black and Adriatic Sea basins. A watershed of these two confluences runs across mountains Plješevica, Šator, Cincar, Raduša, Bitovnja, Bjelašnica, Treskavica, Zelengora and Volujak.

The Black Sea basin takes in 70% of Bosnia and Herzegovina's total, the Adriatic Sea basin takes in 24%, while 6% of overground water dissolves into the karst underground.

In terms of pedology, in Bosnia and Herzegovina prevail soil types from automorphous and hydromorphous division.

## Geologic and tectonic characteristics of Bosnia and Herzegovina

Relief of Bosnia and Herzegovina is from geologic and tectonic standpoint much more complex than it seems at first glance. Rocks that make a country's foundation have been deposited over geologic times at the bottom of former Tetis Sea. Deposited material was then folded by tectonic movements into the mountain chains, while valleys were created by deep faulting.

Metamorphous rocks, of which mountains in central Bosnia and Herzegovina are made of (Vranica, Bitovnja, Zec-planina, Pogorjelica and Komar), date back from Palaeozoic. Palaeozoic layers occur also in other parts of Bosnia in mosaic like manner. Sedimentary rocks originating mainly from Mezozoic, were upraised during Alpine orogenesis, and folded into Dinaric mountains by lateral stress. Northern and southern zones of the mid Dinaric Alps are built of Kenozoic layers. After dynamic geological events that took place in Kenozoic, Tetis Sea has been withdrawn leaving Bosnia and Herzegovina as a dry land with smaller remnant waterbodies in form of lakes (Paratetis). At the end of Kenozoic, the Pannonian Sea, which painted the Pannonian lowland in blue, finally withdrew leaving shallow lakes and marshes behind. Afterwards, the Sava river emerged. Upper flows of Sana, Una, Vrbas, Bosna and Drina river were tributaries of the Pannonian Sea in course of its existence. As the Sea was withdrawing to the East and to the North, rivers followed it by increasing their lengths. In the same time with the Pannonian, existed also the Adriatic Sea. Levels of both World and the Adriatic Sea were lower during Pleistocen. Neretva river was much longer at that time and ended where it is today adriatic bottom. After Pleistocen, level of the Adriatic Sea elevated due to ice melting, which sunk the lower valley of Neretva river.

## Main forms of relief

Dinaric Alps chains extend between plain and hills of Posavina in the North, and Adriatic bay in the South. Dinaric mountain chains extend from NW to SE. Beside orogenous folders, in the Dinaric mountain system dominate also plateaus. By tectonic movements and splits evolved valleys, lowlands and karst fields. Especially large valleys occur along river basins (Sarajevsko-Zenička valley along basin of the Bosna river, Uskopaljska valley and Banjalučka valley along basin of the Vrbas river, Bihaćka valley along basin of the Una river, Tuzlanska valley along basin of the Spreča river, Mostarska valley along basin of Neretva river etc.).

Several factors were crucial for a creation of karst fields. The field's bottom is usually covered by quarternary depositions, and sides are encircled by karstified carboniferous rocks. On the field's margin are to be found many springs and wells, while field's deepest places hide abysses, places where water drains into the karst underground.

The relief of Bosnia and Herzegovina includes also underground karst phenomena in carboniferous rocks, which makes our country one of the richest holokarst area in the world. On the territory of Bosnia and Herzegovina exist great number of both explored and unexplored caves and holes, of which the most famous are: Vjetrenica in Popovo polje, Glavičanska near Foča, Mračna pećina in the valley of Prača river, Bijambarska pećina at Nišići plateau and Orlovača by Sumbulovac.

## Climate of Bosnia and Herzegovina

Climate of Bosnia and Herzegovina is determined by several geographic factors, whereas great importance comes to following, the Atlantic ocean in the West, the Mediterranean and the Adriatic Sea in the South, and vast space of continental masses of Europe in the North, Asia in the northeast and East, and Africa in the South.

Winds coming from the Atlantic ocean and the Mediterranean Sea bring warm and moist air. When this air reaches the Dinaric masiffs, it lifts up toward peaks, slowly cooling down, condense and finally precipitate.

If there is a field of low pressure over Europe in summer, flux of warm and dry air coming from Africa causes high temperatures.

In the course of cold periods, when there is a field of high pressure over northeastern Europe, over our country circulates cold arctic air.

Climate of Bosnia and Herzegovina is temperate, but more extreme than one could expect sole from its geographic position. The mediterranean impact here is substantially reduced. Hence, mediterranean climate occurs only on the adriatic coastline and in low Herzegovina.

Dinaric alpine region strongly modify mediterranean currents coming from the South, whereas it prevents the penetration of cold air from an inland to the coast. But, mediterranean influences still protrude deep in the inland by Neretva river valley. Climate of Bosnia and Herzegovina shows high diversity level. Between areas of temperate continental and modified mediterranean (adriatic) climate, there are areas with continental, pre-alpine and alpine climate.

The lowest temperature characterize highest mountain peaks. An average temperature in January on Bjelašnica Mt. amounts -7,2$^0$C, while in Neum city it is +6,5$^0$C.

Annual precipitation in Bosnia and Herzegovina is unevenly distributed, whereas it increases from the South towards Dinaric masiffs, and declines again towards peri-pannonian margin. Snow occurs regulary in winter, covering mountain peaks over 6 months a year.

Climate of Bosnia and Herzegovina is highly complex. Its southern region is characterized

by modified adriatic climate, while northern part of the country has got climate that is temperate-warm and moist, with hot summers. Space in the mid of Bosnia and Herzegovina is influenced by modified temperate-warm and moist climate, changing in different height zones to climate with fresh summers. Mountain climate characterize hypsometric levels above 700 m, whereby the highest orographic units have got alpine climate.

Climate of Bosnia and Herzegovina is comfortable for human life and health, being therefore an important natural wealth of our country.

## Water of Bosnia and Herzegovina

There are fresh and salt waterbodies in Bosnia and Herzegovina. Our country has got large quantity of, after world's standard, high quality fresh water. Overground and underground karst currents create complex hydrographic network.

Most of our watercourses emerges under the Dinaric masiffs. The basins of Bosna and Vrbas river represent larger watersheds that entirely belong to the territory of Bosnia and Herzegovina. The underground water collection, which our country has got plenty of, occurs in lose depositions (of gravel sand and sand), around large river beds, karst fissures, trenches and caves.

Thermal and mineral springs occur around ingenous bedrocks and tectonic clevages, representing the important natural wealth of Bosnia and Herzegovina. The best known springs of mineral water are to be found in Kiseljak, Kakanj, Srednje, Busovača, Srebrenica, Žepa, Tešanj, Maglaj, Žepče etc.

The hotest thermal spring, with water temperature of $+58^0$C, is Ilidža's spa. Those thermal water contain sulphur being therefore used in medicinal treatment of many diseases. Other thermal springs are to be found in: Fojnica, Olovo, Tuzla, Gradačac, Teslić, Banja Luka etc.

In Bosnia and Herzegovina exist great number of natural mountain lakes, so called "mountain eyes" named after its clear blue water.

Our coastline, which is 22 km long, streches southwards from the delta of Neretva river. Thus, Bosnia and Herzegovina has an access to the Adriatic Sea and covers 8 km$^2$ of the area. The peninsula of Pelješac divides it from the chanel of Mljet and an open sea.

Average annual temperature of sea water at Neum city is $+9{,}6^0$C. It is the warmest in July, when water temperature at surface reaches in average $+20^0$C. Sea water's salinity varies between 29 and 35‰. Colour is blue-green, with 10 m transparency.

Thanks to the fact that it is surrounded by the peninsula Pelješac and Klek, sea in the bay of Neum is quite, with no more than 1 m high waves.

## Population

According to the assessment made by UNHCR in 1999, total number of inhabitans in Bosnia and Herzegovina was around 3.894.000. Of that 2.381.496 (61%) people lived in Federation of B&H, 1.432.020 (37%) in Republic of Srpska and 80.324 (2%) lived in Brčko District.

According to the population register from 1991, inhabitan's density in Bosnia and Herzegovina was uneven (between 40 and 200 inhabitans per square km).

## Macroeconomic indicators

GNP in Bosnia and Herzegovina in 1990 was estimated to amount 10,6 bilions US dollars, which made over 2.400 US dollars per capita. An income was achieved through many economy branches, while the basic industry was one of the best developed among countries in the region, with highly educated manpower and extremely high export rate to the western market (Environmental Performance Reviews, UNECE, 2004).

The war (from 1992 to 1995) has left the country and its economy devastated. A recovery process has started after the Dayton Agreement was signed. Thereafter, in the period from 1996 to 2001, annual economic growth was 25%. The post-war recovery was achieved thanks to many broad donation programmes. Economic structure has been substantially changed, from mainly industrial economy to economy in which prevail service industry.

In year 2002, GNP has reached almost the half of its pre-war value. A transition process that is currently going through a privatisation phase exercise crucial effects onto transformation of economy's structure.

## Strategic documents

Millestones for new social movements are strategic documents, which simultaneously offer solutions for both social and environmental issues. A leading document, which was adopted by both entities and Brčko District, is the National Environmental Action Plan (NEAP, 2003). NEAP was created in way to identify problems, pressures and needs necessary to achieve balance between environment protection and economic development. After NEAP, main priority is to achieve economic development by environmental friendly strategy.

Midle-termed development Strategy for Bosnia and Herzegovina, from 2003 to 2007, includes priorities recognized by NEAP and forsees measures for environmental management, especially in terms of legislative, air quality, climate changes, management of aquatic and terrestrial resources, forests, waste, biological and geological diversity, cultural and natural inheritance, and public health. The Strategy underlines the importance of creation and adoption of laws that would establish effective environmental legislative, but it also emphasizes need after inter-sectoral policy harmonization.

# BIOGEOGRAPHY OF BOSNIA AND HERZEGOVINA

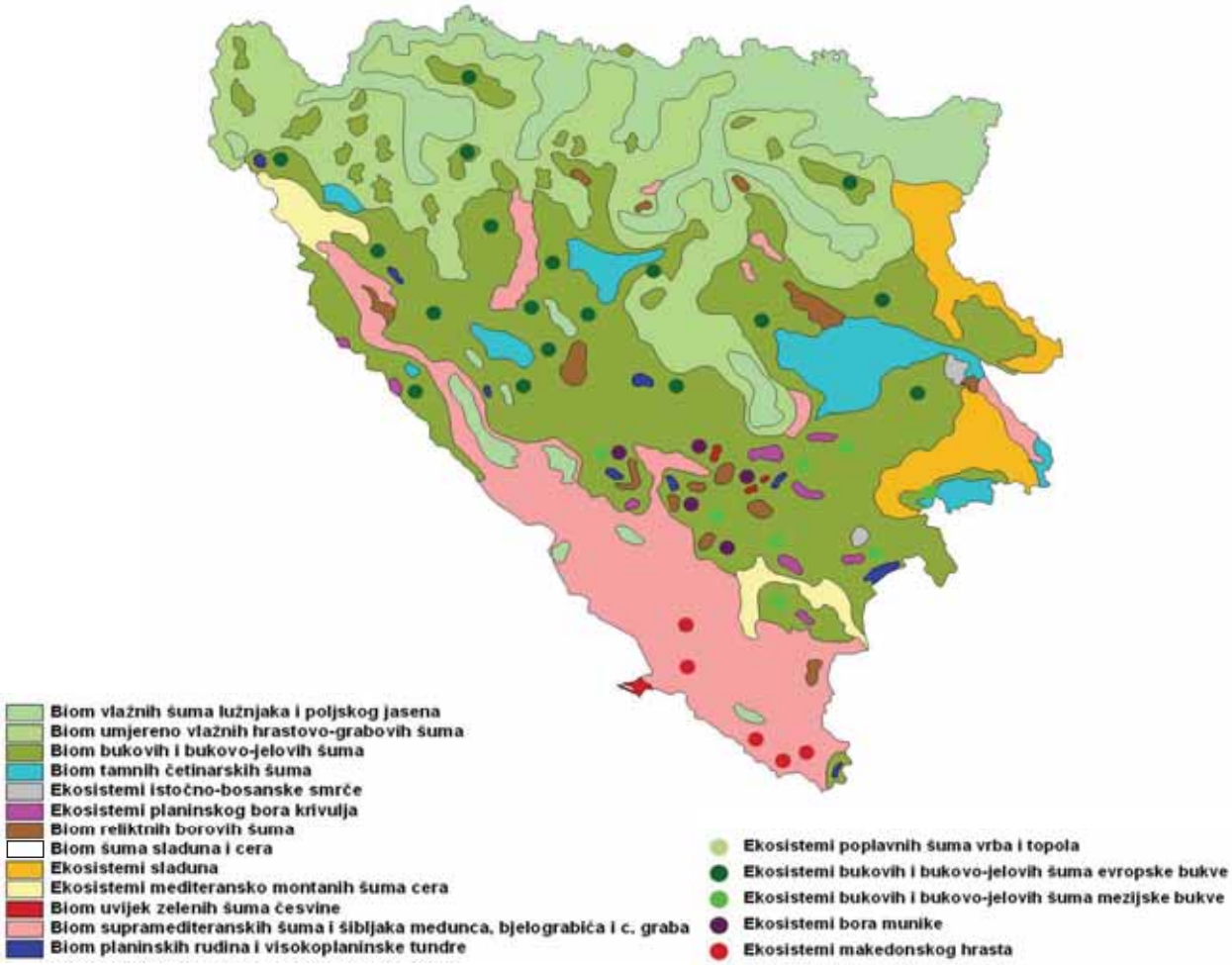



Fig. 2. – Bosnia and Herzegovina: biogeographic overview

Peaks of Maglić Mt

Klek peninsula

# PALAEONTOLOGICAL FINDINGS IN BOSNIA AND HERZEGOVINA


Fig. 3. – Bosnia and Herzegovina: palaeontological findings

Fossil snake from late Cretaceous

Shark fins from mid Triassic

Cephalopods from early Jurrasic

# DIVERSITY OF SPECIES
# DIVERSITY OF FLORA

## DIVERSITY OF SPECIES

The extreme richness of living world that exist on our territory is the result of ecological heterogeneity of Bosnia and Herzegovina, its geomorphological and hydrological diversity, specific geological past and its ecoclimate diversity. Flora, fauna and fungia of Bosnia and Herzegovina are considered to be among the most diverse in Europe, being especially important in terms of global biodiversity due to its high level of endemism and relictness.
Like in no other place in Europe, here, on such small space, occur countless endemic centres in which, even at present-day, continue to unfold process by which new species evolve. Special characteristics of this area represent many canyons and cliffs of bosnia-herzegovina's rivers (canyons of the Una, Neretva, Drina river, canyons and cliffs of tributaries in upper flow of the Bosna river, and a midle part of flow of the Vrbas river with the highly interesting canyon of the Ugar river running between mountains Vlašić, Čemernica and Manjača).
Bellow the highest peaks of bosnia-herzegovina's mountains, in an area of cirques, are to be found development centres of glacial flora and fauna, which wittness about the after Ice Age time on the Balkan peninsula. There are over 450 species and sub-species of vascular plants that are recognized to be endemic, which makes bosnia-herzegovina's flora one of the most unique in Europe.
High diversity of insects (especially hydrophilous), then fish and mammals makes fauna of Bosnia and Herzegovina recognizable on the European scale, whereas some of animal's groups (organisms that inhabit caves or fish that live in karst sinking streams) make it remarkable on global scale. Main factors responsible for high diversity of Bosnia and Herzegovina are as follows:

- Diversity of terrestrial habitats caused by: occurence of rocks of different age, diversity of bedrocks, soil types, unique and diverse forms of relief, and diversity of climate conditions;
- Diversity of aquatic habitats reflected by: rich and diverse hydrological network (mountain lakes, springs, mountain torrents, brooks, rivers, sinking streams, ponds, marshes, underground water, thermal sources, brakish water and sea);
- Long-lasting process of anthropogenesis;
- Diversity of ethnogenesis.

Living world that inhabit different places of Bosnia and Herzegovina compose countless communities and ecosystems at present-day, which are specific for this area, the Balkan peninsula and entire Europe. Thus, it is possible to speak in terms of high level of endemism within biological and ecological diversity.

"Biodiversity of Bosnia and Herzegovina has been considered to be very interesting and challenging one for researchers since ever, which was the main reason for them to come, at that time from far away western and central Europe, into bosnian wilderness and pathless area. Thus, even well known french scientist Ami Boue was overjoyed by curiosity that was awaken by tales he heard from scholars in different parts of the Otoman Empire, while he was travelling across. Those tales were telling a story about magic nature of bosnian vilaet. So, on his journey from Stambol in 1863, he visited what was at that time known to be the European Turkey, which is at present-day Bosnia and Herzegovina. He passed through the valley of the Rzav river, Višegrad city, over Romanija Mt., canyon of the Miljacka river and continued further to the West. This dreamer got so excited by the

beauties and wilderness of bosnian nature that, despite being geologist himself, he collected a lot of herbal material along with specimens of different minerals and rocks. He brought it all to the attention of the European scientific elite to admire it, study and describe new species. That treasure is now being stored in the most famous European museums of natural science and their herbaria. Historians believe that the expedition of Ami Boue has marked the beginning of true scientific research in the area. Otto Sendtner, well known European botanist, has come into Bosnian wilderness after he heard the word about its diversity of life, especially of vascular flora (he was first official scientist, biologist, which came into Bosnia). This researcher has gathered large quantities of floristic material in different parts of Bosnia. But once, while he was completely devoted to the cause of his research, several highlanders from Vlasic Mt. came in his way, just like that, in bosnian manner, motivated by pure small town curiosity. They attacked Otto's caravan, destroyed some of his material and broke the glasses of this great scientist. Scared to death, immediately after he got saved by his servants, Sendtner collected all of his material and as fast as he could left the country. That event intimidated the European scientific elite before the bosnian temper. Long time after that no one has dared to come into this land. Not earlier than the austrio-hungarian government was established, scientist arrived again along with the military and officials. Although there were many of them, one deserves full respect of this country. Karlo Maly was one of the most passionate botanist and the greatest admirer of plant diversity of Bosnia, his favorite country. On his journey he was never stopped by neither natural or human force. This Austrian, with bosnian heart and herzegovinan soul, went around the country, gathered exceptionally rich herbal material, described many endemic and relict species, stored it in Herbarium of Land's Museum of Bosnia and Herzegovina, and took scientific glory of B&H plant uniqueness all over the globe." (quoted from the TV show "Prirodna baština BiH")

# DIVERSITY OF FLORA

## Diversity of cyanophytes and alges

By till now undertaken investigations of this floristic group, identified was 1.457 species from 217 genera (all together 1987 forms).
Preliminary result indicates that class Bacillariophyceae is the richest regarding species (719), varieties (222) and forms (15), whereas class of green alges is also extremely rich regarding forms, with 98 genera, 461 species, 56 varieties and 7 forms. The most numerous genera are: Cosmarium, Navicula, Eunotia, Cymbella etc.
Considering the heterogeneity of aquatic and moist habitats, and existing centres of endemism, it is to expect that at least one third of these organisms is either poorly or completely unknown to the science. This relates especially to the alges inhabiting mountain's raised and blanket bogs, mountain springs and wells, wells and upper flows of sinking rivers, watercourses within refugia of tertiary flora.

Table 1. – Diversity of cyanophytes and alges

| Taxon | genus | species | subspecies | variety | form |
|---|---|---|---|---|---|
| Cyanobacteria | 36 | 193 | - | 1 | 4 |
| Rodophyta | 7 | 15 | - | 1 | - |
| Charophyceae | 33 | 275 | - | 31 | 5 |
| Chlorophyceae | 65 | 186 | - | 25 | 2 |
| Euglenophyta | 3 | 16 | - | - | - |
| Dinophyta | 5 | 15 | - | - | 2 |
| Bacillariophyceae | 55 | 719 | 1 | 222 | 15 |
| Xanthophyceae | 3 | 13 | - | - | - |
| Chrysophyceae | 10 | 25 | - | 4 | - |
| Total | 217 | 1457 | 1 | 284 | 28 |

There is a strong need for more intensive research in terms of making an inventory, classification, identification and determination of threat's level and state's evaluation, in order to obtain an objective view into the living world of alges of Bosnia and Herzegovina.

Within the diversity of alges and cyanophytes special significance comes to species that characterize thermal and mineral springs, turfs, caves and half-caves etc.

Table 2. – Diversity of cyanophytes and alges within turf deposition

| Taxon | Una | Unac | Trebižat | Pliva |
|---|---|---|---|---|
| Cyanobacteria | 31 | 2 | 7 | 6 |
| Rhodophyta | 6 | 2 | 2 | 1 |
| Chlorophyta | | | | |
| Charophyceae | 13 | 6 | 3 | 2 |
| Chlorophyceae | 18 | 4 | 2 | 2 |
| Heterokontophyta | | | | |
| Bacillariophyceae | 115 | 9 | 1 | 2 |
| Chrysophyceae | 1 | 1 | 1 | - |
| Xanthophyceae | 4 | 2 | 1 | 1 |
| Total | 188 | 26 | 17 | 14 |

Diversity of alges is so special because of species that inhabit brakish and sea water of bosnia-herzegovinan part of the Adriatic Sea. Here should be mentioned representatives of brown, red and green alges, with high biomass yield.

Apart from contemporary species of Cyanobacteria and alges, it was also recognized an extreme richness in ancient species (paleo-species) in different aged depositions. Especially numerous and endemic are silicoflagelates (*Dictiocha slavnicii, D. mucibabici, D. soljani, D. krekii, Deflandriocha sp.*) and fossils of one cell alges with carboniferous shields (Coccolitophorales).

## Diversity of vascular flora

High level of vascular flora diversity in Bosnia and Herzegovina is based upon diversity of mosses (Bryophyta), ferns (Pteridophyta) and spermatophytes (Spermatophyta).

Table 3. – Taxonomic diversity of higher plants

| | Family | Genus | Species | Sub-species | Hybrid | Total number of species, sub-species and hybrids |
|---|---|---|---|---|---|---|
| Bryophyta | 52 | 187 | 565 | 0 | 0 | 565 |
| Pteridophyta | 14 | 26 | 61 | 8 | 2 | 71 |
| Spermatophyta | 161 | 858 | 3256 | 1078 | 164 | 4498 |
| Total | 227 | 1071 | 3882 | 1086 | 166 | 5134 |

Identified was 5.134 taxa. This fact underlines the floristic richness of Bosnia and Herzegovina and places our country among the richest ones in Europe, along with the Republic of Croatia, Italy, Greece and others.

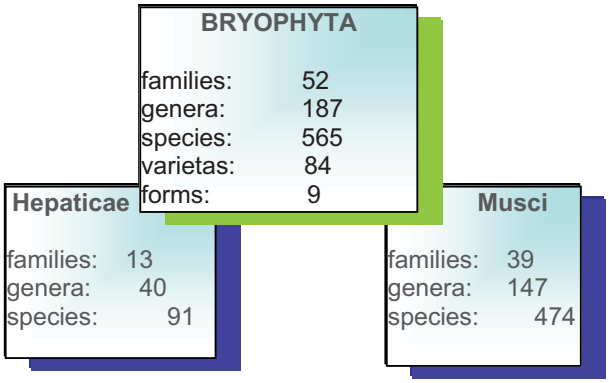
Major part of these species is terrestrial or semi-terrestrial, while a limited number of them is bounded to the aquatic environment.

## Diversity of Bryophytes

According to the existing knowledge level, there is relatively high diversity of mosses in the Bosnia and Herzegovina. After some partial records, this plant group counts 565 species from 187 genera, divided in two classes.

Table 4. – Diversity of Bryophytes (class: Hepaticae)

| Family | Genus | Number of species |
|---|---|---|
| 1. Ricciaceae | 2 | 6 |
| 2. Marchantiaceae | 7 | 7 |
| 3. Aneureae | 1 | 5 |
| 4. Metzgerieae | 1 | 3 |
| 5. Haplolaeneae | 1 | 2 |
| 6. Codoniaceae | 1 | 1 |
| 7. Epigonantheae | 12 | 32 |
| 8. Trigonantheae | 6 | 14 |
| 9. Ptilidioideae | 2 | 3 |
| 10. Scapanioideae | 2 | 10 |
| 11. Raduloideae | 1 | 2 |
| 12. Madothecoideae | 1 | 2 |
| 13. Jubileae | 3 | 4 |
| Total | 40 | 91 |




Graph 1. – Diversity of Bryophytes

Table 5. – Diversity of Bryophytes (class: Musci)

| Family | genus | species | var. | form |
|---|---|---|---|---|
| Sphagnaceae | 1 | 22 | 0 | 0 |
| Fissidentaceae | 1 | 9 | 0 | 0 |
| Archidiaceae | 1 | 1 | 0 | 0 |
| Ditrichaceae | 5 | 11 | 0 | 0 |
| Seligeriaceae | 3 | 5 | 0 | 0 |
| Dicranaceae | 14 | 31 | 0 | 0 |
| Leucobryaceae | 1 | 1 | 0 | 0 |
| Encalyptaceae | 1 | 4 | 0 | 0 |
| Pottiaceae | 20 | 71 | 0 | 0 |
| Grimmiaceae | 2 | 24 | 0 | 0 |
| Funariaceae | 3 | 5 | 0 | 0 |
| Georgiaceae | 1 | 1 | 0 | 0 |
| Bryaceae | 7 | 55 | 17 | 0 |
| Aulacomniaceae | 1 | 2 | 0 | 0 |
| Meeseaceae | 1 | 3 | 2 | 0 |
| Bartramiaceae | 3 | 11 | 3 | 3 |
| Timmiaceae | 1 | 3 | 0 | 0 |
| Ptychomitriaceae | 1 | 1 | 0 | 0 |
| Orthotrichaceae | 4 | 28 | 5 | 0 |
| Fontinalaceae | 1 | 5 | 3 | 0 |
| Climaciaceae | 1 | 1 | 0 | 0 |
| Hedwigiaceae | 1 | 1 | 3 | 0 |
| Leucodontaceae | 3 | 3 | 0 | 0 |
| Neckeraceae | 4 | 8 | 6 | 0 |
| Lembophyllaceae | 2 | 4 | 3 | 0 |
| Hookeriaceae | 1 | 1 | 0 | 0 |
| Theliaceae | 1 | 3 | 1 | 0 |
| Leskeaceae | 5 | 6 | 2 | 0 |
| Thuidiaceae | 6 | 14 | 1 | 0 |
| Amblystegiaceae | 13 | 39 | 18 | 3 |
| Brachytheciaceae | 11 | 42 | 8 | 3 |
| Entodontaceae | 5 | 6 | 2 | 0 |
| Plagiotheciaceae | 1 | 4 | 2 | 0 |
| Hypnaceae | 9 | 21 | 6 | 0 |
| Rhytidiaceae | 4 | 7 | 0 | 0 |
| Hylocomiaceae | 2 | 2 | 0 | 0 |
| Buxbaumiaceae | 1 | 2 | 0 | 0 |
| Diphysciaceae | 1 | 1 | 0 | 0 |
| Polytrichaceae | 4 | 16 | 2 | 0 |
| total | 147 | 474 | 85 | 9 |

Mosses are to be found in almost any kind of the environment. Around 100 species inhabit springs, torrents, turf barriers, rocky river beds. The remaining 460 grows on soil, tree bark, decomposed ligno-humus in forests and meadows, whereas many inhabit limestone, silicate and ultrabasic bedrock.
Some species (*Cratoneuron sp.*) are directly involved into creation of travertine and living organic rocks (tuff), which means that they are involved into creation of rare and important habitats in the Dinaric region.

In the Bosnia and Herzegovina occur mosses that build raised bog's soils (acrohystosol) and relict boreal communities of peatmoss, as a part of wetland's diversity in our country.
In wood's ecosystem mosses build well organized, structure-functional units (synusia) that represent habitats for many animals.
Within flora of mosses in the Bosnia and Herzegovina special care deserve endemic (Table 6), rare and threatened species (Table 7).

Table 6. – Overview of some endemic mosses in B&H

| Taxon | Habitat | Locality |
|---|---|---|
| Pseudoleskea illyrica Glow | Epiphyte of beech woods | Ravna planina Mt., Plaša Mt., Orijen Mt. |
| Trichostomum brevifolium Sendt. | Epilithe on limestone in mountain belt and along coast | Konjic, Ljuta and Doljanka river |
| Ctenidium distiguendum Glow. | Epilithe on limestone in hills and mountain area | Foča, Stambolčić-Hodža, Trebević Mt. |
| Antitrichia curtipendula (L.) Brid.f. pristoides (Glow.) Horvat | Epiphyte and epilithe from coast and lowland to upper line of woods | Jahorina and Ravna planina Mt. |
| Eucladium angustifolium (Jur.) Glow. | Hygrophyte on rocks along coast and bosnian river valleys | Brod near Foča, Ljuta and Bijela river at Konjic, Doljanka river |
| Eucladium verticillatum (L.) B. S. G. subsp. commutatum Glow. | Hygrophyte on rocks along rivers, brooks and waterfalls in coastal and inland areas | Waterfalls of Pliva river at Jajce, Cliffs of Miljacka river, Ljuta river at Konjic |
| Didymodon bosniacus Glow. | Tuff cascades | Waterfalls of Pliva river |
| Bryum schleicheri Schwägr. var. bosniacus Wstf. | Hygrophyte on flooded soil | near Travnik |

Table 7. – Overview of some threatened mosses in B&H

| Taxon | Habitat | Locality |
|---|---|---|
| *Drepanocladus sendtneri* (Schimp.) Wstf. f. *gracilis* Sanis | Bog's meadows and moist places | Kupreško polje |
| *D. aduncus* (Hedw.) Moenkm. var. *capillifrons* (Wstf.) Mkm. | Swamp meadows, bogs | Livanjsko polje |
| *D. revolvens* (S. W.) Wstf. var. *intermedius* (Lindb.) Grout | Marshes | Livanjsko polje |
| *Racomitrium microcarpum* (Hedw.) Brid. | Epilithe on moist rocks | Livanjsko polje, Ždralovac |
| *Polytrichum strictum* Smith. | Bogs, swamp forest's meadows | Livanjsko polje – Sajkovići |
| *Hygrohypnum eugyrium* (B. S. G.) Broth. var. *mackayi* (Hedw.) B. S. G. | Moist habitats in lower mountain belt | Livanjsko polje – Buško blato, Glamočko polje |
| *Hygroamblystegium fluviatile* (Hedw.) Loeske f. *spinifolium* Mkm. | Hydrophyte, on stones and wood construction | Livanjsko polje |
| *Dialytrichia mucronata* (Brid.) Broth. | Epilithe, hygrophyte | Sources of the Pliva river |

Those threatened taxa have wider distribution (euroasian, boreal), being quite rare on our territory. Those are species that constitute relict communities, which are remnants from the period of glaciation. Thus, in the Bosnia and Herzegovina they occur on relatively small territory, which is southern distribution range for some vegetation types that are normally distributed in the boreal belt.

## Pressures onto flora of mosses

Populations and species of mosses in Bosnia and Herzegovina are threatened by many factors. Many hygrophilous species constitute relict canyon communities that have changed in the past, or have been changing, because of artificial lakes made to energize the power-plants (on Drina, Neretva and Pliva river). Many species have their genuine habitat's conditions changed substantially (for instance, tuff cascades of Pliva river at Jajce). Epiphytes are under threat due to general degradation of woodland up to the submountain belt (by cutting, drying, fires or construction with recreation purposes).

## Diversity of Pteridophytes

It has been confirmed that flora of Pteridophytes includes 61 species from 26 genera divided into divisions Equisetophyta, Lycopodiophyta and Polypodiophyta.
Apart from the phylogenetic differentiation, Pteridophytes are also clearly divided by their ecological needs. Thus, many of them indicate ecosystem and environment quality. Representatives of Equisetophyta are attached to swamp like habitats, with clear dominance of horsetail (genus *Equisetum*). Marshes and floating vegetation include some rare ferns, such as *Salvinia* and *Marsillea*, which are required for maintaining the balance and diversity of swamp ecosystems that become more threatened every day. In our woods special significance comes to clubmosses (species of genera *Lycopodium* and *Huperzia*), which grow on humous soil of conifer woods, while genus *Selaginella* inhabit crevices of ultrabasic rocks.

Table 8. – Diversity of Pteridophytes

| Family | Genus | species | Sub-species | hybrid |
|---|---|---|---|---|
| Lycopodiaceae | 4 | 5 | 0 | 0 |
| Selaginellaceae | 1 | 3 | 0 | 0 |
| Equisetaceae | 1 | 8 | 0 | 1 |
| Adiantaceae | 3 | 4 | 0 | 0 |
| Aspleniaceae | 1 | 11 | 7 | 0 |
| Blechnaceae | 1 | 1 | 0 | 0 |
| Dryopterideaceae | 2 | 9 | 1 | 1 |
| Pteridaceae | 1 | 1 | 0 | 0 |
| Marsileaceae | 1 | 1 | 0 | 0 |
| Ophioglossaceae | 2 | 4 | 0 | 0 |
| Polypodiaceae | 1 | 2 | 0 | 0 |
| Salviniaceae | 1 | 1 | 0 | 0 |
| Thelypteridaceae | 3 | 3 | 0 | 0 |
| Woodsiaceae | 4 | 8 | 0 | 0 |
| TOTAL | 26 | 61 | 8 | 2 |

The highest diversity level characterize genera that are attached to diverse wood's habitats (*Dryopteris, Blechnum, Thelypteris, Athyrium, Polystichum, Gymnocarpium*). In rock crevices of sunny and shaded places, occur species of genera *Polypodium, Asplenium, Ceterach*, on mountain heaths *Pteridium*, in shaded humid woods *Phyllitis*, on travertine depositions of fresh and thermal water *Adiantum*. *Notholaena marantae* and *Asplenium cuneifolium* are attached to serpentine-peridote bedrock.

Table 9. – Pteridophytes used as habitat's indicator

| Habitat type | Species |
|---|---|
| Hydrophilous habitats | Salvinia natans, Marsillea quadrifolia |
| Marshes and arable land | Equisetum arvense, E. hyemale, E. sylvaticum, E. telmateia |
| Shaded humid woods | Phylitis scolopendrium |
| Oak woods | Gymnocarpium dryopteris |
| Beech woods | Thelypteris phegopteris, Polystichum aculeatum, Dryopteris filix mas, Athyrium filix femina |
| Coniferous woods | Huperzia selago, Lycopodium clavatum, Blechnum spicant |
| Vegetation of rock crevices | Ceterach officinarum |
| Rocky grassland | Asplenium trichomanes, A. viride |

Pteridophytes play an important role in maintainance of ecosystem's stability. Many of them are resources that have been ever since used in human diet, or in traditional medicine. Some ferns have even been used in the culture of our people with different purposes, for instance as a mean for expulsion of evil spirits.

Those species are irreplaceable in modern ethnotherapy. Clubmosses (*Lycopodium*) are being used to fight lever diseases; harts's tongue fern (*Phyllitis*) against tuberculosis; maidenhair fern (*Adiantum*), fern (*Asplenium*) and rustyback (*Ceterach*) for kidney diseases and urinary infections, polypody to treat diabetes, whereas young leaf tips of bracken fern (*Pteridium*) used to be juicy spring food for highlanders.

## Pressures onto flora of Pteridophytes

Because of impacts onto habitats of ferns (clear cutting, quarries, water pollution, global climate changes followed by acid rain), some species and entire genera are under severe threat. Into these group of ferns belong Notholaena maranthe, Asplenium cuneifolium and Selaginella helvetica growing on old volcanic rocks, Ceterach javorkae and Asplenium lepidum living in limestone rock crevices, Asplenium fissum in rock crevices of mountain belt, all species of genus Lycopodium, then Salvinia natans, Marsillea quadrifolia and Asplenium adianthum nigrum.

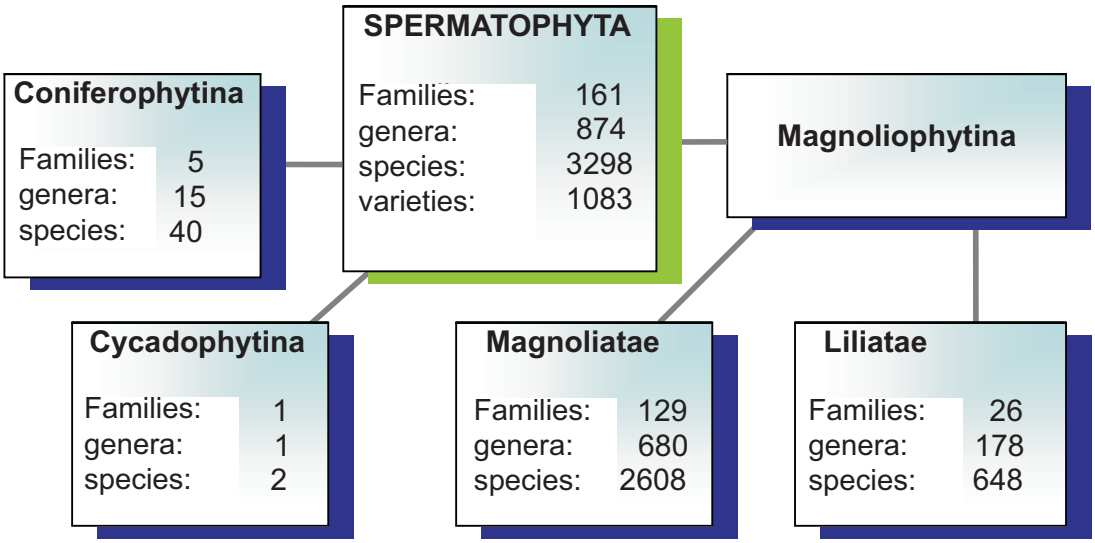
## Diversity of Spermatophytes

Spermatophytes represent the most numerous and diverse group of plants within vascular flora of Bosnia and Herzegovina. Those are plants that grow in terrestrial habitats, while only few of them are adapted to the aquatic environment. This is the group of organisms that makes the framework of life in Bosnia and Herzegovina, being responsible for shaping of landscape's diversity. The diversity of vascular flora includes also the most important biological resources (economically important trees, medicinal, edible and aromatic herbs, genetic herbal resources and ornamental flora). Spermatophytes were the propulsive factor of ethnogenesis, settlement, survival and existance of people in Bosnia and Herzegovina.

Afore mentioned biological resources are carrying pillar of todays dominant economic branches in Bosnia and Herzegovina. The forestry and wood industry are essential to the development and progress of both local

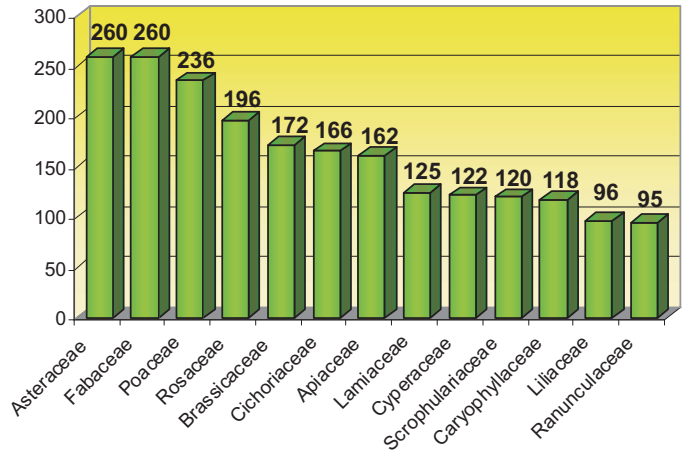
and national community, then pharmacological and food industry, modern dietics, cosmetics, production of fruits, vegetables and fibres, and other economy branches based on the exploitation of biological resources.

Thanks to explorers of Bosnia and Herzegovina's flora (Beck, Hayek and Karlo Maly), it was created firm base for next floristic research resulting in following assessment of spermatophytes diversity:




Graph. 2. – Diversity of Spermatophytes in B&H

The highest diversity level is reached within the class of Magnoliatae (2.608 species, 943 sub-species and 148 hybrids), then the class of Liliatae with 648 species, 135 sub-species and 16 hybrids. The sub-division of Coniferophytina encompass a relatively small number of species (40), sub-species (4) and hybrids (4).
Families with the highest species diversity are: composits, pea family, grasses, roses, crucifers, parsley family, mint family, sedges, figworts, pinks, lilies and buttercups. Within these families are 65% of all Spermatophytes. A special diversity character of this group is reflected through a great number of families with only one genus and species (approximately 30% of total number).




Graph. 3. – Families with the highest species diversity in B&H

Table 10. – Taxonomic diversity of Spermatophytes in B&H

| | genus | species | Sub--species | hybrid |
|---|---|---|---|---|
| Coniferophytina | | | | |
| Cupressaceae | 4 | 15 | 4 | 3 |
| Ginkgoaceae | 1 | 1 | 0 | 0 |
| Pinaceae | 7 | 21 | 0 | 1 |
| Taxaceae | 1 | 1 | 0 | 0 |
| Taxodiaceae | 2 | 2 | 0 | 0 |
| Total | 15 | 40 | 4 | 0 |
| Cycadophytina | | | | |
| Ephedraceae | 1 | 2 | 1 | 0 |
| Total | 1 | 2 | 1 | 0 |
| Magnoliophytina | | | | |
| Magnoliatae | | | | |
| Acanthaceae | 1 | 3 | 0 | 0 |
| Aceraceae | 1 | 12 | 3 | 2 |
| Acoraceae | 1 | 1 | 0 | 0 |
| Actinidiaceae | 1 | 1 | 0 | 0 |
| Adoxaceae | 1 | 1 | 0 | 0 |
| Aizoaceae | 2 | 4 | 0 | 0 |
| Amaranthaceae | 1 | 7 | 0 | 0 |
| Anacardiaceae | 3 | 5 | 0 | 0 |
| Apiaceae (=Umbelliferae) | 60 | 162 | 2 | 0 |
| Apocinaceae | 2 | 3 | 0 | 0 |
| Aquifoliaceae | 1 | 1 | 0 | 0 |
| Araliaceae | 1 | 1 | 0 | 0 |
| Aristolochiaceae | 2 | 4 | 0 | 0 |
| Asclepiadaceae | 3 | 5 | 4 | 0 |
| Asteraceae (=Compositae) | 72 | 260 | 37 | 11 |
| Balsaminaceae | 1 | 5 | 0 | 0 |
| Berberidaceae | 3 | 4 | 0 | 0 |
| Betulaceae | 2 | 5 | 0 | 2 |
| Bignoniaceae | 2 | 3 | 0 | 0 |
| Boraginaceae | 21 | 49 | 15 | 0 |
| Brassicaceae (=Cruciferae) | 56 | 172 | 59 | 2 |
| Buddlejaceae | 1 | 1 | 0 | 0 |
| Buxaceae | 1 | 1 | 0 | 0 |
| Cactaceae | 1 | 3 | 0 | 0 |
| Callitrichaceae | 1 | 1 | 3 | 0 |
| Campanulaceae | 8 | 51 | 11 | 1 |
| Cannabaceae | 2 | 2 | 0 | 0 |
| Capparidaceae | 1 | 1 | 0 | 0 |
| Caprifoliaceae | 5 | 23 | 2 | 2 |
| Caryophyllaceae | 26 | 118 | 67 | 0 |
| Celastraceae | 1 | 5 | 0 | 0 |
| Ceratophyllaceae | 1 | 1 | 0 | 0 |
| Cesalpiniaceae | 3 | 3 | 0 | 0 |
| Chenopodiaceae | 8 | 21 | 0 | 0 |
| Cichoriaceae (=Compositae) | 23 | 166 | 401 | 1 |
| Cistaceae | 4 | 11 | 12 | 0 |
| Convolvulaceae | 4 | 8 | 4 | 0 |
| Cornaceae | 1 | 3 | 0 | 0 |
| Corylaceae | 3 | 6 | 0 | 1 |
| Crassulaceae | 4 | 19 | 2 | 0 |
| Cucurbitaceae | 7 | 10 | 0 | 0 |
| Dipsacaceae | 7 | 33 | 0 | 0 |
| Droseraceae | 1 | 1 | 0 | 0 |
| Ebenaceae | 1 | 2 | 0 | 0 |
| Elaeagnaceae | 2 | 2 | 0 | 0 |
| Empetraceae | 1 | 1 | 0 | 0 |
| Ericaceae | 8 | 13 | 0 | 0 |
| Euphorbiaceae | 5 | 41 | 1 | 0 |
| Fabaceae (=Leguminosae) | 47 | 260 | 68 | 0 |
| Fagaceae | 3 | 11 | 4 | 8 |
| Gentianaceae | 4 | 24 | 3 | 0 |
| Geraniaceae | 3 | 24 | 3 | 0 |
| Globulariaceae | 1 | 3 | 2 | 0 |
| Grossulariaceae | 1 | 8 | 0 | 0 |
| Haloragaceae | 1 | 2 | 0 | 0 |
| Hamamelidaceae | 2 | 2 | 0 | 0 |
| Hippocastanaceae | 1 | 2 | 0 | 0 |
| Hippuridaceae | 1 | 1 | 0 | 0 |
| Hydrangaceae | 3 | 4 | 0 | 0 |
| Hydrophyllaceae | 1 | 1 | 0 | 0 |
| Hypericaceae (=Guttiferae ) | 1 | 9 | 0 | 0 |
| Juglandaceae | 1 | 2 | 0 | 0 |
| Lamiaceae (=Labiatae) | 31 | 125 | 72 | 10 |
| Lauraceae | 1 | 1 | 0 | 0 |
| Lentibulariaceae | 1 | 7 | 0 | 0 |
| Linaceae | 2 | 13 | 2 | 0 |
| Lobeliaceae | 1 | 3 | 0 | 0 |
| Loranthaceae | 3 | 3 | 3 | 0 |
| Lythraceae | 1 | 4 | 2 | 0 |
| Magnoliaceae | 2 | 4 | 0 | 1 |
| Malvaceae | 7 | 17 | 2 | 0 |
| Meliaceae | 1 | 1 | 0 | 0 |
| Menyanthaceae | 2 | 2 | 0 | 0 |
| Mimosaceae | 1 | 1 | 0 | 0 |
| Molluginaceae | 1 | 1 | 0 | 0 |
| Moraceae | 4 | 5 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| Myrtaceae | 1 | 1 | 0 | 0 |
| Nyctaginaceae | 2 | 2 | 0 | 0 |
| Nymphaeaceae | 2 | 2 | 0 | 0 |
| Oleaceae | 6 | 11 | 3 | 2 |
| Oenotheraceae (=Onagraceae) | 4 | 18 | 2 | 0 |
| Orobanchaceae | 1 | 20 | 4 | 2 |
| Oxalidaceae | 1 | 6 | 0 | 0 |
| Paeoniaceae | 1 | 2 | 0 | 0 |
| Papaveraceae | 7 | 24 | 5 | 0 |
| Parnassiaceae | 1 | 1 | 1 | 0 |
| Passifloraceae | 1 | 1 | 0 | 0 |
| Phytolacaceae | 1 | 1 | 0 | 0 |
| Pittosporaceae | 1 | 1 | 0 | 0 |
| Plantaginaceae | 1 | 10 | 0 | 0 |
| Platanaceae | 1 | 1 | 0 | 1 |
| Plumbaginaceae | 3 | 4 | 0 | 0 |
| Polemoniaceae | 2 | 3 | 0 | 0 |
| Polygalaceae | 1 | 7 | 4 | 0 |
| Polygonaceae | 6 | 37 | 0 | 0 |
| Portulacaceae | 2 | 2 | 0 | 0 |
| Primulaceae | 9 | 22 | 2 | 0 |
| Punicaceae | 1 | 1 | 0 | 0 |
| Pyrolaceae | 4 | 6 | 0 | 0 |
| Ranunculaceae | 19 | 95 | 18 | 0 |
| Resedaceae | 1 | 4 | 0 | 0 |
| Rhamnaceae | 4 | 12 | 3 | 0 |
| Rosaceae | 27 | 196 | 30 | 70 |
| Rubiaceae | 5 | 35 | 1 | 0 |
| Rutaceae | 4 | 6 | 2 | 0 |
| Salicaceae | 2 | 28 | 10 | 8 |
| Santalaceae | 2 | 10 | 0 | 0 |
| Sapindaceae | 1 | 1 | 0 | 0 |
| Saxifragaceae | 2 | 22 | 2 | 1 |
| Scrophulariaceae | 24 | 120 | 52 | 19 |
| Simaroubaceae | 1 | 1 | 0 | 0 |
| Solanaceae | 10 | 18 | 2 | 0 |
| Staphyleaceae | 1 | 1 | 0 | 0 |
| Styracaceae | 1 | 1 | 0 | 0 |
| Tamaricaceae | 1 | 4 | 0 | 0 |
| Tetragoniaceae | 1 | 1 | 0 | 0 |
| Thelygonaceae | 1 | 1 | 0 | 0 |
| Tiliaceae | 1 | 4 | 3 | 2 |
| Thymelaeaceae | 2 | 7 | 0 | 0 |
| Trapaceae | 1 | 1 | 0 | 0 |
| Tropaeolaceae | 1 | 3 | 0 | 0 |
| Ulmaceae | 2 | 7 | 2 | 1 |
| Urticaceae | 2 | 5 | 0 | 0 |
| Valerianaceae | 3 | 12 | 3 | 0 |
| Verbenaceae | 2 | 2 | 0 | 0 |
| Violaceae | 1 | 25 | 8 | 1 |
| Vitaceae | 2 | 6 | 2 | 0 |
| Zannichelliaceae | 1 | 1 | 0 | 0 |
| Zygophyllaceae | 1 | 1 | 0 | 0 |
| Liliatae | | | | |
| Agavaceae | 1 | 1 | 0 | 0 |
| Alismataceae | 2 | 4 | 0 | 0 |
| Amaryllidaceae | 4 | 9 | 1 | 0 |
| Araceae | 4 | 6 | 0 | 0 |
| Arecaceae (=Palmae) | 2 | 2 | 0 | 0 |
| Butomaceae | 1 | 1 | 0 | 0 |
| Cannaceae | 1 | 1 | 0 | 0 |
| Commeliniaceae | 2 | 2 | 0 | 0 |
| Cyperaceae | 10 | 122 | 10 | 0 |
| Dioscoreaceae | 1 | 1 | 0 | 0 |
| Hydrocharitaceae | 4 | 4 | 0 | 0 |
| Iridaceae | 6 | 22 | 3 | ++ |
| Juncaceae | 2 | 34 | 14 | 0 |
| Juncaginaceae | 1 | 3 | 0 | 0 |
| Lemnaceae | 3 | 4 | 0 | 0 |
| Liliaceae | 26 | 96 | 2 | 0 |
| Najadaceae | 1 | 2 | 0 | 0 |
| Orchidaceae | 23 | 69 | 35 | 7 |
| Potamogetonaceae | 2 | 16 | 0 | 3 |
| Poaceae (=Gramineae) | 76 | 236 | 67 | 6 |
| Posidoniaceae | 1 | 1 | 0 | 0 |
| Ruppiaceae | 1 | 2 | 0 | 0 |
| Scheuchzeriaceae | 1 | 1 | 0 | 0 |
| Sparganiaceae | 1 | 4 | 3 | 0 |
| Typhaceae | 1 | 3 | 0 | 0 |
| Zosteraceae | 1 | 2 | 0 | 0 |

## ENDEMIC FLORA OF BOSNIA AND HERZEGOVINA

There are several reasons that have led to the development of the unique plant world on the territory of the Dinaric Alps in Bosnia and Herzegovina. Those are: unique process of bedrock's formation, types of soil, relief, ecoclimate, water regime etc. An insulation of distinct habitats, such as cliffs, canyons and the highest mountain peaks, resulted in the development of special forms that are specific for a smaller or larger area. The territory of Bosnia and Herzegovina was a dispersal centre of some floristic forms that expanded over other parts of the Balkan peninsula. The hypothesis of former connection between the Alps, the Carpathians and the Apennines is confirmed by the occurence of kindred forms in these insulated geographic units.

The most specific characteristic of B&H's flora is a great deal of paleo- and neo- endemic

species, tertiary and glacial relicts maintained in refugial habitats, such as cliffs, canyons and mountain cirques.
Because of sensitivity of their organic structure, there is only few preserved paleoendemic species. This group includes famous representatives of silicate and carboniferous alges, higher plants with conifers and trees, such as birch, haselnut, oak and beech.
It is very interesting that among cyanophytes and alges haven't been recorded endemic forms in B&H till now, which doesn't mean that in this world of true wilderness miss floristic uniquenesses bound to, first of all, specific habitats (mountain springs, karst wells, half-caves, tuff depositions, thermal sources, and refugia, especially around old volcanic rocks) characterized by endemisms of mosses, ferns and spermatophytes.
Current information confirm the need after review and establishment of detailed inventory of alges and cyanophytes.
Most of endemic forms (genera, species, subspecies and lower taxonomic categories) is recognized within the flora of higher plants, which at current state of knowledge is estimated to have 450 endemic taxa. Newly undertaken investigations indicate that this number is much bigger, especially as far as poorly investigated genera are concerned, such as: *Alchemilla, Potentilla, Rosa, Rubus, Hieracium, Centaurea, Carex, Festuca*.
Flora of higher plants in B&H is also characterized by stenoendemic species (Table 11.).

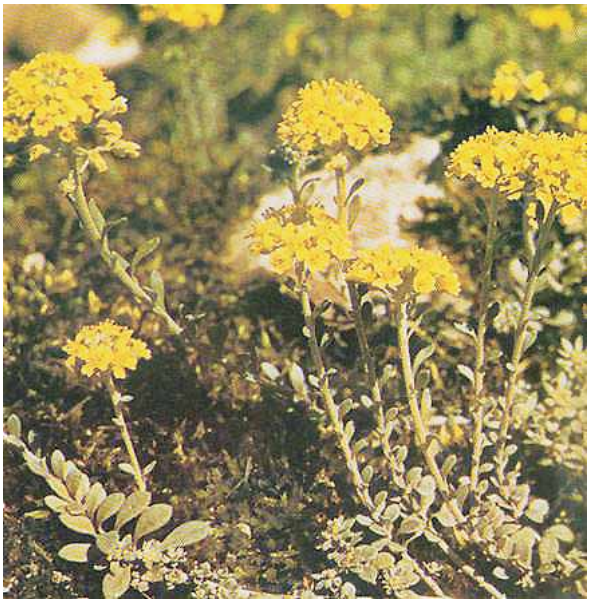
Table 11. – Stenoendemic plants of Bosnia and Herzegovina

| Taxon name | Distribution | Proposal of threat's category |
|---|---|---|
| Acinos orontius (K. Maly) Šilić | Between Konjic and Glavatičevo, around Glavatičevo, in the canyon of Rakitnica, Đepa at Konjic, valley of Trešetnica, Vrtaljica, Suhi do, Zlatar, near Vrbljani, Pirića in the surrounding of Podorašac, at Špiljani, Bigolje | V |
| Alyssum moellendorfianum Aschers. ex G. Beck | Dolomite slopes of Prenj Mt.: valley of Trešanica, between Konjic and Špiljani, Koznik at Konjic, by Vrabac, Borak, Galat, Orlov Kuk at Glavatičevo, near watermouth of the Rakitnice river, Boračko jezero – Glavatičevo | E |
| Asperula hercegovina Degen | Prenj Mt., Čvrsnica Mt., Čabulja Mt., Velež Mt. | R |
| Barbarea bosniaca Murb. | Bosnia; endem of the mid Dinaric Alps | R |
| Campanula hercegovina Degen & Fiala | Čvrsnica Mt., Prenj Mt., Čabulja Mt., Velež Mt., Plasa | R |
| Centaurea bosniaca (Murb.) Hayek | Vranica Mt., Vitruša, Zec Mt., Vukuša Mt., Vis at Kalesija, Tatinica, Ravna Mt. | V |
| C. murbeckii Hayek | Igman Mt., Plazenica Mt., Kupres, Bjelašnica Mt., at Gacko, Velež Mt., Lukomir, Obalj | V |
| Dianthus freynii Vandas | Prenj Mt., Čvrsnica Mt., Plasa Mt. | V |
| Edraianthus hercegovinus K. Maly | Čvrsnica Mt. | R |
| E. niveus G. Beck | Vranica Mt., Zec Mt., Vitreuša Mt. | R |
| Euphorbia gregersenii K. Maly | Valley of the Gostović brook (Kamenica) and its tributaries: Kamenica and Suha, Velež, Borik at Borovnica, on Tajan hills | R |

| | | |
|---|---|---|
| E. hercegovina Beck | Zvekuša, slopes of Zlatar, between Podorašac and Konjic, Suhi do, valley of Ljuta at Bigolje and Pričepa | R |
| Melampyrum trichocalicinum Vandas | Glogovo Mt., gorge of Risovac – Aleksin Han at Jablanica, Pribilje in the valley of Rakitnica, in the valley of Doljanka at Doljani, Skok on Prenj Mt., Orahovica at Nemila, Brasina Mt., above Bijelo polje, at Jablanica, in the valley of Rakitnica at Blaca | V |
| Minuartia handelii Mattf. | Čvrsnica Mt. – Veliki Vilinac | E |
| Oxytropis prenja (G. Beck) G. Beck in Reichenb. & Reichenb. Fil. | Prenj Mt., Čvrsnica Mt., Vran Mt., Plasa | V |
| Potentilla heptaphylla L. subsp. velezensis (Beck) Bjelčić | Prenj Mt., Čvrsnica Mt., Čabulja Mt., Velež Mt., Preslica | K |
| Seseli hercegovinum K. Maly | Karaula, Aleksin han, Prenj Mt., Čvrsnica Mt., Grabovica, Neretva river, Diva Grabovica, upstream from watermouth of Drežnica river, Glogovo | V |
| Symphyandra hofmannii Pantocsek | central Bosnia: around mid flow of the Bosna and Vrbas river, Vranica Mt. – valley of the Kozica river, surrounding of Brčko | - |
| Viola beckiana Fiala | Smolin at Žepče, Stolovac between Donji Vakuf and Jajce, between Bugojno and Kupres, Han Koprivnica, Stožer Plazenica | K |
| V. prenja G. Beck | Prenj Mt. | K |

The distribution range of above given stenoendemic species leads us to the conclusion that more than one half of them occur in Herzegovina, within the area of mountain complex Prenj-Čvrsnica-Velež and canyon of the Neretva river, as well as canyons of its tributaries. These data confirm the statement that it is the centre of endemism in Bosnia and Herzegovina.

