SECOND NATIONAL COMMUNICATION TO THE CONVENTION ON CLIMATE CHANGE
Sector Biodiversity

INTRODUCTION

Global climate changes impact different environmental components. Biological diversity as the most dynamic environmental segment is constantly exposed to the climate change impact and it reacts according to its own adaptational capacity. The direction of adaptations, migrations and successions of different biodiversity components at a certain area or region depends on many factors. Above all these are heterogeneity, differentiation, zonation, richness and complexity and similar parameters of particular biodiversity components.

The Republic of Macedonia has specific geographic position on Balkan Peninsula where different climatic influences (continental and Mediterranean) on a small area in separate parts of the country intertwine. In combination with other ecological and historic factors they have led to development of specific and very rich biological diversity. Beside its intrinsic value, biodiversity in Macedonia has other values, especially economic and it provides a lot of goods and services. This is the reason why Macedonia strives to protect and conserve its biodiversity.

In that sense, we try to assess and find explanation for the impact of the current global climate changes on the most sensitive components of flora, vegetation and fauna in this report. These assessments are mostly based on expert judgement due to the lack of permanent monitoring of biodiversity components. All available data on climate parameters were taken into consideration in assessment.

Analysis of the present status of biodiversity

First National Communication of the Republic of Macedonia (FNC) to the United Nations Framework Convention on Climate Change (UNFCC) presents in general terms the rich floristic, vegetational and faunistic diversity in Macedonia resulting from the specific geographic position of the country, geological past, heterogenic relief and climate characteristics. As an example, according Matvejev (Lopatin and Mavejev 1995) and Filipovski et al. (1996) in the territory of Macedonia eight biomes (out of nine in Balkan Peninsula) and climate-vegetation-soil zones can be recognized. These zones contain large number of ecosystems and habitats characterized by extraordinary species richness.

In order to get an impression about the significance of the biodiversity in Macedonia, a short review of its richness and its status will be presented. It was compiled on the basis of the data from the Study on the Status of Biological Diversity in the Republic of Macedonia (2003).

The biodiversity of the Republic of Macedonia has been relatively well studied, and is noted for its species richness and level of endemism, underlining the country's importance of a "hotspot" for biodiversity in Europe. To date over 16,000 species have been recorded in Macedonia, including 854 endemics.

At present, anthropogenic impacts have affected a range of species and habitats within the Republic of Macedonia. In particular, aquatic and wetland ecosystems are considered the most endangered and relict lowland marsh communities are now only found in fragments (including six sites, which are at critical risk). Similarly, within grassland communities, wet meadow communities are considered threatened. Other specific threats affect certain halophytic (saline) communities, and specific forest types.

Overall, 79 fungi and lichen species, 74 species of algae 392 higher plants and 113 vertebrates are considered to be threatened. In addition, nine species of algae, five conifers, five flowering plants, one fish (Ohrid stream trout, *Salmo lumi*) and one mammal (golden jackal) are considered extinct within the country. The invertebrate fauna may be at particular risk of habitat change, including the 650 endemic taxa, many of which are associated with the three natural lakes (Ohrid, Prespa and Dojran). Among the vertebrates, over 22% of species are considered to be threatened, including 17 species endemic to Macedonia.

Despite the high levels of research, data is still lacking on the status and direct threats to many of the country's endemic species.

The direct causes of biodiversity loss are many and varied, and include:

- Loss and modification of habitats
- Fragmentation of habitats
- Pollution
- Unsustainable exploitation

The factors underlining biodiversity decline in Macedonia include a general history of anthropogenic land use, the recent economic collapse, an unstable political situation, inadequate spatial planning and inappropriate land use. Several basic reasons underlying the loss of biological diversity in the Republic of Macedonia can be identified:

- A low level of education and a lack of information, resulting in low public awareness;
- A reduced and unstable economy, coupled with military actions that have been affecting the region for a number of years;
- Growing poverty;
- Uncontrolled urbanisation, abandonment of agricultural land;
- Ongoing migration from villages to towns;
- The move to the market economy, with the need to engage in a competitive market, growing globalisation and the move towards high production systems (including agricultural systems)

In addition, conservation is hindered by:

- Inadequate and incomplete legislation which fails to clarify responsibilities and results in overlapping roles between the agencies responsible for enforcement;
- Non-compliance with existing regulations;
- Lack of spatial planning regulations for areas with special natural values;
- Lack of up-to-date technologies, including appropriate renewable power generation equipment and lack of treatment facilities for wastewater and waste gases; and
- Outdated spatial planning processes, resulting in improper land use changes, construction of infrastructure systems and agricultural conversion (in previous years).

Key sectors affecting biodiversity listed in order of decreasing impact are:

- Agriculture, which has had a particular impact on biodiversity in the decades following the Second World War, including drainage of marshes and wide-scale agricultural expansion, and subsequent declines in pastoralism;
- Fisheries, since over-fishing has resulted in serious threats to fish diversity in the Republic of Macedonia (especially in Lake Ohrid);
- The transport sector, especially due to the fragmentation of habitats;
- The energy sector, as a result of the consequences of pollution, construction of hydropower reservoirs and power line networks;
- Industry and mining, mainly as a result of soil, water and air pollution which has had major impacts on large areas of Macedonia;
- Tourism, where key impacts are associated with the illegal construction of holiday homes, incomplete infrastructure serving the main tourist resorts and inappropriate behaviour by tourists;
- Construction and civil engineering, as a result of land conversion, habitat destruction, disturbance of animal populations, as well as pollution due to poor waste disposal practices.

All these threats to biodiversity, their underlying causes and economic sectors have coupled impact with climate changes. More precisely, they hamper the ability of natural ecosystems, communities and species to adapt to the changing climate, or to move in space in order to avoid negative climate change impact.

Interlinkages between the present status of biodiversity and current and future climate changes

Climate. The data for climate (average annual temperature and annual sums of precipitation) for XX century show considerable variation during time and no significant trend can be observed. Trends of annual temperatures differ for different regions (positive, negative or no trends can be observed). The same is true for mean July and January temperatures. Trends of annual sums of precipitation do not differ significantly from average multiannual sums. Insignificant negative trend of November precipitation (the month with the highest precipitation in Macedonia) and variation in different regions for May precipitation can be noticed. Summer (August) precipitation shows insignificant positive trend in some regions (mountainous regions were not analyzed).

More useful analyses of basic climate parameters for this purpose were comparison of two climate series - 1961/1990 and 1971/2000.

The data provided by Hydro-Meteorological Institute for this purpose show trends of slight increase of average annual temperatures for 1971/2000 period compared to 1961/1991 period. Positive trend in temperature increase during last 30 years for almost all studied regions (except for the Pelagonija region and Ohrid) was registered. The increase of average temperatures in lowland regions is mostly higher than the increase in mountainous regions (Bistra Mt. - Lazaropole, Shar Planina - Popova Shapka and Jakupica Mt. - Solunska Glava) (See climate report from this communication). The changes in 30 years in average, for the two analyzed periods, were lower during summer (July) compared to winter (January temperature).

The amount of precipitation in last 30 years has dropped significantly for the most regions in Macedonia compared to 1961/1991 period (no changes were registered in

Bitola and Krushevo). Different seasons show different pattern: April, July, August, September and October show significant increase of monthly sums of precipitation, while other months show opposite trend. The most significant changes (negative difference) were observed in mountainous regions (Mavrovo and Popova Shapka - about -100 mm annual precipitation).

The climate report contains data on absolute minimum and maximum temperatures, snow cower, sunny periods and cloudiness, but there is no comparative analysis for different periods. Thus, these data are not useful for the purpose of their impact on biodiversity during forthcoming period.

More detailed analysis of climate change and modeling of possible changes in the course of the next 100 years on a regional level were performed in the frame of this communication to Climate Change Convention in order to produce more reliable estimates of climate change impacts to environmental component. The modeling was performed on the basis of several scenarios for green house gasses emissions and different economic parameters. The elaboration of different scenarios (more pessimistic and more optimistic) was performed for the main climatic regions in Macedonia on the basis of climate parameters from meteorological stations for which sufficient measurement series exist (see: report on scenarios!). Short description of the climate parameters (temperature and precipitation) change expected in different regions in Macedonia (taken as an average values from all scenarios) is given in the Refugial Forest Zones chapter in this report.

It has to be pointed out that there are serious deficiencies in the scenarios because some very important regions for biodiversity in Macedonia were not analyzed. In that context, the lack of scenarios for mountainous regions in western Macedonia (although Lazaropole and Popova Shapka were modeled) is especially restricting assessments. Apart from that, very important parameters, e.g. lasting of the snow pack/cover, flood frequencies etc. were not elaborated in the scenarios. Unfortunately, the lack of data for climate parameters in Macedonia (for the biodiversity as well) is restricting the possibility for more detailed and more precise assessments of the climate change impacts.

Possible impact on ecosystems and species. Mountainous relief intersected by valleys is the main reason for climate induced zonal distribution of the vegetation in Macedonia, i.e. major ecosystem types (or biomes) are distributed in vertical zones along the altitudinal gradient. This distribution pattern was elaborated in FNC in more details. Except for the submediterranean zone, latitudinal belts can not be distinguished on the country level due to its small dimensions.

Considering the zonal character of the biodiversity in Macedonia, global climate change on a regional level could affect it through changes of the temperature and precipitation in different zones. For certain zones, the changes of the temperature regime might be more important factor causing the disturbances of the characteristics and the composition of the ecosystems (in the mountains), while for others, that factor might be the change of the precipitation quantity, i.e. the available humidity (in the valleys). Especially important factor for the biodiversity in individual areas in Macedonia will be the perturbances of the precipitation distribution throughout the year.

Possible impact is expected from the rising erosion problem (related to human activities and redistribution of precipitation - summer dry periods and winter rainy periods) and increased floods. The direct impact of sea level rise is irrelevant for Macedonia.

Considerable movement of plant and animal species in south - north direction (basically significant only for submediterranean oak ecosystem), as well as along the vertical gradient is expected, regardless of which scenario for climate change in the next 100 years should be taken into consideration. In any case, large dislocations of vegetational zones will happen, or a certain redistribution of ecosystems and organisms along with the zones. The size of damages and species loss will depend on the rate of the changes of the climate, since the change of the species distribution depends on their adaptation ability and mobility, or the possibility of coupled shift of the range with the climate change. This is especially important for the long-life plant perennial species as trees, which actually determine the ecosystem to the highest degree and along with it almost all other species.

The most threatened are subalpine and alpine pastures (grassland ecosystems). Subalpine grasslands are secondary vegetation type established on this belt instead of subalpine forest ecosystems during past millennia. They have been created through grazing practices and presently represent very important part of Macedonian biodiversity. Subalpine pastures are also an immense constituent of Macedonian landscape. Alpine grasslands, rocky habitats, scree and rock vegetation are distributed only on the highest parts of mountain summits and occupies very small areas (only 0.5% of the country territory). Vertical movement of these communities will be hindered by many relief related obstacles, ecological preferences and especially available space. Conical shape of the mountain summits means smaller area on the higher elevation. And not the whole area will be available. Only north faced slopes would offer suitable ecological conditions since alpine zone in Macedonian mountains will disappear.

Another significant threat to the biodiversity in Macedonia in relation to climate warming and predicted drop of precipitation is the danger of disappearing of the vegetation and other species in the refugia centers. They are very important for biodiversity in Macedonia due to the extraordinary species richness, especially endemic and relict species, which have found shelter there as a response to the climate changes in the former epochs.

Other azonal communities (subsequently ecosystems) in the river gorges and valleys etc. will be affected as well. It is very difficult in this stage to predict to what extend are they threatened by the global warming. However, it is an important issue for Macedonian biodiversity (giving rise to the rich biodiversity in our small and mountainous country).

Climate change impact to biodiversity (species and natural ecosystems) and possibilities for adaptation and vertical movement of species and communities will be different in different regions due to many reasons, including geology, relief, general geographical characteristics etc. (Jes et al. 1993). Past and present human impact, especially agriculture and infrastructural object will have crucial role in that process.

The impact of climate changes on different plant and animal species in Macedonia can not be correctly assessed due to the lack of data. There are no long-term observations concerning phenology and behaviour of different species in Macedonia. It can only be concluded, based on similar studies performed in different mountainous regions

(especially in the Mediterranean region - Sanz-Elorza et al. 2003; Stanisci et al. 2005), that significant perturbations in species ecology will happen. This includes:

- changes in vertical migration periods - birds (Inouye et al. 1997),
- disturbances in the start of activities of hibernating animals - mammals (Inouye et al. 1997),
- decreased food availability (insects on the edges of snow patches for birds) (FNC),
- earlier egg-laying of birds,
- loss or restriction of habitats for many plant and animal species (Guisan and Theurillat 2000; Pauli et al. 2003), could lead to extinction of cryophilous species,
- unsuitable habitat available for vertical movement of different plant species (Guisan and Theurillat 2000) etc.

The survival of natural ecosystems is to a large extent left to natural adaptation (Jes et al. 1993), unlike farming and forestry that can be adjusted to changing climate. The most important mechanisms are acclimatization (mostly related to genetic variability) and beside that migration as a response to climate change. Therefore, (i) the importance of conservation of genetic diversity as an integral part of biodiversity is again stressed, and (ii) since fragmentation of habitats may hamper the migration, evaluation of habitat fragmentation and biocorridors for Macedonia is needed! The lack of precise distributional data has to be exceeded by analysis and discussion on climatic and biogeographic division of Macedonia and existing altitudinal differences.

The exact prognosis of changes can not be driven since there are too many uncertainties, possible unpredictable shift of human life-styles due to the development of technology during next 100 years - the time range in which we are trying to evaluate changes (Jes et al. 1993). (Although the regional scenarios for temperature and precipitation changes in different regions in Macedonia in the next 100 years take into consideration several development directions of the country, related to rise of the lifestyle - energy and others.) Thus, this report can only offer an evaluation of the type and the magnitude of climate change impact on biodiversity in Macedonia and possibly some guidance for a planned adjustment in sensitive sectors.

Relevant past and ongoing research and projects related to biodiversity

There is significant amount of research on biodiversity issues that has been carried out up to date in Macedonia (see Country Study for Biodiversity in the Republic of Macedonia 2003). However, not a single article on climate change impact on biodiversity or other climate change issues does exist. After preparation of the FNC, several important projects were performed and important documents concerning biodiversity conservation were elaborated. They did not treat climate change impact directly, but they stress its significance for biodiversity or have indirect importance for biodiversity conservation in the condition of changing climate. The most important projects of this type are:

- Country Study for Biodiversity in the Republic of Macedonia and Biodiversity Strategy and Action Plan of the Republic of Macedonia (the Action Plan sets the action E.2.5. - Establishment of the monitoring of climate change impact on biological diversity),
- National Capacity Self Assessment (NCSA project) in the filed of three Rio Conventions, 1992,
- EMERALD 1-st, 2-nd, and 3-rd faze

- Pan-European Ecological Network for South-Eastern Europe (including Turkey) (PEEN SEE) where the main biocorridors in the region were pointed out, and others.

The knowledge gained during elaboration of these projects and measures related to climate change and biodiversity in general proposed in them presents a valuable contribution and they should be respected and implemented since the experience in this field in Macedonia is very limited and unsatisfactorily.

The aim of the report

The climate scenario of 3.2 ^{o}C temperature rise for the next 100 years was taken into consideration for assessment of climate change impact on biodiversity in the FNC. The refugial forest regions in which relict forest communities are developing were taken as a model for changes that have been happening in the past (especially Pleistocene epoch). The development of these communities is to a great extent not in correlation with present climate conditions and they exist only within the locally modified ecological conditions of the habitat (mostly sheltered in the gorges and valleys). Owing to this, they are the most sensitive communities and susceptible to climate changes. Two of all refugial forest zones were analyzed in FNC (Treska and Nidzhe). Apart from that, the general aspects of climate change impact on biodiversity at each of its levels were elaborated in more details. The data availability and the need of data were analyzed as well. In this case, additional analysis of the biodiversity status and data availability is not necessary since nothing has changed over the last few years. For that reason, in this report only more concrete analyses, assessments and views will be presented, taking into consideration biodiversity on the whole territory of the country.

Having in mind the fields that were not covered with FNC, as well as the expertise and scientific knowledge available in Macedonia on climate change issue, we consider that special attention in the Second National Communication (SNC) should be paid to following activities:

- analysis of all major ecosystems with belt distribution (especially the high mountain belt)
- analysis of the rest nine refugial zones with relict forest vegetation in Macedonia;
- the status of the water and wetland vegetation and fauna in and around the natural lakes;
- assessment of the impact of periodical and induced hydrological fluctuations of natural lakes, in global climate change context, that have led to change of ecological conditions in the lakes;
- characterization of the river ecosystems - flora and fauna in climate change context;
- assessment of the impact of water uptake facilities construction (water extraction) on biodiversity in the mountainous regions above 1000 m altitude in climate change context;
- assessment of climate change impact on species, especially some Macedonian local endemics and relicts.
- possibilities for application or testing of models for climate change impact on biodiversity
- assessment of current status of biodiversity components monitoring and proposal for future activities

- assessment of biodiversity and climate change in socio-economic context of the Republic of Macedonia
- proposal for adaptation measures in the sense of climate extremes
- prepare projects for adaptation of threatened ecosystems and species to the changing climate
- possibilities for application or testing of models for climate change impact on biodiversity
- assessment of current status of biodiversity components monitoring and proposal for future activities
- assessment of biodiversity and climate change in socio-economic context of the Republic of Macedonia
- proposal for adaptation measures in the sense of climate extremes
- prepare projects for adaptation of threatened ecosystems and species to the changing climate
- elaboration of action plan for mitigation of climate change effects

METHODS USED IN ANALYSES AND ASSESSMENTS

Data availability and gaps in the knowledge concerning biodiversity and climatology remain the same as for the FNC. This situation restricts the possibility for implementation of currently accepted methods for assessment of climate change impact on biodiversity to only limited approaches. That is the main constraint for detailed and precise assessment, together with ecological and socio-economic uncertainties.

Adopting methodology

There are no new moments and improvement of data availability in the Republic of Macedonia concerning biological distribution data since the last national communication to UNFCCC (FNC). Not much new has been done on the climate parameters as well, except for the few new or improved temperature and precipitation data prepared for this report. They include new data for climate parameters for the period 1925/2000 for some meteorological stations (only 5 stations were elaborated in details in FNC) and elaboration of several new series of climate parameters (temperature and precipitation, including snow) for 1961/1990 and 1971/2000 for all meteorological stations. Particularly important is inclusion of the climate analyses for the XX century of the meteorological stations Ohrid and Lazaropole (Lazaropole is in the mountainous region of the Western Macedonia - 1330 m altitude). For analysis of the climate in subalpine and alpine region, only data from meteorological stations Popova Shapka (1750 m a.s.l.) and Solunska Glava (2540 m a.s.l.) are available. (Data for Solunska Glava were not taken into consideration for elaboration of regional climate scenarios due to the lack of complete data series, which restricts assessments for alpine zone!)

Due to the above reasons, it was not possible to implement more advanced methodology during assessment of climate change impact on biodiversity in Macedonia than the one used for the FNC. Thus, more or less, the same methodology was applied for this report as for the FNC, including species' and ecosystems' assessment.

There are different methods depending on the objects that are studied: species, communities, ecosystems etc. Summary of the methodology approaches is given in Malcolm et al. (1998).

Species. Concerning the climate change impacts on species there are several methods. Dennis (1993) and Millsap et al. (1990) (both from Malcolm et al. 1998) based their methods upon the vulnerability of species. They require data about geographic distribution, biological vulnerability etc. (Malcolm et al. 1998). *Expert judgement* method is the most exploited one. Climate change scenario is assumed and opinion of the experts is formed taking into consideration all the factors that might have influence on the species (changes in vegetation and food resources, human impact, pollution etc.). Other methodological approaches after Malcolm et al. are *climate envelopes and profiles*, *dynamic models, monitoring* and *analogues studies*.

Having in mind the level of the study in Macedonia about various species and published data the most suitable method is one based on the experts' judgement and combined with the method of analogues studies (studies of the changes in the past periods and responses of species).

Communities. There are two approaches for the determination of climate change impact on communities. First one is based on the estimation of the impact on separate species and than combines the predicted results. Second one takes into consideration that not all of the species have equal role and importance in the community. Thus, the main accent is put on the community properties as a whole.

However, because of the limited resources and knowledge, the estimation is performed on the basis of the conservation importance of few species (keystone species, indicator species, umbrella species, flagship species, vulnerable species and economically important species).

The second method of *species assemblages* is more appropriate one for the purposes of this study, but it requires definition of the important species and compilation of lists of these species for the community in consideration. Such data for plant communities in Macedonia generally exist (although definition of important species is more based on the phytocenological than ecological approach - extracting characteristic species from the species combinations and not from their ecological role in the community).

In this report, assessment of vulnerability of communities was done mostly paralelly with ecosystems, and only in some cases communities were treated separately.

Ecosystems. There are three methodological approaches to assess the climate change impact on ecosystems (Malcolm et al. 1998). *Ecosystem screening* is based on the already prepared list of sensitive ecosystems and biomes. *Biome modeling* and *dynamic ecosystem models* are based on the biome (ecosystem in broader sense) changes in distribution and mimics of the system behaviour.

Ecosystem screening is not appropriate approach in our case since it can not be used for all of the ecosystems and biomes present in the Republic of Macedonia. Dynamic ecosystem models require many specific data and difficult calculations. So, the most appropriate method should be the biome modeling approach. Changes of distribution of the ecosystems are expected, as well as shift in horizontal and vertical boundaries of distribution.

Scope of the study

All methods that can be adopted depend on the available data, which are very scarce as it was mentioned before. Having in mind the above-mentioned constraints, more or less the same methodology shall be applied as in the case with FNC. The substantial difference in present communication concerns the scope of the study and assessment. Whereas only two target ecosystems (mountain alpine ecosystems and submediterranean *Quercus coccifera* ecosystem) were treated in the FNC, all important ecosystem types will be treated in this report. The specific position in changing climate conditions and the importance of refugial zones with their relict ecosystems for overall biodiversity in Macedonia was recognized in this report as well. Thus, all such ecosystems will be described and their vulnerability will be assessed (in FNC only two pilot zones were elaborated). The same approach will be used for species. As much as possible important (relict, endemic, sensitive, threatened etc.) species will be included in the assessment.

It is important to note that beside short general description of possibly affected ecosystem or species, its current status or threats was evaluated. This was deemed necessary in order to address all aspects of climate change impact and future behaviour of particular ecosystems or species.

