

The Dinaric Alps

Rare Habitats and Species

A Nature Conservation Project in Croatia

Part A

Edited by: Nikola Tvrtković and Peter Veen

Hrvatski prirodoslovni muzej, Zagreb (CNHM)
Royal Dutch Society for Nature Conservation (KNNV)

Zagreb, 2006

Impressum

Published by: Hrvatski prirodoslovni muzej, Zagreb (CNHM)
Royal Dutch Society for Nature Conservation (KNNV)

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Language editor: Graham McMaster

Maps by: Miroslav Švraka

Photographs by:

Typesetting and artwork by: LASERplus d.o.o.

Printed by:

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**This project was executed in the framework of the MATRA-BBI programme
of the Dutch ministries of Agriculture, Nature and Food Quality
and of Foreign Affairs**

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1. Introduction

In the process of transformation towards membership of the European Community, Croatia has to meet the standards of the European Community in time. Croatia has also to harmonise the national nature conservation policy with European standards. In particular, Croatia has to take care for the protection of habitats and individual species of European interest. In addition, the annexes on the EC Habitats Directive (HD) have to be updated with respect to rare, threatened and endemic species, the results of which might affect their conservation status, and natural or semi-natural habitats that are in danger of disappearance or that have a small natural range and yet present outstanding examples of typical characteristics of biogeographical regions in Croatia. From a preliminary analysis of the listed species and habitats in the HD annexes, it appeared that most of the habitats and animal species mentioned in the HD were distributed in the northern part of Croatia only, and not in karst area of the Dinaric Alps or along the coast of Adriatic Sea. Also, we concluded that there were omissions in the list of habitats and list of species which require a special habitat protection.

By contrast, we concluded that the knowledge of the distribution of species characteristic of the Dinaric Alps is poor and incomplete. This is also true of the population status and the trends for most of these rare species. Croatia has already prepared a list of threatened species for specific habitats and endemic species for uptake in the annexes of the Bern Convention. However, knowledge about the distribution of Dinaric Alps species is currently quite inadequate. We have to pay particular attention to the likelihood that pressure on nature will be very high in the near future because of the strategic location of the Dinaric Alps along the Adriatic Sea. There are already plans to build new highways, gasoline and gas pipelines, and new tourist infrastructure in the whole karst zone including the Dinaric Alps. The recent war caused major changes in the demographic and the socio-economic circumstances in the countryside. Over large areas of the Dinaric karst, agriculture was abandoned or became very extensive due to lack of management and a decline in the farming population (depopulation impact). The consequences are also that the semi-natural habitats and grassland species are under a severe threat. Without management, the semi-natural grasslands with their typical flora and fauna will disappear. Natural surface waters which are rich in endemic fish species and associated cavernicolous water fauna are in danger because in the system of water management they have lost their natural functions: rivers have

been engineered and embanked to prevent flooding, river flow directions have been changed, dams have been built for hydroelectricity power stations and water pollution can be a threat in the karst areas.

The National Strategy on Nature Conservation and the Action Plan for the Protection of Biological and Landscape Diversity of the Republic of Croatia (adopted by the Parliament in June 1999) put some of these rare habitats and species from forests, cave fauna, wetlands and semi-natural grasslands on the priority list of habitats and species of national importance. At the moment, Croatia has to implement the National Strategy and Action Plan through identification of these valuable habitats and priority species and also to upgrade the national legislation for the long term preservation of the habitats and priority species. At the same time, Croatia has to meet European standards for protection of nature that has European-level importance.

It was in this situation that in the summer of 2003 the project of KNNV and CNHM “The Dinaric Alps Rare Habitats and Species Conservation Project - Croatia” (PINMATRA /2003/024) was started. The project is financed by the Dutch Ministry of Agriculture, Nature and Food Quality, and of the Dutch Ministry of Foreign Affairs. This project was also connected with the implementation of the National Strategy on Nature Conservation.

This project also partly overlapped with the Karst Ecosystem Conservation (KEC) project inaugurated by GEF/WB, which had started one year before this project. But the KEC project is connected with the protection of biodiversity in some known hotspot locations in the western part of the Croatian Dinaric Alps, mostly in protected areas where more knowledge is available. However, in the current Dinaric Alps project, the first priority was to provide a good database for rare and endemic species for the identification of potential species and habitats for the updating of the HD.

2. Goal of the project

Project long-term objective

To support the implementation of the Bern Convention and EC Habitats – and Bird Directives, as well as to meet the requirements for the establishment of the Emerald Network and Natura 2000, especially for important Dinaric Alps ecosystems.

Project short-term objectives

- To reach a clear understanding of the importance of the Dinaric Alps as a habitat for rare and endangered relict species of European importance.
- To reach a final and verified list of habitats and species of European importance to be presented by the Croatian Government as an update to the annexes of the EC Bird- and Habitats Directive.
- To report the results of the project in terms of required land use practices and criteria for sustainable land use for application in the Action Plans under the National Strategy for the Protection of Biological and Landscape Diversity..
- To raise awareness of the importance of these natural and semi-natural ecosystems for European biodiversity. To raise awareness of the specific position and high value of the subterranean ecosystems in the Dinaric region.
- To prepare an extended list of habitat types and priority species of rare and relict species connected with the semi-natural grasslands, endemic forests, terrestrial karst habitats and cave ecosystems of the Dinaric Alps as a follow up to the ongoing Emerald Network Pilot Project and the National Strategy for the Protection of Biological and Landscape Diversity.

3. Dinaric Alps Region (Dinarides)

3.1. Biogeographical position

The definition of the Dinaric Alps as a part of the Alpine biogeographical region is in accordance with the Emerald Network Project biogeographical regions map (T-PVS/ Emerald /2001/ 51/ Appendix 11). The Alpine biogeographical region in Croatia (“Croatian highlands”) covers more than true Alpine and Sub-alpine areas from a plant sociology point of view. The Dinaric Alps are a part of a diverse landscape with mountains and karst poljes. However, near the border of the Dinaric Alps, there is also the shallow karst of the Black Sea drainage basin as well as the karstic Mediterranean coastal area along the Adriatic Sea. These areas together with Dinaric Alps form the Dinaric karst as a whole. The Dinaric Alps region can be divided into two hydrogeological subregions: the Adriatic Sea basin and the Black Sea basin. Because of the low altitudes of the mountains (not above 1830 m a.s.l.) and their location close to the Adriatic Sea only local altitudinal gradients from the colline to the subalpine zone exist and real alpine zone are present only in Slovenia, Bosnia and Herzegovina and Montenegro. The Dinaric Alps in fact contain a mosaic of Alpine, Continental and Mediterranean species and habitats. Additionally, small numbers of species from northern regions are also present, of Boreal origin, for example, such as several species of plants, butterflies, birds and of bats. Some isolated mountains on the Dalmatian coast (Mosor, Biokovo, the Pelješac Peninsula) and some parts of the islands (Cres island, Krk island) or isolated hills on the islands (Brač island, Hvar island) are in the true Mediterranean region and yet at higher altitudes or on northern slopes Continental and/or Oro-Mediterranean habitats and species can be found too. These features are in a broader sense also isolated parts of the Dinaric Alps.

The entire mountain range of the Dinaric Alps is classified according to Hadži (1935) into the *Balkanica subprovince* zoogeographical region. In the freshwater classification of Illies (1978) and Botosaneanu (1986) the Dinaric Alps was classified as the *West Balkan* zone. Instead of these names (*Balkanica* and *West Balkan*) we use the biogeographical name the *Dinaric Alps* region (in Croatian *Dinaridi*), because the Slovenian part of the Dinaric Alps in its entirety, as well as some parts in Croatia, are *de facto* not in the Balkan peninsula area. The north-western border of the Dinaric Alps according Hadzi (1935) was set at the Soča River (the Isonzo) northwest of Postojna. The south-eastern border area is situated on the Albanian mountain of

Prokletije, north of Skadar Lake (Sket 1994b: Fig. 2), more precisely on the Drim River (Bonacci & Roje-Bonacci 2004). The Dinaric Alps, as part of the total Dinaric karst area, also covers, in this definition, small parts of north-eastern Italy (Carso near Trieste), southern Slovenia, middle and south-eastern Croatia, south-western Bosnia and the whole of Herzegovina, southern Montenegro and a small part of western Albania. Eastwards, in western Macedonia and western Serbia, there are only isolated karst “islands” with some typical Dinaric species; probably this area too can be included in the eastern part of the Dinaric Alps, not in continuous Dinaric karst area.

The western part of the Dinaric Alps region and the high Alpine locations (mostly in the southern Dinarides) are greatly influenced by the eastern Alps region. Some endemic terrestrial animals mostly from the montane altitudinal belt have a typical distribution in the Eastern Alps and Western Dinarides. The Eastern part of the Dinaric Alps is much influenced by Balkan and eastern Mediterranean fauna. On the southern slopes of mountains near the coast, Mediterranean species are dominant. In the central part of the Dinaric Alps and also in the northern part, Continental Medio-European species dominate, and there is also a greater influence from steppe fauna. Freshwater species are divided predominantly into species of the Adriatic drainage basin and those of the Black Sea drainage basin.

The most characteristic species of the total Dinaric karst region and at the same time of Dinaric Alps themselves are the rock-dwelling terrestrial species, cave-dwelling species, freshwater spring snails and the freshwater fishes from the Adriatic drainage basin rivers. Characteristic endemic Dinaric animal genera are for example terrestrial snails like *Delima*, *Medora*, *Dinaria*, *Vidovicia*, freshwater snails like *Dalmatella*, *Emmericia*, *Hadziella*, *Kerkia*, *Lanzaia*, *Orientalina* and the still undescribed relict lacertid genus “*Lacerta*” *mosorensis* and the relict vole genus *Dinaromys*. The Dinaric Adriatic drainage system has three endemic fish genera: *Aulopyge*, *Delminichthys* and *Salmothymus*. Cave troglobitic fauna (true cave animals) are represented by several endemic genera like the beetle genera *Croatodirus*, *Croatotrechus*, *Leptodirus*, *Lovricia*, *Parapropus*, *Radziella*, *Redensekia*, *Speledromus*, *Speoplanes*, *Velebitiodromus*. Rare holo-dinaric fauna include freshwater stygobitic fauna (true cave water animals) with genera like the

cave tube-worm *Marifugia*, the cave hydrozoan *Velkovrhia*, the niphargid crustacean *Typhlogammarus*, the cave clam *Congerina* and the Dinaric cave salamander *Proteus*.

Employing the original zoogeographical classification of the Dinaric Alps of Hadži (1935) we offer a new biogeographical zonation. Hadži proposed four subregions, running from the northwest to the southeast. The original names for the krajine or regions, Slovenica, Croatica, Dinarica and Hercegovinensis, are not acceptable today because to avoid comparisons with political units. The Hadži (1935) classification was anyway corrected after research into the distribution of cave beetles (Pretner 1973), butterflies (Varga 1975; Carnelutti 1981, 1992; Mladinov & Lorković 1985), terrestrial and freshwater snails (Bole 1981, Radoman 1983), small mammals (Kryštufek & Tvrtković 1984; Tvrtkovic et al. 1985, Krystufek 1987; Petrov 1992; Tvrtković 1994; Kryštufek & Griffiths), and underground water crustaceans (Sket 1986, 1988, 1994). On the basis of stygobiont (true water cave species) crustacean taxa Sket (1994) divided the Continental Dinaric karst into two main units with a third middle region as a broad transitional zone: (1) the north-western area (Slovenia and W Croatia: Istria and Kvarner with the islands of Krk, Cres and Rab, and Kupa river region), (2) the transitional zone (the Lika and Krbava region and part of N Dalmatia in Croatia, Bosanska krajina in BH) and (3) the south-eastern area (the rest of BH, Dalmatia and the Dubrovnik region in Croatia, Montenegro and the NW part of Albania). Discussion about geographical subregions is not over, and in this report we will assume any finality of the names for biogeographical. We hypothesise that from four to seven subregions might exist.

Four potential subregions (Tvrtković, unpublished) are present in Croatia:

- 1) the subregion of Mt. Snježnik, Mt. Risnjak and Žumberak Mt. near the Slovenian border (the larger part being in Slovenia, however),
- 2) the subregion of Kapela Mountains, Mt. Plješevica and most of Mt. Velebit with several small poljes and three large poljes: the Gacko, Ličko and Krbavsko poljes. This subregion is probably also extensive in western Bosnia,
- 3) the subregion of the south-eastern part of the Mt. Velebit area with the large Gračačko polje, Dinara Mountains, with poljes near the upper part of the Cetina River, and the area in Bosnia and Herzegovina west of the Neretva River,

4) subregion south of Neretva river with main parts in Eastern-Herzegovina and probably in Montenegro.

3.2. Geology, hydrogeology, hydrology and climate

The Dinaric karst area extends for about 26,000 km² in Croatia (46 % of land area). It consists of Mesozoic and Tertiary carbonate rocks (limestone and dolomite) with islands of older clastic rocks and Palaeogene flysch rocks (Kuha, in Gottstein Matočec 2002). The Dinaric Alps region covers only 30 % of the Dinaric karst area (14 % of the entire land area of Croatia). It is situated within the Dinaricum carbonate plate, a marginal part of the European plate. The Adriaticum carbonate micro-plate is situated south of the Dinaric karst region and this plate is a subject to underthrusting beneath the Dinaricum plate. This subduction process started during the Palaeogene period and the process is still underway and constitutes a complex orogenic process. The faulting process of Dinaric orogenesis within Alpine orogenesis came to an end about 10-9 My ago. Structural-tectonic movements were characterised by radial tectonics which were accompanied by further disruption of rock masses and a differential downthrow or uplift of individual blocks. The corrosive and erosive water action on the fractured carbonate bedrock resulted in the formation of numerous surface and subsurface karst morphological phenomena. On the surface of the limestone there are very frequent karst forms such as sinkholes and uvalas; some regions have over 160 sinkholes per km². The largest morphological phenomena are the karst valleys, in the Dinaric karst named poljes. In the Croatian Dinaric Alps karst poljes are situated from 260 m a.s.l. to 695 m a.s.l., with some exceptions in southern regions at lower altitudes (Jezero polje, Rastok polje and Konavosko polje). Fourteen major karst poljes with an area of above 10 km² are located in Croatia. The largest polje in Croatia is Ličko polje (near Gospić) with an area of 465 km². Smaller surface karst forms are karren and kamenice (solution pans). Locations that are rich in deep fissures and crevices and thus provide exceptional shelter for small terrestrial fauna are only situated on some types of limestone bedrock. This type of surface has a mosaic distribution pattern.

