



Figure 23.
Submarine cave in
the undersea zone of
the island of V.
Palagruža
(photo by A. Jaklin)

1.2. Ecological systems and habitats

According to their origin ecological systems are classified into primary and secondary systems. **Primary (natural) ecological systems** in the area of Croatia are forests. Without human interference they would almost completely cover this region, with the exception of comparatively small sections of steep rocks, screes and seashores. As a predominant ecological factor man has changed this primary state and, despite his chiefly destructive impact on nature, contributed to a high extent to the increase of diversity of habitats and the living nature. His activities generated a number of **secondary (anthropogenic) ecological systems** such as agricultural (arable land, grassland, orchards, etc.), urban (settlements, towns), artificial water-related ecological systems (storage lakes, fishponds), forest cultures etc. Anthropogenic impacts are, consequently, very significant for maintaining the highest possible biological and landscape diversity, unless they bring about the total destruction of primary ecological systems. Numerous habitats and living communities, primarily grassland, are presently endangered by the very cessation of human activities and restoration of the original natural state.

According to its **phytogeography** Croatia is one of the most interesting countries in Europe. It is situated on the very border of two geographical regions, completely different from the vegetation aspect: the Mediterranean region (islands and a part of the littoral) and the

Eurosiberian-North American region (the remaining continental part of Croatia), which is reflected in the high diversity, wealth and singularity of the vegetation cover. So far about 300 basic plant communities (associations), many of them endemic for Croatia, have been described.

In comparison with the state of ecological systems found in the majority of other countries of central and western Europe, Croatia stands out by the preserved condition of its nature. In addition to comparatively small areas of **natural habitats or communities** (water sources, cliffs, moors, some forests, mountain meadows) this region is to a high degree characterized by **seminatural habitats** (some forests, extensive grasslands) influenced by man, but comprising chiefly native living communities typical of such habitats. **Anthropogenic habitats that developed under the influence of human activities and show the structure and composition of species differing widely from the natural ones are not so dominating as in the great part of Europe.**

During the development of the NSAP a preliminary list of **habitat types** in Croatia was prepared, based on the classification for Europe made within the framework of the international CORINE-Biotopes programme. In Croatia more than 600 habitat types were identified and the European list was supplemented by habitat types specific only to Croatia.

THREATS

The major threats to ecological systems and habitats, among a number of them, are **immediate destruction or degradation, various types of pollution and excessive exploitation of natural resources**. In the following chapters the threats to individual ecological systems will be described in detail.

It should be stressed that certain negative impacts posing threat to ecological systems and habitats in Croatia have their origin partly in neighbouring countries, making it hardly possible or impossible to be influenced on the national scale.

Box 11. Negative impacts on ecological systems originating in the neighbouring countries

- pollution of the Sava river (Slovenia)
- pollution of the Po river, i.e. of northern Adriatic (Italy)
- acid rains brought by cyclones from northern Italy and
- pollution of the Neretva river and the Malostonski bay (Bosnia and Herzegovina).

The following is an overview of the state and threats to individual ecological systems in the way as working groups responsible for the development of the NSAP addressed them. Due to specific problem areas the coast and islands were separately dealt with by a working group although they do not represent a unique ecological system.

FORESTS

Features

Croatia is a medium wooded country. The total area of woodland is about 2,490,000 hectares, which is 44% of the total land area of Croatia. Dense forests interesting from the aspect of both ecology and resources occupy 2,100,000 hectares or 37% of the land area and represent the actual density of forest cover. Forests that are not considered forest cover represent various forest degradation stages with minor coverage and areas in which absolute forest soils and not overgrown surfaces belonging to the forest may be found. They account for some 16% of the total wooded area. Only 460,000 hectares (18.5%) of the forests are privately owned; the majority is owned by the state.

The greatest density of woodland may be found in the west Dinaric Alps (Gorski kotar, a part of Velebit) and a part of eastern Slavonia with the wooded basin of Spačva, whereas the areas round Osijek and Đakovo, the Drava basin

Box 12. State of forests in Croatia

In European proportions the state of Croatia's forests may be considered good. It is much better than in the majority of countries of the central and western Europe, primarily owing to the forest management method that gives priority to natural composition of forests. 95% of forest components show a natural composition and in the last hundred years the woodland areas have not decreased.

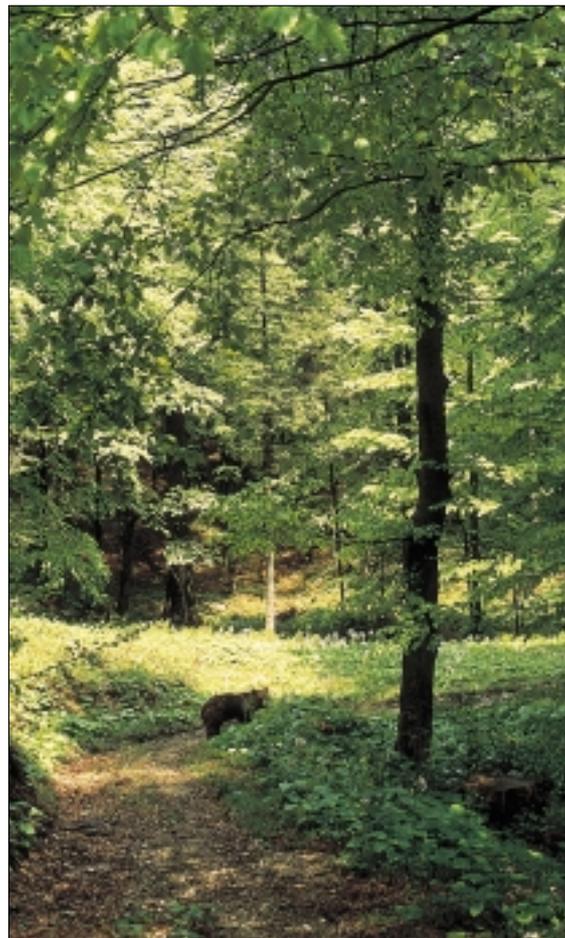


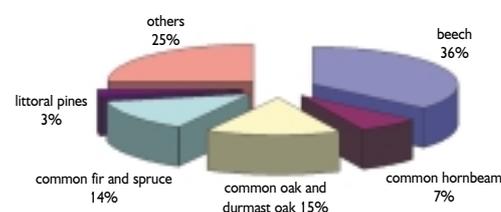
Figure 24. A forest in Gorski kotar
(photo by A. Frković)

near Varaždin, the surroundings of Slunj and Cetingrad and the entire littoral Croatia except the Istrian peninsula and some islands (Rab, Hvar, Mljet) are sparingly wooded.

