Deliverable D5.11 Report on the Biodiversity societal benefit area

Title	Report on the Biodiversity societal benefit area
Creator	AZBOS, ITU, SPSU, TNU
Creation date	19.02.2013
Date of revisions	
Subject	Biodiversity societal benefit area
Status	Draft
Type	Word document
Description	The report present the outputs of the projecrt linked to the Biodiversity SBA
Contributor(s)	Josef Chernichko (AZBOS), Viktor Demchenko (AZBOS), Elena Diadicheva (AZBOS), Oleg Dyakov (AZBOS), Elena Zhmud (AZBOS), Mikhail Zhmud (AZBOS), Yury Karmyshev (AZBOS), Yury Moskalenko (AZBOS), Sergey Podorozhny (AZBOS), Nikolay Rozhenko (AZBOS), Roman Sizo (AZBOS), Sergey Suchkov (AZBOS), Svetlana Vinokurova (AZBOS), Yury Andryushchenko (AZBOS), Volodimir Vorovko (AZBOS), Olga Oreshkova (AZBOS), Kristina Aleynikova (AZBOS), Natalia Demchenko (AZBOS), Filiz Bektaş Balçık (ITU), Çiğdem Göksel (ITU), Seval Sözen (ITU), Ahmet Özgür Doğru (ITU), Vadim Panov (SPSU), Boris Alexandrov (OBIBSS), Mikhail Son (OBIBSS), Vitaly Semenchenko (SPCB), Momir Paunovic (IBISS), Tatiana Bobra (TNU), Alexander Lychak (TNU), Grigoriy Prokopov (TNU), Alexander Rudyk (TNU), Irina Gluchenko (TNU), Viktor Smirnov (TNU), Marina Lukinova (TNU)
Rights	Public
Identifier	EnviroGRIDS_D5.11
Language	English
Relation	EnviroGRIDS_D5.1, EnviroGRIDS_D5.4, EnviroGRIDS_D5.10

Executive summary

The industrialization, irregular and unplanned urbanization and uncontrolled population increase have affected the natural resources all around the world and in the Black Sea Region. The conservation and sustainable management of natural resources and services and biodiversity are very important global problems. There is an urgent need to develop efficient methods to monitor and to determine special ecosystem types to conserve the natural balance. Many different research studies have been applied on special ecosystem types for last decades due to their sensitivity (Magurran, 1988, 2004; Kavgaci et al., 2007).

The presented final deliverable D5.11 is multi-aspect. Such a diversified structure of the deliverable is determined by the nature of such monitoring object as biodiversity, its response to climate and human impacts at the level of individual species and whole communities. Following parts of the executive summary indicate the main scope and results of the executed casestudies within Work Package 5 related with this Deliverable.

Monitoring of biodiversity on the example of indicator species and communities at the Azov-Black Sea coast of Ukraine

The given results are based both on retrospective data and researches in the project framework on more than 50 monitoring plots of the Ukrainian part of the Azov-Black Sea coast of Ukraine located in deltas of the Danube and Dniester, at the coast of Tendrovskyi Bay of the Black Sea, Syvash, Utliukskyi and Molochnyi Liman and on unique spits of the Azov area. The studies included about 20 indicator species and several indicator communities.

Analysis of these data, based on general EnviroGRIDS project objectives was built according to the following scheme: drivers, their direction and extent; current state; estimation of impact on indicator species and communities; socio-economic prognoses; possible response management decisions (Drivers – State – Pressure – Impact – Responsible – DSPIR).

The research (monitoring) outputs within the project are structured in separate blocks depending on an end result of the impact. It was demonstrated how the direction and force of impacts differ for particular climate drivers. Thus, increase of temperature has a positive impact on biomass growth and general productivity of communities. On the other hand, high summer temperatures sharply reduce the activity of many terrestrial organisms and induce changes in wetlands quality. The similar concerns can also be considered for air humidity, increase of precipitation. Increase of humidity has a positive impact on vegetation communities and their productivity though inhibits the imagoes activity and retards their development.

The climate warming favoured extension of species ranges to the north-east in inland Ukraine as far as 400-600 km which is shown on the example of indicator species (the seathorn hawk-moth, dice snake), and also expansion of the northern edge of the wintering area for some wader species (avocet, dunlin, grey plover, etc.) starting from the Mediterranean area and South-Western Black Sea coast to a chain of wetlands in the North Black Sea and Azov regions.

Increase of average monthly temperatures in the region (from 0.5 to 2.5^{o} C in different seasons), sharp increase of summer insolation with fluctuation of seasonal humidity and precipitation sum demonstrate reliable correlations of earlier development and activity of insects from 2 to 8 weeks and growth of their numbers. Positive influence of temperature increase is shown on the example of productivity of the reed, meadow vegetation communities, most of indicator fish species. Additionally, a negative impact of high summer temperatures on physiological activity and changes in phenotypical structure of an indicator species *Lacerta agilis* are also shown in this report.

Against a gradual degradation of such ecotone ecosystems as coastal salt marshes (because of their drying-out) and depletion of species composition of bird dwelled in them there is increase of runoff of large rivers of the Azov Sea Basin along with the rise of sea level. All this had led to a partial freshening of the sea and changes in ichtyocoenoses.

Certain results were received on phenology of indicator species of plants, insects, fish and birds. For example, there were proved trends of changes in migration characteristics of long-distance bird migrants *Anser albifrons* and *Philomachus pugnax*. It is evident from an early start of migration, accelerated gain of departure mass and late return from breeding grounds – as a consequence of bird response to the warming and earlier start of suitable breeding conditions in Arctic tundra and boreal latitudes.

Trends of temperature increase, if retain for decades, will lead to significant changes in the structure of Afro-Eurasian migratory routes of birds, with ecological and medical-biological consequences for humans.

Expected (prognosticated) socio-economic effects induced by changes in numbers, productivity and phenology of particular species or communities are minutely reviewed at various taxonomical levels and groups.

The results of the research simplify the organization of further biodiversity monitoring and give an essential impetus for the sustainable management and anticipatory decision-making.

Each subsection of the first part of the report contains the original factual material received in the process of monitoring of indicator species and communities.

Forest biocoenoses

Forest biocoenoses play an important regulatory and stabilizing role in the biosphere. They are a powerful regulator of water and heat balance, regulate and maintain the gas composition of the atmosphere, reproduce resources and preserve the environment, being as well centers of biological diversity. The deliverable includes two case studies of forest coenoses of different type, located in the Black Sea region. These are **Iğneada alluvial flooded forest in Turkey** and **mountain forests in the Crimea, Ukraine**.

Flooded forests (Iğneada, Turkey)

Flooded (alluvial/longos) forests are one of the important ecosystems of the Earth because of biological diversity, natural functions and financial values they have. The coverage of flooded forests has been decreased in all around the world because of heavy anthropogenic and human induced affects. There is a huge need to investigate these ecosystems and define their function. As a result of this awareness, many studies of floodplain forests have been conducted for elaborating biodiversity, function and their importance.

Selected test region, İğneada, is very valuable, in terms of ecosystem diversity. The rich flora and fauna distribution makes İğneada longos forests more important and sensible. Flooded (alluvial/longos) forests in İğneada are natural conservation areas but they are under threat of different factors. As a result of the intensive forestry, grazing, illegal cutting, uncontrolled tourism activities and unpredictable population growth the structure of the flooded forests in the region has been particularly damaged. Because of this, İğneada Flooded Forests and its surrounding environments have priority for sustainable protection and management. In this project, at the first stage, all related information about flora and fauna of the different İğneada Ecosystems were gathered and documented based on variety of scientific reports, published thesis and articles. Therefore, remote sensing technology used to derive land use and land cover categories of the region. Temporal satellite images were used to determine land use/cover change detection in the selected region. The results were used to analyze the role of the human induced effect in the area.

Floodplain forests in Turkey have an important role in the regional scale and knowledge of them is crucial for management and conservation of very rich and sensitive ecosystems. İğneada flooded forest is very valuable and unique, in terms of ecosystem diversity. It is one of the protected and wildlife management areas on the Thracian Black Sea coast (2,500 ha). Increased awareness of sensitive environment functions and benefits has shifted İğneada flooded forests and its surrounding environments to the forefront of conservation science. As a result of this conservation, documentation of sensitive ecosystems, analyze the impact of loss and degradation and management of these region have expanded. In order to conserve the ecological balance of the world, sensitive ecosystems such as flooded forests, wetlands and sand dunes have to be managed, developed and conserved. In this study, the biodiversity of İgneada was elaborated. In addition, a current national policy on management of biodiversity in selected region was reported based on conservation categories. At the last stage the coverage of sensitive environment was determined by using freely available temporal Landsat 5 TM data. Different change detection methods were conducted to delineate land cover changes occurred in the region because of human induced affects. The results show that a little increase in the barren and urban lands occured in İğneada. Main maps produced within this case study were published through İTU EnviroGRIDS Geoserver (http://160.75.13.13:8080/geoserver/web/).

Mountain forests (Crimea, Ukraine)

In Crimea, forests occupy 270 thousand hectares, about 10% of the region territory and are concentrated in the mountains. In Crimea, oak forests of relatively low soil quality dominate. However, they are on the edge of their distribution, so in environmental terms are very vulnerable.

At the same time, the role of forests of the mountain area for the environmental status of the region, as well as the industrial south of Ukraine and all of southern Europe, is difficult to overestimate. This is explained by the fact that they are the factor in the formation and regulation of water balance, have a high potential of self-purification, and neutralize in the biological cycle pollutants coming from the cross-border transfer, are the South-European Centre for Biodiversity and the storage of the gene pool (as in contrast to the Mediterranean forests they have mostly preserved natural state).

This case study contains the results of studies of mountain forest ecosystem, carried out in the territory of one of the largest nature reserves in Crimea – Yalta Mountain Forest Nature Reserve, as well as other test areas. It gives landscape and ecological characteristics of the study area, accompanied by a series of maps of the propagation of rare species of plants and animals, and plant communities; phytopathological situation, landscape organization, etc. (Database and maps are shown on GeoServer TNU http://envirogrids.crimea.edu/ http://80.245.119.241/geoserver/web/. *All maps in WGS1984 projection*).

Investigation of vertical and spatial structure of forest ecosystems were conducted using a variety of field (stationary, semi stationary and expedition) and laboratory data collection, processing and visualization of data, GIS methods (software – ENVI 4, ArcView 3.2, ArcGIS 10), remote sensing of Earth and satellite image interpretation SPOT4, NOAA, Landsat 7-ETM, aerial images. The state environmental policy and legal framework of biological diversity were analyzed, the structure and content of the environmental monitoring of forest ecosystems in the mountain Crimea was shown. There were identified the main threats to the conservation of biological diversity in forest ecosystems of the mountain area and clear up the problem of regional management of mountain forest areas.

Generally, the factors that determine the ecological status of the Crimean forests are:

• lack of moisture for 6-7 months, which is not conducive to natural regeneration by seeds;

• periodic massive damage of leaves and young plants by phytopathogenic entomofauna, rodents and rabbits, as well as eating the seeds and seedlings by other animals;

• frequent fires;

• long-term (for 2-3 ages) human impact: logging, trampling of soil, grass and undergrowth;

• high recreational and tourist load;

• air pollution (mainly through cross-border transfer).

Invasive alien species

Human-mediated introductions of invasive alien species (IAS) are increasing environmental pressure for the Black Sea region, which need to be properly estimated and relevant management actions should be implemented at the regional and national levels. In order to address IAS-related issues and contribute to relevant capacity-building on the regional level, with support of EnviroGRIDS project we collected relevant information on aquatic and terrestrial invasions in the Black Sea Catchment area. This information is stored in relevant databases, including those hosted by the the Regional Euro-Asian Biological Invasions Centre (REABIC), and conducted analysis of trends in IAS introductions for selected aquatic and terrestrial ecosystems.