The hydrogeological relationships in the Dinaric Alps are complex. The principal retention basins are developed within the mountain massifs and the groundwater drains towards their margins. The type of groundwater flow varies from fast vertical percolation in the unsaturated zone, to

turbulent flow through networks of subsurface channels or slow siphonal water movement in the deeper parts of the karst aquifers. The mean velocity of groundwater flow is 4 cm/s (0,5 – 50 cm/s). In the outflow zones typical karst springs with large water yields occur. The surface hydrography is poorly developed and the flow is confined to a few rivers. In the Croatian part of the Dinaric Alps lie the upper parts of two main rivers flowing towards the Sava River, forming part of Black Sea drainage basin. One is the Kupa River, with three smaller tributaries, the Dobra, Mrežnica and Korana rivers. The second is the Una River along the border with Bosnia and Herzegovina.

In the Adriatic Sea drainage basin is situated a mainly part of the Lika subregion with two large influent streams: the Gacka River and the Lika River. Several sinking (influent) streams have surface parts in karst poljes. The source areas of the three large rivers, the Zrmanja, Krka and Cetina, are located along the foothill of Mt Poštak and the Dinara Massif. These rivers have a very complicated network of surface and underground tributary systems. South of the extensive Neretva River system there is only the isolated Ljuta sinking stream. Several coastal river springs are present in the Dubrovnik area and these rivers are in the underground connected with the Trebišnjica river system (a left tributary of the Neretva River) which is situated in Herzegovina. In several small poljes, intermittent sinking streams also exist. Only one periodical lake has survived human influence: Blato (Begovac) Lake between Plaški and Saborsko in the Mt Mala Kapela area.

The karst limestone and the dolomite bedrock are full of fissures. Larger holes are called caves and they are a typical karst underground phenomenon. They are in a permanent process of corrosion and yet at the same time speleothemes are being created. Croatia has between 7,000 and 8,000 caves, but this number is not final. It is estimated that in the future the definitive number of caves will be found to be at least twice this amount. In the Dinaric Alps the most frequent cave types are the vertical caves (potholes), some of them deeper than 1 km. Large cave systems have been found in the region of shallow karst and not in the Dinaric Alps region. Dependent on the microclimatic conditions the caves are classified as ice caves (ledenice), which contain a permanent snow and ice layer, high mountain cold caves, with a temperature range between 5 and 8°C, continental caves, with a temperature range between 8 and 14°C, and Mediterranean caves with an average temperature above 14°C. For cave fauna the level of

humidity is very important; it usually ranges from 85 to 100 %, with the exception of some Mediterranean caves where it can fall below 60% (dry caves). Cave ecosystems are dependent on the availability of nutrients coming from the surface. Sket (2005) recognized different cave habitats, classified on the basis of different levels of nutrient input. In most cases they are very poor in nutrients, but some cave habitats, like the first underground parts of influent streams, are periodically very rich in concentrations of detritus, organic particles (POM) which are transported by the water. Only 34 % of the caves are hydrologically active.

The climate of the Dinaric Alps region is very varied because the border between the Continental and the Mediterranean climatic zones lies along the mountain chain. This border position, producing air masses of highly differing temperatures, creates in specific circumstances the very cold and dry wind named bora (*bura* in Croatian), common in winter time, but present in other seasons too. On some slopes with intensive influence from the bora we have Alpine meadows in the subalpine zone and in the submontane zone, particularly in types of stony and dry grasslands. The karst geomorphology type of surface can result in very pronounced microclimatic inversions. In some sinkholes and large uvalas in the montane zone we have the remains of some boreal forests that have survived due to the inversions. In general, in the north-western part (the Slovenian Mt Snežnik and the Croatian Mt Risnjak areas) and in south-eastern part (Orjen Mountains area) precipitation is very, more than 2000 litre / year, but in the central part (Northern and Central Dalmatia) the climate is very dry with precipitation lower than 500 litre /year. In the subalpine zone snow exists over half of the year and yet on some southern slopes, there is a drought in summer every year.

3.3. Forests and grasslands

In the Dinaric Alps lies the border of two considerably different Holarctic vegetation regions: the Mediterranean region and the Euro-Siberian region. The peaks of the Dinaric Alps can be classified as Alpine-Nordic biogeographical regions, but we can also identify Oro-Mediterranean influences too. Climazonal vegetation in the Croatian part of Dinaric Alps are forests, and their distribution delineates the vegetation characteristics of the region. Only in the subalpine zone with subalpine meadows in particular microclimatic conditions, some alpine meadows exists, as

rest of a longer cold period. All other areas have semi-natural grasslands, with exceptions in sites with very strong winds, very long flooding or high levels of underground waters.

On the southern slopes on the coastal side (to 900 – 1000 m a.s.l.) a submediterranean zone is present with deciduous broadleaved forests of *Quercetalia pubescentis*, with *Carpinetum orientalis* at the lower and *Ostrya carpinifolia* at the higher altitude. Due to long-lasting degradation, these forests have turned into specific, permanent anthropogenic dry grasslands and rocky pastures of the order *Scorzonero-Chrysopogonetalia*. In the acid type of soil and on the flysch bedrock there are forests with *Quercus cerris*. At the same altitude, under continental conditions with a continental precipitation regime and a lower average annual temperature a *Carpinion betuli* type of forest with *Quercus petraea*, *Carpinus betulus* and *Fagus sylvatica* is present. Most of the forests have been cut and the land has been converted into agricultural land with various semi-natural grasslands types such as *Molinio-Arrhenatheretea*, *Festuco-Brometea* and grasslands with *Nardus stricta*. On deeper soils or silicates there was the development of secondary heath vegetation.

The karst poljes were in the past regularly flooded, and wetland habitats were common. Flooded forest stands of common oak disappeared in the past. In the last century, marshlands with special Dinaric types of wet grasslands with a characteristic summer drought also decreased because of management failings or hydraulic engineering operations.

The montane zone has a lower average temperature and a higher humidity. This area is characterised by temperate mesophilic beech and common fir forests of the *Fagion illyricum* alliance. The forests harbour a great number of species if compared with similar forests in Central Europe. On the border with the submediterranean zone thermophilous beech forests (*Seslerio-Fagetum sylvaticae*) are situated, and from the continental Illyrian beech forest (*Lamium arvalae-Fagetum sylvaticae*). In the middle range there are mixed beech and fir forests (*Abieti-Fagetum*). An azonal vegetation on acidic soils was developed, such as the acidophilic forests from the alliance *Luzulo-Fagion* and *Piceion abietis* (order *Vaccinio-Piceetalia*). The forests were only sporadically destroyed into *Brometalia erecti* grasslands or *Nardetalia* on deeper acidic soils. On

the border with the submediterranean zone are located eastern submontane dry grasslands (*Scorzoneratalia villosae*) rich in endemic species.

At the higher altitudes there is subalpine vegetation with a short vegetation season. In this area subalpine beech forests dominate (*Homogyno alpinae-Fagetum sylvaticae*) with dwarf beech scrubland near the timberline zone. Zonal vegetation forms at higher altitudes of dwarf pine stands (*Pinus mugho*) are present too. Natural grasslands are rare, but in cases in which the forests are destroyed by fire, subalpine and alpine meadows will develop.

3.4. Karst associated habitats

Karst caves

In the more than 8,000 caves in the limestone and dolomite numerous habitats exist. Mostly a single cave contains several different types of habitat. Generally terrestrial, freshwater and transient habitats can be distinguished. Along the Adriatic coast anchialine habitats exist, transitional habitats between freshwater and sea water. Very rare are some other special habitat types like sulphur caves and thermal waters.

(1) Of terrestrial cave habitats very cold are the ice caves (<5°C), which are present mostly in higher altitudes. Typical fauna are cave beetles such as *Astagobius angustatus*, *A. hadzii*, *Duvalius biokovensisi*, *D. comes*, and *Speoplanes giganteus*. Ice caves and cold caves with temperatures between 5 to 8°C are a very good shelter for bat hibernation. It is known that some sites have very large (more than 20,000 specimens) winter colonies of the bat *Miniopterus schreibersi*, but more common are sites with smaller (up to 400 specimens) winter colonies of *Rhinolophus ferrumequinum*. Fissures inside and outside caves provide winter shelter for more than 10 other species of bats. Common are temperate caves with moderate temperatures (8 to 14°C), rich in narrowly endemic cave beetles (carabid beetles, detritivore beetles etc.), pseudoscorpions, terrestrial isopods, millipedes, cave snails, colembolas, harvestmen, spiders etc. In hot caves or cave galleries with temperatures near 20°C and high humidity there are seasonal shelters for the nursery colonies of some bats, like *Rhinolophus ferrumequinum*, *R. euryale*, *R.*

blasii, *Myotis myotis*, *M. blythii oxygnathus*, *M. capaccinii*, *M. emarginatus* and *Miniopterus schreibersi*. Underneath sites with permanent bat colonies there are deposits of bat faeces (guano) with their own rich and specific fauna.

(2) Cave freshwater in general includes different types of habitats. The first type with scarce food supplies consists of percolation waters with small crustacean fauna from the groups Copepoda and Amphipoda. In Dinaric permanent cave waters live the most famous cave salamander *Proteus anguinus*, and several invertebrates like the giant cave cirrolanid isopod *Spheromides virei*, the cave prawns *Troglocaris anophthalmus* and *Spelaecaris pretneri*, the cave pill-bugs *Monolistra*, cave wood louse genera *Asellus* and *Proasellus*, several *Niphargus* cave shrimps, copepods, small cave snails from the Hydrobiidae family as *Lanzaia*, *Plagygeyria*, *Orientalina*, *Hauffenia*, *Hadziella*, *Belgrandiella*, and some rare cave snails from genera like *Acroloxus* and *Theodoxus*, the cave hydrozoan *Velkovrhia aenigmatica*, and the cave sponge *Eunapius subterraneus*. In ponors or estavelas (periodicaly springs and periodicaly ponors) in the hypogean parts of sinking waters with periodically high percentages of detritus (POM) live larger densities of the cave tube-worm (*Marifugia cavatica*), the cave clam (*Congeria kusceri*), the protozoans Foliculinae, amphibious isopods (*Titanethes* group), freshwater snails etc.

(3) The transitional type between terrestrial and freshwater habitats forms a hygropetric habitat with a thin water layer along vertical cave walls, common in deep potholes, but present in other cave types too. Certain special cave beetles from genera *Hadzia*, *Radziella*, *Croatodirus* and *Velebitodromus* filter detritus coming from the surface by water. Amphibious cave isopods like *Titanethes*, cave predaceous amphipod *Typhlogammarus mrazeki*, some snails, and cave leeches like *Croatobranthus mestrovi* are connected with this habitat too. Another transitional habitat consists of periodically emerged layers of tubes of cave tube-worm *Marifugia cavatica*: in terrestrial phases that was a rich habitat for the protozoans Foliculinae, terrestrial cave snails and some other animals. This habitat type was common in Herzegovina (BH) before river canalising.

(4) The transitional type between freshwater and sea water exist in that part of the Dinaric Alps in which the mountains border directly with the Adriatic Sea coast. In anchialine caves in sea water several relict copepod crustaceans from the Calanoida family live, like *Speleohvarella* spp. and

Badiella spp.etc., and the bathyal sponges *Oopsacas minuta*, *Asbestopluma hypogea*. In sea caves the alpheid prawn *Salmoneus sketi* and the viviparous fish *Oligopus ater* are known. In freshwater layers above the sea water there are the shrimps *Hadzia fragilis*, *Salentinella angelieri*, narrowly distributed niphargid shrimps *Niphargus* spp., such as *N. hvarensis*, and snails from the genera *Lanzaia* and *Saxurinator*.

Calcareous rocks

Calcareous rocky slopes are very rich in narrow Dinaric endemics, chasmophytic plants and rock-dwelling snails. We recognized minimal four different types of habitats on rocky slopes, first on the cliffs of the Northern Adriatic exposed to the cold wind the bora, the second on cliffs with southern exposures affected by the *sirocco* or *jugo* and by saltwater sprinkling, the third from the colline to the montane belt, and the fourth in the montane / subalpine belt. Characteristic plant species are from the genera *Centaurea* and *Campanula*, snails from genera *Delima*, *Medora* etc. In the third type are characteristic relict species *Fibigia triquetra*, the bird *Sitta neumayeri*, the lizards *Algyroides nigropunctatus* and *Lacerta oxycephala*. Near rocks the small bat *Hypsugo savii* and the Circum-Mediterranean bat *Tadarida teniotis* are common. On rocks of the montane / subalpine belts the snail *Vidovicia coerulans* and the lizards *Iberolacerta horvathi* and *Lacerta mosorensis* are common, and in autumn, as a migrant from northern Europe, the bat *Vespertilio murinus*. As special type of rocky habitats are **Limestone pavements** too, with probably poor but not investigated fauna.