The forests in Croatia belong to the first or the second generation after the natural renewal of vast primeval forests in the area between the Sava and the Drava, as well as in the karst region to the south of river Kupa. According to the composition of trees they are natural, or rather very similar to primeval forests from which they originated. **As many as 95% of forest components show a natural composition** which is rare and highly valuable in global proportions.

Graph 1 shows the volume share of individual forest species in the composition of Croatia's forests. The remaining 25% of the share in forest composition relate to more than 30 types of trees, with a slightly higher percentage of ash, lime, maple, poplar, black alder and various wild fruit.

Owing to the laws and regulations governing the sector of forestry **the woodland area of Croatia has not substantially changed in the last hundred years.**



Graph 1. Volume share of individual forest species in the composition of Croatia's forests



Figure 25. Lowland flood-affected forest of common ash with late snowflake in the Sava basin (photo by M. Schneider-Jacoby)

Forest communities of Croatia consist of 260 indigenous woody species, approximately one sixth of which is economically important. As a comparison, vast woodlands

of Siberia and Scandinavia are inhabited by only a few types of trees of economic relevance.



Figure 26. Forest of beech and common fir on Medvednica (photo by I. Bralić)

Box 13. Woodland belts (according to the division in the monograph on "Forests in Croatia", 1992)

1. Mediterranean region (40%)

1.1. Coastal belt

- 1.1.1. Forests of allepo pine
- 1.1.2. Forests of holm oak
- 1.1.3. Forests of pubescent oak and white hornbeam
- 1.1.4. Forests of turkey oak and white hornbeam

1.2. Highland belt

- 1.2.1. Forests of holm oak and black hornbeam
- 1.2.2. Forests of holm oaks and Dalmatian black pine
- 1.2.3. Forests of pubescent oak and black hornbeam
- 1.2.4. Forests of turkey oak and black hornbeam

2. Eurosiberian-North American region (60%)

2.1. Lowland belt

- 2.1.1. Forests of common oak
- 2.1.2. Forests of common ash
- 2.1.3. Forests of black alder
- 2.1.4. Forests of willow and poplar

2.2. Hilly belt

- 2.2.1. Forests of durmast oak

2.3. Highland belt

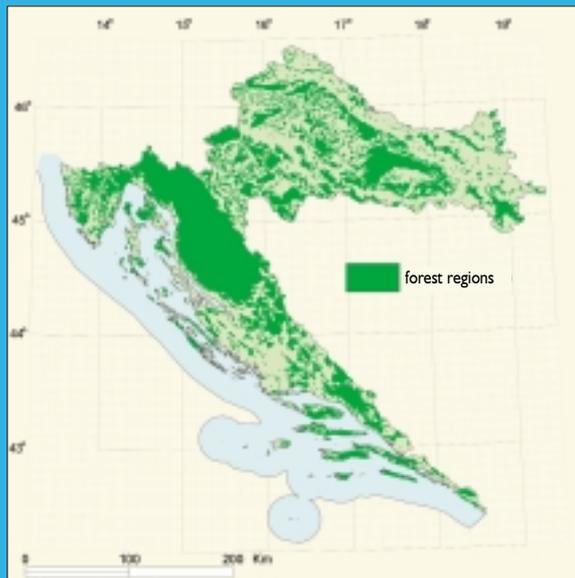
- 2.3.1. Forests of beech
- 2.3.2. Relict forests of lime and yew
- 2.3.3. Relict forests of black pine

2.4. Mountain belt

- 2.4.1. Forests of beech and common fir

2.5. Pre-mountain belt

- 2.5.1. Forests of beech
- 2.5.2. Forests of spruce
- 2.5.3. Forests of dwarf pine



Map 6. Distribution of forest communities in Croatia

(according to data by OIKON d.o.o., original on monograph "Forests in Croatia", 1997)

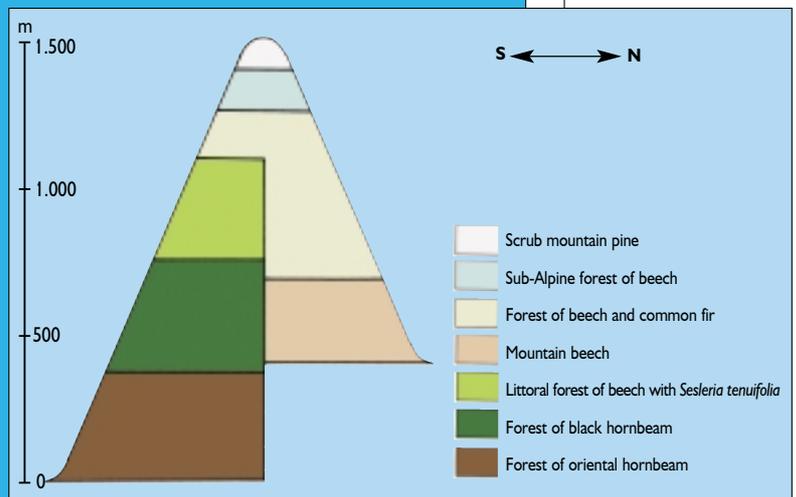


Figure 27. Pattern and width of height belts on the south-western and north-eastern side of Risnjak

(according to I. Horvat, 1962; Forest vegetation of western Croatia; Prirod. istraž. 30: 37)

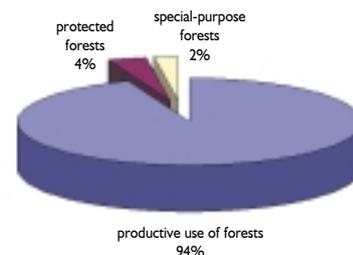
A particular significance of Croatia lies in the fact that the phytogeographical border between two great woodland regions of Holarctic crosses its territory. This border passes the littoral slopes of the Dinaric Alps where the thermophilic oak-woods developed in lower areas belong to the Mediterranean region and the littoral slopes covered by beech woods, as well as the entire forest vegetation of the continental part of Croatia, belong to the European sub-region of the Eurosiberian-North-American region. The thermophilic evergreen and deciduous forests of the **Mediterranean region** of Croatia occupy approximately 800,000 hectares and consist of 17 forest communities. The **Eurosiberian-North-American region** includes 45 forest communities of the lowland, hilly, highland, mountain and pre-mountain stretch with the total area of 1,200,000 hectares.