THE IMPACT OF CLIMATE CHANGE ON ECOSYSTEMS

Ecosystems are subject to many pressures, such as land-use changes, deposition of nutrients and pollutants, harvesting, grazing by livestock, introduction of alien species, and natural climate variability. Climate change constitutes an additional pressure that could change or endanger these systems. The impact of climate change on these systems will be influenced by land and water management adaptation and interactions with other pressures.

Climate change reduces stability of ecosystems. New, more competitive floral and faunal species occur, including pests and pathogenic organisms. Transformation of vegetation associations and forests creates new conditions for fauna, particularly for insects, amphibians, reptilians and birds.

The impact of climate change on a particular ecosystem will depend on its location in relation to the climatic requirements of the species it accommodates. Sites that lie near the current maximum temperature limits of particular species could expect that if climate warms beyond those limits, species would become extinct at that site. Conversely, sites that lie close to the minimum temperature limits of species may assume greater importance for such species as the climate warms.

The response of natural ecosystems to climate change is complex and, for the time being, has been insufficiently investigated. Smaller, fragmented and isolated ecosystems, which do not have the genetic potential, required for adaptation and the spatial capacities for relocating to a new location are particularly vulnerable.

In this occasion an attempt will be done to make a detailed assessment, in the frame of available knowledge and data, of the climate change impact on major ecosystem types in Macedonia. (In FNC only thermophilous Kermes oak and alpine grassland ecosystems were assessed.) The reasons for the changes and the basic problems (mainly of an anthropogenic origin) that influence the decreased potential of natural ecosystems for adaptation and shifting of their range will be presented (Tab. 1).

All zonally distributed ecosystems (see FNC for explanation) as well as the most important azonal (extrazonal) ecosystems were analyzed. The refugial communities (except for the ones elaborated in the FNC) will be analyzed separately, considering their sensitivity and significance for biodiversity in Macedonia.

As mentioned before (see chapter on Methods), the constraints concerning the available data still remain and in this occasion (SNC) the precise quantitative assessment of climate change impact on ecosystems and habitats characteristic for Macedonia is not possible for several reasons:

1. Distribution map of the major ecosystem types does not exist (nor a map of biomes). Only the map of potential distribution of the basic climate-vegetational-soil zones (Filipovski et al. 1996) - they correspond to biomes (Matvejev & Puncer 1989) - which does not represent their present distribution. The situation with habitat mapping is even worse (even theoretical and terminological adjustment of habitats in Macedonia with internationally accepted classifications for habitat types: EUNIS, Palearctic Habitats, Habitats from Annex I from EC Habitat Directive etc. does not exist). Mapping of vegetational types (plant communities) has never been considered.
2. The network of meteorological stations is not developed enough in order to serve for precise determination of climate conditions on meso- and microclimatic level, which is the starting point for modeling of the future changes (imprecise input data for the models). Meteorological stations along the altitudinal gradient are almost absent. The time span of existing measurements is very short in most of the stations.
3. Apart from the lack of input data for elaboration and running of models (distribution maps and precise and numerous meteorological data), lack of trained staff is also evident (see NCSA project report).

Mapping of habitats and plant communities is a priority in nature conservation in Macedonia recognized and acknowledged by the scientific community. It has also political support - it is a priority activity set in the National Biodiversity Strategy and Action Plan (2004) - Action D.1.3. Mapping, carrying out cadastre and creation of data bases of landscapes, habitats and protected species is legal obligation as well (among others Article 49 from the Law on Nature Protection, Official Gazette of RM 67/04).

Due to the above-mentioned situation, the current knowledge in the world will be used and the assessment of climate change impact on ecosystems, as well as habitats and species, will be performed through analogy. In that sense, the results from scientific projects and assessments in Mediterranean region (Iberian and Apennines Peninsula and Bulgaria - see quotations above) are particularly useful since the climate conditions in Macedonia are similar. The experience of contributors to this report will be used as well.

In order to get overall impression for the variety of impacts, degree of impacts, reasons and causes for that, consequences and related human induced affections, the analyses are presented in the table below (Tab. 1).

The main types of ecosystems are listed in the first column. Their sensitivity to changes induced by the changing climate and the trend of the change is presented in the second column. Description of the most important climate variables or climate induced variable that causes the sensitivity is in the third column. The fourth column presents the

consequences of the climate induced changes. The fifth column contains additional information and remarks concerning the present human impact on the ecosystems or their status in relation to the ability of the ecosystem (or its species) to adapt or to move along the vertical gradient in order to avoid negative impact of the changing climate.

Tab. 1 The impact of the regional climate changes on the ecosystems in Macedonia

Ecosystems/ biomes	**Sensitivity/ impact**	**Main reason for the sensitivity in relation to climate change**	**Conce-quence**	**Coupled anthropogenic impact**
Xerothermophilo-us ecosystem with Kermes oak	Sensitive/ positive	Temperature	Expansion	Fragmentation, agriculture
Thermophilous ecosystems of Pubescent oak and Oriental hornbeam	Sensitive/ ±positive	Temperature, precipitation, distribution of precipitation	Expansion	Fragmentation, agriculture; exsploitation
Thermophilous forests with Greek juniper	Sensitive/ ±positive	Temperature, precipitation, distribution of precipitation	Expansion	Remains
Riparian forests - Oriental plane, willow, alder, tamaris	Sensitive/ negative	Water level and flow/ irregular floods and dry periods	Restriction/ destruction	Destruction
Steppe-like grassland ecosystems	Sensitive/ ±neutral up to positive	Temperature, precipitation - indirectly / erosion	Expansion - indirectly	Abandonment of agricultural practices
Hill pastures - grassland ecosystems	Sensitive/ ±negative up to neutral	Temperature, preci-pitation, distribution of precipitation - indirectly / erosion	Redistri-bution	Different impacts and abandonment of agricultural practices
Rocky habitats in the river gorges and valleys	Not sensitive ?			
Thermo-mesophilous forest of Italian and Turkey oak	Sensitive/ negative	Temperature, preci-pitation, distribution of precipitation	Restriction	Fragmentation, over-exploitation
Mesophilous Se-ssile oak forests	Sensitive/ negative	Temperature, preci-pitation, distribution of precipitation	Restriction	Over-exploitation
Beech forests - sub-montane and montane	Sensitive/ positive	Temperature, preci-pitation, distribution of precipitation	Expansion	Exploitation, sheep breeding abandonment
Sub-alpine beech	?Sensitive	Temperature	Probalby	

forests	?neutral		expansion	
Sub-alpine Molika pine forests	Sensitive/ positive	Temperature	Expansion	Conservation
Sub-alpinbe spruce forests	Sensitive/ negative	Precipitation, humidity	Reduction of populations	water extraction???
Sub-alpine fir and Scots pine forests	Sensitive/ pozitive or neutral	Temperature	Similar like beech forests	Exploitation
Sub-alpine pastures and pastures on rocky sites	Sensitive/ negative	Temperature/ Precipitation?/ Competition/ Smaller area	Reduction of populations/ Loss of species	Abandonment of traditional sheep farming
Alpine pastures and pastures on rocky sites	Sensitive/ negative	Temperature/ Precipitation?/ Competition/ Loss of area	Reduction of populations/ Loss of species	Abandonment of traditional sheep farming
Alpine rocks and rocky habitats	Sensitive/ negative	Temperature/ Precipitation?/ Loss of area	Reduction of populations/ Loss of species	

The rising temperature is considered to have positive effect on **xero-thermophilous Kermes oak shrublands** (Coccifero-Carpinetum orientalis) that occupies the southernmost submediterranean part of Macedonia, along the lower flow of the river Vardar up to Demir Kapija gorge (see FNC). Dryer climate (more detailed description of the climate expected in different regions in Macedonia according to the regional scenarios prepared for this purpose is given in the Refugial Forest Zones chapter) will not have negative effect on the ecosystem as a whole since it is dominated by the xerophytic community. The expansion of this ecosystem north of Demir Kapija and higher on the hills and mountains (Kozhuf and Serta, Belasica), in the belt of Pubescent oak and Oriental hornbeam, will not correlate with the changes of the temperature due to the high fragmentation of its area. There is an intensive agriculture in this belt (vegetables and vineyards).

The **Pubescent oak and Oriental hornbeam ecosystem** (Querco-Carpinetum orientalis) will suffer significant changes of its distribution - shifting upward (gain of territory) and loss of southern and lower parts of its distribution (conquested by the Kermes oak). It could be assumed that there will be net positive gain due to the aridification of the climate - it will move high up in the Italian and Turkey oak ecosystem belt. But, the distribution of this ecosystem was even more shrinked and it was more degraded and destroyed through the history than the previous one. It is very obscure if the positive gain of territory and phytomass will happen along with the climate changes in the region.

Detailed mapping and complex modeling is necessary to estimate the approximate changes and their directions in both above-mentioned ecosystems.

Azonal **thermophilous forests with Greek and Phoenician junipers** (Juniperetum excelsae-foetidissimae) will undergo positive changes since higher temperature and dry

climate (especially during summer period) are favorable for their biocenoses. They occupy small territories in Macedonia (fragmentation is not of the main importance since they do not have zonal distribution) and certain enlargement of the distribution is certainly expected if no human intervention will happen. It is rather related to the Vardar valley distribution range than in Prespa region or other areas where oak and hornbeam already dominate.

Azonal **riparian forests** are very diverse and important for the overall biodiversity in Macedonia. The most important are those of the type of Oriental plane (Juglando-Platanetum orientalis) and willow (Salicetum albae-fragilis). They can suffer in different ways, but mostly connected to the water flow and water level changes due to the climate perturbances. Specific threat to these ecosystems will be the spring floods (although these ecosystems can tolerate prolongated flooding). An increased temperature conditions on the mountains (according to the scenarios - higher during the spring and summer than during the winter) could cause fast snow melting, which could create large floods that could make mechanical damage to these woodlands. Tamaris shrublands and willow stands with poplar and *Periploca graeca* in the lowermost flow of the river Vardar (from the villages Marvinci - Grchishte - Prdejci - Djavato to Gevgelija) will be the most threatened habitats.

Steppe-like grassland ecosystems are mostly developed on secondary habitats (formerly occupied by the Pubescent oak and Oriental hornbeam or to lesser degree Italian and Turkey oak ecosystems). Real steppe is not characteristic vegetation type for Macedonia. Thus, it could be expected that they will lose some of their distribution range (which is unlikely due to the drop of humidity). However, if current status of the forests in these vegetational zones is considered, this pattern of changes will certainly be different. Lower edges of oak-hornbeam forest should move somewhat upper and Kermes oak will probably not replace them from bellow due to its fragmented range. In that case, hill pastures (dry grasslands) or steppe-like grassland ecosystems could benefit. In the matter of fact, grasslands will have positive net gain during future climate change. Maybe the most important reason for this change has anthropogenic origin - it is evident that agricultural practices in this region are decreasing during last decades and grasslands take over. This is even more valid for the next ecosystem type - hill pastures.

Dry grassland ecosystems (hill pastures) differ from the previous ecosystem type according to their species composition - steppe species can not be found frequently (animal steppe species occupy equally both grassland ecosystems). It means that these ecosystems are even more adapted to the ecological conditions in their habitats than steppe-like ones. This implicates that climate change for them will be even more favorable. Otherwise, they will have similar fate as previous ecosystem type. They currently occupy larger territories but are more fragmented. It is probable that they will have rather positive than negative effect, especially due to the anthropogenic impact (abandonment of agricultural practices).

It is not possible to predict the impact of climate change on the **rocky habitats in the river gorges** (they are important as habitats of numerous important animal species - vultures, reptiles and others). Beside the lack of data on biodiversity, the data from water sector are necessary.

Thermo-mesophilous Italian and Turkey oak ecosystem (Quercetum frainetto-cerris macedonicum) and **mesophilous Sessile oak** (Quercetum petreae and similar communities) ecosystem represent two distinct sub-montane belts on the upper part of

Macedonian valleys. Italian and Turkey oak ecosystem will lose lower part of its range (oak-hornbeam ecosystem will replace it) but will probably extend higher since the retreat of Sessile oak is very likely to happen (together with beech). It should be stressed that Sessile oak ecosystem range is less fragmented. Without proper modeling this is only a speculation. Comparison with similar situations for the time being is not possible. There are no sufficient data in the scientific literature for vertical shift of closely related and subsequent ecosystem types along the vertical gradient in Mediterranean mountains. The data for boreal ecosystems (taiga) (Tchebakova et al. 2001) mostly appertain to plains and are probably not applicable to southern mountains.

Beech forest ecosystems (Festuco heterophyllae-Fagetum and Calamintho grandiflorae-Fagetum) will extend their range toward upper montane and subalpine region in the mountains. It is also possible that they "climb" in the present alpine belt (together with conifers). Not only climate warming is responsible for that, but also decrease and abandonment of traditional sheep farming will favour this process.

Sub-alpine beech forest (Fagetum subalpinum) will tend to move higher in the alpine belt, but the pattern of this shift is burdened with lot of uncertainties (more bare rocks - unsuitable biotope for beech, smaller available surface toward the summits etc.).

Sub-alpine molika-pine forests (Digitali viridiflorae-Pinetum peucis and especially Gentiano luteae-Pinetum peucis) could serve as a classical example for the pattern of the whole vegetation belt movement toward higher elevations. Of course, what is currently happeneing on Pelister Mt. can not be attributed to climate change (or not entirely), but to the anthropogenic factor (good conservation practices in the National Park "Pelister" and abandonment of sheep breeding in the region). Good conservation practice does not concerns the lower border of these forests - serious mistakes were done there, which resulted in spreading of molika-pine downwards along with other invasive species like *Pseudotsuga mentzesii*. Anyway, in the case of the molika-pine on Pelister, one could directly see how the subalpine ecosystems will move toward alpine region. The effect of climate change for molika-pine ecosystem obviously should be positive. However, if it retreats from its lower border upwards (its territory would be conquested by the sessile oak or beech), than the molika-pine ecosystem will undergo large losses of phytomass and surface since no matter how high it will "climb", the available surface of the Pelister peak is small (cone). A positive result is expected anyway, because the spreading of the forest could happen also in horizontal direction (if the biocorridors will be safeguarded). This is of course possible, since it is well known that historically molika-pine has had much larger range in Macedonia (Nidze, Galichica, Jablanica, and Shar Planina). The example for molika-pine succesfull natural re-collonisation during the last 30-40 years is relevant in this respect (see: Refugial Zone Pelister).

Sub-alpine spruce forests (Piceetum scardicum) are suffering desiccation and visible decline in the south edge of their distribution range (Adzhina Reka). There are no sufficient data about their status on northern parts of Shar Planina Mt. This is maybe the most striking example of climate change impact on forest community and its health. In this case the temperature is probably not decisive factor, but the humidity (decreasing humidity) (unlike molika pine - favorable temperature impact). However, it is not possible to attribute spruce decline only to climate change. Human intervention (water extraction for Mavrovo system), i.e. complete drying of the river could also be a reason

for decrease of humidity in this southernmost part of the spruce areal in Europe, which is anyway dryer than Central and North European habitats.

Sub-alpine Balkan fir (Fago-Abietetum meridionale) and **Scots Pine ecosystems** (Fago-Pinetum silvestris) in climate change conditions will most probably behave similarly to beech ecosystems.

Sub-alpine pastures and pastures on rocky ground - already discussed in FNC.

Alpine grasslands - alpine pastures and pastures on rocky ground as well as **alpine rocky habitats and bare rocks**, screes and similar habitats will be the most endangered. Large portion of species loss is expected due to the shift of this climate belt probably above the highest summits on Macedonian mountains and consequently loss of habitats (except maybe for the northern expositions).

Obviously, there will be a net gain of forest ecosystems' range in Macedonia. One could expect that it will act as positive carbon sink and will contribute to abatement strategies for climate change mitigation. However, we should accept this conclusion with reserves. There are a lot of uncertainties and gaps in the knowledge in this field in Macedonia. Only phytomass in Italian and Turkey oak and beech ecosystems can be estimated sufficiently correct. For other ecosystems only input data from north Europe can be used. Replacement of high productive oak and beech ecosystems with low productive oak-hornbeam and Kermes oak ecosystems will probably act as net carbon loss.

Biocorridors

It is obvious from the above analysis that changes in the distribution of ecosystems (and species with them), redistribution of vegetation belts, movements and migrations of a very large scale will happen in Macedonia during the next 100 years (5^{o}C increased temperature and about 20% decreased precipitation are enormous changes of the climate). Present status of habitat fragmentation, especially in the lower belts (oak forests), suggests that these movements and migrations will be significantly hampered or in many cases impossible. It is clear that if we intend to preserve the biodiversity to the extend maximum possible in the climate changing conditions, the human has to intervene:

- to regulate the development of the infrastructure and agriculture taking into consideration the threats from climate change
- to preserve current vital parts of ecosystems as a source of healthy species populations which could survive the changes
- to restore particular areas which could serve for migration of species and movement of communities
- to change the way and methodology of the spatial planning and to commence full implementation of what already exist at least (the new Spatial Plan of the Republic of Macedonia)
- and many other measures related to definition and establishment of biocorridors' network designed in a way to enable at least minimum free movement and migration of communities and plant species, as well as animal migration.

Present knowledge about the level of degradation and fragmentation of natural ecosystems in Macedonia are very scarce and insufficient. There is no land use map in acceptable scale. This suggests that it would be difficult to define the corridors which could be used by organisms for migration or movement. The project of the Ministry of Environment and Physical Planning (together with many other institutions from the region of South-East Europe and Turkey) on the shape of the ecological network in Macedonia is only a preliminary (indicative) and the scale of the produced map is that small that Macedonia is barely visible. Only the corridors on eastern mountains (Maleshevo-Osogovo) and Shar Planina Mt. were pointed out.
It is clear that the assessment of fragmentation degree of the ecosystems in Macedonia and establishment of biocorridors is one of the main adaptation measures that can be suggested in this study for mitigation of the consequences of climate change impact on biodiversity.

IMPACT OF THE WATER EXTRACTION IN THE MOUNTAINOUS REGIONS ON THE BIODIVERSITY OF THE AQUATIC/WETLAND ECOSYSTEMS FROM THE ASPECT OF CLIMATE CHANGES

The water extraction for the purposes of water supply, hydromelioration, hydroenergetic capacities etc. are present on the large part of the territory of the Republic of Macedonia. Parts of several river gorges (Treska, Crna Reka, Bregalnica, Crn Drim, Radika, Doshnica and others) are already flooded and their ecological features are completely changed. Large land surfaces with important flora and vegetation as well as the habitats of important animal species are under water. The significant water potential of the gorges and specific morphology were the preconditions for their use and sacrifice for the purposes of economy and development goals of the state. However, the degradation and destruction of many relict and endemic communities, plant and animal species accompanied this process.

The water extraction in the higher mountain parts (above 1000 m a.s.l.) and often above timberline represent additional problem. This is the case with some rivers on several Macedonian mountains such as: Shar Planina - system Sharski Vodi (Pirochka Reka, Matene, Jelovjanska Reka, Vrutochka Reka, Adzhina Reka, Radika, Mavrovska Reka), Pena; Bistra - Studenchica, Belichka Reka; Korab; Jablanica - Podgorechko Ezero, Labunishki Ezera; Pelister - hydrosystem Strezhevo (Crvena Reka, Sapundzhica, Rotinska Reka, Magarevska Reka, Caparska Reka), Brajchinska Reka, Kranska Reka; Nidzhe; Kozhuf - Boshava (Lukar); Jakupica; Belasica; Osogovski Planini - the spring of Durachka Reka (below Sultan Tepe up to Vlashki Kolibi, water supply system for Kriva Palanka), Zletovska Reka etc.

Special attention in this report was dedicated to the water systems above 1000 m a.s.l. because of their adverse impact on biodiversity, which is common for all water systems. Moreover, the adverse impact of these systems can be amplified by the influence of climate change. According to regional climate scenarios prepared for the purpose of SNC, rise of temperature in the mountain regions will be about 5^{o}C for the next 100 years. The decrease of precipitation will not be drastic like in lowland south parts of Macedonia, but together with temperature increase, summer decrease of rainfalls will severely affect glacial lakes, bogs and peat bogs, springs and mountain streams and

especially temporal water bodies. (See: climate scenarios for Lazaropole and Popova Shapka). Additional water extraction practices in this zone will only worse the situation. Unfortunately, more complex and precise assessment can not be done due to the lack of predictions for snow cover and melting periods.

Water systems have significant impact on the ecological conditions of the mountainous regions. Combined with the global climate changes, which occur in the wider area, water systems can threaten and even exterminate the mountainous wetlands, including springs and peat bogs. In the past period we have witnessed their desiccation on large surfaces. This process led to the destruction or degradation of the habitats for some species (*Ranunculus degenii* on Shar Planina Mt., *Silene pusilla*, *Sphagnum*-species on Shar Planina, Osogovo Mt., and Jablanica Mt.). The slow succession of mountainous marshy vegetation towards the pasturelands (mountainous pastures and mountainous meadows) is evident.

The impact of the water extraction can be explained by the case of the water supply system of Kriva Palanka in the watershed of Stanechka Reka (=Durachka Reka). This river is formed of several spring areas (characteristic of the springs on silicate mountains) on the western slopes of the Osogovo Mt., in the bases of the peaks Sultan Tepe and Kalin Kamen.

According to the project of the water supply enterprise from Kriva Palanka, it is planed to extract 100 $l \cdot s^{-1}$ from Stanechka Reka in two phases (50 $l \cdot s^{-1}$ in the first phase and 50 $l \cdot s^{-1}$ in the second phase). The impact on the river ecosystem can be illustrated by the data of the waterflow of Stanechka Reka, as an average for 10 years (Tab. 2). The measurement point is situated at 1000 m a.s.l., 7.4 km from the inflow into Kriva Reka and 6.8 km from the spring. The total surface of the watershed is 14.2 km^2.

The average flow during the last 10 years was 442 $l \cdot s^{-1}$ with oscillations from 77 to 6.580 $l \cdot s^{-1}$.

Tab. 2 Water flow of Stanechka Reka (10 years average - 1975/76-1984/85) ($l \cdot s^{-1}$)

Months	**X**	**XI**	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**
Monthly wateflow	**279**	**401**	**338**	**206**	**225**	**329**	**711**	**1114**	**634**	**444**	**368**	**249**
Monthly absolute minimum	**108**	**101**	**86**	**77**	**91**	**102**	**321**	**294**	**200**	**156**	**134**	**82**

(Source: Hydrometeorological Institute - Skopje).