Limestone screes

Two main types of limestone screes are dominant, one in the Mediterranean part, and the other at higher altitudes. In the lower altitudes there are Eastern Mediterranean screes with the plant *Drypis spinosa* var. *jaqeniana* with the small shrew *Suncus etruscus* and the Balkanic karst mouse *Apodemus epimelas*. At higher altitudes there are two subtypes of scree habitats, one with larger rocks (*Drypetum spinosae*), and another with smaller rocks (*Bunio-Iberetum pruitii*) with the endemic Croatian plant *Degenia velebitica*, both accompanied by the snow vole *Chionomys nivalis*. In all screes, as well as in other rocky habitats, the snake *Vipera ammodytes* is common.

Surface limestone bedrock with crevices

Only in parts with a special type of limestone bedrock rich in deep crevices does the endemic and relict Balkan snow vole, *Dinaromys bogdanovi* live. This animal depends on underground shelters and lives in isolated populations all over the Dinaric karst area at all altitudes, but there must be a good network of deep crevices. Crevices, which provide good shelters, are always rich in invertebrates (snails etc.) and small rock-dwelling vertebrates. In parts without this type of habitat these animals are common in areas with artificial stone walls.

Karst pools and kamenice (pools in stones)

In mostly dry surfaces there are rare but very important temporary water habitats with very restricted distributions. In all areas with traditionally extensive cattle breeding the artificial type is common, but, as a semi-natural habitat, it is threatened in a way similar to the semi-natural grasslands. Common animals: *Triturus alpestris*, *Bufo viridis*.

Intermittent karst lakes (Turloughs)

In closed depressions caused by the corrosion process of karstification in dolomite bedrock if there are karst springs (or estavelas) at the corner of the polje, sometimes there will exist a special karst habitat, intermittent or periodical lakes, in Ireland named *turloughs*. This name was accepted in Habitats Directive. For this type of lake to come into being, it is important that there is a characteristic yearly change of the balance in the difference between the inflow and underground outflow of karst waters. In the late autumn, winter and spring this type of habitat is under the water, in summer it is dry and overgrown with *Eleocharis pallustris* and *Polygonum amphibium*. In the fauna the fish *Misgurnus fossilis*, a lot of amphibians, leeches, water snails and insect larvae are common, and one rare primitive crustacean named *Chirocephalus croaticus*, known only in Slovenia (the Cerknjško intermittent lake) and Croatia.

Karst springs and source streams

Karst springs and source parts of some karst streams have specific fauna consist of narrow distributed water snails from the genera *Belgrandiella*, *Hadziella*, *Lanzaia*, *Orientalina* and endemic caddis flies like *Drusus croaticus*, many other insects like the mayfly *Siphonurus croaticus*, and the amphipod shrimps *Fontogammarus* and *Echinogammarus*. The crayfish the

Austropotamobius torrentinum is distributed in the Black Sea catchment area and *A. pallidus* in Adriatic Sea catchment area. The possibility to find shelter in cave waters inside karst springs in winter or in summer droughts with low water levels is useful for small fish of *Telestes* spp., *Aulopyge huegeli* and *Delminichthys* spp..

Rivers with tufa barrages /lakes

Some karst rivers rich in calcium carbonate, at places with good aeration, develop tufa barrages. Barrages divide rivers into several parts, posing problems for upstream fish migration. Between the barrages we sometimes have natural lakes with stream trough as in Plitvice Lakes. On the barrages plant *Cinclidotus* spp. are common, in the benthos the amphipod shrimp *Gammarus balcanicus* is frequent. In Adriatic Sea catchment waters there are several endemic fish like the Dalmatian trout *Salmothymus obtusirostris* and dace *Squalius illyricus*. The highly specialized Mediterranean trawling bat species *Myotis capaccinii* which forages insects from the water surface or just above it is connected with karst waters too.

Intermittent streams and influent streams

The whole Dinaric Alps area has frequent intermittent streams and short sinking streams with, in some cases, underground interrupted river watercourses (interrupted with waterfalls or barrages with interstitial watercourses only) not available for fauna migration, mostly upstreams. In most isolated intermittent streams there is a characteristic absence of crustaceans, common in other running waters, and they are dominated by periodical benthic insect fauna. In these waters of the isolated karst poljes some small fish species (*Telestes*, *Delminichthys*) were trapped for a long time by mountain uplifting, and were unable to swap genes with relatives, but protected from possible predators.

Karst polje marshes

In parts of karst poljes affected by permanent accumulations of stagnant water marshes will occur. Marshes were common in the past, but many of them have disappeared because of land reclamation for agriculture. The vegetation and most of the fauna in the marshes are of common species, but some fish are endemic and still threatened. Present animals: *Acrocephalus melanopogon*, *Ixobrychus minutus*, *Circus pygargus*, *Asio flammeus*, *Leuciscus ukliva*,

Phoxinellus spp., *Aulopyge huegeli*, *Lutra lutra*, *Arvicolla terrestris*, *Neomys anomalus*, *Emys orbicularis*.

Wet meadows of karst poljes

Dinaric karst poljes have several endemic grassland communities, depending on the different hydrological conditions and the duration of the summer drought. All of them are home to the Dinaric endemic plant *Scilla litardierei*. They are moderate to rich in plant species, but poor in animal species, mostly of relicts from colder geological phase. Common species: the plants *Scilla litardierei*, *Edreianthus dalmaticus*, *Ranunculus acris*, *Succisa pratensis*, *Peucedanum coriacea* ssp. *pospichali*, *Molinia caerulea*, *Sesleria uliginosa*, the grasshopper *Chrysochraon dispar*, the butterfly *Euphydryas aurinia*, the shrew *Neomys anomalus*, the frog *Rana dalmatina* and the bird *Crex crex*.

Alkaline fens

In Dinaric karst acid mires and fens are azonal habitats on the southern border of their distribution, but alkaline mires are typical of areas with dolomite bedrock. Typical plants: *Schoenus nigricans*, *Pinguicula vulgaris*, *Tofieldia calyculata*, *Spiranthes aestivalis*. The animals have not been studied.

Heaths on deep karst soils

On the deep karst soils, heaths are common and in the past in some large poljes like Ličko polje they had formed a characteristic landscape. Typical plants: *Pteridium aquilinum*, *Juniperus communis*, *Calluna vulgaris*. Animals have not been studied, and *Euphydryas aurinia* was registered in this project.

Oro-Mediterranean heaths on mountains

In all mountains with a Mediterranean influence, in the subalpine zone oro-Mediterranean heaths with *Genista radiata* or *Juniperus nana* are common. Fauna has not been studied, but the butterfly *Erebia oeme* and the lizard *Lacerta agilis* were observed.

Dry calcareous grasslands

From karst poljes to the montane zone, several types of calcareous grasslands exist. Some of them are on sparse rocky or shingle soils. Two main groups of types are dry grasslands with continental and dry grasslands with Mediterranean influence, with great differences in communities among different altitudinal forest zones. All have an abundance of species and are very rich in regional endemics. Several subtypes are registered. Typical species: *Mellicta dydima*, *Proterebia afra*, *Prionotropis hystrix*, *Saga pedo*, *Polysarcus denticauda*, *Poecilimon elegans*, *Podarcis melisellensis*, *Lacerta agilis*, *Burchinus oedicnemus*, *Anthus campestris*, *Lullula arborea*, *Microtus arvalis*, *Microtus subterraneus*, *Apodemus sylvaticus*.

Woods of broad-leaved oaks

Sessile oak woods with Oriental hornbeam or Hop-hornbeam, Turkey oak woodlands. This type of broadleaved oaks woods are common, but mostly degraded forest is typical of the sub-Mediterranean zone between beech forests and the true Mediterranean zone of holm oak forests. Common species: *Podarcis melisellensis fumana*, *Erebia medusa*, *Coluber gemonensis*, *Elaphe situla*, *Lacerta (viridis) bilineata*, *Myotis bechsteinii*, *M. blythii*, *Emberiza cia*, *E. cirrus*, *Caprimulgus europaeus*, *Otus scops*.

Endemic black pine forests

Between Mediterranean and continental forest types, at some localities on steep and rocky slopes there are zone of rare endemic black pine forests. A common plant in Dalmatia: *Pinus nigra* ssp. *dalmatica*. Animal species were not studied except in northern Velebit. In this area in the black pine zone are sites with *Sibirea altaensis* var. *croatica*, and there is a border region of Continental and Mediterranean fauna: in some years this zone is very rich in species which are rarely found together, but in other extremely poor.

Karst beech and mixed beech and fir forests

Mountain beech and mixed forests are similar to other types of this kind of forest in Europe, but contain more species, especially species connected with karst rocks. Including typical fauna like the dominant birds *Fringilla coelebs*, *Erithacus rubecula*, *Sylvia atricapilla* and the mammals *Sorex araneus*, *S. minutus*, *Clethrionomys glareolus* and *Apodemus flavicollis*, the common

species are *Carabus croaticus*, *Glis glis*, *Muscardinus avellanarius*, *Dryomys nitedula*, *Salamandra atra*, *Barbastella barbastellus*, *Myotis brandtii*, *Plecotus auritus*, *Nyctalus leisleri*, *Microtus (multiplex) liechtensteini*, *Ursus arctos*, *Canis lupus*, *Lynx lynx*, *Glaucidium passerinum*, *Aegolius funereus*, *Strix uralensis*, *Picoides tridactylus*. In the same zone, at some locations on dolomite bedrock there are **relict forests with Scots pine**, rich in amphibians and reptiles. Common bird species are, for example, *Carduelis carduelis*. A similar situation obtains with the azonal **spruce forests** on dolomite bedrock or in microclimatic depressions.

Subalpine and oro-Mediterranean scrub

Subalpine beech scrub (as border part of *Homogyno alpinae-Fagetum sylvaticae* forest type) contains several species typical of the Alps, but other species are restricted to Dinaric Oro-Mediterranean karst area. For example only in the Dinaric karst subalpine scrub zone do the toad *Bufo viridis* and the shrew *Crocidura leucodon* live, both of them being absent in higher altitudes of the Alps region. Typical species are the birds *Turdus torquatus*, *Prunella modularis*, *Dendrocopos leucotos*, *Anthus trivialis*, *Phoenicurus phoenicurus*, *Parus palustris*, the mammals *Dryomys nitedula*, *Muscardinus avellanarius*, *Microtus (multiplex) liechtensteini*, *Sorex minutus*, and the lizard *Iberolacerta horvathi* or *Lacerta mosorensis*. In first faunistically investigated beech scrub (Vuković, unpublished) on Veliki Zavižan peak (Mt Velebit), of invertebrates the dominant species are the earwig *Chelidurella acantopygia*, the spider *Mitopus morio*, the earthworm *Octodrylus lissaensis*, the millipede *Leptoilulus trilineatus* and the carabid beetles *Nebria dahli velebitica*, *Cychrus attenuatus* and *Pterostichus metallicus*. *Trechus croaticus* and *Carabus croaticus* are present too. Above the beech scrub are zone with the dwarf pine *Pinus mugho* with probably similar species as beech scrub, but these zone have been poorly investigated.

Alpine and subalpine meadows

Alpine and subalpine meadows in the Dinaric Alps have several different communities, and one of endemic types are *Festucetum bosniacae* with a distribution from the Kapela Mountains to the mountains of BiH. Common species: *Erebia* spp., *Parnassius apollo*, *Eremophyla alpestris*, *Anthus spinoletta*, *Prunella collaris*, *Falco tinunculus*.

A characteristic animal species is the snake *Vipera ursinii macrops*.

3.5. Habitats of the Dinaric Alps still present in Habitats Directive

In the Dinaric Alps, we recognized 26 habitat types from the present Annex I of the Habitat Directive:

31 Standing water

*3170 Mediterranean temporary ponds

*3180 Turloughs

32 Running water

3260 Water courses of plain to montane levels with *Ranunculion fluitantis*

4 Temperate heath and scrub

*4070 Bushes with *Pinus mugho* (but without *Rhododendron*)

51 Sub-Mediterranean arborescent matorral

5130 *Juniperus communis* formations on heaths or calcareous grasslands

61 Natural grasslands

6170 Alpine and subalpine calcareous grasslands

62 Semi-natural grasslands

6210 Semi-natural dry grasslands *Festuco-Brometalia* (*important orchid sites)

*6230 Species-rich *Nardus* grasslands

62A0 Eastern sub-Mediterranean dry grasslands (*Scorzoneratalia villosae*)

64 Semi-natural tall-herb humid meadows

6430 Hydrophilous tall fringe communities of the montane levels

71 Sphagnum acid bogs

7140 Transition mires (no quaking bogs)

72 Calcareous fens

*7210 Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*

*7220 Petrifying springs with tufa formation (*Cratoneurion*)

7230 Alkaline fens

81 Scree

8140 Eastern Mediterranean screes

82 Rocky slopes with chasmophytic vegetation

8210 Calcareous rocky slopes with chasmophytic vegetation

*8240 Limestone pavements

83 Other rocky habitats

8310 Caves not open to the public

8330 Submerged or partially submerged sea caves

91 Forests of Temperate Europe

9110 *Luzulo-Fagetum* beech forests

91K0 Illyrian *Fagus sylvatica* forests (*Aremonio-Fagion*)

91M0 Pannonian-Balkan turkey oak - sessile oak forests

91R0 Dinaric dolomite Scots pine forests (*Genisto januensis-Pinetum*)

94 Temperate mountainous coniferous forests

9410 Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Picetea*)

95 Mediterranean mountainous coniferous forests

9260 *Castanea sativa* woods

*9530 Sub-Mediterranean pine forests with endemic black pine

4. Survey of pilot areas

In the Dinaric Alps region of Croatia five representative pilot areas (PA) were established, within which fauna species were investigated in selected habitats. Characteristic habitat types were selected also for research.