Viewing the fact that some parts of Croatia are unexplored and some units of vegetation insufficiently explored, it may be assumed that in Croatia there are about **one hundred forest communities** which represents a considerable wealth. Its forests are, moreover, characterized by a **great number of species and vast woodland areas** rarely to be found anywhere in Europe. An extremely rich biological diversity may be found in flood forests of common oak, including forests of beech and common fir in the Dinaric karst. One of the good indicators of forest naturalness and quality is the presence of threatened species that need a wide living space for their survival. So the forests of highland Croatia are characterized by a rich population of big predators (the brown bear, the wolf, the lynx) representing a genetic container and a potential source for these species to inhabit other European countries in which they have become extinct. Similar indicators of the state of flood forests of common oak along the Sava and the Drava are local nesting birds, otherwise threatened all over Europe: white-tailed eagle, lesser spotted eagle and black stork.



Figure 28. Black pines on Biokovo affected by fire

(photo by A. Frković)



Graph 2. Forest management in Croatia (special-purpose forests include those used for scientific research and recreation or belonging to protected nature parts)

State and threats

In European proportions the state of Croatia's forests may be considered good. A natural composition shows 95% of forest components and in the course of the last hundred years the wooded areas have not decreased. The method of forest management is showing a number of advantages in relation to the same applied in the majority of European countries. This advantage is connected with the so-called Zagreb School of Forest Growing that prefers the natural composition of forests.

Forests are nowadays highly threatened by loads that are the result of contemporary civilization – industry, urban development, transport, modern agriculture. Pollution of air, water and soil, accompanied by unfavourable climatic excesses, cause the degradation of entire forest ecological systems, known as **dying woods**.

The most threatened type of trees in this country is **common fir whose population has been permanently damaged by more than 70%** According to the level of damage it is followed by durmast oak, common oak, common ash, black pine, common spruce and sweet chestnut. A higher resisting power may be found in common hornbeam, beech and holm oak. In relation to degradation of forests in Europe Croatia is, unfortunately, above the European average due to excessive degradation of fir.

Lowland forests have been for some time threatened by **changing natural features of watercourse regimen due to technical undertakings** such as river regulation, hydropower plants, land reclamation measures, construction of canals, etc. These measures have resulted in changing habitats and spreading of marshes, in lowering the level of underground waters and drying of hygrophylous trees (common oak, common ash, black alder, etc.).

Box 14. Forest threats

- pollution of air, soil and water (change of the chemical climate)
- change in natural features of watercourse regimen due to technical undertakings in lowland forests
- construction of roads and transmission lines
- striving after the highest possible financial effect of the productive function of forests
- use of pesticides in forests
- insufficient care about the overall biological diversity of forests
- inadequate hunting management
- use of inadequate machinery in forests
- forest fires
- failure to enforce legal provisions and
- macroclimatic changes and climate excesses.

By construction of roads and transmission lines the woodland has been decreased and fragmented and its biological unity broken down which has a highly adverse effect on both its fauna and flora. Forests are further seriously depleted by the use of inappropriate machinery causing damage to trees, compaction of soil and pollution of habitats by waste.

The biological diversity of forests is particularly adversely affected by the use of pesticides in forests, which is prohibited in the majority of European countries. They are just as well threatened by intensive agriculture using various pesticides and fertilizers.

The concern over the overall biological diversity of forests, especially over the species related to dry and rotten trees, as showed within the **forest management** in Croatia, is insufficient and unsystematic. In an effort to preserve fauna and micro-organisms it would be important to leave at least two standing/lying dry trees per hectare of the land. The concern for fauna is at present left chiefly to lease-holders of hunting grounds who, due to their selective care for specific types of game and their distinguishing between “useful” and “harmful” species, often affect adversely the composition of entire living communities.

The majority of climatogenic types of trees are cut down too early, or rather the rounds (cutting ripeness) are made too often. Forests are still generally considered a profitable renewable natural resource that has the adverse effect on their highest value – the function of universal benefit that, according to some evaluation methods, exceeds the productive and energy-related value of forests by at least 30 times.

KARST AND UNDERGROUND

Features

The karst area occupying about 54% of Croatia’s territory represents a part of the relief peculiarity that can be found in no other region of Europe. Owing to its length *running along the entire Adriatic coast* and to its width *extending into the continental part*, Croatia’s karst is both a peculiarity and a “locus typicus” of an exceptional geological structure and hydrogeological characteristics (Map 7). These features are reflected both in the surface morphology and in the distribution of underground system of fissures through which underground watercourses are continuously or temporarily draining. They are connected with a wide diversity of underground fauna whose uniqueness is reflected in the **number of endemic taxa**.

The karst phenomena and forms have developed primarily in limestone. Croatia’s karst is, however, characterized also by **karst phenomena and forms in marl and sandstone rocks**, or rather flysch series, that are rare even in global proportions.

Box 15. Karst and underground features

Viewing its natural features (hydrogeological, geomorphological, landscape-related, vegetation-related, floral and faunal) the karst region is incorporating the highest amount of Croatia’s peculiarities. Regarding its overall uniqueness, wealth in endemic taxa and living communities, including the high degree of preservation, this region represents an exceptional value not only in European, but in global proportions too.



The karst area covers the highland and Mediterranean Croatia in its entirety, with the exception of individual parts of magmatic and metamorphic rocks integrated like islands in the karst space.

It should be highlighted that in addition to the mainland part of Croatia karst includes also a considerable portion of Adriatic littoral.

Outside its integral area, karst with its most significant morphological and hydrological features appears also as an **isolated phenomenon in lowland Croatia** i.e. in the Sava and the Drava basin, accompanied by all forms of faunal peculiarities. These are minor zones of isolated karst, and yet the phenomenon of speleological forms is not negligible.

The landscape value in the karst region is in certain places emphasized as a global value too, whereas its regional importance is more pronounced over almost the entire territory of Croatia. The karst relief is typical of the mountainous and coastal part, determining all of its features in terms of vegetation, climate and hydrology.