Beside endemic species that are exclusively bound to the territory of Bosnia and Herzegovina, here occur plants whose distribution range extend on other areas of the Dinaric Alps and Balkan peninsula. However, dispersal centres for most of them are to be found within refugia of Bosnia and Herzegovina.



*Alyssum moellendorfianum* Asch. ex Beck

*Onosma stellulata* Waldst. & Kit.

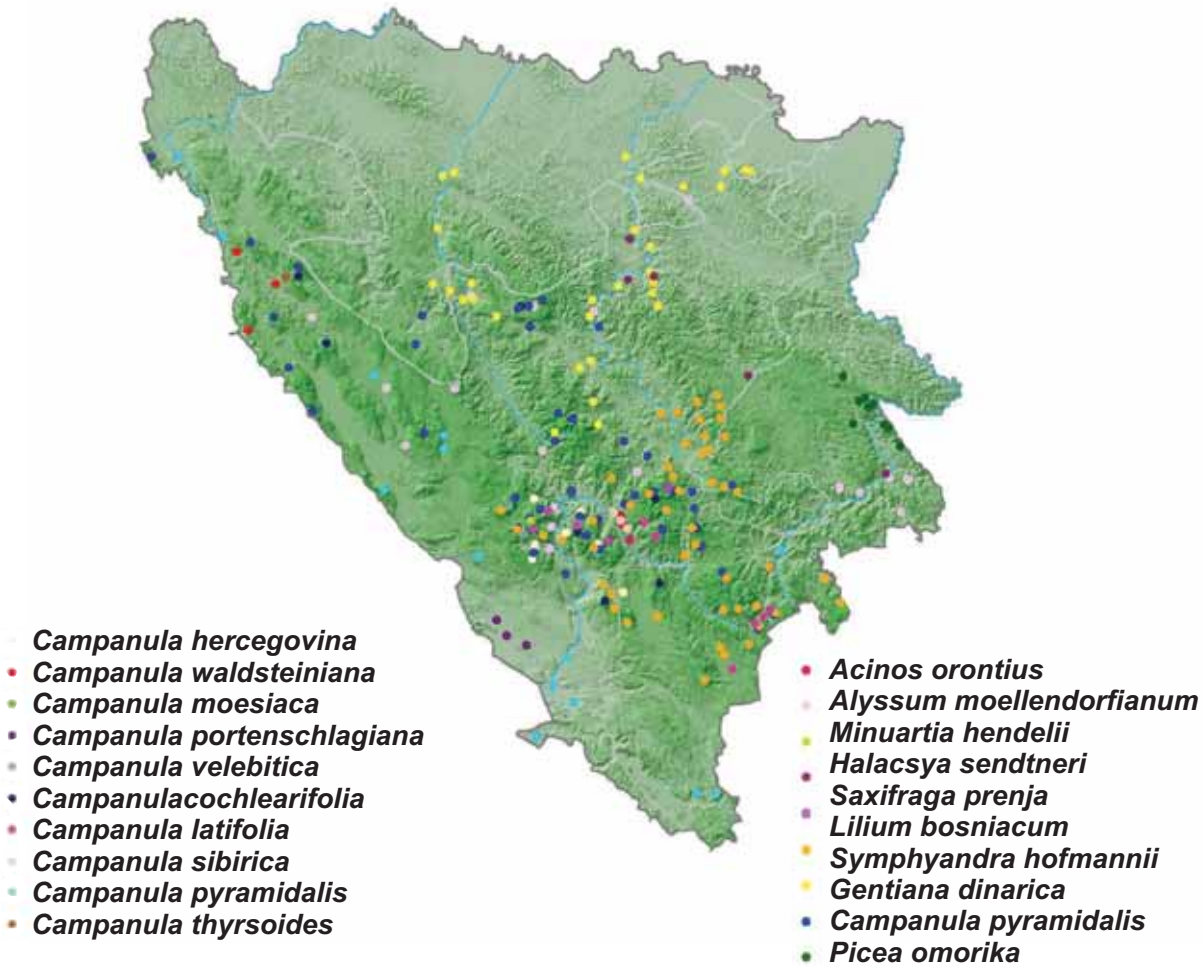



Fig. 4. – Distribution range of some endemic plants in Bosnia and Herzegovina

*Campanula cochlearifolia* Lam.

*Campanula hercegovina* Degen & Fiala

## Pressures on flora of spermatophytes

Because of its sensitivity in biological respect, and different kind of pressures that have been ongoing for centuries (intensive deforestation, soil erosion, disturbances of water regime, drainage, exploitation of mineral and biological resources), vascular flora of Bosnia and Herzegovina is severly threatened.
According to the assessment based on the preliminary plant's list that was compiled for the Red Book (Šilić, 1992-1995), and following criteria of the International Union for Conservation of Nature, there are over 600 taxa under certain threat (species, sub-species, varietes and forms).
If we take into account factors that currently endanger biodiversity in general, and by that also its herbal component, we can classify them into different forms of negative human impacts, so called anthropogenous impacts. These are reflected through:

- Effects of global climate changes followed by acid rain and over-heating;
- Conversion of natural habitats into anthropogenic ones;
- Over-deforestation;
- Drainage of wetlands;
- Conversion of wood's habitats;
- Over-grazing and soil erosion in highmountain areas;
- Unbalanced exploitation of mineral resources;
- Invasive species that take ecological niches of autochtonous ones;
- Over-exploitation of economically important species.

*Dianthus freynii* Vandas

## Alien flora

An alien flora addresses species that have come into ecosystems of B&H by different means from different geographical regions, and exercise their effects on crops and partially in free nature.
High heterogeneity level of habitats in B&H provides living space for numerous alien species. Based on available records, it is estimated that on the territory of Bosnia and Herzegovina occur more than 500 alien species, of which many got adapted in natural habitats. Significant number of them lives only in crops, for their survival depends on human intervention and care (many ornamental species, majority of herbal genetic resources).

# DIVERSITY OF FAUNA

## GLOBAL DIVERSITY OF FAUNA

An attempt to make an inventory and systematic overview of recent animal world has been facing two major obstacles:

- Differences in taxonomic approach;
- Assessment of actual, or potential, number of species, intraspecies categories and genera.

Respecting the approach of modern authors, animal kingdom is divided into numerous phyla. After Miller and Harley (1999), Protozoa is divided into 7, and Metazoa into 36 phyla. After Pechenik (1996), however, animal kingdom consists of 16 phyla of Protozoa and 32 phyla of Metazoa.

According to the most recent EUNIS classification, this kingdom today consists of 43 phyla. This is a classification attempt, which resulted in contrary opinions regarding phylum's extent.

To assess the actual and potential number of animal species in B&H is the most sever problem of all. Despite the fact that we are living in the 21st century, there are many species or even entire phyla, especially invertebrates, that are considered to be a mistery to modern science. The assessment of real species diversity within invertebrates causes the most opposite standpoints. Hence, there is a serious threat that some of these species could become extinct due to impacts of a modern human society before they even get discovered. It is hard to quantify, by currently available methodology, a damage caused by ignorance and neglection of this unique gen pool, but it is for sure that the damage would have severe and long-termed consequences.

***Investigation level***

*Despite of the abundance of distinct animal groups and the fact that they are being unexplored, in Bosnia and Herzegovina hasn't been undertaken any action to make an inventory and compile existing knowledge. Although some zoologist confirm their enormous enthusiasm by attempts to organize the knowledge in more systematic manner, the fauna of Bosnia and Herzegovina is far from being full.*

*There are differences among distinct animal groups regarding the achieved investigation level. The fauna of fish, birds and butterflies is the best investigated.*

*As far as invertebrates are concerned, there are some assessments done on the species number and taxonomic diversity of several groups, such as: Annelida (segmented worms), Hirudinea (leeches), Oribatidae (ticks), Crustacea (crabs), Insecta (insects). The latter includes some well investigated groups: Ephemeroptera, Plecoptera, Trichoptera, Ropalocera, and representatives of pedofauna Colembolla, Protura and Myriapoda.*

## DIVERSITY OF FAUNA IN BOSNIA AND HERZEGOVINA

Thanks to the abundance and diversity of certain animal groups, as well as diversity of fauna in general, Bosnia and Herzegovina belongs to the top of European biodiversity. This is also confirmed by great deal of endemic and relict species, especially among the invertebrates. B&H's fauna is characterized by the occurence of refugia and development centres, and by the most unique fauna of karst sources, mountain torrents and canyons.

The attempt to compile records on fauna of Bosnia and Herzegovina has recognized uneven knowledge level by groups. For the regnum of Protozoa, there are missing data on species and phylla that have been identified

in Bosnia and Herzegovina. Phylla of Metazoa, such as Platihelminthes, Nemertina, Nematoda, Rotatoria, Pogonophora happen to be the least, or not at all investigated in Bosnia and Herzegovina.

Based on the actual knowledge of animal kingdom we can make the assessment of biodiversity by phylogenetic groups, as shown in Table 12:

Table 12. – Assessment of animal diversity in Bosnia and Herzegovina

| Animal group | Number of families | Number of genera | Total number of species | Number of threatened species in B&H | Number of threatened species in Europe | Number of endemic species |
|---|---|---|---|---|---|---|
| Fish | 27 | 69 | 119 | ? | 110 | 12 |
| Amphibians | 7 | 8 | 20 | 3 | 6 | 6 |
| Reptiles | 12 | 26 | 38 | 11 | 10 | 12 |
| Birds | 60 | 165 | 326 | 97 | 78 | - |
| Mammals | 19 | 51 (2?) | 85 (+2?) | 24 | 52 | 9 |
| Total | 125 | 319 (2?) | 588 (2?) | 135 | 256 | 39 |

## Diversity of invertebrates

The invertebrates are both the most numerous and the most diverse group of living world on global, regional and local scale. The framework of B&H's fauna diversity is made by different invertebrates groups, while they, at the same time, represent the least investigated group of organisms.

Table 13. – Overview of invertebrates diversity in B&H by phylogenetic groups

| Phyllum (typ, division, class) | Number of families | Number of genera | Presumed number of species | Number of species(?) | Endemic species |
|---|---|---|---|---|---|
| Protozoa: *Sarcodina, Mastigophora, Ciliophora* | **?** | **?** | | **??** | |
| Porifera: *Demospongiae* | **1** | **3** | | **?4** | |
| Placozoa | **1** | **1** | | **?1** | |
| Cnidaria: *Hydrozoa,Scyphozoa i Anthozoa* | ? | ? | 50 | ?? | |
| Ctenophora | ? | 3 | | 3 | ? |
| Plathelminthes:*Turbellaria, Trematodes i Cestodes* | **?** | **?** | | **98** | |
| Gnathostomulida, Mesozoa, Rhynchocoela | **?** | **?** | | **?** | |
| Nematoda: *Nemata* | **?** | **?** | | **103** | |
| Nematomorpha: *Nectonematoidea, Gordioidea* | **4** | **?** | | **20** | |
| Acanthocephala | ? | ? | 30 | ? | ? |
| Priapulida, Rotifera | **?** | **?** | | **?** | |
| Gastrotricha | 13 | ? | | 50 | |
| Kinorhyncha: *Echinoderida* | ? | 3 | | -3 | |
| Loriciphera | ? | ? | | ? | |
| Mollusca: *Polyplacophora* | 13 | | | ? | |
| Mollusca: *Aplacophora* | 24 | | | | |
| Mollusca: *Monoplacophora* | 1 | | | | |
| Mollusca: *Gastropoda* | 330 | | | | |
| Mollusca: *Bivalvia* | 90 | | | | |
| Mollusca: *Scaphopoda* | 8 | | | | |
| Mollusca: *Cephalopoda* | 44 | | | | |

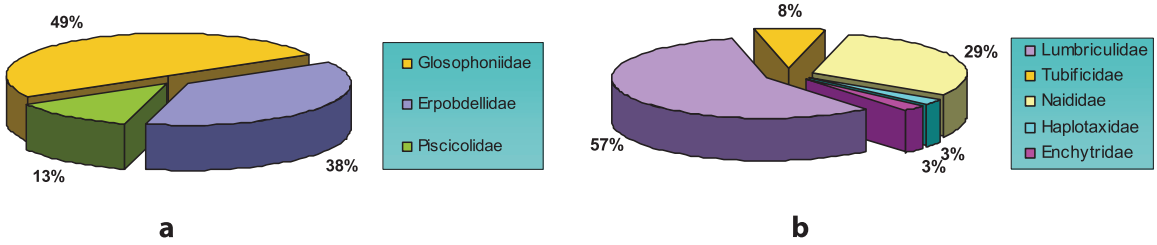
| | | | | | |
|---|---|---|---|---|---|
| Pentastomida | 1 | 1 | 2 | ? | - |
| Annelida:Polychaeta | | | | | |
| Annelida: Oligocheta | 5 | 19 | | 50 | |
| Annelida: *Hirudinea* | 3 | 7 | | 8 | |
| Annelida: *Branchiobdellida* | | | | | |
| Echiura, Sipuncula, Pogonophora | | | | | |
| Arthropoda: Chelicerata: *Arachnida:Acarina* | 48 | 84 | | 208 | |
| Arthropoda: Chelicerata: *Merostomata, Pycnogonida* | | | | | |
| Arthropoda: Crustacea: Malacostraca: Amphipoda | 1 | 8 | | 31 | |
| Arthropoda: Crustacea: Malacostraca: Decapoda | 1 | 2 | | 5 | |
| Arthropoda: Crustacea: Cephalocarida, Branchiopoda, Ostracoda, Mystacocarida, Copepoda, Branchiura, Pentastomida, Tantulocarida, Remipedia, Cirripedia | | | | | |
| Arthropoda: Chilopoda | ? | ? | 60 | 9 | ? |
| Arthropoda: Diplopoda | ? | ? | 80 | 55 | ? |
| Arthropoda: Pauropoda | 4 | 9 | 25 | 23 | ? |
| Arthropoda: Symphila | 2 | 7 | 15 | 12 | ? |
| Arthropoda: Insecta | ? | ? | 30.000 | | |
| Arthropoda: Insecta: Colembola | ? | ? | 255 | 224 | |
| Arthropoda: Insecta: Ephemeroptera | 9 | 20 | 60 | 58 | |
| Arthropoda: Insecta: Plecoptera | 7 | 15 | 80 | 74 | |
| Arthropoda: Insecta: Trichoptera | 19 | 78 | 220 | 215 | |
| Arthropoda: Insecta: Protura | ? | ? | 25 | 18 | |
| Arthropoda: Insecta: Diplura | ? | ? | 20 | 15 | |
| Arthropoda: Insecta: Zygentoma | ? | 2 | 2 | 2 | |
| Arthropoda: Insecta: Mantodea | 2 | 3 | 4 | 4 | |
| Arthropoda: Insecta: Blattodea | 3 | 5 | 20 | 17 | |
| Arthropoda: Insecta: Heteroptera | ? | ? | 1.000 | 705 | |
| Arthropoda: Ins.: Col., Adephaga | 5 | ? | 1.000 | 701 | |
| Arthropoda: Ins.: Col., Polyphaga | ? | ? | 10.000 | 6.000 | |
| Arthropoda: Ins.: Col., Polyphaga: *Lymexylidae* | | 1 | 1 | 1 | |
| Arthropoda: Ins.: Col., Polyphaga: *Buprestidae* | | ? | 150 | 129 | |
| Arthropoda: Ins.: Col., Polyphaga: *Hydrophilidae* | | ? | 60 | 47 | |
| Arthropoda: Ins.: Col., Polyphaga: *Sphaeridiidae* | | ? | 30 | 30 | |
| Arthropoda: Ins.: Col., Polyphaga: *Sphaeritiidae* | | 1 | 1 | 1 | |
| Arthropoda: Ins.: Col., Polyphaga: *Dascillidae* | | 1 | 1 | 1 | |
| Arthropoda: Ins.: Col., Polyphaga: *Trogidae* | | 1 | 3 | 3 | |
| Arthropoda: Ins.: Col., Polyphaga: *Geotrupidae* | | 3 | 9 | 9 | |
| Arthropoda: Ins.: Col., Polyphaga: *Scarabaeidae* | | 45 | 160 | 159 | |
| Arthropoda: Ins.: Col., Polyphaga: *Lucanidae* | | 6 | 7 | 7 | |
| Arthropoda: Ins.: Col., Polyphaga: *Chrysomelidae* | | ? | 350 | 322 | |
| Arthropoda: Ins.: Col., Polyphaga: *Cerambicidae* | | ? | 220 | 218 | |
| Arthropoda: Ins.: Col., Polyphaga: *Scolytidae* | | ? | 55 | 55 | |
| Arthropoda: Insecta: *Lepidoptera* | 58 | 785 | 3.000 | 1.622 | |
| Arthropoda: Insecta: *Caelifera* | ? | ? | 70 | 70 | |
| Arthropoda: Insecta: *Ensifera* | ? | ? | 85 | 85 | |
| Arthropoda: Ins., *Hymenoptera* | 21 | ? | 5.000 | 353 | |
| Tardigrad: *Heterotardigrada* | | | | 31 | |
| Tardigrad: *Mesotardigrada, Eutardigrada* | | | | | |
| Onychophora | 0 | 0 | 0 | 0 | 0 |
| Phoronida | 1 | 1 | | 1 | - |
| Brachiopoda, Bryozoa, Entoprocta | | | | | |
| Echinodermata: *Crinoidea* | ? | 2 | | 3 | |
| Echinodermata: *Holothurioidea* | ? | 3 | | 2 (3) | |
| Echinodermata: *Echinoidea* | ? | 5 | | 5 | |
| Echinodermata: *Asteroidea* | ? | 5 | | 6 | |
| Echinodermata: *Ophiuroidea* | ? | 3 | | 4 | |
| Chaetognatha: *Sagittoidea* | ? | ? | | 13 | |

The diversity of habitats both aquatic and terrestrial ones, on horizontal and vertical profile of Bosnia and Herzegovina, has promoted a diversification of many invertebrates.
Though majority of those species hasn't been enough explored so far, there are numerous animal groups because of which fauna of Metazoa of Bosnia and Herzegovina is considered to be highly diverse.

Table 13 gives an overview of the forseen species number for some groups of invertebrates, this comes especially to Arthropoda. In correlation with the achieved investigation level and realized abundance, it is assessed that groups with greatest abundancy are some of insects: Coleoptera (beetles), Lepidoptera (butterflies) and Hymenoptera (sawflies).

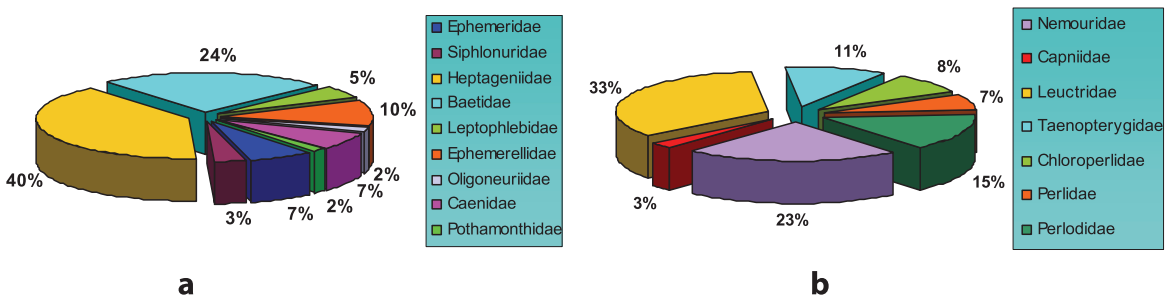
## Characteristics of limnofauna's diversity

Due to the diversity of aquatic habitats, and the occurence of different kind of watercourses, limnofauna of invertebrates of Bosnia and Herzegovina ought to be very diverse. There are 50 species among annelids that belong to 19 genera.




Graph. 4. – Diversity of annelids (**a**) and leaches (**b**) in B&H

Leaches (Hirudinea) have been only partially investigated. According to currently obtainable records, in water ecosystems live 8 species belonging to 7 genera.
River crustaceans (Amphipoda) encompass 31 species, of which 16 are endemic ones. In upper flow of Neretva river it was noted significante abundance of river crustaceans belonging to decapods. In 2002, in Boračko lake was recognized large population of *Astacus astacus*, while in the confluence of Bosna river the same kind of observation was made for *Austropotamobius torentium*.
For freshwater ecosystems in Bosnia and Herzegovina, the most characteristic is fauna of aquatic insects, with high level of the diversity and endemism. Thus, fauna of mayflies comprises 58 species belonging to 20 genera, of which five are dinaric, balkan or dinaric-alpine endemic species.



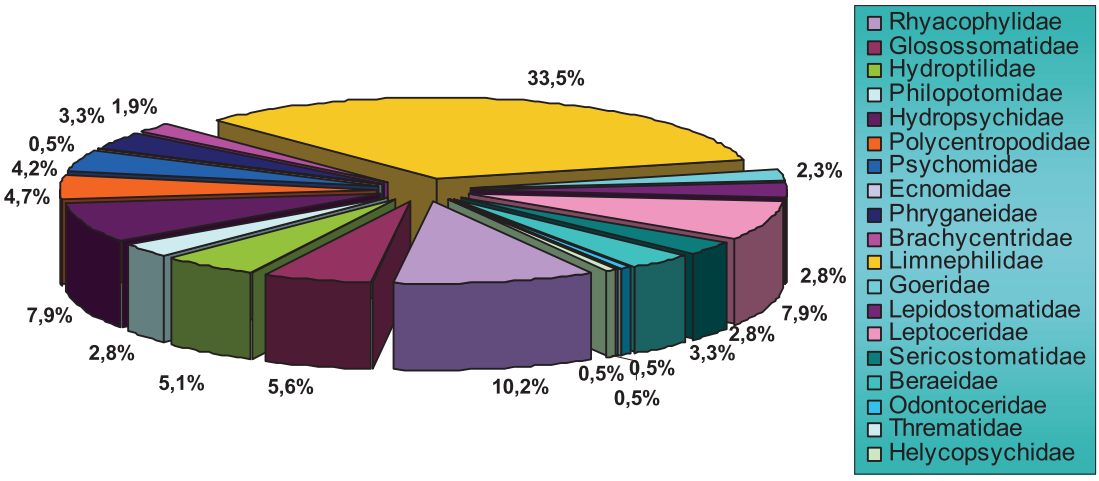

Graph. 5. – Diversity of mayflies (**a**) and stoneflies (**b**) in B&H

Table 14. – Endemic species of Ephemeroptera described in Bosnia and Herzegovina

| Endemic species of Dinaric Alps | Endemic species of Balkan peninsula | Dinaric-alpine endemic species |
|---|---|---|
| *Ecdyonurus ozrensis* (Tanasijević 1974) | *Rhythrogena sowai* Puthz, 1972 | *Siphlonurus croaticus* (Ulmer, 1924, Tansijević, 1974) |
| *Ecdyonurus zelleri* (Eaton, 1885) | *Epeorus jugoslavicus* (Šamal, 1935) | *Ephemera zettana* (Kimmins, 1937) |
| *Rhythrogena ryszardi* Tansijević, 1984 | *Ephemerella ikonomovi* Puthz, 1971 | |
| *R. putzi* Putz, 1972 | | |
| *R. neretvana* Tansijević, 1984 | | |

In the fauna of stoneflies (Plecoptera), it has been described 74 species from 15 genera. There are 13 endemic taxa belonging to genera: Brachyptera (3), Leuctra (4), Isoperla (3), Perla (1), Siphonoperla (1) and Chloroperla (1). Distribution range of Leuctra aptera and Leuctra jahorinensis is limited and relates exclusively to the territory of Bosnia and Herzegovina.

In the aquatic fauna of insects, water moths (caddisflies) ought to be numerous group with 215 detected species from 78 genera. From that number, 50 species possess endemic character and 24 of them are endemic ones with the dinaric distribution range. The most interesting is genus *Drusus* inhabiting water of Bosnia and Herzegovina at sources itselfs.




Graph. 6. – Diversity of water moths in B&H

Habitat of high diversity of aquatic insects (Duman, Livno)

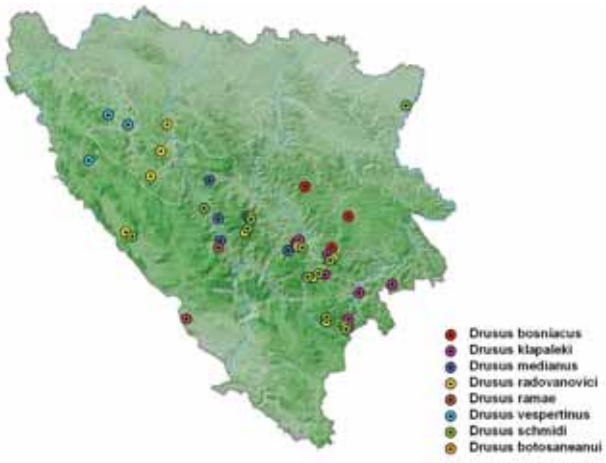



Figure 5. – Distribution range of the genus Drusus in B&H

Despite undertaken investigations, complete systematic overview of ticks (Oribatida) hasn't been done yet. As interesting forms of life it should be mentioned species that inhabit herzegovina's caves. Among them endemic ones are: *Eremulus simplex* Willmann, 1940, *Autognata willmanni* Willmann, 1941, *Chamobates petrinjensis* Willmann, 1940 and *Carabodes bosniae* Frank, 1965. In forests, meadows and rocky grassland of Ozren Mt. near Sarajevo detected were 63 tick species. On the entire territory of Bosnia and Herzegovina exist 208 species belonging to 84 genera identified up to now.

## Pressures on fauna of invertebrates

Due to increasing human pressures, invertebrates picture in Bosnia and Herzegovina has undergone major changes. Those pressures specially affect hygrophilous and hydrophilous organisms, such as crabs, water insects, leaches and molluscs. Pressures onto aquatic invertebrates that prevail are:

- Intensive eutrophication of streams by diverse both organic and inorganic pollutants;
- Intensive eutrophication due to creation of artificial lakes;
- Changes of main physical parameters of streams, such as outflow rate, water quantities, thermic and light regime due to raising of dams and creation of very deep hydroaccumulations. In this way, destroyed are natural habitats of many benthic organisms of canyons (Neretva, Vrbas and Drina river) where used to be development centres of endemic fauna;
- Substantial distrubance of water regime around source area due to conversion of wood habitats into logged or burned surfaces, which promotes erosion process and decrease of water supplies in the natural water cycle;
- Direct activities affecting a fluent's bottom (sand and gravel extraction), followed by a disposal of comunal waste;
- Disposal of different sorts of waste material, including the toxic and dangerous ones (pharmaceutical waste, oils, accumulators, charges of cooling devices), on riverbanks and even in streams itselfs;
- Uncontrolled introduction of alien animal species;
- Water pollution by pesticides and fertilizers draining from arable land;
- Toxification of watercourses by chemical compounds (for instance, diphenols);
- Increased conversion of coastal belt areas by infrastructure for the facilities, which disagree with physical plan;
- Catchement of springs (which are centres of endemism), and re-direction of watercourses into arable land or other confluences.

As a result of impacts of global and local factors, terrestrial invertebrates, such as grasshoopers, ants, butterflies, beetles, ticks, centipedes and molluscs, get threatened, too.

The most important pressures acting on local scale are:

- Conversion of habitats, soil's degradation and destroying of ecological niches for many organisms;
- Loss of natural habitats through the process of progradation of meadows, rock debris communities and other kind of open habitats;
- Nitrification of humus-acumulative horizon by diverse agricultural activities, which directly endangers pedofauna;
- Overgrazing in some areas (high-mountain area of Vranica Mt., Vlašić Mt., Čvrsnica Mt., Zelengora Mt.), which leads to dicrease in yield of plants that animals are vitally bound to (nutrition, laying eggs, microhabitats);
- Fires, floods, currents;
- Introduction of alien species, especially animals that substantially change the structure and functionality of niches in considered ecosystem;
- Usage of pesticides and different kind of ecostimulus;
- Urbanisation, air pollution, acid deposition (change in pH value);
- Overuse of pesticides targeted at massive eradication affecting all organisms (insecticides, molluscides, herbicides, fungicides, rodenticides).

As a consequence of above listed pressures, many animals became endangered and got, unfortunately, in the Red list. It will be possible to disscuss a real threat of distinct avertebrates in details, after Red book of Bosnia and Herzegovina gets done.

Today, our base for planned activities represent Annexes of Habitat's Directive by which are concerned following insects inhabiting our territory and requiring habitat's conservation:

Table 15. – Insects concerned by Habitat's Directive, Annex I, in Bosnia & Herzegovina

| | |
|---|---|
| *Bolbelasmus unicornis* | *Rosalia alpina* |
| *Buprestis splendens* | *Callimorpha (Euplagia, Panaxia) quadripunctaria* |
| *Cerambyx cerdo* | *Euphydryas (Eurodryas, Hypodryas) aurinia* |
| *Graphoderus bilineatus* | *Hypodryas maturna* |
| *Lucanus cervus* | *Leptidea morsei* |
| *Morimus funereus* | *Lycaena dispar* |
| *Osmoderma eremita* | *Nymphalis vaualbum* |

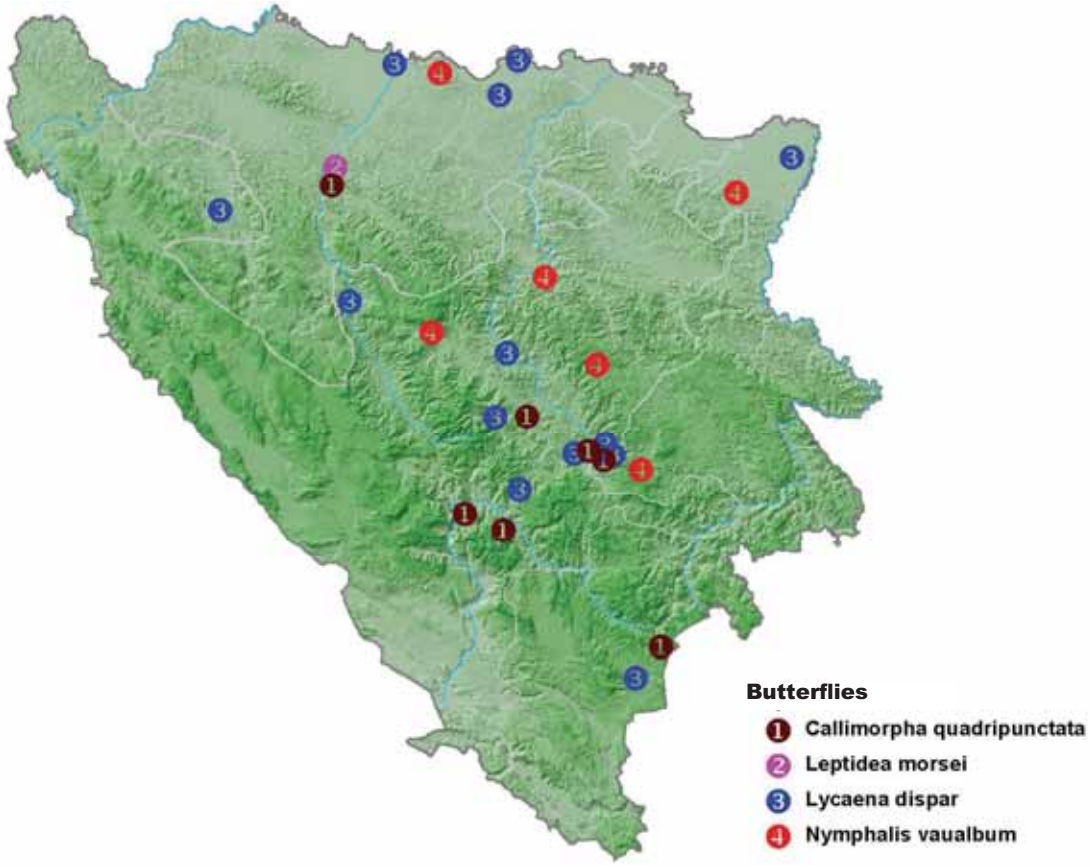



Figure 6. – Distribution of some Lepidoptera concerned by Habitat's Directive in B&H

## Diversity of vertebrates

Fauna of vertebrates in Bosnia and Herzegovina is represented by following organism groups: fish (Pisces), amphibians (Amphibia), reptiles (Reptilia), birds (Aves) and mammals (Mammalia).

## Fish diversity (Pisces)

Fish fauna of Bosnia and Herzegovina is in biogeographical and ecological respect divided in two: marine and freshwater.

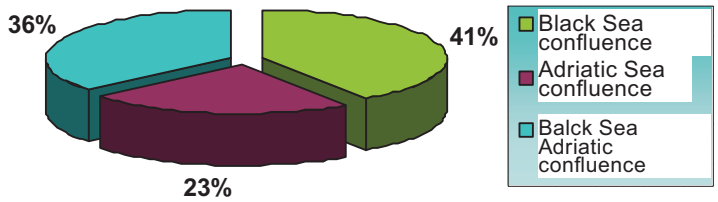
### *Freshwater fishes*

Because of high researchers interest, fish fauna in Bosnia and Herzegovina is relatively well investigated. Official records on freshwater fish species in Bosnia and Herzegovina date back from 1882 (Steindachner). Investigation has became more intensive since 1928 (Taler). In later period, freshwater ichthyofauna got investigated by Vuković and Sofradžija, while Šoljan and Sofradžija did the same for marine fauna. In freshwater fauna recognized are significant differences in structure and level of endemism between Adriatic and Black Sea confluences. There is a high level of endemism in the Adriatic Sea confluence, which isn't the case in the Black Sea confluence that hasn't got endemic forms described so far. Biodiversity of fish in Bosnia and Herzegovina is reflected through the occurence of 119 species and sub-species from 69 genera and 27 families. There are 19 families comprising only one genus, of which 16 families have got only one species.

Table 16. – Endemic species and sub-species of fishes and their distribution in B&H

| CONFLUENCE / LATIN NAME | Confluence of Vrbas | Confluence of Bosna | Conbfluence of Drina | Confluence of Neretva | Confluences of Una and Sana | Confluence of Ukrina | Hutovo blato | Buško jezero | Klinje jezero | Confluence of Sava | Confluence of Tinja | Confluence of Trebišnjica | Water of Livno and Duvno |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Salmothymus obtusirostris oxyrhynchus* | | | | X | | | | | | | | | |
| *Salmo marmoratus* | | | | X | | | X | | | | | | |
| *Phoxinellus alepidotus* | | | | X | | | | X | | | | | |
| *Phoxinellus metohiensis* | | | | | | | | | X | | | X | |
| *Phoxinellus pstrosi* | | | | | | | | | | | | X | |
| *Phoxinellus ghetaldi* | | | | | | | | X | | | | X | |
| *Phoxinellus adspersus* | | | | X | | | X | | | | | | |
| *Leuciscus svallize* | | | | | | | | | | | | X | X |
| *Leusiscus tursky tursky* | | | | X | | | X | | | | | X | X |
| *Chondrostoma kneri* | | | | X | | | X | | | | | | |
| *Chondrostoma phoxinus* | | | | | | | | X | | | | | X |
| *Aulopyge hugeli* | | | | X | | | | X | | | | | X |
| UKUPNO | | | | 7 | | | 4 | 4 | 1 | | | 5 | 4 |

The highest diversity is recognized within the family *Cyprinidae* (26 genera and 51 species) and *Salmonidae* (5; 8). More than one species comprise families: *Acipenseridae* (2; 7), *Mugilidae* (1; 6), *Percidae* (4; 7), *Cobitidae* (3; 6), *Clupeidae* (1; 3), *Gasterosteidae* (2; 2), *Gobiidae* (5; 7) and *Cottidae* (1; 2).
From total number of familes (27), 7 of them live exclusively in the Black Sea and 12 in the Adriatic Sea confluence. Representatives of 8 families can be found within both confluences.
Analysis at the genus level shows that from total number (69), 28 genera live exclusively in the Black Sea and 16 in the Adriatic Sea confluence, while 25 genera inhabit both of them.




Graph. 7. – Occurence of fish genera by confluences in B&H

Relatively small number of species is to be found in both these confluences. Among them are some fish belonging to Black Sea confluence which have been introduced in Adriatic Sea confluence (carp, pikeperch, tench and grayling). Besides, there are 11 alien species originating from euroasian and american water.

### *Marine fishes*

After fish inventory prepared by well known marine biologist T. Šoljan for the bosnia-herzegovina's share of the Adriatic Sea (part of the Neum-Klek bay), it was established high species diversity.

Table 17. – Diversity of marine fishes

| order | family | Number of genera | Number of species |
|---|---|---|---|
| Squaliformes | 8 | 8 | 11 |
| Acipenseriformes | 1 | 2 | 7 |
| Clupeiformes | 2 | 2 | 4 |
| Anguilliformes | 1 | 1 | 1 |
| Beloniformes | 1 | 1 | 1 |
| Gadiformes | 1 | 1 | 1 |
| Gasterosteiformes | 1 | 2 | 2 |
| Mugiliformes | 1 | 1 | 6 |
| Syngnathiformes | 1 | 2 | 3 |
| Zeiformes | 1 | 1 | 1 |
| Cypriniformes | 3 | 30 | 59 |
| Perciformes | 25 | 46 | 77 |
| Pleuronectiformes | 5 | 6 | 9 |
| Salmoniformes | 2 | 6 | 9 |
| Siluriformes | 1 | 1 | 1 |
| Tetraodontiformes | 1 | 1 | 1 |

### *Economic importance*

Fish fauna in general, especially of economically important species, has played fundamental role in the process of ethnogenesis of people in Bosnia and Herzegovina. It is the case even today when many freshwater and marine species are being used as a healthy diet in human nutrition and as a domestic animal's food. Noble ichtyofauna has been the framework for the fishing industry since ever. This is the most important economic branch making a share of general social income in Bosnia and Herzegovina.

Beside fishing of natural populations, it is well developed the production and breeding of noble fish species (trout, carp and grayling) in fishing farms placed in marine and freshwater areas.

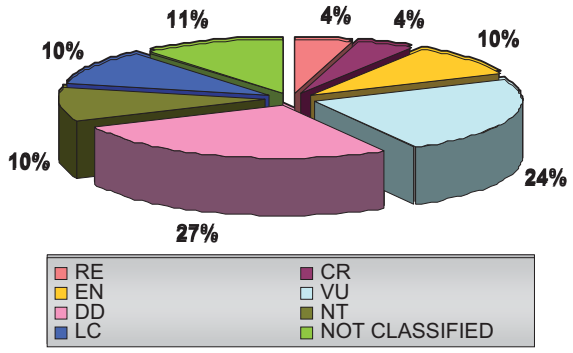
## Pressures on fish fauna

Diversity of ichtyofauna is affected by many factors:

- Pollution and contamination of water with diverse pollutants contained in comunal and industrial waste water, and water run off from arable land (farms, use of pesticides, chemical fertilizers, ecostymulcides);
- Change in flow direction and speed of underground water (dams, hydro-accumulations, melioration trenches, water catchment);
- Introduction of alien fish species, which are potential competitors for the indigenous ichtyofauna;
- Increased blur of water due to intensive soil erosion caused by over-logging;
- Acid rain due to local and trans-boundary air pollution;
- Change in benthal structure due to gravel and sand extraction;
- Waste disposal in enormous quantity along riverbanks;
- Conversion of natural habitats in shoreline area due to unplanned construction;
- Unbalanced fishery, especially in spawn season;
- Unbalanced tourism (too many people swimming and in other way using sea water, lakes and other waterbodies).

Local and global influences onto habitats causing direct changes in its qualitative and quantitive parameters makes some of fish species severly endangered.

Herein should be stressed status of brown trout (*Salmo trutta morfa fario)*, then endemic species of bosnia-herzegovina's sinking rivers (*Paraphoxinus sp.)*, Dalmatian barbelgudgeon (*Aulopyge hugelii)*, Danube salmon (Hucho hucho), soft-muzzled trout (*Salmotimus obtusirostris oxyrinchus*) and many others. This indicates necessity after the assessment of threat's level, definition of conservation priorities and Red book of fish species in Bosnia and Herzegovina.




Graph 8. – Conservation status of lampreys and freswater fish

## Diversity of amphibians

Considering its particular onthogenesis, amphibians confirm tight connection between aquatic and terrestrial environment. Being mainly terrestrial organisms, in the reproductive period of a year amphibians are bound to the aquatic environment.

Since the end of 19th century amphibians have drawn the attention of many zoologist. First records came from the investigation of Werner. In 1888, after the National Museum in Sarajevo was founded, it have been collected and analised reffering records. Afterwards, significant data came from Reiser and Bolkay which made a classification of amphibians in Bosnia and Herzegovina. In 1951 famous zoologist Radovanović presented complete records on amphibian fauna confirmed and added later by Kreso-Đurović and Vuković. To this should be added data on chorology of species *Proteus anguinus*, *Salamandra atra* and *Triturus alpestris* given by Ćuković, Pocrnić, Kosorić and Sofija Mikšić.

Diversity of amphibians in Bosnia and Herzegovina is bespoken in 7 genera, 21 species and 22 subspecies. Among tail-less most abundant is genus *Rana* with 7 species and among caudate amphibians this is genus *Triturus* with 5 species.

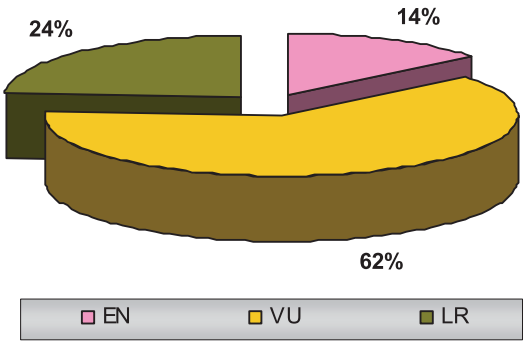
Table 18. – Diversity of amphibians (Amphibia)

| order | family | Species in total | Subspecies in total | Threatened at national level | Threatened in Europe | Endemic species in total |
|---|---|---|---|---|---|---|
| Anura | Discoglossidae | 2 | 2 | 0 | 2 | 0/1 |
| | Paleobatidae | 1 | 1 | 0 | 0 | 0 |
| | Ranidae | 7 | 0 | 1 | 1 | 1 |
| | Bufonidae | 2 | 2 | 0 | 0 | 0 |
| | Hylidae | 1 | 1 | 0 | 0 | 0 |
| Caudata | Proteidae | 1 | 1 | 1 | 1 | 1 |
| | Salamandridae | 7 | 10 | 2 | 2 | 0/2 |
| ukupno | 7 | 21 | 17 | 4 | 6 | 2/3 |

Rarity of amphibians in Bosnia and Herzegovina is reflected through the occurence of endemic prenj's newt population (*Salamandra atra prenjensis)*, alpine Reiser's newt (*Triturus alpestris reiserii)*, danube newt (*Triturus dobrogicus*), yellow-bellied toad (*Bombina variegata scabra*), frog (*Rana graeca*), olm (*Proteus anguinus)* from karst caves.

## Pressures on amphibian fauna

A previous image of amphibian fauna in Bosnia and Herzegovina has been changed substantially. It is estimated that in Europe exist 6 threatened amphibian species, of which 4 are to be found in Bosnia and Herzegovina.




Graph 9. – Conservation status of amphibians in Bosnia and Herzegovina

Main anthropogenic pressures that change habitat's quality for this most sensitive animals, and hereby its abundance, are:

- Proces isušivanja močvara i bara, kao Dry out of moorland and ponds, the most important habitat types for this animal group;
- Water pollution by organic and inorganic pollutants;
- Conversion of humid woods through the logging followed by change in hydrothermic regime;
- Acid rains and effects of global climate changes;
- Eutrofication of mountain lakes, ponds and marshes;
- Unsustainable hunt of species (mainly frogs);
- Trade in rare and endemic species (newts, olms and salamanders);
- Introduction into mountain lakes of Bosnia and Herzegovina of fish species which are natural competitor for newts.

On the other hand, the sustainable use of amphibians as resource by its propagation wasn't established yet in Bosnia and Herzegovina.

## Diversity of reptiles

Considering cold climate conditions that prevail in Bosnia and Herzegovina, diversity of this animal group is not as high as it is common in warmer places of Earth. But, this group uses here all available ecologic niches differentiating in 40 species (45 subspecies) from 12 families.

Reptiles inhabit freshwater, ponds, marshes and almost all terrestrial ecosystems (especially extreme habitats, such as rocky grassland) having hence broad tolerance range regarding habitat types.

The highest reptiles diversity in Bosnia and Herzegovina is evident in the mediterranean region and supra-mediterranean belt. However, some species and entire genera even, are spread up to the highest mountain peaks (mountain lizards, blind worm, vipers). Bosnian and Orsiny's viper live in mountain swards, then on screes and rock crevices all around B&H.

Table 19. – Reptiles diversity *(Reptilia)*

| order | family | Total of species | Total of sub-species | Nationally threatened | Threatened in Europe | Total of endemic taxa |
|---|---|---|---|---|---|---|
| Chelonia | Emydidae | 1 | 2 | 2 | 2 | 0 |
| | Bataguridae | 1 | 2 | 1 | 1 | 1 |
| | Testudinidae | 1 | 2 | 1 | 1 | 0 |
| | Cheloniidae | 2 | 2 | 1 | 1 | 0 |
| | Dermochelyidae | 1 | 1 | 1 | 1 | 0 |
| Squamata | Gekkonidae | 2 | 2 | 0 | 0 | 0 |
| | Anguidae | 2 | 3 | 0 | 0 | 0 |
| | Lacertidae | 11 | 9 | 1 | 0 | 1 |
| | Scincidae | 1 | 1 | 1 | 0 | 0 |
| | Colubridae | 11 | 9 | 1 | 3 | 1 |
| | Viperidae | 4 | 5 | 2 | 2 | 1 |
| | Typhlopidae | 1 | 0 | 1 | 1 | 0 |
| ukupno | 12 | 38 | 38 | 12 | 12 | 4 |

There are also localities that are known by toponyms in relation with the abundance of reptile populations (Zmijanje on Manjača Mt.). Entire geosystem – serpentine, ows its name to snakes.

*"Either for their look or deeply rooted fear before them, many reptile representatives in our country used to be considered as enemies of men and domestic animals. Single thought of them, makes people feel frightened and disgusted. There are many myths on them, for instance it is being told that nose-horned viper, which is usually quite inert venomous snake, folds itself into ball and jumps after its victim for several meters. For some snakes it is believed that they suck cow's milk, and that some green lizards can cling onto human skin, whereby sole solution is to drink milk of 9 mares. It is deeply rooted belief that every house has got its own snake which under no circumstances should be disturbed, especially killed at the doorway or have its eggs destroyed. All that could draw big evil upon the house and its inhabitans." (quoted from TV show "Prirodna baština BiH")*

The specific character of bosnia-herzegovina's habitats and unique evolution pattern is reflected in diversity of sub-species, such as: mountain viper (*Vipera ursinii macrops*), (*Platyceps najadum dahlii*), (*Podacris melisellensis fiumana*).

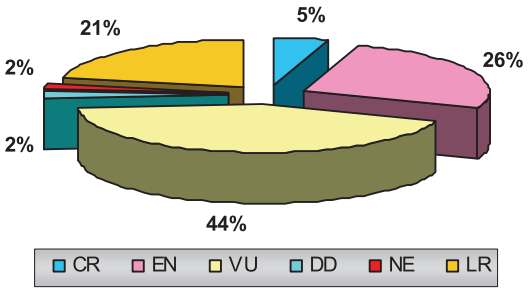
## Pressures on reptiles

As it is the case with many other groups of B&H's fauna, so the reptiles too are endangered group of organisms. Dominant threats posed upon them under our conditions are:

- Conversion of habitats (by drainage, felling, clearing, infrastructure construction, forest fires);
- Forest fires, especially in the mediterranean and supra-mediterranean belt;
- Over-exploitation, especially of vipers, for medicinal purposes;
- Killing for no particular reason of all kind of snakes and snake-like animals (especially lizards);
- Eutrofication of ponds, marshes, rivers and lakes;
- Trade with turtles and other attractive looking reptiles.

For all afore given reasons, many reptile species are tought to be endangered today. About 40% of reptiles in Bosnia and Herzegovina is in some extent endangered, including also endemic forms.

For most of reptiles live in clean habitats, they are considered as reliable indicators for the assessment of state and quality of the environment.




Graph 10. – Conservation status of reptiles in Bosnia and Herzegovina

## Diversity of birds

Birds like no other animal group have been drawing attention of both nature fanciers and scientist.

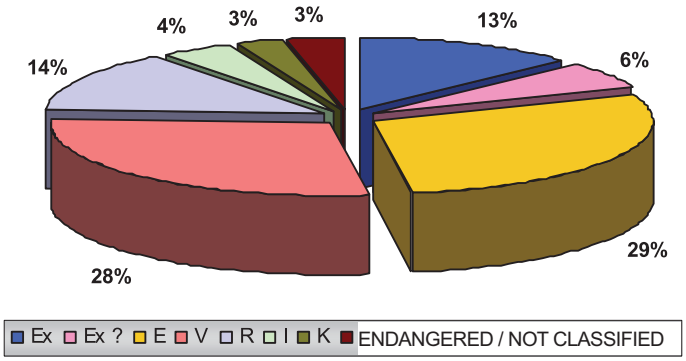
*"Species belonging to this part of wildlife used to be a metaphor for greatest beauty of life, love (nightingale, dove, jay), human faith's misgiving (raven), hero's strength (hawk), greed (eagle, sparrow-hawk) and first children's joy (goose, duck, chickens) Some of them are rooted among common people as a symbol for reproductive power and new day's joy – rooster's crowing in the early reddish dawn, and as a pleasure expression in the dark bosnia's nights."*
*(quoted from TV show "Prirodna baština BiH")*

High birds diversity is the result of habitat's diversity encompassed by landscapes and ecosystems of Bosnia and Herzegovina.
In the investigations that have been undertaken since 1939 till now (Reiser, Matvejev, Vasić, Obratil), recorded are 326 species belonging to 60 families and 18 orders.
This group doesn't contain any species that is endemic for Bosnia and Herzegovina.
Most of them are stationary (nesting), while migratory ones spend some time in ecosystems of Bosnia and Herzegovina only by seasons (wetlands: Buško blato, Hutovo blato, Bardača, lower flow of Drina river etc.).
Birds in general are most endangered animal group. After the proposal for national Red list of birds (Obratil and Matvejev), 97 species are considered to be endangered in some level.

After Bird life's data in Bosnia and Herzegovina nest five endangered species pygmy cormorant (*Phalacrocorax pygmaeus*), ferruginous duck (*Aythya nyroca*), saker falcon (*Falco cherrug*), white-tailed eagle (*Haliaetus albicilla*), corncrake (*Crex crex*), while three globally endangered species, crni strvinar (*Aegypius monachus*), dalmatinski pelikan (*Pelecanus crispus*), orao kliktaš (*Aquila clanga*), are listed in our country as extinct nesting birds. Hereby should be stressed that 16 indigenous bird species in our country are considered to be extinct nesting birds. At the end of 20th century, from our territory has completely vanished griffon vulture (*Gyps fulvus*) after massive poisoning at fishing farm Blagaj near Mostar city, on Buna river.

Table 20. – Diversity of ornithofauna in Bosnia and Herzegovina

| Family | Genus | Species | Family | Genus | Species |
|---|---|---|---|---|---|
| Phasianidae | 5 | 7 | Coraciidae | 1 | 1 |
| Anatidae | 15 | 32 | Alcedinidae | 1 | 1 |
| Gavidae | 1 | 3 | Meropidae | 1 | 1 |
| Podicipediae | 2 | 5 | Upupidae | 1 | 1 |
| Phoenicopteridae | 1 | 1 | Picidae | 5 | 10 |
| Ciconidae | 1 | 2 | Laniidae | 1 | 4 |
| Threskiornithidae | 2 | 2 | Oriolidae | 1 | 1 |
| Ardeidae | 7 | 9 | Corvidae | 5 | 8 |
| Pelecanidae | 1 | 2 | Bombycilidae | 1 | 1 |
| Phalacrocoracidae | 1 | 3 | Paridae | 1 | 7 |
| Falconidae | 1 | 8 | Remizidae | 1 | 1 |
| Accipitridae | 14 | 26 | Hirundinidae | 4 | 5 |
| Otidae | 2 | 2 | Aegithalidae | 1 | 1 |
| Rallidae | 5 | 7 | Alaudidae | 6 | 6 |
| Gruidae | 1 | 1 | Cisticolidae | 1 | 1 |
| Burhinidae | 1 | 1 | Sylviidae | 6 | 25 |
| Haematopodidae | 1 | 1 | Timalidae | 1 | 1 |
| Recurvirostridae | 2 | 2 | Regulidae | 1 | 2 |
| Charadridae | 3 | 7 | Troglodytidae | 1 | 1 |
| Scolopacidae | 10 | 22 | Sittidae | 2 | 3 |
| Glareolidae | 1 | 1 | Certhiidae | 1 | 2 |
| Laridae | 4 | 16 | Sturnidae | 1 | 2 |
| Stercorariidae | 1 | 3 | Turdidae | 1 | 6 |
| Pteroclididae | 1 | 1 | Muscicapidae | 8 | 15 |
| Columbidae | 2 | 5 | Cinclidae | 1 | 1 |
| Cuculidae | 2 | 2 | Passeridae | 2 | 4 |
| Tytonidae | 1 | 1 | Prunellidae | 1 | 2 |
| Strigidae | 7 | 9 | Motacillidae | 2 | 8 |
| Caprimulgidae | 1 | 1 | Fringillidae | 6 | 11 |
| Apodidae | 1 | 3 | Emberizidae | 3 | 9 |




Graph 11. – Conservation status of birds in Bosnia and Herzegovina

Ecologic curiosity represents the fact that largest proportion of extinct birds are kites, which results in changed structure of food web and enduring disruption of an ecologic balance.

In Bosnia and Herzegovina have been identified two areas so far (Hutovo blato and Bardača) designated as Important Bird Areas. In addition to afore named localities, important centres of bird's diversity are to be found in Livanjsko polje (Ždralovac, Buško Blato), Bilećko jezero and lakes on Drina river (Perućac).

## Pressures on bird's fauna

Ornithofauna of Bosnia and Herzegovina is affected today by both global and local factors:

- Intensive conversion of swamp habitats through drainage (especially in karst fields);
- Peat's exploitation (Ždralovac);
- Destruction of aquatic macrophytes and hygrophilous vegetation along waterbodies (Bardača);
- Fragmentation of natural habitats and cutting through bird's migratory routes;
- Construction of dam accumulations in wetland's area(Buško blato);
- Conversion of forest habitats through intensive and unselected feeling;
- Exploitation of mineral resources within bird's refugia (canyon of Tinja river);
- More frequent food poisoning (poisoning by waste disposed from slaughter houses in the area of Buna river, Špiljani in upper Neretva's flow, Paklarevo at southern slopes of Vlašić Mt.; and poisoning with waste on illegal dump sites);
- Noise and vibrations;
- Pesticides and chemical fertilisers (increasing a death rate or disabling embriogenesis);
- Unsustainable hunt in the wilderness and designated reserves (Hutovo blato);
- Unbalanced tourism;
- Illegal bird's trade;
- Lack of knowledge and awareness on birds as possible vectors for diseases.

Although the image of bird's world in Bosnia and Herzegovina has been changed substantially over the last 100 years, especially in bird's reserves such as Hutovo blato, Bardača and Livanjsko polje, the unique diversity of birds is still there. Thus, it can attract public attention for special educational and recreational touristic purposes. There is a high potential in Bosnia and Herzegovina for observing and following the birds which is a form of tourism.

Some domesticated bird species in Bosnia and Herzegovina have got special breeds and represent significant but unexploited resource for healthy food production.