It is obvious that the planed extraction in the autumn and winter months will exceed the total water flow of the river. In such cases the river will be left without water. This problem is proposed to be solved by the construction of damn and accumulation of 800 000 m^3 of water.

However, these water exploitation systems may be less harmful than the existing practises. At the present moment, Kriva Palanka is supplied with water by the pipeline from the source area of Stanechka Reka. Thus, parts of the source area are destroyed together with the bog area (habitat that is very rare in Macedonia). The final consequence is that the climate change in synergy with the irrational and unreasonable water use will cause degradation and complete destruction of these important habitats.

The case of Adzhina Reka and Shtirovichka Reka is even more severe. These rivers are included in the hydrosystem "Sharski vodi" and they were main tributaries of Radika River. Water extraction system is constructed only few meters after the inflow of stream Kaf Kadis into Adzhina Reka. This system collects almost all of the water of these streams (for the purposes of the hydropower plant "Vrben"). Only during the highest water levels (snowmelt) small amount of water can spill over the shaft.

In the period after World War II, i.e. the period of fast reconstruction of the country, the destruction of important natural objects/ecosystems was not considered as an important issue in Macedonia!? Mixing of waters from Adriatic and Aegean watersheds is additional problem in this case.

Another negative example of human intervention is the water extraction at the locality Lukar on river Boshava (1000 m a.s.l.). The waters from one watershed are transferred into another one (from watershed of Boshava river to the watershed of river Luda Mara). These interventions cause disturbance not only in the frames of the ecosystem, but on the landscape level and different watersheds, as well. Hence, the climate change will impact not only one, but two water ecosystems.

The threatened fauna in the high mountain belt

The highest negative impact of climate change will be posed to the relict-endemic fauna from the high-mountain springs and bogs (including peat bogs), glacial lakes as well as to Arctic-Alpine faunistic elements, which have southern border of their range at the high-mountain belt in Macedonian mountains.

Mountain streams: Highly sensitive on water abstraction and climate change in the mountain streams are: Macedonian Stream Crayfish - *Austropotamobius torrentium macedonicus*, Ohrid Stream Trout - *Salmo lumi*, Pelagonian Trout - *Salmo pelagonicus*, Pelister Trout - *Salmo peristericus*, Otter - *Lutra lutra*.

Mountain springs and bogs: relict-endemic taxa of amphipod crustaceans *Bogidiella albertimagna glacialis* and *Niphargus pancici jakupicae* on Jakupica Mt., *Niphargus tauri osogovensis* on the mountain Osogovski Planini; arctic-alpine harpacticoid crustaceans *Arcticocamptus abnobensis* on Jakupica and *Hypocamptus brehmi* on Bistra Mt.; arctic-alpine archaic populations of the ostracod speces *Psychrodromus olivaceus* from Shar Planina, Jakupica and Nidze and *Psychrodromus fontinalis* from Jakupica. These two species are represent throughout their whole range exclusively with parthenogenetic populations. Only on Macedonian mountains bisexual populations were found. The species *Psychrodromus peristericus* is local endemic, restricted in the springs and bogs on the Pelister Mt.

Mountain glacial lakes and temporal waters: the amphipod crustacean *Niphargus pancici peristericus* is distributed only in the glacial lake Golemo Ezero (Big Lake) on Pelister; the Feary shrimp *Branchipus intermedius*, relict mountain species described from high-mountain temporary pools on the Carpathian Mountains, has disapeard more than 50 years ago. The only recent site where this speceis still exist is Toni Voda on the mountain Bistra (temporary pools). Its close relative, the species *Branchipus blanchardi* could be found only on the Franch Alps; arctic-alpine cladoceran species *Alona intermedia* from glacial lakes on Pelister and Shar Planina and *Alona elegans* restricted only to the glacial lakes on Shar Planina; relict palaeo-Balkan oreal calanoid species *Mixodiaptomus tatricus* from glacial lakes and temporary waters of Shar Planina, Jakupica and Jablanica and *Eudiaptomus hadzici* from glacial lakes on Jablanica; *Arctodiaptomus niethammeri* and *Arctodiaptomus osmanus* which represent extremly

rare Caucasian oreal (mountain) elements are distributed in glacial lakes and temporary waters on Pelister and Galichica; relict-endemic harpacticoid species *Arctococamptus macedonicus* is restricted in glacial lakes and temporary waters on Pelister, Shar Planina and Jakupica and ostracod species *Heterocypris erikae* from temporary wates on Galichica; the ostracod species *Eucypris heinrichi* was described as fossile species from Germany, but viable populations of this species develop on the locality Toni Voda on Bistra.

Obviously, biodiversity value of mountain wetland ecosystems is irrefutable. Thus, the negative human impact should be minimized in order to mitigate climate change impact and to help preservation of wetland ecosystems in the mountains, which are anyway the most threatened zones (see Chapter on species). This is especially true for glacial lakes. Although they posses irrefutable landscape and geographical values (beside biodiversity), although they have minimum water reserves, they are used by the people. Such example is Podgorechko Ezero and two lakes above the village Labunishte on Jablanica Mt. This situation is additionally accelerating succession changes of the lakes provoked by the climate change.

CLIMATE CHANGE IMPACT ON SPECIES

Similar reasons as for the ecosystems, limit the possibility for assessment of climate change impact on species in Macedonia. Among others, these are:

- there are no precise distribution maps for rare, endemic and relict plant, animal and fungal species
- the data about population density and abundance of separate sepcies are eve scarcer.

There is a broad agreement among the scientific community that past climatic changes have had strong impact on the distribution ranges of species, and the same can be expected in the future. Evidence from past climate changes, indicates that species respond by migrating rather than by adapting genetically.

The rate of species extinction depends on the speed of climate warming and rate of spreading of these species, which differs greatly between species. These processes are not sufficiently investigated in Macedonia, but they have been already traced. The process of extinction of species also depends of the population size. The species with naturally smaller distribution range (endemic species), or with distribution range reduced by human activities (melioration, destruction of habitats) which recently have been taking place in Macedonia, and other factors, will be the first to disappear.

Adult animals and plants, especially those of higher organized taxonomic groups, have the ability to lessen the effect of global heating by physiological mechanisms (behavior, thermoregulation, hibernation and aestivation, temperature compensation, etc.). Although these mechanisms increase the resistance substantially, they cannot eliminate the secondary effects on ecology of species, particularly the mechanisms connected with breeding at animals. In ecological sense, global heating may as a result have decrease in the number of species in natural habitats, and the effect on their spatial and temporal distribution. Especially affected will probably be the endemic fauna of small wetlands (glacial lakes, mountain streams - see chapter above). With moving of climate zones one can expect the disturbance of unknown physiological and ecological condition necessary for surviving of individual stenoendemic taxa.

To understand the connection between population biology of Vertebrates and climatology, the data is still insufficient.

Amphibians may be especially susceptible to climate change because they have moist, permeable skin and eggs and often use more than one habitat type and food type in their lifetimes. Species that inhabit high-altitude areas (Alpine Newt - *Triturus alpestris* and Common Frog - *Rana temporaria*) may be at particular risk from climate change because as temperatures increase, their habitats may disappear.

The most vulnerable reptilian species to climate change will be the Northern European species which most-southern borders of their range is restricted on the high mountain zone in Macedonia such as: Sand Lizard - *Lacerta agilis*, Viviparous Lizard - *Lacerta vivipara*, Adder - *Vipera berus* as well as Orsini's Viper - *Vipera ursinii* which distribution on the Balkans is disjunctive and restricted on the dry pastures within the alpine zone.

Changes in mammal abundance can occur through changes in food resources caused by climate-linked changes or changes in exposure to disease vectors.

The assessment of the global climate change impact (regardless the scenario) on the vegetation, flora and fauna in this phase can be based only on subjective expert judgment including the analysis of historical and recent data. Having in mind that there is no biodiversity monitoring system in Republic of Macedonia (with the exception of natural lakes) it can be assumed that the impacts will result in:

- expansion of the thermophilous (Mediterranean and sub-Mediterranean) flora and vegetation from the southern to the central and northern parts of Macedonia and
- shift of the forest belts towards higher altitudes.

The analyses of the distributional data for some Mediterranean and sub-Mediterranean species should be performed by caution since the available data are incomplete and unreliable (e.g. the Mediterranean species *Phyllirea media* was discovered in the Treska gorge just recently, but it does not mean that the range of this species was shifted because of the climate change; maybe this species was present at the locality in the last 200 years, but not recorded).

It is most probable that the global climate change impact is combined with many other factors (mostly anthropogenic - the construction of roads, railways, hydrosystems, power lines, antennae, industrial objects, expansion and abandonment of the agricultural lands, water extraction systems, uncontrolled forest exploitation) and modify the species distribution. Other ecological factors, especially competition can have significant influence, as well. The combination of these factors can cause extinction of some species:

- *Gentiana pneumonanthe* (flooding of the Mavrovo valley),
- *Acorus calamus* (Struga: Crn Drim - lowering of the river water level in order to achieve melioration of the Struga swamp),
- The plant species *Allium maritimum* and the ostracod *Mixodiaptomus incrassatus* (Ovche Pole - desiccation of the marshes),
- *Sagittaria sagittifolia* (Bitola: village Novaci - desiccation of the marshes).
- *Salmo marmoratus* and *Salmo dentax* (Crn Drim - construction of dams Globochica and Shpilje, cut of spawning natural corridor),
- ostracode *Limnocythere diebeli* (drainage of the Katlanovo marsh),
- ostracode *Heterocypris gevgelica* (Negorci marsh).

There are many other vulnerable plant and animal species in the lowland areas up to the high mountain belts (see lists bellow). Fairy shrimps *Chirocephalus pelagonicus* and *Tanymastix motasi* are striking example of critically endangered species (the only localities are wetland ecosystems in upper Pelagonija valley). Their habitat is endangered not only from climate change, but from anthropogenic pressure as well, despite the fact they are protected - strict natural reserve. However, the influence of changes in subalpine and alpine region can be considered as the most important.

Flora:

Lowland belt: *Thymus oehmianus, Ramonda nathaliae, Ramonda serbica, Adianthum capillus-veneris*, *Drosera rotundifolia, Blackstonia perfoliata, Cladium mariscus, Carex elata, Marsilea quadrifolia, Salvinia natans,*

Mountain belt. The increase of temperatures (about 5^{o}C, according to the average regional climate scenario) will lead to shorter snow pack lasting on the mountains, which are without typical alpine belt (bellow 2300 m a.s.l. - Galichica, Bistra, Jablanica and others). Changed ecological conditions in sub-alpine region, will affect the species that grow around the melting snow patches. Such species are Macedonian high mountain local endemic floristic species: - *Crocus cvijici* (Galichica), *Colchicum pieperianum* (Bistra), *Fritillaria macedonica* (Jablanica) and others: *Ranunculus degenii, Saxifraga stellaris* subsp*. alpigena, Sphagnum spp., Crocus scardicus, Crocus pelistericus, Trollius europaeus, Salix retusa, Salix reticulata, Salix herbacea, Salix alpine, Rhododendron myrthifolium, Rhododendron ferrugineum, Empetrum nigrum, Loiseleuria procumbens, Dryas octopetala, Listera cordata* (due to the spruce forest decline and dye back).

Fauna:

Lowland belt: Twaite Shad (*Alosa fallax*), Drim Lamprey (*Eudontomyzon stankokaramani*)**,** (salmon species were mentioned above), *Chirocephalus pelagonicus* and *Tanymastix motasi* (already mentioned in "Species" chapter).

Mountain belt: High Mountain Palaeobalkan relict and endemic species: Mammals: Balkan Chamois - *Rupicapra rupicapra balcanica*, Balkan Snow Wole - *Dinaromis bogdanovi*, Macedonian Souslik - *Spermophilus citellus karamani*, Balkan Mole - *Talpa stankovici* (the most threatened will be: *Dynaromis bogdanovi, Rupicapra rupicapra balcanica*). Invertebrates: the most threatened will be taxonomic groups with relict and endemic species and arctic-alpine species in high-mountain belt: arthropods (7,574 recorded species in Macedonia out of which 419 are endemic) - Daddy longlegs (Opiliones), Spiders (Aranea), Millipedes (Diplopoda), from the insects, especially the orders of Grasshoppers (Orthoptera), Beetles (Coleoptera) with the families of Ground beetles (Carabidae) and the Weevils (Curculionidae) and the order of Moths and Butterflies (Lepidoptera). Vertebrates: Common Frog (*Rana temporaria*), Alpine Newt (*Triturus alpestris*), Sand Lizard (*Lacerta agilis*), Viviparous Lizard (*Lacerta vivipara*), Adder (*Vipera berus*), Orsini's Viper (*Vipera ursinii*), Rock/Water Pipit (*Anthus spinoleta*), Snow finch (*Montifringila nivalis*), Wall creeper (*Tichodroma muraria*), Alpine Dunnock (*Prunella collaris*), Alpine Chough (*Pyrrocorax graculus*), Red-billed Chough (*Pyrrocorax pyrrocorax*), Shore Lark (*Eremophila alpestris*), European souslik (*Spermophilus citellus karamani*) and Balkan chamois (*Rupicapra rupicapra balcanica*).

Mediterranean and sub-mediterranean species: Data that show the trends of recent average temperatures and precipitation sums in the lowland parts of Macedonia (see: regional climate scenarios) suggests that conditions for development and spreading of thermophilous vegetation (both forest and grassland) are being established and are still

undergoing or will happen in the coming period. One could expect the extension of the ranges of many Mediterranean and sub-mediterranean plant species in south-north direction (on the mountains as well). Parallely, other species that were not known for Macedonian territory could come from south (Greece). This trend is confirmed with the most recent phytogeographical data and could be illustrated with many examples - Mediterranean species formerly known only from the southernmost parts of Macedonia (the regions of Gevgelija, Dojran, Strumica) were registered recently more to the north along the river Vardar valley and its tributaries - *Corynephorus divaricatus* (Crna Reka), *Phyllirea latifolia* (Treska), *Convolvulus elegantissimus* (Treska).
Concerning the climate change impact on different faunal species, see: chapter on Refugial Zone - Dolnovardarska.

Steppe species that extends their range toward north: The distribution of the most of the steppe species is restricted in central part of Macedonia, in so called "steppe-like" area (between Veles, Shtip and Negotino). Some of these species are extending their range toward north - *Morina persica* (north to Kratovo region), *Onobrychis hypargyrea* (Katlanovo), *and Capparis sicula* (Veles).

Concerning the climate change impact on different faunal species, see: chapter on Refugial Zone - Tikvesh.

It can be concluded that species distributed in the mountains will be the most threatened by the climate change.

CLIMATE CHANGE IMPACT ON THE WETLAND VEGETATION AND FAUNA IN THE NATURAL LAKES AND THEIR SURROUNDING

The organisms in aquatic ecosystems are adapted to temperature conditions. Oxygen content in water, cycles of development and conditions of nutrition of fish, crustaceans depend on temperature.

The impact of climate change on wetlands and water basins is manifold. It affects aquatic and wetland organisms. Water is warming; ice-free periods and duration of temperature stratification become longer because the temperature increases in the lakes. In rivers, water becomes warmer, too. Annual and seasonal water flow and hydrological cycle are changing. Substantially larger influence of temperature increase is observed on the littoral and shallow water basins, wetlands. The impact of climate change is very important in wetlands. They may dry up, which accelerates succession and may lead to a change of flora and fauna.

When limnological parameters are changing, so do the ecosystem and the structure of fish communities, usually undergo a regressive succession. The number of species in the communities decreases, and the communities shift towards later successive stages, as the area and the depth of water bodies, relative permeability and limpidity of water, as well as its cold layer at the bottom decrease, while the parameters related with eutrophication and aging of water bodies become more expressed.

Balkan lakes are of varied origins. The largest lake, Ohrid, is outstanding being a steep-sided graben formed through rifting in a similar fashion to Lakes Tanganyika and Malawi in the East African Rift system, or Lake Baikal. Most other lakes, including Prespa, are product of karstic processes and, thus, are a type of lake particularly well represented in the Balkans compared to many other parts of Europe (Reed et al., 2004).

The diversity of taxa in ancient lake environments has also been linked to long-term environmental stability. Levels of endemism for Lake Ohrid are unique and comparable exclusively to other ancient lakes outside Europe such as in the East African Rift Valley, or Lake Baikal (Korniushin, 2004). The lakes of Ohrid with 216 and Prespa with 24 are unusual in the high number of endemic faunal species and involve many diverse taxonomic groups. Existing continuously for millions of years, such lakes are distinguished by their rich and unique faunas and undoubtedly constitute “hot spots” of biodiversity (Illies, 1978; Petkovski, 2003).

Unfortunately, along with those in other circum-Mediterranean countries, many Macedonian wetlands and the three natural lakes of Ohrid, Prespa and Dojran, nevertheless that are within the system of protected areas as Natural Monuments, are under increasing pressure-through anthropogenic impacts (water abstraction, pollution, fisheries) coupled with the possibly increasing effects of climate aridity (cf. Chergui et al., 1999; Elhance, 1999).

The periodical natural hydrologic fluctuations, combined with the induced ones, represent frequent phenomenon in the natural lakes in the Republic of Macedonia. In the last 20 years it was recorded at Dojran and Prespa lakes. These fluctuations combined with the global climate change have adverse impacts especially on the swampy and flotant vegetation near the lake shores. (More detailed prediction about the status of natural lakes in Macedonia in climate change conditions, including water level fluctuation and other parameters, will be elaborated for this communication - SNC - in "water sector.) These impacts are amplified by the intensified human influence in the coastal belt for the purposes of the tourism and recreation (construction of beaches, promenades). The final result is the destruction of large areas of coastal vegetation (reed beds), which are considered as "unwelcome" vegetation.

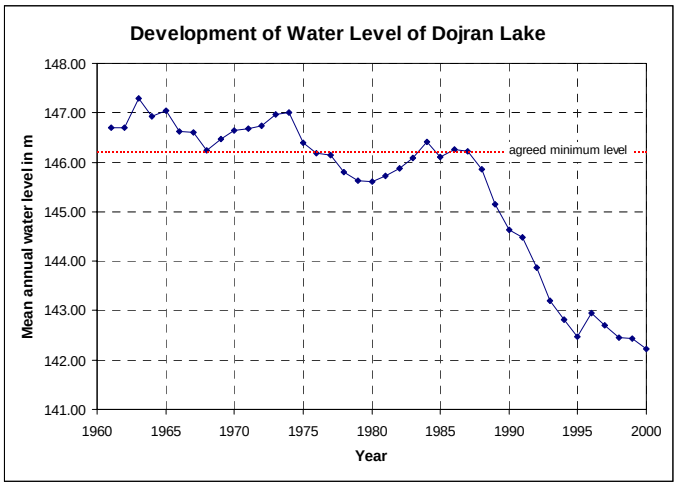

Fig. 1 Water level fluctuations within Lake Doiran (1961-2000).

Dojran Lake

The impact of the climate change on the natural lakes in the Republic of Macedonia can be illustrated by the example of Dojran Lake. During the last 15 years (up to 2000) the lake suffered significant loss of water (Fig. 1). The anthropogenic influence and already documented climate change on the Balkans regarding the precipitation are the underlying causes for the drop of water level.

Lake Dojran that straddles the border of Greece and Macedonia is the smallest natural lake in Macedonia. Despite this, Lake Dojran has been the focus of certain amount of research interest because: (1) the lake was an important inland waters fishery, with the highest yield reported in Europe (178.4 kg/ha/year; Naumovski, 1991), (2) the lake was formerly an important center for lake-based tourism, (3) the Dojran Basin is one of the most arid parts of Europe, so the lake represents a significant hydrological resource

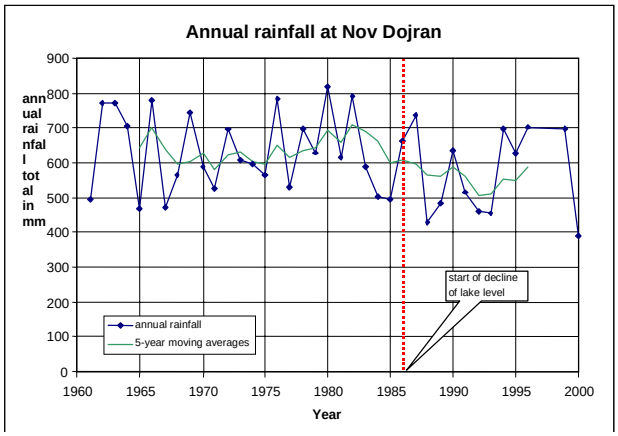

Fig. 2 Annual precipitation at Nov Doiran during the period 1961-2000

for surrounding settlements and agriculture and, finally, (4) because of the biological diversity of the lake.

Ecological problems include not only a major decrease in water level through water abstraction and the diversion of source waters for agricultural purposes, but also recent climatic aridity (Fig. 2). There has been a great deal of recent discussion over the status of Lake Dojran, most of which has focused on the apparent "ecological disaster" at the lake, including reputed loss of fish stocks as a direct consequence and the closure of holidays "beach resorts". The most visible aspects of this have been shoreline recession and damage to the shallow littoral zone and plant communities associated with it.

The status of much of the endemic life remains problematic. At present there appear to be good prima facie grounds for the international protection of Lake Dojran, as the site is both significant for wetland and migratory birds, and has inherent biodiversity value. The formal listing of Lake Dojran would also provide a firmer basis for arguing for stricter management policies and site regulation. It is fundamental that any attempt to improve the status of the lake will require bilateral agreement between Greece and Macedonia on issues such as nutrient input, diversion of feeder streams and, most especially, the pumping of lake source waters for irrigation (Griffiths et al., 2002).

Impact on flora and fauna. The status of Dojran Lake is the most alarming. Since 1988, the level of the water surface has drastically fallen, contributing to a decrease in water depth and a recession of the shore line, accompanied by a complete loss of the littoral zone and its related biological communities. Accelerated eutrophication has led to intensive sedimentation and a dramatic reduction in the epibenthic communities, as well as serious changes in the structure of the Algal microflora. These changes have particularly affected the Common reed (*Phragmites australis*) zone and other aquatic macrophytic vegetation (ass. *Myriophyllo-Nuphraetum* is completely extinct). Endangered plant species are: *Nuphar lutea, Nymphaea alba, and Salvinia natans*. The zooplankton community, under the influence of these changes, has lost its limnetic character. Until 1988, 94 zooplankton taxa were present in the open waters of the littoral and pelagic zones, whereas the recent status of this community shows a reduction to only 28 taxa. Comparative population density analyses indicate that the abundance of the zooplankton community within the pelagic complex is one seventh its former level, and that of the littoral complex one tenth of its previous numbers.