Among **plant communities**, particularly prominent in their peculiarity and the wealth of endemics are the mountain vegetation growing in rock cracks, vegetation of coastal limestone rocks and, above all, and the vegetation of scree – habitats formed by rolling and piling up of stones that came off vertical rocks and swooped down to the foot. One of the rarest and the most threatened Croatia’s plant

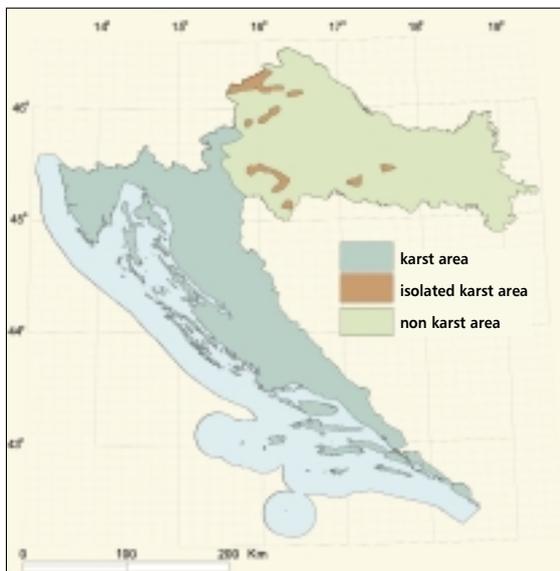


Figure 29. Vrgoračko polje, a karst field subject to flooding

(photo by I. Bralić)

Map 7. Karst region of Croatia; some parts of magmatic and metamorphic rocks integrated into the karst region are not included

(according to the model by MEPPP)



Figure 30. River Zrmanja

(photo by D. Grlica)

endemic – Velebit degenia – is associated with screes. Both the genera and species of this peculiar tertiary relict are endemic for Croatia, and it can be found in several locations of the Velebit area (Box 41, p. 47). A great number of relict taxa originating from the tertiary period survived in Croatia's karst region owing to the fact that they were not affected by icing. Consequently, there remained taxa that in the northern and western parts of Europe died out during ice formation.

Some of the more important animal taxa of aboveground karst habitats are, for example, the relict Martino's snow vole, Dalmatian garden dormouse as a Croatian endemic, the locust (*Pryonotropus hystrix hystrix*) and the genera of terrestrial snails *Medora* and *Delima*.

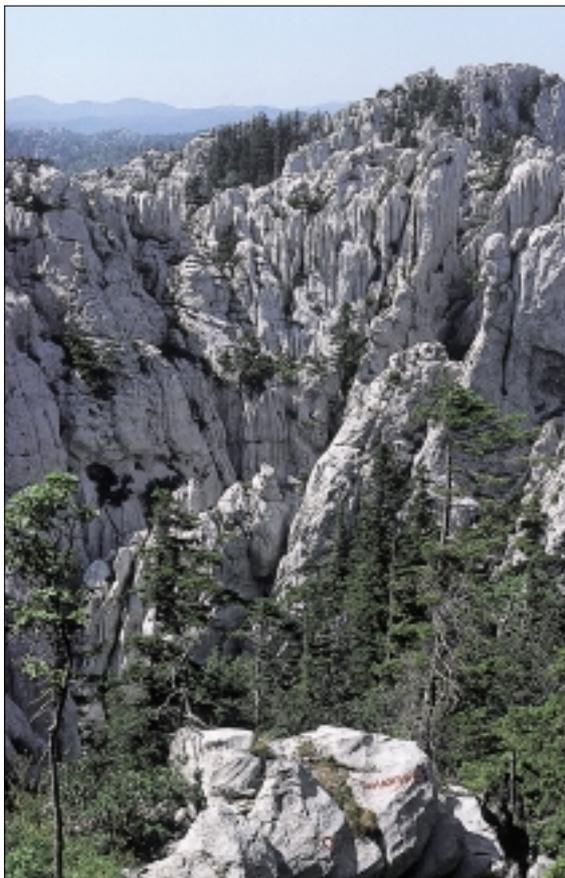


Figure 31. Strict reserve of Bijele and Samarske stijene

(photo by A. Frković)

Rivers of the karst region are often rich in waterfalls and cut their canyons through limestone. Many of them sink underground and continue as underground watercourses. Of fauna-related peculiarities they contain a series of endemic fish taxa. The ichthyofauna of Croatia's karst rivers is a wealth and value in global proportions.

The karst rivers are also remarkable for the phenomenon of travertine that results in the formation of characteristic geomorphological forms, particularly downstream beds. This phenomenon is most evident in the area of the Plitvice Lakes, the worldwide famous national park registered on the World Cultural and Natural Heritage List. It is here that a special travertine-building community of the aquatic moss *Cratoneuron commutatum* has developed. The blue-green algae living on the moss

Box 16. Features of karst of international importance

- landscape value
- geomorphological and hydrogeological peculiarities
- endemic vegetation of rock cracks and screes
- travertine-building living communities
- ichthyofauna of surface and underground watercourses and
- endemic underground mainland fauna.



Figure 32. Endemic species and genus, *Meledella vernerii*, inhabits underground habitats of island Mljet

(photo by B. Jalžić)

surface participate in the process of extracting calcium carbonate from water, producing a special form of loose, diaphanous travertine that mirrors the form of moss. The development of travertine caused the appearance of numerous travertine barriers and downstream beds on river Korana, or rather the formation of sixteen lakes and a number of waterfalls. The survival of the Plitvice Lakes depends on maintaining this biodynamic process and preserving the travertine-building community that is highly vulnerable since dependent on a combination of several conditions, particularly the clean water and shading provided here by the dense surrounding forest. In other karst rivers travertine is also developing, but of a different type, connected with the travertine-building communities of lighted habitats.

The alternation of water-permeable karst sediments and those less permeable or absolutely impermeable enabled penetration of water more or less deeply into its stony substratum, or rather the creation of **underground morphological forms**: caves, caverns, abysses, ice-pits, including underground springs and estavelle as forms characteristic for this medium.

Box 17. Threats to karst and underground ecological systems

- Pollution of flowing waters by municipal and industrial waste waters and their discharge into the underground without a satisfactory degree of purification
- Construction of hydroenergetic plants (hydropower plants) with the indirect impact on the change of underground waters regimen
- Melioration of karst fields used as agricultural land
- Intensive agriculture in areas whose filtering or surface waters belong to the water supply system of the underground;
- Use of speleological facilities as waste disposal sites
- Use of speleological facilities for tourist purposes without previous biospeological studies and an efficient control
- Ineffective enforcement of legal provisions relating to the protection of karst and underground ecosystems and underground fauna, and
- Catching of underground animals for commercial purposes.