## Diversity of mammals

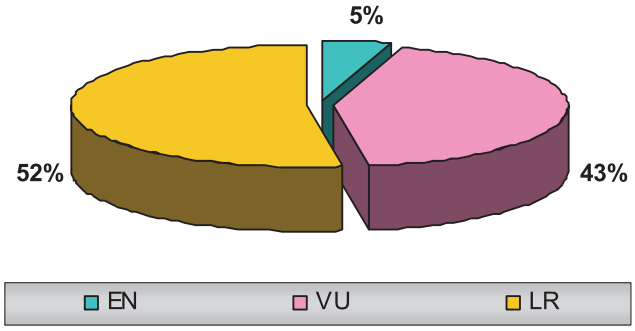
Although fauna of mammals (Mammalia) comprises mainly large animal species, it is considered to be poorly investigated in our country. Based on investigation dating back from first half of 20th century conducted by S. Bolkay, and later undertaken inventories in relation to ex-Yugoslavia's territory (Kryštufek, Tvrtković, Đulić, Mirić, Paunović), as well as the most recent publication on mammals in Bosnia and Herzegovina (Sofradžija et al.), it has been assessed hereafter presented diversity.

The fauna of mammals encompasses 85 identified species from 51 genera and 19 families. Most of the species lives in terrestric habitats, while small number of them inhabits aquatic ecosystems on secondary basis or only occasionally.

High abundance and diversity characterize the family Vespertiolinidae with 20 identified species from 8 genera.

| Family | Genus | Species |
|---|---|---|
| Erinacidae | 1 | 1 |
| Soricidae | 3 | 7 |
| Talpidae | 1(1?) | 2 (+1?) |
| Rhinolophidae | 1 | 4 |
| Vespertiolinidae | 8 (1?) | 20 (+1?) |
| Leporidae | 1 | 2 |
| Sciuridae | 1 | 1 |
| Muridae | 10 | 17 |
| Gliridae | 4 | 4 |
| Capryomidae | 1 | 1 |
| Canidae | 3 | 4 |
| Ursidae | 1 | 1 |
| Mustelidae | 5 | 8 |
| Felidae | 2 | 2 |
| Phocidae | 1 | 1 |
| Suidae | 1 | 1 |
| Cervidae | 3 | 3 |
| Bovidae | 2 | 2 |
| Delphinidae | 2 | 2 |
| UKUPNO | 51 (2?) | 85 (+2?) |

Table 21. – Assessed diversity of mammals in B&H




Graph 12. – Conservation status of mammals in Bosnia and Herzegovina

Mammals include species treated as large game species that have played an important role as a source of protein rich food, covering material and hunting objects since the very first beginning of anthropogenesis. Those species are foundation for sustainable hunt and eco-tourism in Bosnia and Herzegovina. Since the austrio-hungarian rule, it has been developing a tradition of touristic hunt in our country, which unfortunately in last 50 years has become unsustainable.

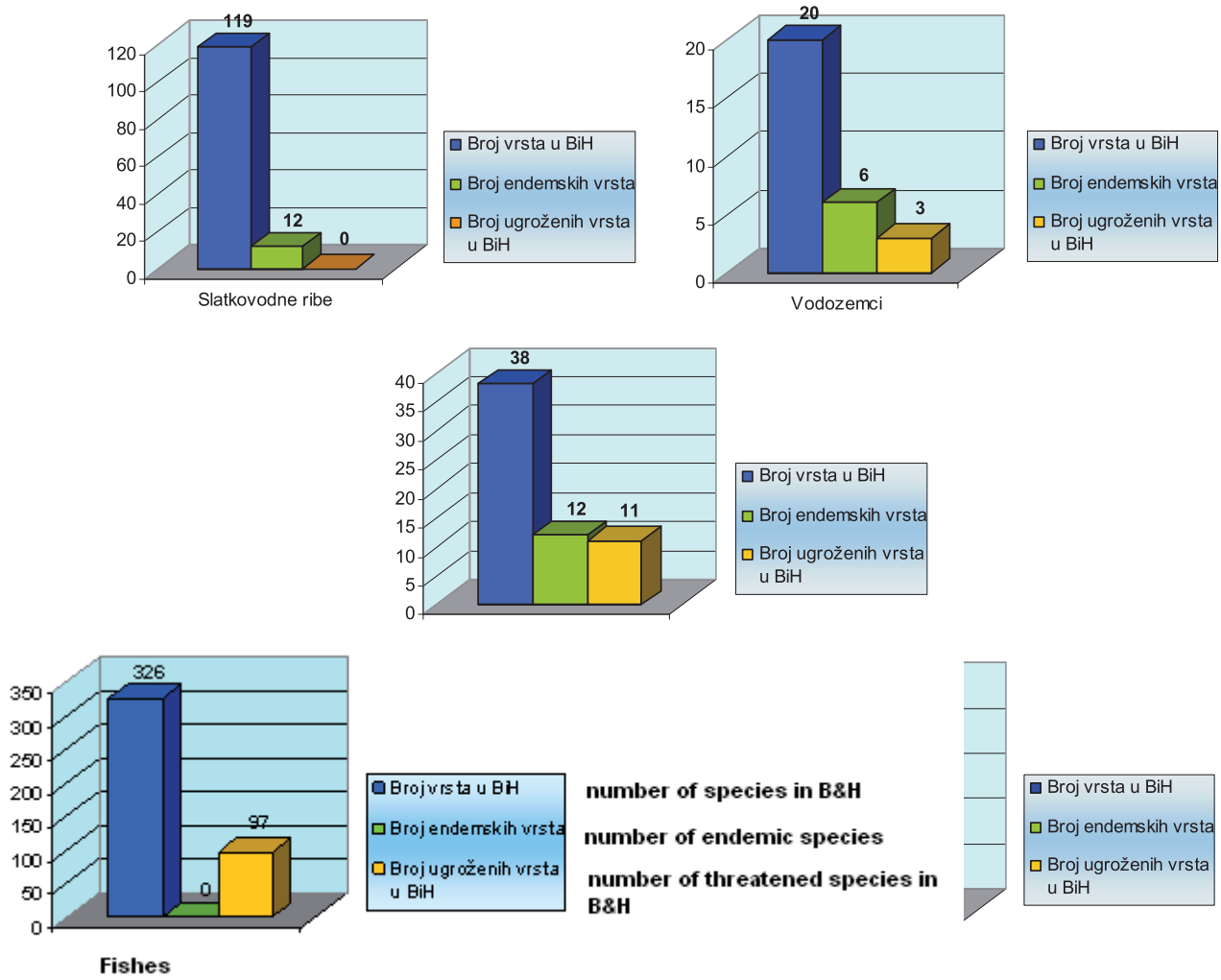
Inspite of efforts done by some hunting societies, wildlife of mammals in Bosnia and Herzegovina is severly threatened. However, scientific data on intensity and threat's categories for some species are still missing. Respecting the assessment of threat's level on european scale, we can claim that 30 mammal species in Bosnia and Herzegovina are threatened to become extinct.

## Pressures on fauna of mammals

The fauna of mammals is affected by line of pressures of which the strongest are:

- Intensive conversion of forest habitats through clearing, fires and felling;
- Intensive hunt (especially of "trophy games");
- Fragmentation of ecosystems and habitats and interception of corridors;
- Poor and inefficient establishment of ecologic corridors;
- Lack of natural food due to threatening of plant species;
- Global climate changes and acid precipitation;
- Eutrophication and toxification of surface water;
- Pollution of herbal food by pesticides and chemical fertilisers;
- Food poisoning on open dump sites;
- Mines causing death of many animals over the last 15 years;
- Unsustainable tourism.

Numerous pressures both on local and global scale have caused the conversion of natural mammal's habitats. Thus, many species are characterized by certain threat's level.




Graph 13. – Relationship between endemic and endangered species in relation to total number by vertebrate groups in B&H

## Value of fauna as a resource

Along with wildlife of mammals, for the entire B&H's biodiversity extremly important are animal resources contained in the rich gen pool and indigenous breeds of domesticated species (horse, cattle, sheep, goat, ass, dog, cat, rabbit).

A special value posses typical bosnia's breeds, such as: bosnia's cow called "buša", sheep "pramenka", bosnia's mountain horse, herzegovina's goat and dog "tornjak". Special gen pool is contained within studs grown wild, living on slopes of Cincar Mt., Glamoč and Livno city.

In Bosnia and Herzegovina have been selectively introduced or re-introduced some species, such as beaver, mouflon and fallow deer.

# DIVERSITY OF FUNGI AND LICHENS

# DIVERSITY OF FUNGI AND LICHENS

There are few groups of organisms on the Earth that occur as frequent as representatives from a misterious world of fungi do, yet they are poorly known to the science. It is also the case with lichens, special life form of biological organisation, where in mutualistic relationship live fungi and cyanophytes and other alges. In difference to plants, fungi are heterotroph organisms with no photosynthetic pigments, which place them close to the animal kingdom. There are several other characteristics of fungi, such as cell wall composition and storage substances, which was the reason why fungi are separated into their own kingdom.

Fungi inhabit both terrestrial and aquatic environment. Their role in the material circulation, through the process of decomposition, is immense. Fungi contain enzimes necessary to decompose even the most complex organic compounds, such as lignin, turning them into humus and, at the end into their mineral components.

Many fungi live as parasites on plants and animals, but also on human beings, where some of them cause pathological conditions (mycosis) by inhibition of the normal growth, development and life cycle of the host. Many of them are recognized to be common pathogens, which cause wide spectrum of mycosis in humans.

Due to diversity of active principles they contain (physiological and pharmacological), fungi had been used in human nutrition and medicinal treatments, but also in cultural tradition, since ever. Nowadays several mushroom's representatives (Penicillium and Aspergilus) have become irreplaceable in the process of antibiotics production, since Alexander Fleming in 1919 proved the bactericide effects of Penicillium notatum. Yeats (especially from genus Saccharomyces) are irreplaceable in the production of bread, vine, beer and pharmaceutics.

Higher fungi (actual fungi) include species with proven nutritive characteristics being therefore used in human nutrition and for medicinal purposes. Among these the most common are: šampinjon (Agaricus bisporus), natural anti-cancerogen shiitake (Lentinula edodes), tartuf (Tuber magnum), smrčak (Morchella sp.), vrganj (Boletus sp.), mliječnica (Lactarius sp.), lisičarka (Cantarellus sp.), and others that represent substantial income source for a local community. Among fungi some are lethal, such as: zelena pupavka (Amanita verna), bijela pupavka (Amanita virosa), species from genera Inocybe and Clytocybe, and many others toxic ones.

Some species (representatives from genera Amanita and Claviceps the most frequently), are used as halucinogens.

In one word, the mushroom's world isn't only diverse and unique in the respect of its living forms, but it has got special biochemical and pharmaco-physiological characteristics. The kingdom of fungi is at present-day connected to a high economic potential, because many of its species posses their own market. Species of genera Morchella, Boletus and Cantharelus have been main forest's product at the European market for a long time.

The habitat's quality, including the cleanness and quality of biomass, makes possible that many local communities in Bosnia and Herzegovina make their income by collection and sale of fungi.

***Investigation level***

*There are only few records that describe occurence and distribution of fungi on the territory of Bosnia and Herzegovina. First information came from the famous researcher Karlo Maly, whose long employement history at the position of custos at the Land's Museum of B&H was devoted to higher plants, fungi and lichenes. Based on his records, it were written*

*some of the first mycological papers in B&H (Picbauer, R. 1927., GZM, BiH, 39 (1) 163-173. (GZM) and European magazines, of which at that time the most important was "Additamenta ad flora Balcanica mycologicam" (GZM 1941.).*

*Maly's collection of zoocecidies was the base for papers that chezch mycologist Baudyš published in GZM. After that period, new interest in these group of organisms in Land's Museum has been awaken in the 60s of the 20th century (Marijana Klinger, "Prilog flori gljiva okoline Sarajeva", GZM). Since this paper began the inventory of higher fungi, research of its distribution, ecology and phenology within forest communities of Trebević Mt., Jahorina Mt., Igman Mt. and Bjelašnica Mt. Sadeta Mehanović, employee of Land's Museum of B&H, has investigated parasitic mycoflora all around B&H in the period from the 60s to the 90s. For the investigation of higher fungi of B&H a great importance comes to papers of Milica Tortić, S. Rončević and Foht, and especially to the monography "Svijet gljiva" (Usčuplić, M. ANUBiH, 2004). One shouldn't neglect records on occurence and distribution of macromycetes provided by amateurs and mushroom's collectors.*

## DIVERSITY OF FUNGI

It is being estimated that in Bosnia and Herzegovina live between 15.000 – 20.000 mushroom species. However, identified are only 552 species.

Table 22. – Diversity of identified fungi in B&H

| DIVISION | CLASS | ORDER | FAMILY | GENUS | SPECIES |
|---|---|---|---|---|---|
| Ascomycota | 2 | 6 | 12 | 28 | 51 |
| Basidiomycota | 2 | 22 | 56 | 139 | 501 |
| **TOTAL** | **4** | **28** | **68** | **167** | **552** |

Table 23. – Estimated diversity of fungi in B&H

| MUSHROOM's GROUP | ESTIMATED | SUPPOSED NUMBER | IDENTIFIED IN EUROPE |
|---|---|---|---|
| Dyscomycetes | 200 | 1000 | 1800 |
| Pyrenomycetes | 11 | ? | ? |
| Gasteromycetes | 50 | 150 | 280 |
| Aphyllophorales | 400 | 700 | 1000 |
| Agaricales | 800 | 2000 | 3400 |
| **TOTAL** | **1461** | **3850 ?** | **6480 ?** |

There are many macromycetes in Bosnia and Herzegovina that posses high economic potential and value being therefore an important income source for a local community since ever. The most important among them are: smrčak (Morchella sp.), vrganji (Boletus sp.), lisičarka (Cantarelus cybarius), sunčanica (Macrolepiota sp.) mliječnica (Lactarius deliciosus), pečurka (Psaliota procera) and others.

## Pressures onto diversity of fungi

Due to diverse pressures, of both global and local character, many fungi suffer under certain threat. Some of them are even threatened to become extinct (Mycenastrum corium from bogs around Bosansko Grahovo – Ždralovac, where it is a sole finding place of this species in our country). It is the also the case with species whose existence is attached to some endemits, such as white barked pine (Pinus heldreichii), black pine (P. nigra ssp. illyrica), greek maple (Acer heldereichii), Pančići's spruce (Picea omorica) etc., which relates especially to lignicole and mycorrhizal fungi.
Pressures onto mushroom's biodiversity are:

- Coversion of natural habitats, and their permanent fragmentation;
- Over-exploitation of forests;
- Pollution of natural ecosystems followed by change in pH and soil composition;
- Endangering or dissapearing of plants and animals with whome fungi are in mycorrhizal or other kind of relationship;
- Over-exploitation of macromycetes;
- Invasive expansion of alien species of fungi, plants and animals;
- Changes on global scale;
- Over-pollution of the atmosphere, acid precipitation etc.

Table 24. – Threatened fungi of B&H

| | |
|---|---|
| **RE (Regionally Extinct)** | *Lentinus strigosus, Pluteus petasatus, Polyporus ciliatus.* |
| **CE (Critically Endangered)** | *Aleuria rhenana, Boletus regius, Bondarzewia montana, Geastrum lageniforme, Gyroporus castaneus, Hericium erinaceum, Hymenochaete cruenta, Macrolepiota konradii, Mycenastrum corium, Pluteus pallescens, Pluteus romellii, Polyporus arcularius, Polyporus tuberaster, Ramaria botrytis, Sarcosphaera crassa, Sowerbyella unicolor, Sparassis nemecii, Suillus placidus, Volvariella bombycina.* |
| **EN (Endangered)** | *Polyporus badius, Camarophyllus niveus, Copinus picaeus, Cortinarius salor* var. *salor, Cortinarius salor* var. *transiens, Cyathus striatus, Hygrocybe quieta, Lactarius salmonicolor, Langermannia gigantea, Leccinum tessellatum, Mycena renati, Ramaria formosa.* |
| **VU (Vulnerable)** | *Albatrellus ovinus, Amanita vaginata* var. *alba, Aureoboletus gentilis, Boletus appendiculatus, Boletus satanas, Boletus subtomentosus, Choiromyces meandriformis, Climacocystis borealis, Clitocybe obsoleta, Leccinum aurantiacum, Lycoperdon decipiens, Lycoperdon echinatum, Scutellinia scutellata.* |
| **NT (Near Threatened)** | *Fistulina hepatica, Ganoderma lucidum, Mycena abramsii, Mycena arcangeliana, Mycena crocata, Mycena haematopus, Phaeolepiota aurea.* |
| **DD (Data Deficient)** | *Agaricus albertii, A. benesii, Agaricus meleagris, Aleuria* |

| | |
|---|---|
| | *aurantia, Amanita ceciliae, Amanita mairei, Gyromitra curtipes, Helvella atra, Helvella crispa, Helvella elastica, Helvella lacunosa, Morchella rimosipes, Onnia tomentosa, Otidea onotica, Peziza micropus, Polyporus brumalis, Polyporus umbellatus, Postia stiptica, Psathyrella murcida, Psathyrella lacrimabunda, Russula aeruginea, Russula betularum, Russula ochroleuca, Strobilomyces strobilaceus, Trichaptum pergamenum, Tyromyces subcaesius, Verpa conica, Xerocomus pulverulentus* |

## DIVERSITY OF LICHENS

Lichens make very unique group of organisms. In the course of evolution of living systems, lichens have brought together interest of, in respect of phylogeny, different organism groups: fungi (Mycota kingdom), cyanophytes (Mychota kingdom) and green alges (Plantae kingdom).

Thanks to the fact that they have characteristics of both alges and fungi, lichens have evolved high adaptibility. They are today spread all over the world, taking wide spectrum of niches within all biomes, or ecosystems. Although lichens have been in the past of science development considered as a certain kind of biocoenoses, today prevails the opinion that they represent separate organisms. This opinion was supported by the fact that mutualistic relationships within lichens are so intense that genuine nature of its constituents is being lost completely. Therefore, lichens are among scientists treated as a separate phylogenetic group within Earth's biodiversity. Nomenclature and taxonomy issues are definied by the International Codex of Botany Nomenclature.

Lichens have played one of the most significant roles in the shaping up of geobiosphere, especially of the soil development. Therefore, in the process of syngenesis and pedogenesis lichens have irreplaceable function. In the natural system they represent initial stage of community's development (phytocoenoses) known as Lichenetea, being the foundation for further syngenesis – toward more complex communites.

Lichens are very sensitive biological systems in terms of the environmental changes, which makes them an excellent bioindicators for the evaluation of ecosystem's state and acceptance capacity, especially for the assessment of air quality. Thus, they play an important role in the sustainable management and biomonitoring of the environment.

Many lichens contain carbohydrates, minerals, organic acids, vitamins and other substances, which is the reason for them to be used as a source of healthy food or phytopharmacs, especially antimicrobics. This lichens group includes: Cetraria islandica, species of genera Lobaria, Parmelia, Usnea, Evernia and others.

### *Investigation level*

*Lichens of Bosnia and Herzegovina are poorly investigated group of organisms. First records date back in 1931 from Fran Kušan who based his work on Karlo Maly's findings. In later period, beside occasionally occuring results on horology of some fungi and facts obtained through the investigation of floristic and phytocoenological cover of Bosnia and Herzegovina, firm data base for this organisms hasn't been established yet. But, flora/fungia of lichens in Bosnia and Herzegovina was in the scope of lichenologic investigation in ex-Yugo-*

*slavia (F. Kušan, M. Murati). Establishment of the catalogue and inventory of lichens in B&H has begun after the check-list of Mediterranean lichens was created (Nims).*

In Bosnia and Herzegovina has been recorded over 300 lichens by now, while the expected lichens biodiversity is about 1.000 from total 20.000 identified species in the world.

Among lichens in Bosnia and Herzegovina the most frequently occuring and abundant are those from genera: Acarospora Massal. (4), Aspicilia Assal. (8), Caloplaca Th.Fr. (25), Cetraria Ach. (4), Cladonia Hill. ex Browne (14), Collema Wigg. (10), Lecanora Ach. (26), Lecidea Ach. (8), Melanelia Ach. (8), Parmelia Ach. (8), Peltigera Willd. (7), Pertusaria DC. (10), Physcia (Schr.)Mich. (8), Physconia Poelt (6), Polyblastia Massal. (5), Problastenia (Zahlbr.)Steiner (5), Ramalina Ch. (8), Rhizocarpon DC. (10), Rinodina (Ach.)Gray (11), Usnea Adans. (10), Verrucaria Schrader (12).

Different lichen populations and species are to be found within all geographic regions, provinces, sectors, biomes and ecosystems on both horizontal and vertical profile of Dinaric Alps. Epilithic lichens are constituents of classes: Lichenetea and Asplenietea trichomanis, screes Thlaspietea rotundfolii, Mediterraneo-mountain rocky grassland Thero-Brachypodietea, and orders of: xeric Mediterranean woods Quercetalia ilicis, thermophilous woods Quercetalia pubescentis, mesic woods Fagetalia, hygrophilous woods Quercetalia robori-petraeae, Alnetalia glutinosae and Populetalia albae. The extreme richness of lichens characterize tertiary-relict forests with black pine and heaths Orno-Ericion, forests with endemic white-bark pine Pinion heldreichi and mountain pine Pinion mugi, mountain grassland on limestone belonging to the class Elyno-Sesleriteta and on siliceous rocks the class Caricetea curvulae.

Having in mind the records addressed in literature, and the hypothesis that many of lichens are still unknown to the science, we can suppose high diversity of them in Bosnia and Herzegovina, especially in endemic centres (the canyons of Una, Vrbas, Neretva and Drina river, and high mountain peaks).

**Pressures on lichens diversity**

By taking into account state of the environment on global scale, acceptance capacity of some ecosystems in Bosnia and Herzegovina, sensitivity of licheno-flora/fungia, and the expected trends of changes, we should emphasize following pressures:

- Global climate changes followed by acid rains and over-heating;
- Pollution of atmobiospheres by the inorganic and organic pollutants;
- Loss of plants diversity, especially trees that epiphytic lichens are bound to;
- Conversion of forest habitats;
- Over-grazing and soil erosion in high-mountain areas;
- Unbalanced exploitation of mineral resources;
- Invasive species of fungi, alges and cyanophytes.

Due to above stated pressures, the number of threatened lichens grows on daily basis (over 200 species on the European Red List of threatened plants and lichenes). However, the assessment of their threat's level in B&H, according to the IUCN criteria, hasn't been completed yet.

# DIVERSITY OF LANDSCAPES

## MEDITERRANEAN LANDSCAPE IN BOSNIA AND HERZEGOVINA

The geological foundation of ecosystems belonging to this landscape is firm mezozic limestone. Soils are mediterranean red earth (terra rosa), brown mediterranean earth (calcocambisol) and on steep slopes prevail organomineral black earth and rendsine. Because of underlined wind erosion and open position toward the Sea, soils posses only shallow humus-accumulative horizon. It is mostly different development stage of organomineral black earth and rendsine. On flattened depression's bottom occur deep ilimerised soils, mainly on flish, covered by remnants of laurel woods.
The climate is typical eu-mediterranean with mean annual temperature between 18 and 16°C. Absolute minimum doesn't fall below -5°C, while absolute maximum reaches up to +40°C within closed stands. Insolation amounts more than 1.800 hours a year. Cloudness is low, while winters are milde. Therefore, the climate suits for the development of traditional, medicinal and eco-tourism.
Although annual precipitation is more than 1.500 mm, due to leakage proof geological foundation, there is either a lack of overground water or it occurs only in early spring and late autumn.

## DIVERSITY OF ECOSYSTEMS IN MEDITERRANEAN LANDSCAPES

Shrubs are persistent vegetation form that emerges by natural succession and whose physiognomy is determined by shrub-like trees (European filbert Coryllus avellana, jerusalem thorn Paliurus spina chrysti and others). Shrubs emerge after natural forest community get degraded.
Maquis are plant communities occuring in the mediterranean belt in which prevail small trees. They represent a succession stage that emerges after climax vegetation, which is evergreen oak wood (Quercus ilex), get degraded. This is the most common forest type in the mediterranean belt of Bosnia and Herzegovina today.
Pseudo-maquis is composed of evergreen and broadleaved decidous elements developing outside the zone of evergreen oak woods, often in the belt of macedonian oak woods (Quercus trojana).
Garrigues represent scrub-like vegetation of the mediterranean belt which emerges after maquis get degraded. Many of garrigue building species have got spines and reduced sclerophyllous leaves as an adaptation to arid and warm eco-climate. Garrigues may also be a progradation stage of the mediterranean rock debris communities.
Mediterranean landscapes are:

### Ecosystems of woods, shrubs and scrubs

- Ecosystems of maquis and evergreen woods and shrubs (Quercion ilicis "adriaticum");
- Ecosystems of mixed evergreen woods and shrubs (Orno-Quercion ilicis);
- Ecosystems of laurel woods (Laurion nobilis);
- Ecosystems of coastal pubescent oak woods (Quercion pubescentis "adriaticum");
- Ecosystems of coastal small shrubs and scrubs with oriental hornbeam and butcher's broom (Rusco-Carpinion orientalis);
- Ecosystems of coastal jerusalem thorn shrubs (Paliurion aculeati);
- Ecosystems with aleppo pine (Pinion halepensis).

Ecosystems of woods, shrubs and scrubs, although covering small space, represent an important biodiversity component characterized by specific biological features. In their high uniqueness, they clearly deviate from adjecent ecosystems. They build the Adriatic province of the Mediterranean region.
On southern and western slopes these ecosystems climb up to 300 m above sea level, while on northern slopes they don't exceed 50 m.
It is the rest of primary vegetation, which is evergreen oak woodland. At present it occurs as different stages of maquis. These communities are best developed on the Klek peninsula, where it makes in some places tightly closed cover which is hard to pass. Here prevail mediterranean lianas, such as butcher's broom, madder and smilax. Stands on the Klek peninsula are still in excellent condition. In 1950 this area was designated as reserve of mediterranen flora and fauna. It is even today very important in terms of preservation of the circum-mediterranean wildlife. Hence it has been designated as a mediterranean arboretum (mediterranetum). Mediterranean landscapes of B&H are an important segment of both Adriatic and Mediterranean biodiversity deserving full attention of the Mediterranean Action Plan.
Going toward supra-mediterranean belt, along with evergreen plants (phyllirea, pistache, evergreen oak and others) more often occur broadleaved elements (oriental hornbeam, jerusalem thorn, flowering ash, pubescent oak). As a special landscape's value we should mention plant communities with strawberry tree, myrtle, pistache. These places are inhabited by unique fauna, too. Fauna of butterflies, birds and amphibians (so called, Frog Mt.), then different insect groups (crickets, grasshoppers, butterflies, mantis) and scorpions is characterized by high diversity.

## Ecosystems of garrigues (mediterranean bushes)

- Ecosystems of garrigues with rock-roses (Cisto-Ericion);
- Ecosystems of prickly juniper (Juniperion oxycedri);
- Ecosystems of spanish broom (Spartion juncei);
- Ecosystems with Calycotome infesta.

Ecosystems of garrigues are recognizable in low bushes with dominance of rock-roses of genus Cystus and mediterranean heaths belonging to genus Erica. The latter one, in bloosom season, provides a special look to the landscape. Garrigues are longlasting stage in the climax vegetation development, occuring always on places previously covered by maquis, for they both have similar geo-pedological demands. The basic difference between these two ecosystem types in terms of eco-climate is greater temperature variance and lower relative humidity in garrigues.
In the supra-mediterranean belt, in ecological sense, garrigues are continued by mediterranean juniper communities. There are only few localities with endangered mediterranean species Calycotome infesta.

## Ecosystems of mediterranean rocky grassland and meadows

- Ecosystems of rocky grassland (Cymbopogo-Brachypodion ramosi);
- Ecosystems of meadows (Vulpio-Lotion).

Because of intensive anthropogenous impacts in the past, most of this territory is now covered by mediterranean rocky grassland. Rocky grassland is entirely open kind of habitat where temperature reaches its extreme values. Soils are shallow humus-

accumulative ones with steep slopes. The diversity of mediterranean rocky grassland is obvious in spring, early summer and autumn. In summer, due to high temperatures and arid climate, this ecosystems stagnate. Most of its plants posses medicinal, aromatic and honey-producing features (common sage, strawflower, savory and others).

Mediterranean rocky grassland is a habitat of many animal species. A high diversity level is being reached by butterflies, bees, humble bees, grasshoopers and crickets, especially in bloosom season. The sound of the latter ones is a component part of the mediterranean landscape.

## Ecosystems of rock crevices and screes

- Ecosystems of limestone rock fissures (Centaureo-Campanulion);
- Ecosystems of mediterranean screes (Peltarion aliaceae).

On more inclinated slopes where prevail shallow type of soils, such as regosol and sirozem, and in the fissures of hard limestone rocks, grow many chasmophytes. Most of them are endemic and considered to be tertiary relicts. Especially beautiful are Moltkea petraea and mediterranean bellflowers. Quite often they are accompanied by Dalmation pyrethrum, whose white and radially composed flowers put the mediterranean landscape in motion.
Beneath cliffs on accumulated matter of weathered rocks, evolve in some place mediterranean screes. Inspite of harsh environment, screes are inhabited by very specific communities composed of numerous endemic and relict both plants and animals. It is habitat of, for instance, Drypis, garlic cress, mediterranean bellfower, robert geranium, gladiola, iris and diverse kind of snails.

## Ecosystems in littoral sea belt

- Ecosystems of sea cliffs (Crythmo-Staticion cancelatae);
- Ecosystems of marine sands (Amophylion maritimae);
- Ecosystems of brakish water (Ulvion lactucae);
- Ecosystems of littoral sea belt (Cystoseirion).

In the littoral belt, where the sea level rises and falls, occur special ecosystems of sea cliffs. Geological foundation here is mezozoic limestone with highly diverse ornaments at the surface resulted by sea water activity. In rock fissures develop very shallow salty soil (salt marshes), to whome is adapted relatively small number of species and communities. Most frequent are typical halophytes (rock and golden samphire and sea lavender). In touristic season these habitats are under tremendous anthropogenous impact making therefore many plant and animal species (for instance date-shell) highly endangered. On sandy beaches, where arenosol is common type of soil, developed are halophylous communities in which prevail species of genera Amophilla, Inula, Sueda etc. These are ecosystems that cover small area, but, yet, play an important role for the mediterranean landscape's stability. In the littoral sea, grow macrophyte alges within their communities. The most common are brown and green alges of genera Cistoseira, Padina and Ulva, of which some are endemic ones. The richness of marine fauna includes seastars, sea urchins, crayfishes, molluscs, sea cucumbers and the unique fish world. Although B&H's sea water posses high quality, it hasn't been recorded the occurence of Posidonia oceanica. The reason for that is probably low salinity of sea water as a result of dilution by Neretva river.
For the mediterranean landscape characteristic are sea ecosystems. There is 27 km long

shoreline that allows B&H direct approach to the Adriatic Sea, in the area of Malostonski zaljev.

The relief of B&H's sea bottom is very dinamic. Because of water quality, hidden postion relating to strong winds coming from the sea and specific mixture of in water dissoluted salts, the living world is highly diverse and rich. There are micro- and macrophyte alges along with numerous inverebrates that create many interesting communities belonging to plankton, necton and benthos. Within these ecosystems live 100 vertebrate species, of which majority make fishes (97 species) and different invertebrate forms of life – sponges, crabs, molluscs, cephalopods, corals, spiny-skinned animals, sea worms.

Table 25. – Fauna of the Adriatic Sea on B&H's territory

| Group | Species |
|---|---|
| Pisces | 97 |
| Mamalia | 4 |
| Porifera | 11 |
| Anthozoa | 6 |
| Anellida | 6 |
| Crustacea | 26 |
| Bivalvia | 12 |
| Scaphopoda | 1 |
| Gastropoda | 11 |
| Cephalopoda | 4 |
| Bryozoa | 4 |
| Echinodermata | 20 |
| Tunicata | 5 |
| ukupno | 207 |

The coastal area is affected by global and local anthropogenic impacts, which is why sensitive species (prstac, morski jež) are seriously endangered.

The hydrographic corridor and direct connection with an open sea, Bosnia and Herzegovina achieves in accordance with the international sea regulations. Like no other area in Adriatic sea, bosnia-herzegovina's sea is still very clean with streched coastline, hence, being suitable for the construction of marine infrastructure in its southern part. The capacity of our marine ecosystems enables the construction of modern harbor for passanger and lighter cargo ships, which will support development of the sustainable shipping.

## Ecosystems of urban and rural habitats

- Ecosystems of nitrified habitats (Inulion viscosae);
- Ecosystems of arable land (Panico-Setarion);
- Ecosystems of abandoned places (Psoraleion bituminosae).

Today, most of the area, especially in the coastal belt, is transformed into urban and rural settlements. Apart from being used for the construction of needed touristic infrastructure, land in mediterranean belt is also used for the sustainable agriculture. It suits for growing vegetables (paprika, tomato, aubergine, spinach, beet, borecole, mangel, salad, onion) and typical mediterranean crops (olives, oranges, tangerins, figs, grapes, actinidies, pomegranates etc.).

Along side of the roads, on trampled soil, occur communities with elecampane, pitch trefoil, white henbane, etc. The natural look of mediterranean landscapes is completed by ornamental plants with unusual shapes and flourishing bloosom. Those are Bougenvilia, Passiflora, Acaccia, Vistaria, Thuja and different kind of palms and cypreses.

## State

Thanks to the fact that main roads have avoided bosnia-herzegovina's shore for a long time, the original image of mediterranean landscapes has been preserved for a same long period of time. In last 50 years, the construction of roads has enabled development of recreational, open and conference tourism. Main share of bosnia-herzegovina's shoreline is today transformed into urban settlement with centre in Neum city.

The evergreen oak woods are quite well preserved in our territory. The massive anthropogenic pressure through over-logging of formerly tall forest has led to sever soil degradation and the occurnece of low-productive ecosystems of garrigues and rocky grassland. The structure of littoral ecosystems has been changed substantially entailing the need after their ecological restoration (especially in the area Hotel Zenit-Surdup).

The more realistic picture of the ecosystem state's assessment emerges from the recent studies, the results of which are shown in Figure 7.

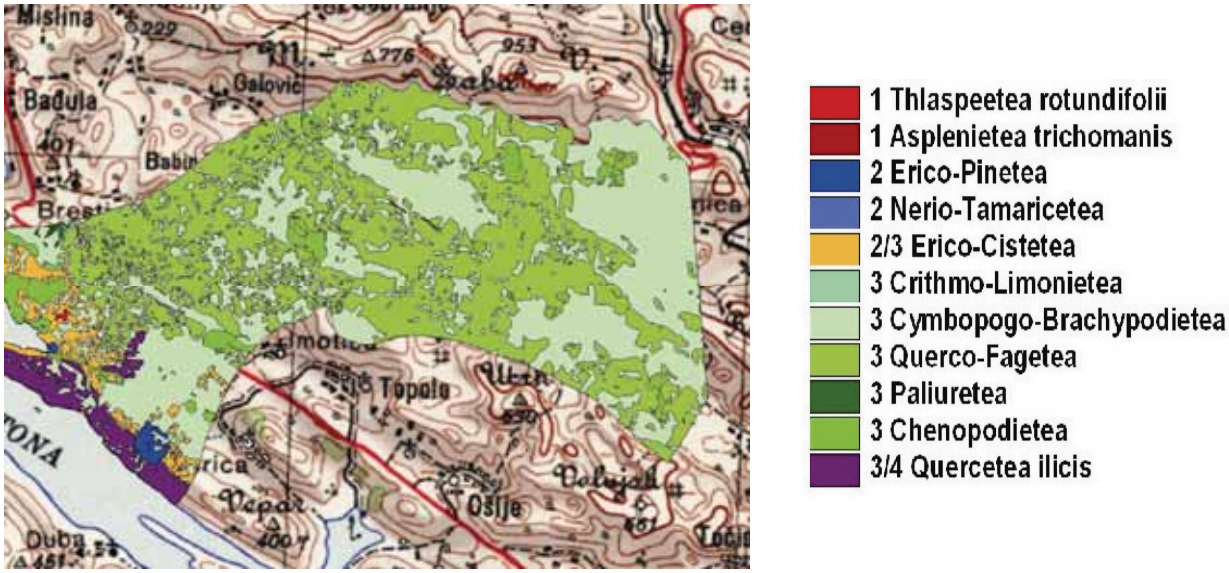



Figure 7. – Carrying capacity of mediterranean landscape's ecosystems in B&H

*Romulea bulbocodium* (L.) Sebast. & Mauri

## SUPRA-MEDITERRANEAN LANDSCAPES OF BOSNIA AND HERZEGOVINA

Geologic foundation in habitats of the supra-mediterranean landscapes is made of carbonate rocks (limestone and dolomites) of different age. On top of them occurs series of carbonate soil, sirozem, limestone black earth, rendsine, limestone brown earth and on flattened ground dry luvisol. Shallow carbonate soils provide optimal conditions for a supra-mediterranean rocky grassland and meadows with woods and shrubs occuring on cambisols. As far as thermal conditions are concerned, mean annual temperature is around $16^0$C. Variation of temperature and other ecoclimate conditions is more pronounced in the rocky grassland and meadows than in the woods and shrubs. Average relative air humidity is low comparing to humid bosnian habitats with arid characteristics in vegetation season. Considering light demands, communities of this belt are heliophyte. Sciophytes are to be found only in some sinusia.

## ECOSYSTEMS DIVERSITY OF SUPRA-MEDITERRANEAN LANDSCAPES IN B&H

Going from the mediterranean belt (50 m above sea level on northern and up to 300 m on southern slopes) in northern direction extends, in orographic sense mildly waved area, in which has evolved special variant of supra-mediterranean climate. Regarding its hydrology this area is bound into unique system through branched network of overground and underground watercourses ending mostly in Neretva river.
Thermophilous oak species, being best bioindicator of supra-mediterranean climate, show that this territory streches along Neretva river up to Jablaničko lake, encompassing valleys of Ličtica and Tihaljina and lower karst fields, going all the way to Bileća in East and Trebinje in South.
Beside suitable climate and well developed hydrologic network this area is characterized by high diversity of soils. Prevailing are black earth, rendsine, brown limestone earth and some variants of ilimerized soils and fluvisols on flat land.
What once used to be flourishing woodland with mazedonian, italian and pubescent oak has in the meanwhile changed completely due to many civilizations that have come to pass.

*"Remnants of previously tall woods, which are shrubs and scrubs today, then rocky grassland, screes, rock crevices, sink holes, stone cottages and possesions surrounded by stone fences are typical image of herzegovina's supra-mediterranean landscape. Herein highligthened is the white colour of karst, bloosom of flowering cherries, peaches and apricots over entire year, and in early spring and fall the redish of pomegranates. Mediterranean cypresses here are almost as tall as clear herzegovina's sky. By hands of skilful builders constructed were towers, cities, bridges whose walls and graceful arches tell the story on noble people from Hum, beautiful Emina, Diva Grabovčeva, Šantić's jasmines, Dučić's poplars, peaceful rest of human souls, cold source of Buna river and vast space of Široki Brijeg.*
*Even today, in dusk and early dawn, one can hear an echo from Hadžibeg's tower in Hutovo, monastery bells from Zavala, silent whisper at Buna's source floating between the bell-towers of Počitelj-town that once used to be beg's possesion on Bregava river's shore. Over the white bridge still cross people from Hum to tell the stories on heroic deeds, skilful builders, clear Radoblja river, beautiful Emina." (quoted from TV show "Prirodna baština BiH")*

Supra-mediterranean ecosystems are divided into following ones:

- Ecosystems of woods and shrubs with pubescent oak;
- Ecosystems of woods and shrubs with mazedonian oak;
- Ecosystems of woods and shrubs with italian oak;
- Ecosystems of woods and shrubs with oriental hornbeam;
- Ecosystems of woods and shrubs with flowering ash;
- Ecosystems of supra-mediterranean rocky grassland with savory and common sage;
- Ecosystems of supra-mediterranean rocky grassland with everlasting;
- Ecosystems of rock crevices with moltkea and Tanacetum cinerariifolium;
- Ecosystems of screes with garlic cress and robert geranium;
- Ecosystems of arable land;
- Rural and urban ecosystems.

Along streams and on the flat land, where the level of underground water is high, occur swamp communities building following ecosystems:

- Ecosystems of willows, poplars and oriental plane;
- Ecosystems of shrubs with purpule willow, chaste tree andsilk vine;
- Ecosystems with grey willow;
- Ecosystems of ponds and marshes in karst fields;
- Ecosystems of supra-mediterranean hygrophilous meadows;
- Ecosystems of freshwater.

## Ecosystems of supra-mediterranean rocky grassland and xeric meadows

All thermophilous meadows and rocky grassland in B&H have got secondary character. They emerge in different kind of egzogenic successions that are quite often anthropogenic triggered, such as clearing and burning down of forests, over-grazing and other similar ways.

At present these ecosystems are spread over habitats whose climax vegetation is composed of mazedonian, italian and pubescent oak. In B&H these ecosystems achieve their optimal development in Herzegovina.

Supra-mediterranean rocky grassland of alliance Satureion montanae occurs most frequently in oriental hornbeam's zone. This vegetation type belongs to class Thero-Brachypodietea. Xeric meadows of supra-mediterranean landscapes in B&H belong to class Festuco-Brometea.

Ecosystems of thermophilous meadows and rocky grassland are differentiated into great number of vegetational units encompassing over 1.000 species of vascular plants. Data on animal diversity aren't as closely that reliable as data on plants. Most distributed plant communities of supra-mediterranean rocky grassland's ecosystems in Herzegovina are:

- community of common sage and needlegrass;
- community of thyme and bellflower;
- community of fescue and quaking grass;
- community of asphodel and kršin;
- community of sedge and knapweed.

### State

Many plants living in these habitats are rare, endemic and relict, while, on the other hand, there is a large group of plants possesing high economic value. Supra-mediterranean rocky grassland and meadows comprise medicinal, edible, aromatic and vitaminous plants that are being used since ever for traditional healing and alimentary purposes. Yet, there are many species being irreplaceable in modern pharmacy, too.

These ecosystems have got enormous economic importance as pastures providing healthy live stock's diet.

**Pressures onto supra-mediterranean rocky grassland and xeric meadows**

Ecosystems of thermophilous meadows and rocky grassland in supra-mediterranean belt of Bosnia and Herzegovina are under tremendous and diverse anthropogenic impacts arising from activities as follows:

- uncontrolled urbanisation;
- construction of traffic and other infrastructure facilities;
- conversion of karst habitats into agricultural land;
- unsustainable use of biological resources (sage, strawgrass and others).

## Ecosystems of karst caves, holes and abysses

In highly specific past of supra-mediterranean landscapes were created and maintained rare habitats of underground fauna. On Herzegovina's territory occurs great number of outstanding biotopes (caves, holes and abysses).

Deep under the surface water is inhabited by ancient taxa, while younger kindred species are expected to be found living close to the surface in connection with overground ecosystems.

Beside palaeo-climate and geomorphologic features for these relict kind of ecosystems, in order to get developed and maintained, important are characteristics of dinaric karst, whereby it is meant on porous mesosoic limestone.

Evolutionary advantage of these habitat types is in hiding from unfavourable climate conditions and possibility to avoid harsh competition which prevails in underground biocoenoses.

In underground habitats both permanent and temporary ones, in aquatic and terrestrial environment, occur troglobionts (fully adapeted to life in underground cavities), troglophylls (adapted to underground habitats, yet occuring in overground biotopes) and trogloxens (occasionally or accidental dwelling in caves).

Constituents of biocoenoses are mainly consumers and reducers, saprobionts and saprofags, in far less extent biofags. Along with representatives from realms Monera and Fungi, major proportion of biocoenoses is made of representatives from realms Protozoa and Animalia (Metazoa).

Small number of ecologic niches occuring in underground habitats is related with low diversity of biocoenoses. Population density is limited by quantity of available food resources, which together with limited space in biotopes leads to critically small abundance or even extinction of populations.

Adaptive features of organisms living underground are: lack of pigmentation, reduction or absence of sight, emphasized tactile and odorous senses (extended anntenas and limbs), developed hearing sense. In relation with high relative humidity of air, reduced is dry protection. Decreased concentration of oxygen and increased concentration of carbondioxid in underground habitats results in development of appropriate physiologic adaptations.

The most famous and best studied underground habitat in Bosnia and Herzegovina is Vjetrenica cave:

*"The cave is hollowed out in limestone and dolomites between Popovo polje and Adriatic Sea... At surface developed are numerous karst relief's forms: karrens, sink holes, holes, caves, heads, beams etc. There must be connection between the surface and underground cavities of Vjetrenica cave."*

Vjetrenica is the longest cave in Bosnia and Herzegovina. It has been so far discovered and described around 5.700 m of its length.

*"Vjetrenica is horizontal cave with branched channels that extend in three levels. Upper level is made of vertical channels, mostly chimneies. They lead from Main channel toward the surface, which is above Vjetrenica, but there are also routes going from some secondary channels. Into same level belong the network of gallery-like channels stretching over a mid part of cave-so called Old Vjeternica – mostly on both sides of Great Lake. Middle level is composed of Main channel with branches spreading horizontally or slowly elevating through a limestone layers. The lowest level are Lower Vjetrenica and Absolon's channel with lateral channel's network."*

Table 26. – Stenoendemic species of Vjetrenica cave

| Latin name | Local name |
|---|---|
| *Scutariella stammeri* Matjasic 1958 | Vjetrenički ili Stammerov rogonjić* |
| *Lanzaia vjetrenicae* Kuscer 1933 | Vjetrenička lancaja* |
| *Zavalia vjetrenicae* Radoman 1973 | Zavalka* |
| *Eukoenenia remyi* Conde 1974 | Remyjev bičerepac* |
| *Lepthyphantes vignai* Brignoli 1971 | Vignaijev sitni baldahinski pauk* |
| *Neobisium (Blothrus) vjetrenicae* Hadzi 1933 | Vjetrenički lažištipavac* |
| *Dinaria vjetrenicae* Hadzi 1933 | Vjetrenička dinarija* |
| *Troglomysis vjetrenicensis* Stammer 1936 | Vjetrenički rašljonožac* |
| *Armadillidium absoloni* Strouhal 1939 | Absolonova mramorirana babura* |
| *Niphargus factor* G. Karaman & Sket 1991 | Sitni slijepi rakušac* |
| *Niphargus zavalanus* S. Karaman 1950 | Zavalski slijepi rakušac* |
| *Typhloiulus (Attemsotyphlus) edentulus* Attems 1951 | Glatka dvojenoga* |
| *Coletinia sp.* | Koletinija* |
| *Aphaenopsis (Adriaphaenops) pretneri* Scheibel 1935 | Pretnerov afenopsis* |
| *Orientalina troglobia* (Bole 1961) | Špiljska orijentalina** |
| *Vitrea spelaea* (A.J.Wagner 1914) | Popovska staklenka** |
| *Phoxinellus ghetaldii* (Steindachner 1882) | Popovska gaovica** |
| *Iglica absoloni* (A.J. Wagner 1914) | Absolonova iglica*** |
| *Aegopis spelaeus* (A.J.Wagner 1914) | Špiljski plošnjak*** |
| Cecilioides **????** spelaea A.J.Wagner 1914 | Špiljski šiškoliki puž*** |
| *Prostoma hercegovinense* Tarman 1961 | Hercegovački vrpčar*** |
| *Stalitella noseki* Absolon & Kratochvil 1933 | Stalitela ili runjavi špiljski pauk*** |
| *Tegenaria annulata* Kulczynski 1912 | Špiljski ljevkar*** |
| *Proasellus hercegovinensis* (Karaman 1933) | Hercegovačka vodenbabura*** |
| *Alpioniscus (Illyrionethes) heroldi* Verhoeff 1931 | Heroldova slijepa babura*** |
| *Titanethes (Cyphonethes) hercegovinensis* Verhoeff 1900 | Hercegovačka špiljska babura*** |
| *Niphargus balcanicus* Absolon 1927 | Bodljikavi slijepi rakušac*** |
| *Niphargus vjetrenicensis* S. Karaman 1932 | Vjetrenički slijepi rakušac*** |
| *Niphargus hercegovinensis* S. Karaman 1950 | Hercegovački slijepi rakušac*** |
| *Lithobius (Troglolithobius) matulicii* Verhoeff 1899 | Matulićeva kamenarka*** |
| *Antroherpon primitivum* (Absolon 1913) | Primitivni antroherpon*** |
| *Hadesia vasiceki* (J. Muller 1911) | Hadezija*** |
| *Speonesiotes (S.) narentinus* L. Miller 1861 | Neretvanski podzemljar*** |
| *Aphaenopsis (Scotoplanetus) arenstroffianus* Absolon 1913 | Vjetrenički afenopsis*** |
| *Troglamaurops ganglbaueri* Winkler 1925 | Ganglbauerov pselafid*** |

* stenoendemic in Vjetrenica, ** stenoendemic in Popovo polje, ***stenoendemic in eastern Herzegovina and Dubrovnik's coastline (Vjetrenica, pogled u dušu zemlje, Lučić, I., Sket, B., 2003, Zagreb-Ravno)

Among underground dwellers frequently occur: Hadzia fragilis, Accubogammarus algor, Monolistra matjasici; Trichoniscus matulići, Tracheoniscus mostarensis; Holocnemus absoloni, Anthroherpon ganglbaueri, Anthroherpon leonhardi, Anthroherpon loreki, Anophtalmus noesskei, Anophtalmus kautianus, Anophtalmus maglajensis; Troglophilus cavicola, Dolichopoda araneiformes.

Remnants of ancient faunistic complexes are to be found among species belonging to order Pseudoscorpiones, frequently occuring in underground ecosystem types.

**Pressures onto ecosystems in karst caves, holes and abysses**

Ecosystems of underground habitats in Bosnia and Herzegovina are affected today by many anthropogenic influences. Most important of those are:

- re-direction of underground streams for dam accumulation purposes;
- dry out of underground streams;
- pollution of watercourses by different pollutants coming from industrial and agricultural sources;
- global climate changes and acidification of habitats;
- undeliberate destruction of biocoenoses by cave's visits;
- unsustainable and forbiden collection activities.

**Ecosystems of thermophilous woods and shrubs of supra-mediterranean landscapes**

On vertical profile pubescent oak woods are distributed about 300 m above sea level reaching even 800 m in eastern, mid and western Herzegovina. This kind of forests occur in continental area, too, eastern from town Ključ toward Bosanski Petrovac and Gornje Pounje, then in river canyons, such as Una, Sana, Vrbas, Bosna, Drina, especially Neretva and its tributaries. Here they posses refugio-tertiary character.

The same features have got italian oak woods in Herzegovina which occur along Neretva river at Donja Jablanica and in the valley of Trebižat river in western Herzegovina.

In western Herzegovina latter ones are continued by forests of turkey oak that go uphills on Čabulja and southwestern Čvrsnica Mt., going further to the southwest in the region of Duvanjsko and Livanjsko polje all the way down to Gornje Pounje where turkey oak builds diverse and well preserved plant communities.

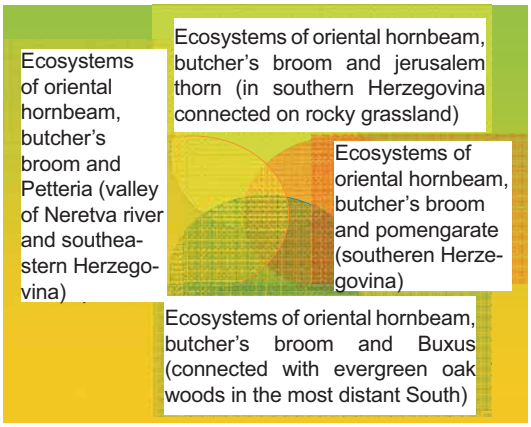
Thermophilous oak woods, including all of its progressive and regressive stages, are characterized by high biodiversity. They cover large area in Herzegovina, respectively supra-mediterranean belt of B&H, in which an adequate life conditions are found by many endemic and relict species.

Largest share of thermophilous forests originates in Tertiary. In general, all circummediterranean oak woods date back from Tertiary. Such is the case with animals living within reffering plant communities, too. Hence, they represent a gen pool of greatest importance. The occurence of species belonging to specific gen pool makes the plant communities endemic-relict.

In the supra-mediterranean Herzegovina's landscape exist various ecosystems of woods and shrubs Differentiation level is high:

- Ecosystems of shrubs with oriental hornbeam;
- Ecosystems of shrubs with maple and orienatl hornbeam;
- Ecosystems of shrubs with butcher's broom and oriental hornbeam;
- Ecosystems of shrubs turkich hazel and oriental hornbeam;
- Ekosistem šikara jesenje šašike i bjelograbića;
- Ecosystems of mazedonian oak woods;
- Ecosystems of italian oak woods;
- Ecosystems of pubescent oak and flowering ash woods;
- Ecosystems of common horsechestnut woods.

## State




For the maintenance of matter circulation and energy flow in this highly sensitive area, great ecologic importance have got ecosystems of thermophilous woods and shrubs in supra-mediterranean belt.

Graph 14. – Differentiation of shrubs with oriental hornbeam and butcher's broom

Woods and shrubs are natural environment for many medicinal, edible, aromatic and vitaminous self-grown plants.
After the Map of natural vegetation in ex-Yugoslavia (Jovanović et al., 1986) thermophilous oak woods used to cover about 30% of B&H's surface. Now it is just 10-15% of tall woods in B&H.

Thermophilous woods and shrubs in Herzegovina today are mainly degraded into different forms of previously fertile climax oak woods. By their ecologic and economic significance, they deserve full and efficient protection, especially the stands that are still well preserved.

### Pressures on ecosystems of supra-mediterranean woods and shrubs

Supra-mediterranean ecosystems in Bosnia and Herzegovina at present are subdued to wide spectrum of anthropogenic impacts, of which stressed should be following ones:

- Forest fires caused by carelessness, negligence, inadequate waste disposal etc.;
- Construction of infrastructure for traffic, building and industry purposes;
- Expansion of arable land (first of all mono-cultures);
- Acidification of habitats as a result of global changes;
- Unsustainable logging of forest stands;
- Construction of dam accumulations and other water supply facilities;
- Uncontrolled exploitation of mineral resources.

# MEDITERRANEO-MONTANE LANDSCAPES OF BOSNIA AND HERZEGOVINA

Geographic passage between Herzegovina from the South and Bosnia from the North, where colide warm mediterranean and cold mountain climate, is characterized by specific ecologic conditions evolved in the past. Pronounced are extreme values in temperature and hygric regime, then high precipitation and its specific distribution. Ecosystems developing under such conditions are inhabited at the same time by thermophilous and frigophilous species, respecitvely mountain plant and animal species.

Being continued on the pubescent oak ecosystems of supra-mediterranean belt these landscapes climbe up to 1.000 (1.100) metres above sea level.

Landscape's physiognomy is determined by turkey and sessile oak forests. In geographic sense, it encompasses belt stretching above lower karst fields (Fatničko, Dabarsko) till ultimate borderline of turkey and sessile oak forests in Gatačko and Nevesinjsko polje in the East and the northwestern borderline in Grudsko, Posuško, Duvanjsko, Livanjsko, Grahovsko and Drvarsko polje. This complex landscape is being differentiated in following ecosystems:

# ECOSYSTEM'S DIVERSITY OF MEDITERRANEO-MONTANE LANDSCAPES

## Ecosystems of mediterraneo-montane sessile and turkey oak woods

Woods of sessile and turkey oak are being developed on carbonate geologic foundation, brown limestone earth and mild slopes. They represent ecologic connection between supra-mediterranean pubescent oak woods with oriental hornbeam and straight turkey oak woods.

## Ecosystems of mediterraneo-montane frigophilous-thermophilous turkey oak woods

Ecosystems of mediterraneo-montane turkey oak woods take highest positions within this landscape. In summer, air temperature is very high which is suitable for typical thermophilous plants to occur. In spring, autumn and winter air temperature falls extremely low (caused by longlasting and strong winds) creating conditions for the existance of frigophilous plants. These ecosystems occur in mediterraneo-montane belt extending eastern from Neretva river. In western Herzegovina, as vicarious, occur ecosystems with turkey oak and flowering ash.

## Ecosystems of mediterraneo-montane thermophilous flowering ash and turkey oak woods

This kind of ecosystems provide unique biogeographic features to the edge of karst fields. It is being developed toward northwestern Bosnia reaching all the way of Unac and upper Una river's confluence. In ecologic sense, this ecosystem dates back from Tertiary indicating strong penetration and influence of the mediterranean climate. It is composed of many tertiary relicts, especially on dolomites and rendsine which are to be found in Unac area.

## Ecosystems of thermophilous pubescent oak woods

On warmer places, along the edges of karst fields in western Herzegovina, often occur special variants of thermophilous pubescent oak woods with asparagus, making ecologic continuity with frigophilous woods of supra-mediterranean landscapes. Unique lanscape's and floristic attributes these woods owe to the special pubesent oak form, dif-

ferent irises (grass-like iris Iris graminea, yellow iris Iris variegata), lily of the valley (Convallaria majalis) and several species of Solomon's seal (Polygonatum sp.).