The most appropriate biological indicators of freshwater ecosystem succession are variations in lake-bottom fauna, which take place over the course of time. Within Lake Dojran, the fauna has undergone dramatic shifts. Such changes include drastic reductions in the abundance of oligochaetes, from 2,000 to 202 individuals/m^2, and of Chironomidae larvae, from 2,000 to 200 individuals/m^2. Although currently severely

disturbed, the benthic community likely still has enough genetic potential to completely restore itself.

The annual fish catch, which in optimal conditions used to be as much as 529 tones. In the past few years it has been reduced to 70 tones, dropping to only 25 tones in 2002. The fish species: Dojran Loach - *Sabanejewia doiranica*, Macedonian Roach- *Pachychilon macedonicum* and Freshwater Blenny - *Salaria fluviatilis* are IUCN Globally Threatened Species.

The accelerated succession of this lake ecosystem is evidenced by the appearance of the Calanoid copepod (*Eudiaptomus gracilis*), a typical representative of marsh ecosystems, which was recorded in Dojran Lake for the first time in 1995. In order to restore the disturbed environmental balance, efforts have been made (2001) to bring additional quantities of water to the lake, which is expected to improve the state of the biological communities within the lake ecosystem.

Prespa Lake

Decrease of the water level of Prespa Lake is also good example of how climate change induced water loss can harm biodiversity of both the lake and surrounding wetland areas, since it happened very recently and one could follow the changes.

Denivelation of Macro Prespa Lake has reached the value of 7.29 m in the period from 1963 to 1995 due to the natural and anthropogenic factors. According to measurements and calculations, natural factors caused denivelation of 4.50 m and anthropogenic impact 3.29 m (Chavkalovski 1997). Obviously, the drop of the water level in the lake is more natural consequence than anthropogenic. The highest and the most rapid water loss have happened during the prolongated drought from 1984 to 1995. However, it is not possible to attribute this event to climate change since this kind of fluctuations is known for Prespa Lake. Although during the last decade there were several very favorable hydrological years, the water level is recovering very slowly (not more than one meter rise).

Due to the drop of the water level, most of the wetlands have dried up - Stenje marsh, Ezerani (which is strict natural reserve) etc. Human factor was also to be blamed for this.

The permanent reduction of the water level of Prespa Lake over the years has adversely affected the state of the floating vegetation and faunal communities in the littoral zone of the lake. The presence of large quantities of organic silt on the lake bottom and phosphorous input are accelerating the process of eutrophication, which manifests itself with the appearance of phytoplankton blooms during the summer period. Of the floating macrophytic vegetation, the most significant is the ass. *Lemno-Spirodelletum polyrhizae* subass. *aldrovandetosum*, which develops only within the inshore areas of Prespa Lake (near Dolno Perovo village) and is directly endangered by the lowering of the water level. The community is now considered to be extinct. Endangered plant species are: *Aldrovanda vesiculosaa, Salvinia natans* and *Trapa natans.*

Of the total number of faunal endemic species (24), the most threatened are fishes. The endemic species, restricted to the Lake Prespa watershed: Pelister Trout - *Salmo peristericus*, Prespa Loach - *Cobitis meridionalis*, Prespa Bleak - *Alburnus belvica*, Prespa Barbel - *Barbus prespensis*, Prespa Nase - *Chondrostoma prespense*, Prespa Minnow - *Phoxinellus prespensis,* Prespa Roach - *Rutilus prespensis* are recognized as IUCN Globally Threatened species. Among the endemic species of fishes, the Prespa

Bleak - *Alburnus belvica* is the most caught; nevertheless, its population is remaining stable. Due to uncontrolled fishing, the Carp (*Cyprinus carpio*) is the most endangered species in Prespa Lake and, according to IUCN, it is included on the list of species being Critically Endangered (CR).

Ohrid Lake

As a result of the water level fluctuations, only fragments of the floating macrophytic vegetation can be seen. However, negative consequences for biodiversity in the lake and surrounding wetlands had anthropogenic origin. The fact that Ohrid Lake did not change significantly its water level like Prespa and Dojran lakes during the prolongated draught period in eighties is a confirmation for that. On the contrary, wetlands were drained or destroyed by men for construction of settlements and tourist facilities.

Endangered communities: ass. *Caricetum elatae* subass*. lysymachietosum*

Endangered plant species: *Carex elata, Senecio paludosus, Ranunculus lingua*.

From a faunal standpoint, Ohrid Lake, with its 216 relict-endemic taxa, is the richest and most important freshwater center of endemism in Europe. As is the case with the other relict lakes, the process of intra-lacustrine speciation is also highly expressed in Ohrid Lake, especially within the taxonomic groups of Gastropoda, Oligochaeta, Ostracoda, Plathelmintes and Porifera. The degree of threats to invertebrate fauna is still insufficiently studied. With regard to vertebrates, seven endemic Ohrid fish species: Ohrid Minnow - *Phoxinellus epiroticus*, Ohrid Roach - *Rutilus ohridanus*, Drim Trout - *Salmo aphelios*, Ohrid Stream Trout - *Salmo lumi*, Ohrid Salmon - *Acantholingua ohridana*, Struga Trout - *Salmo balcanicus*, Ohrid Trout - *Salmo letnica* are recognised as IUCN Globally Threatened Species. The two trout species (Struga Trout - *Salmo balcanicus* and Ohrid Trout - *Salmo letnica*) are particularly caught for food, so their populations are continuously being reduced.

CLIMATE CHANGE IMPACT ON THE REFUGIAL ZONES

First Communication of Macedonia for the UNFCCC paid special attention to the refugial forest zones. According to Em et al. (1985) there are 11 refugial regions in the Republic of Macedonia.

A. Dolno Povardarie-Valandovo-Strumica-Dojran refugial region
B. Refugial region Tikvesh
C. Refugial region of the gorge Taorska Klisura on Vardar river including the gorge of river Pchinja
D. Refugial region in the gorge of Treska river (Poreche)
E. Refugial region of Crna Reka including the gorges of rivers Raec and Blashnica
F. Refugijal region Jama
G. Refugial region Mavrovo-Radika
H. Refugial region Strazha
I. Refugial region Pelister
J. Ohrid-Prespa refugial region
K. Refugial region Nidzhe-Kozhuf

There are many relict communities with azonal distribution in the area of the refugial zones. Their existence in these areas is due to the specific local conditions in the localities where they develop and is not supported by the recent climatic conditions on a wider scale. The refugia are characterized by the specific ecological conditions (temperature regime without severe extremes, higher air and soil humidity during the dry periods of the year compared to the climatogenous communities in the wider region). Thus, the azonal communities are very vulnerable to different influences and interventions in these habitats (uncontrolled woodcut, road construction, water accumulations etc.) as well as to the climate change.

This report presents the most important zonal and azonal forest communities that develop in the aforementioned refugial zones. The prognoses for the future patterns of the development of the refugial zones and vegetation are given in reference to the accepted climate change scenario.

A. Lower Povardarie-Valandovo-Strumica-Dojran refugial region

Description: this region is influenced by the modified Mediterranean climate along the river Vardar valley as well as along the valley of river Struma in Bulgaria to the Strumica region. Dominant vegetation type is pseudomaquis (ass. *Querco cocciferae-Carpinetum orientalis* Oberd. 1948 em. Ht. 54). It develops in the area along Vardar river, to Demir Kapija at the north as well as on some localities in the Strumica valley, Valandovo and Dojran regions.

Characteristic plant species: dominant are evergreen *Quercus coccifera* and *Phillyrea latifolia*, as well as numerous eumediterranean and eastern Mediterranean species such as *Platanus orientalis, Punica granatum, Pinus nigra* subsp. *pallasiana, Juniperus excelsa*, rarely *Arbutus andrachne, Cistus incanus, Periploca graeca, Cionura erecta, Ephedra major* etc. The herb species are represented by *Isoetes phrygia, Imperata cylindrica, Lupinis angustifolius, Tagetes minuta, Briza maxima, Helianthemum aegyptiacum, Asphodelu microcarpus, Silene fabaroides, Silene gallica, Adiantum capillus-veneris, Paeonia peregrina* etc.

IUCN Red List Plants, 1997: *Astragalus physocalyx*, *Alkanna stribrnyi, Anthemis meteorica, Centaurea rufidula, Fritillaria gussichiae, Heptaptera macedonica, Ramonda nathaliae, Malus florentina*

Fauna: The faunal diversity of this refugial zone is complex, both from taxonomic and ecological points of view. The recent faunal diversity is composed mainly of Mediterranean elements, although Northern European and Eastern (Aralo-Caspian) steppe elements are also present in smaller proportions.

The Reptiles are represented by 23 species, among which 19 species are included within Annex IV of the Council Directive 92/43/EEC and Appendix II of the Bern Convention. The subspecies: Balkan Pond Terrapin - *Emys orbicularis hellenica*, Kotschy's gecko - *Cyrtopodion kotschyi skopjensis*, Snake-eyed Skink - *Ablepharus kitaibelii stepaneki* and Erhard's Wall Lizard - *Podarcis erhardii riveti* are Balkan endemics. The Sand Boa - *Eryx jaculus turcicus* was first recorded on the Balkan Peninsula at a location within the Dojran Basin. This species is the only European representative of the large family of boas.

The Birds in the Refugial Zone are represented by more than 100 species, and the mammals by 53 species, or 64% of the total mammal fauna of the country.

The Invertebrates within this Zone are well investigated and show a huge species richness and substantial number of endemic species. On this occasion we shall analyze only the representatives of the Order Lepidoptera (moths and butterflies), as it is one of the best-studied groups of insects within the country, with huge species richness. Within the Refugial Zone, Thurner (1964) recorded 103 species from the Family Noctuidae (noctuid moths), including the national endemic *Cosmia rhodopsis*, and two subtropical species, *Scotia spinifera* and *Mythimna vitellina*. Daniel (1964), in his study of the Families Bombycidae (silk moths) and Sphingidae (hawk moths) from this area, recognized 56 species, including the four local endemic taxa: *Zygaena purpuralis doiranica, Zygaena carniolica paeonica, Zygaena ramburi europensis* and *Cosmotriche potatoria*. The Family Geometridae (geometer moths) is represented by 89 species (Pinker, 1968). The Tribus Microlepidoptera (small moths) is most numerous in the Zone, consisting of 192 species (Klimesch, 1968), including the local endemic species, *Cnephasia klimeschi*. Finally, Thurner (1964) and Schaider & Jaksic (1989), investigating the diurnal butterflies and recognized 86 species, which is 43% of the diurnal butterfly fauna of the country. The total number of recorded species (526) from the Order Lepidoptera shows high diversity within a relatively restricted area. The diurnal butterfly species *Lycaena dispar* is included in Annexes II and IV of the Habitats Directive 92/43/EEC.

IUCN Globally Threatened Animal Species:
Birds: Lesser Kestrel - *Falco naumanni* and the Imperial Eagle - *Aquila heliaca*.
Mammals: Wolf - *Canis lupus*, Wildcat - *Felis silvestris*, Marbled Polecat - *Vormela peregusna*, Mediterranean Horseshoe Bat - *Rhinolophus euryale*, Lesser Horseshoe Bat - *Rhinolophus hipposideros*, Mehely's Horseshoe Bat - *Rhinolophus mehelyi*, Barbastelle - *Barbastella barbastelus*, Long-fingered Bat - *Myotis capaccini*, Geoffroy's Bat - *Myotis emerginatus*, Lesser Mole Rat - *Nannospalax leucodon*, European Souslik - *Spermophilus citellus*.

refugial forest vegetation: apart from the common zonal vegetation in this area (Kermes oak community), the refugial vegetation is partly mesothermophyllous with the presence of Central European dendroflora species (*Fagus sylvatica, Acer pseudoplantanus, Ulmus glabra, Caprinus betulus*), and a combination of evergreen species on some localities (*Taxus baccata, Ilex aquifolium, Buxus sempervirens, Ruscus aculeatus*). There are phytocoenoses with *Castanea sativa, Juglans regia, Plantanus orientalis, Tilia tometosa, Carpinus orientalis* and *Alnus glutinosa* on more humid biotopes. The following forest communities were recorded in this region:

-ass. *Carpino betuli-Buxo-Fagetum* prov Em et al. - Demir Kapija region.
-ass. *Phillyreo-Carpinetum orientalis* Em 1957 *arbutosum andrachis prov.* Em - Gevgelija regiona, river Konjska Reka.
-ass. *Plantano-Castanetum sativae* prov. Em et al . - Belasica Mt.
-ass. *Querco polycarpae- Castaneum sativae* prov. Em. - river Anska Reka.
-ass. *Coccifero-Caprinetum orientalis pinetosum pallasinae* (Rud.) Em. 1974 - avove Strumica town.
-ass. *Periploco-Alnetum glutinosae* Rud. 1938 - Strumica valley
-ass. *Periploco-Fraxinetum angustifoliae-palilisae* Em 1984 - Negorci
-ass. *Cynancho acuti-Plataneum orientalis prov.* Em. – Negorci

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

This refugial zone is located in the southeast part of Macedonia (sub-mediterranean) according to the prepared regional climate scenarios for Macedonia. The analysis of the climate scenarios showed that the mean annual temperature in this refugial zone will increase in 50 years for average 2.3^{o}C, in average, while in 100 years for 4.6^{o}C. The winter temperatures will increase in average less (2.1 and 3.9 ^{o}C for 50 and 100 years) than summer temperatures (2.9 and 6.1 ^{o}C for 50 and 100 years). The annual sums of precipitation will decrease for 5% (50 years) and 13% (in 100 years). The summer decrease of precipitation (-19% in 100 years) is predicted to be significantly higher compared to winter decrease (-4% in 100 years).

It is expected that the Mediterranean and sub-Mediterranean elements of the pseudomaquis will broaden their range towards the central and northern regions of the Republic of Macedonia i.e. the global climate change will cause widening of the range of the zonal vegetation (see Ecosystems' assessment).

Plant communities which grow on a habitats with high level of underground water, such are: *Periploco-Alnetum glutinosae, Periploco-Fraxinetum angustifoliae-palilisae*, *Plantano-Castanetum sativae* will undergo significant negative impact due to climate change and they will be threatened with extinction. Other more xerothermic communities will have a trend of expansion of their range (since they are remains - relicts - from warmer periods). The anthropogenic influence will have critical importance for their performance.

Fauna:

The fauna in this refugial zone will undergo significant changes due to the climate warming. The increase of average annual temperatures and increase of aridity, the fauna that characterizes this area will move to north. Some of the most probably affected species will be: faunistic elements typical for Sub-Mediterranean-Balkan Forests (Hermann's Tortoise - *Testudo hermanii*, Balkan Green Lizard - *Lacerta trilineata*, Snake-eyed Skink - *Ablepharus kitaibelii*, Syrian Woodpecker - *Dendrocopus syriacus*, Sombre Tit - *Parus lugubris*, Lewant Sparrowhawk - *Accipiter brevipes*, Forest dormouse - *Dryomys nitedula*, Yellow-necked mouse - *Apodemus flavicollis*, Eastern hedgehog - *Erinaceus concolor*, Badger - *Meles meles*, Beech marten - *Martes foina*, etc.), East-Mediterranean Maquis (European Glass Lizard -*Ophisaurus apodus*, Snake-eyed Skink - *Cyrtopodion kotschyi*, Worm Snake - *Typhlops vermicularis*, Leopard Snake -*Elaphe situla*, Dahl's Whip Snake - *Coluber najadum*, Spanish Sparrow - *Passer hispalionensis*, Black-headed Bunting - *Emberiza melanocephala*, Yellow/Blue-headed Wagtail - *Motacilla flava*), as well as Ponto-Caspian Steppes (Balkan Wall Lizard - *Podarcis taurica*, Large Whip Snake - *Coluber caspius*, Lesser Kestrel - *Falco naumanni*, Red-footed Falkon - *Falco vespertinus*, Pallid Harrier - *Circus macrourus*, Imperial Eagle - *Aquila heliaca*, Skylark - *Alauda arvensis*, European souslik - *Spermophilus citellus*, Lesser Mole Rat - *Nannospalax leucodon*). As a result, other species will replace them, characteristic for: Aegean-Anatolian Semi-deserts (Moroccan cricket - *Dociostaurus maroccanus*, Italian cricket -*Calliptamus italicus*, Spur-thighed Tortoise - *Testudo graeca*, Erhard's Wall Lizard - *Podarcis erhardii*, Four-lined Snake - *Elaphe quatuorlineata*, Rosy Starling - *Sturnus roseus*, Calandra Lark - *Melanocorypha calandra*, Stone Curlew - *Burhinus oedicnemus*, Little Bustard - *Tetrax tetrax*, Marbled Polecat - *Vormela peregusna*, Guenther's vole - *Microtus guentheri*), as well as faunistic elements characteristic for Iran-Turanian Semi-deserts (Sand Boa - *Eryx jaculus*, Tawny Pipit - *Anthus campestris*, Crested Lark - *Galerida cristata*, Short-toed

Lark - *Calandrella cinerea*, Long-legged Buzzard - *Buteo rufinus* etc.). All species listed above are already present in the area, but with low abundance and frequency.

B. Refugial region Tikvesh

Description: it is the area of the steppe-like vegetation in Macedonia with low hilly relief (between Veles, Kavadarci and Shtip) along the river Vardar. The trees are absent from the vegetation of this region which is considered to be secondary phenomenon. (Chernjavski, 1937, Micevski, 1971). The destruction of forests in this region began in the antiquity. The climatic conditions in the regions did not supported spontaneous regeneration of forest vegetation. Remains of forests can be found in some sheltered localities such are the Plane woodlands along the valley of the river Vatashka Reka, shrublands of the peach (*Prunus tenella*) with *Ephedra major* on Golem Ljubash etc.

Characteristic plant species: *Platanus orientalis*, *Prunus tenella, Ephedra major, Tulipa mariannae, Salvia jurisicii, Astragalus cernjavskii, Onobrychis hypargyrea, Galium rhodopaeum, Ferulago macedonica, Artemisia maritima, Eurotia ceratoides, Camphorosma monspeliaca, Suaeda maritima, Salicornia herbacea*

IUCN Red List, 1997: *Hedysarum macedonicum, Heptaptera macedonica, Malus florentina*

Fauna: From bio-geographical point of view on the territory of the Tikvesh Refugial Zone two main faunal complexes of species are present: Eremial and Arboreal.

The Eremial complex of faunal elements includes species that originate from the Black Sea-Caspian Region adapted to survive in dry steppe-like and semi-desert conditions and species from the Aegean-Anatolian semi-desert areas.

The Arboreal Complex is mainly represented by the Mediterranean sub-complex of faunal elements, which encompasses species connected with broadleaved woodlands.

The Reptiles are represented by 17 species. The subspecies Hermann's Tortoise - *Testudo hermanni boettgeri*, European Pond Terrapin - *Emys orbicularis hellenica*, Erhard's Wall Lizard - *Podarcis erhardii riveti*, Kotshy's Gecko - *Cyrtopodion kotschyi skopjensis* and the Nose-horned Viper - *Vipera ammodytes meridionalis* are Balkan endemics. On the other hand the species: Spur-Thighead Tortoise - *Testudo graeca ibera*, Balkan Green Lizard - *Lacerta trilineata*, Balkan Wall Lizard - *Podarcis taurica*, Snake-eyed Skink - *Ablepharus kitaibellii kitaibellii*, Large Whip Snake - *Coluber caspius caspius*, Worm Snake - *Typhlops vermicularis*, Dahl's Whip Snake - *Coluber najadum dahlii*, Leopard Snake - *Elaphe situla*, Four-lined Snake - *Elaphe quatorlineata*, Cat Snake - *Telescopus fallax* and the Sand Boa - *Eryx jaculus turcicus*, are with range generally extending from the steppes and semi-desert areas around Caspian and Black Sea region through the semi-desert areas of the Aegean-Anatolian region and usually their European boundary reaches as far as Macedonia.

The Birds within the Tikvesh Refugial Zone are represented by 73 species which is only 23% of the entire bird fauna of Macedonia represented by 319 species. The Globally Threatened Species: Lesser Kestrel - *Falco naumanni* and Imperial Eagle - *Aquila heliaca*, are present with abundant populations. Both species are typical for the open steppes of Aral-Caspian Region and Aegean-Anatolian semi-desert areas. The European range of these species is restricted to dry regions of South Europe. Another complex of species that are threatened on European level and prefer steppe-like and semi desert areas are: Black-headed Bunting - *Emberiza melanocephala*, Long-legged Buzzard - *Buteo rufinus*, European Roller - *Coracias garrulus*, Levant Sparrow hawk - *Accipiter*

brevipes, Griffon Vulture - *Gyps fulvus*, Black-eared Wheatear - *Oenanthe hispanica*, Egyptian Vulture - *Neophron percnopterus*, are nesting within the Tikvesh Refugial Zone, as well as the species: Hen Harrier - *Circus cyaneus*, Pallid Harrier - *Circus macrourus*, Great bustard - *Otis tarda*, Glossy Ibis - *Plegadis falcinellus*, that appear in the area only for wintering or staging, during the seasonal migrations.

The Mammals are represented by 33 species, of which, the Balkan Short-tailed Mouse - *Mus macedonicus* is endemic species. From biogeographic aspect the rest mammals of the Tikvesh refugial zone have wider European distribution range. Small portion of species that originate from the Black Sea-Caspian Region and are typical for the steppes, semi desert and dry grassland habitats is also present in the area: Marbled Polecat - *Vormela peregusna*, Lesser Mole Rat - *Nannospalax leucodon*. The most striking feature of the mammal fauna of this refuge zone is their threatened status. From the total number of 33 species, nine are Globally Threatened Species.

IUCN Globally Threatened Species:

Birds: Lesser Kestrel - *Falco naumanni*, Imperial Eagle - *Aquila heliaca*, Great bustard - *Otis tarda*.

Mammals: Lesser Horseshoe Bat - *Rhinolophus hipposideros*, Mediterranean Horseshoe Bat - *Rhinolophus euriale,* Barbastelle - *Barbastella barbastellus,* Geoffroy's Bat - *Myotis emarginatus,* Lesser Mole Rat - *Nannospalax leucodon,* Wolf - *Canis lupus,* Marbled Polecat - *Vormela peregusna,* European Otter - *Lutra lutra,* Wildcat - *Felis silvestris*.