Underground fauna

Croatia is extremely rich in fauna of diverse underground habitats, particularly in the karst region, including the fauna of underground sandy and pebbly alluvial deposits (interstitial fauna). However, considerable possibilities of new discoveries are still open, as substantiated by the recent discovery (1994) of a scientifically new species, genus and perhaps even a family of cave leech in the Luca's cavern on Velebit.

In Croatia's karst underground various aquatic habitats have developed, analogue to those found in surface waters. The region contains small pools and pools, small and big lakes, streams and rivers, each developing different types of animals. There is, for example, a world-famous endemic and relict amphibian olm. Among numerous endemic invertebrates of the underground there are various species and subspecies of underground beetles, pseudoscorpions and snails.

About thirty taxa of the relict genus of *Niphargus* (underground crustacean) and several underground cave shrimp of the genus *Troglocaris* inhabit almost all types of underground aquatic habitats.



Figure 33. Accretion of tubes *Marifugia cavatica*, an endemic of underground waters in Dinaric karst

(photo by B. Jalžić)



Figure 34. Freshwater troglobiontic sponge, *Eumapius subterraneus* ssp. *subterraneus* Sket et. Velikonja, inhabits only underground sink-waters of river Zagorska Mrežnica in the area of Ogulin

(photo by B. Jalžić)

The interstitial underground waters of Croatia's Pannonian region are characterized by certain underground crustaceans of marine origin such as *Bogidiella albertimagni* and *Bogidiella semidenticulata* species. In karst springs and littoral caves *Bogidiella dalmatina* can be found and in hypothermal springs near Zagreb the tertiary relict of *Protelsonia bingarica* subsp. *thermalis*. In underground waters abundant populations of endemic fish species of the *Paraphoxinus* genus are periodically present.

Significant representatives of the cave fauna are bats; for ten species of these flying mammals the underground space is the sole or predominant daily resting-place in summer, a place to mate and rear their young and often the only one to spend winter. For some species like long-fingered bat Croatia's caves are, considering Europe, an important summer habitat and for bent-winged bat and Blasius' horseshoe bat they represent important wintering places for this part of Europe. For many other species these areas are places for a shorter or longer daily stay during spring or autumn migrations.

WETLANDS AND WATERS

Features

Rivers

Croatia is covered by a well-developed hydrographic network. Major watercourses are more than 3,500 km long and the longest rivers are the Sava, the Drava and the Danube. The waters empty into the Black Sea and the Adriatic. The catchment area of the Black Sea occupies 62% and that of the Adriatic 38% of Croatia's territory.

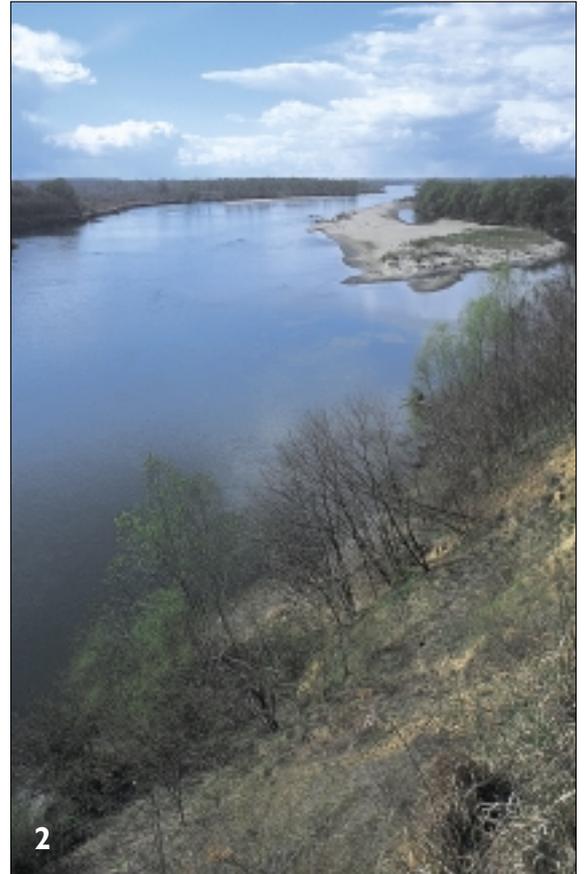


Figure 35. Flood in Kopački rit

(photo by M. Schneider-Jacoby)

Figure 36. River Drava, lowland river of the Black Sea catchment area; river flow dynamic: 1/ 1990 and 2/ 1996.

(photo by M. Schneider-Jacoby)



Rivers belonging to the Black Sea catchment area are lowland rivers along which a number of wetland habitats developed – flood forests and grassland, stagnant backwater, deserted river beds, meanderings. **River Drava**, particularly a section from the mouth of the Mura to Barč in Hungary, is one of few subnatural watercourses of lowland rivers left in the central Europe. These rivers are distinguished by steep, landslide and still unfortified banks in which sand-martins and kingfishers make their nests, and by numerous shallows, pebbly and sandy sandbanks with threatened nesting birds such as small tern and little ringed plover. These types of habitats belong to those most threatened in Europe.

Due to their base consisting chiefly of limestone rocks, **rivers of the Adriatic catchment area** are short, with frequent rapids and waterfalls, including sections formed as canyons. Numerous sink-rivers flow through karst fields, making a system of underground water circulation. The flowing waters of the karst region in the Dinaric Alps, particularly the Krka, the Cetina, the Neretva and their tributaries, contain a large number of endemic animals, primarily fish. Springs are special aquatic habitats in which, as a result of special ecological conditions, peculiar plant and animal communities develop.

Lakes

Lakes in Croatia are few. The total surface area of natural and artificial lakes over 0.2 km² is approximately 81 km². The most famous **natural lakes** are the **Plitvice Lakes** representing a watercourse of the Korana which turned into a series of 16 cascading lakes with numerous travertine downstream beds in a vivid biodynamic process. This area was designated a national park and included in the UNESCO World Cultural and Natural Heritage List. **Vransko Lake near Pakoštane** is the greatest natural lake in Croatia with the surface area of 30.7 km². **Vransko Lake on the island of Cres** is far smaller, but owing to its depth reaching 74 m it is the greatest natural accumulation of fresh water in the North-Adriatic region. **Red Lake** near Imotski is as much as 250 m deep, although very small (Fig. 37).