Information stored in this database was further used for estimation of relevant IAS-related environmental indicators for main assessment units within the Black Sea Catchment area, including Black Sea itself, and river basins of three main tributaries to the Black Sea – Danube, Dnieper and Don Rivers. Specifically, in this report we are presenting our analysis of *Trends of alien species invasions,* which is recognized as main IAS-related environmental indicator for Europe. Trends of alien species invasions were estimated for non-native fish and invertebrates for the Black Sea (Ukrainian part), Danube, Dnieper and Don River Basins. This indicator is useful both for assessment of the ecosystem state in regard of IAS introductions, and as indicator of the effectiveness of preventive management options.

Our analysis of collected information on historical records of aquatic alien species indicated that during last two decades rates of new species introductions in the Black Sea and its main tributaries increased substantially. Increasing shipping activities, canals and aquaculture in the Black Sea and its basin during last 2-3 decades are considered as main reasons of this drastic increase. In case if no relevant management options implemented, new introductions of IAS are expected along with related negative ecological and socio-economic consequences. In addition, in this report we review some cases of terrestrial introductions.

ABBREVIATIONS

ANOVA	**:** Analysis of Variance
ARC	: Autonomous Republic of Crimea
AZBOS	: Azov-Black Sea Ornithological Station (Ukraine)
DBR	: Danube Biosphere Reserve
DHMO	: Danube Hydrometeorological Observatory
DN	**:** Digital Numbers
DOS	**:** Dark Object Subtraction
DSI	: Development Stability Index
DSPIR	: The scheme “Drivers – State – Pressure – Impact – Responsible”
GCPs	**:** Ground Control Points
GEF	**:** The Global Environment Facility
GIS	: Geographic Information System
IAS	: Invasive alien species
ISODATA	**:** The Iterative Self-Organizing Data Analysis Technique
ITU	: Istanbul Technical University (Turkey)
IUCN	**:** International Union for Conservation of Nature
KLES	: Karadag Landscape Ecological Station
MED	: Marine edge of the delta
MFNR	: Mountain Forest Nature Reserve
ML	**:** Maximum Likelihood
MSAVI	**:** Modified Soil Adjusted Vegetation Index
NDVI	**:** Normalized Difference Vegetation Index
NGOs	: Non-governmental organizations
ODKBD	: Outer delta of Kiliya Branch of the Danube
ONU	: Odessa National University named by I.I. Mechnikov (Ukraine)

PC	: Projective cover
PCA	: Principle Component Analysis
PFS	: Protected Fauna Species
PVI	: Perpendicular Vegetation Index
RMSE	: Root Mean Square Error
ROM	: Regional Ornithological Monitoring
RVI	**:** Ratio Vegetation Index
REABIC	: Regional Euro-Asian Biological Invasions Centre
RWMC	: the Regional Waterbird Monitoring Service
SAVI	**:** Soil Adjusted Vegetation Index
SPFS	**:** Strickly Protected Fauna Species
SPSU	: St. Petersburg State University (Russia)
SWOT	**:** Strengths, Weakness, Opportunities and Threats
SZP	: Stensivsko-Zhebrianski Plavni (territory in the Ukrainian Danube Delta)
TM	: Thematic Mapper
TNU	: Tavrida National University
TPC	: Total projective cover
UISK	: Karst Research Institute
UTM	**:** Universal Transvers Mercator
WWF	**:** World Wildlife Fund
YMFNR	: Yalta Mountain Forest Nature Reserve

Table of Contents

List of Figures

List of Tables

Introduction

The preparation of the final deliverable D5.11 involved four partners of the EnviroGRIDS project: AZBOS, ITU, SPSU and TNU. The work of the AZBOS collective was focused on the estimation of changes in biodiversity under climatic and other factors, and the prognostic development of expected ecological and socio-economical effects of these changes.

The work was based on the selected number of indicator species among higher plants (including several key vegetation communities), insects, hydrobionts, fish (including ecological groups), reptiles, birds and mammals, monitoring of which allowed to estimate the impact of climate and some other anthropogenic factors mostly related to land use and water use.

Taking into account the vulnerability of ecotone communities to climate factors, for them, within the Azov-Black Sea coast of Ukraine monitoring plots, were chosen where working programmes were realized to study indicator species or communities. During these monitoring works there was refined the list of indicator species, optimized the number of monitoring plots, tested methods and set of parameters. The main parameters of monitoring constitute the number, productivity (biomass) and population structure (including phenotypical), and phenology. A separate data block was connected with changes in sizes and zones of habitations, integrating in GIS-formats on geographical basis.

All the above-mentioned approaches allowed to implement, practically in the complete volume, the foreseen monitoring research and obtain interesting data how the state of population and communities depend on the impact of different factors. Analysis of these data, basing on general EnviroGRIDS project objectives was built according to the following scheme: drivers, their direction and extent; current state; estimation of impact on indicator species and communities; socio-economic prognoses; possible response management decisions (**D**rivers – **S**tate – **P**ressure – **I**mpact – **R**esponsible – DSPIR).

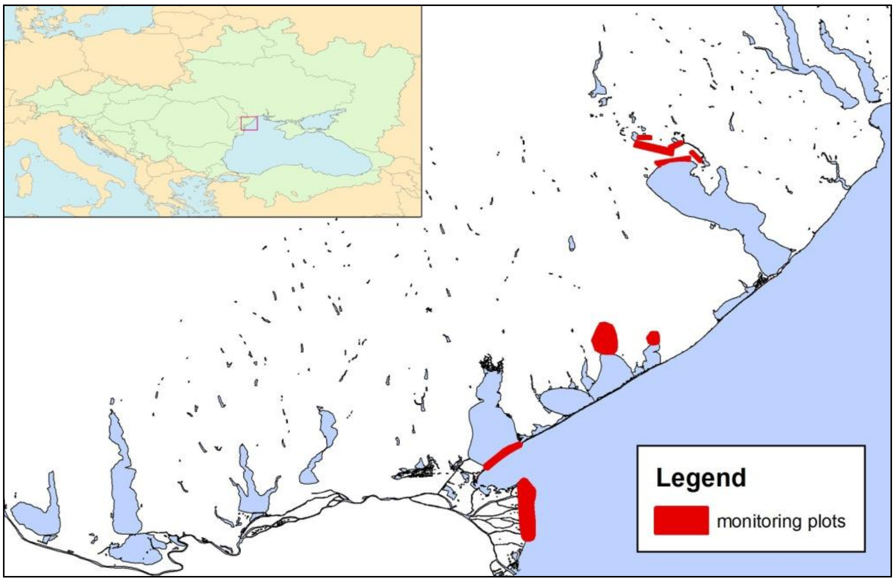
A part of investigations on the dynamics of the marine edge of the Danube Delta and transformation of adjacent areas of the coast was carried out with participation of experts from the Danube Hydrometeorological Observatory (DHMO) and Environmental Monitoring Centre of Odesa National University (ONU), partners of EnviroGRIDS project.

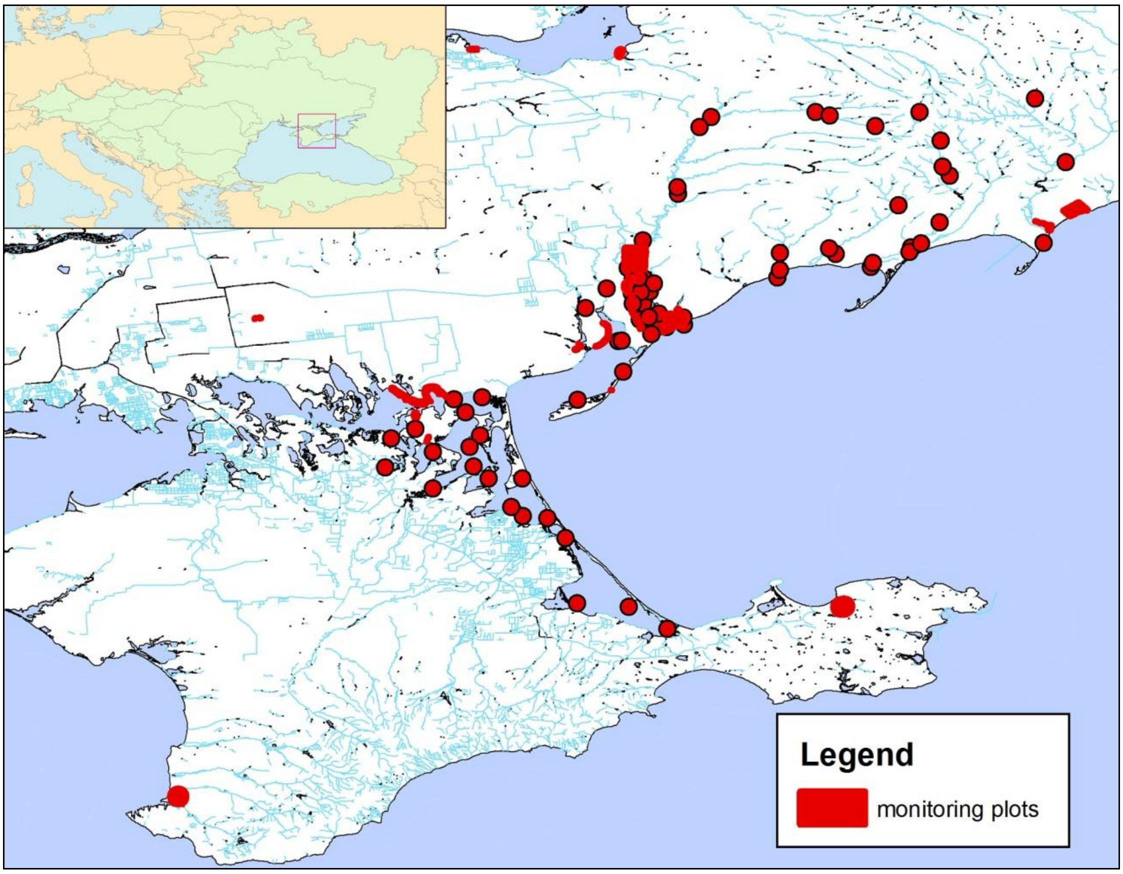
Since, due to objective reasons, we could not cover the whole territory to analyze all the directions of biodiversity changes and all the indicator species, we have used a principle of control monitoring plots. The control plots were selected in different parts of the Azov-Black Sea Region of Ukraine taking into account the specific characteristics of a particular indicator species and the task formulated.

To estimate the state of ecosystems of the Azov Sea, changes in the sea productivity and hydroecological indices we have used a system of numerous stations for taking samples along all the seacoast instead of concentrating efforts on several plots.

In the process of fieldworks the validity of monitoring plots was estimated and, if needed, corrections were made (ineffective plots were excluded from research or replaced with others). The final variant of location of the monitoring plots which data laid in the ground of this deliverable is shown in Figure.

The presented results reflected all the variety of impacts of changing climatic indices, both at the level of particular species, indicators of direction and extent of impact, and at the level of communities. Especially obvious were changes at the level of vegetation communities in delta ecosystems of large and small rivers, and also in rare steppe communities and vulnerable meadow communities.





Distribution of the monitoring plots

Well-expressed changes are described for bird wintering communities. Substantial changes happen with the Azov Sea, unique in its shallowness and high productivity. Practically in all the situations there was analyzed the interaction of climatic and anthropogenic factors which, in most cases, aggravated the state of species and communities. The obtained results of estimation in changes of biodiversity (in spite of the fact that many of them estimate only the initial stage of trends) will be continued with analysis of various socio-economic effects of the observed changes. This concerns not only the branches connected with use of nature resources (irreversible water use, fishing, hunting, harvesting of vegetation resources, grazing, etc.) but also indirect consequences for recreation and land use.