The following fauna groups were investigated in the project:

- bats (Mammalia: Chiroptera)
- small mammals (Mammalia: insectivores and rodents, especially rock-dwelling species)
- birds (Aves: owls and corncrake)
- amphibians (Amphibia) and reptiles (Reptilia)
- freshwater fishes connected with caves (Teleostei: Cyprinidae: *Telestes* spp., *Phoxinellus* spp. and *Delminichthys* spp., *Aulopyge huegeli*)
- butterflies (Lepidoptera: Rhopalocera)
- grasshoppers (Orthoptera)
- diverse cave fauna, especially water cave animals like the Dinaric cave salamander (*Proteus anguinus*) and some crustaceans (Crustacea: Decapoda, Isopoda and Amphipoda).

Special attention was given to species of Community interest from Habitats Directive Annex 2 and Annex 4, and potential species candidates for subsequent inclusion in the Habitats Directive (see part B of this report for the results).

The Fauna inventory was made by several teams of experts (Annex 1) from the Croatian Natural History Museum (CNHM) and three NGOs: Croatian Ornithological Society, Croatian Herpetological Society, Croatian Biospeleological Society, with some individual experts (geology and hydrology, habitats, botany) under subcontracts with the Museum. Support in the

field was given by experts from KNNV. Inventory was done with permits of Ministry of Culture UP/I 612-07/04-33/204, file no.: 532-08/1-04-AV-02 and UP/I 612-07/05-33/0353, file no.: 532-08-01/7-05-02.

The collected data were discussed within teams in workshops and via e-mails. Based on these discussions, potential habitats and species were selected for proposals under the Habitat Directive. In this phase of the project, important support from experts from Slovenia (Professor Boris Sket, Meta Povž, Peter Skoberne), and the KNNV team (Filippo Maria Buzzetti and Jos Notenboom) was given.

4.1. Pilot Areas (PA)

The pilot areas were identified after a review of the Priority Areas of the KEC project, connected with the protected areas in the region (the national parks Risnjak, Plitvice lakes, Northern Velebit and Paklenica, and the nature park Velebit) plus the Kupa River valley near the Slovenian border and shallow karst of the Ogulin area, downstream of source waters in the Velika Kapela Mountains. The pilot areas were based on the biogeographical regions and followed the Dinaric Alps from the west to the southern border. The planned field activities and observations on habitats / species status were restricted to these PA with a minimal inventory programme which was necessary to provide a baseline for valorisation of the importance of biodiversity and for recommendations for the management and restoration of key habitats. Before field activities started, the existing data, mostly historical, covering all the animal groups in the project proposal were reviewed.

Map of Croatian Dinaric Alps with border of five pilot areas

PA 1: **Velika Kapela Mountains**, together with several small karst fields: Ličko polje, Matić poljana, Jasenačko polje, Krakar polje, Drežničko polje, Crnačko polje and Stajničko polje. This area has habitats typical of the north-western part of the Croatian Dinaric Alps, mostly forest-covered. Only in the narrow submontane coastal zone do some sub-Mediterranean habitats exist.

Beech and mixed beech, fir and spruce forests with boreal elements dominate in PA 1 with subalpine dwarf scrub at the relatively low peaks (the highest is Bjelolasica peak 1.534 m a.s.l.). Under the mountain lies the watershed between the Adriatic and the Danube catchment areas. All the poljes except the higher Matić poljana have sinking streams, mostly intermittent.

PA 2: **Plješevica Mountains together** with Koreničko polje, Krbavica polje, Krbava polje, Podlapačko polje, Mutilić polje and Lapačko polje. Plješevica Mountains (highest peak Ozeblin with 1.647 m a.s.l.), are characterised by continental mesophytic beech and mixed beech, fir and spruce forests, with mixed oak-hornbeam forests and hop-hornbeam-downy oak elements on the foot of southern slopes. Intermittent influent streams are mostly tributaries of the Una River (Danube river system), Black Sea catchment area. Underground water directions are to the large Klokot Spring near Bihać city (BH), from Koreničko polje and one part of Krbavsko polje, and northern part of Lapačko polje, but one stream near Udbina village and several sources from Plješevica region north-eastern of Gračac village form part of the Adriatic catchment area (Zrmanja river tributaries).

PA 3: **Dinara Mountains** (Mt. Dinara, Mt. Troglav and Mt. Kamešnica) with Paško polje, Hrvatačko polje and Sinjsko polje. The mountain chain is a border area between the continental and the Mediterranean zone, with oromediterranean dwarf shrub communities at the top (Dinara peak at 1830 m a.s.l. is the highest peak in Croatia). The main river is the Cetina, which is an isolated system of the Adriatic catchment area. Its sources (underground connections with tributaries from the Bosnian side of the mountain chain) are situated from Paško polje along the southern slopes of Troglav and Mt. Kamešnica. The southern part of Sinjsko polje was in the past a regularly flooded area with several marshes.

PA 4: **Mt. Biokovo** with Polje Jezero (Dušina polje, Vrgoračko polje). Mt. Biokovo is a 1,764 m a.s.l. high isolated mountain situated near the Adriatic coast of central Dalmatia. The relatively high peak has typical oromediterranean habitats surrounded by a beech forest belt, forming continental islands with a high Mediterranean influence. The highest part of the mountain is protected as a Nature Park. Polje Jezero was in the 19th century a periodical lake with marshes, and the sinking stream Matica is part of the western tributary system of the Neretva.

PA 5: **Mt Sniježnica** with Konavosko polje under its southern foothills, situated in the most south-east part of Croatia, on the western slopes of Montenegro's highest Mediterranean mountain Cincar. Sniježnica is a 1300 m a.s.l. high mountain with only Mediterranean habitats but with a few oromediterranean elements at the top. Konavosko polje has three small isolated streams, one permanent (the sinking Ljuta stream) and two intermittent tributaries. It was in the past a regularly flooded polje in winter time and the polje had marshes near ponors.

Five pages with maps of pilot areas

4. 2. **Inventory and mapping methodology**

For all PA an initial double habitat map was prepared by Miroslav Švraka (1:25.000), one based on the historical Croatian vegetation (phytocoenological) maps (mapped from 1960 to 1980), and a second map, based on interpretation of the Landsat 7 ETM satellite image of 2001, with 30 meter ground resolution and data classification at the levels of higher vegetation types and potential plant associations. In particular, the grassland vegetation of the karst poljes was checked through the project at several sites to establish exact ground data using GPS for orientation and exact co-ordinates.

Bats were collected by netting with mist nets, and then specimens were released after a standardised protocol including sexing, measurements and identification, and with a survey of potential natural and artificial roosting places. Only a few voucher specimens from sibling species groups were collected for the museum's collection. Rock-dwelling, forest and grassland small mammals were collected with baited aluminium live traps (Sherman type) and released after a standardised protocol, or collected with snap traps.

The breeding bird inventory in the most important habitats was done by line transects counting calling males, or with simple point counts. Owls were recorded with the night playback or tape recording census technique, with tape-recorded territorial calls during breeding seasons.

Corncrake census in karst poljes was made with the method of surveying calling males on

selected survey plots. Two counts were made in the breeding season at least two weeks apart. Counts were performed between 11 pm and 3 am from the middle of May to the end of July.

Lizards and snakes were collected with special poles fitted with nooses and released after a standardised protocol (sexing, weighing etc.). Amphibians were observed and collected in transects in grasslands/forests, or collected with aquatic nets during the mating period in pools.

Fishes connected with karst springs and caves were captured with aquatic fish nets or with help of local fishermen, and in some sites with help of speleodivers.

Butterflies were netted with entomological nets, released after identification, except for a few voucher specimens. Because of different emergence times, all localities were visited a minimum of twice per year, in spring and late summer.

Grasshoppers were collected with special nets like the Catcher, and preserved with the standardised protocol each day in the late afternoon after collecting.

Sampling of terrestrial cave animals included slow and careful observations in all parts of speleological objects and sampling methods with special forceps, brushes and tubular aspirator. Special traps with several types of attractants (baits) for terrestrial fauna were included too. For water cave animals different methods were used, like infiltrating water in the vadose zone and filtering water dropping from the cave ceiling, or with small hand pumps and plastic syringes. Small baited traps were positioned in water at the beginning of the visit (or by the first visit) and collected before leaving the cave or on the next visit, mostly one week after. In some water caves, scuba diving was the only method possible for the sampling of invertebrates, the cave salamander and fish.

All specimens captured for collection were labelled directly after collecting in the field. The standardised label had the following minimum data fields: field catalogue number, locality, data time (year, month, day) and full name or initials and surname of collector. For some animals, tissue samples for further genetic analysis (mostly mtDNA analysis) were taken and preserved in

75 % ethanol, or deposited in the Museum collection in the very deep freezer (-86⁰C). From bat tissue, samples were preserved from wing biopsies too. From lizards, the end part of the tail was preserved, as were parts of fins from fish.

At the start of the project the preparation of a central data base was begun. The project data base will be exported in 2006 to the new Museum (Zoological Department) database, and also to the Slovenian Natural History Museum from Ljubljana. The database will be only partially accessible to the general public at the Web site of the Museum, and will have a special connection to the Ministry of Culture, Department of Nature Protection. All data from the project include genus and species name, locality name, x and y GPS coordinates in 5th area, altitude (z) from 1:25.000 map, year, month and day of finding, noted sex and possible reproduction stages, possible different field measurements for different species groups, simple habitat notes, digital photo documentation, comments of collector and name of collector.

All specimens or tissue samples collected in the project with other documentation were stored in the Croatian Natural History Museum collections of Zoological Department (curators: Nikola Tvrtković /mammals, crustaceans/, Eduard Kletečki /herps/, Martina Šašić /butterflies, grasshoppers/, Srećko Leiner /fish/, Branko Jalžić /Cave beetles/, Biospeleological collection: other cave specimens) and in the herbarium of the Botanical Department (curators: Mirjana Vrbek and Suzana Buzjak).

4.3. Description of results in selected habitat types

In this chapter the results of the field research will be briefly described in each investigated habitat site by listing the observed species which are already listed in the Habitat – and Bird Directive (under 1). The selected habitats and species for subsequent inclusion in the Habitat Directive are listed also (under 2). Other species were documented in the database only, all with coordinates (x, y). Grassland habitats are also indicated by an asterisk.

Field work was done on 18 locations with forests, 76 locations with grasslands (13 in alpine meadows, 42 in dry grasslands, 21 in wet grasslands), 18 in waters connected with caves, and 112 caves (69 with water, 43 only with terrestrial habitats).

Montane forests

PA 1: Beech, fir and spruce forests

Bijele and Samarske stijene forest area; (1): *Strix uralensis*, *Bubo bubo*, *Aegolius funereus*, *Glaucidium passerinum*, *Dryomys nitedula*, *Salamandra atra*; Jasenak, Vrelce: (1) *Rhinolophus ferrumequinum*, *R. hipossideros*, *Bombina variegata*, *Hyla arborea*;

PA 2: Beech, fir and spruce forests

Forests from the border of Plitvička jezera NP to Gola Plješevica; (1): *Strix uralensis*; Poljana, forests near Ozeblin peak, Mt Plješevica: (1) *Barbastella barbastellus*, *Myotis bechsteinii*, *Myotis myotis*, *Myotis emarginatus*, *Rana dalmatina*, *Bombina variegata*;

PA 3: Mediterranean beech forest

Brezovac, Dinara Mt.: (1) *Lacerta viridis*, *Podarcis muralis*, *Rana dalmatina*, *Bufo viridis*; Kovačevića staje, Troglav Mt.; Debelo brdo, Kamešnica Mt.: (1) *Lacerta viridis*;

PA 4: Mediterranean beech forest

Between Vošac and Sv. Jure peak: (1) *Myotis blythii*, *Myotis myotis*; *Podarcis muralis*, *Lacerta viridis*, *Podarcis melisellensis*, *Zamenis longissima*, *Zamenis situla*; (2) *Plecotus macrobullaris*, *Barbitistes yersinii*;

PA 5: Montane forests do not exist

Surface limestone bedrock with deep crevices

General remark: because of bad years with a minimum of rodent density all attempts in the investigations in the project years to find *Dinaromys bogdanovi* were unsuccessful;

PA 1: Bijele and Samarske stijene: only (1) *Dryomys nitedula* (Tvrčković, unpublished), *Iberolacerta horvathi*; Bitoraj peak: not checked;

PA 2: Not found the expected habitat;

PA 3: Mt Troglav: Čatrna voda and Klečarski vrhovi (? Croatia): (2) *Dinaromys bogdanovi* (Đulić & Vidinić 1967); Mt Kamešnica: Gornja Korita -Donja Korita: (1) *Algyroides nigropunctatus*, *Podarcis melisellensis*, *Lacerta oxycephala*;

PA 4: Vošac: (2) *Dinaromys bogdanovi* (Kryštufek & Tvrčković 1988), *Lacerta mosorensis*; Gornje Igrane, Mt Biokovo: (2) *Dinaromys bogdanovi* (Kryštufek & Tvrčković 1988);

PA 5: Glogova jama area and area near Kuna, Mt Sniježnica: (2) *Dinaromys bogdanovi* (Tvrčković, unpublished), *Lacerta oxycephala*; Kišnik, Kuna: (2) *Dinaromys bogdanovi* (Tvrčković, unpublished), *Lacerta oxycephala*;