## Ecosystems of low forests and shrubs with maple and oriental hornbeam

On shallow type of soils, where once used to be a tall turkey and pubescent oak wood, under the conditions of high temperature and low air humidity, develop low forests and shrubs with oriental hornbeam and maples. These are usually longlasting stages in climax vegetation development. Beside prevailing species (which is oriental hornbeam), landscape values to these ecosystems provide: bosnian maple, balkan maple, field maple, transitional maple, flowering ash, smoketree, oriental hornbeam, cyclamen, primerose, cinquefoil, autumn moor grass, sedges, star of bethlehem, violet and others.

## Ecosystems of hazel

In the zone that is submitted to intensive degradation of its vegetation and soil, in habitats where thermic conditions are extreme and where blow strong winds, developed are hazel shrubs. Along the margins of Gatačko, Nevesinjsko, Livanjsko and Rahovsko polje these ecosystems, in which hazel with its medicinal and nutritional values achieves the highest production, look like natural plantages. Most of species composing these plant communities are endemic, with dinaric and balkan distribution range. The communities with high landscape's value are hazel and hellebore, hazel and snowdrop, hazel and dog's tooth violet, hazel and autumn moor grass, hazel and hawthorn, hazel and primerose. But, in its floristic and physiognomic uniqueness outstanding is community of hazel and balkan peony, which is endemo-relict ecosystems occuring only in the zone of karrens along the margins of Kupreško, Livanjsko and Šuićko polje.

## Ecosystems of mediterraneo-montane roky grassland

Mediterraneo-montane rocky grassland and meadows, then vegetation of rock crevices and screes take habitats that used to be forest ecosystems in the past, but got degraded and now are characterized by wide variation of all ecologic factors and strong winds. Geologic foundation like in the entire landscape's zone is carbonate, with eroded black earth and rendsine.

There is a very specific dynamic of these ecosystems, whereby outstanding aspects are in spring – early summer and autumn when large number of species emerges. In summer, most of them stagnates.

Mediterraneo-montane rocky grassland in Bosnia and Herzegovina has got high landscape's value, due to flowers in many different colours.

There are many medicinal, aromatic and honey-producing plants (winter and illyrian savory, rock knapweed, mountain garmander, thyme, sage, Acinos orontius, wood betony, rocky kind of sedges, brome, fescue). Most of mediterraneo-montane rock debris communities are considered to be endemic, with dinaric and balkan distribution range. In the sinkholes, where are being formed deeper soils, develop mediterraneo-montane thermophilous meadows with viper grass (Scorzonera vilosa). These communities have got high diversity level (over 20 species per 1 m ). Along with widely distributed species, these communities include endemic ones, too, such as viper grass (Scorzonera vilosa), spotted hawkweed (Hypochoeris maculata), oatgrass (Danthonia sp.), lathyrus pannonicus, then various orchids, for instance lady orchid, green-winged orchid, ophryses, endemic dianthus, balcan's scabiosa and grasses (brome, junegrass, fescue, sedges).

Many of these plants are fooder plants possesing high nutritional values. This should be a base for sustainable sheep and goat breeding in the area.

## Ecosystems of mesophilous meadows

On mild slopes and deeper soil variants, on the from wind hidden places, occur mesophilous and temperate humid meadows. They are much more productive than previosly described communties.
These meadows accomplish ecologic continuity with the endemic mountain and submountain meadows in Dinaric Alps of alliance *Pancicion*. Special features are ensured by rattle, bentgrass, meadow and red fescue, small gentians, eyebright, selfheal, knapweed, daisy, dropwort, dog's tooth violet, hard-heads and others.

## Ecosystems of rock crevices and screes

These communities are distributed here as fragments. They occur on steep slopes, in the cracks of rocks and shallow soils, such as sirozem and regosol. In the composition of these communties included are chasmophytes with endemo-relict character. A special attributte here represents richness in snails, snakes, lizards and small rodents.

Čabulja Mt.

## UPLAND LANDSCAPES IN BOSNIA AND HERZEGOVINA

Regarding ecoclimate and geomorphology mid part of Bosnia and Herzegovina represents highly dynamic area. All geomorphologic structures exceed 900 (1.000) metres, which is why the influences of warm continental climate from the North and of even warmer mediterranean climate from the South get lost. This is the place where a new world beginns. The world whose physiognomic and bio-ecologic features are determined by mixed broadleaved deciduous and conifer forests.

People have been calling this bosnia-herzegovina's upland area "gora" for ages. Therefore, the entire ecologic complex belonging to this vertical profile's belt was named "gorski", which is up to 1.500 (1.600) metres above sea level.

Upland landscapes comprise the most productive and economically valuable forest ecosystems ("green gold of Bosnia and Herzegovina") where it has been searched after wood biomass, hunted large game species and collected diverse forest fruits since Neolith (medicinal, edible plants and mushrooms).

Upland landscapes encompass best preserved ecosystems with beech and fir, then forests of beech, fir and spruce, forests of spruce and fir, forests of sycomore and european ash, of which many posses all attributes of primeval reserves (Perućica, Igman, Janj, Klekovača, Vitorog, Kozara).

High diversity in geologic foundation, soil types, relief and ecoclimate have in time resulted in diversity of ecosystems in the upland belt, which ensures recognizable ambiental value to these landscapes.

## DIVERSITY OF ECOSYSTEMS IN UPLAND BELT

Landscapes of upland belt on vertical profile of bosnia-herzegovina's mountain is composed of:

- Ecosystems of mixed broadleaved-conifer foersts with illyrian beech, fir and spruce;
- Ecosystems of acidophilous forests with beech, fir and melicgrass;
- Ecosystems of mixed broadleaved-conifer forests with moesian beech and dinarci fir;
- Ecosystems of forests with illyrian beech and autumn moor grass;
- Ecosystems of forests with moeasian beech and autumn moor grass;
- Ecosystems of sycomore and european ash;
- Ecosystems of conifer forests with spruce and fir;
- Ecosystems of balkan alder buckthorn and fir;
- Ecosystems of conifer woods with spruce and Scot's pine;
- Ecosystems of Serbian spruce;
- Eocsystems of mountain heaths with blue berry;
- Ecosystems of mountain heaths with common heather;
- Ecosystems of forests with birch and european aspen;
- Ecosystems of shrubs with hazel and hawthorn;
- Ecosystems of mountain thermophilous meadows with brome;
- Ecosystems of tall herb communities;
- Ecosystems of mountain temperate humid meadows;
- Ecosystems of hygrophilous meadows with illyrian purple moorgrass;
- Ecosystems of raised and blanket bogs;
- Ecosystems of lakes, ponds and marshes;
- Ecosystems of mountain springs and rivulets;

- Ecosystems of hygrophilous woods and shrubs with grey alder;
- Ecosystems of rock crevices and screes;
- Ecosystems of nitrified and trampled habitats;
- Ecosystems of arable land.

## Ecosystems of beech-fir woods

As an example how the habitat factors affect differentiation of these forest ecosystem types, we shall address here the high mountainous ecosystems on Vranica Mt. Vranica Mt. is in geologic respect silicate island surrounded by carbonate masiffs of Dinaric Alps. On the one hand, the influences from central and atlantic Europe here are still strong, but on the other, the influences coming from the Mediterranean are also evident. Due to geologic and climate diversity, it exists underlined differentiation of all ecosystem types, while beech-fir forests differentiate as follows:

- Cold and moist beech-fir forests in deep valleys on colluvial ground;
- Cold and dry beech-fir forests on deep acid ground;
- Warmer and moist beech-fir forests on filits;
- Dry beech-fir forests on humus-poor acid ground;
- Dry beech-fir forests on carbonate rocks.

In the composition of forests ecosystems in upland belt apart from beech and fir, in the area of Bosnia and Herzegovina, occur many different trees, shrubs, scrubs and ground floor herbs. The inevitable element of beech-fir forests is spruce.In diverse variants exchange sycomore, norway maple, common maple and Acer obtusatum.

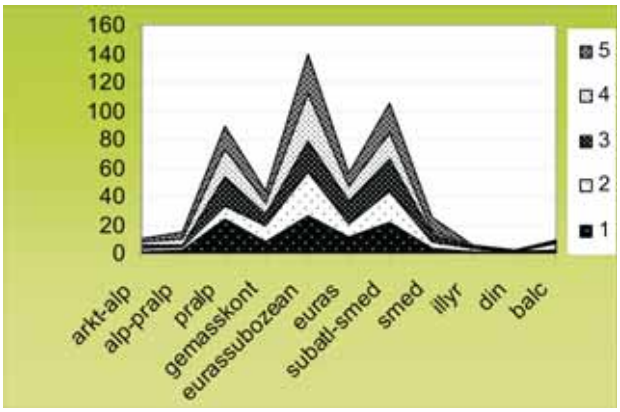
Beech-fir forests from dinaric area are considered to be one of the richest forest communities, encompassing large number of for bosnia-herzegovina's flora relict and endemic species.

Diversity of shrub like species in these stands is enormous. Quite often here occurs woodbine, spindle tree, dwarf bay, alder buckthorn and others.

Some species are exclusively bound to certain forest variants, such as some gound layer herbs. However, it can be extracted one large group of ground floor herbs which are adapted to specific conditions in reffering stratum, and which are regular component in these forests. Those are: wood sanicle, herb Paris, male and lady fern, coral-wort, melicgrass, dead nettle, broad-leaved garlic etc.

This complex ecosystem is characterized by following animals: brown bear, wild boar, dormouse, wild cat, stock dove, grey woodpecker, robin, buzzard, blind worm, meadow lizard, tree frog and others.

Graph 15. – Floral element's spectra in beech-fir communities of upland belt on Vranica Mt.




The continuity of hilly and upland vegetation belt of Bosnia and Herzegovina is achieved over montane beech woods in colder and montane sessile oak woods in warmer conditions.

Montane mesophilous beech woods are developed in lower part of the upland belt, mainly on colder slopes and deep brown earth. These highly productive forest stands regarding their diversity keep pace with upland beech forests. In relation with geologic

foundation and ecoclimate, these forests are clearly differentiated, whereby differentiation related to the whole complex of factors results in belonging to specific biogeographic region.
For the structure of montane beech woods, fir and spruce are less important. On the other hand, frequently present are species from the lower vegetation belts, such as hornbeam, sessile oak, wild cherry etc.
On acid ground, within these forest stands, well developed are blue berry populations, while on neutral ground occur typical "fagophilous" species.

## Primeval forest reserves in Bosnia and Herzegovina

In 1952, because of its outstanding beauty and species richness, the primeval forest named Perućica was designated as natural forest reserve. It is today part of the Sutjeska national park, encompassing large area of mountains Maglić (2.386 m), Volujak (1.978 m), Snježnica (1.804 m). One of the highest landscape values here represents 75 m high waterfall called Skakavac, which is a share of Perućac's brook. The primeval forest Perućica, covering 1.291 ha, is mainly composed of climax vegetation which is beech-fir woodland. In these woods are being preserved most valuable treasures of plant and animal world. There are beech trees which are over 50 metres tall, in diameter 150 cm, and few centuries old. On vertical profile of Sutjeska surrounding mountains, they take positions between montane and sub-alpine beech forests creating most complex ecosystems in respect to structure and seasonal dynamics. The animal world is rich and includes different species of mammals, birds, reptiles, amphibians, fishes and many invertebrates. Frequently occuring are: bear, chamois, roe-deer, wild boar, pine and beech marten, wild cat, fox and others; as for the birds there are: golden eagle, imperial eagle, capercailie, peregrine falcon, red-tailled blackbird, rock partridge, hazel hen and others.
On the territory of Bosnia and Herzegovina occur few more primeval forest reserves of which the most famous is Janj (295 ha), situated at altitude from 1.180 to 1.510 m on Stolovaš Mt., then Lom (297, 8 ha) situated on mountain carrying the same name at about 1.250 m altitude. Main living communitiy in the both afore named reserves are beech-fir woods with significant share of spruce.
Besides, here are well preserved populations of sycomore, European mountainash and many other species of higher strata. Within shrubs most frequently occur woodbine, dwarf bay, dog's rose, gooseberry and blue berry. Fauna of these two reserves is also very rich, and includes, among others: bear, wolf, fox, wild boar, hare, roe deer and globally threatened species: lynx, stoat and squirrel. Among birds here are identified following ones capercailie, black grouse, goshawk and peregrine falcon.
The basic biologic value these reserves owe to the primeval forest of beech, fir and spruce. Depending on edificator species here can be differentiated following communities: beech-fir woods *Abieti-Fagetum dinaricum*, fir-spruce woods *Abieti-Piceetum illyricum*, mixed beech-fir woods with spruce facies *Abieti-Fagetum piceetosum abietis*.
Plants possesing high biologic value within these ecosystems are: *Lilium martagon, Vicia oroboides, Dentaria enneaphyllos, Gentiana asclepiadea, Saxifraga rotundifolia, Listera cordata, Goodyera repens, Platanthera bifolia, Galanthus nivalis, Polygonatum latifolium* and diversity of macromycetes.

High preservation level of primeval forest reserves in Bosnia and Herzegovina ensures excellent conditions for many wild animals, including the globally threatened ones, for instance: brown bear (*Ursus arctos)*, wolf (*Canis lupus)*, capercailie (*Tetrao urogallus)*, lynx (*Lynx lynx*).

Apart from afore named primeval forests, there are several small beech-fir forests with spruce: Ravna vala on Igman Mt. (45 ha), Trstionica near Kakanj town (32,5 ha). Beside, it is on the way a designation of new primeval forest reserves: in Kladanj and Kakanj straight beech woods, on Blidinje lake whitebark pine woods.

## Ecosystems of dark coniferous woods

Conifer woods in Bosnia and Herzegovina take colder places in the upland belt, representing therefore a true balkan range taiga. It is being differentiated in several living communities, which cover the largest surface in the region of mountains Romanija, Ozren, Zvijezda and Vitorog. Elsewhere their occurence is induced by ecoclimate conditions.

Abiotic component of these ecosystems are different series of silicate and carbonate rocks, whereas soils are mainly distric cambisol and calcocambisol But, on more inclinated slopes and in lower part of mounatin belt, occur soils with A-C profile – rankers, calcomelanosol and rendsine.

Habitats of dark coniferous woods have got perhumid and humid climate over entire year. After its thermal character, the climate is cold, having in some months character of nival ecoclimate. Annual precipitation is regulary over 1.500 mm. Average annual temperatures vary between +6°C and +2°C; absolute minimum falls till -35°C (-45°C), whereas absolute maximum doesn't exceed +25°C.

Within dark coniferous woods of Bosnia and Herzegovina accomplished is high biologic and ecologic diversity.

Depening on hydro-thermic regime, geologic foundation and altitude, dark coniferous woods are differentiated into several ecosystem types:

- *Ecosystems of montane spruce woods*. These woods are developed in the upper hilly and upland belt, usually continuing onto fragmented belt of beech woods. They occur mainly on carbonates and partially silicates of hornblende series. Soils are calcocambisol and distric cambisol;
- *Ecosystems of spruce-fir woods in the upland belt.* The communities of spruce-fir woods *Abieti - Piceetum illyricum* develop on colder places in the upland belt, more frequently on acid brown earth, whereas seldom on limestone brown earth;
- *Ecosystems of spruce woods with coltsfoot*. On well developed and more acid soil type, such as distric cambisol laying over hornblend on northern slopes of Dinaric masiffs, exists smaller surface covered by this community;
- *Ecosystems of spruce with clubmosses.* On deep brown earth laying over hornblend or on podsols, developed are fragments of this community. It develops in spruce-fir area, sometimes in fir-beech area with spruce;
- *Ecosystems of spruce-scots pine woods*. On the territory of Bosnia and Herzegovina these woods inhabit mainly warmer expositions, till 25, respectively 30 degrees inclinated slopes, carbonate geologic foundation and carbonate brown earth, sometimes even calcomelanosol. Those are mainly lovely and well developed forest communities with high economic importance. They are rich in species. Beside species occuring in coniferous woods, there is a line of, in some extent, thermophilous forms;
- *Ecosystems of spruce woods with bogmosses.* In this area, spruce communities on humid

and peat-like ground have got azonal and local character. This has been recorded in several localities. These communities develope on silicate foundation and acrohystosol, partially on gley transformed in peat, on plain or slightly inclinated terrain;

- *Ecosystems of Serbian spruce*. The Serbian spruce communities are being differentiated in several types, which are induced by differences in abiotic factors. Nevertheless, these communities reach their optimal development on carbonate rocks, only sporadically on serpentine and peridote;
- *Ecosystems of fir and Oreoherzogia*. Stands of this community develop in the upland belt of the investigated area. Special characteristic of these ecosystems represent the occurence of huge limestone and limestone-dolomite blocks at the surface. Stands of fir and *Oreoherzogia* between limestone blocks are with limited distribution on the investigated area.

Apart from afore mentioned, in the area of Bosnia and Herzegovina exist ecosystems of spruce woods on podsol, then woods with fir and *Galium rotundifolium*, fir and hard fern, fir and reedgrass between carbonate blocks in the upper upland belt and lower sub-alpine belt, and woods with fir and common buckthorn.

Physiognomic and structural features of this biom are determined by: spruce, fir, scots pine, Serbian spruce, european mountain-ash, species of genus *Lonicera*, dog's rose, blue berry, plar tree, red whortlerberry, dwarf bay, lesser buterfly, melicgrass, wood sorrel, creeping lady's tresses, cow wheat, willow gentian, clubmosses and many others.

## Ecosystems of tall herb communities

As azonal vegetation type, in specific edaphic, orographic, pedologic and ecologic conditions in general, occur tall herb communities. Reffering habitats are mainly in small depressions, which aren't exposed neither to high evaporation nor extreme temperatures.

These ecosystem types are optimally developed at altitude spanning from 1.100 to 1.400 metres, on places with high air humidity maintaned continous by the occuring species. Tall herb communities go down to lower altitude, reaching even montane beech belt, or get mixed with the hygrophilous wood communities.

As far as physignomy is concerned, there is a part of tall herb communities characterized by large-leaved plants that in short vegetation period produce great quantity of green biomass. Decompostion of such biomass that is soft due to high proportion of water in it, evolves under conditions of high air humidity, high level of underground water and frequent floodings coming from the mountain streams. The consequence of such decomposition is nitrates being accumulated, which is the prerequisit for most of the species within these plant communities to occur.

In difference to tall herb communities emerging in high humidity milieu, along forest edges and on dry, open and mild nitrified places emerge thermophylous tall herb communities.

## Ecosystems of mesophylous meadows in the upland belt

Meadows are developed in the zones of all forest ecosystems. High diversity within the meadows here is caused by highly dynamic ecologic factors. Considering the soils, it prevails semigley, ilimerized soil and brown earth. The geologic foundation is diverse.
In the upland belt of southeastern Dinaric Alps exist special kind of meadow communities that differs in its structure from the similar communities in Alps, Pirines and even northwestern Dinaric Alps. Main feature of our meadows is the occurence of dinaric and balcan range endemic species. On the territory of Bosnia and Herzegovina these meadows reach their northwestern boundary. That kind of meadows is being extensively treated giving smaller yield. Due to differences in ecologic conditions they can be differentiated as follows:

- Ecosystems of upland meadows on wet, humus-rich limestone ground;
- Ecosystems of upland meadows on brown limestone earth;
- Ecosystems of buttercup and *Pancicia serbica*;
- Ecosystems of buttercup and crocus on deep acidified soils;
- Ecosystems of upland meadows on base-rich ground;
- Ecosystems of upland meadows with Bosnian lily;
- Ecosystems of *Pancicia serbica* and Bosnian lily;
- Ecosystems of upland mowed meadows.

Within these meadows grow also Bosnian lily (*Lilium bosniacum),* Bosnian catchfly (*Silene bosniaca),* Sendtner's cathfly (*Silene sendtneri),* mountain violet (*Viola elegantula)* and many others.
Beside afore mentioned endemic kind of ecosystems, on bosnia-herzegovina's mountains frequent and widely distributed are meadows of fescues and common bent. Apart from their astonishing beauty, from early spring till late summer, these meadows achieve high economic values. Hay is high quality food for both small and large catlle, and even for game species.
From early spring these meadows are dominated by green-yellow colour of dandelion's flower, then a bit later by golden colour of various buttercups and whole spectrum of colours created by knapweed, purple loosestrife, small yellowhead, in autumn there is a deep blue colour of marsh gentian, then light violet of autumn crocus that usually announce the arrival of fresh and sunny autumn, followed by long and cold winter.
In central and western Europe widely distributed ecosystems of matgrass *Nardus stricta* develop on silicate, and on limestone too if a deeper acidifed soil is laying over. These meadows give low quality hay being therefore rarely mowed and mainly left over for grazing purpose. These ecosystems emerge after spruce and spruce-fir woods get degraded.
On warmer slopes and more shallow soil types developed are thermophilous meadows from the order *Brometalia erecti,* which on even more shallow soil gradually turn into montane and upland's rocky grassland. In the composition prevail brome, hoary platain, germander, sweet woodruff, perfoliate alexanders, thistle, dropwort, common milkwort, common self-heal, Danthonia, sweet scedent and others.
Meadow communities in the upland belt are mostly composed of honey-producing, medicinal and vitaminous plants.

## Ecosystems of upland brooks

The most beautiful and powerful share of upland landscapes is to be seen along the mountain brooks in bosnia-herzegovina's Dinaric Alps. Clear water rushes through a narrow passages that are squized between surrounding masiffs toward calm streams of Bosna, Vrbas and Drina rivers. The cold mountain water, hiding unique living world in it, is considered to be a treasury of bosnia-herzegovina's biologic and ecologic diversity. Hereafter are listed some endemic forms of aquatic insects living around springs of mountain brooks and karst streams:

Table 27. – Endemic species of aquatic insects in mountain and karst springs in Bosnia and Herzegovina

| | | |
|---|---|---|
| *Rhyachopila bosniaca* Schmid | | Miljacka, Bioštica |
| *Allotrichia marinkovacae* Malycki | | Lištica, Trebišnjica |
| *Hidropsyche dinarica* Marinkovic | | Bistrica, Žabljak |
| *Hidropsyche smiljae* Marinkovic | | Lištica, Trebišnjica |
| *Chaetopteryx bosniaca* Marinković | | Bistrica, Žabljak, Pliva, Sanica, Bioštica, Miljacka |
| *Chaetopteryx gonospina* Marinković | | Ribnik, Sanica, Pliva, Bioštica, Miljacka |
| *Chaetopteryx shmidi* Botosaneanum | | Bistrica, Žabljak |
| *Annitella apfelbecki* Klapalek | | Bistrica,Pliva, Sanica, Trebišnjica, Lištica, Miljacka |
| *Drusus bosnicus* Klapalek | | Ribnik, Sanica, Pliva |
| *Drusus klapaleki* Marinković | | Miljacka, Bioštica |
| *Drusus medianus* Marinković | | Ribnik, Sanica, Pliva |
| *Drusus rad. septentrionis* Marinković | | Bistrica, Žabljak |
| *Rhyachopila vranitzensis* Mar. et Bot. | Dinaric Alps | Bistrica, Pliva, Sanica, Lištica, Miljacka, Bioštica |
| *Drusus ramae* Marinković | Dinaric Alps | Lištica, Trebišnjica |
| *Drusus shmidi* Botosaneanum | Dinaric Alps | Miljacka, Bioštica |
| *Drusus vespertinus* Marinković | Dinaric Alps | Bistrica, Žabljak |
| *Potamophylax winnwguthi* Klapalek | Dinaric Alps | Ribnik, Pliva, Sanica, Miljacka, Bioštica |
| *Limnephilus graecus* Schmid | Western Balkan | Lištica, Trebišnjica |
| *Rhyachopila trescaviscensis* Bot. | Western Balkan | Lištica, Miljacka, Bioštica, Pliva, Sanica |
| *Rhyachopila balcanica* Radovanovic | Western Balkan | Bistrica, Lištica, Trebišnjica,Miljacka, Pliva, Sanica |
| *Rhyachopila trescaviscensis* Bot. | Western Balkan | Lištica, Miljacka, Bioštica, Pliva, Sanica |
| *Rhyachopila balcanica* Radovanovic | Western Balkan | Bistrica, Lištica, Miljacka, Ribnica, Pliva, Sanica |
| *Micrasema sericeum* Klapalek | Balk. | Bistrica, Žabljak, Lištica, Trebišnjca |
| *Annitella triloba* Marinković | Balk. | Lištica, Trebišnjica, Miljacka, Bioštica |
| *Rhyachopila loxias* Schmid | Balk. | Lištica, Miljacka, Bioštica |
| *Glossosoma discophorum* Klapalek | Balk. | Bistrica, Lištica, Trebišnjica,Miljacka,Bioštica |
| *Potamophylax pallidus* Klapalek | Balk. | Ribnik, Pliva, Sanica, Miljacka, Bioštica |
| *Hidropsyche tabacarui* Botosaneanum | Balkan, Karpati | Pliva, Sanica, Miljacka, Bioštica |
| *Threma anomalum* MacLachan | Balkan, Karpati | Lištica, Trebišnjica, Bioštica, Miljacka |
| *Beraeamayia shmidi* Botosaneanum | Balkan, Karpati | Lištica, Trebišnjica |
| *Rhyachopila furcifera* Klapalek | Balkan, Karpati | Miljacka, Bioštica |

The uniqueness in structure and dynamics of dinaric upland landscapes, apart from diversity of plants and mushrooms, has induced special patterns of animal diversity. This relates especially to organisms living in mountain springs and brooks, like it is the case in the upland belt of Bosnia and Herzegovina. Specific ecologic conditions determined by different kind of forests resulted in the pronounced endemogenesis for many aquatic insects. In the springs of upland landscapes lives great number of endemic aquatic insects of which many were for the first time described right here, in this belt. The existance of such places (locus classicus) represents the outstanding value in the global animal diversity.

Table 27 shows only some of the species that are exclusively bound to the upland parts of bosnia-herzegovina's rivers. This illustrates how exceptional is the connection between forests and water regime in mountain springs. It also helps in recognition of unique speciation processes, because of which the maintenance of forest ecosystem's stability is sacred for the protection of mountain streams.

The best studied group of organisms here is Psychodidae (Pericoma glacialis, P. ljubiniensis, P. marinkovići, P. mučibabići, P. rotunda, P. vaillanti, Mormia curvistylia, Panimurus bosnicus, P. Verbassicus, Threticus optabilis).

Beside unique insects world, in mountain brooks frequently occur straight lines of brown trout, bullhead and crayfish.

## State of upland landscape's ecosystems

Dominant ecosystems of upland landscapes in Bosnia and Herzegovina are forest communities, whereby we should stress the anthropogenic impact placed upon them and recent state of ecosystems.

Beech-fir and sole beech communities are most productive forest ecosystems, being therefore as a wood resource first in line of anthropogenic pressures. On state of forest ecosystems witness the best data from different periods that follows.

Graph 16. – Proportion of species in the straight woodland stands

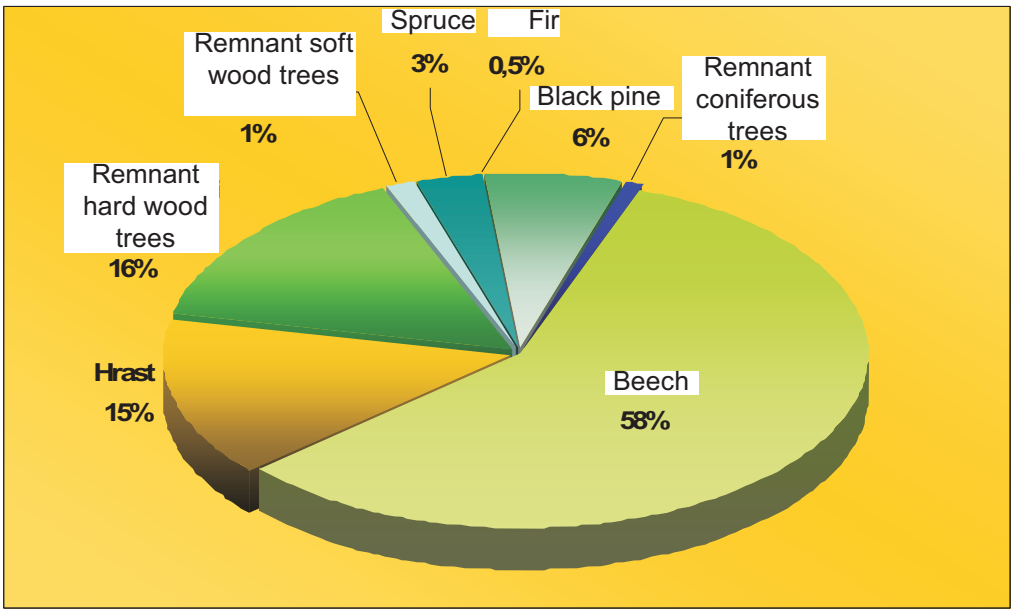


Table 28. – Assessment of woodland surface in Bosnia and Herzegovina in 1992

| WOODLAND | SURFACE (ha) | % of total B&H's surface |
|---|---|---|
| Straight wood habitats | 532.703 | 10.42 |
| Deciduous | 478.393 | 9.36 |
| Coniferous | 54.310 | 1.06 |
| Mixed wood habitats | 1.798.359 | 35.17 |
| Deciduous | 1.107.039 | 21.65 |
| Coniferous | 66.609 | 1.30 |
| Deciduous-coniferous | 624.701 | 12.22 |
| Total woodland | 2.331.052 | 45.59 |
| Bare mountain terrain | 250.839 | 4.91 |
| Total surface in B&H | 5.112.900 | 100% |

Source: Statistic yearbook of Republic Bosnia and Herzegovina, Sarajevo 1992.

It is estimated that in Bosnia and Herzegovina has been felled 82.552 ha of forests since then. Most of the clearings are in the southwestern region. The biggest deforestation proportion (72%) relates to the surfaces less than one hectars, whereas 7% are surfaces taking 100 and more hectares. Of felled forests, 65.121 ha were deciduous and 17. 431 ha coniferous woods.

In the post-war period felling became more intense around many localities, no matter what their biologic and ecologic value was.

Although the upland landscapes are under influences from dinaric mountain climate, with plenty of snow, and existing conditions limit the permanent human inhabitation, they have been inhabited since the earliest age.

Even today, in this belt are situated not only villages, but small towns of which Kupres (at 1.200 m above sea level) is the largest urban complex in the upland belt of bosnia-herzegovina's Dinaric Alps and entire western Balkan.

Settlements here occur mainly as small villages, with dwellings built in typical mountain-like fashion, with highly heaved roofs, thick stone walls and small openings in it. Basic traditional activity in some areas is sustainable cattle breeding, especially used to be in earlier days.

*"Even today, over juicy meadows of the upland belt graze thousands of sheeps, whose safety is taken care of by awaken ears of bosnian sheepdog, which is the unique and endemic dog's breed. Beside sheep, there are also herds of milk producing cows and studs that have grown wild. All that is some kind of decor to the upland openings and represent most valuable share in the european animal gen pool. On fertile upland's ground, enriched only by natural dung, grows the most healthy potato (of widely known sorts and lines fojnički, glamočki, kupreški potato) that, if prepared in traditional manner with dinaric cream and a lot of in Vlašić, Kupres, Glamoč and Livno made chees, represent top quality delicacy for the European gastronomy, and some kind of attraction for both locals and tourists. Another uniqueness of bosnia-herzegovina's highlander is reflected in their cultural diversity expressed through fancy clothing and footware, house furniture, agricultural tools and special souvenirs.*

*Well preserved indigenous ethnologic elements, such as frankness, warmth and hospitality, along with clear and clean spring wa-*

*ter, clean mountain air, picture-like upland's landscapes of meadows, openings and forests are unique prerequisites for the more intensive colonization in this area and development of medicinal and recreational, especially rural, tourism in all seasons.*
*These landscapes and highlanders that mow juicy grass, fertile rye, crummy barley and oat, then handsome women in their fancy clothes as seen in the period of golden ear's harvesting and collection of odorous hay, were the inspiration for many poets, writers, travel writers, artistic virtuoso in paitings and on strings (Skender Kulenović, Ivo Andrić, Ćamil Sijarić, Ethem Mulabdić, Husein Đogo, and famous painters Jurkić, Berber, Ramić).“ (quoted from TV show “Prirodna baština BiH“).*

Ecosystems of upland's landscapes contain many natural resources, such as medicinal, edible, vitaminous and aromatic plants, but also many edible and medicinal kind of mushrooms and lichens.
Special economic value have got wild sorts of plants that have played rescuing role in the restoration, as well as in the pre-industrial stage of our society. Great value on the market achieve deadly nightshade, raspberry, strawberry, black berry, willow herb, foxglove, lady's mantle, crocus, tansy daisy, red elder, yellow ox-eye, willow gentian, blue berry, wood cudweed, autumn crocus, violet, then lichens: old man's beard, lungwort, Cladonia. There are many representatives from the realm of fungi, especially valuable are those from genera: morel, chanterelle, bolete and many both lignicol and tericol species with significant function in the wood's decomposition.

## Pressures on ecosystems of the upland landscapes

Despite the fact that this area is poorly inhabited, ecosystems of these dynamic landscapes are today endangered by impacts arising from diverse human activities, such as:

- Intensive and non-selected felling of tall forests;
- Uncontrolled hunt;
- Destruction and degradation of soil by non-selected construction of forest communication network and use of forest machines;
- Over-exploitation of medicinal plants and mushrooms;
- Intensive natural progradation and overgrowing of meadows;
- Unacceptable construction and concentration of building sites in the attractive parts of upland belt (recreational winter centres Babin Dol on Bjelašnica Mt., Vlašić Mt., Kupres plateau and Dugo polje on Čvrsnica Mt);
- Climate changes;
- Air pollution;
- Disturbances in water regime of springs and brooks.

## HILLY LANDSCAPES IN BOSNIA AND HERZEGOVINA

Hilly belt in Bosnia and Herzegovina covers significant area going from the peripannonian in the North to the mediterraneo-montane belt in the South. Habitats are scattered over very dynamic and pronounced relief, up to 900 metres above sea level. Its dynamism is enhanced by heterogeonus geologic conditions (limestone, silicate, ultrabasic rocks), wide spectrum of soil types and different variants of temperate continental climate. In the complex with other ecologic factors these conditions have determined specificity of life which determines typical bosnian lanscape.

Especially underlined is a diversity of broadleaved decidous woods and meadows. Typical image of hilly landscapes is made of:

- Ecosystems of hornbeam and sessile oak in several floristic and geo-pedologic variants (with sedges, dog's tooth violet, bladdernut);
- Ecosystems of montane beech woods with alpine barrenwort;
- Ecosystems of montane beech woods with melicgrass;
- Ecosystems of beech and *Acer obtusatum*;
- Ecosystems of black pea and sessile oak;
- Ecosystems of acidophilous sessile oak woods.

On higher inclinated slopes with shallow humus-accumulative soil and over permeable bedrock occur habitats of azonal forest vegetation represented by:

- Ecosystems of autumn moor grass and beech;
- Ecosystems of sessile and pubescent oak;
- Ecosystems of flowering ash and pubescent oak;
- Ecosystems of flowering ash and beech;
- Ecosystems of flowering ash and oriental hornbeam.

Because the landscapes of hilly belt are intercepted by numerous streams (from Una river in the West to Drina river in the East), present are ecosystems of hygrophilous woods with alder, willow, wallnut tree and purpule willow shrubs.

In the belt of hilly landscapes, significant area on ultrabasic rocks is taken by thermophilous ecosystems of black pine with heaths and rock debris communities and screes. The latter ones complete the image of relict pine woods.

Hilly landscapes are dense populated, especially in the area of central, eastern, southeastern and northwestern Bosnia. Natural image of these landscapes has been altered by intensive clearings, expansion of arable land, arising of settlements and construction of traffic network.

There are few ecosystems (especially oak-hornbeam forests) that posses well preserved primary structure. Except for their landscape's value, these ecosystems are valuable because of rich wildlife: game species (rabbit, roe, red-deer), nesting birds, reptiles (lizards and snakes, such as ratsnakes, common viper, horn-nosed viper, blind worm etc.).

Forest ecosystems represent wood resources. In that sense, especially valuable are beech and sessile oak as a base for future development of traditional wood manufacturing industry. Besides, forest ecosystems are common habitat of fungi.

*"It is a special challenge, in reddish autumn, to spend some time under transparent crowns of broadleaved deciduous forests and enjoy meeting the mushrooms of highest nutritional values (parasol mushroom, king bolete, delicious milk cap, chanterelle). Nothing less pleasant is to be*

*there when the first wild cherries ripe and when these forests are intercepted by fairy circles of delicious milk cap. Along with the richness of mushrooms and noble lichens (oak's lichen, old man's beard, lung lichen) these forests provide shelter for many medicinal, edible and vitaminous plant species, which have been since ever an important piece of ethnology and ethnotherapy of bosnia's people." (quoted from TV show "Prirodna baština BiH).*

Ecosystems of hilly landscape comprise about 300 medicinal plants that have played a crucial role in the ethnogenesis either as a supplementary food or in traditional healing practice. Many of them are being used even today, representing some kind of logo for the ethnoculture of people living in Bosnia and Herzegovina. In this belt are to be found habitats of numerous medicinal plants, such as: mountain garmander ("that makes a dead man alive"), yarrow, St.John's wort, european centaury, oregano, different kind of platains,spiny rest harrow, thyme, linden, black elderberry, blackthorn, hawthorn, dog rose, strawberry, blackberry, dropwort, brown knapweed, ivy, ajuga.

Plant resources in hilly belt represent huge potential for a herbal sector's development. However, traditional knowledge and practice regarding use of plant resources are fading away day after day, causing the lost in traditional values of indigenous people. Today, plants only occasionaly play a role in traditional ceremonies and cultures of some volks (Đurđevdan), as well as in religous ceremonies and practice (use of incense, oak, yew, twigs of common rue for a "removal of spells", hyssop leaves for a "protection before evil spells", making of talismans etc.).

Hilly landscapes encompass genetic plant resources that fruit-gardening is based upon (wild cherries, pears, cotoneaster and european mountainash). Diverse and high quality biomass of wood used to be a base for wood carving and production of traditional objects made in wood (spindle, purr, tub, cask, pistons, musical instruments: trumpets, flutes, fiddles, spoons, ladles, plates, glasses, vessels, griddles, baskets, light furniture). In the past, in Bosnia and Herzegovina existed full and well harmonized connection between man and its environment.

Due to strong pressures, significant surface that was previously woodland with shrubs now is transformed into meadows, pastures, arable land and settlements. In hilly landscape considerable area is covered by:

- Ecosystems of lowland's temperate humid meadows;
- Ecosystems of temperate humid eutrophic meadows with oat grass;
- Ecosystems of acidophilous meadows with bentgrass and fescue;
- Ecosystems of thermophilous meadows with brome and hoary plantain;
- Ecosystems of thermophilous meadows and rocky grassland;
- Ecosystems of rock crevices and screes.

Large area is covered by agricultural crops, ruderal and weed vegetation developing along the roads and human settlements. This is optimal ecologic framework for barley, oat, winter and spring wheat, maize, buckwheat, various sorts of bean (trešnjo, kućićar-ćućo, mesni, aligrah, koma), pea, lens, soya bean, potato (bjelac, crvenac), cabbage, tomato, cucumber, aubergine, different sorts of onions, salads, spices, parsley, love-in-a-mist, wild parsnip, carrot, different sorts of pumpkins, flax and diverse fooder plants (clover, medick, mustard).

### Pressures onto ecosystems in hilly landscapes

Main threats to the biodiversity of hilly landscapes are:

- Intensive conversion and fragmentation of forest habitats by new opened quarries, building sites, fellings;
- Intensive felling of economically important species (beech, oak, fine deciduous woods);
- Building of roads in forest area and fragmentation of wildlife habitats;
- Erosion of arable land by wind and water;
- Eutrophication of surface watercourses;
- Unbalanced hunt and fishing;
- Over-exploitation of plant and animal resources (snails, medicinal and edible plants and fungi).

Hilly landscapes have got a strategic potential for the sustainable development of bosnia-herzegovina's society. Hence, special actions should be undertaken to reveal new models for sustainable and economically justified use which is required for the maintenance of ecosystem's services. These landscapes include open and underground coal mines, facilities for stone exploitation and gravel extraction, then facilities of basic and light industry. New settlements with accompanied infrastructure cause additional pressure and illustrate how threatened the environment really is. By that, emphasized is the need after urgent design and establishment of mechanisms required to meet community demands, and based on internationally embraced ecological principles.

## PERI-PANNONIAN LANDSCAPES IN BOSNIA AND HERZEGOVINA

If we shall go from hilly landscapes toward lowland of Posavina, we would first encounter softly waved hills of Peri-pannonia. Ecologic conditions are changed here completely in sense that the landscapes and wildlife become more dynamic. The mountains of Peri-pannonia (northwestern Kozara, northern Prosara and Motajica, northeastern Trebovac and Majevica) are the product of specific oro- and geogenesis. The entire area, up to 400 (600) m, is splashed by warm pannonian climate which is under strong influence from continental climate of steppes. Geologic foundation is mainly silicate with deep pseudo-gley or ilimerized soils. Here are well developed broadleaved deciduous forests with oak and peri-pannonian beech, which along with non-forest vegetation constitute the peri-pannonian landsacapes. Going up hill on vertical profile of the peri-pannonian mountains, differentiate several ecosystem types:

- Ecosystems of woods with hornbeam and common oak;
- Ecosystems of woods with sessile oak and *Ruscus hypoglossum;*
- Ecosystems with sessile oak and silver linden;
- Ecosystems with sessile and turkey oak;
- Ecosystems with italian and turkey oak in northeastern region;
- Ecosystems of beech woods with hart's tongue fern;
- Ecosystems of acidophilous beech-melicgrass woods;
- Ecosystems of woods with hornbeam, sessile oak and butcher's broom;
- Ecosystems of woods with hornbeam, sessile oak and bladdernut.

After degradation process take place, emerge non-forest ecosystems:

- Ecosystems of hygro-mesophilous meadows with tufted hair-grass;
- Ecosystems of acidophilous meadows with bentgrass and fescue;
- Ecosystems of thermophilous meadows with brome.

The peri-pannonian belt has been inhabitated from the beginning, since it provides an outstanding conditions for human settlements. Today, substantial woodland area is converted into agricultural ecosystems:

- Ecosystems of arable land (cereals and gardening cultures);
- Ecosystems of fruit-gardens;
- Ecosystems of abandoned habitats along roads and settlements;
- Urban and rural ecosystems.

Most of the settlements in peri-pannonian landscapes (Čelić, Maoča, Srebrenik, Gradačac, Derventa, Banja Luka, and lower Pounje in northwest) are with neatly arranged yards, settled household's infrastructure and monuments of material and spiritual culture.
This area offers excellent conditions for sustainable fruit-gardening, by which it is famous. Here are some examples: high quality plums (the Gradačac's fair of plums), indigenous apple sorts (šarenika, senabija, golubača, krompiruša), pears (takiša, karamut, ječmenka, kantaruša, jeribasma), cherries (hašlame, bjelice, crnice, hruštovi, alice), quinces, wallnuts, cotoneaster, mulberries. Besides, addressed should be gardens in blossom with hollyhock, common rue, common box, rose called đubešećerka, lilies, marigold, basil, lovage, fuchsia, evening primerose, tsar's eye, calendula, wenlock beauty, mock orange. Many horticultural species were introduced (petunia, lobelia, aster, sage, violet, figwort, primerose). Hence, the gen pool of peri-panonian landscapes in Bosnia and Herzegovina comprises horticultural species and herbal genetic resources contained in species belonging to legume family, cereals, mallow family, nightshade family, mustard family, composite family, fruits and indigenous tree species.
On more dynamic carbonate relief, in the broad zone of woodland with turkey and sessile oak, and woodland with silver linden and sessile oak, scattered are fragments of woods and shrubs with hope hornbeam and flowering ash (slopes of the old city Srebrenik, surrounding of Banja Luka, northern slopes of Motajica Mt. and northwestern Kozara Mt.).
Fortresses of old cities (Srebrenik, Gradačac, Derventa, Doboj, Tešanj, Maglaj, Banja Luka and Dubica) build unique ambiental complexes with walls that are inhabited by specific flora, fauna and vegetation. Those ancient walls are well known finding place of bosnian bellflower, rustyback, stonecrops, *Micromeria thymifolia* and polypodi. These ambiental units are important segments of the peri-pannonian landscape.
Herein, should be addressed endangered species of which most important are butcher's broom (*Ruscus aculeatus*) and *Ruscus hyppoglosum*. The entire populations of them are being completely destroyed for ornamental purposes.

## Pressures onto peri-pannonian landscapes

Due to high population density, the peri-pannonian landscapes are exposed to tremendous anthropogenic impact that seriously endanger their structure.
The most dominant impacts are:

- Excessively felling (especially of fine deciduous trees, such as wild cherry), which directly endangers different kind of birds and small game species;
- Exploitation of economically important species (medicinal and ornamental plants);
- Unprofessional opening of quarries;
- Uncontrolled waste disposal;
- Intensive and uncontrolled urbanisation;
- Construction of traffic communication network and accompanying infrastructure;
- Uncontrolled use of pesticides and fertilisers;
- Pollutants emission in all spheres of life;
- Unselected catchment of springs;
- Massive introduction of alochthonous plant and animal species, and GMOs;
- Periodical floodings, especially in more humid seasons;
- Invasion and maintenance of pathogenic bacteria, viruses, yeats (agents of check , dullness of cabbage, virus diseases in plants from nightshade family).

The peri-pannonian landscapes involve many thermal and mineral springs (Gradačac, Tešanj, Maglaj, Teslić, Banja Luka, Laktaši) which are huge potential for medicinal, educational and recreational tourism.

## PANNONIAN LANDSCAPES OF BOSNIA AND HERZEGOVINA

*"In the utter northern Bosnia, even the strongest winds become silent. This is the place where dynamic and cliffy relief of Dinaric mountains merges with vast plane through which runs Sava river looking like braids of most beautiful bosnian girl. In its silence shiver the shadows of willows and poplars whose crowns conceal the secrets of anxious hearts trembling in the moonlight. This is the place where ripe plums more blue than a sea and undulate ears of golden corn, more golden than true gold. This is Bosanska Posavina. It extends from beneath Kozara Mt. in the West, then it meets lovely Una river and goes, under Prosara Mt., all the way to mighty Sava river. Then it gets to Donje Podvrbasje rushing right after that to Lijevče polje and turns beneath Motajica Mt. whose slopes press it even more against Sava river. It sees off Bosna river toward its shelter at Vučijak and Trebovac, whereas it gets stonger and as if it had wings stretches them as wide as possible, from Majevica Mt. to deep Sava river. Thus, through vast Semberija it gets to daring Drina river that, under the white willow and silver leaved poplar trees, hands over all of its pearls to mighty Sava."*
*(quoted from TV show "Prirodna baština BiH")*

The pannonian area of Bosnia and Herzegovina takes the lowest positions (between 100 and 200 m above sea level). The ground is more or less flatened with deep alluvial kind of soils, pseudo-gley and moulder, and high water table. The climate is continental.
Warm summers, deep hydromorphous or automorphous soil, douce relief and hydrogeological past enabled the emergence of very specific wildlife of the pannonian landscapes. Plain landscapes of northern Bosnia are dominated by vast fields covered by cereals, maize, watermelons, different sorts of vegetables and fruits, forests of willow, poplar, common oak, ash, robinia, then settlements, artesian wells and houses of worship.
The pannonian landscapes are differentiated in several ecosystems:

- Ecosystems of woods with willow and poplar along riversides of Sava river and its tributaries;
- Ecosystems with *Fraxinus angustifolius* and summer snowflake;
- Ecosystems with alder and sedges, then alder buckthorn and *Fraxinus angustifolius*, and common oak;
- Ecosystems of shrubs with purpule and basket willow;
- Ecosystems of shrubs with desert indigo and low forests with robinia;

- Ecosystems with common oak and dyer's broom;
- Ecosystems with common oak, hornbeam and butcher's broom;
- Ecosystems with common oak and silver linden;
- Ecosystems with pannonian beech and *Ruscus hypoglossum*;
- Ecosystems of hygrophilous and eutrophic meadows;
- Ecosystems of hygrophilous meadows with moorgrass and tufted hairgrass;
- Ecosystems of standing water with sedges and reed;
- Ecosystems in coastal belt of freshwater.

Since many primary ecosystems in the past were replaced by less integrated ecosystems, among pannonian landscapes now prevail:

- Ecosystems of arable land;
- Rural ecosystems;
- Ecosystems in urban areas.

The latter ones determine the physiognomy of the Pannonian area in Bosnia as it is today. The highest yield is achieved by different crops (wheat, maize, barley, oat and johnson-grass), then cultivated vegetables (watermelon, gombo, sunflower, paprika, tomato, aubergine, different sorts of cabbage), herbal genetic resources (plums called "požegače", wallnuts, pears, apples, grapes) and a lot of horticultural species.

The rural ecosystems are vivid settlements with neatly arranged land and agricultural households around them. The similar structure is typical for old urban centres, such as Bijeljina, river-harbour Brčko, Šamac, Brod, Srbac and Dubica. Along trenches and dams emerge ruderal ecosystems with clear dominance of the communities with common milkweed, goat's tooth, narrow-leaved mint, plantains and dandelion. The accompanying plant communities of arable land are weed communities with many adventive and invasive species.

Forest and shrub communities on the territory of Posavina exercise protective function in terms of maintenance the riverbed stability (especially along Sava river) which is managed through well balanced water regime in the highly sensitive soil. However, the wetland woods are important as a habitat of various birds, reptiles and amphibians.

In the entire area, in dead armlets called "starače", emerge communities of standing water, ponds and marshes. Today, these are very important habitats from the aspect of wildlife protection in wetlands.

The grassland ecosystems of Posavina provide shelter for plant species which are more endangered every day because of continual changes in water regime. Such is the case with: field scabious, small scabious, moorgrass, tufted hairgrass, chamomile, marsh gentian, diverse buttercups, marsh horsetail, rushes, sedges.

Frequently occuring floodings cause changes in soil structure, decrease in crops yield, threatening of populated area, re-direction of surface streams, changes in water regime of underground water. Floodings are dominant factor in this area which substantially change the quality of habitats and image of living world.

Water that floods the area contains high concentration of nutrients which results in the nitrification of soil and underground water. As a result of changed pH value, disappear acidophylous plant species and related pedofauna. Alien species are being spread by

floodings, too. In that way, the Pannonian area of Bosnia got invaded by *Echinocistis lobata, Amorfa fruticosa*, and few Bidens species, then pigweeds and other weeds. In order to prevent floodings, along Sava river constructed were huge dikes that changed natural appearance of these ambiental units. Special natural resource in this area is underground water, a priceless treasure. Surface water, which is with low value, is mainly being used for water-supplies.

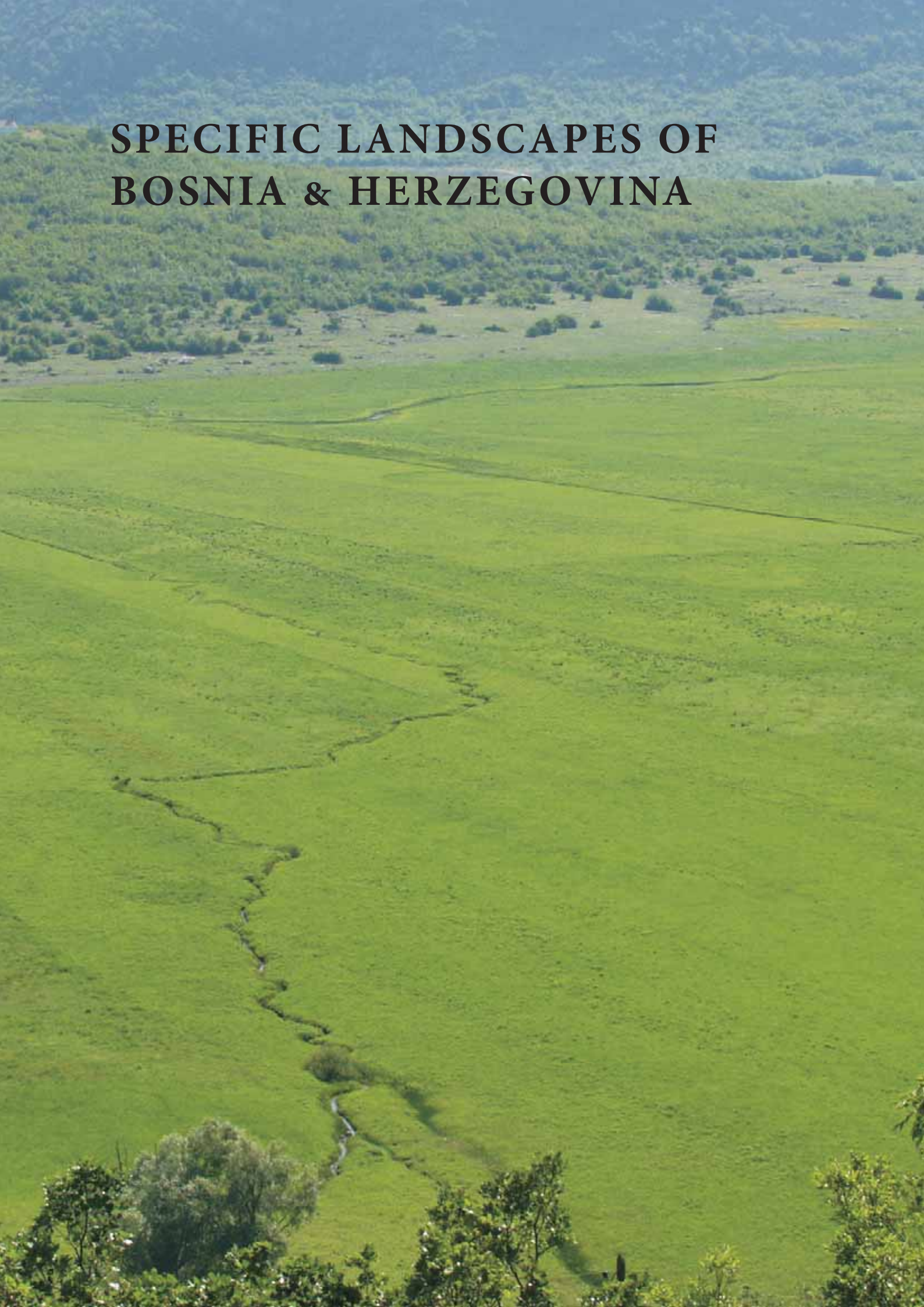
**Pressures on ecosystems of the pannonian landscapes**

Apart from global threats (climate changes, transboundary pollution), the most significant threats at local scale are:

- Melioration of hydromorphous soil;
- Over-extraction of sand and gravel on the alluvial terrain along Sava river and at Drina river's estuary;
- Floodings;
- Toxification of drainage water with pesticides and fertilisers;
- Continual eutrophication of surface water;
- Unbalanced urbanisation through the conversion of arable land into construction sites;
- Uncontrolled fishing on larger streams;
- Waste disposal (of all kind, including toxic and dangerous one) along riverbanks;
- Massive invasion of alochthonous plants and animals;
- Appearance of new pathogens (agents for bacterial, viral and fungal infections on main crops);
- Planting of artificial forests;
- Lack of monitoring of GMOs.

Hilly landscapes (Maglaj)

# SPECIFIC LANDSCAPES OF BOSNIA & HERZEGOVINA



# HIGH MOUNTAIN LANDSCAPES IN BOSNIA AND HERZEGOVINA

## ECOSYSTEMS DIVERSITY OF HIGH MOUNTAIN LANDSCAPES IN BOSNIA AND HERZEGOVINA

The territory of Bosnia and Herzegovina is so unique and special because of the mountain landscapes that comprise high diversity of biological forms and habitat types. These ecosystems characterize all high mountains belonging to Dinaric Alps in Bosnia and Herzegovina taking place in the sub-alpine and alpine belt on vertical profile (from 1.600 m to the highest mountain peaks).

The relief here is highly dynamic with habitats occuring on steep slopes, in the sinkholes, depressions, on carbonate and silicate screes, with shallow humu-accumulative soil.

The climate is typical mountainous one with plenty of snow, strong mountain winds and protruding temperature extremes. At the bottom of mountain depressions in some places snow is being kept over entire year, hence, there is even modified nival type of climate.

Although the ecological conditions on major part of mountains in Bosnia and Herzegovina are similar, the living world possesses certain specificities and uniqueness. Each of the mountains was some kind of insulated island in the sea of melted lava and has been through its own development patterns and evolution of living world. The final result of those processes are high endemism and relictness level, on one side, and on the other differences.

High mountain landscapes are differentiated in separate biogeographic and bio-ecological units. The entire area belongs to the Alpine-Highnordic region, respectively highdinaric province. From northwest to southeast there are 10 sectors in which the mountains are differentiated.

These sectors reflect the richness of wild life, processes of speciation and endemogenesis, ongoing evolution, as well as the geo-morphologic and ecologic diversity. The diversity of mountain landscapes is of great importance for the entire biodiversity in Bosnia and Herzegovina. The mountain landscapes in Bosnia and Herzegovina regarding physiognomy differentiate in two major units:

- Sub-alpine belt comprising low woodland and mountain pine woods;
- Alpine belt above mountain pine woods (upper forest line of the Dinaric Alps in Bosnia and Herzegovina) which is vast space of alpine grassland, mountain tundra and fragmented sub-nival vegetation around snow patches.