The obtained results can be essentially helpful for the development of future management-plans for valuable nature complexes, and for the protection and reproduction of reversible nature resources, the development of adaptation strategies to expected changes. In this respect, we see certain perspectives for the follow-up of the initiated monitoring research. It emphasizes the importance of EnviroGRIDS project which served as a trigger for launching several directions of monitoring works within the Azov-Black Sea coast of Ukraine where detail investigations and biodiversity control is still poor budgeted from governmental sources.

Understanding the importance of public, and especially decision-makers, awareness of changes in biodiversity under the impact of different factors, in this deliverable we also elucidate the current communication mechanisms and also the possibilities of information dissemination which were designed or reinforced within the project.

In this final deliverable some materials are intentionally abridged in text and illustrations, since they were explicitly represented in the previous deliverable D5.1. Fist of all, it relates to the retrospective analysis of the previous state of biodiversity in the region and impact of different factors, description of all the monitoring plots, schemes and parameters of monitoring. These D5.1 materials can be addressed for more details of monitoring and other specifics of its organization.

1 Assessment of biodiversity in the Black Sea wetlands at the level of indicator species and communities (AZBOS)

1.1 Analysis of main biodiversity drivers

1.1.1 Current situation and trends of main climate indices at the Azov-Black Sea coast of Ukraine

In spite of ambiguity of climate predictions, developed for the Black Sea area, we can notice certain trends of recent decades for temperature and, in lesser extent, for humidity. It is natural, that variability range of these factors differs in details even within the region, but general trends are similar. In whole, increase of average air temperature at coastal stations for the last 30 years constituted 0.42-0.55 ^{o}C per each 10 years (Hydrometeorological conditions… , 2009).

Changes in climate indices are shown on the example of Bekhtery meteostation data (Kherson region, Ukraine), located in the centre of the Azov-Black Sea coast.

To analyse dynamics of meteorological conditions the following indices were used: average annual, average seasonal and average monthly temperatures, sums of positive temperatures, annual and seasonal precipitation sums. To estimate the integrated influence of temperature and humidity on indicator communities and species the hydrothermal coefficient was used.

Hydrothermal coefficient was calculated by formula:

$$C=10*R_{ef}/\Sigma t_{ef},$$

where: C – hydrothermal coefficient; R_{ef} – annual precipitation (rainfall) sum for the temperature-effective period (i.e. period with average diurnal temperatures 10ºC and higher), mm; Σt_{ef} – sum of effective temperatures (i.e. annual sum of average diurnal temperatures equalling or exceeding 10ºC).

Average annual temperature

Average annual temperature for the last 30 years has a pronounced increasing trend. Thus, in the first decade of the considered period (1981-1990) cool years dominated, with average annual temperature lower than long-term values (+10.6º), and two of these years -1985 and 1987 -were extremely cool (average annual temperature was, correspondingly, +8.2º and +8.4ºC).

In the second decade (1991-2000), warm years dominated (average annual temperature of warm years slightly exceeded the average long-term norm). At the same time, average annual temperature of the coolest years of this decade was, nevertheless, substantially higher than that in extremely cold years of the first decade.

Over the period 2001-2011 the values of average annual temperature were, as a rule, essentially higher than average long-term values. The exception was 2003, 2006 and 2010. Also, it should be noted that in 2007 it was registered the highest value of average annual temperature – +12.6^{o}C.

Analysis of temperature per seasons

Warming trends are also well traced at the level of particular seasons (Figure 1.1.1, 1.1.2-1.1.6). At the same time, for winter season (December-February), with average long-term temperature of *-0,3ºC*, it is sooner the reduction of cold seasons and growth in number of seasons close to the norm than the noticeable increase in frequency of warm winters (Figure 1.1.1).

It should be also mentioned that in recent years (since 2010) there is not sharp but pronounced declining trend in the average temperature of winter season.

Spring and summer have a common pattern of substantial increase in frequency of warm seasons. With long-term values of spring temperature (March-May) +9.6° and summer (June-August) +21.8°, the number of years with temperatures close to the norm is reducing (Figure 1.1.1.) but frequency of warm and very warm seasons is sharply increasing.

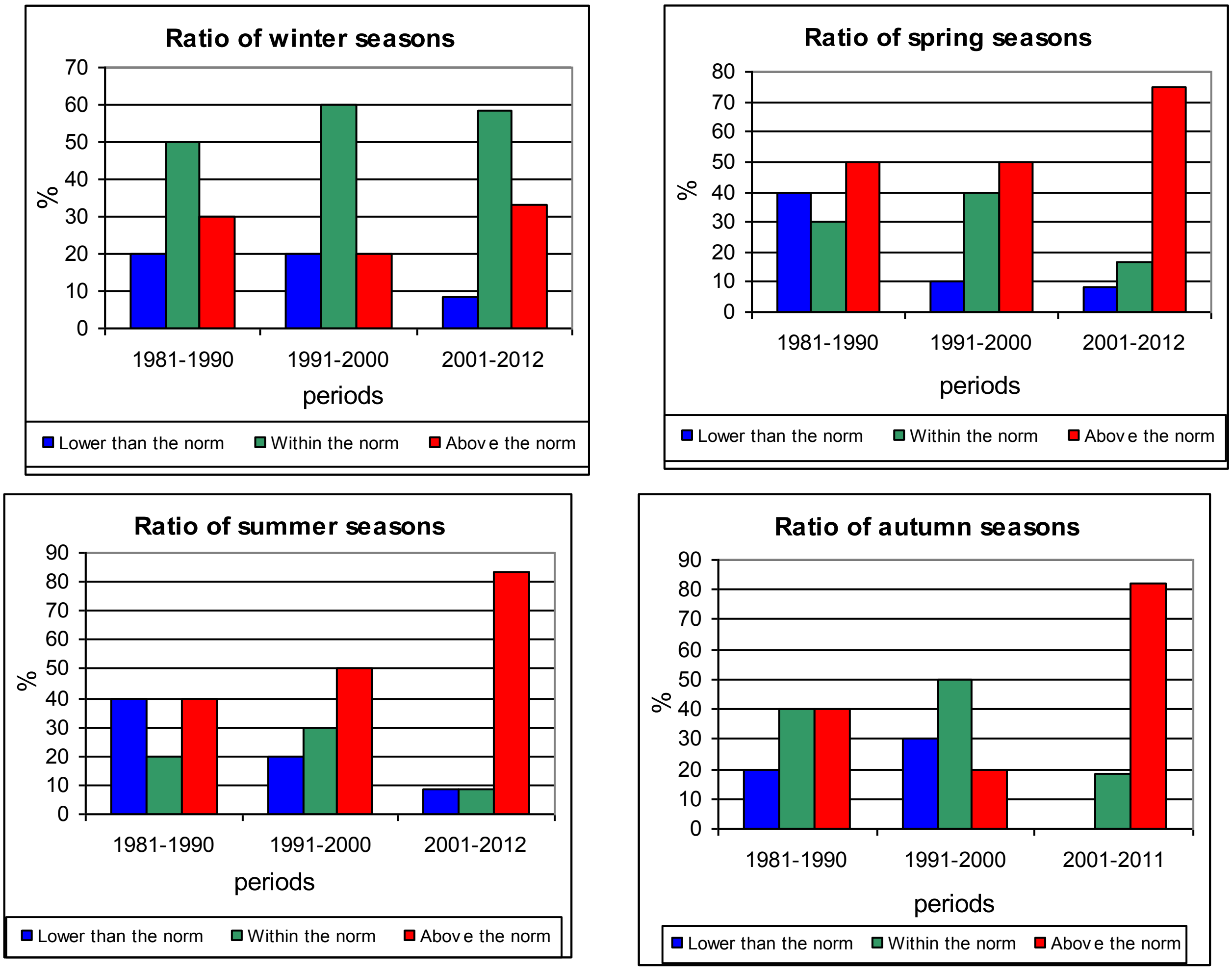


Figure 1.1.1. Trends of warming of seasons over the period 1981-2012 (by data of Bekhtery meteostation, Kherson Region)

As for autumn seasons (September-November), it should be noted that with average long-term values of autumn temperature +10.9°, the frequency of seasons close to the norm is slightly reducing (Figure 1.1.1.), but a particular feature of the recent period (2001-2011) is a complete absence of seasons with the temperatures lower than the norm. It is an evidence of gradual accumulation of the sum of positive temperatures by the time when autumn comes, and is well accorded with many trends in phenology and in productivity of indicator species and communities.

More detailed picture of the temperature and humidity dynamics per seasons is shown in Figures 1.1.2-1.1.6.

Precipitation

Distribution of precipitation in the region is much more variegated than temperature trends. As for annual precipitation sum, we can state only that it considerably fluctuates between years. The annual precipitation sums greatly differs inland and in the coastal zone.

Since a majority of the studied indicator species and their communities are located in the coastal zone, it is reasonable to estimate trends in changes of precipitation amount exactly for this coastal zone.

Average value of annual precipitation sum for the observation period is 382.4 mm. Since 1981 an obvious decreasing trend of annual precipitation sum is observed. It is well illustrated by minimum extremum points of the curve of long-term dynamics of this index (Figure 1.1.2): in dry years (1983, 1986, 1990) the values of annual precipitation sum tend to be lower and lower. This trend of decreasing humidity resulted in quite a severe draught of 1990-1994. During this draught period the values of annual precipitation sum retained, mostly, within 227.7 … 255.4 mm. The only exception was 1992, with 369.8 mm of precipitation.

The year 1995 initiated the extremely wet period which lasted until 2005. In this period, the annual precipitation sum was lower than the norm only once – in 1999 (332.3 mm). Especially humid were 1997 (580.4 mm or 151.2 % of the norm) and 2004 (603.2 mm or 157.1 % of the norm).

After 2005, a relatively dry period started again. In 2006-2007 the annual precipitation sum made up, correspondingly, 347.4 and 339.1 mm. After the wet year of 2008 (447.7 мм), in 2009 the annual precipitation sum dropped even lower (up to 291.4 mm).

The most remarkable for the considered 32-year period was the year 2010, which annual precipitation sum (685.1 mm or 178.5 % of the norm) turned out to be the absolute record for the whole observation period and 71.5 mm exceeded the previous record of 1970. It is interesting that in 2011 the value of this index dropped until 300.1 mm, almost corresponding to the level of 2009.

It is also difficult to distinguish any pronounced trends of growth or decline of precipitation per seasons. We can only state that a particular feature of the recent period (2001-2012) was a high frequency of wet winters and dry summer seasons. Details of precipitation dynamics per seasons are shown in graphs (Figure 1.1.2.-1.1.6).

Hydrothermal coefficient

Hydrothermal coefficient is an index of moisture supply in a territory during the vegetation period. Long-term dynamics of hydrothermal coefficient, annual precipitation sum for the temperature-effective period and annual sum of effective temperatures is shown in Figure 1.1.7.