Alpine and subalpine meadows

PA 1: Klek – Klečice*, Mt. Klek: (1) *Parnassius mnemosyne*, *Maculinea arion*;

PA 2: Gola Plješevica*: (1) *Parnassius apollo*; Ozeblin*, Trla*: (1) *Parnassius apollo*; Ruda poljana;

PA 3: Mt Dinara*, peak area: (1) *Vipera ursinii*, *Anthus campestris*, *Emberiza hortulana*, *Lanius collurio*;

Mt Troglav: Vješćić gora, (1) *Lacerta agilis*, *Parnassius apollo*; Čakolice-Kleka: (1) *Vipera ammodytes*; Marasovac: (1) *Vipera ursinii*; Gubalj: (1) *Vipera ursinii*;
Mt Kamešnica: Debelo brdo*: (1) *Parnassius apollo*; area over Gornja Korita *: (1) *Vipera ursinii*, *Vipera ammodytes*, *Podarcis muralis*, *Lacerta agilis*;

PA 4: Sv. Jure peak area*, Mt Biokovo (2) *Plecotus macrobullaris*;

PA 5: Without this habitat

Dry karst grasslands of poljes, colline, submontane and montane grasslands

PA 1: Matić poljana*: (1) *Bufo viridis*, Bukovnik*: (1) *Euphydryas aurinia* (on

grasslands, but on heaths with *Pteridium aquilinum* too); Rokina bezdana*: (1) *Euphydryas aurinia* on grassland near heath with *Pteridium aquilinum*; Fužine: (1) *Rana dalmatina*; Bjelsko-Klek*;

PA 2: Koreničko polje: (1) *Maculinea arion*; Mazin*: (1) *Euphydryas aurinia* (on heaths with *Pteridium aquilinum*);

PA 3: (Dinara Mountains):

Mt Dinara:

Korana: (1) *Lacerta agilis*; Brezovac*: (1) *Lacerta agilis*; Lazaret; Badanj; Veliko Suhopolje, Vrlika: (1) *Burchinus oedicephalus*, *Podarcis melisellensis*, *Hierophis gemonensis*; (2) *Prionotropis hystrix*, *Protoerebia afra*; Paško polje – Glavaš*: (1) *Podarcis melisellensis*, *Vipera ammodytes*, *Zerynthia polyxena*, (2) *Protoerebia afra*; Paško polje*: (1) *Anthus campestris*, *Lacerta viridis*, *Hierophis gemonensis*; Over Krčić valley: (1) *Podarcis melisellensis*, *Coronella austriaca*; Glavaš-Kijevo: *Algyroides nigropunctatus*, *Coronella austriaca*, *Lacerta viridis*, *Podarcis melisellensis*, *Hierophis gemonensis*;

Mt Troglav: Ravno Vrdovo: (1) *Vipera ammodytes*; *Rana dalmatina*; Šibenica, Gubalj; *Testudo hermanni*; Duvnjačka draga; Bitelići: (1) *Bufo viridis*; Penića staj: (1) *Lacerta viridis*, *Coronella austriaca* (2) *Lacerta oxycephala* (artificial stone wall); Lovrića dolac: (1) *Bufo viridis*;

Mt Kamešnica:

Bili brig – Vaganj*: (1) *Podarcis melisellensis*, (2) *Prionotropis hystrix*, *Paracryptera brevipennis*; Vaganj- Debelo brdo*: (1) *Podarcis melisellensis*, *Vipera ammodytes*, (2) *Prionotropis hystrix*; *Paracryptera brevipennis*; Kamensko-Voštane: *Vipera ammodytes*; Poduba-Tovarnici: (1) *Podarcis muralis*, *Lacerta viridis*; Poduba; Donji Voštani: (1) *Lacerta viridis*, *Podarcis muralis*; Rude-Voštani: (1) *Hyla arborea*; Donja Korita; Rumin: (1) *Hierophis gemonensis*, *Zamenis longissima*; (2) *Prionotropis hystrix*; Sinj-Čitluk: (1) *Rana dalmatina*; Bila Glavica, Panj: *Zamenis longissima*; Kotluša: (1) *Lacerta melisellensis*, *Lacerta viridis*;

PA 4: Brzice*: (2) *Protoerebia afra*, Lončari*: (2) *Protoerebia afra*; Staro Selo*; Stanići*: (2) *Protoerebia afra*; Okmadžići*: (1) *Parnassius mnemosyne*; Vošac*:

(1) *Podarcis melisellensis*, *Podarcis muralis*, *Zamenis situla*, *Parnassius mnemosyne*,
(2) *Pararcyptera brevipennis*; Lađena: (1) *Parnassius mnemosyne*; (2) *Prionotropis hystrix*,
Barbitistes yersinii;

PA 5: Kuna – Glogova jama: (1) *Podarcis melisellensis*; (2) *Lycaena ottomana*,
Pachytrachis bosniacus, *Pararcyptera brevipennis*, *Barbitistes yersinii*;
Duba; Dubravka;

Wet grasslands of karst poljes

PA 1: Jasenačko polje: (1) *Rana dalmatina*, *Hyla arborea*, *Triturus carnifex*, *Euphydrias aurinia*; Drežničko polje: (1) *Rana dalmatina*, *Hyla arborea*, *Zerynthia polyxena*, *Lycaena dispar*; Krakar*; Crnač polje*: (1) *Crex crex*, *Lanius collurio*, *Zerynthia polyxena*; Stajničko polje*: (1) *Crex crex*;

PA 2: Koreničko polje*: (1) *Euphydrias aurinia*; Krbavica: (1) *Euphydrias aurinia*;
Krbavsko polje*: (1) *Lacerta agilis*, *Crex crex*, *Circus pygargus*, *Lanius collurio*;
Krbavsko polje, Bunić*: (1) *Triturus carnifex*, *Euphydrias aurinia*, Krbavsko polje,
Močila*: (1) *Lacerta agilis*, *Rana dalmatina*, *Hyla arborea*; Podlapača*, Svrčkovovo Selo*; Mutiličko polje*: (1) *Strix flammeus*; Lapačko polje*: (1) *Triturus cristatus*,
Crex crex, *Lanius collurio*, *Lanius minor*, *Euphydrias aurinia*; Mazin*;

PA 3: Paško polje near source of Cetina river* and Paško polje near Balečki most*: (1)
Euphydrias aurinia; *Rana dalmatina*, *Crex crex*, *Circus aeruginosus*, *Circus pygargus*; Hrvatačko polje*: (1) *Euphydras aurinia*; *Crex crex*, *Emys orbicularis*,
Podarcis sicula, *Hyla arborea*, *Rana dalmatina*; Sinjsko polje: agriculture*;

PA 4: Polje Jezero: agriculture*

PA 5: Konavosko polje: agriculture*

Surface waters connected with caves

PA 1: Jasenački potok; Jezero lake: (1) *Austropotamobius torrentinum*, *Telestes souffia*,
Drežnički potok: (2) *Telestes polylepis* - extinct, Krakar potok: (2) *Telestes polylepis*
- extinct; Crnački potok: (2) *Telestes polylepis* – extinct; Stajnička jaruga: (2)
Telestes polylepis (not checked);

PA 2: Korenički potok; Krbavica potok: (1) *Austropotamobius torrentinum*, (2) *Telestes*

fontinalis - extinct; Krbava potok: (2) *Telestes fontinalis* - extinct; Podlapača potok; Suvaja potok: (2) *Delminichthys krbavensis*; Vukovića potok: (2) *Delminichthys krbavensis*, *Telestes polylepis*; Močila lake and marshes: *Delminichthys krbavensis* (only from literature); (Mutilić potok;

PA 3: Cetina river main sources: (1) *Natrix tessellata*, *Rana dalmatina*, *Telestes souffia*, *Austropotamobius pallipes*, *Ixobrychus minutus*, *Egretta garzetta*; Otok subsurface springs area: (1) *Emys orbicularis* – extinct, *Proteus anguinus*, *Telestes souffia*;

PA 4: Matica sinking river: (1) *Alburnus albidus*, *Lenthentheron zanandrei*, (2) *Delminichthys adspersus* (not checked)

PA 5: Ljuta sinking stream: (1) *Mauremys rivulata*, *Austropotamobius pallipes*, (2) *Telestes metohiensis* – extinct;

Caves, especially caves with waters, karst springs and wells:

PA 1: Zagorska peć cave, Novi Vinodolski: (1) *Myotis blythii*, *M. capaccinii*, *Miniopterus schreibersi*, *Rhinolophus euryale*, *R. ferrumequinum*; Kamačnik spring; Zeleni vir spring; Muževa hižica cave; Velika jama pit: (2) *Troglocaris anophthalmus*; Spring Izvor na Vodi; Miroši spring; Spring near Papići; Sinčića cave; Markarova pećina cave: (1) *Proteus anguinus*, (2) *Troglocaris anophthalmus*; Studenac spring; Vidovića studenac spring; Vidovića cave; Komarčeva jama II pit: (1) *Proteus anguinus*; Veliko vrelo (Krakar) spring; Periodical spring, Krakar; Milino vrelo (Krakar) spring; Crno vrelo (Kotao) spring; Zagorska peć cave, Ogulin: (1) *Proteus anguinus*, *Rhinolophus ferrumequinum*; (2) *Niphargus croaticus* (locus typicus), *Troglocaris anophthalmus*; Izvor Bistrac spring; Izvor Vitunjčice spring; Turkovića cave; Pećnik cave: (1) *Leptodirus hochenwarti*; Cave Rokinka; Crnačka (Obajdinova) cave: (1) *Proteus anguinus*, (2) *Troglocaris anophthalmus*; Jezero cave: (1) *Telestes souffia*, (2) *Troglocaris anophthalmus*; Izvor Zagorske Mrežnice river spring: (1) *Proteus anguinus*, (2) *Troglocaris anophthalmus*, *Niphargus croaticus*, *Marifugia cavatica*; Bistrac spring: (2) *Marifugia cavatica*; Izvor Rupečica cave: (1) *Proteus anguinus*, *Cottus gobio*, (2) *Troglocaris anophthalmus*, *Marifugia cavatica*, Rupečica ponor sinkhole: (1) *Proteus anguinus*, (2) *Telestes polylepis*, *Troglocaris anophthalmus*, *Marifugia cavatica*; Cave pod Mačkovom dragom (Vrelo): (2) *Troglocaris anophthalmus*; Cave Pećina Debeli Lug (Luška pećina cave; estavela); Bunar (well)

in Debeli Lug; Izvori Košarice spring; Rokina bezdana pothole: (1) *Proteus anguinus*, (2) *Troglocaris anophthalmus*;

PA 2: Kukuruzovića pećina cave: (2) *Niphargus croaticus*, *Troglocaris anophthalmus*, *Marifugia cavatica*; Barićeva pećina cave: (1) *Barbastella barbastellus*, *Miniopterus schreibersi*, *Myotis blythii*, *M. capaccinii*, *M. myotis*, *Rhinolophus euryale*, *R. ferrumequinum*, *R. hipposideros*; Zelena pećina cave: (1) *Myotis blythii*, *M. myotis*, *Rhinolophus ferrumequinum*, *R. hipposideros*, (2) *Niphargus croaticus*, *Telestes* sp.; Una spring pothole; Šarića jama pothole; Vukova pećina cave: (2) *Delminichthys krbavensis* (locus typicus), *Telestes fontinalis*; Nežić spring; Hrnjakova pećina cave-spring: (2) *Telestes fontinalis* (locus typicus) – extinct; Gutešino vrelo spring; Snježnjača ice cave, Dubanac spring, Jablan spring: (2) *Monolistra hercegovinensis brevipes*; Krčevina cave, Smrzlinka ice cave;

PA 3: Krka river spring: (1) *Rhinolophus ferrumequinum*, *Myotis* cf. *capaccinii*, (2) *Speleocaris pretneri*, *Monolistra hercegovinensis*; Ćulumova pećina cave: (1) *Myotis capaccinii*, *Miniopterus schreibersi*, *Myotis myotis*, *M. blythii*, *Rhinolophus blasii*; Vrlika (artificial shelter: bunker): (1) *Rhinolophus hipposideros*; Glavaš spring pit: (2) *Monolistra hercegovinensis brevipes*; Rudelića pećina cave: (1) *Telestes souffia*, (2) *Monolistra hercegovinensis*, *Troglocaris* or *Speleocaris*; Vukovića (Jarebica) vrelo spring: (1) *Telestes souffia*; (2) *Monolistra hercegovinensis brevipes*; Vukovića pećina cave; Pećina near Glavaš kula cave; Krivnica jama pothole; Gospodska pećina cave: (1) *Rhinolophus ferrumequinum*, *R. hipposideros*, *Myotis capaccinii*; (2) *Monolistra hercegovinensis brevipes*, *Speleocaris pretneri* or *Troglocaris* sp.; Kotluša pećina cave; (2) *Monolistra hercegovinensis*, *Spheromydes virei*; Špilja Pećine cave; Pećina Dragića I cave: (2) *Spheromydes virei*; Pećina Dragića II cave: (2) *Spheromydes virei*, *Monolistra hercegovinensis atypica* (locus typicus); Veliki Rumin cave-spring: (1) *Rhinolophus ferrumequinum*, *Myotis emarginatus*; (2) *Troglocaris anophthalmus*; Suhi Rumin cave: (1) *Rhinolophus ferrumequinum*, *Myotis emarginatus*, *M. capaccinii*, *M. blythii*; Jama (pit) kod Rumina: (1) *Myotis capaccinii*, *M. emarginatus*, *M. blythii*, *Rhinolophus ferrumequinum*; Vodena peća cave; (1) *Rhinolophus euryale*; Kosinac spring, Han: (2) *Troglocaris anophthalmus*; Krenica spring, Gala: (2) *Speleocaris pretneri*; Fissure in artificial tunnel Orlovac I, Mala Ruda: (1) *Miniopterus schreibersi*, (2) *Monolistra hercegovinensis brevipes*, *Sphaeromydes virei*, *Troglocaris anophthalmus*; Beguša (Ruda source); Grab spring: (2) *Spheromydes virei*; Jama na Korani (pit); Kosilova jama pothole;