Artificial lakes are the result of human activities carried out on natural river courses and used either as storage-lakes for hydropower plants, for water supply and protection against floods, or for exploitation of gravel and sand. There are a number of storage-lakes made on karst rivers and in the continental part the greatest of them may be found on river Drava. Yet these lakes, although sometimes showing some ornithological relevance, imply degradation or destruction of valuable natural wetland and aquatic habitats and change substantially the hydrology of the region where they are situated.

Figure 37. Red Lake near Imotski, some 250 m deep although very small

(photo by I. Bralić)



Box 18. Wetlands and waters

In the region of Croatia vast natural wetland areas are preserved in river valleys which represents one of the highest values of biological and landscape diversity, especially at the level of the western and central Europe. However, these are **at the same time the most threatened ecological systems in Croatia**. For that reason they require priority in nature protection and a national programme for their preservation and management.

Wetlands

Croatia has an outstanding wealth of wetland habitats, in particular those whose origin is connected with rivers. The most important areas are **flood zones** of the Sava, Drava and Danube basin in which extensive and, to the most part, well-preserved wetland habitats have developed, three of which are included in the Ramsar list of wetlands of international significance. One of them is **Lonjsko polje** in the central course of the Sava – a flood area with wide, wet flood forests of common oak, flood meadows and pastures and numerous river backwaters. Here habitats of numerous European threatened species may be found, such as the white-tailed eagle, lesser spotted eagle, black stork, spoonbill, white stork, blackbird and others. **Kopački rit** situated at the **mouth of the Drava** into the Danube is full of lakes, ponds and canals, spacious reeds and a large tract of fishponds. It is here that the greatest population of white-tailed eagles is living and 90% of Croatia's population of wild geese nesting. It is also the only one place in Croatia where great cormorant is known to nest. This area is particularly valuable as a resting and feeding place for migratory waterfowls. Sometimes during migration flocks of several tens of thousands ducks and geese may be met here. This flood area is also important as a hatchery for fish from the Danube and the lower Drava.

The remnants of formerly vast marsh at the mouth of the Neretva are significant for the **Mediterranean region of Croatia** as another Ramsar region. Although the major part of the former vast marsh in this area has been mostly reclaimed, in the **Neretva valley** there are still wide areas of wetland habitats among which the most important are extensive reeds as the largest and the richest in species in the entire Mediterranean part of Croatia. This is the only place in Croatia where bearded tit make their nests and at the same time one of the last Mediterranean nesting localities of bittern, little bittern, marsh harrier, crake, warbler and other European threatened species.

In the north-western part of Lake Vransko in Dalmatia there is a comparatively large reed protected as an ornithological reserve. The reserve still accommodates a small colony of purple heron and pygmy cormorants may be found on the lake almost all the year round. Lake Vransko is an important resting and feeding place during migration and wintering of waterfowls.

Along the entire Croatia's coastal zone there is a series of smaller wetlands. As this is a karst, warm and dry region, the network of such localities is irreparable and even very small ponds (puddles) are important. Namely, nearly all of the country's waterbirds and a number of European ones migrate over this coastal area. A peculiarity of Croatia's coastal area are "muds" or rather ponds found in valleys and karst fields with usually well developed wetland vegetation. **Velo blato on the island of Pag** (Fig. 38) distinguishes itself by the wealth and diversity of its ornithofauna.

Among **artificial wetland habitats** in the continental part of Croatia there are numerous **carp fishponds**. Their **surface area is 131 km²**, which is more than the total surface

area of natural and artificial lakes. They are especially significant as habitats for a number of threatened waterfowls. So, for example, over 50% of the total Croatia's nesting population of almost all types of ducks (excepting the mallard) nest at fishponds. With the **ferruginous duck** this share very likely exceeds 90% which is extremely important, as this is one of the most threatened European nesting birds in general. The majority of heron and spoonbill colonies may be found at or near the fishponds, because these birds fly for food mostly to the fishponds. A considerable part of the population of the white-tailed eagle in Croatia is directly dependent on carp fishponds and so are grebes, coots and black-headed gulls. More than 50% of black tern and whiskered tern populations are also connected with fishponds. During migration the majority of waterbirds species and the highest concentrations of these birds gather exactly at these fishponds.

Figure 38. *Velo blato* on the island of Pag

(photo by D. Grlica)



Moors

In Croatia moors are very rare, have small surfaces and are conditioned by special habitat conditions. Low temperatures and a high humidity were favourable for the development of **transitional and flat moors** (typical vegetation of heaved moors characteristic for the northern Europe has not developed). Flat moors develop under the influence of limestone waters and contain no peat bog moss *Sphagnum*, while transitional moors are formed under the influence of acid waters and are characterized by predomination of peat bog moss *Sphagnum*.

Although, as distinguished from formally vast moors of northern and central Europe, Croatia's moors cover smaller surface areas, they are still botanically interesting as the last moor branches in this part of Europe. Due to their rarity, isolation and size **moors belong to the critically threatened habitats in Croatia**. They are also habitats for some plants very rarely found in Croatia, such as white beadrush, round-leaf sundew (Fig. 39), broad-leaved cotton grass, bog clubmoss, brown birch, peat bog mosses of genus *Sphagnum* and algae from the family *Desmidiaceae*. Moors are also characterized by certain species most likely extinct in Croatia, such as the butterfly heath ringlet discovered at the moor remnants on Velebit and Dinara at the beginning of this century.

Box 19. Last remaining moors in Croatia

1. Flat moors

- 1.1. Area of Plaško – to the south-east of Ogulin
- 1.2. Jasenačko polje
- 1.3. Gospić – Jasikovac
- 1.4. Vicinity of Karlovac (Lušiči, Jelsa, Debela glava, Orlovac, Kozjača, Skakavac, Banski Kovačevac, Trebinje)
- 1.5. Samobor (Ludvić potok, Lipovečka gradina)

2. Transitional moors

- 2.1. Dubravica – near Zaprešić in the region of Hrvatsko zagorje
- 2.2. Vicinity of Karlovac including the region of Banija (Jelsa, Bratuša – Đon močvara, Topusko, Vrginmost, Vukmanić)
- 2.3. Gorski kotar (Fužine – brook Ličanke, Sungerski lug, Mrzla vodica, Trstenik)
- 2.4. Northern Velebit (Sunder)

Figure 39. Round-leaf sundew, a rare flesh-eating species of moors

(photo by T. Nikolić)



Threatened species of aquatic and wetland habitats

Among **wetland plants** which are threatened or rare at the European level, but comparatively abundant in Croatia, the following are particularly prominent: Siberian iris, arrowhead, water-aloe (Fig. 40), grassy-rush, calamus, rootless duckweed, greater bladderwort, water chestnut, scullcap, water germander, fritillary, water-clover, certain types of orchids and others.