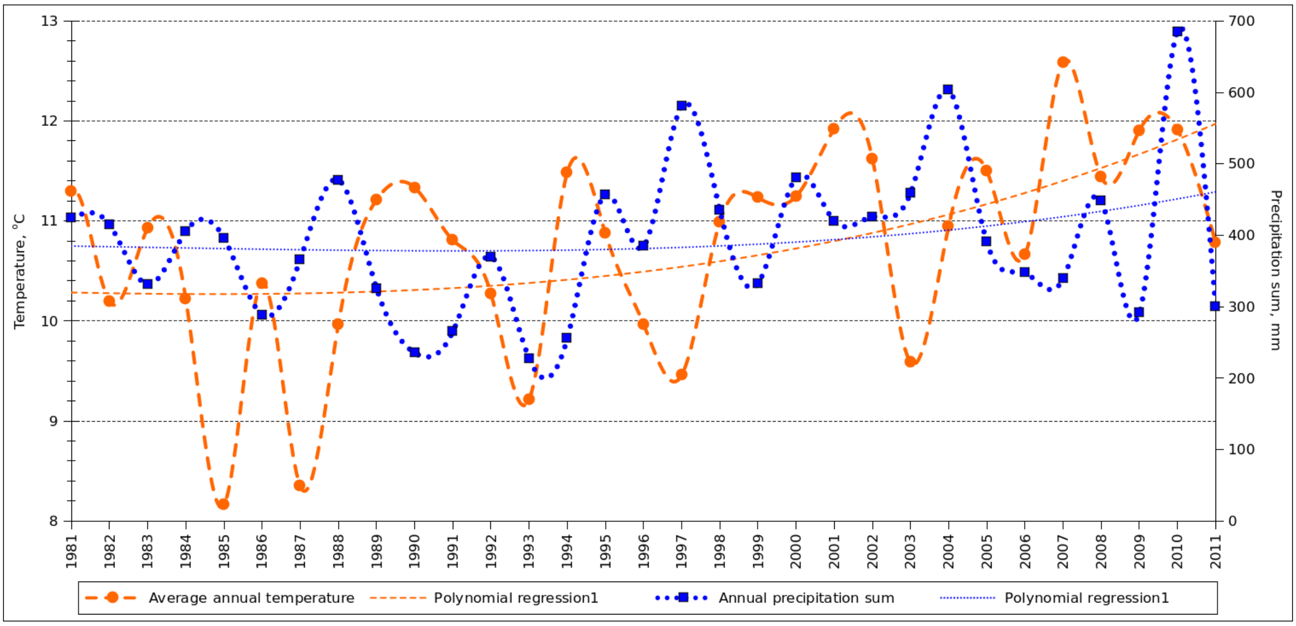


Figure 1.1.2 Long-term dynamics of average annual temperature and annual sum of precipitation.

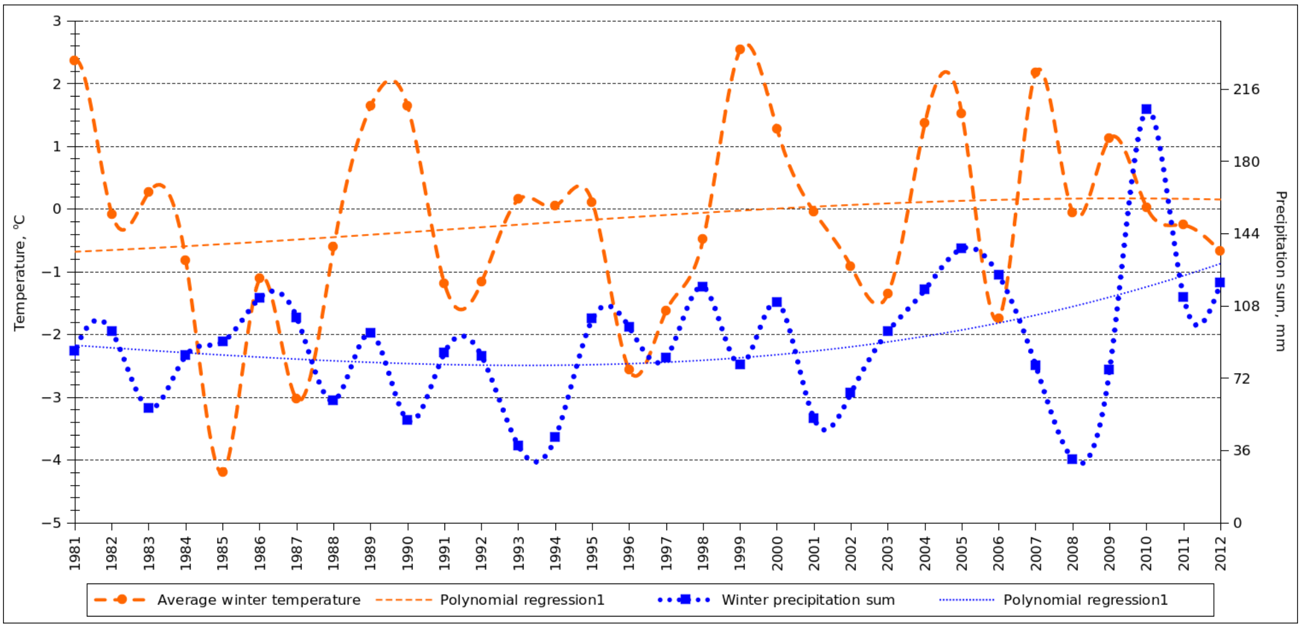


Figure 1.1.3. Long-term dynamics of average seasonal temperature and precipitation sum of winter season**.**

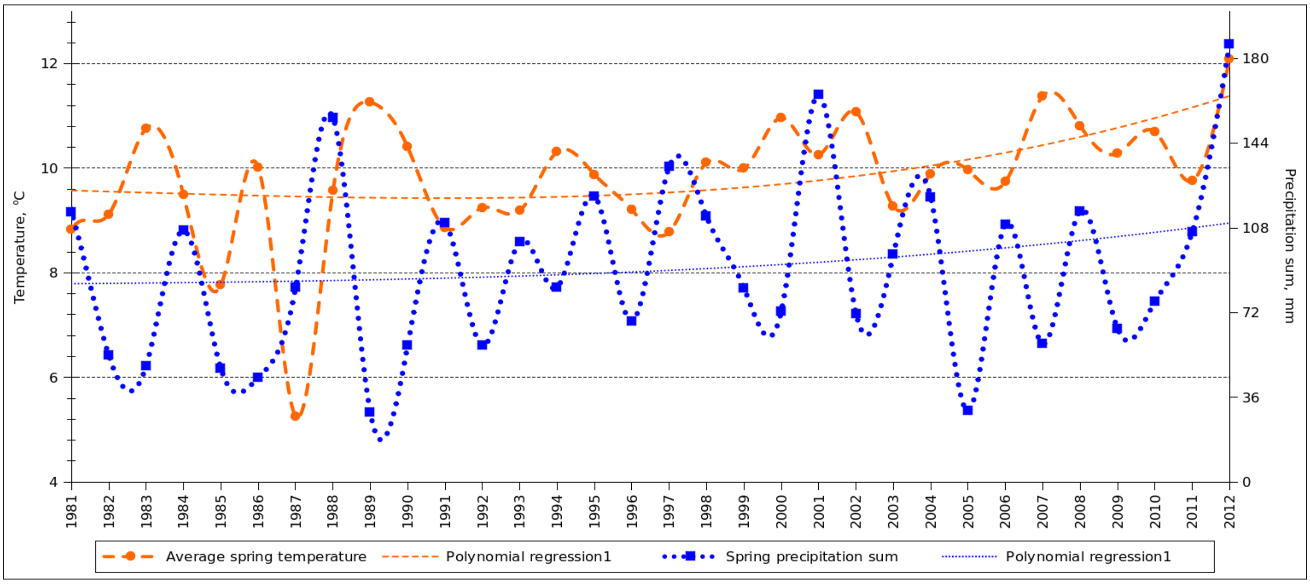


Figure 1.1.4. Long-term dynamics of average seasonal temperature and precipitation sum of spring season**.**

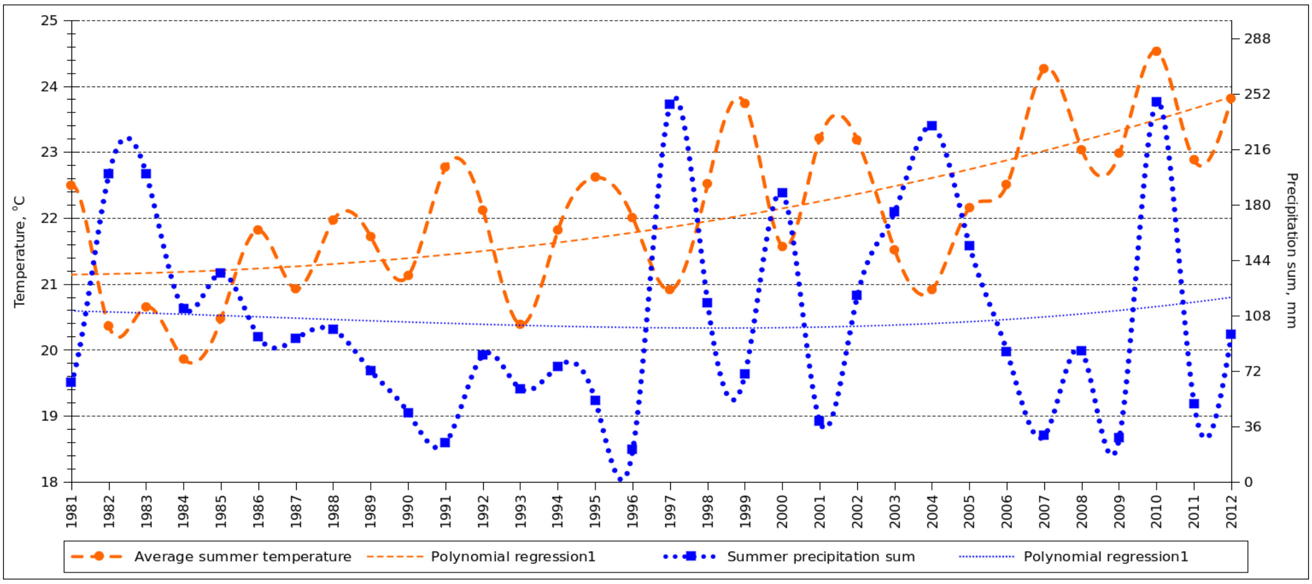


Figure 1.1.5. Long-term dynamics of average seasonal temperature and precipitation sum of summer season.