Refugial forest vegetation:

-ass. *Juglando-Plataneum orientalis* Em et Džek. - dales in the whole region, especially Kavadarci

-ass. *Ephedro-Prinetum tenellae* Em. - Ljubash, Kavadarci region

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

This refugial zone is located in the central part of Macedonia (under the sub-mediterranean influence) according to the prepared regional climate scenarios for Macedonia. The analysis of the climate scenarios showed that the mean annual temperature in this refugial zone will increase in 50 years for average 2.2^{o}C, in average, while in 100 years for 4.5^{o}C. The winter temperatures will increase in average almost equally as the average (2.3 and 4.4 ^{o}C for 50 and 100 years) while summer temperatures will increase somewhat more (2.6 and 5.4 ^{o}C for 50 and 100 years). The annual sums of precipitation will decrease for 6% (50 years) and 13% (in 100 years). The summer decrease of precipitation (-23% in 100 years) is predicted to be significantly higher compared to winter decrease (-1% in 100 years). Obviously, the average decrease of precipitation in central parts will be higher than the south region.

Regional climate change will positively impact grassland ecosystems (if anthropogenic impact is considered along with the climate change; see chapter on ecosystems). Refugial forest vegetation in this area is heavily degraded and only fragments exist. The stands with *Platanus orientalis* are more compact compared to other communities, especially those of the wild peach (*Prunus tenella*), which are very heavily degraded. Their survival is connected to anthropogenic influence rather than to climate changes, since they are distributed in the vineyards region.

The fauna in the refugial zone Tikvesh will undergo similar changes as the fauna from the previous zone, but with lower intensity. Faunistic elements characteristic for Sub-Mediterranean-Balkan Forests and East-Mediterranean Maquis will retreat slowly toward north and higher altitudes. The penetration of faunistic elements from Ponto-Caspian Steppes, Aegean-Anatolian Semi-deserts and Iran-Turanian Semi-deserts will be stronger in this zone.

C. Refugial region of the gorge Taorska Klisura on river Vardar including the gorge of river Pchinja

Description: Taor gorge is characterized by the presence of shrubs of Lilac (*Syringa vulgaris*) with *Buxus sempervirens, Phillyrea latifolia, Jasminum fructicans* and *Carpinus orientalis,* which form a community rich in plant species. There are well developed stands of Greek Juniper (*Juniperus excelsa*) in the river Pchinja gorge, on the steeper slope before the mouth into river Vardar. The bedrock in this area is very diverse: limestone, serpentine, magnezite etc.

Characteristic plant species: *Anchusa macedonica, Delphinium albiflorum, Convolvulus compactus, Periploca graeca, Pistacia terebinthus, Tamarix parviflora, Cerastium dichotomum, Ephedra major, Sedum tuberiferum*

IUCN Red List, 1997: *Alkanna stribrnyi, Fritillaria gussichiae, Ramonda nathaliae, Sempervivum kindingeri*

Fauna: With regard to the amphibians we should emphasis the presence of the Balkan endemic taxa: Eastern Spade foot - *Pelobates syriacus balcanicus*. The consequences of human activities are resulting in declining of the abundance of the populations of species that are closely related with the marsh and wetland habitats, especially concerning the drained Katlanovo Marsh.

With regard to the reptiles the composition is similar to the Tikvesh Refugial Zone represented by 15 species. The subspecies Hermann's Tortoise - *Testudo hermanni boettgeri*, European Pond Terrapin - *Emys orbicularis hellenica*, Erhard's Wall Lizard - *Podarcis erhardii riveti*, Kotshy's Gecko - *Cyrtopodion kotschyi skopjensis* and Nose-horned Viper - *Vipera ammodytes meridionalis* are Balkan endemics.

The birds within this refuge zone were formerly represented by more than 100 species, especially in the Katlanovo Marsh. After the desiccation of the marsh the frequency and abundance of the waterfowl species is highly reduced.

Recently recorded bird species with European Threat Categories are the following: Levant Sparrow hawk - *Accipiter brevipes*, Griffon Vulture - *Gyps fulvus*, Imperial Eagle - *Aquila heliaca*, Lesser Kestrel - *Falco naumanni,* Peregrine Falcon – *Falco peregrinus*, Red-footed Falcon – *Falco vespertinus*, Egyptian Vulture - *Neophron percnopterus*, Long-legged Buzzard - *Buteo rufinus*, Black Kite – *Milvus migrans*, Stone Curlew – *Burhinus oedicnemus*, White Stork – *Ciconia ciconia*, Rock Partridge – *Alectoris graeca*, Quail – *Coturnix coturnix*, Eagle Owl – *Bubo bubo*.

The fauna of the mammals is also similar to the Tikvesh Refugial Zone with much less species.

IUCN Globally Threatened Species:

Birds: Imperial Eagle - *Aquila heliaca*, Lesser Kestrel - *Falco naumanni*.

Mammals: Wolf - *Canis lupus,* Wildcat - *Felis silvestris*, Marbled Polecat - *Vormela peregusna,* Lesser Horseshoe Bat - *Rhinolophus hipposideros*, Mediterranean

Horseshoe Bat - *Rhinolophus euriale,* Barbastelle - *Barbastella barbastellus,* Geoffroy's Bat - *Myotis emarginatus*.

Refugial forest vegetation:

-ass. *Jasmino fruticantis –Syringetum* Em 1976
-ass. *Periploco-Ulmetum prov.* Em
-ass. *Pruno webii-Juniperetum excelsae* Em 1962
-ass. *Alysso orientalis-Celtetum australis* prov. Em - Katlanovo spa

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

This refugial zone is situated in the central part of Macedonia (under sub-mediterranean climatic influence) according the prepared regional climate scenarios. Thus, the data for previous refugial zone are the same in this case (Tikvesh).

The global climate change will impact this refugial region in a positive way i.e. it will stimulate spreading of the distribution ranges of the refugial forest communities. These communities are thermophyllous refugial sub-Mediterranean communities that spread their distribution northwards using the corridor Aegean See-Vardar River in the past. Thus, the global climate change will stimulate their spread (e.g. stands of Greek Juniper and the Lilac are already recorded on Zheden Mt. which is more to the north than the Taor and Treska gorge. The only obstacle could be negative anthropogenic influence (habitat degradation and fragmentation).

The current composition of the fauna in this refugial zone represents a complex of faunistic elements in which the life forms characteristic for Sub-Mediterranean-Balkan Forests dominate, and Ponto-Mediterranean and Ponto-Caspian faunistic elements have restricted presence. The climate induced changes will force movement of characteristic fauna for Sub-Mediterranean-Balkan Forests toward north and penetration of Ponto-Mediterranean and Ponto-Caspian faunistic elements will be favorized.

D. Refugial region in the gorge of the river Treska (Poreche)

Only faunal characteristics will be described since they were not elaborated in the FNC.

Characteristic faunal species:

Amphibians: Fire Salamander - *Salamandra salamandra,* Balkan Stream Frog - *Rana graeca,* Green Toad - *Bufo viridis,* Common Toad - *Bufo bufo,* Common Tree Frog - *Hyla arborea*.

Reptiles : Hermann's Tortoise - *Testudo hermanni boettgeri*, European Pond Terrapin - *Emys orbicularis hellenica*, Slow Worm - *Anguis fragilis,* Common Wall Lizard - *Podarcis muralis,* Erhard's Wall Lizard - *Podarcis erhardii riveti*, Dalmatian Algyroides - *Algyroides nigropunctatus,* Dice Snake - *Natrix tessellata,* Grass Snake - *Natrix natrix,* Large Whip Snake - *Coluber caspius caspius,* Nose-horned Viper - *Vipera ammodytes meridionalis,* Cat Snake - *Telescopus fallax.* With regard to the reptiles we shall emphasize the presence of the West Balkan faunistic element Dalmatian Algyroides - *Algyroides nigropunctatus.* The disjunctive distribution of the species within the Treska Valley Refugial Zone is the far-most eastern range of the species.

Birds: *Ciconia nigra, quila chrysaetos, Circaetus gallicus, Circus aeruginosus, Gyps fulvus, Neophron percnopterus, Falco peregrinus, Bubo bubo, Caprimulgus europaeus,*

Alcedo atthis, Dendrocopos medius, Dendrocopos syriacus, Dryocopus martius, Lullula arborea,Lanius collurio, Ficedula albicollis, Emberiza hortulana, Otus scops, Phoenicurus phoenicurus, Oenanthe hispanica, Phylloscopus sibilatrix, Lanius senator.

Mammals: Mediterranean Horseshoe Bat - *Rhinolophus euriale,* Lesser Horseshoe Bat - *Rhinolophus hipposideros*, Mehely's Horseshoe Bat - *Rhinolophus mehelyi*, Greater Horseshoe Bat - *Rhinolophus ferrumequinum*, Schreiber's Bat - *Miniopterus schreibersi*, Wolf - *Canis lupus,* Wildcat - *Felis silvestris*, Balkan Lynx – *Lynx lynx martinoi*, Otter – *Lutra lutra*.

Endemic Invertebrates: Segmented worms: *Italobalkaniona treskavensis*. Pseudo-scorpions: *Chthonius (Ephippiochthonius) microtuberculatus*, *Chthonius (Neochtonius) karamanianus*, *Atemnus balcanicus*. Noctuid Moths: *Copiphana lunaki*, *Agrochola wolfschlageri*, *Cosmia rhodopsis*. Small Moths: *Aethes kasyi*, *Ephysteris treskensis*, *Eremica kasyi*, *Stogmathophora klimeschi*, *Scythris albostriata*, *Scythris subschleischiella*, *Argyresthia kosyi*, *Acrolepia macedonica*, *Acrolepia heringi*, *Coleophora gigantella*, *Coleophora medicagivora*, *Coleophora quadristraminella*, *Coleophora flavescentella*, *Coleophora latinineella*, *Coleophora depunctella*, *Coleophora coarctataephaga*, *Stigmella globulariae*.

IUCN Globally Threatened Species:

Mammals: Mediterranean Horseshoe Bat - *Rhinolophus euriale,* Lesser Horseshoe Bat - *Rhinolophus hipposideros*, Mehely's Horseshoe Bat - *Rhinolophus mehelyi*, Wolf - *Canis lupus,* Wildcat - *Felis silvestris*, Otter – *Lutra lutra*.

E. Refugial region of Crna Reka including the gorges of rivers Raec and Blashnica

Description: the canyon of Crna Reka river stretches for 80 km from the village Skochivir to the highland Vitachevo at the beginning of Tikvesh reservoir. It passes through old and young limestone, granites and volcanic rocks. Rivers Raec and Blashnica are the most important tributaries of Crna Reka. The influence of the warm sub-Mediterranean climate in the canyon is evident. It provides conditions for the development of sub-Mediterranean vegetation that is similar to the pseudomquis, but without *Quercus coccifera*; dominant species are *Juniperus excelsa, Phyllirea latifolia*, and *Arbutus andrachne* (the last one on some localities). The stands of *Prunus webbii, Quercus trojana, Pistacia terebinthus, Platanus orientalis* can be found i.e. associations belonging to the order *Quercetalia pubescentis* and alliance *Ostryo-Carpinion oirentalis* and *Quercion confertae.*

Characteristic plant species: *Arbutus andrachne, Prunus webbii, Campanula formanekiana, Juniperus excelsa, Thymus parnassicus, Galium setaceum, Chaenorhinum rubrifolium, Helianthemum hymettium, Galium kerneri, Ruta graveolens, Eryngium wiegandii, Lilium candidum, Periploca graeca, Colchicum bivonnae, Daphne laureola*

IUCN Red List, 1997: *Alyssum doerfleri, Centaurea grbavacensis, Heptaptera macedonica, Melampyrum heracleoticum, Onobrychis degenii, Silene viscariopsis, Ramonda nathaliae, Verbascum macedonicum, Verbascum herzogii*

Characteristic faunal species:

Amphibians: *Salamandra salamandra, Rana graeca, Rana dalmatina, Hyla arborea, Bufo viridis, Bufo bufo, Pelobates syriacus balcanicus.*

Reptiles*: Testudo graeca ibera, Testudo hermanni boettgeri, Emys orbicularis hellenica, Elaphe quatuorlineata, Elaphe situla, Eryx jaculus turcicus, Anguis fragilis, Podarcis muralis, Podarcis erhardii, Natrix tessellata, Natrix natrix, Coluber caspius, Malpolon monspessulanus, Vipera ammodytes*. With regard to the reptiles, the most frequent and abundant snake species within this refugial zone is the Montpellier Snake - *Malpolon monspessulanus*.

Birds: *Phalacrocorax pygmaeus, Ardeola ralloides, Casmerodius albus (Egretta alba), Egretta garzetta, Ciconia nigra, Ciconia ciconia, Aythya nyroca, Cygnus cygnus, Accipiter brevipes, Aegypius monachus, Aquila chrysaetos, Aquila heliaca, Buteo rufinus, Circaetus gallicus, Gypaetus barbatus, Gyps fulvus, Hieraaetus fasciatus, Hieraaetus pennatus, Milvus migrans, Neophron percnopterus, Pernis apivorus, Pandion haliaetus, Falco biarmicus, Falco naumanni, Falco peregrinus, Bonasa bonasia, Sterna albifrons, Bubo bubo, Caprimulgus europaeus, Alcedo atthis, Coracias garrulus, Dryocopus martius, Lullula arborea, Melanocorypha calandra, Anthus campestris, Lanius collurio, Lanius minor, Pyrrhocorax pyrrhocorax, Monticola solitarius, Falco subbuteo, Oenanthe hispanica, Lanius senator, Coturnix coturnix.*

Mammals: *Rhinolophus euryale, Rhinolophus ferrumequinum, Miniopterus schreibersi, Myotis blythii, Myotis myotis, Canis lupus, Lutra lutra, Mustela nivalis, Meles meles, Martes foina, Capreolus capreolus, Felis silvestris, Mustela putorius.*

IUCN Globally Threatened Species:

Fishes: Vardar Loach – *Cobitis vardarensis*, Macedonian Gudgeon – *Gobio banarescui*, Balkan Vimba - *Vimba melanops*, Vardar Chop - *Zingel balcanicus*.

Birds : Imperial Eagle – *Aquila heliaca,* Pygmy Cormorant – *Phalacrocorax pygmeus,* Ferruginous Duck – *Aythia nyroca*, Lesser Kestrel – *Falco naumanni*,

Mammals: Mediterranean Horseshoe Bat - *Rhinolophus euriale,* Wolf - *Canis lupus,* Wildcat - *Felis silvestris*, Otter – *Lutra lutra*.

Refugial forest vegetation:

-ass. *Quercetum trojanae macedonicum* Em et Ht (1950)1959- Rae~ka Reka
-ass. *Phyllireo-Juniperetum excesae* prov. Em
-ass. *Arbuto andrachnis-Carpientum orientalis phillyreetosum* prov. Em
-ass. *Paliuro-Prunetum webbii* Em 1976

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

This refugial zone is situated in the central part of Macedonia (under sub-mediterranean climatic influence) according the prepared regional climate scenarios. Although there are no meteorological stations in the range of this refugial zone, one can say that the actual climate characteristics and the vegetation are similar to those from Tikvesh zone. Thus the climate sceanrios for Tikvesh are applicable.

The regional climate change will impact the refugial region of Crna Reka and its thermophyllous forests (with pseudomaquis elements) in the direction of spreading of the existing forest communities. Great concern in this area is the plan for construction of large reservoir "Chebren" that will destroy parts of the refugial forest communities and parts of the associations that belong to the vegetation of hill pastures (ass. *Biserrulo-Scleranthetum dichotomae*). The construction of the reservoir on Crna Reka and the consequent changes in the microclimatic conditions would stimulate the succession of

hill pastures towards the existing thermophyllous forest vegetation. The endemic species *Silene paeoniensis* will suffer changes in its distribution areal since some parts of its populations would be flooded.

Faunistic elements from Sub-Mediterranean-Balkan Forests dominate in this refugial zone, with strongly expressed presence of Ponto-Mediterranean faunistic elements. The latest faunistic elements (characteristic for East-Mediterranean Maquis) will penetrate stronger in the zone. The fauna with Aegean-Anatolian and Iran-Turanian, as well as Ponto-Caspian origin will also colonize the area, but wit less intensity.

F. Refugial region Jama

Description: This refugial region is spread in the western parts of the Republic of Macedonia, between Kichevo and Debar, mainly on limestone bedrock. There are mixed forests of Turkey oak, sessile oak and beech. The sub-Mediterranean influence can be noticed on some localities. Special attention should be paid to horse chestnut (*Aesculus hippocastanum*) that can be found in some thermomesophyllous coenoses like hornbeam, beech stands and in the habitats of ass. *Aceri-Fraxinetum* and ass. *Ostryo-Fagetum.* However, it can be found in the riparian vegetation along river Garska Reka, together with *Alnus glutinosa* and *Salix elaeagnos.* Horse chestnut occurs on some rocky sites outside of the river valleys, as well. These sites are characterized by low water availability, especially during the summer months.

Characteristic plant species: *Acer platanoides, Acer pseudoplatanus, Aesculus hippocastanum, Inula bifrons, Ribes multiflorum, Hypericum annulatum, Mulgedium pancicii, Corylus colurna, Asarum europaeum, Geranium reflexum, Iberis sempervirens, Laserpitium garganicum*

IUCN Red List, 1997: *Acer heldreichii* subsp. *visiani, Alkanna noneiformis, Ramonda serbica, Solenanthus scardicus, Melampyrum heracleoticum*

Characteristic faunal species:

Amphibians: *Salamandra salamandra, Rana dalmatina, Rana graeca, Hyla arborea, Bufo viridis, Bufo bufo.*

Reptiles: *Testudo hermanni boettgeri, Ablepharus kitaibellii kitaibellii, Podarcis erhardii riveti, Podarcis muralis muralis, Anguis fragilis, Elaphe longissima, Coronella austriaca, Natrix natrix, Natrix tessellata, Vipera ammodytes meridionalis.*

Birds: *Scolopax rusticola, Bonasia bonasia, Bubo bubo, Accipiter gentilis, Falco subbuteo, Accipiter nisus, Falco subbuteo, Aquilla chrysaetos, Falco peregrinus.*

Mammals: *Rhinolophus hipposideros, Myotis blythi, Eptesicus serotinus, Miniopterus schreibersi*, *Erinaceus concolor*, *Sciurus vulgaris, Dryomys nitedula, Glis glis*, *Martes foina*, *Meles meles*, *Vulpes vulpes*, *Felis silvestris*, *Lynx lynx, Canis lupus*, *Ursus arctos*, *Sus scrofa, Capreolus capreolus.*

IUCN Globally Threatened Species:

Mammals: Wolf – *Canis lupus*, Wildcat - *Felis silvestris,* Lesser Horseshoe Bat - *Rhinolophus hipposideros*.

Refugial forest vegetation:

- *Aesculo hippocastani-Aceri-Fraxinetum prov.* Em. - Suvi Dol
- *Aesculo hippocastani-Alnetum glutinosae prov.* Em. - Valjavica, Garska Reka
- *Juglando-Aesculetum hippocastani typicum* Matv. et Nik.

- *Juglando hippocastani cotyledonetosum* Matv. et Nik.

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

This refugial zone is located in the north-western mountainous part of Macedonia (under the mountain-continental climate influence) according to the prepared regional climate scenarios for Macedonia. The analysis of the climate scenarios showed that the mean annual temperature in this refugial zone will increase in 50 years 2.5^{o}C, in average, while in 100 years for 5.1^{o}C. The winter temperatures will increase in average almost equally as the average (2.7 and 5.2 ^{o}C for 50 and 100 years), which is similar to the summer temperatures will increase somewhat more (2.5 and 5.3 ^{o}C for 50 and 100 years). The annual sums of precipitation will decrease for 2% (50 years) and 6% (in 100 years). The decrease of precipitation is expected only for the spring, summer and autumn season (-16% in 100 years - summer), while winter precipitation will increase (+6% in 100 years). Obviously, the average decrease of precipitation in north-western part will not be that extreme like in central and southern parts of Macedonia.

The communities of horse chestnut are the most important relict communities in this region. These are thermomesophyllous communities that owe their existence to the suitable climatic conditions in the gorge of Garska Reka and Jama (temperature, soil and air humidity). The climate change impact of this intensity will not alter the existence of these communities in the refugial region. However, the most important problem will arise due to the planned construction of the reservoir "Boshkov Most".

Faunistic elements from Balkan-Middle-European Forests dominate in this refugial zone, with strong impact of the fauna characteristic for Sub-Mediterranean-Balkan Forests. Regional climate change will have insignificant impact on the fauna in this zone, related to their vertical redistribution.

G. Refugial region Mavrovo-Radika

Description: This is an area under influence of the modified sub-Mediterranean climate through the corridor Adriatic See - Crn Drim - Radika. Mesothermophyllous deciduous forests, mainly on limestone bedrock are characteristic for this area. There are fir stands on altitudes higher than 1200 m a.s.l. One of the most southern spruce forests on the Balkans can be found in the region, as well. The refugial communities contain two important representatives of Illyric floristic elements - *Ostrya caprinifolia* and *Acer obtusatum*. The shrublands of *Myricaria germanica* in the alluvium of the lower parts of Radika river valley can be considered as refugial communities.

Characteristic plant species: *Tragopogon orientalis, Trifolium spadiceum, Astragalus creticus* subsp. *rumelicus, Astragalus glycyphylloides, Coronilla coronata, Cynanchum hutteri, Peltaria aliacea, Sesleria autumnalis, Moeringia bavarica, Myricaria germanica*

IUCN Red List, 1997: *Eryngium serbicum, Ramonda serbica, Sempervivum kosaninii, Solenanthus scardicus, Vicia montenegrina, Viola elegantula*

Characteristic faunal species:

Amphibians: *Salamandra salamandra, Rana dalmatina, Rana graeca, Hyla arborea, Bufo viridis, Bufo bufo.*

Reptiles: *Testudo hermanni boettgeri, Ablepharus kitaibellii kitaibellii, , Podarcis erhardii riveti, Podarcis muralis muralis, Anguis fragilis, Elaphe longissima, Coronella austriaca, Natrix natrix, Natrix tessellata, Vipera ammodytes meridionalis.*

Birds: *Gavia arctica, Casmerodius albus, Egretta garzetta, Aquila chrysaetos, Circaetus gallicus, Circus aeruginosus, Gyps fulvus, Pernis apivorus, Falco naumanni, Falco peregrinus, Bonasa bonasia, Crex crex, Aegolius funereus, Bubo bubo, Caprimulgus europaeus, Alcedo atthis, Dendrocopos leucotos, Dendrocopos medius, Dryocopus martius, Picus canus, Lullula arborea, Lanius collurio, Ficedula albicollis, Pyrrhocorax pyrrhocorax.*

Mammals: *Rhinolophus hipposideros, Rhinolophus euryale, Myotis blythi, Eptesicus serotinus, Miniopterus schreibersi*, *Erinaceus concolor*, *Chionomys nivalis*, *Sciurus vulgaris, Dryomys nitedula, Glis glis*, *Martes foina*, *Meles meles*, *Vulpes vulpes*, *Felis silvestris*, *Lynx lynx, Canis lupus*, *Ursus arctos*, *Sus scrofa, Capreolus capreolus*.