Box 20. Rare and threatened species and communities of the coastal area of River Drava

- dwarf cattail with the community of *Phragmiti-Typhetum minima*
- German tamarisk with the community of *Salici-Myricarietum* and
- sea buckthorn with the community of *Hippophao-Berberidetum*

Figure 40. Water-aloe (*Stratiotes aloides*), a rare species connected with old backwaters
(photo by D. Grlica)

As to the **fauna**, 2,001 species of **invertebrates** have been found in mainland waters of Croatia, but the estimated number is about 4,600 species. **Endemic taxa** found in underground waters of the Dinaric karst are **particularly significant**. Attention should be drawn to the diversity of dragonflies that are very good indicators of the preservation of aquatic and wetland habitats. In Croatia 65 species have been recorded (8 more are doubtful), of which 14 are threatened in Croatia and the further 15 at the level of Europe.

Aquatic and wetland habitats in Croatia are inhabited by about 145 kinds of **freshwater fish** of which 33 are **endemic**, including 11 endemics specific to Croatia. Considering the number of endemic fish, Dalmatia's rivers Zrmanja, Krka and Neretva are particularly important.

Among **amphibians** certain **endemic and relict species** such as the Italian agile frog, the alpine salamander and olm, including fire-bellied toad, are **threatened**. All amphibians are threatened by disappearance of aquatic and wetland habitats. Among **reptiles** very important species in the south of Croatia are the stripe-necked terrapin and the dice snake.

Croatia is regularly inhabited by 104 kinds of **waterbirds**. Out of 23 threatened European waterbirds breeding in Croatia, nine are important on the European scale, considering the size of the nesting population: squacco heron (1.1%), whiskered tern (1.3%), black-crowned night heron (1.4%), common kingfisher (1.5%), white-tailed eagle (1.8%), little bittern, black stork and the spoonbill (2% each) and ferruginous duck with 13% of the total European population.

The **common otter** used to be widespread all over the country's wetland habitats, but presently belongs to threatened species. The **beaver** that had been formerly exterminated was successfully reintroduced into Croatia.

State and threats

By their nature wetland habitats are not permanent. Due to sedimentation of organic and inorganic substances shallow water areas become relatively rapidly even shallower, grown





Figure 41. Waterbirds find a plenty of food in flooded areas of Lonjsko polje

(photo by M. Schneider-Jacoby)



Figure 42. Formerly exterminated beaver was successfully reintroduced into Croatia

(photo by M. Schneider-Jacoby)

reclamation of natural wetland areas and smaller marshes has been performed too. The moors once occupied far larger spaces, so that present areas represent only the remnants of those greater that disappeared under human influence, most often by draining them and turning into marshy meadows or by reclaiming and turning them completely into the agricultural land. The 1996 data show that the drainage system covers an area of 1,350,064 hectares and that drainage was performed on 1,106,282 hectares of land of which 69.7% is arable land. It is a fact that drainage system has been constructed on only 19% of the total agricultural area, with

Figure 43. Lake Lepeničko in Gorski kotar (Fužine) as a result of obstructing the brook Lepenica and flooding the Lepeničko polje

(photo by A. Frković)

over and finally dry out. These natural processes of eutrophication have recently considerably accelerated by introduction of additional organic substances into the water due to various human activities (pollution). In vast natural wetland areas the process of eutrophication represents no problem, because new marshes are constantly appearing instead of those old and dried out – mostly by river meandering and flooding. However, these processes are presently prevented as a result of having regulated a great number of watercourses. Therefore in the future a number of wetland habitats will be able to survive only with the help of technical measures such as sludge and vegetation removal, dredging and similar.

The regulation of watercourses, either full or partial, was carried out at the majority of Croatia's rivers, which means that to date 11,000 km of watercourses has been regulated. The construction of hydropower plants and formation of storage-lakes have considerably changed the river courses, the karst rivers in particular. So far extensive

Box 21. Threats to wetland and aquatic habitats

- changes in water regimen (drainage, regulation of watercourses, etc.)
- physical changes (eg. backfilling or natural overgrowing, particularly related to smaller wetland habitats)
- biological changes (excessive exploitation of certain resources or introduction of foreign species) and
- pollution of watercourses.

Consequences of changes

- total degradation of wetland habitats and creation of new ecological systems (agricultural, urban) with other species, leading to impoverishment of the flora and fauna at large
- degradation of aquatic and wetland habitats causing the reduction of habitat diversity and the number of species, and
- loss of the mechanism needed for maintenance and natural rehabilitation of wetland systems.



Box 22. Problems in the protection of wetland and aquatic habitats

- the lack of an inventory and evaluation of aquatic and wetland habitats
- only a minor portion of valuable aquatic and wetland habitats covered by legal protection
- protection measures and management plans are either not adopted or not implemented in the majority of protected areas
- special reserves, including some important wetland areas, are managed on the level of counties: management plans do not exist, security guard is not organized, monitoring of plant and animal species is not performed, and
- technical measures sometimes necessary for wetland habitats preservation are not implemented.

Figure 44. Lower Neretva included in the Ramsar list of internationally important wetlands

(photo by D. Grlica)



such systems being only partly constructed on 16%. According to plans a total of as many as 1,790,070 hectares of land will be improved.

A special problem of protecting the aquatic and wetland ecological systems is the increasing **use of water** for drinking water supply, for sanitary and production purposes, irrigation, including the use of the power of watercourses for production of electricity, for navigation, recreation and similar. Another serious problem is connected with the **planned development of the inland-waterway traffic** in Croatia, particularly the construction of the traffic corridor between the Danube basin and the Adriatic that will necessitates the canalization of the Sava in the length of 340 km.

Water pollution is becoming an ever-growing problem. Urban development and industrialization generate the constantly increasing volumes of waste waters with a harmful effect on natural watercourses that serve as recipients.

In the Mediterranean area another serious problem is a rapid **overgrowing of the remaining small wetland habitats**. Numerous pools on islands that people used to maintain and clean are presently disappearing, because cattle breeding is dying out and the population migrating to towns.

Carp fishponds that are extremely important for the protection of waterfowls are highly threatened by **dying away of the extensive and semi-intensive fish farms**, causing rapid changes in habitats and living conditions for waterbirds.