In the sub-alpine belt prevail the landscapes differentiated in following ecosystems:

- Ecosystems of sub-alpine woods with illyrian beech and sycomore;
- Ecosystems of acidophilous woods with illyrian beech and european mountainash;
- Ecosystems of acidophilous woods with moesian beech and melicgrasss;
- Ecosystems of sub-alpine woods with moesian beech and greek maple;
- Ecosystems of sub-alpine spruce woods;
- Ecosystems of sub-alpine Serbian spruce woods;
- Ecosystems with mountain pine and blue berry;
- Ecosystems with mountain pine and twoflower violet,
- Ecosystema with mountain pine and sub-alpine spruce and european mountainash;
- Ecosystems with mounatin pine and yellow gentian;
- Ecosystems of shrubs with *Genista radiata*;

- Ecosystems of shrubs with *Genista radiata* and alpine bearberry;
- Ecosystems with mountain juniper;
- Ecosystems with mountain pine and rhododendron;
- Ecosystems of shrubs with silesian willow (*S. silesiaca*);
- Ecosystems of shrubs with green alder on silicate bedrock of Vranica Mt.;
- Ecosystems of sub-alpine woods with white-bark pine.

Above upper forest line stretches the belt with typical mountain landscapes that comprises following ecosystems:

- Ecosystems of alpine grassland on alkaline ground with elyna and sedges;
- Ecosystems of alpine grassland on acid ground with sedge and rush;
- Ecosystems around snow patches on alkaline ground with silesian willow;
- Ecosystems around snow patches on acid ground with white buttercup;
- Ecosystems of alpine screes on carbonate bedrock;
- Ecosystems of alpine screes on silicate bedrock;
- Ecosystems of carbonate rock crevices;
- Ecosystems of silicate rock crevices;
- Ecosystems with lichens on both carbonate and silicate bedrock.

Due to intensive degradation of mountain pine woodland and sub-alpine woods, the mountain vegetation often constitutes the ecosystems of sub-alpine grassland. The sub-alpine area is frequently reached by alpine screes and vegetation of rock crevices.

The mountain landscapes are characterized by the ecosystems occuring around sub-alpine springs and rivulets, ecosystems around mountain lakes and ecosystems of raised bogs. Their occurence is bound to dynamic of hydrologic network, geologic foundation and soil types.

The vegetation of low shrubs is considered to be a special ecological complex. The mountain heaths as a connection between forest and non-forest ecosystems encompass some healthy mountain fruits (blue berry, red whortelberry, alpine bearberry).

The mountain landscapes ensure plenty of healthy food which is the reason for them to be known since ever as a cattle breeding region. Our mountain areas suit the best to sheep breeding. There stil can be seen sheep herds on mountains Vlašić, Vranica, Cincar, Vitorog, Bjelašnica, Zelengora, Maglić and Volujak, on some mountains occur herds of cows and horses.

For the mountain landscapes in Bosnia and Herzegovina typical are summer cottages called "katuni". They are small cottages made of wood or stone in which are being made famous chees, cream and other milk products in summer. Right by the dwellings settled are open sheepfolds where the cattle is being kept over night. Close to these settlements which are to be found at high altitude (at 1.640 m on Vranica Mt. and at 1.700 m on Maglić Mt.) develop special ecosystem types composed of mainly nitrophilous plant species (alpine dock, good king Henry, white hellebore, nettle).

The ecosystems of mountain landscapes comprise more than one third of flora of Bosnia and Herzegovina. Many of the plants are endemic and relict, whereby some posses medicinal, aromatic, edible and honey-producing features. That is why they have been used in traditional ethnotherapy and natural nutrition. Best renowned are: blue berry, red whortelberry, bearberry, germander, thyme, mountain pine, mountain violet and widely known

endangered species – yellow gentian. Even though it is concerned by Red list, the remaining populations of yellow gentian are main income source for people that have lost their homes and working places in the recent war.

## REFUGIA OF GLACIAL FLORA AND FAUNA

As a result of glaciation process that stroke peaks of high mountains in Bosnia and Herzegovina, some places (cirques) are still inhabited by plant and animal species whose closest kin live in the boreal belt of northern hemispere.
Glacial relicts, the remnants of formerly numerous glacial flora and fauna, are restricted unto refugial habitats or shelters. Best preserved habitats of glacial flora, fauna and vegetation are to be found around snow patches. On the mountains in Bosnia and Herzegovina, around snow patches can be found several endemo-relict communities that comprise dozens of plant and animal species.
The glacial refugia, as development centres of endemic and glacial-relict flora and fauna, along with tertiary refugia in the canyons of our rivers represent priceless natural treasure. That places Bosnia and Herzegovina among the countries with highest biodiversity level in Europe.

### Ecosystems of alpine grassland

**Ecological conditions in alpine grassland habitats**
In B&H the mountain belt, in vegetation sense, begins at 2.000 m above sea level stretching above the upper forest line and comprising the ecosystems of alpine grassland. Because the forest vegetation on many mountains in B&H often climbs to the mountain peaks, alpine grassland is poorly present. On the other hand, ecologic conditions, specific floristic composition and community diversity indicate the presence of typical alpine meadows.

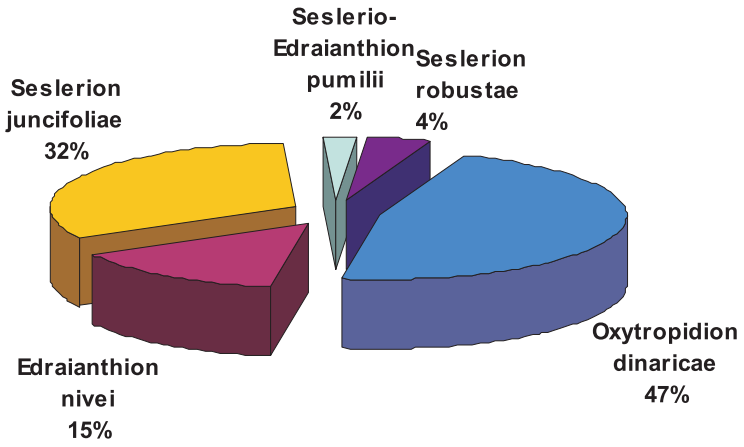
**Alpine grassland on carbonate bedrock** occurs on limestone-dolomite geologic foundation. Soil is alpine black earth called "buavica" with high content in non-decomposed humus. This is typical organogenous calcomelanosol. Besides, on mealy limestone-dolomite substratum develops up to 20-25 cm deep rendsin. Soil has got mainly degraded humus-accumulative horizon, due to strong mountain winds that blow in the area. The ecologic conditions here are extreme (mean annual temperature below 4°C, absolute minimum -30°C, intense wind, plenty of snow, great number of days with frost occurence), vegetation season last only 2-3 months. The result of these extreme conditions is low ecosystem's productivity. The highest diversity level on mountains in B&H is realized in alpine grassland ecosystems on carbonate bedrock.

**Alpine grassland on silicate bedrock**
Alpine grassland on acid soil, concerning its physiognomy and floristic composition, differs in significant extent from alpine grassland on carbonate bedrock. Therefore, it is separated in its own class *Caricetea curvulae*. It develops on acid ranker that emerges on top of silicate rocks, sometimes it can develop on acidified soil above carbonate substratum (especially on less inclinated slopes, in lower part). Acidophilous alpine meadows in Bosnia and Herzegovina are less represented than carbonate ones. The highest diversity is reached on Vranica Mt.. On rest of the mountains, on sillified limestone, this kind of grassland emerges resembling to islands represented by communities with matgrass (*Nardus stricta)* .

Diversity of alpine grassland ecosystems

On the territory of B&H, ecosystems of alpine and sub-alpine grassland with adjacent vegetation types are very important in respect to total biologic and ecologic diversity. They are characterized by great number of vegetation units comprising over 1.500 vascular plants (which is one fourth of total B&H's flora). There are no reliable data on number of animals and fungi.

Many plants living in these ecosystems are rare, endemic and relict, which is why they represent gen pool of inestimable importance. Many of them posses also medicinal, edible, aromatic and vitaminous features being therefore used for ethnobotanical, ethopharmacological and alternative nutrition purposes. Some species have got high economical value, too.




Graph 17. – Diversity of alpine grassland on carbonate (by number of identified plant communities)

## State of alpine grassland ecosystems

Alpine grasslands, in respect to their floristic, vegetation and faunistic attributes, represent some kind of islands in which the speciation processes evolved ease, by unique evolutionary patterns. As a response to unique combination of ecologic factors, in time were created unique habitat types and plant communities with high floristic richness, especially in endemic and relict species. It is quite often the case that stenoendemic forms exist, forms that are bound to sole massif or geographic area.

Diversity and uniqueness of development of ecoclimate, geologic foundation soil and relief, have caused specific types of phylogenesis and community genesis. This, on the other hand, has led to a protrude floristic-vegetational differentiation of the Dinaric Alps. Diversity of alpine grasslands was a key parameter for many authors and explorers to evolve its own biogeographic division of the Dinaric Alps in B&H.

## Ecosystems of sub-alpine grassland

In the sub-alpine belt, in habitats that were degraded by felling, fires and clearing, in the zone of low woodland and shrubs, on most of the massifs in Bosnia and Herzegovina occur sub-alpine grasslands.

In their floristic composition they resemble to alpine grasslands. But, according to more favorable climate conditions in which they survive, protected from wind, they comprise more plant and animal species. Soil is deeper calcomelanosol and rendsine, with well preserved humus-accumulative horizon.

In these habitats soil is acid ranker on top

of silicate rocks, sometimes even on acidified soil above carbonate substratum, especially on less inclinated places with more intense leaching.

## Distribution of sub-alpine grassland ecosystems

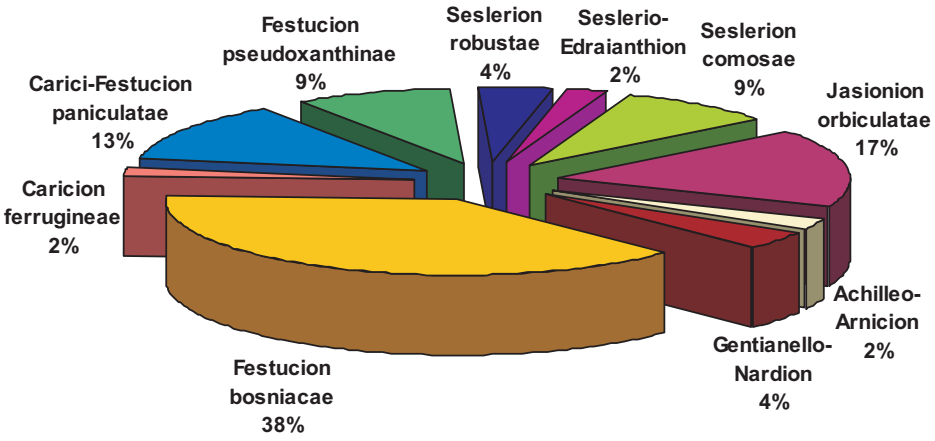
The sub-alpine grasslands on carbonate rocks in Bosnia and Herzegovina take very large surface.
On most of the mountains in B&H this is a belt with mountain pine (often discontinued today), green alder on Vranica Mt. in central Bosnia, sub-alpine beech (northwestern Dinaric massifs), spruce (northern slopes of mountains Vranica, Hranisava, Vitorog) and white-bark pine (southeastern Dinaric massifs, which are mountains Orjen, Prenj, Čvrsnica).
These ecosystems occur on every higher massif of the Dinaric Alps in B&H. Sub-alpine grasslands on acid soil in term of syngenesis and ecology are connected with upland's mesophilous meadows.

## Diversity of sub-alpine grassland ecosystems

Likewise alpine, so the sub-alpine grasslands on carbonate rocks and acid soil are characterized by high species and community diversity. These ecosystems are specific by emphasized presence of endemic and relict species, hence, the plant communities are mainly with dinaric or balkan distribution range.

Table 29. – Diversity of alpine and sub-alpine grasslands in Bosna and Herzegovina (by number of identified plant communities)

| | | Alpine grassland | | Sub-alpine grassland | |
|---|---|---|---|---|---|
| Elyno-Seslerietea | Seslerietalia juncifoliae | Seslerion juncifoliae | 15 | Festucion bosniacae | 18 |
| | | | | Caricion ferrugineae | 1 |
| | | | | Carici-Festucion paniculatae | 6 |
| | Crepidetalia dinaricae | Edraianthion nivei | 7 | Festucion pseudoxanthinae | 4 |
| | | Oxytropidion dinaricae | 22 | | |
| | Edraiantho-Seslerietalia robustae | Seslerion robustae | 2 | Seslerion robustae | 2 |
| | | Seselerio-Edraianthion pumilii | 1 | Seselerio-Edraianthion pumilii | 1 |
| Juncetea trifidi | Seslerietalia comosae | Seslerion comosae | 4 | Seslerion comosae | 4 |
| | | | | Jasionion orbiculatae | 8 |
| | | | | Achilleo-Arnicion | 1 |
| | | | | Gentianello-Nardion | 2 |




Graph 18. – Diversity of sub-alpine grassland in Bosnia and Herzegovina ( by number of identified plant communities)

## Ecosystems of discontinued nival vegetation belt

The highest positions on the mountains in Bosnia and Herzegovina take the ecosystems around snow patches. They often emerge in the alpine grassland zone, at depression's bottom where snow is being kept for a long time. Because they alternate with alpine grasslands, they comprise, apart from typical kryophytes, in the alpine grassland occuring species. The vegetation around snow patches evolves on both carbonate and silicate bedrock. Soil is shallow organogenous black earth – "buavica" and shallow ranker with low pH value. The primary bioproduction is low, hence, species *Salix herbacea* is known as "the smallest tree in the world – *arbor minima*". In term of biodiversity protection, these habitats are valuable for they encompass many glacial and boreal elements.

Considering phytocoenological belonging, the vegetation around snow patches belongs to *Salicetea herbaceae* class as it is on other euro-asian mountains. In our conditions, it is being differentiated in two vegetation orders: vegetation around snow patches on silicate and carbonate rocks.

By activities of glaciers and continual splitting of rocks beneath peaks, arose alpine and sub-alpine screes. On screes, rock debris runs continuously downhills toward mountain's base. Despite unstable substratum, which are stones with size from few centimeters to one meter, evolves loose and shallow rocky soil called regosol. On that kind of soil emerge species with well developed root, which enables them to endure on this quite often »alive« geologic foundation.

In term of syngenesis, vegetation of screes is associated with vegetation of rock crevices on steep slopes, whereas on less inclinated terrain and settled screes it is combined with communities of sub-alpine grasslands.

This vegetation includes relatively small number of species, but the ones that occur are endemo-relict. All communities comprised by this vegetation type are differentiated in term of ecology and biogeography characterizing the mountains in B&H. On the territory of Bosnia and Herzegovina are situated some of the most famous dinaric cirques, which is why these habitats represent diversity centres of high importance on broad scale.

On the mountains belonging to high-Orjen, high-Prenj and hig-Maglič sectors, due to emphasized inclinations and geo-morphologic plasticity of the highest mountain peaks, survive ecosystems on bare rocks. Those rocks are so hard and compact that it can not be wheatered by harsh mountain climate, and later on inhabited by chasmophytes. The ecologic conditions are determined by strong mountain winds, high insolation and sudden

temperature changes. So, after all, those are not completely bare rocks. At their surface evolves a layer of tiny little particles arising from smashed minerals combined with even smaller particles of organic matter brought here by wind. In this way forms the initial stage of soil which ensures first step of syngenesis in terrestrial ecosystems.

First communities in such places are assembled of bacteria, bluegreen alges and later on lichens. The quality of these habitats is directly influenced by geologic foundation. The lichens communities can be very diverse, which additionaly emphasize the mountain landscapes dynamics. On silicate rocks of Vranica Mt. occurs a nice example of this phenomenon.

Significant surface of sub-alpine and alpine belt is taken by ecosystems of rock crevices. Habitats are characterized by inclination up to 90 degrees, shallow soil of regosol type, and highly variable ecoclimate. Temperature and relative air humidity vary in wide range. That is one of the reasons for well adapted, mostly endemic and stenodendemic, communities to develop. Those communities reflect the biogeographic uniqueness of Bosnia and Herzegovina. Although this vegetation type emerges in all zones on vertical profile of B&H, its presence in alpine and sub-alpine belt of mountains Prenj, Čvrsnica, Bjelašnica, Vlašić, Maglić, Volujak, Lebršnik is emphasized.

In the zone of alpine and sub-alpine grasslands at localities with permanent or occasionally occuring cold springs, on hydrogenous black earth or initial stage of hydromorphous soils, emerge hygrophylous vegetation type of class *Montio-Cardaminetea.* In that kind of marsh habitats live many relict and endemic species of great importance for the entire biodiversity in Bosnia and Herzegovina.

In the same belt, discontinuously emerges vegetation of alpine and sub-alpine blanket bogs. Inclination of its habitats is low, peat is being formed and planohistosol created. The mountain bogs provide shelter for many glacial relicts, both plants and animals, and take important place in the system of habitats as whole.

The vegetation with low shrubs belonging to family *Ericaceae* develops in the zone of alpine and sub-alpine grasslands, on from wind protected places and soil that contains high proportion of raw humus. It is being differentiated, in term of ecology and floristic composition, in two variants: heaths on acid soil and silicate rocks, and heaths on from neutral to alkaline soil and carbonate rocks. On the dinaric massifs prevail heaths on acid soil.

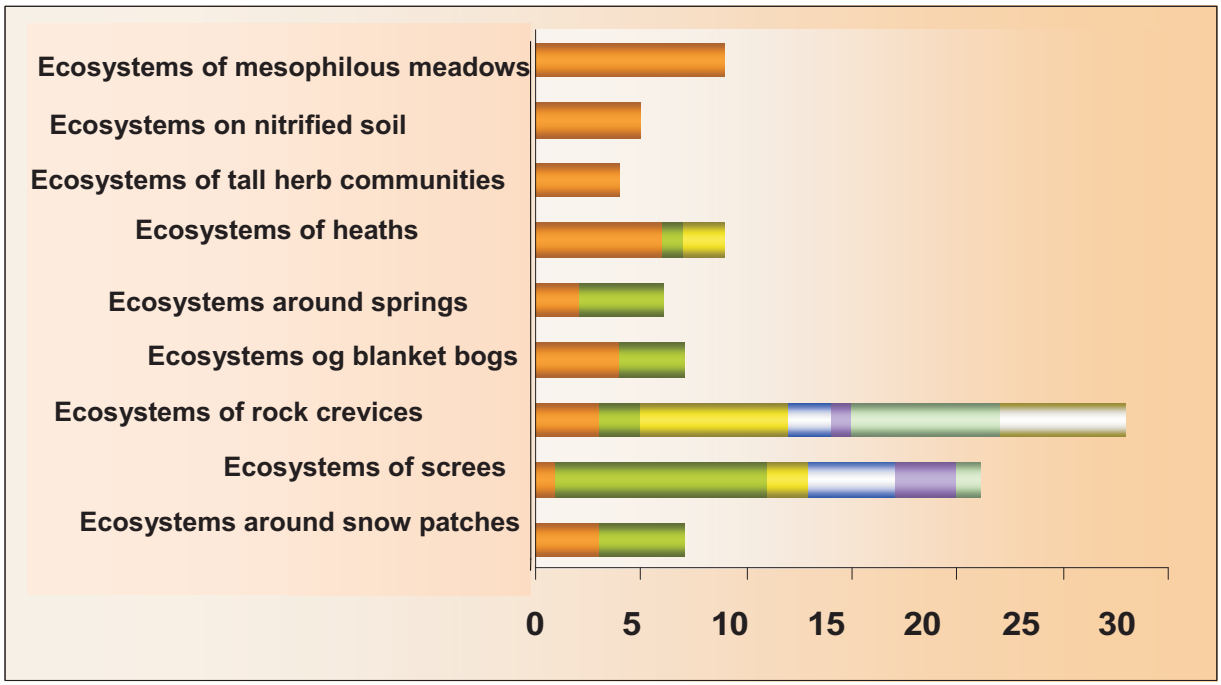
In the zone of sub-alpine grassland, on deeper calcomelanosol and ranker, on less inclinated slopes with longer persistent snow, develop communities with tall, up to 1 m high, herbs. Considering syngenesis these are succesive stages between sub-alpine grassland and climax vegetation, which is woodland of mountain pine, green alder, sub-alpine beech or sub-alpine spruce.

Habitats that are enriched with nitrates and phosphates, often next to sheepfolds, are characterized by special form of nitrophilous tall herb communities. On the territory of Dinaric Alps in B&H, this vegetation is being differentiated in several plant communities of which some are endemic.

In the sub-alpine belt of some dinaric massifs, on places with low inclination and neutrophilous soil developed are sub-alpine mesophilous meadows of the endemic dinaric alliance *Pancicion* with optimal conditions in the upland belt of most mountain in B&H.

## Diversity of ecosystems in discontinuously distributed sub-nival belt

In the discontinuously distributed sub-nival belt the highest diversity posses ecosystems of rock crevices and screes, which co-relates with the fact that in such ecosystems live only species with narrow tolerance range. Thus, the smallest change in any of the ecological factors can cause change in the community composition.




Graph 19. – Diversity of ecosystems in sub-nival belt
(by number of identified alliances and plant communites)

## Ecosystems of sub-alpine woods

Above upper forest line on highest mountains of the Dinaric Alps in Bosnia and Herzegovina stretches the belt of mountain pine woods. Mountain pine stands don't occcur like continuously developed belt, but in mosaic like manner with fragments of alpine grasslands, screes and vegetation of rock crevices.

The communities of mountain pine, nowadays, are limited on narrow belt of the highest dinaric mountains. Out of that belt mountain pine can be found as a single tree or in groups which is related to temperature inversions.

Geologic foundation are either carbonate or silicate rocks, with different kind of solis. Soil belongs mainly to the class of humus-accumulative ones, which is black earth, rendsine and ranker.

Edificator species, *Pinus mugo* Turra, builds very thick stands in which are to be found many wood plants and species belonging to the sub-alpine grasslands. As far as animals are concerned, here occur: bear (Ursus arctos), wild boar (Sus scrofa), wolf (Canis lupus), hare (*Lepus europaeus),* fox *(Vulpes vulpes),* yellow-necked mouse *(Apodemus flavicolis),* dinaric vole *(Dolomys sp.),* mole *(Talpa sp.)* and others. In this ecosystem most frequently build the nest: *Tordus torquatus, Prunella modularis, P. merula, Purrhula pyrulla, Regulus ignicapuillus, Parus cristatus, Carduelis carduelis* and others.

Reptiles occur only occasionally. But, in summer, in cleared and open places can be easily found *Vipera berus bosniaca, V. ursini macrops, Coronella austriaca, Lacerta vivipara,* and from amphibians *Salamandra atra.*

**Ecosystems in the upper boundary of tall forests**

The upper line of tall forests in Bosnia and Herzegovina is composed of sub-alpine beech and spruce stands.

Ecosystems with sub-alpine beech are recognizable in their physiognomy: under the pressure of snow that persists here for long time, basal part of beech trees deforms and lies close to the ground. These communities are relatively poor in the floristic composition which is connected with ecoclimate that enables the survival of small number of plants over entire year.

The communities with sub-alpine beech and maple emerge on limestone substratum, whereas the soil is either limestone black earth or limestone brown earth.

In the depressions evoloves soil with deeper profile covered with inverted spruce woods.

This space is significant in ecosystems with stenoendemic species that occur here with high abundance and coverage. One of the ecosystems in which significant abundance is achieved by the endemic species, which is bosnian fescue, is Festuco bosniacae--Fagetum (subalpinum). It develops in the upper forest line on mountains Bjelašnica and Hranisava.

On silicate bedrock develops special kind of sub-alpine beech woods. They are characterized by poor floristic composition, which is determined by: short vegetation season, low mean annual temperature, long persistence of snow cover, strong winds, lack of available water and acid ground. The latter one is induced by substratum, whereas shallow type of soil can not buffer its influence. Ground is covered by low shrubs of blue berries or poorly inhabited by other species.

Among animals that characterize this complex ecosystem occur: Ursus arctos, Sus scrofa, Glis glis, Felis silvestris, Collumba oeans, Erithacus rubeculla, Picus canus, Buteo buteo, Anguis fragilis, Lacerta fragilis, Hyla arborea, Rana agilis and many others.

Sub-alpine coniferous woods are communities with spruce taking positions that are highly inclinated. Mean annual temperatures are between 4 and 2 °C, whereas absolute minimal temperature falls to -35 °C. This ecosystem in term of its composition is very poor. The acid ground causes the occurence of small number of species. For the physiognomy of sub-alpine spruce woods responsible are honeysuckle, blue berry, wintergreen, red whortlerberry, mezereon, sorrel, willow gentian, tufted hairgrass and different kind of mosses.

As sub-alpine spruce woods considered are also famous inverted spruce woods occuring on mountains Igman, Bjelašnica and Javornik. These woods develop under conditions of temperature inversions, respectively descend and holding of cold air masses on the territory of Veliko and Malo Polje and other sinkholes of above named vertical profile.

Moraine alluvion, on which the inverted spruce woods emerge, witnesses the evolution of Malo and Veliko polje (eng. field) that is by dilluvail glacier's activity. We can make an assumption that inverted spruce woods used to cover the entire field area. Today, meadows in this area have got secondary character for they arise after woodland gets cleared for grazing and mowing purposes.

**Pressures on biodiversity of high-mountain ecosystems**

Pressures on the ecosystems of mountain landscapes that caues changes in their structure, dynamics, succession and bioproductivity are:

- Global climate changes accompanied by extreme temperatures, especially in warm season, which leads to warming and arising of threat for many glacial and boreal relicts to disapear;
- Over-grazing in some parts of distribution range which causes changes in the community structure;
- Intensive deforestation;
- Building sites in the sub-alpine belt that cause disapearance of some habitats and destabilization of mountain ecosystems. Best examples for that are mountains around Sarajevo, then Vlašić Mt. and Vranica Mt. with Prokoško jezero;
- Over-erosion of surface soil layer. Usually caused by intensive grazing, deforestation in the sub-alpine belt and over-exploitation of some economically important medicinal plants;
- Acid precipitation (as a result of transboundary pollution). Acid precipitation changes substantially pH value in habitats, especially in surface layer of the humus-accumulative horizons to which is bound decomposition of organic matter and active part of rhyzosphere. Decrease in pH value causes by basophilous species reduction of vitality and abundance, which affects reproductive cycles. In that way could disapear some species and communities with narrow tolerance range, especially those on dolomites and dolomited limestone;
- Over-use and unsustainable use of natural resources contained within medicinal and aromatic plants of which some find their optimal conditions .

Edraianthus niveus G. Beck

Lebršnik

# REFUGIO-RELICT LANDSCAPES OF BOSNIA AND HERZEGOVINA

Refugio-relict habitats represent the most unique share in bosnia-herzegovina's environment, created in a stormy process of the Earth's crust formation, geogensis, evolution of both climate and living world. Those places have been least altered in a period between pre- and post-glaciation having preserved their natural ecologic values. In these habitats occur many tertiary plant and animal species which have endured drastic climate changes in last glaciation period. For these habitats have been a shelter for many plant and animal species during an Ice Age, they are called refugium. Species living here are considered to be very old in the evolutionary sense, addressed therefore as relicts. This kind of habitats where the numerous tertiary relict species of plants and animals live, are of the greatest importance for Bosnia-Herzegovina's biodiversity, and by that also for the global biodiversity. Position of tertiary relict ecosystems in Bosnia and Herzegovina is connected with, first of all, canyons, cliffs and steep slopes of mountains in the basins of: Una, Vrbas, Bosna, Drina and Neretva rivers.

In the relict and refugial landscapes of Bosnia and Herzegovina the wildlife is, in terms of ecology and biogeography, differentiated in several clearly separated complexes. Largest proportion of these ecosystems belongs to Eurosibirean-boreoamerican region represented here by the province of relict pine woods. Yet, refugial habitats in lower supramediterranean and montane belt belong to the illyrian province in the West and moesian in the southeast. Part of it is situated in the midle-adriatic sector of the Adriatic province in Mediterranean region.

## LANDSCAPES OF RELICT PINE WOODS

After Lakušić (1969; 1980), these landscapes in biogeographic sense belong to the province of relict pine woods. This corresponds with a distribution range of woods of white-bark pine (Pinus heldreichii), illyrian black pine (Pinus nigra subsp. austriaca) and dalmatian black pine (Pinus dalmatica).

The landscape of relict pine woods differentiates on vertical and horizontal profile as follows:

- Ecosystems of dalmatian black pine *Pinion dalmaticae;*
- Ecosystems of white-bark pine *Pinion heldreichii;*
- Ecosystems of illyrian black pine *Pinion austriacae* in geologic/pedologic/floristic series:
  - Series of black pine ecosystems on peridote and serpentine *Pinenion austricae "serpentinicum"*;
  - Series of black pine ecosystems on dolomites *Pinenion austricae "dolomiticum"*;
  - Series of black pine ecosystems on limestone *Pinenion austricae "calcicolum".*

### Ecosystems of dalmatian black pine

This ecosystem is fragmentary represented in the Adriatic province of Bosnia and Herzegovina. These fragments are recognizable in the former woods and shrubs of evergreen oak Quercetum ilicis "adriaticum" on the Klek peninsula at Neum city, peninsula's southeastern region.

Althoug covering small surface, these communities are important as a landscape and as a share of B&H's mediterranean flora and fauna.

## Ecosystems of white-bark pine

This ecosystem develops within the distribution range of endemic white-bark pine *Pinus heldreichii*. This is a tertiary relict species which is one of the most important coniferous kind of trees today. Its distribution range in Bosnia and Herzegovina encompasses mountains Orjen, Velež, Prenj, Čvrsnica, Čabulja and Vran in Herzegovina, then western and southwestern slopes of Hranisava Mt. in southern Bosnia. In respect to ecology, geography and flora, on the territory of B&H has been differentiating three series:

- Woods of white-bark pine on Orjen Mt.;
- Woods of white-bark pine on the mountains around Neretva river;
- Woods of white-bark pine on Hranisava Mt.

### *Woods of white-bark pine on Orjen Mt.*

White-bark pine on Orjen Mt. occurs in some localities that regarding geography belong to Bosnia and Herzegovina. It accomplishes its optimum in in the upper montane, upland and subalpine belt characterizing it in the most protruding way and making it different from the rest of Dinaric Alps. White-bark pine's belt make this area of Dinaric Alps so unique in terms of vegetation zoning.
The geologic foundation is limestone of mesosoic age shaped by intensive precipitation and mountain winds. Habitats of white-bark pine look like typical karst area with diverse karst relief's forms. Soil types are shallow and permeable (calcomelanosol, rendsin, on flat ground occur calcocambisol). On extremely inclinated slopes, as a typical chasmophyte, white-bark pine penetrates deep into the cracks of limestone rocks, forming endemic vegetational units. Populations of white-bark pine build communities on stabilized subalpine screes. In wet and cold places white-bark pine builds mesophilous communities with balkan beech Fagus moesiaca.
On Orjen Mt., landscapes with woods of white-bark pine are composed of endemic communities:

- Woods of white-bark pine in the mediterraneao-montane belt *Pinetum heldrechii mediterraneo-montanum* Blečić et Lakušić 1969;
- Woods of white-bark pine and *Viburnum maculatum Viburno maculatae-Pinetum leucodermis* Fukarek 1970;
- Woods of white-bark pine and balkan beech *Fago moesiacae-Pinetum heldreichii* Redžić 2004;
- Woods of white-bark pine and fennel *Peucedano-Pinetum heldreichii* Redžić 2004;
- Woods of white-bark pine and Amphoricarpus *Amphoricarpo neumayeri-Pinetum heldreichii* Redžić 2004.

Within the distribution range of above named habitats are to be found endemo-relict species: Amphoricarpus (*Amphoricarpus neumayeri*), white-bark pine (*Pinus heldreichii*), honeysuckle (*Lonicera glutinosa*), *Viburnum maculatum*, Tomasini's Campion (*Silene tommasinii*) and others.
These landscapes include the entire complex of habitat types encompassing biocoenoses which make this area so unique and divide it into distinct biogeographic units. Those are communities in the rock crevices of the endemo-relict alliance *Amphoricarpion neumayeri*, and scree communities of the alliances *Silenion marginatae* and *Peucedanion*.

### *Woods of white-bark pine on the mountains around Neretva river*

For the white-bark pine optimal habitats in Bosnia and Herzegovina are on the mountains around Neretva river.It takes positions in the upland and sub-alpine belt of mountains Velež, Prenj, Čvrsnica, Čabulja, and on southeastern slopes of Vran Mt. which is its western borderline on the Balkan peninsula.
In the typical herzegovina's karst area its habitat is on limestone, whereby type of soil is either calcomelanosol or rendsine

(seldom calcocambisol). On the less inclinated slopes, white-bark pine forms closed stands. On more inclinated slopes it is a component of chasmophyte communities of rock crevices and stabilized screes. On Prenj Mt., stands of white-bark pine are well preserved with trees that are several hundred years old, and whose diameter ranges between 2 and 3 metres.
The white-bark pine on the mountains around Neretva river builds few endemo-relict communities:

- Woods of white-bark pine *Pinetum heldreichii mediterrano-montanum* Blečić et Lakušić 1969;
- Woods of white-bark and illyrian black pine *Pinetum nigrae-leucodermis* Fukarek 1966;
- Woods of white-bark pine and Visiani's ragwort *Senecioni-Pinetum leucodermis* Fukarek 1966;
- Woods of white-bark and mountain pine *Mugheto-Pinetum leucodermis* Fukarek 1966;
- Woods of white-bark pine and potentil *Potentillo speciosae-Pinetum heldreichii* Redžić 2004;
- Woods of white-bark pine and rock moltkea *Moltkeo-Pinetum heldreichii* Redžić 2004.

These forest communities are habitats of many endemo-relict species: *Sibirea croatica*, Visiani's ragwort (*Senecio visianii)*, apennines potentil (*Potentilla apennina)*, potentil (*P. speciosa)*, rock moltkea (*Moltkaea petraea)*, and other endemic species of rocky grassland, subalpine grassland, rock crevices and screes.
High endemism level of species and communities represents reason for urgent conservation measures to be undertaken for this is an extremely important bosnia-herzegovina's biodiversity spot.

## Woods of white-bark pine on Hranisava Mt.

On western and southwestern slopes of Hranisava Mt. (which is western part of Bjelašnica Mt.) exist forest communities in which the white-bark pine reaches high abundance and vitality. This is the northern borderline of white-bark pine's distribution range. The habitats are inclinated slopes, on limestone bedrock. Soil type is either calcomelanosol or rendsine (1.600-1.800 m above sea level). On colder places, white-bark pine builds the communities with balkan beech or, on extremely inclinated ground, chasmophyte kind of communities. On Hranisava Mt., white-bark pine builds following endemo-relict communities:

- Woods of white-bark pine and balkan beech *Fago moesiacae-Pinetum heldreichii* Redžić 2004;
- Woods of white-bark pine and fennel *Peucedano longifolii-Pinetum heldreichii* Redžić 2006;
- Woods of white-bark pine and bearberry *Arcstostaphyllo-Pinetum heldreichii Redžić* 2006.

## Woods of illyrian black pine

Illyrian black pine in our country is represented by special sub-species *Pinus nigra* subsp. *nigra* with disjunctive distribution range on bosnia-herzegovina's Dinaric Alps. It lives on different kind of bedrocks (old volcanic rocks, dolomites and limestone) having the features of tertiary flora's refugia. *Pinus nigra* subsp. *nigra* is heliophylous, thermophylous and xerophylous species. Depending on geologic foundation and other ecologic conditions, it is being differentiated in the geologic/pedologic/floristic series:

- Woods of black pine on peridote and serpentine *Pinenion austricae* "serpentinicum";
- Woods of black pine on dolomites *Pinenion austricae* "dolomiticum";
- Woods of black pine on limestone *Pinenion austricae* "calcicolum".

## Woods of black pine on serpentine and peridote

These ecosystems take large area in the zone of ophyolithes in Bosnia and Herzegovina built of an old volcanic or ultrabasic rocks. In the composition prevail serpentine, peridote,

diabaz and amphibol. However, most important for the determination of geo-floristic features is serpentine in the series with peridote. Long time ago (Riter-Studnička, 1963, 1970), it was recognized strong influence of the abiotic component on the characteristics of living world, especially when it comes to plants.

The zone of ophyolithes stretches from Kozara Mt. (southwestern B&H), through the valley of Vrbanja river, where it coveres large area on the mountains Uzlomak and Borja, continuing towards Bosna river's basin, where it creates a dense complex between Zavidovići and Nemila. The zone extends further along the valley of Gostović river till it reaches Konjuh Mt. Here, these rocks make huge complexes going all the way down to Kladanj and Olovske luke in the South, and Banovići in the North. Highly dynamic and picture-like is the valley of Krivaja river which is mainly built of ultrabasic rocks. There are some fragments of these rocks on Ozren Mt.( right side of Spreča river) and in the surrounding of towns Maglaj and Lukavac. In the East and southeast of our country these rocks occur seldom. But, close to Višegrad city (slopes of Sjemeč Mt., Vard and Banja), like some kind of islands, occur dark volcanic rocks extending futher along the valley of Lim river and near place called Rudo continue toward western and southwestern Serbia.

A dynamic geomorphologic processes in the past have led to diverse relief forms with sharp peaks and vertical standing cliffs. On such places emerge different developmental stages of eutric kind of soils (ranker and eutric cambisol). Soils are very sensitive to the erosion being hence often degraded and represented by shallow eutric regosol and sirozem. These soils warm up quickly which results in more or less xeric vegetation cover. This feature is the reason why our flora and vegetation on serpentine bedrock are considered to be highly specific.

Geologic foundation contains high concentration of heavy metals, which along with hydro-thermic regime creates specific combination of the ecologic conditions. Flora and vegetation in this area have got tertiary-relict character preserved till present. Beside pine forests, in these habitats emerge some endemo-relict species living on serpentine-peridote's rocky grassland, rock crevices and screes. On deeper developed soil occur forests with black pine and sessile oak, whereas final stage of the vegetation development represent woods of sessile oak on the eutric cambisol.

Table 30. – Syntaxonomic overview of the communities on serpentine and peridote

| | | | | |
|---|---|---|---|---|
| **Ecosystems of woods on serpentine** | ERICO – PINETEA Ht. 1959 | ERICO – PINETALIA (Oberd. 1949) em. Ht 1959 | Orno – Ericion serpentinicum | *Erico – Pinetum nigrae* Rt. 1970 (syn. *Erico – Pinetum nigrae serpentinicum* Fuk. P.p. MS) |
| | | | | *Erico – Pinetum nigrae serpentinicum* Stef. 1963 |
| | | | | *Pinetum nigrae baziferens* Stef. 1973 |
| | | | | *Pinetum silvestris – nigrae* Pavl. *bosniacum* Marv. |
| | | | | *Erico – Quercetum petraeae* ((Krause et Ludw. 1957) Ht. 1958) Rt. 1970 |
| | | | | *Erico – Abieti – Fagetum* Rt. 1970 |
| **Ecosystems of rocky grassland on serpentine** | THERO – BRACHYPODIETEA Br. – Bl. 1947 | HALACSYETALIA SENDTNERI Rt. 1970 | Polygonion albanicae Rt 1970 | *Halacsyo – Seslerietum rigidae* Rt. 1970 |
| | | | | *Dorycnio – Scabiosetum leucophphyllae* Rt. 1970 |
| | | | | *Silenetum willdenowii serpentinae* Rt. 1970 |
| | | | Potentillion visianiii Rt.1970 | *Erysimo – Sempervivetum heuffelii* Rt. 1970 |
| | | | | *Euphorbio – Fumanetum bonapartei* Rt. 1970 |
| | | | | *Linarietum concoloris* Rt. 1970 |

Table 31. – Species diversity on serpentine and peridote

| |
|---|
| **Relict serpentinophytes**:<br>*Halacsya sendtneri* (Boiss.) Doerfl., *Potentilla visianii* Panc., *Fumana bonapartei* Maire et Petitm., *Haplophyllum boissierianum* Vis. et Panc., *Gypsophila spergulaefolia* Gris. f. *serbica* Vis. et Panc. |
| **Typical (exclusive ) serpentinophytes**:<br>*Scrophularia tristis* K. Maly, *Sesleria latifolia* (Adam.) Degen var. *serpentinica* Deyl., *Linaria concolor* Gris. f. *rubioides* (Vis. et Panc.) Maly, *Potentilla rupestris* L. var. *mollis* (Panc.) A. et G., *Polygonum albanicum* Jav., *Euphorbia gregersenii* K. Maly, *Potentilla opaca* Jusl. f. *malyana* (Borb.) Hayek, *Centaurea dubia* Sut. subsp. *nigrescens* (Willd.) Hayek var. *smolinensis* (Hay.) Kusan, *Verbascum bosnense* K. Maly (=*V. ostrogi* Rohl. var. *bosnense* Maly), *Cytisus heuffelii* Wierzb. var. *maezeius* K. Maly, *Leucanthemum montanum* DC. var. *crassifolium* Fiori, *Asplenium adulterinum* Milde, *Asplenium cuneifolium* Viv., *Notholaena marantae* (L.) Desv. |
| **Plants prefering serpentine bedrock**:<br>*Cardamine plumierii* Villars., *Stachys recta* L. subsp. *Baldacci* (K. Maly) Hay. var. *chrysophaea* Panc., *Viola beckiana* Fiala, *Sesleria rigida* Heuf., *Stachys scardica* Gris., *Silene armeria* L., *Silene longifolia* Ehrh., *Polygala supina* Schreb., *Euphorbia glabriflora* Vis., *Scleranthus perennis* L., *Pedicularis brachyodonta* Schloss. et Vuk. var. *heterodonta* (Panc.) Maly, *Cerastium moesiacum* Friv. f. *serpentini* Nov., *Bupleurum karglii* Vis., *Silene paradoxa* L., *Sedum glaucum* W. K., *Rumex acetosella* L., *Rubus zvornikensis* Fr. |

Among few hundred plants occurring on serpentine-peridote bedrock, most numerous are the ones from families Compositae, Caryophyllaceae and Fabaceae. Largest proportion of serpentine-peridote flora occurs on bare rocks, whereas smaller number of species occur on well developed forest soils.

Table 32. – Spectrum of systematic belonging in different habitat types

| Family | On bare rocks | | In the mesophilous woods | |
|---|---|---|---|---|
| | species | genera | species | genera |
| Compositae | 45 | 26 | 12 | 10 |
| Caryophyllaceae | 27 | 17 | 2 | 2 |
| Fabaceae | 23 | 11 | 7 | 2 |
| Scrophulariaceae | 22 | 10 | 6 | 3 |
| Gramineae | 21 | 13 | 15 | 12 |
| Rosaceae | 13 | 5 | 10 | 9 |
| Umbelliferae | 9 | 7 | 7 | 5 |

Analysis of living forms (Riter-Studnička, 1963) shows domination of hemikryptophytes in all types of serpentine-peridote habitats. Extreme conditions are illustrated by the small proportion of phanerophytes and high abundance of terophytes.

Table 33. – Spectrum of living forms in different habitat types

| Living form | P | CH | H | G | T |
|---|---|---|---|---|---|
| Species on bare rocks | 3.06 | 18.72 | 52.28 | 8.16 | 17.34 |
| Species in the mesophilous woods | 20.25 | 11.39 | 55.70 | 8.86 | 3.80 |
| Species in heathes | - | 23.80 | 61.90 | - | 14.28 |

Serpentine-peridote's habitats are sensitive; continually eroding and sliding, submitted to tremendous human pressure (over-logging, unselected exploitation of mineral resources). Because all of that, plants and their communities in these habitats are endangered.

## *Woods of black pine on dolomites*

As a geologic foundation, dolomite represents a habitat for many endemo-relict plant and animal species originating from Tertiary. It used to be refugium for plant and animal species, and even entire communities, in the glaciation period. During that period, sudden decrease in temperature has caused a damage to flora and fauna that existed at that time. But, some of those species have endured till present on the dolomite bedrock.

In Bosnia and Herzegovina dolomite occurs in several localities. Usually it is a small surface, but there are also large complexes where it was created unique living world in the past.

Most important dolomite complexes in B&H with the outstanding landscape's value are:

- Area around Konjic town in Herzegovina (valley of Trešanica river, Zlatar and Vrataljica hills), long time ago designated as the Botanic Reserve of dolomite flora and vegetation;
- Area in the upper flow of Neretva river (Borci, Glavatičevo and area upstreams to Ulog);
- Smaller dolomite complex in the midle of Neretva river's flow (area around Doljanka river, downstreams from Jablanica, Drežnica area);
- Area around Lastva, in the valley of Trebišnjica river (artificially impoded accumulation "Gorica") upstreams from Trebinje town;
- Area of Koprivnica between Bugojno, Donji Vakuf, Prusac and Kupres, including Mala Plazenica;
- Area around Drvar in the western Bosnia;
- Smaller complex near Rakovica and Lepenica southwestern from Sarajevo;
- Smaller complex along the Glasinac river and Bravnička Rika between Bravnice and Janj;
- Complex called Bila at Travnik city and smaller localities in the limestone zone.

Main characteristic of bosnia-herzegovina's landscapes on dolomite is high level of endemism and relictness of plant and animal species, which reffers also to their communities.

Flora and fauna on dolomite is highly specific. Many species live exclusively on this kind of bedrock. These are dolomitobionts, of which biggest proportion make dolomitophytes. On dolomite bedrock can be found many high-mountain plants, such as: mountain buttercup, crucifers, dinaric gentian which go down till 800 meters above sea level. On the other hand, warmth of climate made possible for many mediterranean and supra-mediterranean plants to live here, such is the case with greenweed (Genista dalmatica), herzegovina's spurge (Euphorbia hercegovina), sage (Salvia officinalis), rock moltkea (Moltkaea petraea) and others.

Dolomite is a kind of rock that crumbles, erodes and slides. On dolomite bedrock emerges mainly rendsine with shallow humus-accumulative horizon. Due to protruding erosion, the soil is frequently degraded and exchanges with sirozem and regosol. On less inclinated slopes develops brown earth in which the influence of dolomite weakens because of profile's depth. On that kind of soil emerge species with wider distribution range. It is commonly believed that magnesium's content is responsible for the dolomite's crumbling, but also for the selection of vegetation cover and animal communities.

Table 34. – Syntaxonomic overview of the communities on dolomite

| | | |
|---|---|---|
| Vegetation of pine woods | ERICO – PINETEA Ht. 59 | **ERICO – PINETALIA** (Oberd. 49) em. Ht 59 |
| | | **Orno – Ericion dolomiticum** Ht 59 |
| | | *Erico verticillati – Pinetum* Rt. 67 |
| | | *Orchido zlatari – Pinetum* Rt. 67 |
| | | *Cephalario flavae – Pinetum* Rt. 67 |
| | | *Orchido (spitzelii) – Pinetum nigrae* Rt. 67 |
| | | *Daphno cneori – Pinetum* Rt. 67 |
| | | *Pinetum silvestris dinaricum* Stef. 58 |
| Vegetation of littoral rocky grassland, pastures and meadows | THERO – BRACHYPODIETEA Br. – Bl. 47 | **SCORZONERO – CHRYSOPOGONETALIA** H-ic et Ht (56) 58 |
| | | **Peucedanion neumayeri** Rt. 67 |
| | | *Centauretum atropurpureae* Rt. 67 |
| | | *Micromerio – Crepidetum pantocseki* Rt. 1967 |
| | | *Saponario – Scabiosetum canescentis* Rt. 1967 |
| | | *Alyssetum moelendorfiani* Rt. (1956) em. 1967 |

Special value to these habitats is provided by the occurence of bosnia-herzegovina's dolomitophytes, such as alyssum (Alyssum moelendorfianum), thyme (Thymus aureopunctatus ), acinos (Acinos orontius). Because of the characteristics of dolomite and anthropogenic pressures (over-logging, collection of medicinal and aromatic plants, over-grazing) these habitats, species and communities are under certain threat.

Apart from the illyrian black pine woods (Orno-Ericenion "dolomiticum"), on dolomite occur also different kind of xeric stands of oak and thermophilous beech woods. The highest level of endemism and relictness is reached in the communities of rocky grassland, rock crevices and screes on dolomite.

## *Woods of black pine on limestone*

Black pine woods are also developed on the bedrock made of limestone, on shallow humus-accumulative type of soil (black earth), even on sirozem and regosol. Brown earth emerges only on the flattened ground. These woods have got a disjunctive distribution range with specific ecosystems of great landscape's value occuring in the zone of broad-leaved deciduous thermophilous woods.

Highly valuable habitats of black pine on the limestone are to be found in canyons of: Sutjeska, Neretva and Drina rivers. In the rock crevices of these canyons, black pine builds few endemo-relict communities.

# LANDSCAPES OF ENDEMO-RELICT ECOSYSTEMS IN THE CLIFFS AND CANYONS OF BOSNIA-HERZEGOVINA'S RIVERS

Specific orographic, geomorphologic and hydrologic, respectively ecologic, conditions have caused the occurence of cliffs and canyons in the basins of all important watercourses in Bosnia and Herzegovina. Sides of the cliffs and canyons are steep, mainly built of the limestone (carbonate and dolomite). They are as ten or hundred metres as deep. The canyon of Neretva river, between mountains Prenj and Čvrsnica is 1.700 metres deep. The most famous canyons are those of Sutjeska and Una rivers. In the past, here was created a specific ecoclimate of canyons and cliffs. Those sheltered, safe and remote places enabled survival of distinct populations from Tertiary till today.

The ecoclimate of canyons and cliffs is characterized by high diurnal and seasonal variation in all factors, especially in temperature. In these habitats frequently occur so called temperature inversions, which is one of the world's rarities. Highly specific complex of ecologic factors has led to the development of unique living world that is rich in endemic and relict species.

The canyons and cliffs of Bosnia and Herzegovina are characterized by high diversity in geomorphology, ecosystems and species, hence many authors consider it as global value. In the refugial habitats, such as our canyons and cliffs, are situated a development centres of flora, fauna and vegetation.

Because of the underlined dynamics and variation of the main ecologic factors, in these habitats still evolve intensive processes of speciation and endemogenesis, respectively the creation of new species. That kind of development centres are to be found in the basins of Una, Drina, Vrbas and Bosna rivers, and in the peri-pannonian region on the slopes of mountains Kozara, Prosara, Motajica and Majevica.

## Polydominant communities

The uniqueness of the biodiversity in these habitats is reflected through the occurence of polydominant communities and ecosystems which are characterized by the highest level of floristic and faunisitic diversity.

As a result of specific combination of ecologic factors, in the cliffs and canyons of bosnia-herzegovina's rivers, along with high variation in hydro-thermic regime in the past, evolved such biocoenoses whose physiognomy is determined by a different tree species. Those communities are unique in the high proportion of trees as edificator species. In typical terrestrial kind of communities occur only few edificator and sub-edificator species. In the refugial communities that role is overtaken by dozens of tree species. There are even some cases when in the floristic composition of refugial habitats, such as cliffs and canyons, occur over 50 tree species being therefore named as polydominant communities. One of the most famous such communities in Bosnia and Herzegovina is *Aceri-Tilietum mixtum* Stefanović, 1979, developed in the canyon of Una, Vrbas, Drina and Neretva rivers.

Apart from the polydominant communities, the landscapes of canyons and cliffs are unique by the communities of rock crevices and screes, which are mainly endemic and relict ones. Majority of endemic species and communities in Bosnia and Herzegovina is situated here. The refugial-relict ecosystems posses the highest value within bosnia-herzegovina's biodiversity from the standpoint of gen pool's preservation on national scale. This is our share in the global natural value on European and world's scale.

# REFUGIAL-RELICT ECOSYSTEMS IN THE BASIN OF UNA RIVER

Una river is a typical karst river. Its source is calm and situated beneath Stražbenica Mt., which is in Croatia, in the zone of relict beech-hope hornbeam woods (*Ostryo-Fagetum*). On its 207 km long journey, it makes several tuff cascades (Martin Brod, Štrbački Buk, Veliki and Mali Slap upstreams from Ripač), flowing more or less swiftly from Bihać city making on its way to Novi few water curtains and small cascades. Thereafter it becomes lowland river, calm and slow. On its way Una river flows through the narrow passages and canyons where it has been preserved a genuine vegetation, flora and fauna, with many endemic species. In Figure 6. highlightened are refugia in the basin of Una river, designated in accordance with international criteria for habitat's categorization.

Table 35. – Endemo-relict plant species in the canyon Una river

| |
|---|
| *Campanula pyramidalis, C. unensis, C. wetsteinii, Moehringia maly, Asplenium lepidum, Edraianthus croaticus, Potentilla clusiana, Corydalis leiosperma, Micromeria thymifolia, Cerastium dinaricum, Satureia montana, Ruta divaricata, Satureia subspicata, Iris illyrica, Iris reichenbachii, Daphne cneorum, Asparagus tenuifolius, Sesleria autumnalis, Ruscus aculeatus, Acer hircanum.* |

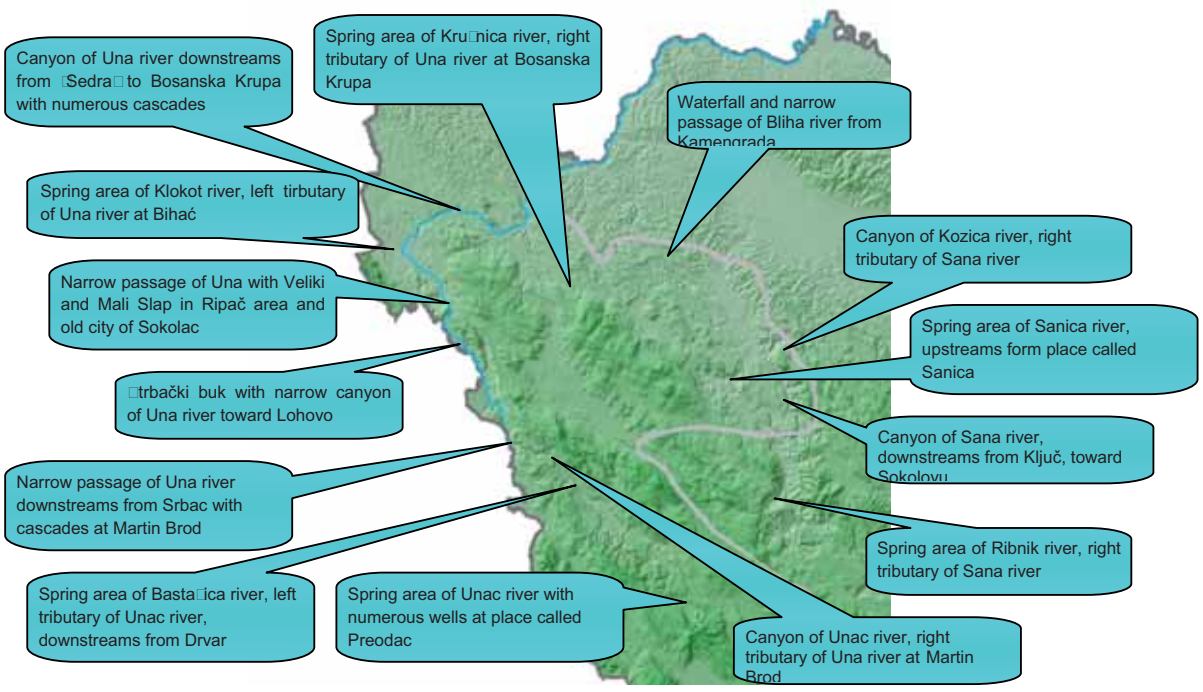



Figure 8. – Refugial-relict habitats in the basin of Una river

A special refugial attributes to these habitats are provided by the populations of relict species *Platanus orientalis*, which, in the canyon area along the riversides, forms relict hydrophilous community with alder. This is a sole finding place of that community.

Fauna of bosnia-herzegovina's canyons is very interesting, too. The recent investigations have confirmed that canyons are finding places of genera of different age and shelter for many relict forms. The study of terrestrial gastropods in the canyon of Una river has revealed 11 species that are remnants from the glaciation and pre-glaciation periods.

Table 36. – Relict gastropods in the basin of Una river

| |
|---|
| *Acanthinulla lamellata, Acanthinulla harpa, Vallonia tenuilabris, Vitrea contortula, Vitrea subefusa, Vitrea pygmaea, Oxychilus alliarius, Oxychilus diaphanelus, Phenacolimax annularis, Semilimax semilimax, Acicula polita.* |

In the basin of Una river were recorded populations of *Scolopendrellopsis microcolpa* Muhr 1881, which is a tertiary relict, and relict species from genera *Cochlostoma* and *Vitrea* dating back in Oligocoen.

Special value and dynamics to the landscapes of Una river's basin are ensured by the ecosystems of tuff barriers and cascades, natural phenomena in the Dinaric Alps and this part of the world in general.