IUCN Globally Threatened Species:

Birds: Lesser Kestrel - *Falco naumanni*, Corncrake – *Crex crex*.

Mammals: Mediterranean Horseshoe Bat - *Rhinolophus euriale,* Lesser Horseshoe Bat - *Rhinolophus hipposideros*, Wolf – *Canis lupus*, Wildcat - *Felis silvestris*

Refugial forest vegetation:

- *Aceri obtusati-Fagetum* Fuk. et al. - Kozha Mt.
- *Aceri obtusati-Fagetum* Fuk. et al. var. *colurnetosum* - St. Jovan Bigorski Monastery
- *Castaneo sativae-Aceretum obtusati* prov. Em. - St. Jovan Bigorski Monastery
- *Tamarici-Myricarietum* prov. Em. - Radika

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

This refugial zone is located in the north-western mountainous part of Macedonia (under the mountain-continental climate influence) according to the prepared regional climate scenarios for Macedonia, similar to the previous zone. The analysis of climate scenarios for previous zone can be applied here as well. However, it should be noted that the valley of the river Radika is the region with the highest precipitation in Macedonia. Thus, the assessment of the climate change impacts on the basis of the same scenario as for the Jama could not be safe enough.

If the rainfall quantity does not change drastically, the relict maple communities will not undergo significant changes of their range since maples grow in the beech belt on the extreme habitats (rocky ground in deep dales).

The regional climate change will impact the spruce stands in the upper flow of the river Radika (Adzhina Reka). Ecological conditions in this refugial region were significantly disturbed during the last 50 years because of the water extraction system "Sharski Vodi" on Adzhina Reka and upper parts of Radika river. As already mentioned, the spruce stands are one of the most southern spruce forests on the Balkan Peninsula. These are considerably degraded (die back was already recorded). The rise of the temperatures will contribute to their further degradation, especially due to the altered hydrologic regime and impossibility for vertical shift of the populations (south exposition of the slopes on Korab Mt.).

The fauna characteristic for Balkan-Middle-European Broad-leaf Forests dominates in this refugial zone, with significant contribution of European Forests of Taiga Type on higher altitudes. In the same time, along the river Radika flow, Mediterranean faunistic elements penetrate. The regional climate change will affect the vertical distribution of faunistic species to a limited extent.

H. Refugial region Strazha

Description: It is distributed on the Bistra Mt., in the area between Polog and Kichevo valleys (1050-1150 m a.s.l.). Three forest communities can be mentioned: beech, sessile oak and hornbeam forests on north-eastern and south-eastern exposition. The beech and oak communities develop on silicate bedrock and the hornbeam community on limestone. The relict features can be noticed in all three communities. Some of the species in these communities grow on lower altitudes than expected.

Characteristic plant species: *Erodium absinthoides* subsp. *glandulosum, Kitaibelia vitifolia, Cytisus rectipilosus, Corylus colurna, Ribes multiflorum, Delphinium fissum, Hyssopus officinalis* subsp. *pilifer, Asarum europaeum, Eryngium palmatum, Geranium reflexum, Cotoneaster nebrodensis*

IUCN Red List, 1997: *Ramonda serbica, Solenanthus scardicus*

Characteristic faunal species:

Amphibians: *Salamandra salamandra, Rana dalmatina, Rana graeca, Hyla arborea, Bufo viridis, Bufo bufo.*

Reptiles: *Testudo hermanni boettgeri, Ablepharus kitaibellii kitaibellii, Podarcis muralis muralis, Anguis fragilis, Elaphe longissima, Coronella austriaca, Natrix natrix, Natrix tessellata, Vipera ammodytes meridionalis.*

Birds: *Scolopax rusticola, Bonasia bonasia, Bubo bubo, Accipiter gentilis, Falco subbuteo, Accipiter nisus, Falco subbuteo, Aquilla chrysaetos, Falco peregrinus.*

Mammals: *Rhinolophus hipposideros, Myotis blythi, Eptesicus serotinus, Miniopterus schreibersi*, *Erinaceus concolor*, *Sciurus vulgaris, Dryomys nitedula, Glis glis*, *Martes foina*, *Meles meles*, *Vulpes vulpes*, *Felis silvestris*, *Lynx lynx, Canis lupus*, *Ursus arctos*, *Sus scrofa, Capreolus capreolus*.

IUCN Globally Threatened Species:

Mammals: Wolf – *Canis lupus*, Wildcat - *Felis silvestris,* Lesser Horseshoe Bat - *Rhinolophus hipposideros*.

Refugial forest vegetation:

- *Colurno-Aceri obusati-Ostrietum* Fuk. et al.
- *Melampyro heracleotici-Quercetum polycarpae* prov. Em et al.
- *Fagetum montanum*

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

This refugial zone is located in the north-western mountainous part of Macedonia (under the mountain-continental climate influence) according to the prepared regional climate scenarios for Macedonia, similar to the refugial zone Jama. The same analysis of climate scenarios for Jama zone is applicable. Thus, the assessment for the climate change impact in that case can be used in this zone as well.

It is not likely that the growth of the azonal communities will be threatened. The changes in the refugial beech community will be the same as for the zonal forests since the beech community is very similar to the climatogene coenoses in the area. Consequently, the changes in zonal beech forests will be followed by these refugial communities.

The faunistic species characteristic for Balkan-Middle-European Broad-leaf Forests dominate in this refugial zone. Significant changes of the fauna are expected in the zone since it is restricted in a very narrow belt of only 100 meters approximately (between 1050 and 1150 m a.s.l.). Namely, it was already mentioned that faunal elements from lower belts (Sub-Mediterranean-Balkan Forests) will settle the beech zone in this altitudes. Actually, the changes will happen in the whole belt (the fauna is the same in the refugial forest communities), but the lowest part of the beech belt (where these communities are distributed) will be the most altered.

I**. Refugial region Pelister**

Description: The special position of Pelister Mountain between Lake Prespa to the west and the Pelagonia valley to the east, both of which are relatively open to the south, as well as its connection with a continuous mountain chain to the north, expose Pelister to varying climatic influences, modified by its complex mountain relief. These are the major abiogenic factors contributing to the great biodiversity of its territory.

A large part of the subalpine region of Pelister Mt. is occupied by the relict species *Pinus peuce* (Molika or Macedonian pine). These localities are primary biotopes for molika stands. However, molika pine is spreading in the montane altitudinal belt, on the localities that are characteristic for climatogene beech-fir forest. If the ecological conditions are favorable the Molika pine shows more intensive growth on this secondary biotope.

Molika pine is spreading (not exclusively because of the climate change, still to be investigated) not only on the Pelister higher parts, but also on other localities/mountains. Very striking example is Jablanica. In 1973, Trajkovski reported only one Molika stem near the village Jablanica. Later on (1978), the same author recorded one other stem above the Vevchanska Lokva glacial lake. Presently, there are hundreds stems of Molika pine on these localities, which are of about 3-5 m high.

Characteristic plant species: *Alchemilla peristerica, Crocus pelistericus, Dianthus stenopetalus, Pedicularis orthantha, Viola parvula, Viola velutina, Viola doerfleri, Soldanella macedonica, Blechnum spicant, Huperzia sellago, Centaurea deustiformis, Gentiana acaulis, Gentiana lutea* subsp. *symphiandra, Knautia magnifica, Sempervivum marmoreum, Trifolium pilczii, Ranunculus incomparabilis, Tozzia alpina* subsp. *carpathica*

IUCN Red List, 1997: *Alkanna pulmonaria, Dianthus myrtinervius, Malus florentina, Pedicularis limnogena, Pinus peuce, Sempervivum octopodes, Viola eximia*

Fauna: From the invertebrates several taxonomic groups that play important role in any natural ecosystem are worth mentioning. From the order Coleoptera (Beetles), two families (Carabidae and Curculionidae) have been investigated. The total number of Carabidae is 61 taxa, of which 7 taxa (11,5%) are local endemics (*Cychrus semigranosus peristericus, Nebria aetholica peristerica, Nebria macedonica, Tapinopterus comita, Tapinopterus monastirensis, Trechus cardioderus athonis* and *Trechus goebli goebli*) and 16 taxa (26,2%) are Balkan endemics. The family

Curculionidae is represented by 35 species, including two Balkan endemics (*Phyllobius lateralis* and *Phyllobius pinicola*).

The most attractive insect group, butterflies (Rhopalocera), is represented by 91 species, of which two are Balkan endemics (*Colias caucasica* and *Erebia epiphron*). The diversity of grasshoppers (Orthoptera) is represented by 43 taxa, of which six are Balkan endemics (*Psorodonotus fieberi, Poecilimon gracilis, Metrioptera oblongicolis, Modestana ebneri, Poecilimon jonicus jonicus, Poecilimon orbelicus*).

With regard to Vertebrates (Vertebrata), the fauna of Amphibians (Amphibia) is represented by 10 species. The diversity of Reptiles (Reptilia) within the Pelister Refugial Zone is represented by a total of 15 species (one tortoise, eight lizards and six snakes).

From a zoogeographical point of view, the most conspicuous feature of Pelister herpetofauna is the lack of dominance of any particular species. The next striking feature is related to the presence of numerous endemic and subendemic taxa typical for the Balkan Peninsula, as well as the positions of the populations at the boundary of their distribution and the proximity of areas of intergradations between the closely related taxa.

The class of Birds (Aves) is also well investigated on Pelister. Recently, the total number of birds was established at 91 species. Nine of these are included in the CORINE list, and 25 species are included in the Directive for Protection of Wild Birds - Council of Europe (seven species in SPEC1, three species in SPEC2 and 15 species in SPEC3).

The mammal fauna on the Pelister Mountain is represented by 50 taxa. The level of diversity richness of the Pelister mammal fauna could be clearly understood if we compare this number with the total number of Macedonian mammal fauna (82), which gives a figure of 61%. Only a few species which are of special value for the Pelister Refugial Zone will be mentioned. The Balkan mole - *Talpa stankovici* was described from Pelister, based upon specimens collected from the humid meadows in the vicinity of the village Magarevo (type locality of the species). The Balkan mole is Balkan endemic species, with its range restricted to the zone west of the Vardar River, from Shar Planina Mt. on the north to Mount Olympus on the south.

The Bank vole *(Clethrionomys glareolus)* on Pelister Mountain is represented by the subspecies, *Clethrionomys glareolus macedonicus.* The subspecies is described on the basis of specimens collected from the locality "Kopanki". The known range of the Pelister subspecies is restricted to Pelister Mountain. The Pelister bank vole is most abundant in mixed woodlands on open terrain with dense low vegetation. Besides the type locality, the subspecies has been recorded at the localities Begova Cheshma, Jorgov Kamen, Viroi (below the peak of Pelister), Palisnopje and the village, Brajchino, on the western side of the mountain.

The Balkan pine vole (*Microtus felteni*) is described from Pelister. The range of the Balkan pine vole is restricted to the mountains of western Macedonia, which indicates that this vole is Macedonian endemic species. On Pelister Mountain, the species is most abundant within the Macedonian Pine forest belt, on open dry terrains.

The Lesser mole rat *(Nannospalax leucodon)* is represented by the subspecies, *Nannospalax leucodon macedonicus*, whose distributional area is restricted to the mountains of western Macedonia. On Pelister Mountain, the Lesser mole rat inhabits

open dry terrains with rich humus soil, from the piedmont areas to the high mountain zone, especially in alpine pastures.

Characteristic faunal species:

Amphibians: *Salamandra salamandra, Rana dalmatina, Rana graeca, Hyla arborea, Bufo viridis, Bufo bufo.*

Reptiles: *Emys orbicularis, Testudo hermanni, Lacerta agilis, Lacerta viridis, Lacerta trilineata, Podarcis taurica, Podarcis erhardii, Podarcis muralis, Anguis fragilis, Ablepharus kitaibelii, Coluber caspius, Coronella austriaca, Elaphe longissima, Elaphe quatuorlineata, Natrix natrix, Natrix tessellata, Vipera ammodytes, Vipera berus*.

Birds: *Pernis apivorus, Milvus migrans, Circaetus gallicus, Accipiter gentilis, Accipiter nisus, Accipiter brevipes, Buteo buteo, Buteo rufinus, Aquila pomarina, Aquilla chrysaetos, Falco subbuteo, Falco naumanni, Falco peregrinus, Bonasia bonasia, Alectoris graeca, Perdix perdix, Coturnix coturnix, Scolopax rusticola, Columba oenas, Columba palumbus, Cuculus canorus, Otus scops, Bubo bubo, Athene noctua, Strix aluco, Asio otus, Caprimulgus europaeus, Prunella collaris, Phoenicurus ochrurus, Phoenicurus phoenicurus, Saxicola rubetra, Saxicola torquata, Monticola saxatilis, Turdus torquatus, Turdus merula, Parus montanus, Parus ater, Passer montanus, Montifringilla nivalis, Pyrrhula pyrrhula, Pyrrhocorax graculus, Pyrrhocorax pyrrhocorax.*

Mammals: *Erinaceus concolor, Sorex minutus, Sorex araneus, Neomys fodiens, Neomys anomalus, Crocidura suaveolens, Crocidura leucodon, Talpa caeca, Talpa stankovici, Rhinolopus ferrumequinum, Rhinolophus hipposideros, Rhinolopus euryale, Rhinolopus blasii, Myotis nattereri, Myotis blythi, Myotis daubentoni, Myotis capaccinii, Pipistrellus savii, Lepus europaeus, Sciurus vulgaris, Clethrionomys glareolus makedonicus, Arvicola terrestris, Microtus rossiaemeridionalis, Microtus subterraneus, Microtus felteni, Chionomys nivalis, Apodemus flavicollis, Apodemus sylvaticus, Mus macedonicus, Nannospalax leucodon macedonicus, Myoxus glis, Muscardinus avellanarius, Dryomis nitedula, Canis lupus, Vulpes vulpes, Ursus arctos, Mustela nivalis, Mustela putorius, Martes martes, Martes foina, Meles meles, Lutra lutra, Felis silvestris, Lynx lynx, Sus scrofa, Cervus elaphus, Capreolus capreolus, Rupicapra rupicapra balcanica.*

IUCN Globally Threatened Species:

Birds: Lesser Kestrel - *Falco naumanni,*

Mammals: Wolf – *Canis lupus*, Wildcat - *Felis silvestris,* Otter – *Lutra lutra,* Mediterranean Horseshoe Bat – *Rhinolophus euryale*, Lesser Horseshoe Bat - *Rhinolophus hipposideros*, Long-fingered Bat - *Myotis capaccinii*, Lesser Mole Rat - *Nannospalax leucodon*.

Refugial forest vegetation:

- *Gentiano symphyandrae-Pinetum peucis* Ht et al. 74
- *Silene asterias- Alnetum glutinosae* prov. Em.

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

There is no model for Pelister in the regional climate scenarios. The scenario for Pelagonija - Bitola does not correspond to the high mountain region on Pelister where

the refugial zones are distributed. Thus we base predictions for the climate change impacts on an expert assessment. According to Kolchakovski (1994) upper forest border on Pelister is something above 2,300 m a.s.l. since the average July temperature (extrapolated) is 10°C (or about 1°C average annual temperature). If we use the July temperature gradient of 0.66°C, than we can calculate that the same temperature in 50 years will be on 2,700 meters a.s.l. It means that Pelister will loose its alpine belt in 50 years.

The global climate change impact in Macedonia can be explained by the example of the past and recent distribution pattern of molika pine. It is subalpine (oro-Mediterranean actually) species that forms continuous belt up to 2100 m a.s.l. There is clear tendency for spreading of the molika pine distribution on higher altitudes. It is in connection with changed climatic conditions and abandonment of the sheep and cattle breeding in this area during last 50 years. The final result is that some molika trees can be found almost on the highest peak of Pelister Mt. (2601 m). It can be concluded, if the same pattern continues, that negative effect will be posed by the climate change (the smaller available surface can be considered as threat) since the lower broader part will shift upwards.

Complex and heterogeneous fauna is present in this refugial zone due to the fact that it occupies very large altitudinal belt - starting from Mediterranean faunal elements present at the lowest parts of the mountain up to Arcto-Alpine elements in the high mountain zone. Climate change in the region will force the molika-pine forest belt to move upwards and to conquest part of the current alpine pastures' belt in which a lot of Oro-Mediterranean and Arcto-Alpine faunistic elements are preset now. In that way, a part of the natural habitats for some high mountain species will be lost and they will be threatened with extinction. These species include: (Sand Lizard - *Lacerta agilis*, Adder - *Vipera berus*, Rock/Water Pipit - *Anthus spinoleta*, Snow finch - *Montifringila nivalis*, Wall creeper - *Tichodroma muraria*, Alpine Dunnock - *Prunella collaris*, Alpine Chough - *Pyrrocorax graculus*, Red-billed Chough - *Pyrrocorax pyrrocorax*, Shore Lark - *Eremophila alpestris*, Balkan chamois - *Rupicapra rupicapra* etc.).

J. Ohrid-Prespa refugial region

Description: This refugial region covers the area between Ohrid and Prespa Lake as well as parts of the river gorge of Crn Drim and Jablanica Mt. The influence of the lakes on the climate is evident: daily and seasonal extremes are lower and the air humidity is higher. The area is under influence of modified sub-Mediterranean climate which provides conditions for development of rich flora and vegetation with presence of many relict and endemic species. The south-eastern coast of Ohrid Lake is very important from this aspect since many Mediterranean and thermophyllous trees, shrubs and herbs can be found.

The refugial forest communities occupy significant surfaces on Galichica Mt. The stands of Macedonian oak (*Quercus trojana*), Horse chestnut (*Aesculus hyppocastanum*), last remains of the destroyed Munika pine forests (*Pinus leucodermis*), subalpine thickets of *Cytisanthus radiatus* are the most important among the refugial communities.

The Prespa slopes of Galichica Mt. are characterized by the presence of several refugial communities, as well. Special attention requires the community of Greek juniper (*Juniperus excelsa*) that covers almost all of the island of Golem Grad. The relict species *Celtis glabrata* is present on the island. This species was recorded on the Prespa

lake shore in Albania. Its closest relatives are known from north-eastern parts of Bulgaria, Crimea and Asia Minor.

An interesting shrubby community of *Erica carnea* is developing on Jablanica Mt. It riches the most eastern border of its distribution range on the Balkan Peninsula. One community of the chestnut (*Castanea sativa*) and *Ruscus aculeatus* can be found in the foothills of Jablanica Mt. Other forest communities are represented by the oak and beech forests.

Characteristic plant species: *Nepeta ernesti-mayeri, Crocus cvijici, Lilium albanicum, Sideritis raeseri*, *Trifolium pilczii, Astragalus mayeri, Bupleurum mayeri*, *Centaurea galicicae*, *Centaurea tomorosii*, *Dianthus galicicae*, *Dianthus ochridanus, Edryanthus horvaii, Festuca galicicae, Helichrysum zivojinii*, *Laserpitium ochridanum, Micromeria kosaninii, Sempervivum galicicum, Alyssum subvirescens, Astragalus geremlii, Cephalaria setulifera, Coronilla vaginalis, Crepis vesicaria, Cytisus procumbens, Damasonium bourgaei, Erigeron alpinus* var. *gracilis, Gnaphalium hoppeanum, Lilium chalcedonicum, Prunus prostrata,* etc.

IUCN Red List, 1997: *Ajuga piskoi, Alkanna noneiformis, Anchusa serpentinicola, Astragalus baldaccii, Aubrieta thessala, Centaurea soskae, Erodium guicciardii, Eryngium serbicum, Jurinea taygetea, Malus florentina, Melampyrum heracleoticum, Minuartia baldaccii, Narthecium scardicum, Oxytropis purpurea, Pinus heldreichii* var. *leucodermis, Pinus peuce, Ramonda serbica, Rindera graeca*, *Soldanella pindicola*, *Viola eximia, Solenanthus scardicus.*

Fauna: Notwithstanding the relatively small size of the Ohrid-Prespa Refugial Zone, it represents a center of an extremely high level of faunistic heterogeneity. With its own 26 endemic faunistic taxa, represent a relatively restricted area with high level of endemism. Concerning the biodiversity richness, for this discussion, however, only representatives of the Order Lepidoptera (moths and butterflies) which are completely investigated will be included. Through an examination of moths and butterfly composition and diversity, we can make relatively good assumptions about the total invertebrate fauna, since butterflies are a major portion of the total composition as well as being very strong bioindicators of the status of other invertebrate groups. The Family Noctuidae (noctuid moths) is represented by 347 species, which is 75% of the entire Macedonian noctuid moth fauna (468 species [Thurner, 1964]). At first glance, this paradoxically high diversity is not impressive, because Macedonia itself has an extremely rich moth fauna compared with other countries. According to the data given by Thurner (1964), the entire country of Albania possess only 225 species of noctuid moths, which is far less than the number of species present only on Galichica Mountain itself. Another interesting fact is that, of the eight Macedonian endemic noctuid moth species, seven are present on Galichica Mountain.

The moths of the tribe Microlepidoptera are represented by 695 species (Klimesch, 1968). This is much more than the Microlepidopteran fauna of any other mountain in the Balkans or Europe. Twelve of these species are Macedonian endemic taxa, six of which are present exclusively on Galichica Mountain.

To summarize, the total number of moth and butterfly species present on Galichica Mountain is 1,644, which is an enormous concentration of butterfly diversity present in a very restricted area.

Because of their high level of composition complexity and diversity of features, the vertebrates embrace the most significant group of the Animal Kingdom.

Amphibians are represented by 10 species (Sidorovska et al., unpublished data). The species *Rana graeca*, as well as the subspecies *Bombina variegata scabra*, *Triturus vulgaris graecus* and *Triturus carnifex macedonicus* are Balkan endemics.

Reptilians on the Galichica Mountain are represented by 21 species (Petkovski et al., unpublished data). The species *Algyroides nigropunctatus*, as well as the subspecies *Testudo hermani boettgeri*, *Emys orbicularis hellenica*, *Ablepharus kitaibellii stepaneki*, *Podarcis erhardii riveti*, *Podarcis muralis albanica* and *Coluber gemonensis* are Balkan endemics.