PA 4:

Mt Biokovo:

Cave Pasji manastir, Jama na Brezdanu; Brikinjeva pećina cave; Mravinjuša jama pothole; Bošak pothole; Gornja jama na Grljaku; Jama iznad Prozorčića pothole; Jamina pit: (1) *Miniopterus schreibersi*; Cave Podrum; Cave Svetica; Dovanj jama pothole; Tučepska vilenjača cave; Crna ledenica ice cave; Mucića ledenica ice cave; Gradska spila cave; Matijaševa peć cave; Zečica jama pothole; Jama kod Dvije sise; Turija well; Jama Betina Velika pothole; Jama kod Bratuša (pit): Semicave by Bast: (1) *Rhinolophus blasii*;

Polje Jezero:

Vučija spring: (2) *Troglocaris anophthalmus*; Izvor Matica: (2) *Troglocaris anophthalmus*; Stinjevac spring: (1) *Congeria kusceri*; (2) *Troglocaris anophthalmus*; Fissure in artificial tunel Jezero-Ploče: (1) *Congeria kusceri*, (2) *Troglocaris anophthalmus*, *Marifugia cavatica*; Ponor Crni vir sinkhole: (1) *Proteus anguinus*, *Congeria kusceri*, (2) *Marifugia cavatica*;

PA 5: Glogova jama pothole: (1) *Myotis blythii*, (2) *Antroherpon* sp.; Pećina Jezero cave; Ljuta stream spring; Kladenac spring; Zvekavica spring; Malo vrelo spring; Veliko vrelo spring; Klimor spring; Dobra voda spring; Đurovića jama pothole; Runjovača jama pothole; Cave near artificial tunnel, Ljuta – Adriatic sea; Jama Bezdanjača pothole; Cave in Komalji; Spring and pool in Stravča, Duba: (2) *Delminichthys ghetaldii* – extinct;

4.4. Remarks about the results of fauna investigations

Mammals

Of the 77 mammal species noted for the Dinaric Alps, from Annexes 2 and 4 of Habitats Directive there were 38 species (30 bats, 2 rodents, the chamoix and 5 carnivores). Only rock-dwelling rodents and bats (Chiroptera) were investigated. From the investigated groups, in Annex 2 there are 11 bat species: *Rhinolophus blasii*, *R. euryale*, *R. ferrumequinum*, *R. hipposideros*, *Miniopterus schreibersi*, *Myotis bechsteinii*, *M. blythii*, *M. capaccinii*, *M. emarginatus* and *M. myotis*. Annex 4 list all other species of bats and two dormice species, *Dryomys nitedula* and *Muscardinus avellanarius*.

One of the goals was to find new sites of the relict Balkan species *Dinaromys bogdanovi*, but this was not achieved. Only the typical habitats – limestone rocky areas with deep crevices – were observed, but it would seem that this creature is restricted to isolated sites: we did not find it in the whole investigated area of Mt Plješevica, Mt Dinara and Mt Kamešnica. Of the 30 bat species present in the Dinaric Alps, for each pilot area we registered between 10 and 20 species. In lower altitudes, mostly on the borders of the karst poljes, are most of the maternity colonies (we registered 11 nursery colonies, and two wintering colonies at all), and at higher altitudes bats are present in summer only, with males in June and July, except for common forest species like *Plecotus auritus*, and *Hypsugo savii*, which is frequent in all rocky habitats. In August migration starts, and all species migrate to areas in which they will hibernate. Some important nursery colonies were found in caves in PA 2 and PA 3. Under the forest species in the investigations it was confirmed that *Barbastella barbastellus*, *Myotis brandtii* and *Nyctalus leisleri* males are common in the montane forest belt of the Dinaric Alps. *Myotis bechsteinii* was for the first time found as a resident species in the submediterranean submontane belt, but only in places with old oak trees. Of the two new identified species, *Plecotus macrobullaris* was found in PA 1, PA 2 and PA 3 area, but nursery colonies are restricted to attics and lofts of churches in lower altitudes. *Plecotus kolombatovici* is an extremely rare species and it was found only in the coastal part of Mt Biokovo.

Birds

In a review from the Croatian Ornithological Society, the Dinaric Alps in Croatia were noted as having 173 species of birds, including migratory only and wintering species. From the Annexes of the Birds Directive there are 37 resident (nesting) species identified in the Dinaric Alps: *Ciconia nigra*, *Ixobrychus minutus*, *Aquila chrysaetos*, *Hieraaetus fasciatus*, *H. pennatus*, *Gyps fulvus*, *Circaetus gallicus*, *Circus aeruginosus*, *C. pygargus*, *Pernis apivorus*, *Falco biarmicus*, *F. peregrinus*, *Bonasia bonasia*, *Tetrao urogallus*, *Crex crex*, *Burchinus oediconemus*, *Bubo bubo*, *Glaucidium passerinum*, *Strix uralensis*, *Asio flammeus*, *Aegolius funereus*, *Caprimulgus europaeus*, *Alcedo atthis*, *Picus canus*, *Dryocopus martius*, *Dendrocopus leucotos*, *Picoides tridactylus*, *Lullula arborea*, *Anthus campestris*, *Acrocephalus melanopogon*, *Hippolais olivetorum*, *Sylvia nisoria*, *Ficedula parva*, *F. albicollis*, *Lanius collurio*, *L. minor*, *Emberiza*

hortulana. This project investigated only owls at one site of the Velika Kapela montane forests, birds on the dry montane and subalpine grasslands in the Dinara Mountains, and birds in the karst poljes, especially the corncrake (*Crex crex*).

Data from the area of Samarske and Bijeke stijene (Kapela Mt., PA 1) together with the results from other projects confirmed that in all belts of mixed beech, fir and spruce karst montane forests (*Abieti- Fagetum*) several boreal owls are present: *Strix uralensis* is a common species, *Glaucidium passerinum* and *Aegolius funereus* are present with different annual activities dependent on available prey and weather. Previous speculations that these species were restricted to boreal spruce forests were incorrect. At the same time some migratory boreal species (*Vespertilio murinus*, *Eptesicus nilssonii*) were not found in the same habitats in Velika Kapela and the Mt Plješevica area. They are connected with mountains rich in rocks with fissures for wintering, like in the Velebit Mountains.

On the Dinara Mountains in Croatia the threatened shore lark (*Eremophila alpestris*) was found in only 2 breeding pairs (PA 3). A considerable decline over the last 20 years was noted, because of the succession during the war period (loss of extensive sheep breeding).

A high density of corncrakes (*Crex crex*) was registered in a transect on wet karst grasslands in Crnačko polje (23 singing males in 2004, 19 singing males in 2005), and this vulnerable bird was found in all other investigated poljes too: Stajničko polje (10 singing males), Krbavsko polje (15 singing males), Lapačko polje (11 singing males), Paško polje (10 singing males), and Hrvatačko polje (counting not performed).

Reptiles

Of the 30 species of reptiles registered in the Dinaric Alps, the number in the PA ranges between 8 species in the continental part and 27 species on the southern slopes of mountains and in karst poljes with Mediterranean influence. From Annex 2 there are only 6 species: *Testudo hermanni*, *Emys orbicularis*, *Mauremys caspica* (= *M. rivulata*), *Elaphe quatuorlineata*, *Elaphe situla* (= *Zamenis situla*), and *Vipera ursinii*. From Annex 4 there are an additional 17 species:

Algyroides nigropunctatus, *Lacerta agilis*, *Lacerta horvathi* (= *Iberolacerta h.*), *Lacerta trilineata*, *Lacerta viridis* (= *L. v. bilineata*), *Podarcis melisellensis*, *Podarcis muralis*, *Podarcis sicula*, *Ophisaurus apodus* (= *Pseudopus apus*), *Coluber laurenti* (= *Hierophis gemonensis*), *Coluber najadum*, *Coluber viridiflavus*, *Coronella austriaca*, *Elaphe longissima* (= *Zamenis longissimus*), *Natrix tessellata*, *Telescopus fallax* and *Vipera ammodytes*.

The most systematic investigation was on Mt Dinara, Mt Troglav and Mt Kamešnica (all PA 3). For the first time we completed a list of reptiles from this mountain chain with 2 terrapins and tortoises, 8 lizards and 9 snakes, in all 19 reptiles. Of Mediterranean snakes only *Hierophis gemonensis* and *Malpolon monspessulanum* were found, along the Cetina valley's southern slopes. The most interesting results are new sites for *Algyroides nigropunctatus* and *Lacerta oxycephala* (one larger site in a rocky canyon, and the other on artificial rocky walls) isolated from the rest of the distribution area, and mapped sites of *Vipera ursinii macrops*. The karst meadow viper was found on one site in the area of Dinara peak (1.551 m a.s.l.), at one site near the border with BH on Mt Troglav (1.570 m a.s.l.), and at one site near the border with BH on Mt Kamešnica (1.253 m a.s.l.). The most registered sites (9 in all) are actually in Bosnia and Herzegovina. Probably the widest distribution area is on the Croatian side around Dinara peak. The most findings were at over 1.500 m a.s.l., all in alpine and subalpine meadows with grass tussocks. It is interesting that *Vipera berus bosniensis*, from the literature known to be very common in the past, was not found, probably being restricted to the northern slopes (BiH). The most common lizard in the karst meadow viper habitats was *Lacerta agilis*. On Mt Biokovo 8 lizard species (6 from Habitats Directive and *Lacerta mosorensis* and *L. oxycephala*) and 9 snake species were known. On Mt Sniježnica 8 reptiles were registered; 7 from the Annexes to the Habitats Directive and *Lacerta oxycephala*.

Amphibians

Of the 14 species of amphibians noted for Croatian part of Dinaric Alps, in western part 12 species are common, but in the eastern part only 6 species. From Annex 2 there are only *Triturus carnifex*, *Proteus anguinus* and *Bombina variegata*, and from Annex 4 in addition there are *Salamandra atra*, *Rana dalmatina*, *Hyla arborea* and *Bufo viridis*.

On Mt. Kapela the literature records was known of *Salamandra atra*, *S. salamandra*, *Triturus cristatus*, *T. alpestris*, *T. vulgaris*, *Proteus anguinus*, *Bombina variegata*, *Bufo bufo*, *B. viridis*, *Hyla arborea*, *Rana dalmatina* and *R. temporaria*. Mt. Plješevica probably has the same amphibian fauna. In PA 1 and PA 2 we could not confirm the presence of *Triturus carnifex* in some old known sites. For Dinaric cave salamander (*Proteus anguinus*), we noted one new finding site, near Otok village (PA 3) in an underwater spring situated in a channel (previous tributary creek) on the left bank of the Cetina River. For Mt Dinara 8 species were registered for the first time with a good outline of altitudinal distribution. Only *Triturus alpestris*, *Bufo viridis* and *Rana dalmatina* were found at higher altitudes. On Mt Dinara (PA 3) 6 species were registered (*Salamandra salamandra*, *Triturus alpestris*, *Bufo viridis*, *Bufo bufo*, *Hyla arborea* and *Rana dalmatina*), on Mt Biokovo only three species (*Salamandra salamandra*, *Triturus vulgaris*, *Bufo viridis*), and on Mt Sniježnica four species (*Triturus vulgaris*, *Bufo viridis*, *Hyla arborea*, *Rana ridibunda*).

Fish connected with caves

Of the 77 species mentioned in the literature for the Dinaric Alps as fish connected with caves it is worth mentioning small cyprinids like *Aulopyge huegeli*, *Phoxinellus* spp., *Telestes* spp. and specimens from the newly discovered genus *Delminichthys*. Some other species must cross cave habitats during migration, or periodically live in caves as shelter in the winter time or during summer droughts, like *Lethenteron zanandrei*, *Anguilla anguilla*, *Chondrostoma phoxinus*, several *Squalius* spp. and *Knipowitschia* spp.. Of this group of fish, from Annex 2 there are *Lethenteron zanandrei*, species from the genus *Phoxinellus* (*P. alepidotus*, *P. dalmaticus*) and *Telestes souffia*.

In the project we found in PA 1 a small isolated population of *Telestes souffia* (Dobra River tributary), and confirmed *T. polylepis* from the Ogulin side of Mt V. Kapela. In most of karst poljes *Telestes* spp. became extinct in the last twenty years. In PA 2 we confirmed findings of *Delminichthys krbavensis* in an isolated area of Krbava polje, but we could not confirm *Telestes fontinalis* in the *locus typicus* or in the Krbavica intermittent stream. In PA 3 in the Cetina River

system *Telestes souffia* was collected by diving in a cave and by also collected after spawning behaviour was observed near an underwater spring. In the Matica River (PA 4) *Delminichthys adspersus* was not observed, and in Ljuta stream (PA 5) *Telestes metohiensis*, probably extinct (Mrakovčić et al. in press), was not confirmed. At one site of the two known in Croatia the extinction of *Delminichthys ghetaldii* (PA 5) was registered.