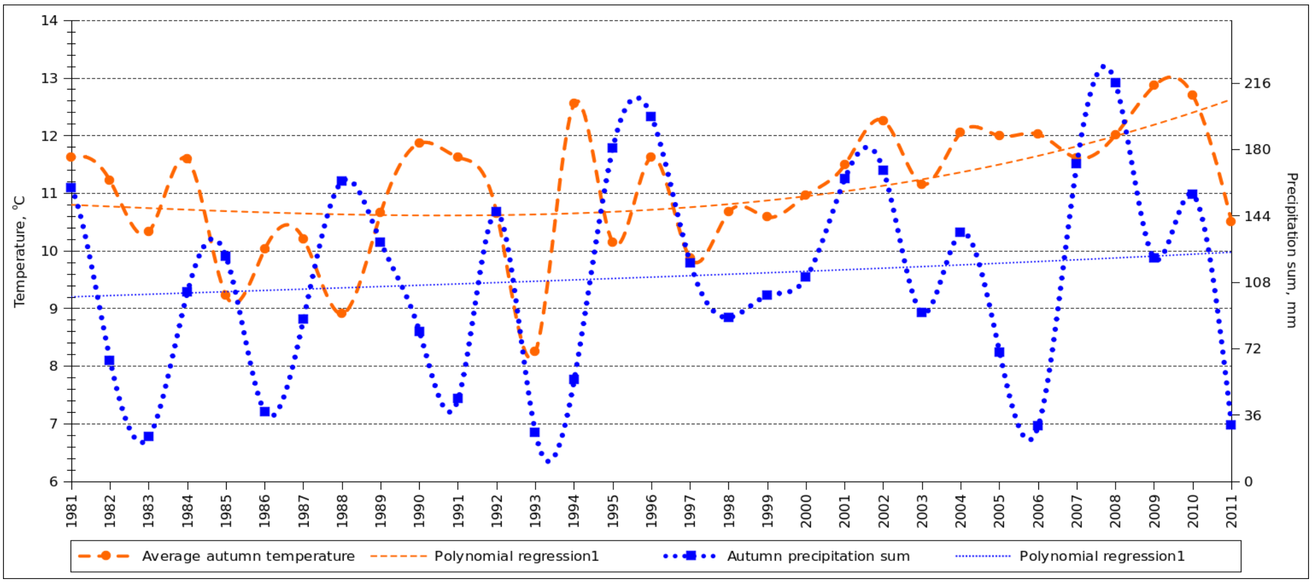


Figure 1.1.6. Long-term dynamics of average seasonal temperature and precipitation sum of autumn season**.**

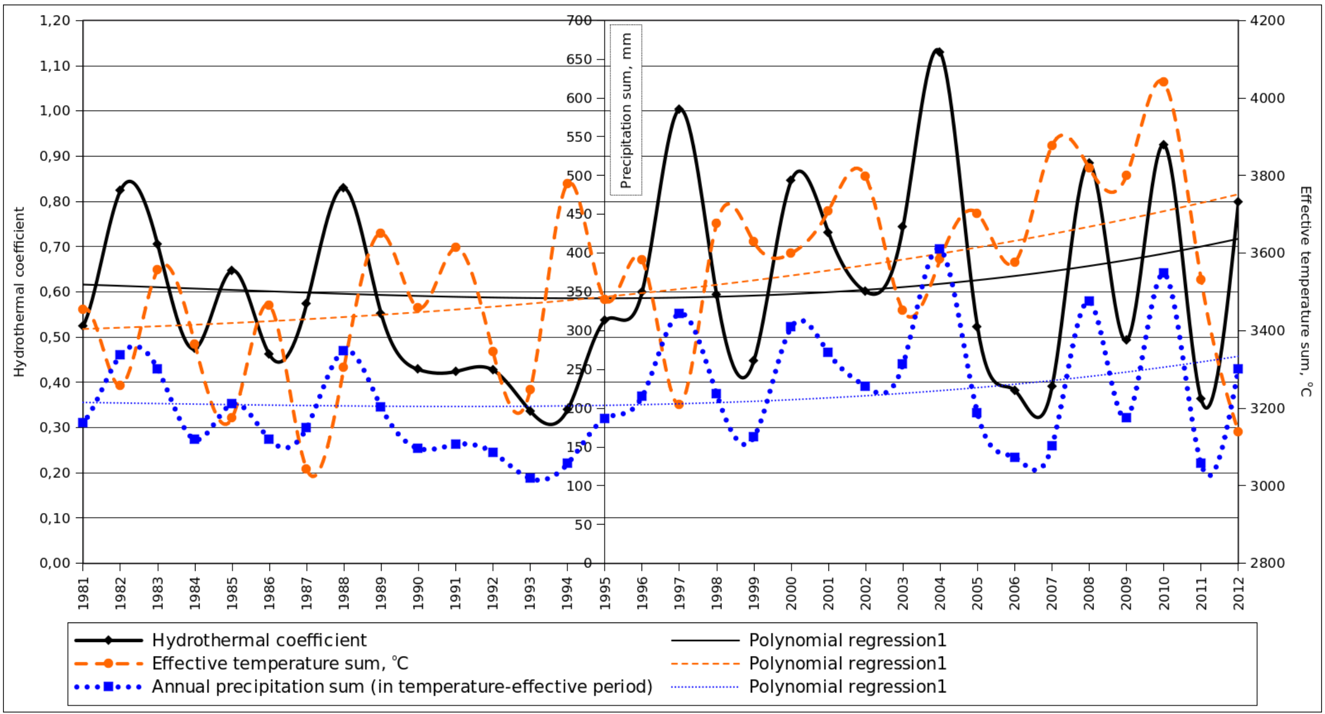


Figure 1.1.7. Dynamics of hydrothermal coefficient and some integral meteorological indices (in the temperature-effective period) per years

According to the data, represented in the Figure 1.1.7, the extremely high moisture supply during the vegetation period was in 1997 (hydrothermal coefficient 1.00), 2004 (1.13) and 2010 (0.93). Also a very humid vegetation period was in 1982 (0.82), 1988 (0.83), 2000 (0.85) and 2008 (0.88).

An extremely low moisture supply during the vegetation period was in 1993-1994 (hydrothermal coefficient 0.34) and 2006-2007 (hydrothermal coefficient, correspondingly, 0.38 and 0.39) and

2011 (0.36). Quite arid temperature-effective period was also in 1984 (0.47), 1986 (0.46), 1990-1992 (correspondingly, 0.43; 0.42; 0.43), 1999 (0.45) and 2009 (0.49).

Short comparison of climate indices for other parts of the Azov-Black Sea Region

To compare, it is presented a short analysis of climate trends in the region of Vilkovo City (Hydrology of the Danube Delta, 2004). There is also observed a positive trend of average annual air temperature (+1.2°C for the period from 1945 to 2003); it is especially obvious in the second half of the period (1974-2003). The growth of average January temperature for the period 1974-2003 was 0.9°C, and average July temperature 3.2°C.

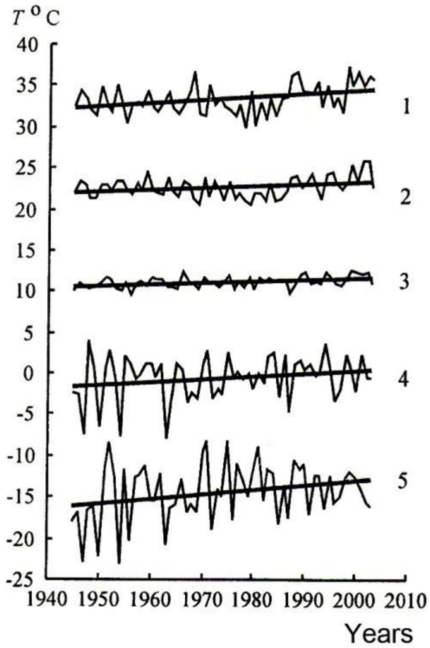


Figure 1.1.8. Long-term changes of air temperature in Vilkovo over the period 1945-2003: 1 - maximal annual; 2 - average monthly of July; 3- average annual; 4 - average monthly of January; 5 – minimal annual.

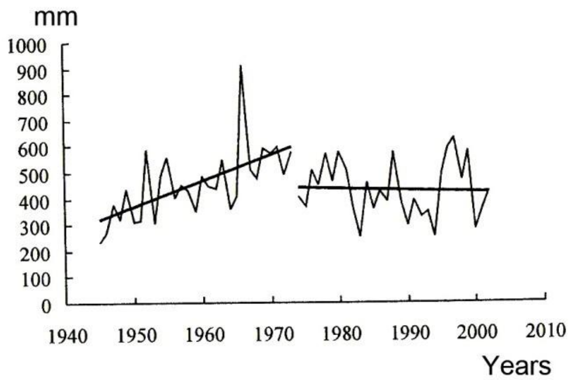


Figure 1.1.9. Long-term changes of annual precipitation sum in Vilkovo over the period 1945-2002

Also, it is revealed a slight increase of annual precipitation sum. In intra-annual dynamics of precipitation there were following changes: precipitation amount in winter and spring has reduced (insignificantly in summer), and in spring and autumn increased.

These temperature trends are similar for the whole Azov-Black Sea Region of Ukraine, which is confirmed by graphs (below) for other two meteostations, located in different parts of South Ukraine: Henichesk (Figure 1.1.10), Mariupol (Figure 1.1.11). It should be noted that we have analyzed only coastal meteostations.

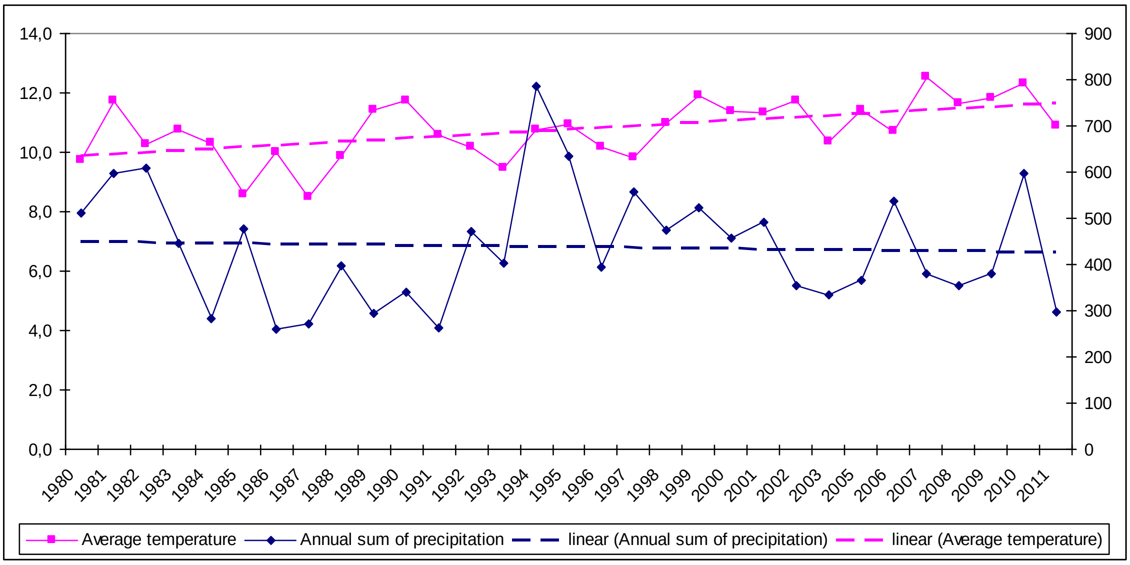


Figure 1.1.10. Dynamics of main climate indices by the data of Henichesk meteostation

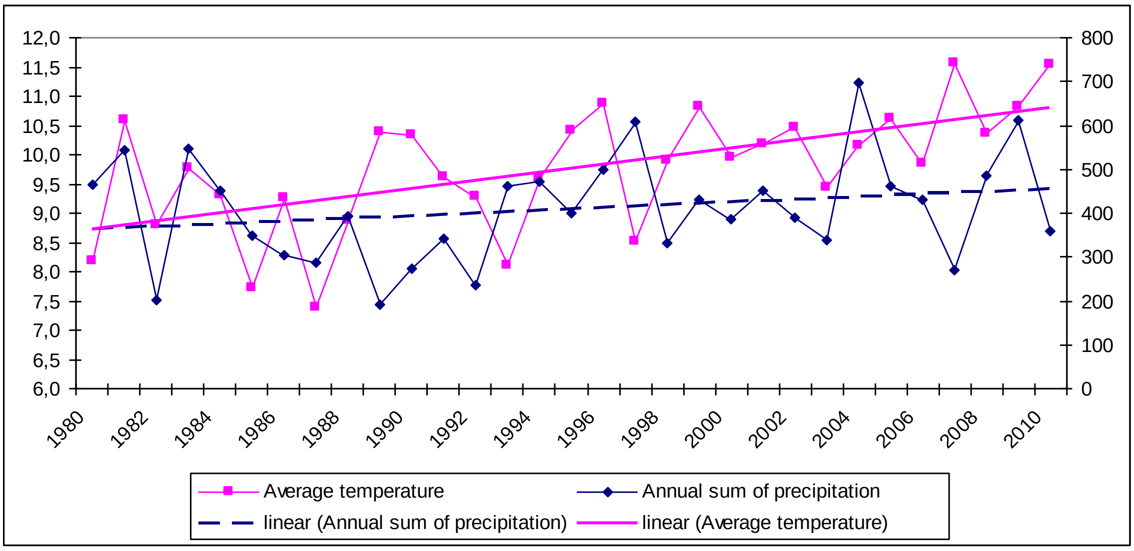
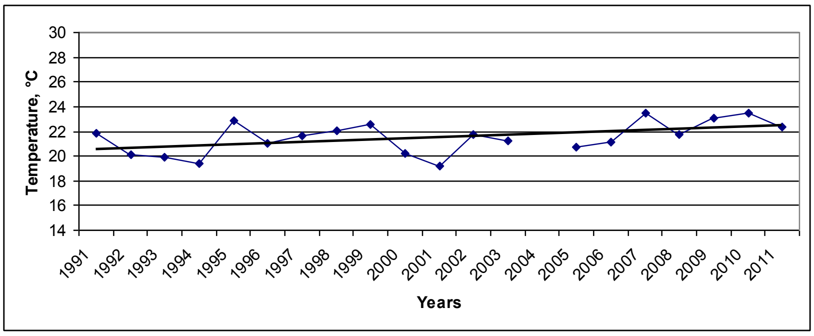