Table 37. – Syntaxonomic overview of the communities in refugio-relict habitats of the Una river's basin

| | | |
|---|---|---|
| Vegetacija u pukotinama stijena | ASPLENIETEA RUPESTRIS (H.Meier) Br.-Bl. 1934 | **MOLTKEETALIA PETRAEAE** Lakušić 1968 |
| | | **Edraianthion** Lakušić 1968 |
| | | ***Centaureo glaberimae – Onosmetum stellulati*** **Lakušić & Redžić 1991** |
| | | ***Hyssopi – Crepidetum hondriloidis*** **Lakušić & Redžić 1991** |
| | | ***Centaureo deustae – Campanuletum pyramidalis*** **Lakušić & Redžić 1991** |
| | | ***Asplenio lepidi – Campanuletum unaensis*** **Lakušić et Redžić 1991** |
| | | ***Euphorbio – Asperuletum scutellaris*** **Lakušić et Redžić 1991** |
| | | ***Saxifrago – Polypodietum australis*** **Lakušić et Redžić 1991** |
| | | ***Achnanthero – Moehringietum malyi*** **Lakušić et Redžić 1991** |
| | | **AMPHORICARPETALIA** Lakušić 1968 |
| | | **Micromerion croaticae** Ht. 1931 |
| | | ***Leonopodio – Edraianthetum croatici*** **Lakušić et al. 1975** |
| | | ***Edraiantho – Potentilletum clusianae*** **Lakušić 1968** |
| | | ***Asplenietum fissi*** **Ht. 1931** |
| | | ***Potentilletum clusianae*** **Ht. 1931** |
| | | **POTENTILLETALIA CAULESCENTIS** Br. – Bl. |
| | | **Moehringion muscosae** Ht. et H-ic. 1959 |
| | | ***Moehringio – Corydaletum*** Ht. 1962 |
| Vegetacija sipara | THLASPEETEA ROTUNDIFOLII Br. – Bl. 1947 | **DRYPEETALIA SPINOSAE** Quezel 1967 |
| | | **Peltarion alliaceae** H-ic (1956) 1958 |
| | | ***Micromerio thymifolii – Corydaletum leiospermae*** Lakušić & Redžić 1991 |
| | | ***Asplenio – Ceterachetum officinari unaensis*** Lakušić & Redžić 1991 |
| | | **ARABIDETALIA FLAVESCENTIS** Lakušić 1968 |
| | | **Silenion marginatae** Lakušić 1968 |
| | | ***Cerastietum dinaricae*** Ht. 1931 |
| | | **Bunion alpini** Lakušić 1968 |
| | | ***Bunio – Iberetum*** **carnosae** Ht. 1931 |
| | | **THLASPEETALIA ROTUNDIFOLII** Br. – Bl. 1926 |
| | | **Thlaspeion rotundifolii** Br. – Bl. 1926 |
| | | ***Petasitetum paradoxi*** Beg. 1922 ***dinaricum*** Lakušić 1990 |
| Vegetacija kserofilnih livada | FESTUCO – BROMETEA Br. – Bl. | **SCORZONERO – CHRYSOPOGONETALIA** H-ic & Ht. (1956) 1958 |
| | | **Satureion montanae** Ht. 1962 |
| | | ***Physospermo – Satureietum montanae*** Redžić et Lakušić 1991 |
| | | ***Artemisio albae – Rutetum*** Redžić et Lakušić 1991 |
| | | **Satureion subspicatae** Ht. 1962 |
| | | ***Satureio subspicatae – Festucetum dalmaticae*** Redžić et Lakušić 1991 |
| | | ***Thymi – Teucrietum chamaedrys*** Redžić et Lakušić 1991 |
| | | ***Achilleo nobilis – Dorycnietum herbacei*** Redžić et Lakušić 1991 |
| Vegetacija borovih šuma | ERICO – PINETEA Ht. 1959 | **PINETALIA MUGHI** Lakušić 1972 |
| | | **Pinion mughi** Pawlow. 1928 |
| | | ***Pinetum mughi dinaricum calcicolum*** Lakušić et al. 1973 |
| | | **PINETALIA HELDREICHII – NIGRAE** Lakušić 1972 |
| | | **Pinion nigrae** Lakušić 1972 |
| | | ***Daphno cneori – Pinetum*** Rt. 1967 |

| | | |
|---|---|---|
| Vegetacija tamnih četinarskih šuma | ABIETI – PICEETEA (Br. – Bl. 1939) Lakušić et al. 1979 | **ABIETI – PICEETALIA** (Br. – Bl. 1939) Lakušić et al. 1979 |
| | | **Abietion albae** (Ht. 1956) Lakušić et al. 1979 |
| | | *Calamagrosti – Abietetum* Ht. 1950 |
| | | *Rhamno – Abietetum* Fuk. 1958 |
| Vegetacija liščarsko listopadnih šuma | QUERCO – FAGETEA Br. – Bl. & Vlieger 1937 | **QUERCETALIA PUBESCENTIS** Br. – Bl. (1931) 1932 |
| | | **Quercion pubescentis – petraeae** Br. – Bl. 1931 |
| | | *Asparago tenuifolii – Quercetum pubescentis* Lakušić et Redžić 1991 |
| | | **Quercion petraeae – cerris** (Lakušić 1976) Lakušić et B. Jovanovic 1980 |
| | | *Orno – Quercetum cerris* Stefanovic 1968 |
| | | **OSTRYO – CARPINETALIA ORIENTALIS** Lakušić, Pavlovic, Redžić 1982 |
| | | **Carpinion orientalis** Blecic &Lakušić 1966 |
| | | *Aceri – Carpinetum orientalis* Blecic &Lakušić 1966 |
| | | *Rusco – Carpinetum orientalis continentale* Lakušić et Redžić 1991 |
| | | **Seslerio – Ostryon** Lksic., Pavlov. & Redžić 1982 (Syn.: Orneto – Ostryon Tom. 1940 p.p.) |
| | | *Seslerio autumnalis – Ostryetum carpinifoliae* Ht. et H-ic. 1950 |
| | | *Rusco aculeati – Ostryetum carpinifoliae* Redžić et Lakušić 1991 |
| | | **FAGETALIA MOESIACAE** Lakušić 1991 |
| | | **Ostryo – Fagenion moesiacaeae** B. Jovanovic 1976 |
| | | *Aceri obtusati – Fagetum (moesiacae)* Fab., Fuk. & Stef. 1963 |
| | | *Aceri – Tilietum mixtum* Stef. 1979 |

*"The armlets run skillfully between trees of alder, white and crack willow, Fraxinus angustifolius, elder bourtree and usually descend steep tuff slopes which are created by the longlasting activity of clear, oxygen rich water, alges, blue-green bacteria, aquatic insects and mosses. As a tuff layer gets bigger year after year, it changes the microrelief features and direction of the armlets. Thus, it is quite common the case that some of them dry out, while the new ones emerge. This dynamics includes a magic of nature, tuff-forming organisms and tuff itselfs. Tuff barriers that were created in this way had an impact onto formation of depressions in which water settle down like in some kind of lake. In this way created are many tuff lakes within dinaric karst." (quoted from TV show "Prirodna baština BiH")*

**Flora of tuff cyanophytes and alges:**
*Chamaesiphon incrustans* Grun., *Homoeothrix crustacea* W.Oronichin, *Homoeothrix varians* Geitler, *Hydrocoleum homoeotrichum* Kütz *f. tenue, Hydrocoleum uncinatum, Microcoleus subtorulosus Bréb., Nostoc punctiforme* (Kutz.)Hariot, *Nostoc sphaericum* Vacher ex Bornet et Flahault, *Phormidium faveolarum* (Mont.) Gom., *Phormidium uncinatum* (Ag.) Gom., *Rivularia haematites* (DC.)Ag., *Schizotrix fasciculata (Naeg.) Gom., Tolypotrix distorta* Kutz.ex Bornet et Flahault, *Bangia atropurpurea* (Roth) Ag., *Chantransia pygmea* Kutz., *Lemanea fluviatilis* (L.) C.Agardh, *Hydrurus foetidus* Kirch., *Vaucheria sessilis* Dcand., *Vaucheria sp.* Dcand., *Spirogyra sp., Mougeotia sp.,Closterium ehrenbergii* Menegh. ex Ralfs, *Closterium moniliferum* (Bory) Ehrenb., *Cladophora glomerata* (Kutz.), *Microspora amoena* (Kutz.)Rabenh., *Oedogonium sp.,* te dijatomeje *Achnanthidium minutissimum* ( Kutz.) Czarn., *Amphora ovalis* ( Kutz.) Kutz., *Amphora pediculus* (Kutz.)Grunow, *Caloneis silicula* (Ehrenb.)Cleve, *Cocconeis pediculus* Ehrenb., *Cocconeis placentula* Ehrenb., *Cymatopleura solea* (Breb.) W.Smith, *Cymbella prostrata* (Berkely)Cl., *Cymbella sinuata* W.Greg., *Denticula tenuis* Kutz., *Diploneis oblongella* (Naeg.)Cl.,*Ellerbeckia arenaria* (Moore)Craw., *Fragilaria capucina* Desmazieres, *Fragilaria ulna* (Nitzsch.) Ehrenb.var.*ulna* Nitzsch.Lan.-Bert., *Melosira varians* C.A:Ag., *Navicula reinhardtii* Grun ., *Nitzschia fonticola* (Grunow) Grunow, *Surirella angustata* Kutz., *Surirella spiralis* Kutz.

High dynamics of, by organisms made, tuff rocks, high biological quality of water and fuctional connection with the riverside ecosystems, all that has led to the development of endemo-relict communities with micro- and macrophytes and enormous aquatic insect's richness (belonging to Plecoptera, Trichoptera, Psychodida, Simulida). Among latter ones, many are stenoendemic. Besides, the priceless value to these ecosystems is ensured by the fish populations that include some salmonids maintained only here.

# REFUGIAL AND RELICT ECOSYSTEMS IN THE BASIN OF VRBAS RIVER

*"There are not many streams in Bosnia and Herzegovina as attached to the hearts of handsome boys and girls as Vrbas river. This mighty and splendid river has found its place deep in their souls. Like some kind of frivolous bosnian child it stretches as a 253 km long emerald necklace. Each drop of rain, dew and pearl-like water arosen from the snowflakes, from the surface of 5.400 km² that is its basin size, flows into Vrbas river. It is being born like a small source somewhere beneath the slopes of Vranica Mt., called Zec Mt.. Both of its riversides reach the mountain peaks up to 2.000 metres above sea level. Soon after that, Vrbas, a daring mountain river rushes into picture-like valley. Its riverbed surrounded by willows, alders, purpule willows and other hydrophilous woods and shrubs seems to hide this natural beauty from people sight." (quoted from TV show "Prirodna baština BiH").*

The basin of Vrbas river is characterized by the outstanding geomorphologic, hydrologic, biologic and ecologic diversity. In its etire length Vrbas river posses natural values, but there are some ecologic complexes that can be selected as refugial and relict. This is underlined by the diversity of geologic foundation (silicate rocks, limestone, dolomites, gypsum and tuff). The valley of Vrbas river is hence very rich in both geologic and hydrologic phenomena. Apart from special forms of relief (cliffs, canyons, depressions, narrow passages, tuff creations), the hydrologic diversity is supported by typical karst wells, mountain springs and brooks, mountain small rivers, rivers, calm streams, numerous swirls, cascades and waterfalls, natural lakes and thermal water springs.

The unique landscape's value to the refugio-relict habitats in the basin of Vrbas river is given by:

- Ecosystems of thermophilous illyrian black pine woods on dolomite and rendsine;
- Ecosystems of low woods and shrubs with hope hornbeam and autumn moor grass;
- Ecosystems of low woods and shrubs with oriental hornbeam and bosnian maple;
- Ecosystems of low woods and shrubs with hope hornbeam and young fustic;
- Ecosystems of butcher's broom and oriental hornbeam in the Vrbas canyon;
- Ecosystems of polydominant woods with linden and Acer obtusatum;
- Ecosystems of polydominant woods with Acer obtusatum and hornbeam;
- Ecosystems of woods and shrubs with Quercus daleschampii.

The highest level of endemism and relictness is also accomplished in the habitats of limestone rock crevices and screes, especially in the canyons.

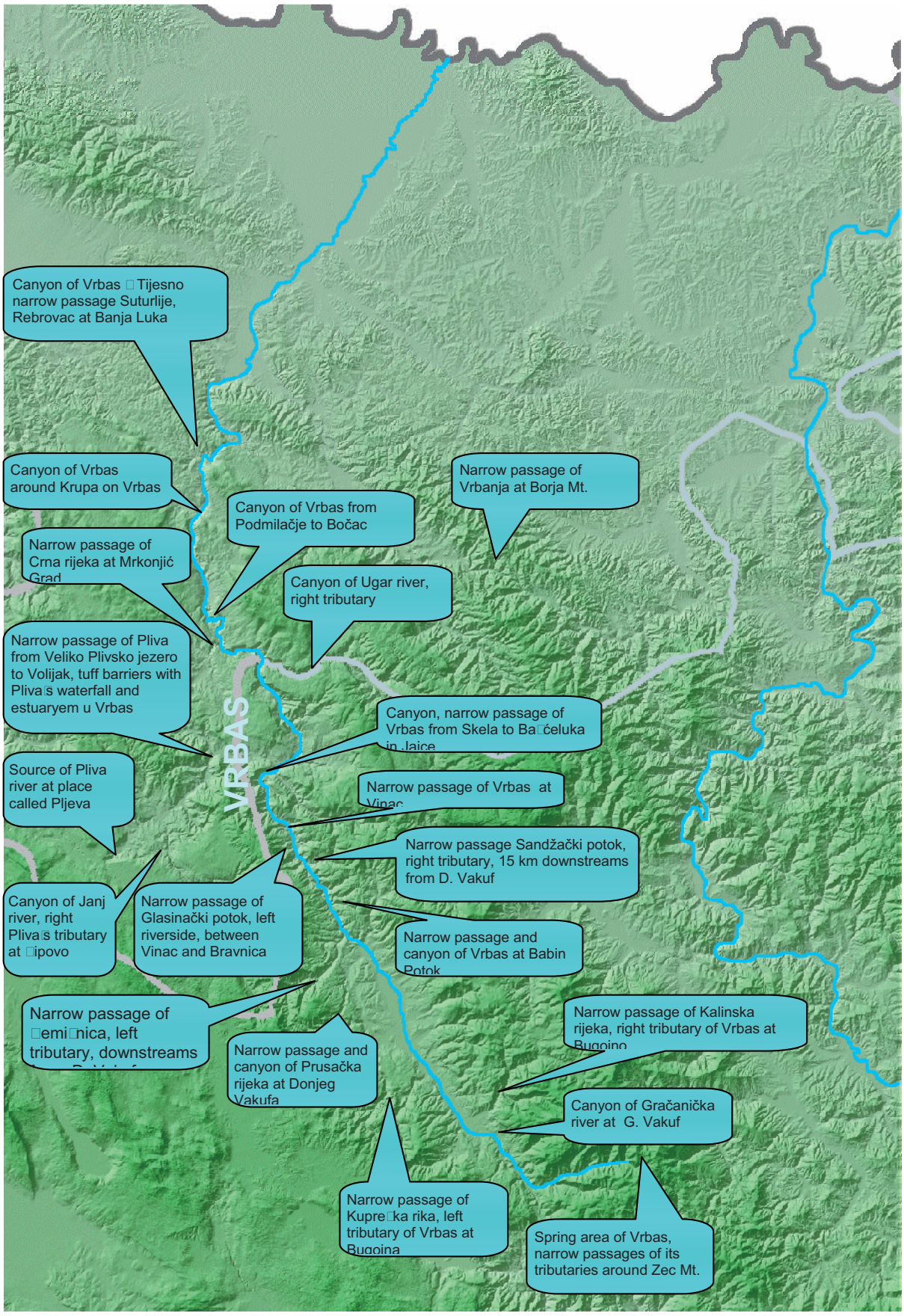



Figure 9. – Relict-refugial habitats in the basin of Vrbas river

Table 38. – Syntaxonomic overview of the communities in refugio-relict habitats in the basin of Vrbas river

| | | |
|---|---|---|
| Vegetation of rock crevices | ASPLENIETEA RUPESTRIS (H.Meier) Br.-Bl. 1934 | POTENTILLETALIA CAULESCENTIS Br. – Bl. |
| | | Moehringion muscosae Ht. et H-ic. 1959 |
| | | *Moehringio – Corydaletum* Ht. 1962 |
| | | *Saxifrago – Polypodietum australis* Lakušić et Redžić 1991 |
| | | *Achnanthero – Moehringietum malyi* Lakušić et Redžić 1991 |
| | | Potentillion caulescentis |
| | | *Potentilletum persicinae* Blečić 1958 |
| | | *Moehringio-Potentilletum persicinae* Redžić |
| | | *Dianthetum petraeae* Redžić |
| | | Symphyandrion hofmanni Redžić 1983 |
| | | *Symphyandretum hofmanni* Redžić 1983 |
| | | *Hieracio-Symphyandretum hofmanni* Lakušić et al. 1980 |
| | | *Campanulo balcanicae-Symphyandretum hofmannii* Redžić 1983 |
| | | *Diantho-Symphyandretum hofmannii* Redžić et Omerović 1986 |
| Vegetation of screes | THLASPEETEA ROTUNDIFOLII Br. – Bl. 1947 | DRYPEETALIA SPINOSAE Quezel 1967 |
| | | Peltarion alliaceae H-ic (1956) 1958 |
| | | *Coridalo leiospermae-Symphyandretum hofmannii* Redžić et Omerović 1986 |
| | | *Micromerio thymifolii – Corydaletum leiospermae* Lakušić & Redžić 1991 |
| | | *Asplenio – Ceterachetum officinari* Lakušić & Redžić 1991 |
| | | *Campanulo sibiricae-Pelltarietum alliaceae* Redžić 1983 |
| | | Achnatherion calamagrostis Jenny-Lips 1930. |
| | | *Corydalo-Achnatheretum* Redžić et Omerović 1986 |
| Vegetation of light coniferous woods | ERICO – PINETEA Ht. 1959 | PINETALIA HELDREICHII – NIGRAE Lakušić 1972 |
| | | Pinion nigrae Lakušić 1972 |
| | | *Daphno cneori – Pinetum* Rt. 1967 |
| | | *Aquilegio-Pinetum nigrae* Redžić |
| Vegetation of relict dinaric fir woods | ABIETI – PICEETEA (Br. – Bl. 1939) Lakušić et al. 1979 | ABIETI – PICEETALIA (Br. – Bl. 1939) Lakušić et al. 1979 |
| | | Abietion albae (Ht. 1956) Lakušić et al. 1979 |
| | | *Calamagrosti – Abietetum* Ht. 1950 |
| | | *Rhamno – Abietetum* Fuk. 1958 |
| Vegetation of broadleaved deciduous woods | QUERCO – FAGETEA Br. – Bl. & Vlieger 1937 | QUERCETALIA PUBESCENTIS Br. – Bl. (1931) 1932 |
| | | Quercion pubescentis – petraeae Br. – Bl. 1931 |
| | | *Asparago tenuifolii – Quercetum pubescentis* Lakušić et Redžić 1991 |
| | | *Ostryo- Quercetum daleschampi* Redžić 1990 |
| | | *Aceri obtusati-Carpinetum betuli* Redžić et Omerović 1986 |
| | | OSTRYO – CARPINETALIA ORIENTALIS Lakušić, Pavlovic, Redžić 1982 |
| | | Carpinion orientalis Blecic &Lakušić 1966 |
| | | *Aceri – Carpinetum orientalis* Blecic &Lakušić 1966 |
| | | *Rusco – Carpinetum orientalis continentale* Lakušić et Redžić 1991 |
| | | Seslerio – Ostryon Lksic., Pavlov. & Redžić 1982 (Syn.: Orneto – Ostryon Tom. 1940 p.p.) |
| | | *Seslerio autumnalis – Ostryetum carpinifoliae* Ht. et H-ic. 1950 |
| | | FAGETALIA MOESIACAE Lakušić 1991 |
| | | Ostryo – Fagenion moesiacaeae B. Jovanovic 1976 |
| | | *Aceri obtusati – Fagetum (moesiacae)* Fab., Fuk. & Stef. 1963 |
| | | *Aceri – Tilietum mixtum* Stef. 1979 |
| | | FAGETALIA SYLVATICAE Pawlowsky 1928 |
| | | Acerion pseudoplatani (Oberd. 1959) Fukarek P. 1969 |
| | | Staphylleo-*Fraxinetum angustifoliae* Redžić 1983 |
| | | *Asplenio scolopendrii-Fraxinetum angustifoliae* Redžić |
| Vegetation around thermal sprionge and half- shaded habitats | ADIANTETEA | Adiantetalia |
| | | Adiantion |
| | | *Adianthetum capili-veneri* |
| | | *Symphyandro-Adiaantetum capili-veneri* |
| | | *Asplenio scolopendrii-Symphyandretum hofmannii* Redžić |

*"The refugia in the basin of Vrbas river are characterized by a unique biodiversity, represented by many plant, animal and mushroom species.*
*Right here, in the rocks of Vrbas river's canyon, is the locus classicus of bosnian bellfower Symphyandra hoffmanni Pantocs., for the first time collected by Florian Hoffmann, passionate collector of plants in the valley of Suturlija near Banjaluka, and described by famous Hungarian botanist Jozef Pantoček. This jewell of Bosnia is exclusively bound to the basin of mighty Vrbas river, yet it can be found in few localities in the basin of Bosna river.*
*On the rocks of Hum Mt., above the fairy tale Jajce city, is the locus classicus of Corydalis ochroleuca subsp. leiosperma described and gifted to this country by Paul Conrath, famous botanist."* (quoted from TV show "Prirodna baština BiH")

This area's gen pool encompasses: Maly's sandwort (*Moehringia maly*), bavarian sandwort (*Moehringia muscosa*), potentil (*Potentilla caulescens* subsp. *persicina*), aster (*Aster bellidiastrum*), balkan's bellflower (*Campanula balcanica*), sibirian bellflower (*Campanula sibirica*), *Campanula lingulata*, pinks (*Dianthus sp.*), *Peltaria alliacea*, rocks campion (*Silene petraea*), fritillary (*Fritilaria tenella)* and others.
In the tuff barriers and its layers prevail alges, cyanophytes, mooses and aquatic insects (Plecoptera, Trichoptera, Diptera, Ephemeroptera) representing a valuable gen pool. In its travertine creations, some refugial habitats in the basin of Vrbas river are unique in the world. The most beautiful example of global importance is the basin of Pliva river, with the waterfall in Jajce city itself.
Thermal springs too take share in the landscapes of Vrbas river (Gornji Šeher near Banjaluka, Vrbanja and Laktaši). The thermal water habitats are rich in thermal kind of alges and cyanophytes, which supplements the value that they have got for their mineral content. There is a habitat of community with maidenhair fern *Adiantum capillus veneris*, which is very decorative and medicinal species, also considered as endangered.

## REFUGIO-RELICT ECOSYSTEMS IN THE BASIN OF BOSNA RIVER AND ITS TRIBUTARIES

The basin of Bosna river is characterized by the habitat's heterogeneity, diversity of flora, fauna and landscapes. Due to specific orogenesis and patterns of both ecoclimate and soil creation, formed were habitats of high biologic and ecologic value. Here has been preserved tertiary flora and fauna. These habitats are important for the entire landscape's diversity of Bosnia and Herzegovina.
There are different kind of refugial habitats relating to the main streamline and major tributaries. Among them, sources of Bosna river have got a significant function for the preservation of relict flora and fauna, which reffers also to the canyons of its upper tributaries.
High landscape's value of the refugial habitats of Željeznica, Miljacka and Vogošća rivers is accomplished by:

- Ecosystems of carbonate rock crevices;
- Ecosystems of screes on carbonate;
- Ecosystems of low woods and shrubs with hope hornbeam and autumn moor grass;
- Ecosystems of hope hornbeam and narrow-leaved moor grass;
- Ecosystems of *Quercus daleschampii* and hope hornbeam;
- Ecosystems of shrubs and scrubs with hope hornbeam and young fustic;

- Ecosystems of woods with moesian beech and autumn moor grass;
- Ecosystems of woods with bladdernut tree and hornbeam;
- Ecosystems of grey alder;
- Ecosystems of supra-mediterranean and continental rocky grassland on limestone and dolomite;
- Ecosystems of shrubs with alder buckthorn and autumn moor grass.

In the refugial habitats of Misoča and Stavnja rivers, right tributaries of Bosna river upstreams from Visoko town, the highest contribution to the landscape's value is given by tertiary-relict kind of ecosystems:

- Ecosystems with pinks and bellflowers in the rock crevices;
- Ecosystems of screes on carbonate with *Corydalis leiosperma*;
- Ecosystems of woods and shrubs with hope hornbeam and autumn moor grass;
- Ecosystems of low woods and shrubs with hope hornbeam and pubescent oak;
- Ecosystems with bosnian maple and moesian beech;
- Ecosystems with *Acer obtusatum* and oriental hornbeam.

In the basin of Fojnica river (left tributary of Bosna river), relict are:

- Ecosystems of woods and shrubs with bosnian maple and illyrian beech in the region of Lepenica river;
- Ecosystems with maple, oriental hornbeam and hope hornbeam in the region of Lepenica;
- Ecosystems with autumn moor grass, illyrian beech and hope hornbeam in the region of Lepenica;
- Ecosystems with false hellebore and oriental hornbeam in the region of Visočica at Visoko;
- Ecosystems with flowering ash and oriental hornbeam in the region of Buci at Visoko;
- Ecosystems with grey alder in the narrow passage of Fojnica river at Fojnica;
- Ecosystems with illyrian beech and bosnian bellflower in the valley of Kozica;
- Ecosystems of rock crevices with *Micromeria thymifolia*.

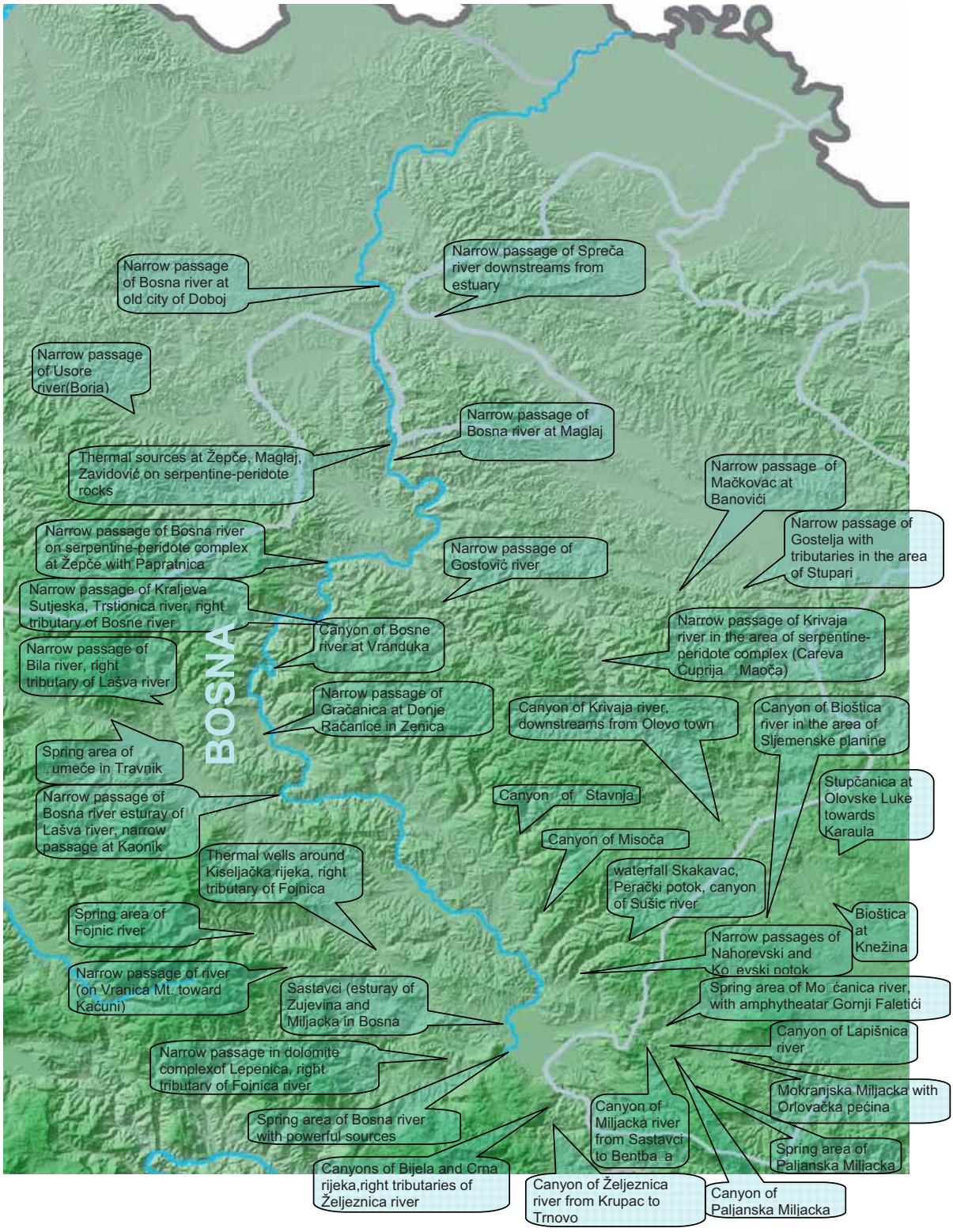



Figure 10. – Refugio-relict habitats in the basin of Bosna river

The largest refugium of tertiary flora and fauna in this area of Bosnia is the 1.000 m deep narrow passage (canyon) of Bosna river at Vranduk. There are many evidences that this area used to be connected with former Pannonian Sea which is obvious in the protrusion of warm continental masses coming from the North. The ecosystems with tertiary-relict character are:

- Ecosystems of low woods and shrubs with butcher's broom and oriental hornbeam;
- Ecosystems of low woods and shrubs with oriental hornbeam and maple;
- Ecosystems of silicate rock crevices;
- Ecosystems of woods with illyrian beech and snowdrop;
- Ecosystems of woods with hope hornbeam and illyrian beech.

In the basin of Lašva river (left tributary of Bosna river) occur several refugial habitats (Kaonik, narrow passage of Bila and source of Šumeća). Its main refugial elements are tuff creations and communities in the ecosystems:

- Ecosystems with bosnian bellflower on tuff layers;
- Ecosystems with oriental hornbeam and young fustic;
- Ecosystems around springs with aquatic mosses;
- Ecosystems with illyrian beech and european mountainash;
- Ecosystems with illyrian beech and dinaric gentian.

In the midle of Bosna river's valley, near Žepče, in the zone of very dynamic relief and old volcanic rocks (peridote, serpentine, amphibol, piroxen) occur refugia of tertiary flora and fauna:

- Ecosystems of rock crevices and screes;
- Ecosystems of serpentine rocky grassland with *Halacsya sendtneri*;
- Ecosystems of serpentine screes with figwort;
- Ecosystems of relict black pine woods with heath;
- Ecosystems of shrubs with young fustic, hope hornbeam and flowering ash;
- Ecosystems of thermal springs.

The basin of Gostović river (right tributary of Bosna river) at Zavidovići, is characterized by the specificity of occuring ecosystems:

- Ecosystems of serpentine-peridote rocky grassland;
- Ecosystems of serpentine-peridote rock crevices and screes;
- Ecosystems of black pine woods;
- Ecosystems of low woods and shrubs with hope hornbeam, flowering ash and beech;
- Ecosystems of thermal springs.

Krivaja river (right tributary of Bosna river) with its estuary at Zavidovići is characterized by the highest biodiversity level in the entire basin of Bosna river. The diversity of relief, geologic foundation, soil types, especially flora, fauna and vegetation is fully expressed here. The basin of Bioštica river has got special landscape's value for its spring area at Knežina, in deep canyon between Sljemenske Mt., encompasses relict ecosystems:

- Ecosystems with aquatic mosses, macro- and microphytes;
- Ecosystems with hope hornbeam and autumn moor grass;
- Ecosystems with beech and european mountainash;
- Ecosystems with oriental hornbeam and maple;
- Ecosystems of grey alder;
- Ecosystems of carbonate rock crevices.

After the junction of two rivers, Bioštica and Stupčanica, emerges Krivaja river at Olovo. From there, it flows through the most impressive canyon of 300 m depth, which is mainly built of carbonate rocks. Here is one of the largest tertiary flora and fauna refugia in this dinaric area, characterized by:

- Ecosystems with autumn moor grass and hope hornbeam;
- Ecosystems with narrow-leaved moor grass and hope hornbeam;
- Ecosystems with illyrian beech and hope hornbeam;
- Ecosystems with maple and oriental hornbeam;
- Ecosystems with grey alder;
- Ecosystems with pinks and bellflowers in the carbonate rock crevices;
- Ecosystems of carbonate screes.

Narrow passages of Krivaja river and its tributaries, in the zone of ophiolites (Careva Ćuprija, Maoča) encompass many refugia with:

- Ecosystems of black pine woods and Balkan daphne;
- Ecosystems of black pine woods with broad-leaved moor grass;
- Ecosystems with hornbeam and dog's tooth violet;
- Ecosystems with black pine and yellow gentian;
- Ecosystems of rock crevices with *Selaginella sp.*;
- Ecosystems of screes with beck's violet;
- Ecosystems of rocky grassland with maly's potentil;
- Ecosystems of rocky grassland with *Halacsya sendtneri* and *Notholaena maranthe*.

Narrow passages of Bosna river at Maglaj city are characterized by the occurence of tertiary-relict communities on reffering habitats, whereby special landscape attributes are given by:

- Ecosystems of rocky grassland with *Halacsya sendtneri*, at *locus classicus* of this endemo-relict species;
- Ecosystems of serpentine rocky grassland with fennel;
- Ecosystems of black pine woods;
- Ecosystems of low woods and shrubs with hope hornbeam and oriental hornbeam.

In the area of Mravići village, on dynamic peri-pannonian terrain where the protrusion of continental masses from the North is obvious, emerge refugial habitats. These are habitats occuring on carbonate bedrock, steep slopes (up to 70°), shallow soil like rendsine and regosol, and warm climate. In this landscape of Bosnia, relict ecosystems are:

- Ecosystems with hope hornbeam, silver linden and *Eranthis hyemalis*;
- Ecosystems with hope hornbeam, hornbeam and *Eranthis hyemalis*;
- Ecosystems with *Quercus daleschampii,* silver linden and butcher's broom;
- Ecosystems of carbonate rock crevices with *Polypodium vulgare*.

In the area of Usora river (left tributary of Bosna river) with its estuary at Doboj city, on the serpentine-peridote complex of Borja Mt. occur refugia of the relict ecosystems:

- Ecosystems of serpentine rocky grassland and screes with *Silene wildenovi*;
- Ecosystems of black pine woods;
- Ecosystems of thermal springs.

In the area of mineral spring in Tešanj, at altitude of 300 m, emerge valuable habitats of the communities with fir and illyrian beech. In the narrow passage of Tešanjka river occur inter-

esting communities of carbonate rock crevices.
The basin of Spreča river is characterized by high diversity of habitats and ecosystems. Among whome protrude the refugia in the narrow passages of Gostilja river and its tributaries near Stupari, with tertiary-relict ecosystems:

- Ecosystems of tall woods with hope hornbeam at Kozica;
- Ecosystems of low woods and shrubs with hope hornbeam and young fustic;
- Ecosystems of low woods and shrubs with hope hornbeam and autumn moor grass;
- Ecosystems of woods with bosnian maple and illyrian beech;
- Ecosystems of woods with bosnian maple and hornbeam;
- Ecosystems of carbonate rock crevices with saxifrage;
- Ecosystems of shrubs with oriental hornbeam;
- Ecosystems of silver linden and butcher's broom in Spreča canyon (Stanić rijeka).

In the valley of Oskova river (left tributary of Gostilj river), near Banovići, Svatovac and Mačkovac, occur the refugia with ecosystems:

- Ecosystems of black pine woods with heath;
- Ecosystems of black pine woods with *Halacsya sendtneri*;
- Ecosystems with sessile oak and heath;
- Ecosystems of serpentine rocky grassland and screes;
- Ecosystems of thermal and mineral springs.

## REFUGIA IN THE PERI-PANNONIAN AREA

In the peri-pannonian area of Bosnia and Herzegovina occur several refugial habitats with the unique biodiversity values.

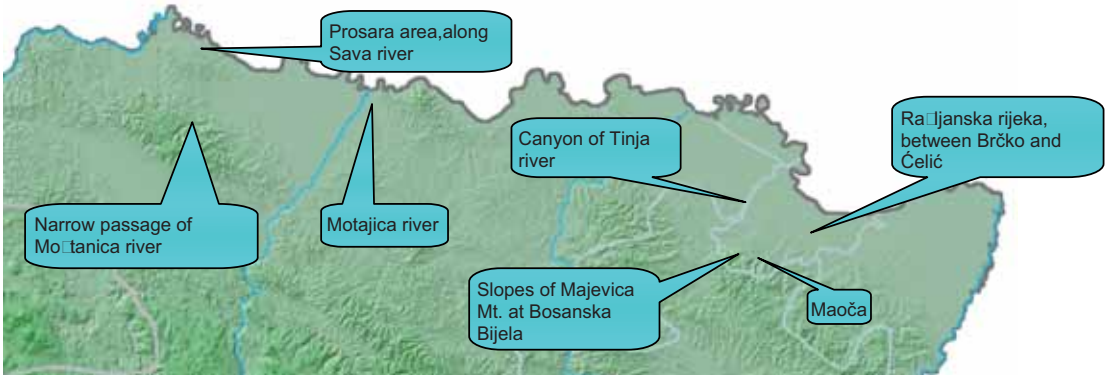



Figure 11. – Refugio-relict habitats in the peri-pannonian area

The creation and maintenance of the refugia in this area was enabled by factors that are most dominant here: specific geogensis and orogenesis, geologic and geomorphologic diversity, existance and withdrawal of Pratetis, and impacts of the continental climate.
Here emerge many well preserved narrow passages, canyons, caves, half-caves and other similar phenomena witnessing the activity of above named factors.
In the narrow passage of Moštanica river, its refugial shelter have found the ecosystems with silver linden and fir (at 250 m above sea level), then ecosystems of mountain streams on silicate bedrock with high richness of alges and tall herb communities.
The canyon of Tinja river (between places Tinja and Srebrenik) is built of carbonate rocks. This ought to be the first canyon from the Pannonia toward central Bosnia, being therefore very important for the survival of tertiary-relict species. It is under strong in-

fluences of temperate continental climate from the South and warm continental climate from the North. The canyon is characterized by high geologic diversity reflected in:

- Ecosystems of organogenous and carbonate rock crevices with bosnian bellflower around caves and half-caves;
- Ecosystems with silver linden, *Quercus daleschampii* and english holy;
- Ecosystems with autumn moor grass and hope hornbeam;
- Ecosystems with pubescent oak and young fustic.

Similar ecosystem types occur in the nearest surrounding of an old city called Srebrenik, where in the complex with thermophilous woods and shrubs they create an ambiental unit of immense importance for the landscape's diversity in the pannonian and peri-pannonian region.

On the northern slopes of Majevica Mt., going from Bosanska Bijela to Ćelić, is fully expressed the diversity of both geologic foundation and living world. This is the result of the former Pannonian Sea's presence. Here, in the carbonate layers, can be found fossiles, caves and half-caves, and different kind of tuff creations.

These peri-pannonian refugia are well known habitats of:

- Ecosystems on organogenous rocks with bosnian bellflower;
- Ecosystems with pubescent oak and hope hornbeam;
- Ecosystems with hope hornbeam and autumn moor grass;
- Ecosystems with bosnian maple and peri-pannonian beech;
- Ecosystems with *Quercus daleschampii* and silver linden;
- Ecosystems with silver linden, sessile oak and butcher's broom;
- Ecosystems with common oak and butcher's broom;
- Ecosystems with silver linden, sessile oak and *Ruscus hypoglossum*;
- Ecosystems with peri-pannonian beech and *Ruscus hypoglossum.*

## REFUGIO-RELICT ECOSYSTEMS IN THE BASIN OF DRINA RIVER AND ITS TRIBUTARIES

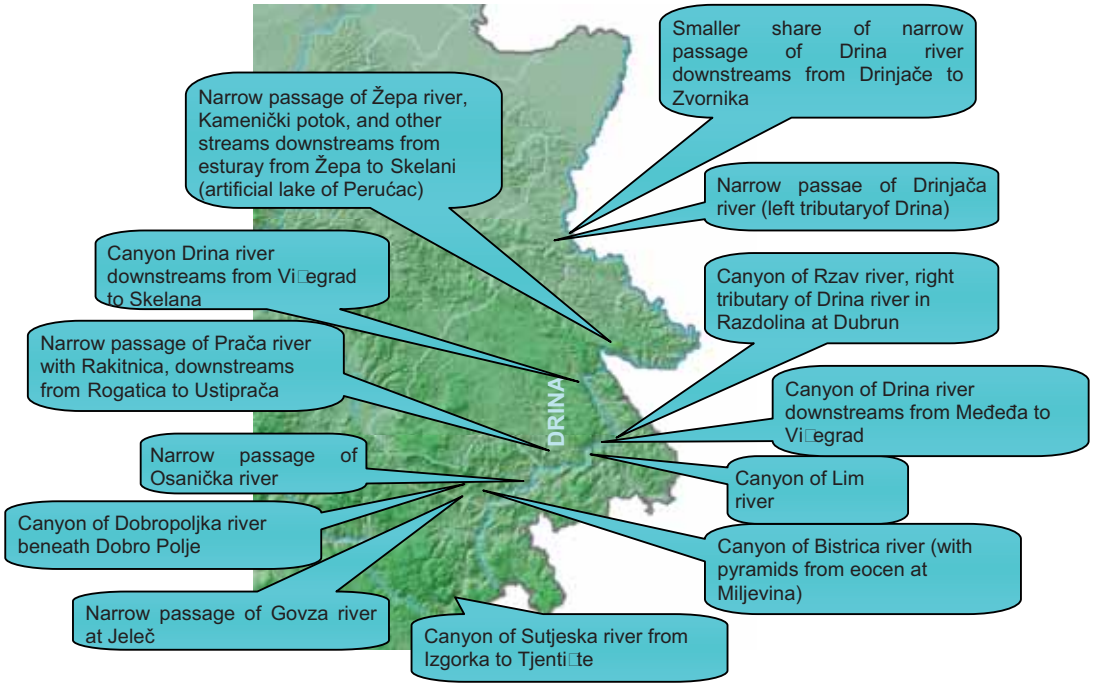



Figure 12. – Refugio-relict habitats in the basin of Drina river

In the basin of Drina river recognized are many refugia of tertiary flora, fauna and vegetation.

Refugial habitats in the basin of Drina river are centres of both species and ecologic diversity. In this area occur the populations of many stenoendemic and endemic species (endemic species of Bosnia, Dinaric Alps and Balkan) making it valuable on the global scale. Similar centres are to be found in the refugia of Neretva river, whereas on larger scale they occur today on Pirines and Apennine peninsula, Little Asia and Himalays. Right here in these refugia emerge best preserved fragments of nature in the entire Europe (primeval forest Perućica, primeval forest reserve with illyrian black pine and moesian beech in the canyon of Sutjeska river, woods with Serbian spruce in the midle of Drina river's canyon, than canyons of Žepa and Govza rivers, polydominant communities with hope hornbeam, flowering ash, silver linden, bosnian maple, oriental hornbeam and wallnut, then many stenoendemic communities of carbonate rock crevices and screes.

Table 39. – Endemic geen pool of plants in tertiary refugia of Drina river's basin

| |
|---|
| *Edraianthus sp., Daphne malyana, Atamantha haynaldii, Saxifraga rocheliana, Centaurea incompta, Dianthus kitaibelii, Cerastium lanatum Centaurea derventana, Auilegia grata, Amphoricarpus autariatus, Valeriana brauni-blanceti, Campanula balcanica, Adenophora liliifolia, Cirsium wetsteinii, Cicerbita pancicii, Melampyrum hoermanianum, Opoponax hironium, Corylus colurna, Achillea abrotanoides, Teucrium arduinii, Corydalis leiosperma, Taxus baccata, Acer hircanum, Acer intermedium , Cytisus tomasinii, Iris bosniaca,* itd. |

Table 40. – Syntaxonomic overview of the communities in refugio-relict habitats of Drina river's basin

| | | |
|---|---|---|
| **Vegetacija u pukotinama stijena** | **ASPLENIETEA TRICHOMANIS** Br. – Bl. 34 corr. Oberd. 77 | **üüüüüüüüü** Lakušiæ1968 |
| | | **Protoedraianthion tarae** Lakušiæ1988 |
| | | *Protoedraianthetum glisicii* Lakušiæ1988 ass. nova |
| | | **Amphoricarpion autariati** Lakušiæ1968 |
| | | *Silenetum (petraeae) serbicae* Lakušiæet Redžiæ1988 |
| | | *Atamanthetum haynaldii* Lakušiæet Redžiæ1988 |
| | | *Edraiantho-Globularietum cordifoliae* Lakušiæet Redžiæ1988 |
| | | *Genisto dalmaticae – Daphneetum malyanae* Lakušiæet Redžiæ1988 |
| | | *Saxifragetum rochelinae* Blecic 1958 |
| | | *Seslerio – Saxifragetum crustatae* Lakušiæet Puvelic 1979 |
| | | *Centaureo incompte – Asteretum belidiastri* Lakušiæet Redžiæ1988 |
| | | *Micromerio – Dianthetum kitaibeli* Lakušiæet Redžiæ1988 |
| | | **Edraianthion jugoslavici** Lakušiæ1975 |
| | | *Achilleo serbicae – Edraianthetum jugoslavici* Lakušiæ1969 |
| | | *Edraiantho – Dianthetum kitaibeli* Lakušiæ1975 |
| | | *Cerastietum lanati* Lakušiæet Redžiæ1988 |
| | | *Edraiantho – Centauretum derventanae* Lakušiæet Redžiæ1988 |
| | | *Moehringio – Asplenietum lepidi* Lakušiæ1972 |
| | | **MOLTKEETALIA PETRAEAE** Lakušiæ1968 |
| | | **Edraianthion** Lakušiæ1968 |
| | | *Campanuletum balcanicae* Lakušiæet Redžiæ1988 |

| | | |
|---|---|---|
| Vegetacija sipara | THLASPEETEA ROTUNDIFOLII Br. – Bl. 1947 | **ARABIDETALIA FLAVESCENTIS** Lakušić 1968 |
| | | **Corydalion ochraleucae** Lakušić 1975 |
| | | *Corydalo – Geranietum macrorhyzi* Blecic 1958 |
| | | *Thalictro – Geranietum macrorhyzi* Lakušić et Redžić 1988 |
| | | *Corydalo – Cardaminatum graecae* Lakušić et Redžić 1988 |
| | | *Moehringio – Corydaletum ochroleucae* Lakušić 1975 |
| | | **Peltarion *alliaceae*** *H-ic (1956) 1958* |
| | | *Marrubio – Rumicetum scutati* Lakušić et Redžić 1988 ass. nova |
| | | **Achnatherion calamagrostis** Jenny – Lips 1930 (Stipeion **calamagrostidis** Jenny – Lips 1930) |
| | | *Achnanthero – Petasitetum kablikianii* Lakušić et Redžić 1988 ass. nova |
| Vegetacija visokih zeleni | CARDUUO – CIRSIETEA Lakušić 1978 | **CICERBITETALIA** Lakušić 1978 |
| | | *Cirsio – Cicerbitum pancici* Lakušić et Redžić 1988 |
| | | *Cicerbito – Petasitetum hybridi* Lakušić et Redžić 1988 |
| | | *Molinio – Adenophoretum liliifoliae* Lakušić et Redžić 1988 |
| | | *Chaerophyllo – Cirsietum wettsteinii* Lakušić et Redžić 1988 |
| Vegetacija liščarsko listopadnih šuma | QUERCO – FAGETEA Br. – Bl. et Vlieg. 37 | **OSTRYO – CARPINETALIA ORIENTALIS** Lakušić, Pavlovic, Redžić 1982 |
| | | *Querco – Carpinetum montenegrinum* Blecic 1957/8 |
| | | *Carpino orientalis – Quercetum cerris* Lakušić 1976 |
| | | *Aceri – Carpinetum orientalis* Blecic et Lakušić 1966 |
| | | *Seslerio angustifoliae – Ostryetum carpinifoliae* Lakušić 1975 |
| | | *Carpino betuli – Ostryetum carpinifoliae* Lakušić et Redžić 1988 |
| | | **FAGETALIA SYLVATICAE** Pawlowsky 1928 |
| | | **Fagion moesiacae** Blecic et Lakušić 1970 |
| | | *Fraxino excelsioris – Fagetum moesiacae* Lakušić et Redžić 1988 |
| | | *Convallario – Fagetum moesiacae* Lakušić et Redžić 1988 |
| | | *Seslerio autumnalis – Fagetum moesiacae* Blecic et Lakušić 1970 |
| Vegetacija četinarskih šuma | ABIETI – PICEETEA (Br. – Bl. 1939) Lakušić et al. 1979 | **ABIETI – PICEETALIA** (Br. – Bl. 1939) Lakušić et al. 1979 |
| | | **Piceion omorikae** Lakušić 1982 |
| | | *Ostryo – Piceetum omorikae* Lakušić et al. 1982 |
| Vegetacija borovih šuma | ERICO – PINETEA Ht. 1959 | **PINETALIA HELDREICHII – NIGRAE** |
| | | **Pinion nigrae** Lakušić 1972 |
| | | *Junipero – Pinetum nigrae* Lakušić et Redžić 1988 |
| | | *Fago moesiacae – Pinetum nigrae* Lakušić et Vuckovic 1984 |

The unique development patterns of both hygrophilous and hydrophilous plant and animal communities is the result of specific geogenesis, pedogenesis and syngenesis in the ecosystems of riverside. There is a great number of endemic forms and tertiary relicts among insects (Psychodida, Ephemeroptera, Plecoptera, Trichoptera, Orthoptera, Ropalocera). The biodiversity in this area is high due to the diversity and abundance of mammals, birds, reptiles, amphibians and species belonging to pedofauna or realm of fungi. In the biodiversity in general, important place take salmonids, of which *Hucho hucho* and brown trout have preserved their indigenous genetic lines. Along the riversides of deep canyons still exists the diversity of natural gen pool, contained in least investigated and potentially, in economic sense, significant species, such as wild cherry, apple tree, common plar tree, rockcherry, eu-

ropean mountainash, raspberry, black berry, wallnut tree.
The spatial and temporal organisation reflect high species biodiversity, which is visible in the ecosystems that landscapes of Drina river's basin are composed of.

## REFUGIAL AND RELICT ECOSYSTEMS IN THE BASIN OF NERETVA RIVER

The Neretva river on its long journey flows through the deepest and best preserved canyons and narrow passages not only in Bosnia and Herzegovina, but in the entire world. The insulation in orographic sense toward the North, and strong influence of mediterranean climate from the South, enabled the unique process of both climate and living world evolution in this area.
It is not often the case that the climate diversity is as high as in the basin of Neretva river. Namely, here exchanges mediterranean, supra-mediterranean, temperate continental and typical mountain climate in the upper area.
The canyon's depth (reaching in some places close to 2.000 m), carbonate geologic foundation and ecoclimate specificities have caused the occurence of development centres of endemic flora, fauna and vegetation. By its biodiversity level, this area is one of the most significant and best preserved endemic development centres on global scale.
The refugial habitats in the basin of Neretva river posses unique geomorphologic forms, high diversity of: soils, hydrologic network and ecoclimate, which resulted in the highest level of species and ecologic diversity in Bosnia and Herzegovina, and even wider in Dinaric Alps.
In the upper flow of Neretva river, in the canyons, contained are a genuine forms of both biotic and abiotic nature, as well as the richness of stenoendemic and relict plant and animal species. One of the most unique canyons in the area is canyon of Rakitnica river. The refugia of mountains Prenj, Čvrsnica and Čabulja are development and survival centres for the endemic gen pool. These refugial habitats owe their landscape's value to the endemic communities of broadleaved deciduous forests and shrubs, light coniferous woods and shrubs, hygrophilous woods and shrubs with willow, alder, poplar and oriental plane, and especially to the wildlife of carbonate rock crevices and screes.

Canyon of Neretva river

If we go downstreams from the source of Neretva river and its tributaries we can selecte many spatial and ecologic units with the refugial character:

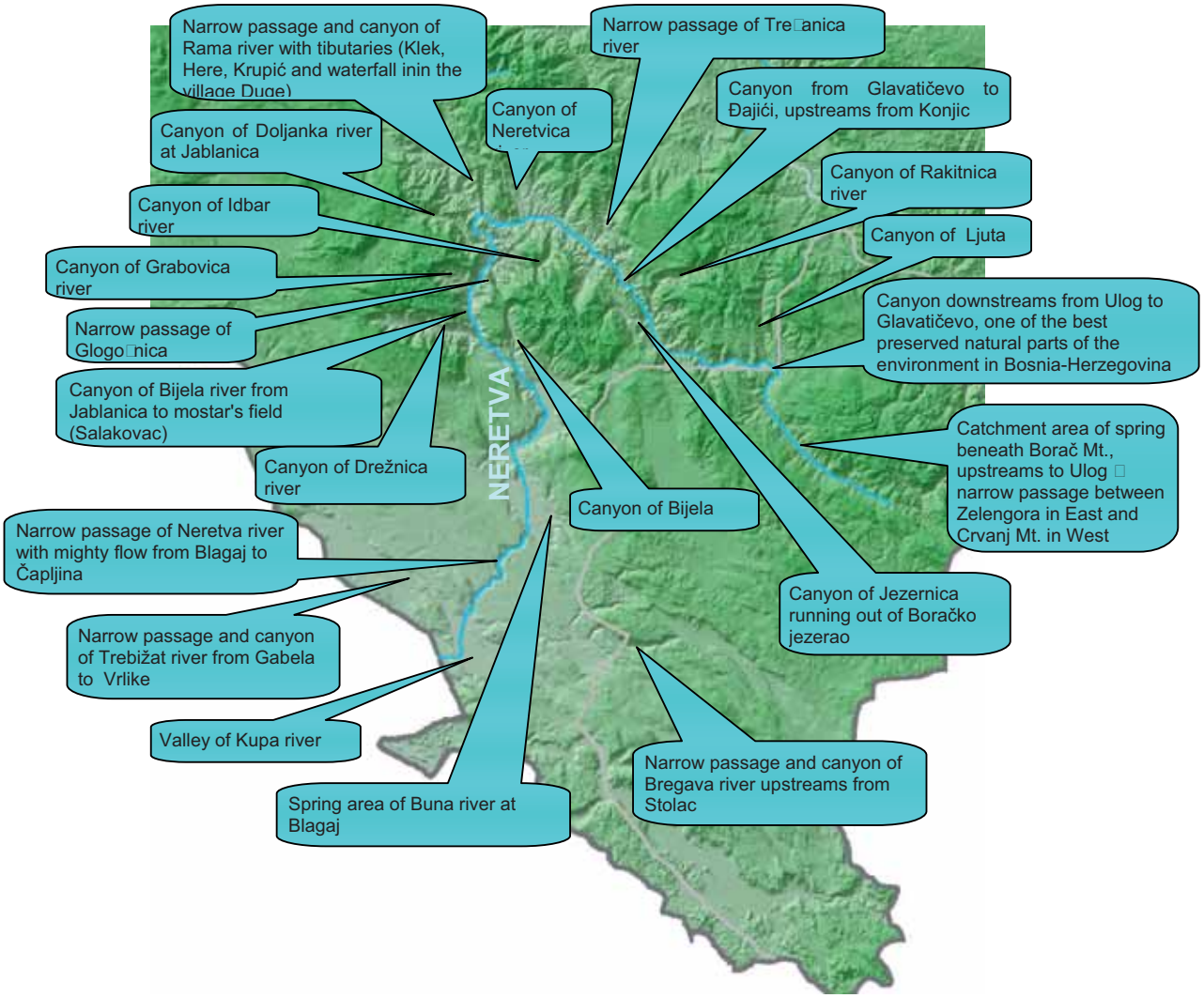



Figure 13. – Refugio-relict habitats in the basin of Neretva river

The uniqueness of landscapes in the refugial habitats is underlined by the communities of thermophilous italian oak (forming special form of herzegovina's woods at Donja Jablanica) and chestnut (that on silicate bedrock in lower flow of Neretva river and around Neretvica's estuary forms herzegovina's chestnut forests).

The refugial habitats of Neretva river and its tributaries are important for their endemo-relict gen pool, but also for the gen pool that enables sustainable bee keeping, production of phytopharmacs, sustainable cattle breeding, fruit-gardening and production of vegetables. The primary lines of many cultivated plants (wild sorts of vine, cherry, apple, pear, rockcherry, fige and pomegranate) have been poorly investigated yet.

In Neretva river, water is characterized by high biologic quality in most of its flow. Thus, many (endemic) alges, mosses, crabs, aquatic insects and fish live in it.

However, the anthropogenous impact that grows each day endangers mainly endemic species (soft-muzzled and brown trout), which are under threat to become extinct.