The Birds on the Galichica Mountain (including the shore areas of the lakes Ohrid and Prespa) are represented by 260 species, which is 84% of the total Macedonian ornithofauna (Micevski, 1988, 1992, 1997, 1998; Vasić, pers. Comm.).

The Mammals, according to Petkovski & Krystufek (1998) and Krystufek & Petkovski (1999) on the Galichica Mountain are represented by 51 species, which is 62% of the total mammal fauna of Macedonia.

Characteristic faunal species:

Amphibians: *Salamandra salamandra, Rana dalmatina, Hyla arborea, Bufo viridis, Bufo bufo.*

Reptiles: *Emys orbicularis, Testudo hermanni, Lacerta viridis, Lacerta trilineata, Podarcis taurica, Podarcis erhardii, Podarcis muralis, Algyroides nigropunctatus, Anguis fragilis, Ablepharus kitaibelii, Coluber caspius, Coluber gemonensis, Coronella austriaca, Elaphe longissima, Elaphe quatuorlineata, Natrix natrix, Natrix tessellata, Vipera ammodytes*.

Birds: *Aquila heliaca, Falco naumanni, Crex crex, Milvus migrans, Haliaeetus albicilla, Neophron percnopterus, Gyps fulvus, Circaetus gallicus, Circus cyaneus, Circus macrourus, Accipiter brevipes, Buteo rufinus, Aquila pomarina, Aquila chrysaetos, Hieraaetus pennatus, Falco tinnunculus, Falco vespertinus, Falco peregrinus, Alectoris graeca, Perdix perdix, Coturnix coturnix, Burhinus oedicnemus, Tyto alba, Otus scops, Bubo bubo, Athene noctua, Asio flammeus, Caprimulgus europaeus, Alcedo atthis, Merops apiaster, Coracias garrulus, Jynx torquilla, Picus canus, Picus viridis, Riparia riparia, Hirundo rustica, Anthus campestris, Lanius collurio, Lanius minor, Lanius excubitor, Lanius senator, Phoenicurus phoenicurus, Saxicola torquata, Oenanthe hispanica, Monticola saxatilis, Hippolais pallida, Sylvia hortensis, Muscicapa striata, Emberiza cia, Emberiza hortulana, Pyrrhocorax pyrrhocorax.*

Mammals: *Erinaceus concolor, Sorex minutus, Sorex araneus, Crocidura suaveolens, Crocidura leucodon, Rhinolopus ferrumequinum, Rhinolophus hipposideros, Rhinolopus euryale, Rhinolopus blasii, Myotis capaccinii, Pipistrellus savii, Lepus europaeus, Sciurus vulgaris, Microtus subterraneus, Microtus felteni, Chionomys nivalis, Apodemus flavicollis, Apodemus sylvaticus, Dinaromys bogdanovi, Nannospalax leucodon macedonicus, Myoxus glis, Muscardinus avellanarius, Dryomis nitedula, Canis lupus, Vulpes vulpes, Ursus arctos, Mustela nivalis, Mustela putorius, Martes martes, Martes foina, Meles meles, Felis silvestris, Lynx lynx, Sus scrofa, Capreolus capreolus, Rupicapra rupicapra balcanica.*

IUCN Globally Threatened Species:

Birds: Imperial Eagle – *Aquila heliaca*, Lesser Kestrel – *Falco naumanni*, Corncrake – *Crex crex*.

Mammals: Wolf – *Canis lupus*, Wildcat – *Felis silvestris*, Mediterranean horseshoe bat - *Rhinolophus euriale,* Lesser horseshoe bat - *Rhinolophus hipposideros,* Long-fingered bat - *Myotis capaccinii,* Lesser mole rat - *Nannospalax leucodon.*

Refugial forest vegetation:

- *Quercetum trojanae macedonium phillyreo-lilietosum* Em - Galichic Mt.
- *Juglando-Aesculum hippocastani cotyledonium* Matv. et Nik.
- *Aesculo hippocastani-Aceri-Ostryetum* Em (syn.) - Galichica Mt.
- *Pruno- Celtetum glabratae* S. Jakv. end Em - Island of Golem Grad.
- *Biaro tenuilifoliae-Juniperum excelsae* prov. Em. - Island of Golem Grad.
- *Daphnidi- Cytisanthetum radiatae* Lak. et al. - Galichica Mt.
- *Ericetum carnae* prov. Em - Jablanica Mt.
- *Spiraeetum creneatae* prov. Em. - M. Galichica Mt.

Climate change induced changes of the vegetation and shift of the flora and fauna in this refugial zone

This refugial zone is located in the south-western part of Macedonia (under the dominant-continental climate influence) according to the prepared regional climate scenarios for Macedonia. (The climate in Ohrid-Prespa region is under sub-mediterranean influence from Crn Drim valley, thus the continental climate influence does not dominate.) The analysis of the climate scenarios showed that the mean annual temperature in this refugial zone will increase in 50 years for 2.0^{o}C, in average, while in 100 years for 4.0^{o}C. The winter temperatures will increase in average almost equally as the average (2.0 and 3.9 ^{o}C for 50 and 100 years), which is similar to the summer temperatures increase in 50 years, but not for the 100 years period (2.1 and 4.4 ^{o}C for 50 and 100 years). The annual sums of precipitation will decrease for 3% (50 years) and 8% (in 100 years). The decrease of precipitation is expected only for the spring, summer and autumn season (-18% in 100 years - summer), while winter precipitation will increase (+4% in 100 years). Obviously, the average decrease of precipitation in south-western part will not be that extreme like in central and southern parts of Macedonia. This region is actually characteristic because of the lowest expected changes of the temperatures compared to all other modeled regions in Macedonia, whish points out the significance of the lakes for the regulation of the temperature of the region.

The climatic conditions in this refugial region are fairly constant because of the presence of Ohrid and Prespa lakes, as well as the gorge of Crn Drim (Mediterranean influence). This is the reason that the region offers favorable condition for development of the refugial vegetation. This statement is valid for almost all refugial communities from this refugial zone, except for the community with Erica, which is high mountain community. The changes that will happen in this community are similar with those already explained in the chapter for Ecosystems - Sub-Alpine and Alpine Pastures.

Significant changes of the vertical/altitudinal gradient of the fauna belonging to different biogeographical regions are expected in this refugial zone due to the climate change impact. Mediterranean fauna will undergo the most significant movement toward the lower altitudes sites. On the other hand, penetration of the Balkan-Middle-European Forests (beech) is expected on the higher elevations causing loss of current high mountain pastures and rocky sites. Thus, the current natural habitats of many relict paleo-Balkan mountain faunistic elements will be lost leading to extinction of their characteristic faunal elements.

K. Refugial region Nidzhe-Kozhuf

Only faunal characteristics will be described since they were not elaborated in the FNC.

The most striking features of the fauna within the Nidze-Kozhuf Refuge Zone today are its richness and heterogeneity: Mediterranean faunal elements goes hand-in-hand with the faunal species of the Euro-Siberian regions, while the high mountain belts are the natural habitats of the indigenous Oro-Mediterranean fauna.

Characteristic faunal species: Amphibians: *Salamandra salamandra salamandra, Bufo bufo spinosus, Bufo viridis viridis, Hyla arborea arborea, Rana dalmatina dalmatina, Rana graeca graeca, Rana balcanica.*

Reptiles: *Testudo hermanni boettgeri, Testudo graeca ibera, Emys orbicularis hellenica, Ablepharus kitaibellii kitaibellii, Lacerta agilis bosnica, Lacerta viridis, Lacerta trilineata, Podarcis erhardii riveti, Podarcis muralis muralis, Podarcis taurica taurica, Anguis fragilis, Pseudopodus apodus, Coluber caspius, Coluber najadum, Natrix natrix, Natrix tessellata, Elaphe quatuorlineata, Elaphe longissima, Coronella austriaca, Malpolon monspessulanus, Vipera ammodytes meridionalis, Vipera berus bosniensis.* Birds: *Falco naumanni, Crex crex, Aquila heliaca, Coracias garrulus, Alectoris graeca, Caprimulgus europaeus, Lullula arborea, Lanius senator, Oenanthe hispanica, Emberiza hortulana, Emberiza melanocephala, Phoenicurus phoenicurus, Aquila chrysaetos, Falco vespertinus, Perdix perdix, Coturnix coturnix, Bubo bubo, Alauda arvensis, Anthus campestris, Pyrrhocorax pyrrhocorax, Scolopax rusticola, Buteo rufinus, Burchinus oedicnemus, Sylvia hortensis, Oriolus oriolus, Fringilla coelebs, Sitta europaea, Turdus merula, Turdus viscivorus, Turdus philomelos, Parus ater, Parus caeruleus, Corvus corax, Eremophila alpestris.*

Mammals: *Erinaceus concolor, Sorex minutus, Sorex araneus petrovi, Neomys fodiens, Crocidura leucodon, Talpa caeca, Rhinolophus mehelyi, Rhinolophus hipposideros, Rhinolopus euryale, Rhinolopus blasii, Myotis capaccinii, Nyctalus noctula, Lepus europaeus, Sciurus vulgaris, Clethrionomys glareolus makedonicus, Microtus subterraneus, Apodemus flavicollis, Apodemus sylvaticus, Rattus rattus, Myoxus glis, Muscardinus avellanarius, Dryomis nitedula, Canis lupus, Vulpes vulpes, Ursus arctos, Mustela nivalis, Mustela putorius, Martes martes, Martes foina, Meles meles, Lutra lutra, Felis silvestris, Lynx lynx, Sus scrofa, Cervus elaphus, Capreolus capreolus, Rupicapra rupicapra balcanica.*

IUCN Globally Threatened Species:

Birds: Lesser Kestrel - *Falco naumanni*, Corncrake - *Crex crex*, Imperial Eagle - *Aquila heliaca.*

Mammals: Mehely's Horseshoe Bat - Rhinolophus mehelyi, Lesser horseshoe Bat - *Rhinolophus hipposideros,* Mediterranean horseshoe Bat - *Rhinolophus euriale,* Long-fingered Bat - *Myotis capaccinii,* Wolf - *Canis lupus,* Wild Cat - *Felis silvestris.*

Other refugial communities outside of refugial zones

There are other refugial communities outside the above mentiond refugial zones. Their analysis and prognosis of changes is not possible in this phaze.

- *Bruckenthalio-Myrtillo-Fagetum* Em. - Shar Planina Mt., Jakupica Mt.
- *Roietum coriariae* Tomas. - river Vardar watershed and its tributaries

- *Spiraeetum crenatae* prov. Em. - middle flow of Vardar river
- *Carici-Alnetum glutinosae* Matv. et Nik. - Polog valley

CLIMATE CHANGE IMPACT ON LOWLAND SWAMPS AND MARSHES

Lowland swamps and marshes: Two types of wetland vegetation could be distinguished in the lowland swamps and marshes:

- First type represents plant communities that are with wide distribution and their development, floristic composition and vegetational structure is in accordance with the present climate conditions (*Scirpeto-Phragmitetum, Cyperetum longi* and others).
- Other type of wetland plant communities has completely different floristic composition and vegetational structure and they exist only on the specific sites with favorable local ecological conditions. They have relict origin and represent the remains (fragmentary distribution) of the vegetation that was widely distributed during former geological times. Owing to this, these communities can not fit into the natural succession processes, i.e. in the syndynimic of the wetland vegetation. They are very sensitive to any kind of changes and represent the most endangered habitats in Macedonia. The most important communities of this type are:
    - ass. *Caricetum elatae* subass*. lysymachietosum* – Ohrid and Struga Marshes
    - ass. *Mariscetum* - Marsh at the Negorci Spa
    - ass. *Cypero-Caricetum acutiformis* - Gostivar
    - ass. *Osmundo-Thelipteretum* - Strumica: Bansko Spa
    - ass. *Scirpo-Alopecuretum cretici* - Strumica: Monospitovo Swamp

The most important factor threatening all relict wetland plant communities is melioration (drying out) of the swamps and marshes for extending the agricultural land. As a consequence, significant drop of the ground waters happens, which in combination with lower natural inflow in the biotope (decreased precipitation quantity and higher average temperatures) favors the succession towards the recent wetland communities - *Scirpeto-Phragmitetum* or *Cyperetum longi.*

It is predicted, on the basis of models, that climate change will be the most expressed in south and southeast lowland parts of Macedonia (see: climate scenario for that region - Chapter on refugial zone Dolno Povaradrie). Decrease of precipitation will be the highest in that region. It is obvious that climate change will have the most serious impact on the lowland wetlands and they will be the most affected ecosystem type in Macedonia (together with the mountain ecosystems).

The examples of threat status and disappearance of these communities due to the anthropogenic impact could serve as a model of how the climate change will affect wetlands since the essence is the same - drop of surface and underground waters in and around the swamps and marshes.

Relict plant species in the swamps: As a result of the above-mentioned reasons the ranges of different wetland relict species are critically reduced and a trend of gradual extinction of these species exists. The low adaptational capacity resulting form their ecological narrow valence does not allow them to spread on new areas. The following plant species contribute to that list: *Carex elata, Senecio paludosus, Rumex hydrolapathum, Ranunculus lingua* (Struga and Ohrid marshes), *Cladium mariscus,*

Ophioglossum vulgatum (Gevgelija; Negoreci Spa), *Osmunda regais, Thelipteris palustris* (Strumica: Bansko), *Thelipteris palustris, Scirpus silvaticus* (Gostivar), *Glyceria maxima* (Pelagonija: village Chepigovo).

Fauna: Together with the high mountain ecosystems, wetlands and temporal waters in the lowland belt will be the second ecosystem type that will undergo the most intensive impact from climate change. Drainage of swamps and marshes in Macedonia was the way to combat malaria problem during the first half of the last century (Stanković 1925). However, the process of melioration of the wetlands did not stop till the end of the twentieth century and current situation with the wetland ecosystems in Macedonia is radically changed compared to the past. The only wetland ecosystem preserved in original form is the swamp Belchishko Blato. Other wetlands are currently represented with remains on small areas that do not resemble original swamps and marshes - very important habitats for Macedonian biodiversity. However, these habitats with degraded status still bear many globally significant faunal species with reduced abundance of populations.

Numerous relict and endemic invertebrate species using these ecosystems for the whole or a part of their life cycle will be endangered by the climate change. These are: Pelagonian fairy shrimp - *Chirocephalus pelagonicus*, Macedonian endemic species from temporary pools in Gorna Pelagonia (the last remains from previous large swamp). The Feary shrimp *Tanymastix motasi*, is distributed in the same wetlands. Macedonian endemic Cyclopoid copepods *Diacyclops pelagonicus* and *Allocyclops kieferi*, can be found in the remains of past swamp Pelagonisko Blato as well. The Ostracod crustacean species *Cypridopsis concolor* can be found only in these wetlands and the swamp at village Negorci in the frame of the whole European continent, while the species *Heterocypris hartwigi* is Macedonian endemic species existing only in one small marsh ecosystem obove the village Stracin.

The most typical inhabitants of wetland ecosystems among the vertebrates are amphibians. The increased aridity caused by the climate change, especially in the lowland belt (see: climate scenarios) will first affect marshes and small temporary waters wich are important for the life history of amphibians. The following species will be the most threatend: Macedonian Crested Newt (*Triturus carnifex macedonicus*), Common Newt (*Triturus vulgaris*), Balkan Crested Newt (*Triturus karelinii*), Yellow-Bellied Toad (*Bombina variegata*), Eastern Spadefoot (*Pelobates syriacus balcanicus*), Greek Marsh frog (*Rana balcanica*) and from Reptiles, the European Pond Terrapin (*Emys orbicularis*).

Waterfawls will be the most threatend bird category and especially the species: Collared Pranticole (*Glareola pratincola*), Common Snipe (*Gallinago gallinago*), Greylag Goose (*Anser anser*), Lapwing (*Vanellus vanellus*), Marsh Harrier (*Circus aeruginosus*), Eurasian Spoonbill (*Platelea leucorodia*), Avocet (*Recurvirostra avosetta*), Black-winged Stilt (*Himantopus himantopus*), Redshank (*Tringa totanus*), Greenshank (*Tringa nebularia*), Marsh Sandpiper (*Tringa stagnalis*), Common Sandpiper (*Tringa hypoleucos*), Savi's Warbler (*Locustella luscinicides*), Eurasian Bittern (*Botaurus stellaris*), Purple Heron (*Ardea purpurea*), Grey Heron (*Ardea cinarea*), Great White Egret (*Egretta alba*), Little Egret (*Egretta garzetta*), Squacco Heron (*Ardeola ralloides*), Black-crowned Night Heron (*Nycticorax nycticorax*), Little Bittern (*Ixobrychus minutus*), Mallard (*Anas platyrhynches*), Teal (*Anas crecca*), Pintail (*Anas acuta*), Shoveler (*Anas clypeats*), Wigeon (*Anas penelope*), Gadwall (*Anas strepera*) Garganey (*Anas querquedula*), Eurasian Curlew (*Numenius arquata*), Black-tailed Godwit (*Limosa limosa*), White Stork (*Ciconia ciconia*).

It is obvious that climate change induced draught will pose extremely negative impact on wetland communities.

TESTING AND APPLICATION OF MODELS

As mentioned before, there are no sufficient data in Macedonia for application of models that will explain in more details movement and migration patterns of communities and species in climate change conditions. The lack of data concerns both species and communities distribution and precise meteorological parameters.
Since modeling is an important tool for understanding of climate change threats to biodiversity and application of mitigation measures, it is important to establish necessary base of data and distribution maps. To overcome this problem an urgent action is needed. Thus, the action plan bellow considers data collection, mapping and modeling of changes in selected pilot areas and ecosystems as a top priority.

MONITORING

Monitoring of different component of biological diversity in Macedonia was not established so far although it is an obligation resulting from the Law on Nature Protection (Official Gazette of RM nr. 67/04). Only few sporadic examples of organized and permanent monitoring of individual species (vultures, lynx, Ohrid Lake species etc.) are undergoing or are in the phase of preparation. This monitoring is carried out by some non-governmental organizations.
In that sense, monitoring of climate change impact on biodiversity is completely absent and far from being even considered. Since it is very important to start this kind of monitoring immediately, elaboration of bioindicator species lists, study of their phenology, mapping and collection of other data, is considered as very urgent matter. As a result of this, establishment of monitoring system for climate change impact on biodiversity has received significant attention in the proposed action plan.

BIODIVERSITY AND CLIMATE CHANGE IN SOCIO-ECONOMIC CONTEXT

For the most important socio-economic context affecting biodiversity in Macedonia, see Introduction chapter - Analysis of the present status of biodiversity.
Due to the above mentioned reasons, several threats to biodiversity can be distinguished. Threats arising from economic use of biodiversity components in some cases could be considered not very significant at present condition, but in changed climate conditions their impact, coupled with worming and decrease of precipitation, becomes highly negative. The most important economic activities resulting from social status of the citizens of the country (predominately local communities and rural areas) and may have negative impact on biodiversity, as well as low law enforcement can be summarized as follows:

- Sheep breeding - high-mountain belt (alpine zone - summer pastures) and dry grasslands in hilly region (winter pastures). Currently sheep breeding in the mountains, from nature conservation point of view, is considered as an important activity for keeping the landscape diversity on a current level. However, large changes are expected in the high mountain zone as a consequence of the global

warming. In that sense, this activity will be even more important in the future to keep timber line at current altitude, but in case of dryer climate overgrazing could have negative effect on vegetation and could provoke erosion. This situation will be even more pronounced in the hilly region (winter pastures) where dryer winters are expected (see: regional climate scenarios). Although not high priority, these possibilities have to be considered and discussed with agricultural sector.

- Collection and trade of plants and mushrooms is regulated with national law and international treaties (CITES Convention). Climate change will have cumulative effect on threats arising from less sustainable use of wild medicinal and aromatic plants and mushrooms. This effect will have different intensity and various directions, depending on the species ecology, degree of change and anthropogenic pressure. Thus, targeted research and permanent monitoring is needed in order to establish measures that will be included in the existing legislation. Bilberries could serve as an example. They are used very intensively in Macedonia but the way of collection does not harm the whole plant significantly. Additionally, quotas can be set up. However, climate change will force these communities to "climb" higher in the mountains on the smaller area and less suitable habitats and they will be much more vulnerable.
- Hunting - Notwithstanding the fact that the Balkan chamois (as an example) by the Law on Hunting (Official Gazette of RM no. 20/96) is seasonally protected game species, its population is highly reduced (bellow ecological optimum) on all high mountains in Macedonia except on the Korab Mt. (due to the inaccessible terrain). Since the high mountain plant communities are highly endangered from climate change, chamois are also endangered. Urgent measures are necessary to safeguard their existence during changing climate.
- Forestry - in the chapter for ecosystems we emphasized that there will be significant changes in the coming period in the phytomass quality and quantity related to tree species redistribution in different belts. It is therefore that the sector "Forestry" has to shift forestry use practices significantly in the changing climate conditions.
- Fisheries. Water ecosystems will be changed due to the rise of temperature and decrease of precipitation, so they are considered endangered (see chapter on wetlands and lakes in this report). The general assessment of changes to fishing in open water bodies within Macedonia is negative. Drastic reductions in annual fish catch in the three natural lakes have been noted. The current trend of intensive illegal fishing does impact fish populations and leads to unbalanced ecosystem by reducing populations of one fish species while favoring others. Additional reduction of fish populations is expected in changed climate conditions. Thus, the fishing regime has to be adjusted to changing climate in the future.
- The pressure on water sources in the mountains will be higher during future changed climate conditions. Since these ecosystems are enriching overall biodiversity and are endangered by the climate change, water extraction above 1000 m elevation has to be strictly regulated.
- Road infrastructure development has extremely negative effect on habitat quality in sense of its fragmentation. Habitat fragmentation was considered as the main threat to biodiversity in National Biodiversity Strategy. Its negative effect will be more pronounced during the changing climate. In order to avoid cutting of migration routs of animals, suitable biocorridors should be protected and kept away from

degradation. For this reason precise habitat maps are vital for the whole territory of the country.

- Power lines - it is the most probable that power line network will increase in Macedonia since the use of hydropower is strategic goal of the government. Construction of accumulations will be necessary during the future dryer climate and use of water energy will definitely accompany the use of water for irrigation purposes (See; Water sector and agricultural sector). It is very important to consider the needs for migration of species during future climate change while designing the power line routs.