Figure 1.1.11. Dynamics of main climate indices by the data of Mariupol meteostation

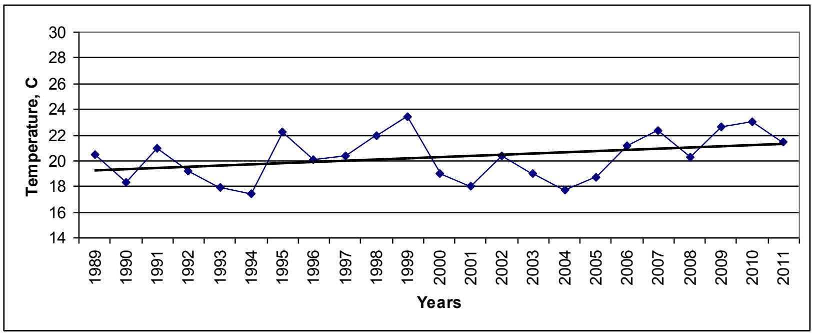
Temperature trends of particular months in the region

Temperature of June

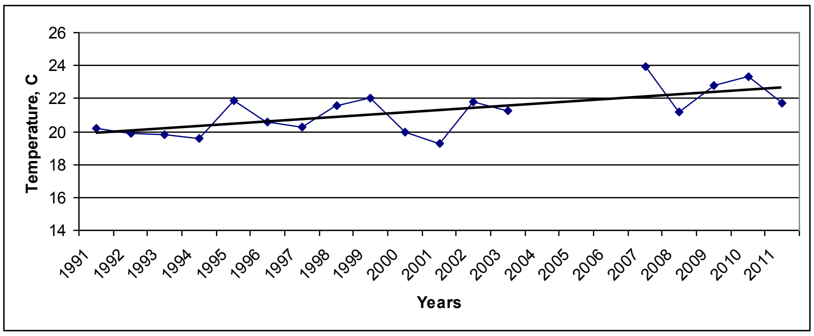
Average temperature of June (Figure 1.1.12) turned out to be an important index to estimate conditions for egg development of reptiles (see Chapter 1.3.5).



Henichesk



Zaporizhzhia



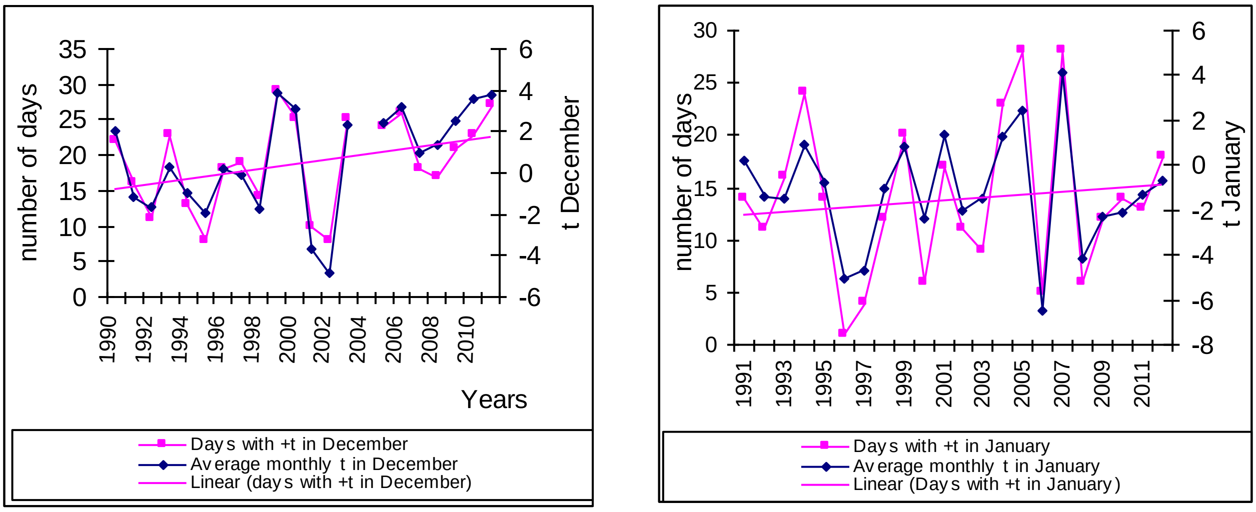
Yalta

Figure 1.1.12. Dynamics of June temperature in different areas in the south of Ukraine

Temperature of December and January

Temperatures of December and February were estimated by us in terms of impact of winter temperatures on the formation of winterings of indicator species (waders) in the region. The analysis of long-term changes in average monthly temperature of **December** in the region (data of Henichesk meteostation) has revealed a gradual increasing trend, though there were fluctuations between years (trend line in Figure 1.1.13A). This trend is the most obvious in the end of the 1990s-2000s, with a pronounced dominance of positive average monthly temperatures (Figure 1.1.13) ranging from +1 to +4^{o}C. This period is also characterized by a substantial increase of species diversity of wintering waders in the region (see Chapter 3.6).

At the same time, average monthly temperature of January shows wide-range fluctuations from -6.5 to +4.1˚C without pronounced long-term trends (Figure 1.1.13B).



A **B**

Figure 1.1.13. Long-term dynamics of the number of days with positive air temperatures and average monthly temperatures in December (A) and January (B).

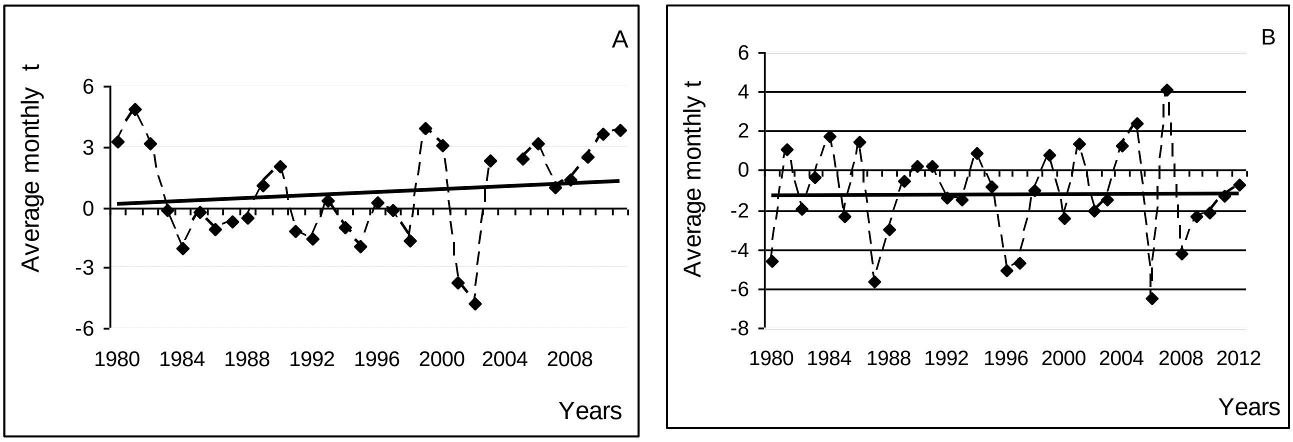


Figure 1.1.14. Changes in average monthly temperature of December (A) and January (B) in the region during the 1980s-2000s (by the data of Henichesk meteostation)

Number of days (per decade) with positive air temperatures in winter months

According to direction of impact and long-term trends it coincides with dynamics of average monthly temperatures of December and January (Figure 1.13A,B), characterizes mildness of winters and possibility of freezing of water bodies. That is why it can be analyzed in association with the previous factor to receive more accurate estimate. There is also traced a pronounced long-term trend of increasing number of days with positive temperatures in December and the same, but weak-expressed trend, – for January (Figure 1.14AB).

Extent of water bodies freezing

The extent of freezing of water bodies has a high impact on distribution of waterbirds including waders (Delany et al., 1999). In severe winters, when water bodies are completely frozen, many waders leave their wintering areas and move west and south, to the regions with milder weather (Baillie et al., 1996). Thus, this factor, above all, limits the biodiversity of wintering waders but it is difficult for quantitative estimate and there are no sufficient retrospective data. That is why its impact was estimated indirectly, through average monthly air temperatures and average air temperatures for each 10 days (decade) along with ratio of positive and negative temperature periods.

In monitoring periods 2010/2011 and 2011/2012 the decrease of average air temperature in December per decade was below -3˚C; when number of days with positive temperatures per decade was less than 5 it resulted in freezing of limans, and waders left control territories. Factor of freezing of water bodies and duration of ice cover is considered at greater length in the analysis of structure of winter species communities in zonal and intrazonal lands.

1.1.2 Impact of hydrological factors

Changes in the climate of the Azov-Black Sea Region, temperature regime, annual precipitation sum and its seasonal redistribution can provide a direct and indirect impact on hydroecological indices of water bodies. Main factors, depending on the climate, are the following:

– water temperature.

– rate of water flow for river ecosystems;

– water transparency.

– wind activity,

– sea level;

– salinity;

– productivity of water communities.

Main trends in changes of hydroecological indices in the region of the Azov Sea, according to the data (Hydrometorological conditions…, 2009), are the following:

– 1°C increase of average annual water temperature for the last 50 years.

– 2.28 g/l decrease of salinity for the southern coast, and 2.67 g/l decrease for the northern coast over the last 30 years.

– gradual growth of annual runoff of large and small rivers

1.2 Direction and extent of impact of major drivers

Taking into account the materials of the previous Chapter we based on two obvious trends when estimating the state of indicator species and communities under the influence of climate factors. The first is a gradual **increase** of average monthly, average seasonal and average annual **air temperatures** followed by the rise of sea level. The second trend is not as obvious as the temperature trend (because of fluctuations between years) but already forms certain ecological effects – changes in average annual humidity, **increase of precipitation sum** and its intra-annual redistribution. Indirect evidence of changes in precipitation sum is changes in the normal headwater level and salinity of end water bodies as well as dynamics of river runoff.

Increase of temperature in some cases is a purely positive factor, inducing the growth of biological productivity of the whole ecosystem and improving the environment for many hydrobionts. At the same time, high summer temperatures provoke “aridization” of ecotone communities (salt marshes) and drying-out of shallow salt and freshwater lakes, thus limiting species diversity and forming other, simpler, communities.

Precipitation amount and air humidity have a strong impact on habitats of many species, changing salinity and level of water bodies (even such large as the Azov Sea), and in association with the temperature gradient they considerably extend the range of their impact, and especially – the impact direction.

Seasonal trends of temperatures and precipitation affect the indicator species in a various way depending on their biological organization and ecological specialization.