In the basin of Neretva river, many refugial habitats posses karst relief's features. The maintenance of these habitats is directly

connected with the state in the entire basin, especially with the state in one of the largest deltas in Europe – Hutovo blato, which is the wetland of international importance, is placed within.

To the uniqueness of landscapes contribute tuff creations as a result of travertine building processes. The continual activity of water, alges, mosses and aquatic insects results in the formation of different "alive" rocks (tuff or travertine). Travertine makes barriers that clear and clean water flows over building cascades and waterfalls of the magnificient beauty. These are true emeralds of bosnia-herzegovina's natural heritage.

Most famous cascades are at GornjaNeretva, Đajića buk, on Krupić river at Duge village, and waterfalls and cascades on Trebižat river (Kravice and Koćuša). Under tuff barriers occur habitats of maidenhair fern (*Adiantum capillus veneris*), which is endangered relict species with the outstanding decorative attributes.

Table 41. – Endemic gen pool of plants in tertiary refugia of the Neretva river's basin

| | | |
|---|---|---|
| **Vegetacija u pukotinama stijena** | **ASPLENIETEA RUPESTRIS** (H.Meier) Br.-Bl. 1934 | **MOLTKEETALIA PETRAEAE** Lakušić 1968 |
| | | **Edraianthion** Lakušić 1968 |
| | | *Centaureo glaberimae – Onosmetum stellulati* Lakušić & Redžić 1991 |
| | | *Centaureo deustae – Campanuletum pyramidalis* Lakušić & Redžić 1991 |
| | | *Heliospermo retzdorffiani-Oreoherzogietum illyricae Šilić 1970* |
| | | **AMPHORICARPETALIA** Lakušić 1968 |
| | | ***Amphoricarpion autariati*** Lakušić 1968. |
| | | *Athamanthetum haynaldii Lkšić.et Redž. 1988* |
| | | **Micromerion croaticae** Ht. 1931 |
| | | *Edraiantho – Potentilletum clusianae* Lakušić 1968 |
| | | *Asplenietum fissi* Ht. 1931 |
| | | *Potentilletum clusianae* Ht. 1931 |
| | | **POTENTILLETALIA CAULESCENTIS** Br. – Bl. |
| | | **Moehringion muscosae** Ht. et H-ic. 1959 |
| | | *Moehringio – Corydaletum* Ht. 1962 |
| **Vegetacija sipara** | **THLASPEETEA ROTUNDIFOLII** Br. – Bl. 1947 | **DRYPEETALIA SPINOSAE** Quezel 1967 |
| | | **Peltarion alliaceae** H-ic (1956) 1958 |
| | | *Micromerio thymifolii-Corydaletum leiospermae Lkšić.et Redž. 1991* |
| | | *Marrubio-Rumicetum scutati Lkšić.et Redž. 1988* |
| | | ***Achnatherion calamagrostis* Jenny-Lips 1930.** |
| | | *Achnathero-Petasitetum kablikiani Lkšić.et Redž. 1988* |
| | | *Micromerio thymifolii – Corydaletum leiospermae* Lakušić & Redžić 1991 |
| | | *Asplenio – Ceterachetum officinari* Lakušić & Redžić 1991 |
| | | **ARABIDETALIA FLAVESCENTIS** Lakušić 1968 |
| | | **Silenion marginatae** Lakušić 1968 |
| | | *Cerastietum dinaricae* Ht. 1931 |
| | | **Bunion alpini** Lakušić 1968 |
| | | *Bunio – Iberetum* carnosae Ht. 1931 |
| | | *Euphorbio-Valerianetum bertisceae Lkšić. 1968* |
| | | ***Silenion marginatae*** Lakušić 1967. |
| | | *Geranio-Heracleetum balcanicum Lkšić. 1967* |
| | | *Dripidi-Silenetum marginatae Lkšić.1967* |
| | | ***Saxifragion prenjae*** Lakušić 1967. |
| | | *Saxifrago-Papaveretum kerneri Lkšić. 1967* |
| | | *Sagino-Gnaphalietum pichlerii Lkšić. 1968* |

| | | |
|---|---|---|
| Vegetation of xeric meadows | FESTUCO – BROMETEA Br. – Bl. | **SCORZONERO – CHRYSOPOGONETALIA** H-ic & Ht. (1956) 1958 |
| | | **Satureion montanae** Ht. 1962 |
| | | *Physospermo – Satureietum montanae* Redžić et Lakušić 1991 |
| | | *Artemisio albae – Rutetum* Redžić et Lakušić 1991 |
| | | **Satureion subspicatae** Ht. 1962 |
| | | *Satureio subspicatae – Festucetum dalmaticae* Redžić et Lakušić 1991 |
| Vegetation of pine woods | ERICO – PINETEA Ht. 1959 | **PINETALIA HELDREICHII – NIGRAE** Lakušić 1972 |
| | | **Pinion nigrae** Lakušić 1972 |
| Vegetation of coniferous woods | ABIETI – PICEETEA (Br. – Bl. 1939) Lakušić et al. 1979 | **ABIETI – PICEETALIA** (Br. – Bl. 1939) Lakušić et al. 1979 |
| | | **Abietion albae** (Ht. 1956) Lakušić et al. 1979 |
| | | *Calamagrosti – Abietetum* Ht. 1950 |
| | | *Rhamno – Abietetum* Fuk. 1958 |
| Vegetation of broadleaved deciduous woods | QUERCO – FAGETEA Br. – Bl. & Vlieger 1937 | **QUERCETALIA PUBESCENTIS** Br. – Bl. (1931) 1932 |
| | | **Quercion pubescentis – petraeae** Br. – Bl. 1931 |
| | | **Quercion petraeae – cerris** (Lakušić 1976) Lakušić et B. Jovanovic 1980 |
| | | **OSTRYO – CARPINETALIA ORIENTALIS** Lakušić, Pavlovic, Redžić 1982 |
| | | **Carpinion orientalis** Blecic &Lakušić 1966 |
| | | *Aceri – Carpinetum orientalis* Blecic &Lakušić 1966 |
| | | *Rusco – Carpinetum orientalis continentale* Lakušić et Redžić 1991 |
| | | **Seslerio – Ostryon** Lksic., Pavlov. & Redžić 1982 (Syn.: **Orneto – Ostryon** Tom. 1940 p.p.) |
| | | *Seslerio autumnalis – Ostryetum carpinifoliae* Ht. et H-ic. 1950 |
| | | **FAGETALIA MOESIACAE** Lakušić 1991 |
| | | **Ostryo – Fagenion moesiacaeae** B. Jovanovic 1976 |
| | | *Aceri obtusati – Fagetum (moesiacae)* Fab., Fuk. & Stef. 1963 |
| | | *Aceri – Tilietum mixtum* Stef. 1979 |

Table 42. – Syntaxonomic overview of the communities in refugio-relict habitats of the Neretva river's basin

*Campanula hercegovina, Euphorbia hercegovina, Peteria ramentacea, Moltkaea petraea, Edraianthus tenuifoliuss, Pinus heldrechii, Pinus illyrica, Seseli tomasinii, Peucedanum neumayeri, Heliosperma retzdorphianum, Oreoherzogia illyrica, Potentilla speciosa, Potentilla persicina, Tanacetum cinerarifolium, Cardamine fiala, C. graeca, Reichardia macrophylla, Crepis pantocseki, Festuca corabensis, Silene reichenbachii, Centaurea nicolai, Acinos orontius, Onosma stellulata, Micromeria croatica, Rus coriaria, Celtis australis, Periploca graeca, Vitex agnus-castus, Platanus orientalis, Drypis jacquiniana, Peltaria aliacea.*

*Vipera ammodytes* (Linnaeus 1758).

# WETLAND LANDSCAPES IN BOSNIA AND HERZEGOVINA

Moorland and standing water are most endangered type of ecosystems today in Bosnia and Herzegovina. Due to valuable gen pool contained within them (different plant and animal species, birds, reptiles, amphibians and fishes) they enjoy highest priority in the systems of sustainable conservation.
Distribution of hydromorphous soils in Bosnia and Herzegovina is very limited (taking 15% of its territory) tending to become even less than that by melioration and drainage, which is the reason for wetlands to be distributed over small area.
This habitat type with often local character in Bosnia and Herzegovina is induced by specific orographic and edaphic conditions. Wetland is being formed either on leakage proof geologic foundation or different kind of depositions and deep hydromorphous soil.

Wetland landscapes include series of ecosystems with high ambiental values that give special ecologic and biogeographic features to the entire lowland.
These ecosystems have been possesing an outstanding economic value ever since. This is a habitat of many noble kind of fishes and game species that are considered to be a base for successful fishing and hunt. Wetland ecosystems that are actually forests, beside their ecologic importance, are important for making a gain based on wood production. Wetland ecosystems comprise significant resource of medicinal, edible and vitaminous plants.
Considering whole ecologic picture of Bosnia and Herzegovina, dominated by diverse terrestric kind of soils and vegetation, marsh ecosystems have got special importance in terms of being rare.

Table 43. – Syntaxonomic overview of the communities of B&H's wetlands

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| Vegetacija visokih tresetišta |
| OXYCCOCO – SPHAGNETEA Br.-Bl. et Tx. 1943 |
| SPHAGNETALIA FUSCI |
| Sphagnion fusci Br.-Bl. 1920 |
| *Comaro-Menyanthetum trifoliatae* Lkšić et col. 1969 |
| *Sphagnetum fusci* Luq. 1926 |
| *Sphagnetum medii* Kasn. et al. 1933 |
| Vegetacija primorskih močvara |
| JUNCETEA MARITIMI Br.-Bl. 1931 |
| JUNCETALIA MARITIMI Br.-Bl. 1931 |
| Juncion maritimi Br.-Bl. 1931 |
| *Juncetum maritimo-acuti* H-ić 1934 |
| Vegetacija brakičnih voda |
| RUPPIETEA MARITIMAE J. Tx 1960 |
| RUPPIETALIA MARITIMAE J. Tx 1960 |
| Ruppion maritimae J. Tx 1960 |
| *Ulvaetum lactucae adriaticum* Lkšić 1975 |
| Vegetacija niskih cretova |
| SCHEUCHZERIO – CARICETEA FUSCAE (Nordh. 1936) Tx. 1937 |
| CARICETALIA DAVALLIANAE Br.-Bl. 1949 |
| Caricion davallianae Klika 1934 |
| *Schoenetum nigricantis* W. Koch 1926 |
| *Valeriano – Caricetum buxbaumii* Rt. 1972 |
| *Eryophoro – Caricetum davallianae* Rt. 1972 |
| *Carici – Orchidetum bosniacae* Lkšić et Mišić1969 |
| Vegetacija bara i močvara |
| PHRAGMITETEA Tx. et Prsg. 1942 |
| PHRAGMITETALIA W.Koch 1926 |
| Magnocaricion W.Koch 1926 |
| *Mariscetum* Zobr. 1935 |
| *Hydrocotylo – Caricetum elatae* H-ić (1958 a) 1962 |
| *Acoreto – Glycerietum aquaticae* Slavnić 1956 |

Wetland ecosystems in Bosnia and Herzegovina emerge on leakage proof geologic foundation, frequently these are lake and river depostions, plain ground and natural formed depressions.
At present, that kind of ecosystems in Bosnia and Herzegovina occur along large watercourses (Una, Vrbas, Bosna, Drina, Nerteva) with hygrophylous woods and shrubs of willow, alder, purpule and marsh willow.

Going upwards on vertical profile of bosnia-herzegovina's Dinaric Alps, emerges special kind of wet habitats around springs and brooks. On some places occur bog ecosystems. At lower altitude form alkaline blanket bogs, whereas in the zone of dark coniferous woods (at altitude over 1.000 m) form raised bogs with a domination of bogmosses. In the subalpine belt. In the small depressions and around springs develop special form of boreo-relict blanket bogs.

Wetlands occur in many karst fields, too (Ždralovac area in Livanjsko polje, Buško

blato, Duvanjsko, Kupreško, Popovo, Dabarsko, Fatničko, Gatačko, Nevesinjsko and Podrašničko polje).

The most important wetland areas with macrophyte vegetation made of reedbed and pondweed in Bosnia and Herzegovina are:

- Hutovo blato in the Neretva delta's area not far from Čapljina;
- Ždralovac (northwestern part of Livanjsko polje toward Bosansko Grahovo);
- Plivska jezera by Jajce town;
- Bardača near Srbac at Vrbas river's estuary;
- Velika and Mala Tišina near Bosanski Šamac at Bosna river's estuary;
- Han Kram at Han Pijesak;
- Some regions on Modrac lake near Tuzla;
- Mountain lakes of bosnia-herzegovina's Dinaric Alps (Šatorsko, Kukavičko, Rastićevsko and Turjača on plateau of Kupres, Prokoško jezero on Vranica Mt., Blatačko jezero on Bjelašnica Mt., Idovačko jezero on Raduša Mt., Blidinje jezero in Dugo Polje between Čvrsnica and Vran Mt., Uloško jezero on Crvanj Mt.;
- Boračko jezero beneath Prenj Mt., Veliko, Blatno, Crno and Bijelo jezero on Treskavica Mt., Kotlaničko, Orlovačko, Crno, Bijelo, Štirinsko, Kladopoljsko, Donje Bare and Gornje Bare on Zelengora Mt.

Apart from these localities, there is a significant number of wetland ecosystems which provide habitats for stationary and migratory birds and are situated by lowland river's effluents, in the small depressions and along riverbanks.

| |
|---|
| ***Scirpo – Phragmitetum mediterraneum*** **Tx. et Prsg. 1942** |
| ***Polygono – Stratiotetum aloidis*** **Slavnić 1956** |
| **Vegetacija vodenjara** |
| **POTAMETEA Tx. et Prsg. 1942** |
| **POTAMETALIA W.Koch 1926** |
| **Potamion eurosibiricum W.Koch 1926** |
| ***Myriophyllo-Nupharetum*** **W.Koch 1926** |
| ***Myriophyllo-Potametum*** **Soo 1934** |
| ***Nasturtio – Beruletum angustifoliae submersae*** **Rt. 1972** |
| **Nymphaeion Oberd 1957** |
| ***Polygonetum amphibii – natantis*** **Lkšić et col. 1969** |
| ***Hydrocharidi – Nymphoidetum peltatae*** **Slavnić 1956** |
| ***Nymphoidetum peltatae*** **Oberd. et Th. Mull. 1960** |
| ***Lemno – Utricularietum vulgaris*** |
| ***Ranunculeto – Callitrichetum vernae*** **Bajić 1978** |
| **Vegetacija priobalnih područja slatkih voda** |
| **ISOETO – NANOJUNCETEA Br.-Bl. et Tx. 1943** |
| **Isoetetalia Br.-Bl. 1931** |
| **Nanocyperion flavescentis W.Koch 1926** |
| ***Eleocharetum ovatae*** **Hay.** |
| **Fimbristylion dichotomae H-ić 1954** |
| ***Cypero – Paspaletum distichi*** **H-ić 1954** |
| ***Paspaleto-Leersetum oryzoidis*** **Bajić 1978.prov** |
| **Vegetacija vodenjara sa plutajućim cvjetnicama** |
| **LEMNETEA W. Koch et Tx. 1954** |
| **Lemnetalia W.Koch et Tx.1954** |
| **Lemnion W.Koch et Tx.1954** |
| ***Lemnetum minoris*** **(Oberd. 1957) Th. Mull. et Gors. 1960** |
| ***Lemno – Spirodeletum polyrrhizae*** **W. Koch 1954** |
| ***Hydrocharidetum morsus – ranae*** **van Lengend. 1935** |
| ***Lemnetum trisulcae*** **Trinajstić 1964** |
| **Vegetaija oko izvora i potoka u gorskom i subalpinskom pojasu** |
| **MONTIO – CARDAMINETEA Br.-Bl. et Tx. 1943** |
| **Montio-Cardaminetalia Pawl.1928** |
| **Cardamino-Montion Br.-Bl. 1925** |
| ***Calthetum cornutae Lkšić*** **1965** |
| **Cratoneurion commutati W.Koch 1928** |
| ***Heliospermo – Saxifragetum stellaris*** **Pawl. et Lkšić 1966** |

## Ecosystems of wetland forest

Wetland's area in Bosnia and Herzegovina comprises standing water, reedbeds, sedges and bogs, but also hygrophilous woods and shrubs.

In the lowland area, on hydromorphous soil, such as fluvisol or swamp kind of gleys, along riverbanks of Sava river and estuaries of its tributaries, developed are:

- Ecosystems of silver leaved and black poplar;
- Ecosystems of white willow and black poplar;
- Ecosystems of alder and sedges;
- Ecosystems of alder and buckthorn;
- Ecosystems of snowflake and *Fraxinus angustifolia*;
- Ecosystems of white willow;
- Ecosytsmes of woadwaxen and common oak;
- Ecosystems of alder and common oak;
- Ecosystems of purpule willow shrubs;
- Ecosystems of basket willow shrubs.

In the basin of Neretva river, downstreams from Počitelj (Hutovo Blato, lower flow of Trebižat, Buna and Krupa rivers), landscapes are valuable for the occurence of:

- Ecosystems of oriental plane and black poplar;
- Ecosystems of silver leaved poplar and luštrike;
- Ecosystems of chaste tree shrubs.

At higher altitude, on hydromorphous soils of the alkaline blanket bogs, occur communities belonging to:

- Ecosystems of montane alder woods;
- Ecosystems of white and crack willow;
- Ecosystems of grey alder;
- Ecosystems of grey and black alder woods;
- Ecosystems of marsh willow shrubs;
- Ecosystems of green alder shrubs on Vranica Mt.

On raised bogs occur boreo-relict communities of:

- Ecosystems of downy birch;
- Ecosystems of spruce and bogmosses;
- Ecosystems of downy birch and Scot's pine;
- Ecosystems of mountain willow;
- Ecosystems of grey alder and bogmosses;
- Ecosystems of grey alder and spruce;
- Ecosystems of marsh willow shrubs;
- Ecosystems of green alder shrubs and bogmosses on Vranica Mt.

In the upland and subalpine belt, on hydromorphous soil, in the zone of broadleaved deciduous woods of beech and dark coniferous woods, covering small surface but possesing high ecologic value occur:

- Ecosystems of European ash and sycomore;
- Ecosystems of hornbeam and sycomore on Vranica Mt.;
- Ecosystems of grey alder and marsh pea;
- Ecosystems of sycomore and Scotch elm;
- Ecosystems of hornbeam and grey alder.

On stone rich fluvisols, often along the riverbanks and brooks, on places where the water regime strongly varies, developed are communities belonging to:

- Ecosystems of grey willow and *Petteria ramentacea* shrubs;
- Ecosystems of grey and creeping willow shrubs with sage.

In wetland forest communities, due to continual changes in water regime caused by human activities, many species are endangered including following ones: spring and summer snowflake, woadwaxen, black and grey alder, bogmosses, downy birch, laurel, willow, orchis and silver leaved poplar.

## Pressures onto wetland ecosystems

Forest wetlands are also under severe anthropogenic pressures which arise a danger that structure and ecologic stability of these ecosystems could get disturbed, whereby main threats are:

- Global climate changes followed by temperature extremes and frequent over-heating, which causes increase in eutrophication level resulting in the regression of sensitive plant species;
- Acid precipitation as a result of transboundary atmophere's pollution, changing significantly pH value in habitats, especially in upper layer of soil and water. Decrease in pH value influences the vitality and abundance of basophilous species effecting their reproduction success. This can cause disapearance of stenophyllous and species bound to neutral and alkaline water;
- Eutrophication and inflow of organic matter, most frequently by surface water;
- Conversion of wetland habitats as a consequence of property's transition leading to irreversible changes in ecosystem's structure (example: in the area around Bardača, downstreams from Banja Luka city, cleared was complete shore vegetation of woods and shrubs with willow, poplar and purpule willow, of surface amounting 600 ha. In order to produce large quantity of fish, wetland vegetation is being removed by machinery from almost each basin which destroys the wetlands'"heart" itself. The similar situtation is in the Ždralovac area, between Livno and Bosansko Grahovo, where it was permited concession for peat exploitation without a prior environmental impact assessment. This has caused severe damage to this pearl among the European, even world's, wetlands. Similar trends are to be expected in the Nature Park Hutovo Blato, also in the Buško blato area, and other localitites where there is an economic interest for fishing and hunt);
- Dry out as a result of melioration;
- Re-direction of surface streams that water-supply the wetlands (example: actions in the zone called Gornji horizonti, eastern Herzegovina);
- Impacts of drainage water arising from the agricultural acitivities.

## Pressures on wetland forests

Wetland forests are under tremendous anthropogenic presssure hence being in danger to have their floristic and faunistic composition disturbed and by that their ecologic balance, too. Main threats in Bosnia and Herzegovina are:

- Unselected and intensive felling;
- Continual drainage of underground water;
- Disturbances in surface water regime for a majority of watercourses;
- Continual water eutrophication;
- Unbalanced hunt and fishing;
- Continual inflow of fertilisers and pesticides washed out from arable land;

- Exploitation of humus-accumulative horizon;
- Artificially induced fires in some places;
- Unbalanced construction of residental, economic and travel infrastructure on riverbanks.

## Conservation status

Due to above named pressures, wetland ecosystems are threatened in certain extent. Especially endangered are ecosystems of standing water, small ponds, blanket and raised bogs. After criteria of the International Union for Conservation of Nature (IUCN) and proposed list of vascular plants for the Red Book B&H (Šilić, 1992-96), as well as considering current information on state of marsh species and habitats, among endangered vascular plants are to be found:

- Endangered species on raised bogs (*Drosera rotundifolia, Betula pubescens, Sphagnum subsecundum, S. squarrosum, Polytrichum commune, Carex stellulata*);
- Blanket bog's species in the lowland area (*Sagittaria sagitifolia, Butomus umbellatus, Typha laxmanii, T. Schuttelewortii, Acorus calamus, Thelypteris palustris, Periploca graeca*);
- Species occuring in ponds and marshes: (*Marsillea quadrifolia*, *Salvinia natans*, *Castalia alba*, *Nuphar luteum*, *Ludwigia palustris*, *Trapa natans*, *Hippuris vulgaris*, *Hottonia palustris*, *Utricularia neglecta*, *Utricularia vulgaris*, *Nymphoides peltata*, *Hydrocharis morsus ranae*, *Zanichellia palustris*, *Wolffia arrhiza*);
- Species occuring in high-mountain's alkaline blanket bogs (*Caltha longirostris, Potentilla palustris, Pinguicula leptoceras, Pinguicula hirtiflora, Pinguicula vulgaris, Menyanthes trifoliata, Iris sibirica, Eriophorum gracile, Carex davalliana, Orchis bosniaca, Orchis maculata*).

Wetland ecosystems represent habitats for many fishes, amphibians, reptiles, birds, mammals and invertebrates, such as aquatic insects, snails, shells, leeches, cephalopods etc.

Among fishes protrude ciprinids (of which many are endangered): carp, crucian carp, rudd, roach, pike, catfish, perch. Among amphibinas most frequently occur: small and large newt, salamander, red-bellied toad, swamp frog, european toad. As far as reptiles are concerned, common are: european pond turtle, viviparous lizard, grass snake and dice snake.

Wetland ecosystems ought to be important habitat for birds, of which most threatened are: wild duck, ferruginous duck, northern shoveler, great stork, heron, goosander, crane and many others.

# LANSCAPES OF KARST FIELDS IN BOSNIA AND HERZEGOVINA

These are unique phenomena that reflect specific patterns of Earth's crust development. Here are different karst creations, such as specific hydrological network, biological and ecological diversity.

Karst (kras) in wider sense, represents rocky desert or crag. In narower sense, it is a specific relief with special, mainly underground, water circulation ongoing within soluble rocks (limestone, dolomite, tuff). The karst is being created by calcite's dissolution in water that contains $CO_2$, whereby $CaCO_3$ is being transformed into, in water soluble, $Ca(CO_3)_2$. Limestone fissures are being increased by a corrosion and joined together to form a network of underground cavities and tunnels, which then extend deep into the ground, even under a sea level.

Depressions are huge bays extending along large karst fissures. Fields, the largest plains with flattened alluvial bottom, evolve in contact zones of limestone and leakage proof rocks. Sinking rivers are streams which, through cracks or abysses, dissolve into the ground, where they continue its underground flow.

Karst fields are most interesting phenomena within a karst region. As a result of specific orogenesis, geogenesis and hydrogenesis under different climate conditions, created are numerous karst fields. They make bosnia-herzegovina's biological and ecological diversity recognizable at the European and global scale.

Considering the ecoclimate, karst fields of Bosnia and Herzegovina are divided in several groups:

- Karst fields in western Bosnia (Glamočko, Livanjsko, Kupreško, Duvanjsko and Šuićko polje);
- Karts fields in western Herzegovina (Posuško, Grudsko);
- Karst fields in lower western Herzegovina (Lištićko, Ljubuško and Mostarsko Blato);
- Lower karst fields in eastern Herzegovina (Buško Blato and Popovo Polje);
- Mid karst fields in eastern Herzegovina (Ljubinsko, Dabarsko, Fatničko and Plansko);
- Upper karst fields in eastern Herzegovina (Nevesinjsko and Gatačko).

Karst fields are mostly elongated following the extension direction of Dinaric Alps. Field's bottom is usually covered by quarternary deposits, while its sides are encircled by karstified carbonate masses. Along field's margin are sources and wells, and at the deepest places are abysses, through which water dissolves into the karst underground. Between sources and abysses, across the field, extend permanent or periodical overground water network. In quarternary depositions are to be found some hydrographic objects through which water in wet season comes to the surface, and in dry season vanishes again. The lowest positions in the field, especially around abysal zone, are flooded after heavy rain.

There are some karst fields (Gradac polje) that neither have got overground water nor any siginificant sources and wells. Kupreško polje has got features of karst plateau. It is neither homogenous nor flat, but composed of several smaller fields connected by low elevations.

Many karst fields are endemic centres of flora and fauna of B&H.

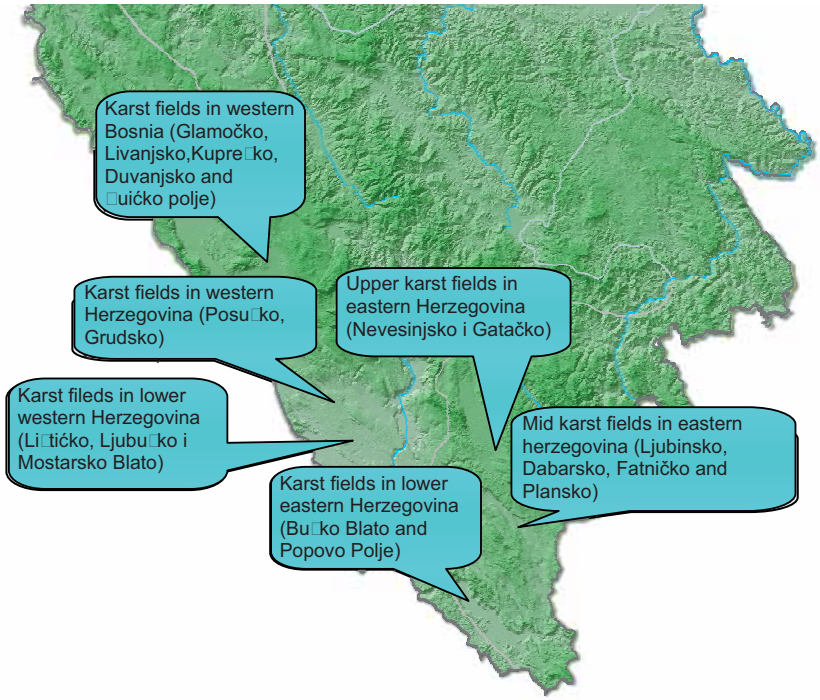



Figure 14. – Karst fields in Bosnia and Herzegovina

## Karst fields in western Bosnia

In this part of B&H occur our largest karst fields (Livanjsko, Glamočko and Kupreško polje) with still well preserved nature image.

Along with surrounding mountains (Kamešnica, Dinara, Cincar, Staretina, Šator, Vitorog and Raduša) characterized by high biodiversity, this karst fields represent unrepeatable geomorphological and ecological units. The network of overground and especially underground water is well developed (rivers, overground and underground sources, lakes and river armlets). As a special phenomenon should be mentioned estavels (openings through which, in both hydrologic and biologic sense, communicate the underground with field's surface).

These fields are true rarity in the world, for in them has been evolving the natural karstification process. It includes carbonate particles, ecologically hard water and, in some cases, microorganisms.

From the hydro-geological standpoint, karst fields of this area make connection with the confluence of Cetina river, then with Grahovsko polje in northwest and Duvanjsko polje in southeast.

In Livanjsko polje (surface of 400 square kilometers), especially in Ždralovac area (field's northwestern part), have been ongoing postglacial processes of alkaline bogs formation. The unique type of hydromorphous soil which occurs here, planohystosol, is vitally important for the survival of wilderness in swamps. Ecosystems encompass specific flora, fauna and vegetation shown in Figure 15.

Special place within the landscape of these karst fields take ecosystems of arable land and human settlements that are out of underground's water reach.

Settlements are situated along the field's margin, on elevated karst ground, with clear dominance of stone as a main construction material in the local architecture. There are, in some places well preserved and colourfull, mills along riverbanks and different cultural monuments (old cities and citadels of Livno, Kupres, Glamoč), which reveal and maintain specific forms of cultural development happening through a long period of inhabitation.

As a special landscape's value in this karst fields considered are estavels, sinking rivers, mountain lakes (at the plateau of Kupres) and picture-like flow of Šuica river with meanders and narrow passages. The upper flow of this river, around its source, is an important refugium for the unique living world. Hence, it

was designated as a protected area long time ago.

The world of flora and fauna happens to be interesting and rich. It is made of hydromorphous plant species, of which many are endemic (dinaric squil), then endemic fishes (Dalmatian barbelgudgeon, sneep, roach), numerous swamp birds and diverse amphibians and reptiles.

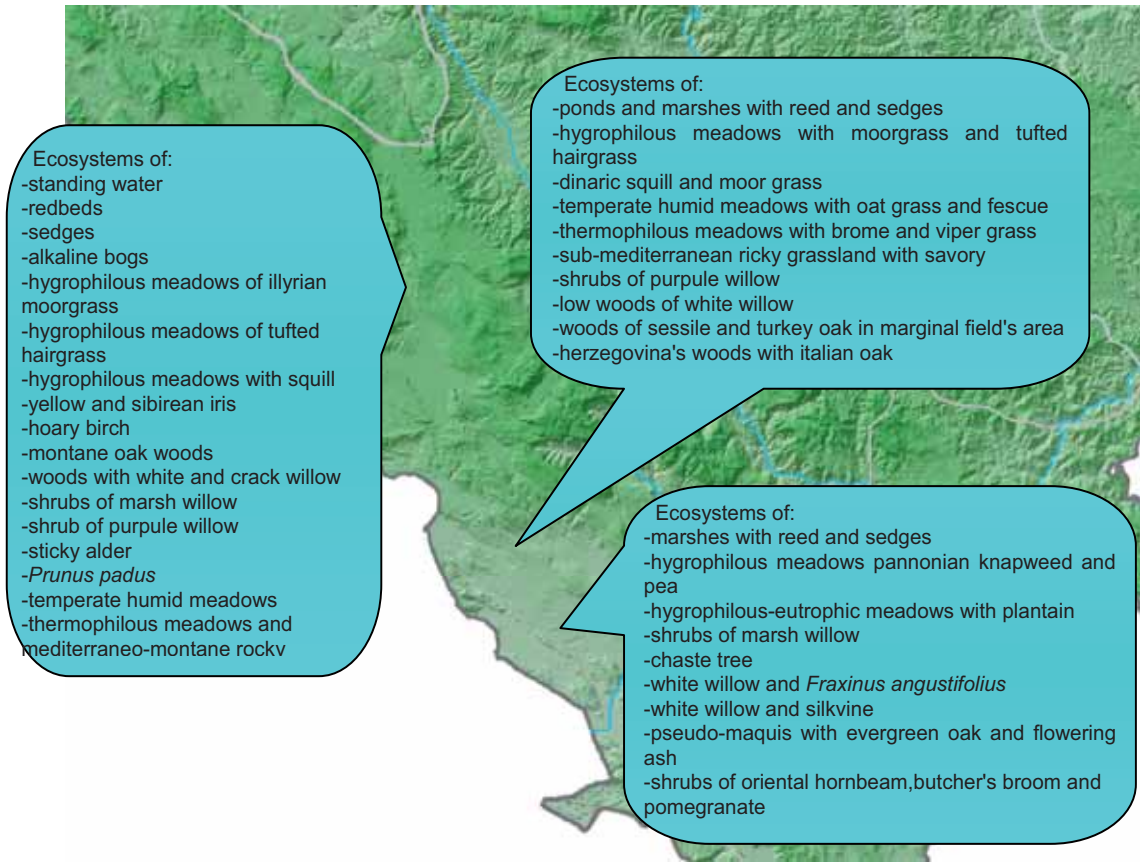
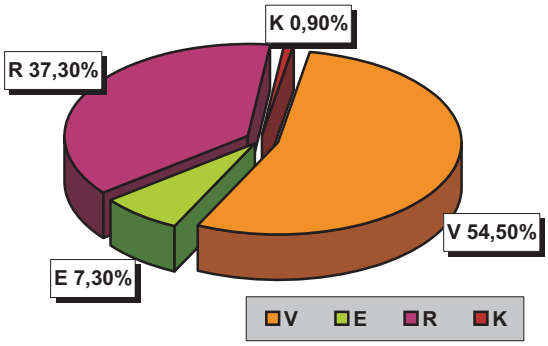



Figure 15. – Ecosystems of karst fields western from Neretva's valley

Due to high biomass production of meadows, it is traditionally developed sustainable cattle breeding, agriculture and gardening. Here are to be found habitats of large game species (bosnian wolf, brown bear, fox, hare, roe deer), which makes this area even more valuable and indicates what the potentials of this complex ecosystems are.




Swamp habitats in the karst landscape are irreplaceable not only for the survival of stationary birds, but also as a route for many migratory species (Ždralovac and Buško Blato). By previous investigation in this area were recorded 96 bird species (63 during spring and 49 during autumn migration of birds). The wilderness in karst fields is threatened in some extent, which is the result of various impacts. Among rare plant species belong: *Helleborus hercegovinus, Ranunculus croaticus, Corydalis leiosperma, Hesperis dinarica, Rhamnus intermedius, Bupleurum karglii, Athamantha haynaldii, Scrophularia bosniaca, Onosma visianii* and others, while to the category of vulnerable belong: *Salvia bertolonii, Utricularia vulgaris, Scilla litardierei, Narcissus radiiflorus, Iris illyrica* etc.

## Karst fields in western Herzegovina

At lower altitudes, under the conditions of supra-mediterranean and montane mediterranean ecoclimate, occur the karst fields in western Herzegovina (Posuško, Grudsko). These are fields characterized by the same water regime as previous ones, being, hence, flooded in late autumn, winter and spring. Although covering small area, they posses high ecosystem's diversity.

## Karst fields in lower western Herzegovina

Flat area of western Herzegovina encompasses following karst fields: Ljubuško, Lištićko polje and Mostarsko Blato. They owe its specificifty to geomorphological phenomena, well developed underground network and special variant of the mediterranean climate. The central field's part is characteristic in its hygrophilous communities, while in the marginal area occurs pseudo-maquis (Figure 15).

The landscape gets its special features by cypresses trees whose pyramid-like shapes bring some dynamics into degraded marginal field's area. The flattened field's area is taken by arable land, vineyards and fruit-gardens of widely known cherries, plantages of high quality tobbaco and different sorts of vegetables (especially in Ljubuško polje).

Picture-like landscape image is made of settlements placed along the field's margin. They are specific in their supra-mediterranean architecture with dominance of the white herzegovina's stone that along with the blue sky, crystal clear water and rich culture create typical image of this Bosnia and Herzegovina's area. To that landscape belongs also Lištica river, whose spring is some kind of refugial place for tertiary flora and fauna.

*"Trebižat, river that carries four names (Tihaljina, Koćuša, Klobuk), is rich in cascades and waterfalls, of which the most imposing is Kravice waterfall, karst-tuff phenomenon of surreal beauty, splendid form and high ecological value. To those fields are bound civilization roots of the area, witnessed in remains of different cultures: roman, otoman, austrio-hungarian and slavic (old town of Ljubuški, Široki Brijeg) that even today bring peace to human souls in troughout the world known houses of worship."* (qouted from TV show "Prirodna baština Bosne i Hercegovine")

A tuff formation process streching over many years, has caused the occurence of tuff barriers on Tihaljina river all the way down to its estuary at place called Gabela. This, along with the influence of mediterranean climate coming from the South and modified mountain climate coming from the North, completes typical image of this splendid Herzegovina's region.

## Lower karst fields in eastern Herzegovina

On the left side of Neretva river, in the area belonging to supra-mediterranean and mediterranean climate and going toward southeastern Herzegovina, emerges special kind of karst fields (Hutovo Blato, Popovo, Ljubinjsko and Stolačko polje).

Both, past and future of this phenomena is related to hydrologic and ecologic regimes of Bregava and Trebišnjica rivers. Besides, the survival of these fields is defined by hydrologic regime of upper situated karst fields in eastern Herzegovina. In geomorphological and hydrological sense, this landscape survives thanks to the rich and diverse network of watercourses and karst relief, which are united into single structure-functional unit. Only under such conditions, it is possible to maintain its natural genuinity.

Destiny of lower fields is closely related to the hydrological regime of upper fields (Fatničko and Dabarsko polje), whereby

their survival depends upon water level in Nevesinjsko and Gatačko polje.
Future of other wells too depends upon the stability in hidrological regime of this landscapes (wells in the confluence of Bregava river, wells around Deransko lake – Hutovo Blato, sources of Buna river and water regime in upper flow of Neretva river). Maintenance of biologic and ecologic phenomena in Neretva river's delta, which is a wetland area of international importance, is directly connected with maintenance of water regime in karst fields of this Herzegovina's area.
Directly co-related is also maintenance of underground relief and life in it, as it is the case in Vjetrenica cave in Popovo polje, which is doubtless the cave of global value.
Due to intensive anthropogenic activities (melioration, construction of hydropower plants in last 50 years, concreting of Trebišnjica's riverbed in length of 60 kilometers, building of the compensation Svitavsko lake for purposes of HE Čapljina), landscape's image has changed completely. In this way were lost many ambiental and biologic values of Popovo polje and Hutovo blato forever.
Yet, there are still few oasis hiding wetland's wildlife under mediterranean climate conditions, such as the Ramsar site and Park of Nature – Hutovo Blato. There are many swamp plants, animals (especially birds and fishes) that are endemic and part of communities characterizing this landsapce.
This landscape is recognizable in cypress trees, arable land with vineyards, tobbaco plants, cereals and vegetables.
Settlements in marginal field's area, which is often the karst, are recognizable in their architecture and dominance of white Herzegovina's stone that used to be a building material for highly functional and decorative roofs. This, regarding ecology and ecoclimate for a man suitable area, has been inhabited since the earliest days. Many people have left rich expressions of their material and spiritual culture contained within fortresses, houses of worship and especially in graceful stone bridges. Evlija Čelebija, famous travel writer, termed Popovo polje as Misir in this part of the world.
Strong mediterranean influence is reflected in the architecture of Trebinje city, in its cultural and scenic units placed on riverbanks of once timid Trebinjčica river.

## Mid karst fields of eastern Herzegovina

At higher altitude (600 m), on the next karst terrace, under conditions of modified supra-mediterranean and montane mediterranean climate situated are Dabarsko, Fatničko and Plansko polje. These natural phenomena have got special patterns of water regime. Under natural conditions, during cold period of a year, fields are covered with water looking like a true lakes. Because of that, settlements are moved toward the edge and agriculture is limited onto crops having short vegetation season. Not so long time ago, these karst fields used to encompass well preserved natural elements. Yet, unique living world occuring organised in diverse communities, respectively ecosystems, still exists. (Figure 16)

### Pressures onto karst fields in eastern Herzegovina

Survival of these fields including the entire biological and landscape's diversity encompassed within them is jeopardized by, in ecological sense, unacceptable water management. The mega-project called "Gornji horizonti" is designed to collect and re-direct water from these fields by specially constructed infrastructure into artificial water accumulation – Bilećko jezero. That is completely opposite to the natural drain direction.

## Upper karst fields in eastern Herzegovina

On next terrace under conditions of harsh herzegovina's karst and mountain climate, situated are upper karst fields in eastern Herzegovina (Gatačko in the East and Nevesinjsko in the West). Both are surrounded with high Dinaric mountains (Bjelašnica, Zelengora, Crvanj and Velež) completing its geomorphologic and ecologic uniqueness. Diverse climates, then diversity of geomorphologic phenomena and soil types, have shaped rich and diverse plant and animal world. Ecosystems are composed of many endemic and relict species inhabiting these karst fields. (Figure 16)

Field's landscapes are also recognizable in the ecosystems of arable land (widely known potato, rye, barley, buckwheat). In the area exists an excellent ground for the ecologic and open kind of tourism reflected in traditional cattle bredding, chees production, availability of healthy and cold drinking water.

Landscape's value of the area make ecosystems stretching along watercourses, such as Mušnica river and 100 years old accumulation lake called Klinje made on it, narrow passages of Gračanica river and picture-like passage of Zalomka river, which is an outstanding refugium of tertiary vegetation connecting two fields Gatačko and Nevesinjsko polje.

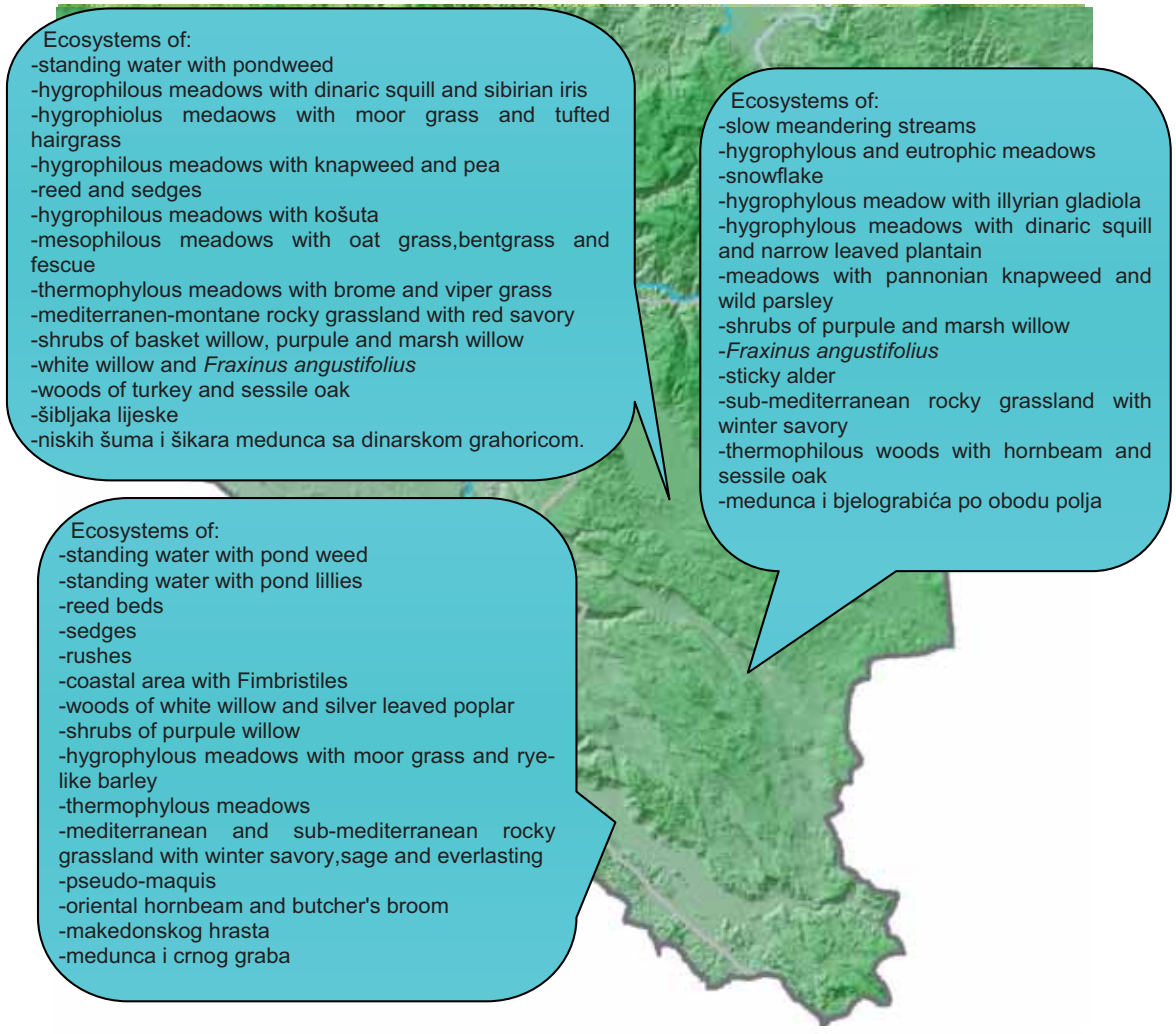



Figure 16. – Ecosystems of karst fields eastern from Neretva river

## Pressures on karst fields in Bosnia and Herzegovina

Landscapes of karst fields are thought to be the most sensitive group of ecologic phenomena in Bosnia and Herzegovina, whereby their structure and functions have been changing. Factors that alter the structure and function in most significant way influencing by that the biodiversity's state are as follows:

- Different kind of melioration activities;
- Re-directing of streams into other basins;
- Unbalanced exploitation of moorland's humus horizon;
- Unbalanced coal's extraction;
- Purposely caused fires in dry season;
- Eutrophication of surface water;
- Succession either natural or by human activities induced;
- Logging in the marginal field's area;
- Global climate changes (acid precipitation);
- Globalne klimatske promjene (kisele kiše).

Any change in variation pattern results in disturbance that affects either distinct populations or common process of succession.
It has to be stressed that karst fields are an integral part of migratory birds routes. Even globally threatened bird species find their habitats here, for instance *Anthya nyroca*, *Aquila pomarina*, *Falco neumanni*, *Crex crex* (IUCN Redlist) and kindred species. Species listed by EU Wild Bird Directive in terms of requiring special protection that includes habitats needed for their reproduction and survival, and which are to be found in this area are as follows: *Gavia artica, Ixobrychus minutes, Nycticorax nycticorax, Ardeola ralloides, Egretta alba, Egretta garzetta, Ardea purpurea, Platalea leucorodia, Plegadis falcinellus, Ciconia ciconia.*

A demand after full and integral kind of protection, as well as management in each landscape's segment, is posed by the karst field's biodiversity and pressures affecting it.

Karst fields in Bosnia

# GENETIC DIVERSITY

# GENETIC DIVERSITY OF BOSNIA AND HERZEGOVINA

Genetic diversity means richness of gen pool comprised within different plant and animal forms both cultivated and domesticated ones through a long process of ethnogenesis in Bosnia and Herzegovina.
Factors that determine genetic diversity on national scale are:

- High heterogeneity of ecosystems and landscapes in Bosnia and Herzegovina;
- Unique processes and levels of cultural diversity;
- Hystorical process of inhabitation;
- Other civilization's influences coming from the East and West;
- A total biodiversity of indigenous gen pool results in high diversity of genetic resources in Bosnia and Herzegovina contained in great number of original (especially genotypes and ecotypes) animal breeds and plant sorts.

As in any other aspect of biodiversity, genetic biodiversity in B&H too is a big mistery. There are only sporadic scientific and expert data on identified sorts and breeds.
Now, it is being believed that basic data on rich genetic diversity of plants and animals were lost in time. Legislative that would consider the issues of inventory and protection hasn't been inforced yet. Special importance comes to the fact that the scientific inventory of genetic diversity hasn't been completed yet, meaning that bank of gens that should obey the international rules hasn't been established neither.
What once used to be the richness in indigenous (either deeply rooted or domesticated) sorts of apples, pears, plums and other fruits, and sorts of wheat such as "bjelica" and other cereals, now are only traces recorded in volk's songs and tales illustrating former cultural richness and ethnologic diversity.

## Herbal genetic resources in Bosnia and Herzegovina

Except for several sorts of grape ("Blatina" i "Žilavka") and one sort of apples, there are no gen pool's protection measures in place.
The diversity of herbal genetic resources is addressed as a significant gen pool, which is based on available information on vegetable, fruit and cereal richness in Bosnia and Herzegovina.
Among cereals as a genetic resource valuable are sorts of maize (*Zea mays*), wheat (*Triticum sp.*), barley (*Hordeum sp.*), oat (*Avena sativa*), rye (*Secale cereale*), broomcorn millet (*Panicum miliaceum*).

Table 44. – Overview of recognized wheat sorts from the territory of B&H

| Sort | Institution |
|---|---|
| Bosanka | Poljopr. inst. Banja Luka |
| Granada | Poljopr. inst. Banja Luka |
| Kristina | Poljopr. inst. Banja Luka |
| Prijedorčanka | Poljopr. inst. Banja Luka |
| Banjalučanka | Poljopr. inst. Banja Luka |
| Orion | Poljopr. inst. Banja Luka |
| Stojanka | Poljopr. inst. Banja Luka |
| Jelena | Poljopr. inst. Banja Luka |
| Šamčanka | PIK "Šamac" - Šamac |

The diversity of ecoclimate has supported high and still well preserved diversity of genetic resources contained in fruits. This is reflected in great number of sorst of cherries (*Prunus avium*: alice, ašlame, hašlamuše, hrušćovi, crnice, bjelice); plums (*Prunus domesticus*: bijele, prskulje, mrkulje, savke); pears (*Pyrus sp.*: ječmenke, krivočke, mednjače, takiše, bijeli karamut, crni karamut, krupnjače, jeribasme); apples (*Malus sp.*: petrovače, golubače, šarenike, zelenike, senabije, šahmanuše, krompiruše, crvenike etc.), as well as sour cherries, apricots, peaches, almonds, raspberries, blackberries, strawberries and currants.

Among gardening genetic resources diversity of forms and special ecotypes characterizes: pumpkins from genus *Cucurbit*a, bean (*Phaseolus vulgaris*: čućo, bubnjo, trešnjo, kućićar, mesni), cabbage from genus *Brassica*, paprika (*Capsicum annuum*), widely known okra (*Hibiscus esculentum*), watermelon called semberka (*Cytrullus colocynthus*), melon (*Cucumis melo*), and spectrum of potato's sorts (*Solanum tuberosum*: romanijski, kupreški, fojnički, glamočki etc.).

Table 45. – Overview of recognized soya bean sorts from the territory of B&H

| Sort | Year of recognition | Institution |
|---|---|---|
| Sana | 1997 | Poljopr. inst. Banja Luka |
| Sonja | 1997 | Poljopr. inst. Banja Luka |
| Marina | 1999 | Poljopr. inst. Banja Luka |
| Milica | 1999 | Poljopr. inst. Banja Luka |

Of high importance are many fruit sorts that are being used for inoculation purposes cited often by scientists and experts as a base for growing of certain sorts.

Table 46. – Recognized sorts used as base for growing

| | |
|---|---|
| *Amigdalus communis L. - badem* | *Crataegus oxyacantha L. - glog* |
| *Armeniaca vulgaris Lam. – kajsija* | *Olea europea L. - maslina* |
| *Prunus cerasifera Ehrh.- džanarika* | *Prunus avium l. trešnja* |
| *Prunus domesticaL. - šljiva* | *Prunus mahaleb L. - rašeljka* |
| *Castanea sativa Miller – kesten pitomi* | *Prunus persica L. - breskva* |
| *Cerasus vulgaris Mill - višnja* | *Punica granatum L. - nar* |
| *Cornus mas L. – dren* | *Pyrus pyraster L - kruška* |
| *Cydonia oblonga Mill. - dunja* | *Rosa canina L. – Ružin šipak* |
| *Juglans regia L. – orah* | *Sambucus nigra L. – domaća zova* |
| *Malus sylvestris Mill. – divlja jabuka* | *Sorbus domestica L. – oskoruša* |
| *Mespilus germanica L. - mušmula* | *Sorbus aucuparia L. - jarebika* |

Within herbal genetic resources of B&H, different sorts of fodder plants take significant place.

Table 47. – Sorts of fodder plants

| Sort |
|---|
| Lucerka (*Medicago sativa* L.) : BL-422, Banjalučanka, Sonja, Biljana |
| Smiljkita (*Lotus corniculatus* L.): BL-17, Tera |
| Ježevica (Dactylis glomerata *L.*): BL-4, BL-Krajina |
| Mačiji rep (*Phleum pratense* L.): BL-B |
| Crveni vijuk (*Festuca rubra* L.): Buki |
| Stočni grašak (*Pisum sativum ssp. arvense* L.): Saša |

Ornamental flora too takes significant place in the diversity of herbal genetic resources of our country as a decoration for many gardens and backyards. Highly significant gen pool is contained within different forms of roses (*Rosa sp.*), such as đulbešećerka (*Rosa poliantha*); đulhatma or hollyhock (*Althaea rosea*); common rue (*Ruta graveolens*); rejhan or basil (*Ocymum basillicum*); miloduh or lovage (*Levisticum officinale*); šekaik or peony (*Paeonia sp.*); wenlock beauty (*Erysimum sp.*) and many other of which the last trace was lost long time ago.

Thanks to modern molecular-genetic studies, there are pioneer information on genetic markers identified within endemic gen pool of Bosnia and Herzegovina (*Lilium bosniacum, L. cataniae, Iris bosniaca, L. martagom, Hypochoeris macullata, Juniperus sabina*). The genetic diversity of afore named species is reflected in the number of ribosomal DNA's loci, number of repetitions of ribosomal genes, activity of ribosomal genes, respectively the number of nucleoli; occurence and number of B chromosomes, size of genom and different levels of ploidia.

## Genetic diversity within indigenous breeds of domestic animals in Bosnia and Herzegovina

Through the longlasting existance of different civilizations on the territory of Bosnia and Herzegovina, domesticated were many animal breeds. Majority of them evolved in time as distinct ecotypes representing today clearly separated, even insulated, forms in the general gen pool of domestic animals. High diversity is achieved among the breeds of horses, cattle, sheeps, goats, pigs, dogs and pigeons.

Table 48. – Indigenous breeds of domestic animals in B&H

| Vrsta | Domestificirane pasmine | BH pasmine |
|---|---|---|
| **Konj**<br>*Equus caballus* L., 1758; | *E. ferus* Boddaert, 1785 (*E. f. przewalskii*, *E. f. gmelini)* i njihovi križanci | Bosansko–hercegovački brdski |
| **Govedo**<br>*Bos taurus domesticus* L., 1758; | *B. primigenius* Bojanus, 1827 (=*B. primigenius taurus*) i njihovi križanci | Buša<br>Gatačko |
| **Ovca**<br>*Ovis aries* L., 1758<br>(*O. a. domestica* = *O. ovis*); | *O. orientalis*, *O. musimon*, *O. vignei* i njihovih mogućih križanaca | Pramenka |
| **Koza**<br>*Capra hircus* L., 1758; | *C. h. domestica* | Domaća balkanska rogata |
| **Svinja**<br>*Sus scrofa* L., 1758; | *S. s. domestica* (=*S. domesticus*) | Šiška |

| | | |
|---|---|---|
| **Pas**<br>*Canis familiaris* L., 1758<br>(=*C. canis*= *C. donmsticus*=*C. lupus familiaris*=*C. l. domesticus*) | | Bosansko–hercegovački pastirski tornjak |
| | | Bosanski oštrodlaki gonič barak |
| **Golub**<br>*Columba livia* L., 1758; | *C. l. domestica* | Travnički kratkokljuni |
| | | Sarajevski prevrtač |
| | | Bihaćki prevrtač |
| | | Zenički prevrtač |

In the tradition, traces of indigenous breeds have been linked since ever with herzegovina's donkey, dog and chicken.

The game species of Bosnia and Herzegovina too posses underlined uniqueness taking its share in B&H's gen pool.

Table 49. – Indigenous sub-species of game species in B&H

| Species | Sub-species |
|---|---|
| Roe deer *Capreolus capreolus* (L.) | *C. c. grandis* |
| Chamoix *Rupicapra rupicapra* (L.) | *R. r. balcanica* |
| Wild boar *Sus scrofa* (L.) | *S. s. reiseri* |
| Wolf *Canis lupus* (L.) | *C. l. kurjak* |
| Beech marten (Samsar) *Martes foina* (Erxleben) | *M. f. bosniaca* |
| Brown bear *Ursus arctos* (L.) | *U. a. bosniensis* |

## Traditional biotechnologies

As a good indicator for the sustainable use of biodiversity and comprehension of the Convention on Biodiversity could be taken products made by traditional biotechnological processes. Different cultures emerging in long and rich tradition of Bosnia and Herzegovina used to make many traditional products out of domain of bread making, milk-production, brewery, viniculture and especially chees production.

Special value of Bosnia and Herzegovina is represented by thousand-year old roots of various biotechnological procedures in food production and preservation, from traditionally refreshing drinks and sour salad, over "sour" food supplies for winter to mild and strong alcohol drinks. In the beginning those products were ment for personal needs, getting later more comercial dimension. Based on rich experiences from the "home-made" biotechnological practice, in Bosnia and Herzegovina has been developing very successful industrial biotechnological production of livegoods and alcohol drinks.