Marshes and waters are in general **the most threatened ecological systems in Croatia**.

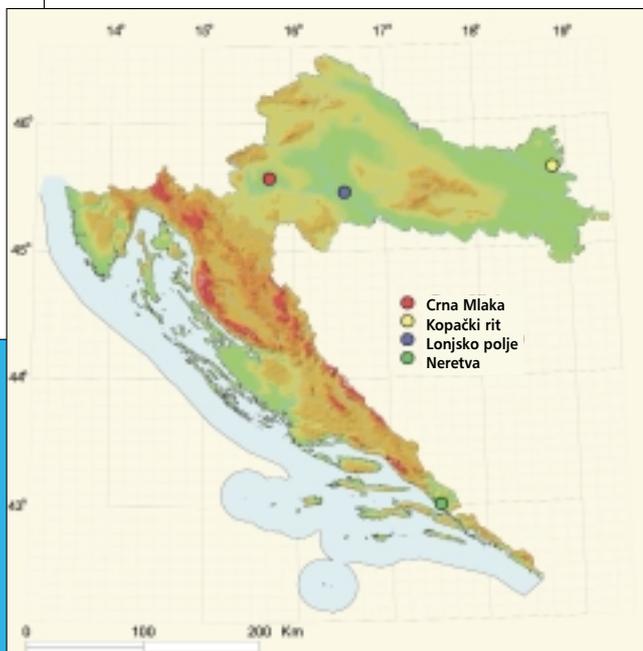
Protection

A major part of the preserved wetland areas in Croatia is currently protected within one of the categories specified by the Nature Protection Act or even included in the Ramsar list of globally important wetlands. Nevertheless, **the practical protection is poor and ineffective**, particularly in special reserves managed on the county level.

In numerous wetland areas **it is necessary to apply technical protection measures** (cleaning of vegetation, sludge removal, watercourse regulation). In Croatia such measures are hardly ever implemented.

Numerous unprotected localities are worth protecting and some even meet the criteria for the inclusion in the Ramsar list. This suggests that one of the top-priorities of the NSAP should be inventorying, evaluation and adequate protection of wetland habitats, including the formulation of management plans for individual areas.

Map 8. Wetland areas of Croatia included in the Ramsar list



Box 23. Croatia's wetlands included in the Ramsar list

- | | |
|---------------------------------|-----------------|
| • Lonjsko polje and Mokro polje | 50,560 hectares |
| • Kopački rit | 17,700 hectares |
| • Lower Neretva | 11,500 hectares |
| • Crna Mlaka fishponds | 625 hectares |

SEA

Features

The Adriatic Sea is a gulf of the Mediterranean Sea lying in the southeast-northwestern direction in the length of 783 km, with the surface area of 138,595 km² at the mean sea-level.

The Adriatic is a shallow sea, with the greatest depth not exceeding 1,330 m and the mean 173 m. The depths of up to 200 m (continental shelf) occupy as much as 73.9% of the Adriatic sea bottom. Depths exceeding 200 m may be found in the depression of the island of Jabuka and of the south Adriatic.



Figure 45. Undersea rock in Veli Bok cove, island of Lošinj
(photo by A. Jaklin)

The Adriatic as a whole is a low productive, oligotrophic sea, but it is more productive along the coast and in the area of channels than in the open sea. However, due to various specific influences Northern Adriatic is considered a highly productive region, one of the most productive in the Mediterranean Sea. The low level of organic production in the Adriatic Sea is a result of a low content of nutritious salts in water, of phosphorus and nitrogen in particular.

Viewing the number of flora and fauna endemics, the Adriatic stands out as a special biogeographical unit of the Mediterranean.

Box 24. Sea

The biological diversity of the Adriatic Sea is more and more threatened both by municipal and industrial waste waters pollution and by the uneconomical use of biological resources and non-observance of legal provisions.

Adriatic flora and fauna

According to very rough estimates, between 6,000 and 7,000 plant and animal species have been found in the Adriatic Sea so far. A number of groups, particularly invertebrates, are insufficiently explored, making the basic data on their diversity either not available or very scarce.

Box 25. Number of taxa of green, brown and red algae

• Northern Adriatic	361
• Central Adriatic	535
• Southern Adriatic	414

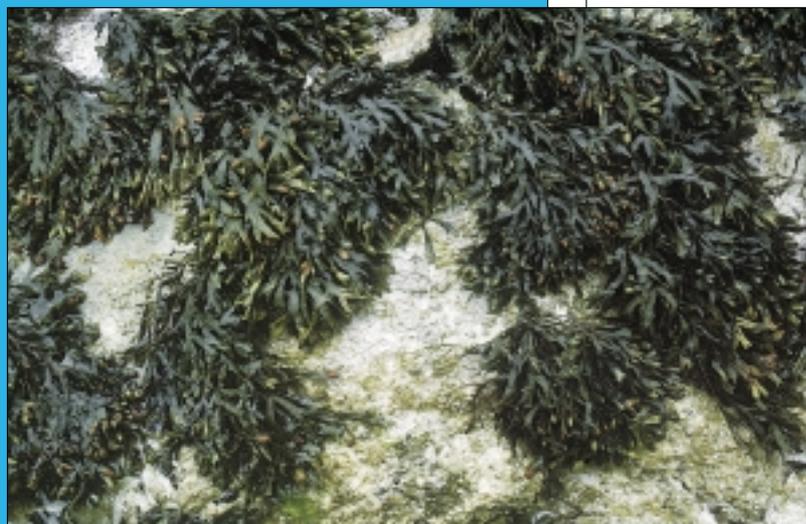


Figure 46. Adriatic wrack, endemic brown alga of the Adriatic
(photo by D. Zavodnik)

Special emphasis is to be given to a great number of endemic Adriatic elements present in the flora of the central Adriatic numbering 64 taxa or 12.1% of its content. In the Adriatic two development centres for Adriatic endemics have been discovered: the former is situated in the northernmost part of the Adriatic (the western coast of Istria and parts of Kvarner) and the latter in the open part of central Adriatic (the islands of Jabuka, Brusnik, Svetac, Vis, Biševo and Palagruža).

For the purpose of protecting rare and threatened species and communities (monk seals, marine turtles, settlements of "pavements", settlements of red corals) all of their former and potential habitats are to be examined.

Figure 47. Sea slug *Cratena peregrina* in the undersea zone of the island of Mljet
(photo by A. Jaklin)