Impacts of main factors (individual and integrated impact) we have shown in the flowcharts (Figure 1.2.1-1.2.2).

For insects, increase of winter temperatures contributed to more successful survival of pre-imago stages. It allowed for some southern species to extend their distribution range to the north. Spring, and especially, summer temperatures have lengthened phenological summer cycle of imagos, also provoking long-lasting presence of all insect species in the ecosystems including dangerous agricultural pests.

As for hydrobionts, on them the two above-mentioned climate factors influence indirectly, through water temperature and salinity on which the primary productivity of water ecosystems depends. Changes in the primary productivity entail further changes in fattening and size of indicator fish species.

As for reptiles, temperature and humidity have a direct impact on them, substantially changing not only distribution but also morpho-functional characteristics of populations of the indicator species.

Temperature has also indirect impact on birds and mammals: in winter through formation of ice cover, and in combination with precipitation amount – through formation of snow cover. The latter considerabley reduces the forage value of aquatic and terrestrial ecosystems for a majority of their inhabitants.

The warming of winter months, especially December, has lengthened the stay of many waterbird species in the Azov-Black Sea Region favouring the extension of their wintering ranges and survival success of populations. In addition to the growth of absolute temperatures we have revealed another important factor for wintering communities – increase in the number of days with positive temperatures in winter months.

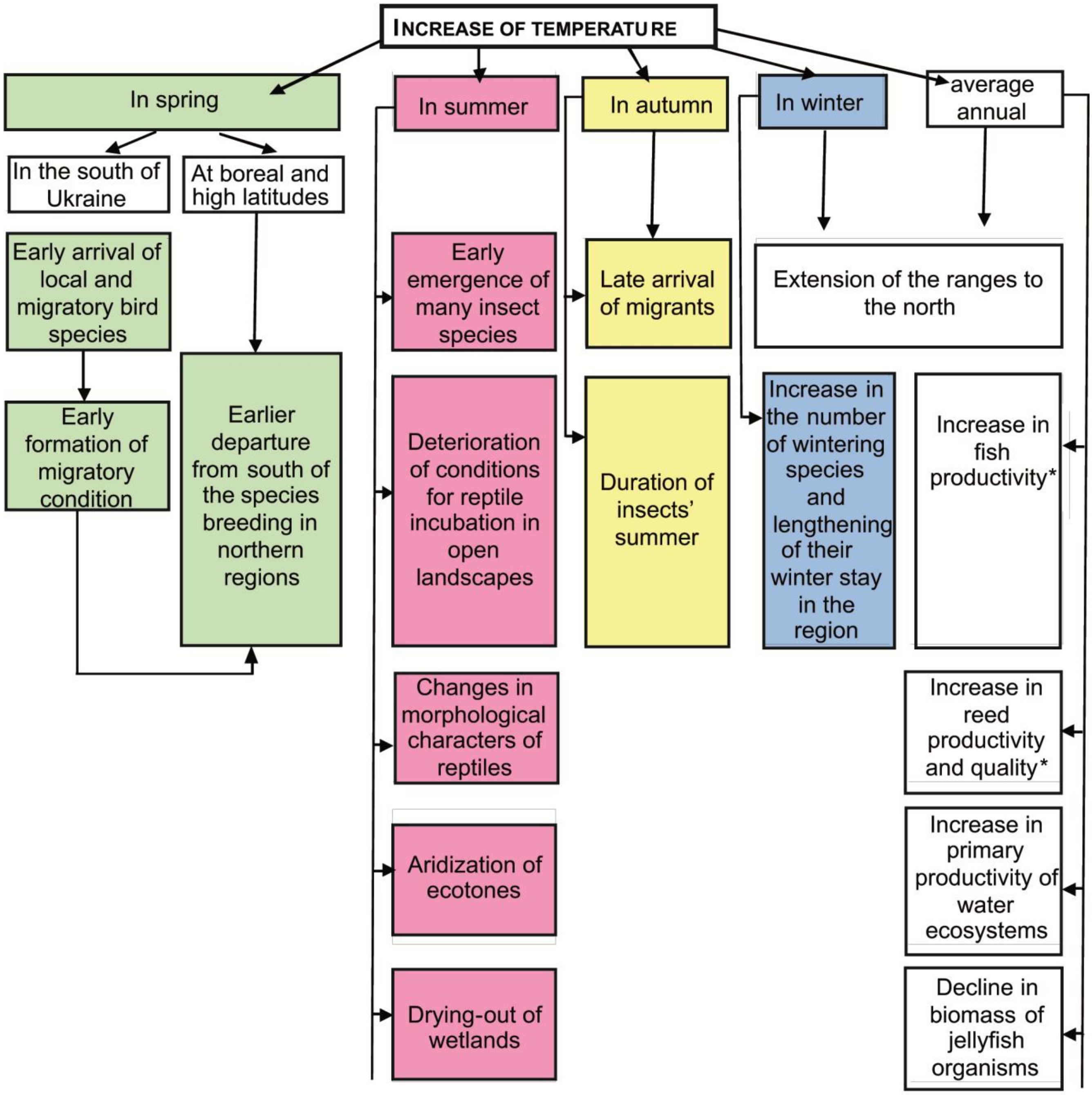


Figure 1.2.1. Impacts of temperature factor on biodivesity

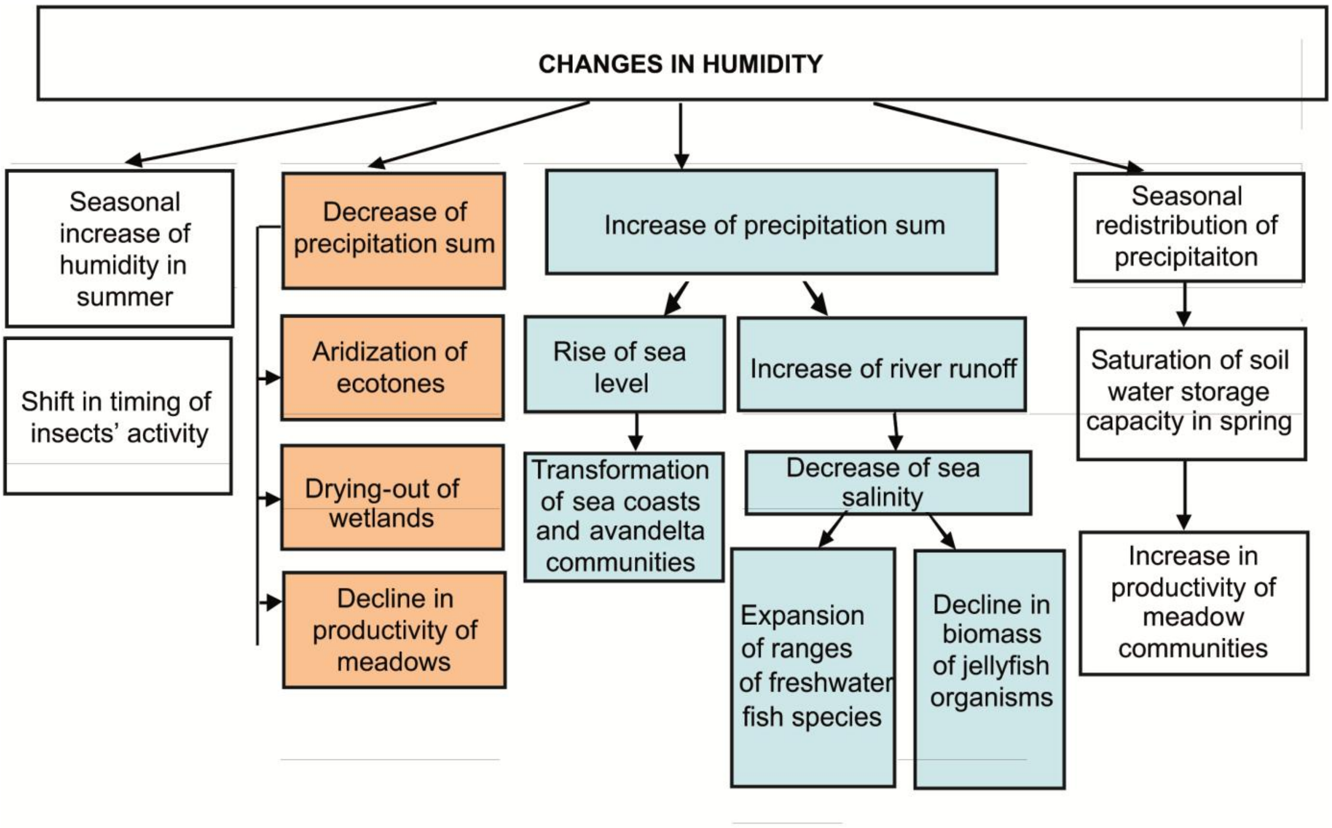


Figure 1.2.2. Impacts of humidity factor on biodiversity**.**

Changes in average monthly temperatures during spring and autumn start making substantial changes in timing of migrations. Many indicator species, breeding in the region, began arriving in reliably earlier terms (2-3 weeks earlier). And the long-distance migrants, breeding at boreal latitudes, finish formation of their migration condition earlier and, therefore, depart earlier to the tundra zone where the gradient of increase of summer and late-spring temperatures is higher than in the Azov-Black Sea Region.

It should be noted the direction of impact for some air temperature-depending weather factors such as changes of water level in the end and intermediary water bodies. It can lead to impoverishment of bottom communities, loss of forage capacity and value for fish and birds. On the contrary, increasing frequency of showers in summer entails a sharp inundation of temporary feeding areas, eliminates imago stages of insects in the coastal zone, etc. The list of these factors also can be added by wind-driven tides, for them it is traced a trend of changes in the "direction rose" and uneven distribution per seasons for winds of moderate and high velocity.

In a number of cases the extent of impact and, moreover, the original cause of influence of a nature factor is difficult to estimate because of anthropogenic component. Human activities interfere more and more in the extent and direction of impact of purely natural (climate factors). It is the most obvious when arise some extreme values. For example, the apparent increase of summer temperatures and prolongation of climate summer period (from +15 ^{o} to +15^{o} C) with decrease of precipitation amount for the same period sharply rise human water consumption not only for communal use but also for agriculture. It aggravates the level regime of most reservoirs, lakes and limans, accelerates drying-out of many valuable permanent and seasonal wetlands, having important buffer capacities for the steppe and dry steppe zone of the Black Sea Region.

Main anthropogenic factors providing direct and indirect impacts on the indicator species and communities are the following:

Land use. The most typical form of land use is building of hydrotechnical constructions (sluices, dykes, irrigation canals, artesian wells). A convenient example for demonstration of impact of various constructions on indicator species (waders) is the following man-made reservoirs: self-flowing wells which do not freeze for a long time; biological filtration fields for sewage; discharges of warm waters of heat stations; technological desilting work sumps with warming-up of water. These are especially readily used as artificial wintering biotopes by the green sandpiper, black-winged stilt (Red Data Book of Ukraine), jack snipe, kentish plover (Red Data Book of Ukraine), and snipe.

Not less important are ploughing up of water protection strips, changes in crop rotation and replacement of dominating crops.

Grazing, hAi-making, and fires which became more frequent because of hot summer seasons in the vegetation period, may sharply reduce the surface area of the rarest communities of zonal plants and almost completely eliminate habitats of rare vegetation species (feather grass, orchids, etc.) This process can be also assisted by introduction of new consort and forage plant species.

Fish-breeding, as a form of transformation of ponds and backwaters, is most frequently a positive factor. It increases the forage value of neighbouring wetlands for birds and mammals. On the other part, in recent decades the fish-breeding contributed to “pollution” of ichtyocoenoses with invasive fish species, stimulated increase in numbers of some ichtyophagous bird species which, in turn, provide a negative impact on populations of rare indigenous species of waterbirds entered in international and national Red Lists.