Butterflies

Of the 158 species of butterfly registered in the Dinaric Alps, the numbers in some better known PA range between 80 or 100 per PA. From Annex 2 there are only 5 species, but two are restricted to the Kupa valley and Mt Žumberak near the border with Slovenia (*Leptidea morsei*, *Hypodryas* /= *Euphydryas*/ *maturna*), and the third is a migratory species once found on Mt. Plješivica in the past (*Nymphalis vaualbum*). From other two, *Lycaena dispar* was restricted to north-west, and only *Euphydryas aurinia* seems to be distributed in the whole of the continental part of Dinaric Alps. In Annex 4 there are additional 5 species: *Maculinea arion*, *Papilio alexanor*, *Parnassius apollo*, *P. mnemosyne* and *Zerynthia polyxena*.

The first data for karst poljes were our results from Jasenačko polje, Drežničko polje, Krakar polje, Crnačko polje and Stajničko polje (PA 1), Krbavica polje, Krbavsko polje and Lapačko polje (PA 2) and Paško polje (PA 3). Several new sites of *Euphydryas aurinia* were found, almost all in wet grasslands, but three in heaths with *Pteridium aquilinum*, a habitat known from the Alps too. The finding of a large population of *Euphydryas aurinia* in wet grasslands of Paško polje in Dalmatia was very important, for it confirmed literature data from the past from some karst poljes in Dalmatia. In alpine meadows we were without success because of bad weather in both years, only some sites for *Parnassius apollo* were checked (PA 1, PA 2). For the Dinara Mountains (PA 3) in the past 25 species were known but after autumn 2005 in total 52 species, without any checking of the early and late spring generations. The species *Polymmatius damon* was found on Mt Kamešnica, the first locality in Croatia. For Mt Biokovo (PA 4) with seven new species the number of all species reached 109, the highest for one mountain in Croatia. For Mt Sniježnica (PA 5) our data are the first for this unexplored area. From first set of 35 species, one is new in the Croatian butterfly fauna, *Lycaena ottomanus*. For the rare Dalmatian ringlet

Proterebia afra dalmata we found new sites on the southern slopes of Mt Dinara and confirmed sites from northern side of Mt Biokovo

Grasshoppers

With about 140 known species, the Croatian grasshopper fauna is poorly explored, because of lack of experts. With some very old data only were some parts of Croatia (Istria, Kvarner area, Hvar island) better known. From Annex 2 there is only *Paracaloptenus caloptenoides*, a xerophilous species of the forest-steppe but without any known distribution in Croatia (only two old data, one from Istria, second for Kvarner), and probably not still in Croatian Dinaric Alps. In Annex 4 the only additional species is *Saga pedo*, known from Istria, the Kvarner area, Cres island and Mt Velebit.

In field investigations made in the project several sites of *Chrysochraon dispar* on wet grasslands of karst poljes were found; for the first time 13 species were found in Paško polje (PA 3), 24 species on Mt Kamešnica (PA 3), 17 species on Mt Biokovo (PA 4) and 20 species on Mt Sniježnica (PA 5). *Poecilimon elegans* was found as a rare species on the dry grasslands of Krbavsko polje (PA 2), but in large densities at localities investigated for the first time on Mt Kamešnica (Vaganj – Debelo brdo), Mt Biokovo (Vošac) and Mt Sniježnica (above Kuna). *Polysarcus denticauda*, a rare species, was found on Krbavica polje (PA 2), Debelo brdo on Mt Kamešnica, at Sv. Jure peak and Vošac on Mt Biokovo. Seven new sites with *Prionotropis hystrix* on dry grassland types on the southern slopes of Dinara Mountains (PA 3) was registered, one site on Mt Biokovo and one site on Mt Sniježnica (PA 4, PA 5) were found too. The most important finds were of *Barbitistes yersinii* on Mt Biokovo and Mt Sniježnica, *Pararctiptera brevipennis* on Kamešnica, Mt Biokovo and Mt Sniježnica. Above Kuna village on Mt Sniježnica at an altitude of 700 m a.s.l. a new species was found for Croatia, *Pachytrachis bosniacus*, which is the second known locality anywhere. The first locality (*locus typicus*) is at 1.500 m a.s.l. of Mt Cincar (BH).

Crustaceans

In Annex 2 two crayfish species from the Dinaric Alps are listed: *Austropotamobius pallipes* and *A. torrentinum*. The first species was found in the source part of the Cetina River (PA 3) and in Ljuta stream (PA 5). The second species was found in the small Jezero Lake near Jasenak (PA 1), and in the Kravica influent stream (PA 2).

In the Croatian part of Dinaric Alps, 36 species of cave freshwater decapods, isopods and amphipods are known, but this number is not final because of poor knowledge of cave fauna and their distribution. The Annexes of the Habitats Directive have no cave species from this group, and at the same time, of cave species only the amphibian *Proteus anguinus*, the beetle *Leptodirus hochenwarti* and the clam *Congeria kusceri* are on the list. Efficient protection of all caves not open for public is impossible, and for the distinction of caves into those with lesser and with greater importance we need more cave species in the Annexes. Water cave habitats have more threatened species than caves with only terrestrial habitats. With only two freshwater species it is not possible to pick out threatened caves with a higher position in biodiversity evaluation. This was the reason for our aspiration in this project additionally to investigate caves with water habitats, priorities being given to the identification of crustacean groups for which experts are known.

In PA 1 the first systematic research was started tending to produce better knowledge in all areas, especially in cave crustaceans. Some new localities with *Troglocaris anophthalmus*, for example in the Cave pod Mačkovom Dragom, were found. After the project's investigation, two distribution areas of this species in the Mt Velika Kapela area have become apparent: first along the N border of mountain, and second along the coastline. Both are in underground waters with input of influent streams. In Rupečica Cave we found a new species of the genus *Monolistra*, still not described (Sket, personal information). In PA 2 one cave rich in water cave fauna was found in the area NE of NP Plitvice lakes (with probably one *Monolistra* species new for Croatia), only two with nursery bat colonies, and several caves on the S border of Kravsko polje with an underground population of the fish *Delminichthys krbavensis*. In PA 3 some new localities with *Speleocaris pretneri* and *Spheromides virei* was found. In PA 4 the most important sites with caves and springs rich in aquatic cave species are along the northern border of Polje Jezero. In

PA 5 findings of water crustaceans were very scarce, because only some caves have water habitats inside.

Other cave fauna was only collected, mostly not identified in this project. From about 60 samples of cave sediment, more than 4000 cave snail shells were isolated. More than 1400 specimens of other different cave invertebrates have been stored in Museum collections, after two years of field work on the project.

4.5. Impact of land use on biodiversity

The Dinaric Alps natural habitats are not at the same level of threat as other karst habitats in Croatia. The shallow karst in the continental part of the Dinaric karst and the karst in the lowlands of Istria and Dalmatia are in several cases more threatened. Generally there is in the Dinaric Alps a lower pressure from possible dangerous human activities than in the karst habitats at lower altitudes, especially in cave habitats. In the Dinaric Alps we have no industry with its concomitant danger of pollution, we do not have the same pressure from tourism as can be found on the Adriatic coast, but the loss of traditional semi-natural habitats should in theory be higher than in areas with more inhabitants. Through the selection of the pilot areas we attempted to reach a balance in the review of the different types of characteristic habitats, and to reach a broader review of real threats.

At the first level of data analysis from project field observations (from our own observations and from talk with local inhabitants, foresters etc.) we have assembled the main threats for selected habitats' fauna in individual pilot areas (Tab. 1).

Table. 1. Review of fauna threats in six key habitats and five pilot areas (PA 1 to PA 5)

/ Habitats	Forest	rivers	land	land	Surface	
tion			Fauna			

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ation				5		
ion						
g						
ation						
ollution						
flows direction changing						
egulation					5	
y from poljes canalization						
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pecies					5	
ng						,5

Detailed review of individual observations:

1. Habitat loss (destruction)

1.1 Destruction from constructions (highways and road constructions, several objects:

- loss of alpine grasslands): Gola Plješevica Mt. (PA 2); Sv.Jure peak, grasslands near villages on northern slopes of Mt Biokovo; - loss of cave and spring fauna: northern border of Polje Jezero (PA 4);

1.2 Succession of abandoned seminatural grasslands – loss of dry grasslands: Matić poljana (PA 1); Krbavica, Krbava, Mutilić, several small isolated grasslands on Plješevica Mt. (PA 2: only in the first two years of project!); Mt Troglav (PA 3; mined area!); Biokovo Mt. (PA 4); Mt Sniježnica (PA 5);

1.3 Reclamation of wetlands – loss of marshes and wet grasslands: Ličko polje (Lič), Drežničko polje (PA 1); Hrvatačko polje, Sinjsko polje (PA 3); Polje Jezero (PA 4); Konavosko polje (PA 5);

1.4 Bedrock excavation – loss of wet grasslands: Lapačko polje wet grasslands (PA 2); -loss of dry grasslands, disturbance of threatened birds: Vrlika dry stony grasslands (PA 3);

1.5 Flooding with artificial water bodies – loss of marshes, wet grasslands, typical river fauna: Cetina river and poljes near the river (PA 3);

2. Habitat degradation / disturbance

2.1 Degradation with overexploitation /selective exploitation - impact on forests: Dinara Mountains (PA 3);

- 2.2 Degradation with tourism activities – impact to all fauna: Sv. Jure peak (PA 4);
- 2.3 Degradation with waste deposits – impact to all fauna: Lapačko polje wet grasslands (PA 2);
- 2.4 River regulation
River bed canalization – impact to marshes, fens, wet grasslands: water fauna: Ličanka stream (PA 1); Cetina river (PA 3); Matica river, polje Jezero (PA 4); Ljuta stream (PA 5);
Construction of dams – impact to water habitats and fauna, trawling bats: Cetina river (PA 3);
- 2.5 Water pollution – impact to cave animals: Cave waters NE Plitvice lakes; Kravsko polje (PA 2); Polje Jezero (PA 4);
- 2.6 Flow direction modification – impact to water habitats: Cetina river (PA 3);
- 2.7 Water outflow canalization – impact to fish migration, cave filtrators, cave habitats: Ličanka stream in Ličko polje (PA 1); Matica river in Polje Jezero (PA 4); Ljuta stream in Konavosko polje (PA 5);
- 2.8. Disturbance to bat colonies in caves – impact to local bat population, guano habitat: Barićeva cave (PA 2); Čulumova pećina (PA 3);
3. Community composition modification
- 3.1 Acid rain – impact to amphibians ?, selection of trees: forests of Velika Kapela (PA 1), forests of Plješevica (PA 2);
- 3.2 Burning of abandoned land – all small animals including meadow viper: alpine meadows Dinara (PA 3), grasslands of Koreničko polje, Mutilić and Kravsko polje (PA 2),
- 3.4 Introduction of predaceous alien species - impact to small relict fishes: introduction of *Oncorhynchus mykiss*: Jasenački potok, potok Krakar, Drežnički potok, Crnački potok, Stajnički potok (PA 1); Kravica stream (PA 2); Krka river, Cetina river (PA 3); Ljuta river (PA 5); Introduction of *Esox lucius*: Cetina river (PA 3);
- 3.5 Introduction of genetically close alien species (genetic pollution) – impact to *Salmo dentex*, *S. faroides*: introduction of *Salmo trutta* (from Macedonia) in trout farm on Ruda stream, tributary of Cetina river (PA 3); introduction of *Salmo trutta* in trout farm at the Krka river source (near Knin) (PA 3);
- 3.6 Overexploitation – impact of fish fauna: Matica river (PA 4);
4. Selected species collecting

4.1 Illegal collecting (trading): cave beetles: (all PA); *Parnassius apollo*: Velika Kapela (PA 1); *Proterebia afra* (PA 3, PA 4), *Vipera ursinii* (PA 3);

4.2 Overexploitation: *Austropotamobius pallipes*, *Rana ridibunda*: Cetina river (PA 3); *Rana ridibunda* (PA 2);

Table. 2. Summary review of observed preliminary status of key habitats' fauna in five pilot areas

Habitats /	Area 1 Kapela	Area 2 Šteševica	Area 3 Čara	Area 4 Čukovo	Area 5 Čežnica
fauna	seems protection	seems	protection	protection; protection past	protection
meadows fauna	protection	protection	protection	protection; protection	
grasslands	protection	protection	seems good	protection	protection
grasslands of poljes	seems good; protection	seems warned	protection; reclamation for agriculture	reclamation for agriculture	protection agriculture
waters	protection; species	species	protection; exploitation; species	protection; exploitation; protection	protection; species
water fauna	seems good; protection; protection	good;	good;	good; protection; protection? protection canal.	protection canal.

5. Recommendations for conservation and management

5.1. General recommendations for biodiversity preservation action in Dinaric Alps:

(1) Inclusion of proposed habitats and species in the Habitats Directive, especially in Annex 1 and 2 ;

- (2) To change management in sub-Mediterranean forests to retain more hollow oak trees;
- (3) To prevent agricultural improvements in karst poljes without preservation of refuges of semi-natural grasslands;
- (4) The recovering of traditional grazing with livestock, cows and sheep, with regulation to prevent overgrazing, especially in the karst poljes, on the dry southern slopes of mountains and on subalpine meadows;
- (5) To prevent the introduction of alien fishes, especially salmon and trout, in small isolated karst influent and/or intermittent streams, and the introduction of alien species in the waters of Adriatic drainage basin;
- (6) To start with the mapping and proper evaluation of important small habitats, such as karst poljes wet grasslands, small marshes, small isolated karst streams, etc.
- (7) To prevent the engineering of karst polje streams, modifications to the direction of their flow or to their natural outflow without previous biodiversity impact studies, especially on endemic flora, surface and cave fauna;

5.2. Special recommendations for selected habitats of this project pilot areas:

Forests:

- (1) International action to reduced cross-border acid rains;
- (2) To change present forest management in the sub-Mediterranean broadleaved forests in

the direction of management with protection for hollow trees and/or protection of some old oak trees in all stands (PA 3, PA 4, PA 5). Cases of finding sites of *Myotis bechsteini* in the a) protected stand with old oak trees in Laudonov gaj (Krbavsko polje), b) Poljana (Plješevica Mt.), all PA 2, and c) former finding near Čikola river in Dalmatia, strongly argue in favour of this type of forest management;

(3) To put protection for Laudonov gaj (Krbavsko polje, PA 2) at a higher level (SSSI): action plan *Myotis bechsteini*; Species from Annex 2: *Lucanus cervus*, *Cerambyx cerdo*, *Triturus carnifex*, *Myotis bechsteini*; Species from Bird Directive: *Lanius collurio*, *Picus canus*; Spec. candidates for Annex 2: *Plecotus macrobullaris*;

Alpine and subalpine meadows: Habitats from Annex 1: 6170 Mt

(4) Action plan for *Vipera ursinii macrops* (PA 3): to check ecology and density in Mt Dinara; to make the Dinara peak area an SSSI area (together alpine meadows and other habitats) with species from Annex 2: *Vipera ursinii macrops* and plant *Cerastium dinaricum*; Habitat candidate for Annex 1: *Festucion bosniacae*.