The biodiversity of genetic resources is highly co-related with the traditional biotechnological processes. Among indigenous sorts of grape grown are widely known "Blatina" and "Žilavka", produced are also herzegovina's grape brandy; "šljivovica" brandy made of plums called savke, different kinds of beer from healthy barley and hops, then home-made jams, marmelades, and "himbers" from domestic sorts of apples, pears and plums.

As a special expression of ethnogenesis, nutritional culture and traditional biotechnological skills and solutions considered is high richness in indigenous sorts of chees, made by "secret" biotechnological procedures from the highest quality milk of bosnian cows, sheeps and goats. In the uniqueness of herbal diversity comprised by pastures in Bosnia and Herzegovina, where domestic animals graze, lies a secret on the quality and composition of chees. Apart from so far identified and recognized 15 sorts of indigenous chees, for sure exist many other unknown biotechnological formulas, deeply hidden in the mountain cottages of Dinaric Alps in B&H.

Table 50. – Indigenous sorts of chees in Bosnia and Herzegovina

| Chees | Identification area |
|---|---|
| Travnički (Vlašićki) | complex of Vlašić Mt. and neighbouring mountains |
| Masni | eastern Bosnia: around Čajniče, Tjentište, Sokolac and in some other areas |
| Presukača | Herzegovina and Piva river(Montenegro); Bosnia and Herzegovina: wider area of Gacko, Konjic and Sjemeč |
| Sirac | Bosanska krajina, especially its mountain areas |
| Livanjski | Proizvodi se na kompleksu Cincara i okolnih planina, te na kraškim poljima: Livanjskom, Glamočkom i Duvanjskom |
| Posni | wide area in Bosnia and Herzegovina |
| Suhi ili mješinski punomasni | Herzegovina |
| Svježi kiseli i sušeni kiseli | areas oriented toward northern Bosnia |
| Zajednica | eastern Bosnia: areas in which cream is being produced. |
| Basa | Bosanska krajina, around Bihać and wider (Lika, Croatia) |
| Kalenderovački | northern Bosnia:slopes of Motajica Mt., some areas around Majevica Mt. and Šekovići |
| Tvrdi kozji | Herzegovina |
| Bijeli kozji | Herzegovina and some villages beneath Vlašić Mt. (Bosnia) |
| Zarica | eastern Bosnia |
| Urda | all mountain areas in B&H |

A long tradition in milk production and substantial capacities that are available, made base for the branched network of milk-biotechnological facilities, with more than 60 units located all around Bosnia and Herzegovina.
Development of economy subjects in the field of bread-making biotechnological production, brewering-biotechnological solutions, production of vine and other alcochol drinks, treating of fruits and vegetables based on traditional knowledge, represent important segments of the economy in Bosnia and Herzegovina. These economy branches employ the largest proportion of working population.

## Pressures

Like the wildlife so the genetic resources too sustain sever pressures raised upon them, which tend to cause the reduction, most probably even extinction, of many sorts and breeds from the territory of Bosnia and Herzegovina.
Prevailing pressures on genetic resources are:

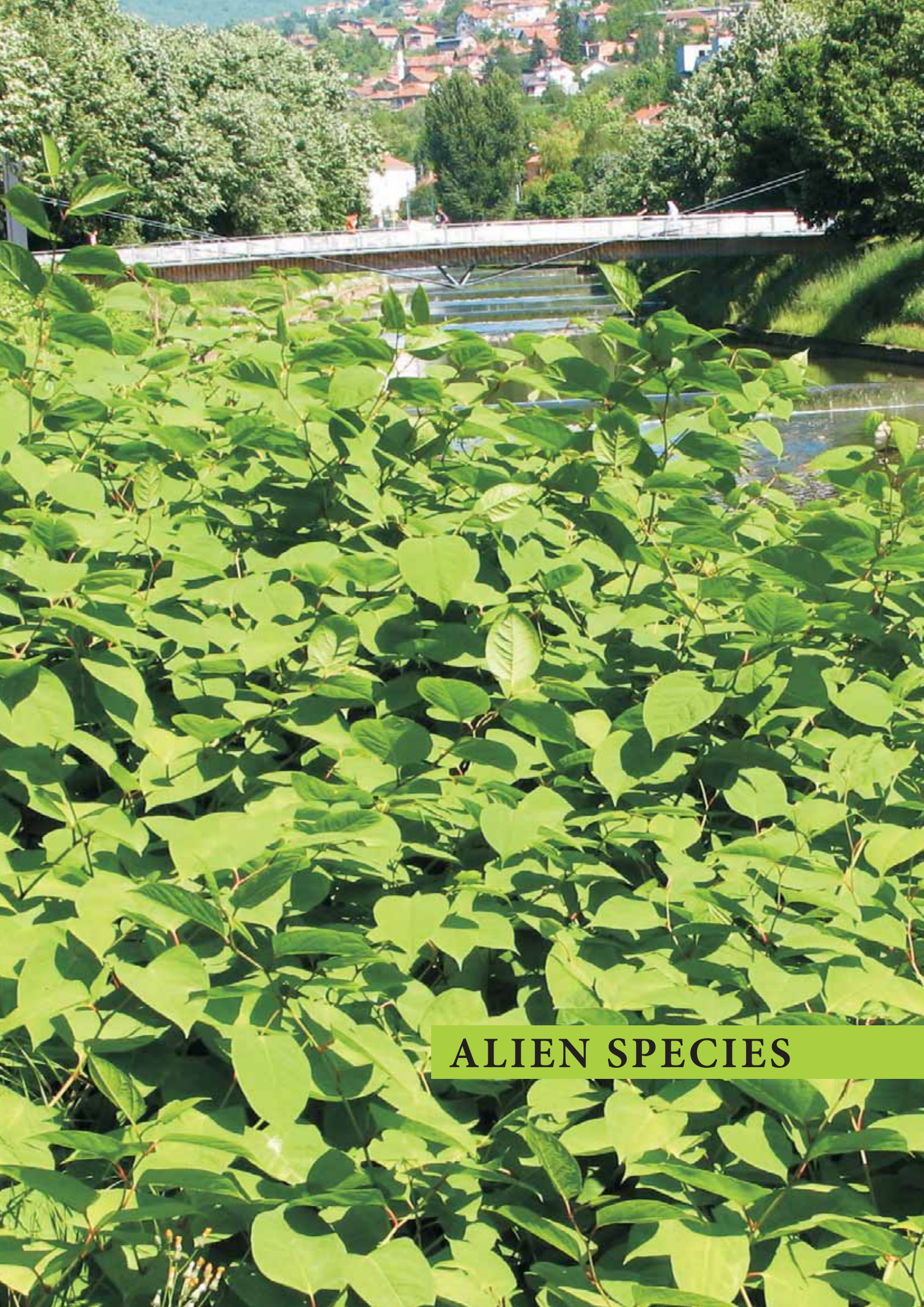
- Intensive change in the agricultural production through mechanisation use, and use of such means as pesticides and fertilisers;
- Very intensive migration and displacement of population from villages to cities, especially from insulated areas in respect to nature and ethnology (mountain villages on: Bjelašnica, Čvrsnica, Zelengora, Kupres, Vlašić, Vitorog etc.);
- Social negligence for the protection of this segment in natural and cultural heritage;
- Intensive dispersal of alien plants and animals;
- Changes in traditional mode of living and income gain of people in Bosnia and Herzegovina;

- Disrooting of cultural traditions in which indigenous plant sorts and animal breeds play undoubtedly important role;
- Global changes supported by communication advantages which enable swift dispersal of pathogens;
- Favoring of plants and animals evolved by controlled selection, which either directly or indirectly supress the indigenous gen pool;
- Steady increasing in the occurence of GMOs and dietary and medicinal products obtained by their usage.

Due to above stated pressures, large proportion of indigenous gen pool of breeds and sorts vanished long time ago. And many are dissapearing right in front of our eyes. Hence, urgent actions are required in order to make an inventory and ensure conservation of herbal and animal genetic resources remained.

Inspite of that, genetic diversity that is available represents the outstanding resource and mighty potential for the production of healthy and high quality food, as well as for the obtaining of noble sorst of fruits, vegetables, cereals and healthy breeds of animals.

The mentioned potential is one of the greates comparative advantages of Bosnia and Herzegovina compared to other countries in the region and entire Europe. In the nearest future, country's richness shall be assessed by its diversity level and potentials contained within its genetic resources.



# ALIEN SPECIES

# ALIEN SPECIES IN BOSNIA AND HERZEGOVINA

As an alien species considered are those species of plants, animals and mushrooms that originate from other floristic and zoogeographic regions and which in the competition with indigenous gen pool supress it by taking all available ecological niches. An alien species are the most commonly spread as accidental followers of different human activities. At the beginning, these species take urban and rural habitats, and later on they spread all across the free nature.

Not even the territory of B&H has been spared from the arrival of adventive species, which beside alien include all sorts of plant genetic resources (vegetables, fruits, cereals, ornamental and cultural plant species), and diverse animals and mushrooms.

## ALIEN PLANTS

Many indigenous species are followers of different herbal genetic resources. Those are weeds that retain in crops and leave an agroecosystem seldom by taking ecological niches of the indigenous flora. But, there is a share of alochthonous species which adjusted entirely to local habitat's conditions and got out of the human control long time ago.

After international standards regarding understanding of alien species and degree of knowledge of B&H's floristic diversity, it can be stated that in B&H were identified dozens of alien species.

Table 51. – Some alien species recorded in B&H

| Species | Origin |
|---|---|
| *Amaranthus blitoides* S. Watson | S.Amerika |
| *Asclepias syriaca* L. | S. Amerika |
| *Ambrosia artemisiifolia* L. | Amerika |
| *Artemisia verlotiorum* Lamotte | Kina |
| *Artemisia vulgare* L. | Sjeverna Amerika |
| *Bidens bipinnata* L. | Južna Amerika |
| *Bidens frondosus* L. | Sjeverna Amerika |
| *Bidens subalaternus* D.C. | Južna Amerika |
| *Coniza canadensis* ( L.) | Sjeverna Amerika |
| *Erigeron annuus* (L.) Pers. | Sjeverna Amerika |
| *Galinsoga ciliata* (Rafin.) S. F. | Meksiko - Čile |
| *Galinsoga parviflora* Cav. | Južna Amerika |
| *Helianthus tuberosum* L. | Sjeverna Amerika |
| *Iva xanthifolia* Nutt. | Sjeverna Amerika |
| *Picris eschioides* L. | Južna Europa |
| *Solidago gigantea* Ait. | Sjeverna Amerika |
| *Tagetes minuta* L. | Južna Amerika |
| *Xanthium strumarium* L. subsp. *strumarium* subsp. *italicum* ( Moretti) D. Love | Južna Amerika |
| *Bunias erucago* L. | Južna Europa |
| *Euclidium siriacum* (L.) R.Br. in Aiton | Istočna i srednja Europa |
| *Lepidium virginicum* L. | Srednja Amerika |

| | |
|---|---|
| *Sisymbrium altissimum* L. | Centralna i Istočna Europa |
| *Coronilla valentina* L. | |
| *Sedum sarmentosum* Bunge | I. azija |
| *Juniperus communis* L. | |
| *Euphorbia spinosa* L. | |
| *Euphorbia maculata* L. | S. Amerika |
| *Euphorbia nutans* Lagasca | S. Amerika |
| *Amorpha fruticosa* L. | C. I Amerika |
| *Lathyrus tuberosum* L. | |
| *Robinia pseudacacia* L. | S. Amerika |
| *Iris germanica* L. | |
| *Stachys annua* L. | |
| *Oxalis stricta* L. | S. Amerika |
| *Phragmites communis* L. | |
| *Phytolacca americana* L. | S. Amerika |
| *Eleusine indica* ( L.) Geartn. | Tropi i subtropi |
| *Paspalum dilatatum* Poir. in Lam. | S. Amerika |
| *Paspalum paspaloides* ( Michx) Scribn. | tropi |
| *Sorghum halepense* ( L.) Pers. | S. Afrika i jugozapadna Azija |
| *Polygonum communis* L. | |
| *Reynoutria japonica Houtt.* | Japan |
| *Rubus ceasiues* L. | |
| *Ailanthus altissima* ( Mill.) Swingle | Kina |
| *Urtica dioica* L. | |
| *Echynocistis lobata* (Michx) Torrey & A. Gray | Sjeverna Amerika |
| *Elodea canadensis* Michx. | Sjeverna Amerika |

Among species that are used for horticultural purpose and which got out of human control, in Bosnia and Herzegovina, the most common are: *Asclepias siriaca, Helianthus tuberosus, Solidago gigantea, Tagetes minuta, Amorpha fruticosa, Robinia pseudacacia, Phytolaca americana, Reynoutria japonica, Ailanthus altissima, Impatiens glandulifera*.

The largest proportion of these species lives in the river banks belt of ravine rivers, clear cuttings, wood clearings and similar kind of habitats.

Species given in brackets (*Asclepias syriaca, Helianthus tuberosus* and *Amorpha fruticosa*) negatively affect habitats of hygrophilous woods of willow, alder and poplar, which in Bosnia and Herzegovina are to be found especially in the Posavina area. Hygrophilous ecosystems today are under severe threat coming from the alien species.

Well adjusted species, such as *Robinia pseudacacia, Ailanthus glandulosa* and *Syringa vulgaris*, envade today habitats in the belt of oak – hornbeam woods and beech woods over the entire territory of Bosnia and Herzegovina. Acacia even creates special kind of anthropogenous ecosystems (*Smyrnio-Robinietum pseudacaciae*). *Ailanthus glandulosa* takes habitats in the river banks belt of the peripannonian, mountainous and supra-mediterranean zone. *Syringa vulgaris* got out of human control long time ago and envaded even sensitive habitats with relict-refugial character. Though, this species hasn't got any tendency to spread in larger extent and to envade new habitats.

*Impatiens glandulifera* occurs lately more often in the zone of alder, fragile and purpule willow woods, especially in the confluence of Vrbas river.

Some alien species spread along with crops and today are considered as frequently occuring weeds:

- *Ambrosia artemisifolia*, which often envades habitats of moist and flooded woods, then ruderal and urban type of habitats and artificial meadows;
- *Bidens bipinata, B. frondosus, B. subalaternus* and *Echinocystis lobata* envade habitats of all kind of communities along banks of great ravine and mountainous rivers.

Pokeweed, *Phytolaca americana* that earlier used to be an ornamental plant and mean to colour the vine, now occurs massively on clear-cuttings of beech woods in the peripannonian belt.
*Elodea canadensis* invades calm freshwater of relatively high quality.
As far as marine ecosystems are concerned, there are no reliable records on the occurence of alien species belonging to genus *Caulerpa* in water of the bosnia-herzegovina's Sea.

## ALIEN ANIMALS

Alochthonous animal species have been reaching territory of Bosnia and Herzegovina either by direct human influences for breeding purposes or spontaneously.
Alien species of aquatic ecosystems are the most frequently fish species that came into free water from fish farms or occured spotaneously from adjacent rivers and lakes. Natural and artificial lakes are kind of habitats that are easily envaded by alien species. Alien fish species are to be found in following hydro-accumulations: Salakovac, Grabovica, Svitavsko jezero, Gorica, Bilećko jezero on Trebišnjica, Buško jezero, hydro-accumulation on Vrbas river, then Višegradsko jezero, Perućac and Zvorničko jezero on Drina river.
Natural lakes get envaded through the introduction of alien species, thereafter the picture of living world in those lakes changes (that kind of lakes are: Prokoško; Kotlaničko, Orlovačko, Crno, Bijelo, Donje Bare, Gornje Bare, Štirinsko and Kladopoljsko on Zelengora Mt.; Veliko and Blatno jezero, Crno and Bijelo jezero on Treskavica Mt.; Blatačko jezero on Bjelašnica Mt.; Uloško jezero beneath Crvanj Mt.; Boračko jezero beneath Prenj Mt., Blidinje jezero at Dugo Polje in between Čvrsnica and Vran Mt.; Idovačko on Raduša Mt.; Šatorsko on Šator Mt.; Kukavičko, Rastićevsko and Turjača on plateau of Kupres; Veliko and Malo Plivsko jezero).

Table 52. – Alochthonous fish species and their distribution in B&H

| CONFLUENCE / LATIN NAME | **Confluence** Vrbasa | **Confluence** Bosne | **Confluence** Drine | **Confluence** Neretve | **Confluence** Une I Sane | **Confluence** Ukrine | Hutovo blato | Buško jezero | Klinje jezero | **Confluence** Save | **Confluence** Tinje | **Confluence** Trebišnjice | Vode Livna i Duvna |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Oncorhynchus mykiss* | X | X | X | X | X | | X | X | X | | | X | X |
| *Salvelinus fontinalis* | X | X | | X | | | | | X | | | X | |
| *Salvelinus alpinus* | X | | X | X | | | | | X | | | X | |
| *Carassius auratus gibelio* | X | | | X | | | X | | | | | | |
| *Carassius auratus auratus* | | | | | | | | | | X | | | |
| *Hypophthalmichthys molitrix* | X | | | | | | X | | X | | | X | |
| *Pseudorasbora parva* | | | | | | X | | | | | | | |
| *Ctenopharyngodon idella* | X | X | X | X | X | X | X | | | X | X | X | |
| *Ameiurus nebulosus* | X | X | X | | X | X | X | | | X | | X | |
| *Gambusia affinis* | | | | X | | | X | | | | | | |
| *Lepomis gibossus* | X | X | | | X | X | X | | | X | | X | |
| TOTAL | 8 | 5 | 4 | 6 | 4 | 4 | 7 | 1 | 4 | 4 | 1 | 7 | 1 |

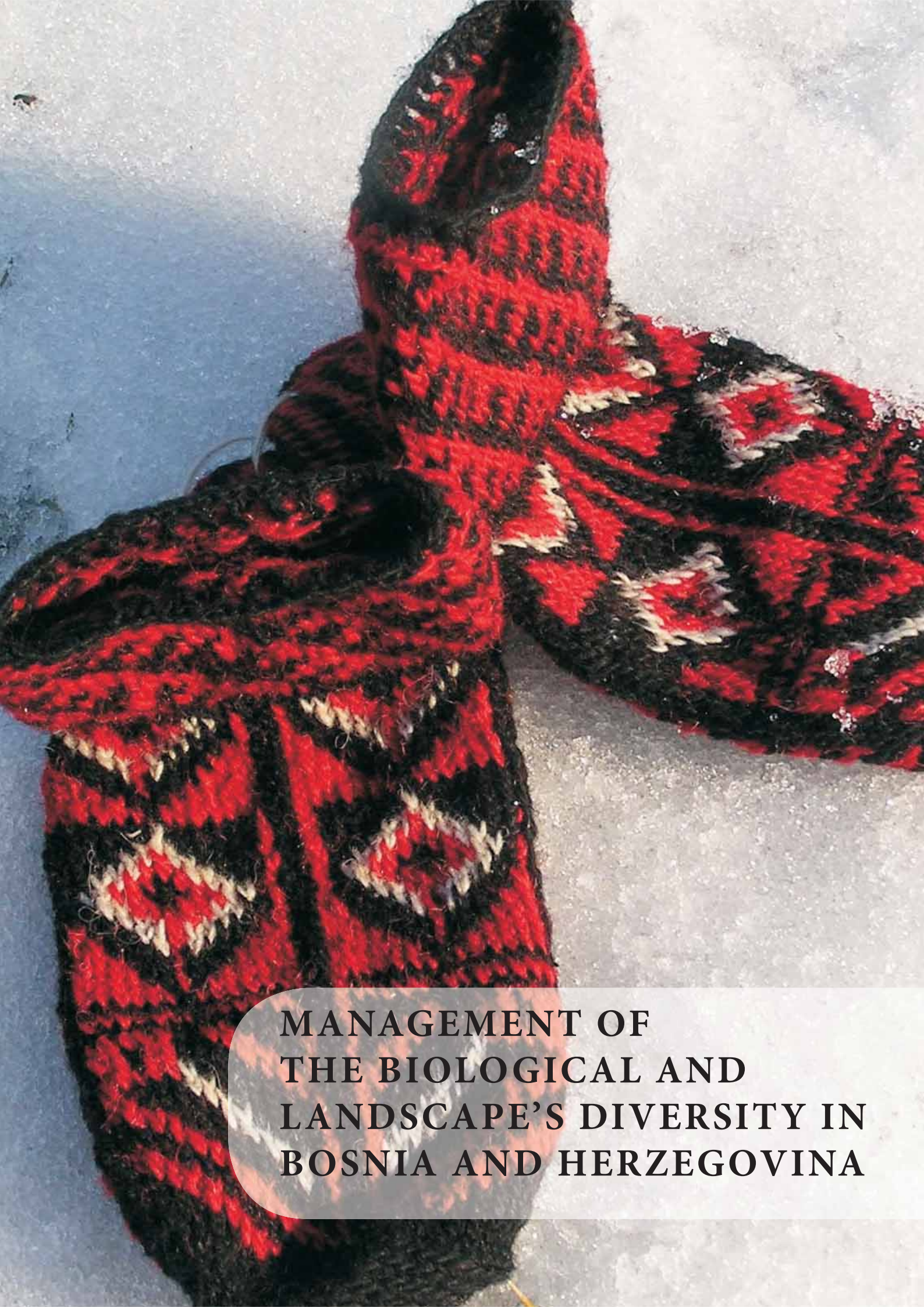
Gudgeon *Gobio gobio* is one of the most important invasive fish species in our country.
Within warmer hydro-accumulations, such as Bardača, Hutovo Blato and Buško blato, often occurs goldfish *Carassius auratus gibelio*. In the hydro-accumulation of Neretva river occurs carp *Cyprinus carpio* that reaches extremely high abundance of its populations. Due to lack of the attention, from many fish farms has fled californian trout, *Oncorhynchus mykiss*, while arctic char *Salvelinus alpinus* was introduced in several occasions by ranching of Neretva river and its hydro-accumulations.
Invasive fish species have substantially distrubed the ecosystem's structure of many watercourses. This has endangered the endemic gen pool of species, such as neretva's soft-muzzled trout *Salmothymus obtusirostris oxyrhynchus*. Through the arrival of invasive species, today are especially endangered endemic species of karst and sinking rivers, such as *Paraphoxinus metohiense* and *Leuciscus svallize*.
Among mammals, introduced was beaver *Castor fiber*, now well adjusted in the coastal belt of waterbodies in upper confluence of Vrbas river and mouflon *Ovis aries musimon*, which lives in the high mountain area of our country. Due to an intensive poaching, the abundance of mouflon's population is very small.
Not far from Sarajevo city, in the area called Rakovica, recently was introduced a population counting 300 deer fallow deer *Dama dama* individuals. Although still under human surveillence, it is only matter of time when it will get into free nature.
In Bosnia and Herzegovina occur several invasive species belonging to the invertebrates. One of the most important is potato beetle *Leptinotarsa decemlineata*. It is vitally bound to a potato plant, but it also attacks other species from the same family. It is extremely well adapted to our conditions causing sever troubles in the bioproduction, and therefore, significant decrease in crop's yield.
In 1995, on the territory of Bosnia and Herzegovina arrived very dangerous invasive species, which is *Diabratica virgifera* that has been decreasing corn's yield in the area of Semberija and other parts of Posavina.
To the list of invasive species should be added certain intruders that are vitally bound to some alien species, or cereals, vegetables, fruits and ornamental plants. Many of them are reason for a massive use of pesticides and herbicides, which severly contaminates the environment.
There is a certain form of invasivity expressed by some fungi and bacteria that cause different pathological stages on their hosts. Fungi that live as parasites on different sorts of cultivated plants, are well investigated. But, there are still data missing on the distribution of these species, the way they get into free nature and how do they envade indigenous flora and fauna.

## Factors of invasivity

Basic factors that enable the invasion of different species of plants, animals and fungi onto the territory of Bosnia and Herzegovina are as follows:

- Heterogeneity of bosnia-herzegovina's habitats that can support a large number of invasive species possessing diverse tolerance ranges;
- Geographic and biogeographic connection of Bosnia and Herzegovina with other european regions;
- Hydrological network connecting different geographical and ecological areas, which enables seed's dispersal for alien plant species;
- Communication with other parts of the world, which enables spreading for different invasive forms of life;
- Unsufficient control by import of horticulture plants, their seeds and planting and seed material for vegetable, fruit and cereals cultures; unsufficient control by domestic animals import;

- Uncontrolled urbanisation without ecologically acceptable and sustainable infrastructure, and adequate waste management's practice;
- Lack of network for the monitoring of invasive species;
- Low ecological awareness on need after maintenance of indigenous flora and fauna.



# MANAGEMENT OF THE BIOLOGICAL AND LANDSCAPE'S DIVERSITY IN BOSNIA AND HERZEGOVINA

# STATE OF THE BIOLOGICAL AND LANDSCAPE'S DIVERSITY IN BOSNIA AND HERZEGOVINA

Based on the state's assessment made in the framework of NBSAP's project, emphasized are following characteristics of landscape's and biological diversity in B&H:

- High level of genetic, species and ecosystem's diversity;
- High preservation level of landscape diversity's units important on european and global scale;
- Significant degree of changes, reffering to the distribution and composition of climax ecosystems;
- Protruding loss trend regarding biological and landscape's diversity, caused by wide spectrum of anthropogenous factors.

The significant threat's level to the biological and landscape's diversity is reflected through:

- Critically endangered species/habitats/ecosystems/landscapes of national, regional and global importance;
- Habitats and ecosystems with numerous endemic and relict or threatened taxa or with high biodiversity richness;
- Ecosystems possessing high economic and ecologic value;
- Landscapes with the significant biological and cultural diversity.

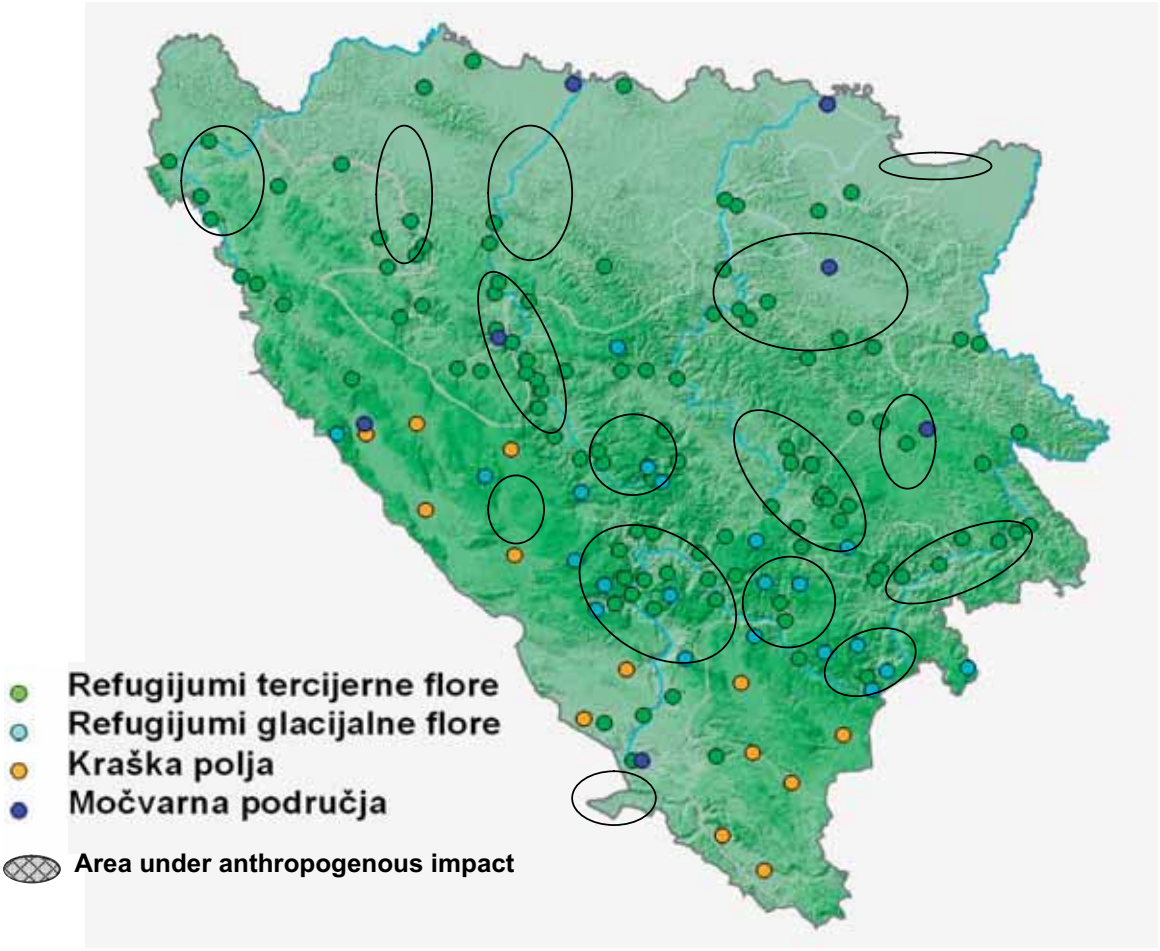



Figure 17. – Specific ecosystems and areas under anthropogenous impacts in Bosnia and Herzegovina

The biodiversity management in Bosnia and Herzegovina leaves special place for the priorities of a long-termed protection, as follows:

- Diversity of endemic or relict taxa, species that are endangered on national, european and global scale; economically important species and autochtonous genetic resources;
- Richness in canyons and cliffs considered as development centres of flora, fauna and vegetation; then refugia of biodiversity from Tertiary;
- Diversity of habitats out of their usual distribution range and of naturally rare habitats (bogs, saltmarshes, mountain sources, sea cliffs, smaller marshes, caves etc.);
- Diversity of karst ecosystems as the largest natural phenomena (karst fields, sinking rivers, caves, karst);
- Diversity of high-mountain ecosystems – islands of the preserved glacial flora and fauna;
- Diversity of ecosystems belonging to the province of relict black pine woods on different foundation (limestone, dolomites, ophyolites, tuff).

## Pressures onto the biological and landscape's diversity in Bosnia and Herzegovina

On the biological and landscape's diversity of B&H exercised are pressures on both scales national and global.

Table 53. – Pressures onto biological and landscape's diversity on global and national scale

| | Pressures on national scale | Pressures on global scale |
|---|---|---|
| PRESSURES ON BIOLOGICAL DIVERSITY | • Habitats conversion<br>• Unsustainable use of resources<br>• Logging, hunt and poaching<br>• Permanent pollution of all environmental spheres<br>• Devastation and destruction of ecosystems<br>• Degradation and fragmentation of ecosystems<br>• Disturbance in willderness<br>• Unsustainable gathering of economically important species<br>• Uncontrolled use of pesticides and fertilisers<br>• Uncontrolled introduction of alien species<br>• Uncontrolled introduction and manipulation with GMOs | • Growth of human population<br>• Unsustainable use of resources<br>• Climate changes<br>• Conversion of habitats<br>• Desertification<br>• Usage of GMOs<br>• Spreading of invasive species<br>• Poor agreement's implementation<br>• Low public awareness level on global scale |
| PRESSURES ON LANDCAPE'S DIVERSITY | • Construction of full infrastructure:<br>◊ Construction of traffic network;<br>◊ Construction of power facilities (hydro-accumulation, power plants, power transmission, pipelines, gasslines etc.;<br>◊ Construction of water supply facilities (catchment areas, trenches, dam lakes,retentions, dams);<br>• Agricultural activities (melioration, replotting, exhausting of habitats by monoculture, use of pesticides and fertilisers);<br>• Uncontrolled urbanisation and ruralistion;<br>• Disharmony between development goals by sectors; | |

# MANAGEMENT OF THE BIOLOGICAL AND LANDSCAPE'S DIVERSITY IN BOSNIA AND HERZEGOVINA

Institutional framework for the management of the biological and landscape's diversity in B&H is composed of:

A) International rules and legal framework of Bosnia and Herzegovina for the maintenance and protection of the biological and landcape's diversity;
B) Institutions of the governmental sector;
C) Institutions for study, inventory and conservation of the biodiversity;
D) Non-governmental organisations.

## A) INTERNATIONAL RULES AND LEGAL FRAMEWORK OF BOSNIA AND HERZEGOVINA FOR THE MAINTENANCE AND PROTECTION OF BIOLOGICAL AND LANDSCAPE'S DIVERSITY

### International rules for the protection of biological and landscape's diversity

On the international level, the protection and sustainable management of natural resources is treated by the line of international documents and bilateral and multilateral agreements. According to these documents each country is souveren to deal with management of its own biodiversity taking into consideration: a) its own needs and goals; b) socio-economic interest and c) international obligations.

Bosnia and Herzegovina is a signatory of 46 international documents considering environmental issues. The protection and sustainable management of biodiversity is an objective of following documents, to whome Bosnia and Herzegovina is obliged to implement:

Table 54. – Overview of relevant international rules

| Document | Status in B&H |
|---|---|
| Convention on Biodiversity (Rio de Janeiro, 1992.) | Ratified in 2002. |
| Convention on wetlands of international importance (Ramsar, 1971.) | Overtaken by succesion |
| Convention on protection of world cultural and natural heritage (Paris, 1972.) | Overtaken by succesion |
| Convention on Mediterranean Sea's protection from the pollution (Barcelona, 1976.) | Overtaken by succesion |
| International convention on plants protection (Rome 1951.) | Ratified in 1994. |
| Framework UN Convention on climate changes (Rio de Janeiro, 1992.) | Ratified in 2000. |
| UN Convention on desertification combat in the countries stroke by severe droughts and/or desertification, (Paris, 1994.) | Ratified in 2002. |
| Convention on survey of trans-boundary traffic with dangerous waste and its disposal (Basel, 1989.) | Ratified in 2000. |
| Convention on trans-boundary air pollution over big distance (Geneva, 1979.) | Overtaken by succesion |
| Vienna's Convention on ozon layer 's protection (Vienna, 1985.) | Overtaken by succesion |
| Protocol on protection of Mediterranean Sea from the land pollution (Athen, 1980). | Overtaken by succesion |
| International Convention on pollution by ships (London, 1973.) | Overtaken by succesion |
| Convention on persistent organic pollutants (Štockholm, 2001) | Ratified in 2001. |

| | |
|---|---|
| Convention on international trade with endangered species of wild flora and fauna (Washington, 1973) | In the procedure |
| Convention on protection of wildlife and natural habitats in Europe (Bern,1979) | In the procedure |
| Arrhus Convention (Arrhus) | In the procedure |
| Kyoto protocol | In the procedure |
| Convention on protection of migratory wild animals (Bonn,1979)<br>Agreement on protection of euroasian-boreoamerican migratory wetland birds;<br>Agreement on protection of European bats | - |
| Convention on Environmental Impact Assessment in trans-boundary sense (ESPOO, 1991.) | - |
| Convention on protection and use of trans-boundary streams and international lakes (Helsinki, 1992.) | - |
| Protocol on especially protected areas and biodiveristy in the Mediterranean (Barcelona,2000) | - |
| Protocol on biosafety (Kartagena, 2000) | - |
| Convention on European landscapes (Firenca, 2000) | - |

Since 2002, Bosnia and Herzegovina has been a Party of the Convention on biodiversity. NFP for the implementation of the Convention is Federal Ministry of tourism and environment. Being an operational body, the Ministry is responsible for the communication with international institutions, initiating of activites considered by the Convention and co-ordination with other relevant authorities and stakeholders.

## Legal framework for the protection of biological and landscape's diversity in Bosnia and Herzegovina

Legal framework for the protection of biological and landscape's diversity at national level make the Constitution of B&H, the Constitution of FB&H, the Constitution of RS, Statut of Brčko District, and sets of environmental laws at level of entities and Brčko District.

The constitution of B&H
After article III 2.c, Annex 4 of Dayton Agreement: *"entities shall ensure safe and protected environment for all people living under their jurisdiction, by sustaining the Agency for the implementation of civil law that shall be functioning in accordance with internationally acknowledged standards respecting human rights and fundamental freedoms addressed in article II, and undertaking other measures according to needs"*.

The constitution of Federation B&H
After article 2., along with article 3. Chapter III, in the environmental domain the federal Government and cantons are in authority to define ecological policy and natural resources use.
The federal Government should create policy and make the laws for each of these objectives as far as the obligations on the territory of Federation of B&H are concerned. Competencies can be accomplished together, separately or at canton's level, co-ordinated by federal authorities.

The constitution of Republic of Srpska
After article 12. of the Constitutional Law for the realization of Constitution of Republic of Srpska (Official Herald of RS 21/92) applied are laws and rules of SFRJ and SRBiH which are in accordance with the Constitution of Republic of Srpska.
After articles 35., 64. and 68. an individual has got right to healthy environment, whereby the Republic protects and encourages rational use of natural resources and ensures protection of the environment

Statut of Brčko District
After article 9. of the Statut, one of functions and competency of Brčko District is the environment protection.

After Dayton Peace Agreement, the responsibility in the field of environment comes to governments of entities and District, which have, in the period from 2003 to 2004, adopted sets of environmental laws, as follows:

| Federation B&H | Republic of Srpska | Brčko District |
|---|---|---|
| Law on nature protection | Law on nature protection | Law on nature protection |
| Law on environment protection | Law on environment protection | Frame law on environment protection |
| Law on air protection | Law on air protection | Law on air protection |
| Law on water protection | Law on water protection | Law on water protection |
| Law on waste management | Law on waste management | Law on waste management |
| Law on Fund for environment protection | Law on Fund for environment protection | Law on comunal activities |

Endorsed laws on nature protection in Federation B&H, Republic of Srpska and Brčko District are based on Habitat's Directive (EU HABITATS DIRECTIVE (92/43/EEC) and Birds Directive (Council Directive 79/409/EEC).
Entity ministries are obliged to establish and develop sub-legal rules in order to enforce the set of environmental laws.
Cantonal ministries in Federation B&H are in power to develop its own legal framework that shall be consistent with the set of environmental laws in Federation.

## Efficiency of legal rules

As far as biodiversity is concerned, among fundamental laws is the Law on nature protection. Although it possess many good sides, this law is also characterized by inadequacy to bosnia-herzegovina's circumstances and complex implementation process for some basic terms.
For the implementation of valid entity laws on nature protection encountered are problems of:

- Undeveloped sub-legal rules;
- Lack of expert institutions at state and entity level;
- Disaccordance between the Development Strategy of Bosnia and Herzegovina and ecotouristic and economic potentials that present and future protected areas posses. This fact is a final consequence of public awareness state and poor knowledge on environmental management;

- Lack of decking law on nature management in Bosnia and Herzegovina with targets and mechanisms for the CBD's implementation at national level.

## B) INSITUTIONS OF THE GOVERNMENTAL SECTOR

The responsibility for environmental issues at state level is by law on ministries and other administrative bodies in Bosnia and Herzegovina assigned to the Ministry of foreign trade and economic relationships. Apart from that, afore mentioned Ministry is in charge for the enforcement of B&H's jurisdiction and harmonization of entity government's plans with institutions from sectors of agriculture, energetics, environmental management, development and exploitation of natural resources. Sector for natural resources, energetics and environment protection of the Ministry is divided in three departments (department for coordinated management of natural resources, department for energetics and department for environment protection). The biodiversity management is within the competency of Ministry for tourism and environment (Federation B&H) and Ministry for physical planning, urbanism, construction and ecology (Republic of Srpska), while in Brčko District related activities are undertaken by comunal sector services and sector of agriculture. Named ministries encompass special services engaged with the protection of biological and landscape's diversity (Sector for the environment protection in FB&H; OJ for water and natural habitats in RS).

Further competency for the implementation of environmental laws in FB&H comes to cantonal (municipality) ministries.

Management of genetic and biological resources is within the competency of entity resor's ministries (Ministry of agriculture, water management and forestry in FB&H and Ministry of agriculture, forestry and water management in RS).

The protection of natural heritage and implementation of UNESCO's terms are too within the competency of entity resor's ministries (Ministry of education and science in FB&H and Ministry of education and culture in RS).

### Efficiency of institutions from governmental sector

Although natural heritage of Bosnia and Herzegovina looses each day some of its jewels, there isn't any state institution in Bosnia and Herzegovina in charge for the evaluation and re-evaluation of its natural heritage and creation of legislative and institutional framework for the sustainable management.

Because of poor efficiency in application of entity and state laws in Bosnia and Herzegovina after Dayton Peace Agreement, and complex law implementation at any administrative level, stroke are areas that are valuable from biological and landcape's point of view (river banks, canyons, mountain areas etc.). Although the biodiversity protection is an objective of the *Law on criminal procedure,* its implementation regarding ecological criminal deeds isn't efficient enough. Incidents related to disposal of toxic, dangerous and other substances in the nature, illegal logging, exploitation of protected plants and animals, poaching aren't penalised in sufficient and effective manner. The inspection network in place can not meet all needs, while the monitoring on usage of biological and landscape's diversity doesn't exist.

# C) INSTITUTIONS FOR STUDY, INVENTORY AND CONSERVATION OF BIODIVERSITY

## Scientific and exploring institutions

Today in Bosnia and Herzegovina, exploring of biological and landscape's diversity is carried out mainly by expert teams within faculties at the University of Sarajevo, Banja Luka, Tuzla, Mostar, Bihać and Zenica. Currently achieved level of inventory and systematic order of biodiversity records doesn't satisfy, inspite of long research tradition. There is obvious lack of independent scientific and exploring institutions dedicated exclusively to biodiversity research and the assessment of conservation status for species, habitats and ecosystems.

*Related institutions*

The biological and landscape's diversity are in a way objectives of institutions occupied by planning of development (Institute for planning of development and Urbanistic institute). Forest management is arranged through a system of public enterprises (Forestry). Water management, including the biodiversity comprised by water resources, is arranged through a system of public enterprises (Waterbodies of RS, Watershed of Sava river, Watershed of Neretva river, Institute for water management).

## Conservation of biodiversity in Bosnia and Herzegovina

Bosnia and Herzegovina has got a long tradition in protection of natural values. The law on nature protection NR BiH from 1946 has regulated an adequate management on nature characterized by special biological and landscape's values. The same law requires an inventory to be completed and designation of protection level for natural objects possessing different values.

Despite to a large number of areas with high natural values, and on the other hand, the way that development has affected the nature, extremely small proportion of B&H's territory is designated as a protected area (0,67%). This small amount of the protected territory places Bosnia and Herzegovina at very bottom of the European scale.

After *Law on nature protection of FB&H* and *Law on nature protection of RS*, in Bosnia and Herzegovina are defined four protected area types:

- protected natural area (Ia, Ib and IV IUCN's category);
- national park (II IUCN's category);
- nature monument (III IUCN's category);
- protected landscape (V IUCN's category).

The extention of protected territory is advised by National environmental Action Plan, Physical Plan of Bosnia and Herzegovina and midle-termed Development Strategy.

The biodiversity conservation in Bosnia and Herzegovina faces several crucial problems:

- undeveloped and inadequate financing modes;
- dissaccordance degree between before-war and present protected area categories (designated in accordance with IUCN's categorization) is high. The adjustment of those categories has never been completed;
- real protection is conducted in very limited number of areas, which are several primeval forest reserves, two national parks, two wetlands of international importance, two nature monuments, one protected landscape and two parks of nature (protection category at cantonal level). Remaining areas protected by previous laws haven't got a management plan with clearly defined responsibilities.

The managament of protected area is assigned to special public enterprises or forestry, whose jurisdiction the area is within. In the field of agricultural and genetic resources management, significant role comes to institutions like agricultural institutes, institutions for soil management, institutions dealing with organic production and certifying of sustainable wild plants and animals use.
In B&H after Dayton Peace Agreement, the condition of well managed natural value's protection is far from being satisfying because of:

- Dismissing of key institutions (Institute for protection of natural and cultural heritage);
- Lack of state's interest and strategy for nature protection;
- Intensive transition and privatisation without fundamental documents;
- Inadequate development strategy;
- Undeveloped mechanisms for making a gain through protection of natural units and lack of financial means for conservation value's research purposes;
- Inadequate position of biodiversity issue within planning process;
- Low public awareness level.

## *In situ* conservation

*In situ* protection represents a system of ecologic and legislative rules streaming to maintain key biological and ambiental values of biodiversity in concrete space and given time dimension.
The protection of genetic diversity means its preservation within medium where it fulfills its natural features and accomplishes the best adaptibility.
The protection of species diversity is achieved through a legal framework created for protection purpose of plant and animal species at their habitats.
The protection of landscape's diversity, including all comprised ecosystems, results in designation of protected areas with different level and character. Trying to keep up with the european trend of sustainable environmental management and to adjust to its modern tempo, Bosnia and Herzegovina has become a member of the network developed by the European Environment Agency. As a state, B&H tends to develop its own and accept european indicators on environmental state. As one of its obligations toward the Agency is to submitt regular reports on the environmental state. In terms of biodiversity, as an indicator established is the Common Database of Designated Areas (CDDA), which is some kind of fundament for the register and inventory of protected areas at national level.

Table 55. – Overview of areas protected by laws of SR B&H (NEAP, 2003)

| Category of protection zaštite | number | Under-category | number |
|---|---|---|---|
| Strict nature reserve | 3 | | |
| Managed nature reserve | 2 | | |
| National park | 2 | | |
| Special reserve | | Geologic | 2 |
| | | Botanic | 5 |
| | | Ornithologic | 1 |
| Reserve of natural areas | 9 | | |
| Plant species | 7 | | |
| Animal species | 5 | | |
| * Ptice pjevice | 153 | | |
| * Ptice mocvarice | 66 | | |
| * Ptice grabljivice | 38 | | |
| Nature monument | | Geologic | 3 |
| | | Geomorphologic | 65 |
| | | Paleontologic | 1 |
| | | Individual trees | 21 |
| | | Group of trees | 1 |

## *Ex situ* conservation

This method of nature conservation includes a system of measures designed for the protection of selected biodiversity elements out of their natural habitats, which plays a special role in preservation of highly endangered wild species.

At present, *ex situ* conservation means the creation of botanic collections (botanic gardens, arboretums and mediterranetums).

*Ex situ* conservation of both genetic resources and endangered autochtonuos species is conducted in greeneries through the establishment of seed collections and gen's bank.

This form of protection in B&H gets form one day to another more and more neglected, if it is to be judged by the state that Botanic Garden of the National Museum is in.

The Botanic Garden has begun to work in 1888, right after the National Museum was established. It was officialy established by Karlo Maly. However, many of its collections got destroyed entirely in recent war. After the war, there was no financial means for its revitalisation and reconstruction. Hence, this part of the Museum, which is very important scientific institution, isn't in capacity to provide an effective *ex situ* conservation.

On the northern slopes of Trebević Mt. is to be found Alpinetum whose original purpose was forgotten long time ago. It was established by V. Gligić and intended for the conservation purpose of many glacial and relict species.

Fifty years ago, on Klek peninsula was established Mediterranetum with purpose to preserve mediterranean flora and fauna. Today, it doesn't accomplish its original purpose.

*Right after the National Museum was established, initiated was Herbarium's collection with purpose to document biological and genetic diversity. This was accomplished through a longlasting research and inventory. Despite hard conditions in which it has been working since 1992, the Herbarium of the National Museum still preserves a priceless treasure contained in more than 2 milions specimens of B&H's flora. In the nature department of the National Museum exist, since it was founded, very rich animal collections (of avertebrates, fishes, amphibians, reptiles, birds and mammals). Special value comes to rich and visually attractive butterfly collection, then collections of beetles and birds. In order to ensure its re-conservation according to IUCN principles, those collections require at the moment firm financial, technical and skilled manpower help.*

*There has been herbarium's and some animal group's collections situated at the Faculty of Science, Faculty of Forestry and Agricultural Faculty that used be applied in education and research, but got completely destroyed in recent war by fires and explosions.*

In B&H after Dayton, it hasn't been established any kind of new *ex situ* conservation forms.

## D) Non-governmental organisations

In Bosnia and Herzegovina, after database created by the Regional Environmental Centre – B&H's Office, exist 120 NGOs with more than 85.000 members (Environmental Performance Reviews, UNECE, 2004.) that are environmentally oriented by the programme of their activities, underlining the environmental awareness raising and education. Since the war, in Bosnia and Herzegovina have been ongoing numerous environmental projects and programmes co-ordinated and conducted by NGOs.

The bigest issues for NGO's activities and further development represents a financial support.

The activity of NGOs is regulated by Law on societies and unions at state and entity level, after whome NGOs have got legal entity status. After REC's records in 2003, 34% of NGO's total product was reached through international and bilateral donations. The support from local institutions (ministries, local community and economy) has been increasing slowly. Some of NGOs finance themselfs through member fees.

### Environmental awareness and approach to information

The public awareness level regarding environmental issues in Bosnia and Herzegovina is not satisfactory. Reasons for that are: environmental education, presence of environmental issues in media, information on civil rights, information on duties of responsible governmental structures, legal background for the environment protection.

The law on free approach to information in Bosnia and Herzegovina was adopted in 2002, yet it is poorly applied in terms of accomplishment the right of free approach to environmental information.

The media in Bosnia and Herzegovina don't show enough interest and education regarding local environmental issues and troubles. However, there are many topic documentaries (Eco-lexicon, Eco-show, Eco-logic, Eco-vision, To live with nature, Natural heritage of Bosnia and Herzegovina) included into local, entity and state radio and TV shows.

Environmental awarness

# EVALUATION OF BIODIVERSITY MANAGEMENT IN BOSNIA AND HERZEGOVINA

Characteristics and evaluation of the process of biodiversity management in Bosnia and Herzegovina are summarized as follows:

- Unsufficient data on spatial and temporal organisation of entire biological and landscapes diversity in B&H, including its heterogeneity, operativity and reliability from scientific and expert standpoint;
- Low implementation level of current legislative and international conventions considering biodiversity management (as well as environmental management);
- Lack of mechanisms and methodology for biodiversity protection;
- Lack of infrastructure and institutional support (from diverse centres, institutes, agencies and state administration) for appropriate protection and sustainable biodiversity management;
- Lack of intersectoral connections in the process of decision making regarding biological and landscapes diversity.

Problems in the process of biodiversity management in Bosnia and Herzegovina:

- Uneffective institutional framework for protection and management of biodiversity, natural resources and integral natural values;
- Highly stretched current legal rules;
- Lack of horizontal and vertical connectivity, lack of co-operation and information flow between social, political and the rest of organisation systems in Bosnia and Herzegovina, of which the most serious consequences come from the level of decision maker;
- Unsufficient implementation of available legal framework;
- Lack of strategy considering use of spatial capacities at national, entity and local level;
- Mismatching and lack of connectivity between strategic, including all associated, documents (in the sectors of forestry, agriculture and water management) and biodiversity management;
- Lack of strategy and associated development documents in the field of herbal sector ( for economically important plants and animals);
- Lack of clearly definied legislative framework and mechanisms for GMO's monitoring and biotechnological and genetic-engineering trade;
- Lack of financial means and funds for science and expert research in the biodiversity field;
- Lack of definied association oriented topic research with intention to solve actuel problems in the field of biodiveristy and implementation of relevant international conventions and directives;
- Unsufficient and unarranged data on biological and landscapes diversity of Bosnia and Herzegovina, as well as their unavailability to the researchers, planneres and public;
- Unsufficient scientific and expert capacities;
- Low public awarness on biodiversity significance in term of environmental values, especially when it comes to climate changes regulation and biodiversity importance in achieving an income and poverty reduction;
- Lack of available and functional data on biodiversity state and its potentials as a resource, in MEA's context;
- Inefficient implementation of targets in the field of biodiversity and protection of natural and cultural heritage which were identified through the National Environmental Action Plan (NEAP, 2003);
- Inadequate understanding of ecological and environmental issues, as well as involvement

of institutions and individuals which aren't referent for the management, finding solutions and environmental research, especially when it comes to biodiversity in B&H;
- Lack of connectivity and poor co-ordination between governmental and non-governmental sectors and academic, as well as general democratic, public in Bosnia and Herzegovina;
- Minor impact and engagement of resor ministiries at each organisation level and inadequate positioning of biodiveristy issue in the system of general socio-political constitution of B&H.

## BIOLOGICAL AND LANDSCAPE'S DIVERSITY IN BOSNIA AND HERZEGOVINA BY TANGENTIAL SECTORS

### Forestry

More than one half of B&H's territory is covered by woodland and appropriate type of soil, whereby most of it are low forest and scrubs (UNECE, 2004). The exploitation of woods in Bosnia and Herzegovina is poor in general, but it is "from place to place unbalanced". Bosnia and Herzegovina is below the European mean regarding wood roads, which is 8 km of roads per 1000 ha of territory. Hunting activities based on conducted inventories are regulated by entity laws. The inventory is usually made by hunting societies and expert teams.

### Economy

After in 2001 published records (UNECE, 2004), 12% of GNP made gain in agricultural production. Domestic nutritional products cover for 35-40% needs, which is much less than before the war (60%). Except for potatoes, Bosnia and Herzegovina doesn't produce any important agricultural product in needed quantity. An age structure of people employed in agriculture was changed, for young people leave to cities and abroad, searching after better life. After records from the same year, 33-50% (RS-FB&H) of arable land remained unused. There is neither register on agricultural enterprises nor monitoring on land use, despite agro-ecological zoninig made in 2003.

### Energetics

By tradition, energetic sector in B&H ought to be its highly important economy branch (UNECE, 2004). The power production is mainly based on use of country's resources – hydroenergy and coal, while the alternative source of energy, such as wind power, sun radiation, geothermal energy and energy of biomass, haven't got any significant share in the energetic sector today. Despite to high capacities for the energy production based on water resources and coal, Bosnia and Herzegovina is obliged to join the unified european market and to produce "green energy" according to EU Directive 2001/77/EC.

### Tourism

Before the war, in Bosnia and Herzegovina were developed capacities mainly for transit tourism, except for massive development because of the Winter Olimpic Games (Sarajevo, 1984). Hystorical monuments from medieval and Otoman empire, sacral places and mediterranean tourism in Neum used to be the most visited touristic destinations. However,

Bosnia and Herzegovina posses high potential for ecotourism, respectively sustainable tourism, which includes: mountain tourism, rafting, thermal, cultural, village and transit tourism. In order to develop the ecotourism, on the territory of Federation B&H (UNECE, 2004) forseen is the establishment of new protected areas (Una river confluence, Igman-Bjelašnica mountains near Sarajevo, endemic centre Prenj, Čvrsnica, Čabulja etc.).

## Pressures onto biological and landscape's diversity in B&H coming from different economy sectors

Bosnia and Herzegovina is characterized by substantial natural resources comprised by its biodiversity, and other components of nature (water, mineral resources, soil) whose exploitation is directly related to the biodiversity state.

### Forestry, hunt and fishery

The civilization development in the region has been since Neolit determined by natural resources of Bosnia and Herzegovina. The leading role hereby used to have forest ecosystems, for even today they are crucial in profit gain for many people in B&H. Today, forestry in B&H is definied by war events and after-war period of transition. The diversity of wild fauna has been since ever base for hunting, especially fishing in traditional way in both fresh and marine water. Both of those activities, hunting and fishing, require development and establishment of a monitoring system.

### Agriculture, use of biological resources and biotechnology

In our country, by the tradition, exist diverse forms of agricultural production. In the plain it is cereals, in the hilly area fruits, and in the mountain area cattle breeding.
Although agricultural activity in Bosnia and Herzegovina isn't sufficiently developed, there are still some pressures arising from uncontrolled or over-use of pesticides and fertilisers.
There are approximately 5.000 species of higher plants and mushrooms, of which are being used only 600. Many of these, because of their medicinal, edible, vitaminous and aromatic features, were crucial for the development of herbal sector. If a gathering of herbal material should be unsustainable, the structure and state of natural ecosystems could change. On the other hand, the potential that our country could have if this economy branch is developed in sustainable way, is not used enough.
In B&H, the biotechnology development gets in power every day. It relies mainly on traditional knowledge and represent needed potential to promote healthy sorts and breeds, which are well preserved on our territory.

## Energetics, industry and urbanisation

Development of the energetic sector, especially in last 50 years, has been contributing to visible destruction and degradation of entire complexes of diverse habitats (hydro-accumulations, thermal power plants), leaving internationally important areas destroyed (Buško blato, Popovo polje). The similar trend is still ongoing.
Specific industrial development patterns in B&H over last 100 years (open coal's mining, metallurgical plants, heavy industry, chemical industry, processing industry), have been severly changing the biodiversity picture.
Lack of clear and consistent framework for the sustainable space use over last 50 years, has became more obvious in B&H after the Dayton Peace Agreement was signed. It is the result of unbalanced urbanisation process. Along with the unplanned expansion of urban and rural units, evolves construction of a communication system, conversion of arable land and more often woodland with outstanding natural values.

## Tourism and recreation

Inspite of its high touristic potentials, this economy branch in Bosnia and Herzegovina is poorly and inadequately developed. The situtation is like that because of limited knowledge on what these potentials are, planning of required activities, lack of needed comunal infrastructure. There is a troublesome sight along our rivers and roads, in cities and villages, which is the result of low ecological and public awareness level. Due to the fact that physical and environmental planning are separated, emerges disordered space that destroys the natural picture and touristic potential of our country.

Hutovo blato, touristic potential of B&H

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