ADAPTATION MEASURES IN THE SENSE OF CLIMATE EXTREMES

Floods - it is expected that the spring floods frequency will increase since it was predicted that there will be more snow in mountains - 6% more precipitation, and faster melting due to the increased temperature - see Regional climate scenarios). The flood wave in the lower flows of large rivers could reach serious dimension. It is especially important that the last remains of riparian communities (Periploca, Salicetum albae-fragilis, Juglando-Platanetum etc.) in Vardar valley have to be preserved in favorable state in order to enable them to survive periodical spring floods that are expected.

Dryness - more severe and prolongated droughts are expected in Macedonia - on average 16-26% les precipitation is expected in the summer period (see regional climate scenarios). These dry periods will have significant negative impact on biodiversity.

Wild animal species inhabiting dry carbonaceous areas (Galichica, Bistra, dry grassland hilly regions etc.) will be especially affected. They will suffer from lack of drinking water. Possibilities should be investigated for additional water supply for wild animals. This measure could serve for surviving of certain plant species (refugee centers around the water supply facilities).

ADAPTATION PROJECTS - PROJECT PROPOSALS:

Analyses of the climate change impacts on biodiversity in SNC have pointed out mountain and high-mountain ecosystems, as well as aquatic - wetland ecosystems as the most threatened. Thus, the following projects are proposed as urgent measures for planning of mitigation activities:

1. Vulnerability Assessment of Wetland Ecosystems in the Republic of Macedonia under the Global Climate Change
2. Vulnerability Assessment of Mountain Ecosystems in the Republic of Macedonia under the Global Climate Changes

Project activity:	**VULNERABILITY ASSESSMENT OF WETLAND ECOSYSTEMS IN THE REPUBLIC OF MACEDONIA UNDER THE GLOBAL CLIMATE CHANGE**
Project number:	
Capacity deficit area:	
Primary develop-ment goal:	
Short description:	Wetland ecosystems are the most vulnerable category within the key ecosystems in Republic of Macedonia (along with the mountain ecosystems), since the most intensive impact of the global climate change is expected. Wetland ecosystems

comprise:

- Stagnant waters (relict lakes, glacial lakes, swamps, marshes and temporary pools)
- Running waters (springs, streams, rivers)
- Ground waters

The assessment of status of wetland ecosystems, for establishment of vulnerability level, will be developed in two phases:

I. Phase I. (24 months)

1. Analysis of physical and chemical parameters

1.1. Analysis of the chemical and physical parameters within the stagnant waters, with ecological comments

1.2. Analysis of the chemical and physical parameters within the running waters, with ecological comments

2. Current Status of Biodiversity

2.1. Current Status of Floral diversity in stagnant and running waters

2.1.1. Assessment of the status of globally significant species sensitive to climate changes (including endemic species)

2.1.2. Ascertaining a list of species, the most sensitive biodiversity indicators to climate changes

2.1.3. Investigation of distribution of sensitive species and determination of their population density

2.1.4. Elaboration of precise GIS distribution maps of rare, endemic, relict species of plants sensitive to climate change

2.1.5. Ascertaining a system of monitoring for the biodiversity indicator species, sensitive to climate change, by monitoring of their phenology.

2.1.6. Ascertaining a system of monitoring of the population status on certain algal groups, sensitive to climate change

2.2. Current Status of Faunal diversity

2.2.1. Assessment of the status of globally significant species sensitive to climate changes (including endemic species)

2.2.2. Ascertaining a list of species, the most sensitive biodiversity indicators to climate changes

2.2.3. Investigation of distribution of sensitive species and determination of their population density

2.2.4. Elaboration of precise GIS distribution maps of rare, endemic, relict species of plants sensitive to climate change

2.2.5. Ascertaining a system of monitoring for the biodiversity indicator species, sensitive to climate change, by monitoring of their ethology and life history

2.2.6. Ascertaining of conservation measures for the economically important species of the wetland ecosystems, threatened by climate change through elaboration of action plans (Globally Threatened Trout species, Carp, Barbel).

2.3. Key threats to biodiversity

3. Socio-economic context

3.1. Key economic sectors affecting wetland ecosystems

3.1.1. Fisheries

3.1.2. Introduced an Invasive Species

3.1.3. Tourism and recreation

3.1.4. Pollution of wetland ecosystems

3.1.5. Industry

3.1.6. Agriculture

3.1.7. Energy

3.1.8. Water extraction of the springs and mountain streams

3.1.8.1. Ascertaining of biological minimum in the flows of mountain streams as an

	ecological precondition for populations maintaining of the endemic and threatened species 3.1.8.2. Ascertaining of biological minimum in the springs as an ecological precondition for populations maintaining of the endemic and threatened species 4. Analysis of possible global climate change impact on wetland ecosystems 4.1. Assessment of the impact of periodic natural and induced hydrological fluctuations on biodiversity of three natural lakes in climate change context 4.2. Assessment of the impact of periodic natural and induced hydrological fluctuations on biodiversity of glacial lakes in climate change context 4.3. Assessment of the impact of periodic natural and induced hydrological fluctuations on biodiversity of mountain bogs and springs in climate change context 4.4. Assessment of the impact of periodic natural and induced hydrological fluctuations on biodiversity of lowland marshes and bogs in climate change context 4.5. Assessment of the impact of periodic natural and induced hydrological fluctuations on biodiversity of streams and rivers in climate change context 5. Existing measures and programmes for wetland ecosystems 5.1 Legislation 5.2 Protected wetland ecosystems 5.3 Non protected wetland ecosystems 6. Problem analysis **II. Phase II (12 months)** 1. Synthesis of the results from the problem analysis 2. Vulnerability assessment on wetland ecosystems 3. Recommendations for undertaking specific measures and activities for improvement of the current status	
Project activity target(s):	Vulnerability assessment and management efficiency of wetland ecosystems, for undertaking measures and activities for mitigation of negative effects, in function of biodiversity protection and sustainable development.	
Resources:	Study preparation demands active involvement of the Ministry of Environment and Physical Planning and Ministry of Agriculture, Forestry and Water Economy. The Study development should be assigned to national experts; eminent international expert should be also included	
Expected outputs:	Vulnerability assessment of separate wetland ecosystems in Republic of Macedonia prepared; Measures and activities for facing future climate change scenarios established;	
Achievements indicator(s):	Study prepared; Established functional mechanism for implementation of certain activities for biodiversity protection and sustainable use of natural resources	
Expected starting date (year)	2007	
Project duration (in months):	36	
Finance (Euros):	International consultants (10 months x 10,000) Project Manager (36 months x 2,000) Technical Assistant (2 x 36 months x 1,000) National experts (6 x 36 x 2,000) Field work - travel and subsistence Workshops (4 x 10,000) Administrative cost Campaign Printing (study, leaflets, posters etc)	 100,000 72,000 72,000 432,000 50.000 40,000 50,000 30,000

	Total:	30,000 **876,000**
Executing agency:	UNDP-Macedonia, Ministry of Environment and Physical Planning	
Stakeholders/Partners:	Research and educational institutions, NGOs, individuals	

Project activity:	**VULNERABILITY ASSESSMENT OF MOUNTAIN ECOSYSTEMS IN THE REPUBLIC OF MACEDONIA UNDER THE GLOBAL CLIMATE CHANGES**
Project number:	
Capacity deficit area:	
Primary development goal:	
Short description:	Mountain ecosystems are the most vulnerable category within the key ecosystems in Republic of Macedonia (along with wetland ecosystems), since the most intensive impact of the global climate change is expected. Mountain ecosystems comprise the following habitat types: • Mountain and high mountain forests • Mountain and high mountain heaths and shrubs • Mountain pastures and pastures on rocky terrains • High mountain pastures and pastures on rocky terrains Mountain wetland habitats will be treated in the project for wetland ecosystems. The assessment of status of mountain ecosystems, for establishment of vulnerability level, will be developed in two phases: **I. Phase I (24 months)** 1. Analysis of Regional Climatic Scenarios 2. Status of biodiversity 2.1. Assessment of the ecosystem's fragmentation as a tool for understanding of the constrains for adaptation of the mountain ecosystems against the global climate change 2.2. Assessment of the Status of floral diversity in the Mountain Ecosystems 2.2.1. Assessment of the distribution of the upper forest edge of the mountain and high mountain forests (horizontal and vertical) 2.2.1.1. Study for the reasons for die back of spruce populations 2.2.1.2. Determination of biological minimum of the flow of Adzina Reka as an ecological precondition for maintaining of the endangered spruce population 2.2.2. Assessment of the distribution of the mountain pastures and rocky terrains (horizontal and vertical) 2.2.3. Assessment of the distribution of high mountain pastures on rocky terrains (horizontal and vertical) 2.2.4. Preparation of a detailed GIS mapping and modeling of changes of mountain forests, mountain pastures as a pilot study for climate change 2.2.5. Assessment of globally significant habitats and species sensitive to climate changes (including endemic species) 2.2.6. Assessment of snow-melting changes and the vegetation that develops on the edges of the snow patches (snow caps) 2.2.7. Ascertaining a list of species, the most sensitive biodiversity indicators to climate changes, by their biogeographically origin (palaeo-balkan mountain elements; arctic-alpine elements).

	2.2.8. Ascertaining of a list of species that need "ex-situ" conservation. 2.2.9. Ascertaining of conservation measures for the economically important species of the mountain and high-mountain belt, threatened by climate changes through elaboration of action plans (bilberries). 2.2.10. Ascertaining a system of monitoring for the biodiversity indicator species, sensitive to climate change, by monitoring of their phenology. 2.2.11. Ascertaining of protected areas in mountain climate change threatened landscapes 2.2.12. Ascertaining of possible bio-corridors for movement of plant species sensitive to climate changes 2.3. Status of faunal diversity in the Mountain Ecosystems 2.3.1. Assessment of the globally significant faunal species (including endemic species) 2.3.2. Ascertaining a list of species, most sensitive biodiversity indicators to climate change, by their biogeographically origin (palaeo-balkan mountain elements; arctic-alpine elements). 2.3.3. Ascertaining a system of monitoring for the biodiversity indicator species, sensitive to climate change, by monitoring of their ethology and life history 2.3.4. Ascertaining of possible bio-corridors for migration of faunal species sensitive to climate change 2.3.5. Ascertaining of conservation measures for the economically important species of the mountain and high-mountain belt, threatened by climate change through elaboration of action plans (Balkan Chamois). 3. Analysis of the main threats to biodiversity 3.1. Socio-economic sector 3.1.1. Human effect on mountain ecosystem 3.1.2. Overgrazing 3.1.3. Hunting 3.1.4. Tourism and recreation 4. Analysis on possible global climate change impact on mountain ecosystems 4.1. Establishment of a pilot network of mountain meteorological stations (e.g. Jakupitza Mt.) with vertical and slope distribution 5. Analysis on existing measures and management programmes for mountain ecosystems 6. Legislation 6.1. Protected areas with mountain ecosystems 6.2. Non protected areas with mountain ecosystems 7. Problem analysis **II. Phase II (12 months)** 1. Synthesis of the results from the problem analysis 2. Vulnerability assessment on the mountain ecosystems 3. Recommendations for undertaking specific measures and activities for improvement of the current status
Project activity target(s):	Vulnerability assessment and management efficiency of mountain ecosystems, for undertaking measures and activities for mitigation of negative effects, in function of protection of biodiversity and sustainable development.
Resources:	Study preparation demands active involvement of the Ministry of Environment and Physical Planning and Ministry of Agriculture, Forestry and Water Economy. The Study development should be assigned to national experts; eminent international expert should be also included
Expected outputs:	Vulnerability assessment of separate mountain ecosystems in Republic of Macedonia prepared; Measures and activities for facing future climate change scenarios established; distribution GIS maps
Achievements indicator(s):	- Study prepared - Established functional mechanism for implementation of certain activities for

	biodiversity protection and sustainable use of natural resources	
Expected starting date (year)	2007	
Project duration (in months):	36	
Finance (Euros):	Obtaining and mounting of meteorological stations (10 x 5,000) International consultants (10 months x 10,000) Project Manager (36 months x 2,000) Technical Assistant (2 x 36 months x 1,000) National experts (6 x 36 x 2,000) Field work - travel and subsistence Workshops (4 x 10,000) Administrative cost Campaign Printing (study, leaflets, posters etc) **Total:**	50,000 100,000 72,000 72,000 432,000 50.000 40,000 50,000 30,000 30,000 **926,000**
Executive agency:	UNDP-Macedonia, Ministry of Environment and Physical Planning	
Stakeholders/ Partners:	Research and educational institutions, NGOs, individuals	

ACTION PLAN

The Action Plan reflects the basic determination of the government of the Republic of Macedonia to protect and conserve the biodiversity in Macedonia in terms of the forthcoming climate change. This is the main goal which was derived from the analysis of the biodiversity and vulnerability assessment in the conditions of predicted changed climate. The assessment of the possible changes of biodiversity components was performed in correlation with the predicted intensity of the change of climate parameters (temperature and precipitation) according to the climate scenarios that were elaborated for the purposes of this report.

The Action Plan contains a number of actions that are aiming towards better understanding of the problems concerning biodiversity in the conditions of changed climate. The final goal of these actions is to implement effective measure for the future. Some of the proposed actions are more specific and determine the activities that will ensure improvement of the protection of some species that will be most severely affected by the climate change, while some are more general (they have to establish a basis for implementing other actions). The proposed actions are tool for implementation of the measures for the mitigation of the adverse effects caused by the climate change on biodiversity. These actions were proposed on the basis of the list of identified problems during the analysis (in total 10 problems were identified) and the established goals for solving the problems.

The analyses showed that the climate change will have more significant impact on the ecosystems and regions of the mountainous areas (especially high mountain areas) as well as lowland wetland ecosystems (swamps and marshes). Thus, the greatest attention in the Action Plan was paid to these ecosystems.

It should be stressed out that the Action Plan does not reflect the modern trends in the developed world or activities that are usually proposed in recent times. The basic goal

of the Action Plan is to solve the basic problems concerning the biodiversity conservation in the climate change conditions in our country i.e. to provide conditions to establish more specific measures. The Action Plan does not contain all of the recommendations of the Convention of biological diversity. However, it is in full accordance with the National Strategy on Biodiversity and its Action Plan.
Beside above, the actions in the Action Plan are prioritized according to the needs of their implementation. The responsible institution(s) and approximate budget was defined for all of the actions, as well.

Priority
Each individual action is given relative priority in three levels marked from I to III:

I - the highest priority - the action should be undertaken immediately;
II - intermediate priroty - the action should be taken in mid term period, mostly after completition of high priority actions;
III - the lowest level of priority - the action should be undertaken on the long term basis.

For definition of priority, several criteria were used:

- the connection of action with the most vulnerable biodiversity components, defined in the textual part of this report,
- emergency level,
- the impact of undertaking the action on implementation of other action(s),
- financial implikations, etc.

Budget
The budget for each action was assessed through approximate cost categories. These categories gives rough estimation of funds needed for fulfillment of actions:

category I: up to 100.000 Eur
category II: from 100.000 to 500.000 Eur
category III: over 500.000 Eur

Action plan for mitigation of effects of global climate change on biodivrsity							
	Identified problem	**Necessary measures**	**Action**	**Priority**	**Responsible institution**	**Time period**	**Budget**
1.	Lack of data for precize distribution of different species, population density and abundance; Vegetational map - communities and habitats; Unsufficient definition of biogeographical characteristics of Macedonian territory (**aim/goal**: exiding the problem of data deficiency)	Collection od data necessary for assessment of the basic component of biodiveristy in biogeographical context	Defining sensitive species in relation to climate change	I	MoEPP, Scientific inst., NGOs	2007/08	I
			Protection of populations of economically important species in high mountain belt threatened by the climate change through elaboration of action plans for bilberries and chamois	I	MoEPP, Scientific inst., National parks	2007/08	II
			Investigation of distribution of sensitive species, determination of their population density	I	Scientific inst., National parks, NGOs, MoEPP	2008/09	II
		Collection od data necessary for assessment of the basic component of biodiveristy - communities and habitats	Charmonisation of vegetational types with European classifications (EU Habitat Directive)	I	Scientific inst., NGOs, MoEPP	2007	I
			Elaboration of vegetational map and habitat map(s)	I	Scientific inst., NGOs, MoEPP	2008>	III
			Detailed maping and modeling of the changes of Kermes oak and Pubescent oak forests as a pilot study for climate change	I	Scientific inst., NGOs, MoEPP	2008/2010	II
		Collection od data necessary for assessment of the basic component of biodiveristy - species	Elaboration of precize distribution maps of rare, endemic, relict species of plants, animals and fungy, sensitive to climate change	II	Scientific inst., NGOs, MoEPP	2009/2010	II
			Monitoring of the melting of snow patches and changes of the vegetation close to them, as well as monitoring of plant speces connected to the snow melting	II	Scientific inst., National parks, NGOs	2008>	II
			Monitoring of population status of different important animal groups	II	Scientific inst., National parks, NGOs	2008>	II
			Monitoring of population status of different algal and fungal groups	II	Scientific inst., National parks, NGOs	2008>	II
2.	Monitoring system of climate	Establishment of bioindicators	Elaboration of the list of bioindicator species on	I	Scientific inst.,	2008	I

	change impact on biodiversity does not exist (**aim/goal**: establishment of such monitoring system)	species sensitive to climate change (target species - "key-stone species" and "flag species") and study of the phenology of these species	the basis of their biogeographic distribution		NGOs, MoEPP		
			Study of the fenology of the defined species	II	Scientific inst., National parks, NGOs	2008>	II
			Establishment of a system for monitoring the status of biodiveristy components through monitoring of the fenology of bioindicator species	III	MoEPP Scientific inst., National parks, NGOs	2010	I
3.	"Ex sity" conservation of wild species threatened by the climate change does not exist (**aim/goal**: establishement of "ex situ" conservation)	Establishement of sustainable system for "ex situ" conservation	Elaboration of list of species for which "ex situ" conservation is necessary	II	MoEPP, MAFWE, Scientific inst.	2008	I
			Implementation of measures from National Biodiversity Strategy and Action Plan concerning "ex situ" conservation (measures B.1. and B.2.)	I	MoEPP, MAFWE	Kontinuira no	n/a
4.	Spatial plan does not consider consequences of climate change (**aim/goal**: spatial planning considers climate change impacts)	Halting the proces of habitat fragmentation	Assessment of ecosystems' fragmentation in RM as a tool for understanding of obstacles for adaptation of ecosystems against global climate change	II	MoEPP, Scientific inst.	2008	II
5.	Suitable network of meteorolo-gical stations does not exist in RM (**aim/goal**: increasing the number of stations)	Establichment of suiteable network of meteorological stations	Establishement of a pilot network of mountain meteorological stations (e.g. Jakupica Mt.) - vertical and slope distribution	I	Scientific inst., MAFWE -UHMR	2007/08	II
6.	Lack of awarenes rising about climate change impact on biodiversity (**aim/goal**: rising of awarenes level)	Rising of public and decision makers awarenes level concerning the climate change impacts	Preparation and printing of leaflets and borshures	I	MoEPP, NGOs	2007>	I
7.	Water extraction in mountains is not regulated (**aim/goal**: water estraction in mountains is strictly regulated)	Implementation of this issue in the legislation throug pilot case studies	Determinatin of biological minimum of Ad`ina Reka as an ecological precondition for maintaining endangered spruce poplulation in the region	I	MoEPP, Scientific inst., MAFW-UHMR	2007/09	I
			Study for the reasons for die back of spruce populations	I	Scientific inst., NP "Mavrovo", MAFW, MoEPP	2007/08	II
			Assessment of the impact of reservoirs in the gorges of larger rivers in RM (Treska, Crna Reka, Zletovska Reka) on biodiversity in climate change context	II	Scientific inst., MoEPP, MAFW-UHMR	2007/09	II
8.	Problem of periodic natural and	Finding out the real current situation	Assessment of the impact of periodic natural and	II	Scientific inst.,	2007/09	III

	induced hydrological fluctuations that led to changes of ecological characteristics in natural lakes, swamps, bogs and their surrounding (**aim/goal**: uderstanding the connection of this problem with climate change and setting up necessary measures)	of the components of biological diversity	induced hydrological fluctuations on biodiversity of three natural lakes in climate change context		MoEPP, MAFW-UHMR		
			Assessment of the impact of periodic natural and induced hydrological fluctuations on biodiversity of glacial lakes in climate change context	II	Scientific inst., MoEPP	2007/09	I
			Assessment of the impact of periodic natural and induced hydrological fluctuations on biodiversity of mountain bogs and springs in climate change context	II	Scientific inst., MoEPP	2007/09	I
			Assessment of the impact of periodic natural and induced hydrological fluctuations on biodiversity of lowland marshes and bogs in climate change context	II	Scientific inst., MoEPP	2007/09	I
			Assessment of the impact of induced floods on Tamaris shrublands, willow woodlands with poplar and Periploca in the region of Gevgelija	II	Scientific inst., MoEPP	2007/09	I
9.	Impact of climate change on mountain ecosystems (**aim/goal**: understanding of changes and precize prediction in order to undertake direct measures for mitigation)	Collection of data with regard modeling of changes induced by the climate change	Monitoring of the status of upper forest border (vertical and horizontal spreading of the forest species ranges and migration of animals)	II	Scientific inst., MoEPP	2007>	II
			Detailed maping and modeling of the changes of some mountain pasture types as a pilot study for climate change	I	Scientific inst., NGOs, MoEPP	2008/2010	II
10.	Unsufficient capacities - systemic, institucional and individual (**aim/goal**: increasing capacities at all levels)	Improvement of the protected areas' system with regard mitigation of negative climate change impacts	Establishing of protected areas in climate change threatened landscapes	III	MoEPP, Scientific inst., NGOs	2009>	III
			Definition of possible routes (biocorridors) for movement and migration of threatened plant and animal species by the climate change	II	Scientific inst., NGOs, MoEPP	2008/09	II
			Establishing protected areas of category V and VI on the main corridors previously defined	II	Scientific inst., NGOs, MoEPP	2009/10	II
		Capacity building	Training of specialized staff in the MoEPP, scientific and professional insitutions	I	Scientific inst., NGOs, foreign experts	2007>	I
			Purchase of software	I	MoEPP, Scientific inst.	2007	I
			Establishing of data base	II	MoEPP	2008	I
			Establishing of a department for paleobotany	II	Min. od Edu. and	2008/2009	II

					Scinece, Min. of Culture, Natural History Museum of RM		
			Establishing of an intersectoral body among the administrations that have the responsibility for managing water resources and biodiversity, with a strategy for activities	I	MoEPP, MAFW	2007	I

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