(5) To prevent construction and building (all PA) on peaks with isolated alpine meadows;

(6) In Biokovo Nature Park to prevent tourists visiting selected parts of the remainder of oromediterranean alpine meadows around Sv. Jure peak. Habitat from Annex 1: 6170 Alpine and subalpine calcareous grasslands. Possible action plan for *Prunella collaris* (PA 4);

Dry grasslands:

(7) In all areas with existing grazing, protected and stimulated traditionally by the grazing of livestock (sheep), but with prevention of overgrazing (PA 3);

(8) In areas without existing grazing, action plans to establish grazing:

Montane grasslands at Matić poljana – (PA 1); Habitats from Annex 1: *6230 – Species-rich *Nardus* grasslands;

The last small submontane and montane grasslands in Biokovo Nature Park – (PA 4) on the northern side to include into the management plan of the Nature Park measures for the prevention of succession. Species from the Birds directive: *Lullula arborea*, *Lanius collurio*, *Emberiza hortulana*; Species candidates for Annex 2: *Proterebia afra dalmata*, *Prionotropis hystrix hystrix*;

Last small grasslands on Mt Sniježnica – (PA 5). Species from the Birds Directive: *Emberiza hortulana*; Species candidates for Annex 2: *Pachytrachis bosniacus*, *Prionotropis hystrix hystrix*;

(9) In Veliko Suhopolje (PA 3), limitation of gravel excavation. Species from the Birds Directive: *Burchinus oediconemus*, *Lullula arborea*, *Anthus campestris*; Species candidates for Annex 2: *Prionotropis hystrix hystrix*, *Proterebia afra dalmata*;

Wet grasslands in karst poljes:

(10) In all sites with remains of typical (endemic) Dinaric karst polje wet grasslands, stopping reclamation for agriculture;

(11) In all sites with remains of typical (endemic) Dinaric karst polje wet grasslands, traditional mowing or seasonal grazing are recommended and should be encouraged;

(12) In Lapačko polje (PA 2), the protection of *Schoenetum nigricantis* meadows together with wet grasslands (*Molinio-Lathyretum pannonicae*) and intermittent streams. Species from Annex 2:

Euphydryas aurinia, *Scilla litardierei*. Species from Bird Directive: *Crex crex*, *Lanius collurio*, *Lanius minor*; Habitat candidate for Annex 1: *Molinio-Lathyretum pannonicae*.

(13) In Paško polje (PA 3), initiate protection of the whole source area of the Cetina including karst springs, the source river part & caves; semi-natural grasslands (*Deschampsietum mediae*) must be protected but with extensive cattle breeding . Species from Annex 2: *Telestes souffia*, *Austropotamobius pallipes*, *Euphydryas aurinia*, *Scilla litardierei*. Species from the Bird Directive: *Crex crex*, *Ixobrychus minutus*, *Circus aeruginosus*, *Circus pygargus*, *Pernis apivorus*, *Anthus campestris*, and several birds in migration. Habitat candidate for Annex 1: *Deschampsietum mediae*.

(14) In Hrvatačko polje (PA 3): protection of semi-natural grasslands (*Deschampsietum mediae*) with extensive cattle breeding or moving. Species establishing the need for protection for semi-natural grasslands are *Scilla litardierei* and *Crex crex*, for the better protection of all areas, including natural river banks and tributaries: *Acrocephalus melanopogon* and *Emys orbicularis*. Habitat candidate for Annex 1: *Deschampsietum mediae*. Endemic plant *Edraianthus dalmaticus* have DD status species in the Red Book of Vascular Flora of Croatia (2005): populations in Paško polje and Hrvatačko polje seem to be the last in Croatia.

(15) In Krbavsko polje (PA 2) the recommendations are for the recovery of traditional livestock grazing; there are several species from Annex 2 and the Bird Directive: *Scilla litardierei*, *Triturus carnifex*, *Crex crex*, *Circus pygargus*, *Lutra lutra*. Habitat candidate for Annex 1: *Molinio-Lathyretum pannonicae*.

Limestone area rich in crevices:

(16) In isolated sites with the rock- and cave-dwelling relict vole *Dinaromys bogdanovi* to initiate a kind of protection (a designated area in physical plans for the prevention of building) with

monitoring of the isolated relict vole population (area around Čatrnja voda on Mt Troglav, Mt Sniježnica over Kuna).

Potential area for protection - canyon between Donja and Gornja Korita (Kamešnica Mt.): *Algyroides nigropunctatus*, *Lacerta oxycephala*;

Surface waters connected with caves:

- (17) At the national level to prevent future introduction of *Oncorhynchus mykiss* and other predatory or competitive fish in small isolated karst influent streams and intermittent streams; In waters with introduced *O. mykiss* populations, the extraction of this species;
- (18) To protect the Jezero (cave and lake) site on the northern border of Jasenovačko polje; Species from Annex 2: *Bombina variegata*, *Telestes souffia*, *Austropotamobius torrentinum*;
- (19) To protect all sites with fish of the relict genus *Delminichthys* by establishing action plans for all four species (two out of the project priority area):
- (19.1) For *D. krbavensis* in Krbavsko polje (SW part), but with the catchment area of all springs from Bunić to Mekinjar with this fish species too – in small karst poljes near Podlapača village and Svračkovo village (karst poljes higher than Krbavsko polje);
- (19.2) For *D. ghetaidii*, after we lost the site in Duba village (PA 5), the last site of this species in Croatia is the underground part of the Ombla (near Dubrovnik): the Croatian government in the recent past signed document approving a plan for construction of a large underground water reservoir for an electric power station, the construction of which will destroy the habitat of this species together with the exclusively bat colony (with several bat species from the Habitats Directive) in the same cave system. We expect that this decision will be checked, and that next document will be protection of this site. It is also a site of *Proteus anguinus* and *Speleocaris pretneri*. The main action to save this fish species will be in Bosnia and Herzegovina.

(20) To protect the river terrapin *Mauremys rivulata* and last population of *Austropotamobius pallipes* in Ljuta river (PA 5);

Caves:

(21) To protect all caves with important colonies of bats from Annex 2, and rich in cave water fauna (Only the part in Annex 2, the rest are species candidates):

(21.1) Area on the northern border of Mt. Velika Kapela (PA 1) with a southern line from Jasenačko polje – Drežničko polje – Crnačko polje – Stajničko polje. Cave species from Annex 2: *Cottus gobio*, *Telestes souffia*, *Proteus anguinus*, *Rhinolophus ferrumequinum*, *Myotis capaccinii*; Species candidates for Annex 2: *Telestes polylepis*, *Troglocaris anophthalmus*, *Niphargus croaticus*, *Marifugia cavatica*;

(21.2) Area NE Plitvička jezera (PA 2) with Kukuruzovićeve cave and Barićeve cave. Caves with species from Annex 2: *Rhinolophus euryale*, *Rhinolophus ferrumequinum*, *Myotis capaccinii*, *Myotis blythii*, *Myotis myotis*, *Miniopterus schreibersi*; Species candidates for Annex 2: *Niphargus croaticus*, *Troglocaris anophthalmus*, *Marifugia cavatica*;

(21.3) Zelena pećina near Bunić (PA 2). Caves with species from Annex 2: *Myotis myotis*, *Myotis blythii*, *Rhinolophus hipposideros*. Species candidates for Annex 2: *Niphargus croaticus*; *Telestes* sp.

(21.4) Jablan Spring, E Gračac city (PA 2): Species candidates for Annex 2: *Monolistra hercegovinensis*;

(21.5) Artificial tunnel connected with a cave on the Krka River source near Knin (PA 3). Caves with species from Annex 2: *Rhinolophus ferrumequinum*, *Myotis* cf. *capaccinii*; Candidates for Annex 2: *Speleocaris pretneri*, *Monolistra hercegovinensis*;

- (21.6) Caves of main Cetina sources from all boundaries of Paško polje (PA 3). Caves with species from Annex 2: *Telestes souffia*; Species candidates for Annex 2: *Sphaeromides virei*, *Monolistra hercegovinensis*, *Troglocaris anophthalmus*;
- (21.7) Caves in area of Rumin stream sources (PA 3). Caves with species from Annex 2: *Rhinolophus ferrumequinum*, *Myotis capaccinii*, *Myotis emarginatus*, *Myotis blythii*;
- (21.8) Area around Dragića caves near Maljkovo village (PA 3). Caves with species candidates for Annex 2: *Sphaeromides virei*, *Monolistra hercegovinensis atypica*;
- (21.9) Area on the northern side of Sinjsko polje from Otok to Vedrine (PA 3). Caves and springs with species from Annex 2: *Proteus anguinus*, *Telestes souffia*. Species candidates for Annex 2: *Speleocaris pretneri*, *Troglocaris anophthalmus*, *Sphaeromides virei*;
- (21.10) Area of Ruda river sources (PA 3). Caves with species candidates for Annex 2: *Sphaeromides virei*, *Monolistra hercegovinensis*;
- (21.11) Sources on the northern border of Polje Jezero (Vrgoračko polje) (PA 4). Caves with species from Annex 2: *Proteus anguinus*, *Congerina kusceri*; Species candidates for Annex 2: *Delminichthys adspersus*, *Troglocaris anophthalmus*;
- (21.12): Crni ponor, one of the ponors of the Matica river (PA 4). Caves with species from Annex 2: *Proteus anguinus*, *Congerina kusceri*, *Lethenteron zanandrei*, Species candidates for Annex 2: *Marifugia cavatica*, *Delminichthys adspersus*. The most dangerous threat is pollution from the agriculture area in Polje Jezero.
- (21.13) Glogova jama pothole, Mt Sniježnica (PA 5). Caves with species from Annex

2: *Myotis blythii*; Spec.candidates for Annex 2: *Dinaromys bogdanovi*, *Anthroherpon* sp.;

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Annex 1

Persons involved in the project

General co-ordination:

Peter Veen
Nikola Tvrtkovic

KNNV expert team:

Filippo Maria Buzetti
Jos Notenboom
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Vegetation mapping:

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Educational activities:

Petra Sović
Jana Bedek

Steering Group members:

Darka Spudić from Ministry of Culture, Directorate for Nature Protection
Jasminka Radović from State Institute for Nature Protection
Željka Ivanović from Ministry of Forestry and Agriculture
Marija Jokić / Ms. Dagmar Šurmanović from Water Management Institute (Croatian Waters)
Dr. Giuseppe Messina and Professor Boris Sket from International Biospeleological Society
Representative of Dutch Embassy
Peter Veen
Nikola Tvrtkovic

Bat recording was confided to Igor Pavlinić, Draško Holcer and Nikola Tvrtković from CNHM. For small mammal recording Marijana Vuković and Nikola Tvrtković from CNHM were responsible.

Bird recording was confided to members of the Croatian Ornithological Society: Dragan Radović, Vesna Tutiš, Davor Ćiković and Jelena Kralj with Ivan Budinski, Luka Jurinović, Duje Lisičić, Robi Crnković, Ognjen Vukadinović, Krešo Mikulić and Krešo Leskovar.

For recording reptiles and amphibians Eduard Kletečki (CNHM) was responsible, with a team from Hyla, the Croatian Society for the Investigation and Preservation of Amphibians and

Reptiles: Dragica Šalamon, Ivan Budinski, Vilim Elez, Sven Kapelj, Vedran Lucić, Sunčica Strišković and Tea Šilić.

Butterfly recording was confided to lepidopterists Martina Šašić (first two years) and Iva Mihoci (last year), both from CNHM. For grasshoppers, a special field workshop for students (Iva Mihoci, Jure Skejić,) was organised with a review of collecting and conservation techniques by Filippo Maria Buzzetti, an expert from Italy.

For recording cave animals Branko Jalžić (CNHM) was responsible together with the Croatian Biospeleological Society (HBSD) with support in the field in summer 2004 of Jos Notenboom, an expert from Netherlands. From the HBSD, work in the field was carried out by Roman Ozimec, Sanja Gottstein Matočec (only first year), Jana Bedek and Hrvoje Dragušica, Stipe Bušelić, Predrag Rade, Martina Pavlek, Helena Bilandžija, Fanica Kljaković Gašpić, Marko Lukić, Hrvoje Cvitanić and Damir Basara. For recording fish connected with caves Nikola Tvrtković and Branko Jalžić (speleo-diver) from CNHM were responsible, with help in collecting from Franjo Perović (CNHM) and Josip Šipek from Otok bei Sinj, and an anonymous collector from Jasenak.

Martina Podnar Lešić from DNA lab of CNHM was responsible for .mtDNA analysis and genotyping for the identification of some species