Use of nature resources. Use of nature resources provides indirect impact on the state of the indicator species of plants, fish, birds and mammals. These are such types of activities as commercial fishery, sport hunting and fishing, harvesting of reed and other plants (especially medical and ethereal oil plants). Excavation of sand on accumulative formations most frequently leads to reduction in areas of small islands and spits which are breeding grounds for rare bird species and habitats of rare plants.

Irreversible water use is one of the most important anthropogenic factors. In the period of gradual increase of temperature of summer months and growing requirements of agriculture it is the irreversible water use which may bring the ecological situation in dry steppe zone of Ukraine to the edge of the critical level.

During our monitoring researches, we have also paid attention to such ***biotic factors***, which provided indirect influence on numbers and distribution of indicator species and structure of communities. These are natural population cycles of the species numbers and range dynamics overlapping with cyclicity of climate factors; predation, competition and parasitism as well as introduction of invasive species.

The impacts of particular factors on indicator species are highlighted in more detail in other chapters of the deliverable.

1.3 Estimation of the state of indicator species and communities under influence of main factors

1.3.1 Distribution of indicator species and changes in their ranges

Insects (Class: *Insecta*)

The seathorn hawk-moth – *Hyles hippophaes Esp. (Sphingidae, Lepidoptera)* is a unique (for hawk-moths) example of the appearance, establishment and rapid spread over Ukraine (actually expansion) of this Mediterranean species, new for Ukrainian area. It is connected with two reasons. The first, certainly, is a fast distribution in recent decades, almost all over the Ukrainian territory, the sea buckthorn (*Hyppophae rhamnoides*) in cultural growing and also introduction of the silverberry (*Eleagnus argentea*), which seems to be the main food plant for caterpillars of this species. The second reason is that almost all the hawk-moths of our and subtropical latitudes spend winter at the pupa stage in the surface layer of soil, and are extremely sensitive to a significant decrease of temperatures during winter. Thus, winter temperature of air and, correspondingly, soil, is one of the main limiting factors which formerly constrained representatives of Mediterranean fauna from moving to the north. Until recently, their appearance was restricted to accidental flights of adults of some species and other seasonal invasions. The gradual softening of winters, "blurring" the borders of seasons also stimulated a successful expansion of the species into temperate latitudes. In Ukraine, this species was found for the first time in the Crimea – one specimen, captured by Yu.P.Korshunov on 22.06.1954 in the Crimean Hunting Reserve (Derzhavets 1984). By the early 1980s, the species individuals were repeatedly captured by I.G. Plyushch, in Krasnohvardiiske District of the Crimea, and then the seathorn hawk-moth was also detected in many other areas of the Crimea (Efetov, Budashkin 1990). In particular, in 1984 the seathorn hawk-moth was revealed in Kerch, in 1985 – in the Karadah Reserve, in 1986 – in Sonyachna Dolyna, in 1987 – in Simferopol, in 1989 – in Chornomorske (Figure 1.3.1). As it can be seen, during that period annual finds of the species moved to the west, from the extreme eastern point of the Crimea in 1984 (Kerch) to its extreme western point in 1989 (Tarkhankut Peninsula – Chornomorske). It is obvious that, moving northward, the species followed the gradient of a gradually increasing winter air temperature which is directly connected with the species adaptive capacities, while the westward movement is connected with introduction and growing of its major food plant (in the Crimea) – the silverberry.

In September 1985 in Kerch and Feodosia, in September 1987 in Planerske and in June 1986 in Sonyachna Dolyna there was recorded a great number of the seathorn hawk-moth caterpillars. These, and further annual finds of the species in the Crimea and further, in inland Ukraine, is an evidence that already in that period the species completely finished its life cycle at our latitudes. In catches there were regularly recorded already indigenous specimens and not migrants from the Mediterranean and Balkans, opposite to the situation which probably had taken place in the 1950s. Therefore, we can say that the climate conditions, settled on the Crimean Peninsula by the late 1980s, favoured to final establishment of the species in our fauna and did not contradict to species adaptive capacities.

By the mid – late 1980s the Seathorn Hawk-moth had became common throughout the all steppe zone of Ukraine from Odesa to Donetsk and Luhansk Regions. In particular, in 1989 it was recorded in Zaporizhzhia Region, in 1990 – Mykolaiv and Kherson Regions, in 1991 – in Odesa Region, in 1992 – in Donetsk and Luhansk Region, and in 1993 – in Dnipropetrovsk Region. Thus, shifting further and further to the north following the gradient of increasing air temperature and having penetrated to the south of continental Ukraine, the species at first actively moved westward and occupied numerous plantations of the silverberry in coastal areas and occasional plantations of the cultural sea buckthorn. The second later wave of inland expansion went in the eastern and north-eastern direction, and in that period the species occupied considerable areas of the introduced silverberry in steppe regions of Donets Basin and Dnipropetrovsk Region. Moving on to the north, the Seathorn Hawk-moth penetrated in the forest-steppe zone and in 1994 it was discovered in Kyrovohrad Region, and in 1995 – already in Kharkiv and Poltava Regions. At last, in 1996 the species was found in Chernihiv Region (Plyushch, Sheshurak 1997), assimilated, as a result, two new natural zones for two years. During the northern expansion, connected with increase of air temperature, the seathorn hawk-moth has reached the northern border of Ukraine and further occupation of the territory of the country can be expected in the north-west direction (the species is still not found in north-western regions). However, the distribution of the species in this direction will be rather associated with availability of essential amount of forage plants than with further increase of temperature.

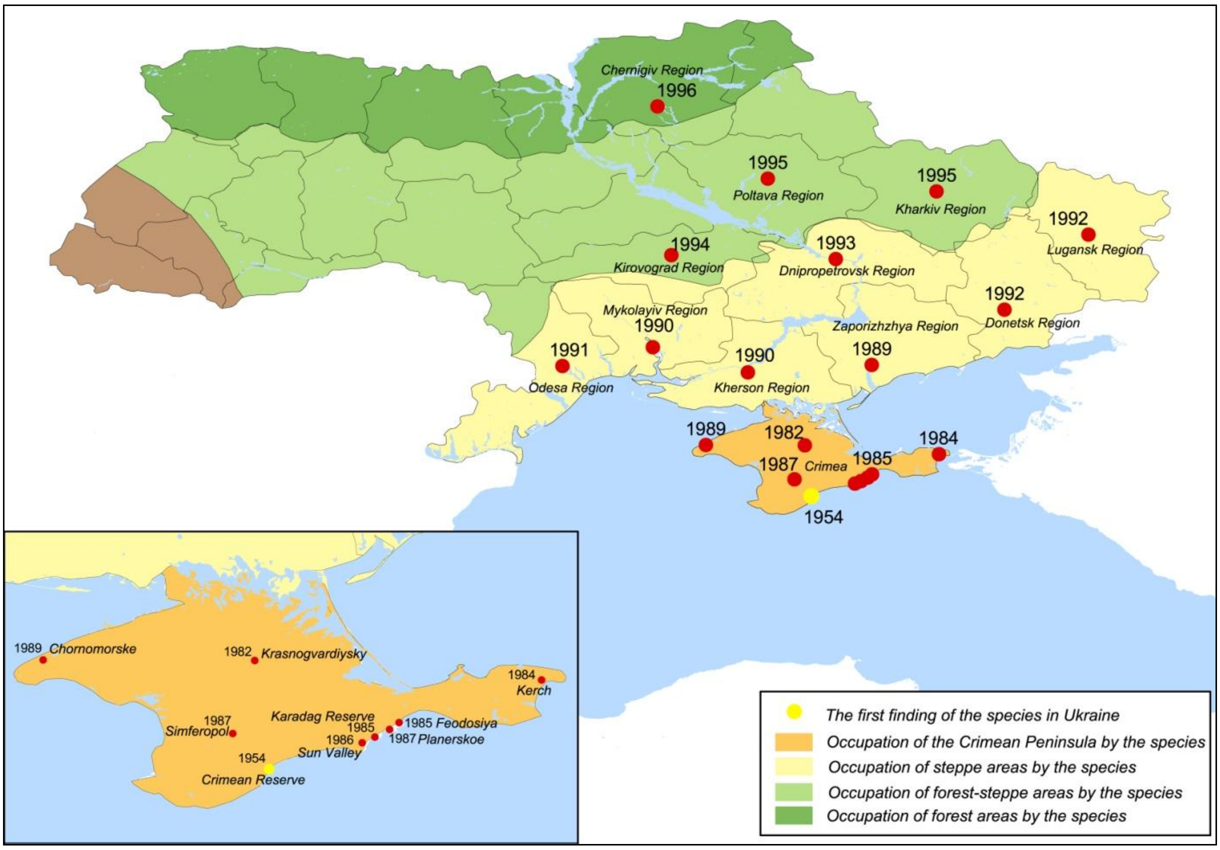


Figure 1.3.1. Extension of the range of the seathorn hawk-moth in Ukraine.

It should be noted that a gradual increase of air temperature had an impact also on other representatives of hawk-moths in Ukraine. Thus, the death's-head hawk-moth (*Acherontia atropos*), being a southern species (a major part of the population is located within North Africa) though indigenous for our fauna, was a rarity 10 years ago. It is still listed in the Red Data Book in

Ukraine but in the last 5-7 years became common and sometimes even numerous. Similar to the seathorn hawk-moth, the main limiting factor, determining the survival rate of the species at our latitudes, is temperature in the winter period (wintering of pupae). The factor of availability or lack of forage plants is not actual in this case, since the death's-head hawk-moth includes almost all species of wild and cultivated *Solanaceae* in its diet.

This example of correlation between the temperature and such apparent shift of the species range to the north makes the seathorn hawk-moth a convenient monitoring object. Considering this species as a marker species, according to its presence in a biotope (Rouwel, 1996), and recommending its monitoring in the territory of Belarus and Ukraine we can, further, indirectly link its expected northern expansion to a temperature factor. Using this species as an indicator (Rouwel, 1996) and combining together indexes of temperature in a cold season, depth of soil freezing and number of imagoes in a summer period, we will be able to estimate the relationship between temperature dynamics in winter and fluctuation of species numbers in newly occupied areas, and make prognosis of future changes in configuration of the species range.

Fishes (Class: *Actinopterygii*)

Changes in the distribution of the Prussian carp (*Carassius gibelio*)

A modern range of the Prussian carp in the Azov Sea has considerably extended. A trend of decreasing salinity up to 9-10 ‰ in average for the marine waters, observing since 1998, contributed to this process. In addition, considerable freshwater discharges from canals of the North-Crimean irrigation system desalinated some water bodies of Eastern Syvash to 4-9‰. Such substantial changes in ecological conditions of the water bodies have lead to a wide distribution of the species in the Azov Sea, its limans and bays. Nowadays, the Prussian carp occurs along the all coast of the Azov Sea, in the channel of Molochnyi Liman, in all parts of Utliukskyi Liman and in freshened parts of Syvash.

Present distribution of the Prussian carp in water bodies of the investigated region is shown in Figure 1.3.2. (see the picture inserted in top left corner). The Prussian carp is the most frequently recorded during spring-summer catches, less frequently – in autumn catches. Its movement along the coast is mass, in large concentrations. In some catches the numbers of Prussian carp constitutes a more than half of captured fish.

Since the distribution of the Prussian carp in the region reached its maximum, its further expansion is impossible, and we can only predict a possible increase of the species numbers if salinity trend remains the same (see the chapter "Numbers" for more details). If the salinity of the Azov Sea increases due to some reasons, we can expect that the Prussian carp will return to former borders of its distribution range, even to the historical range (Figure 1.3.2).

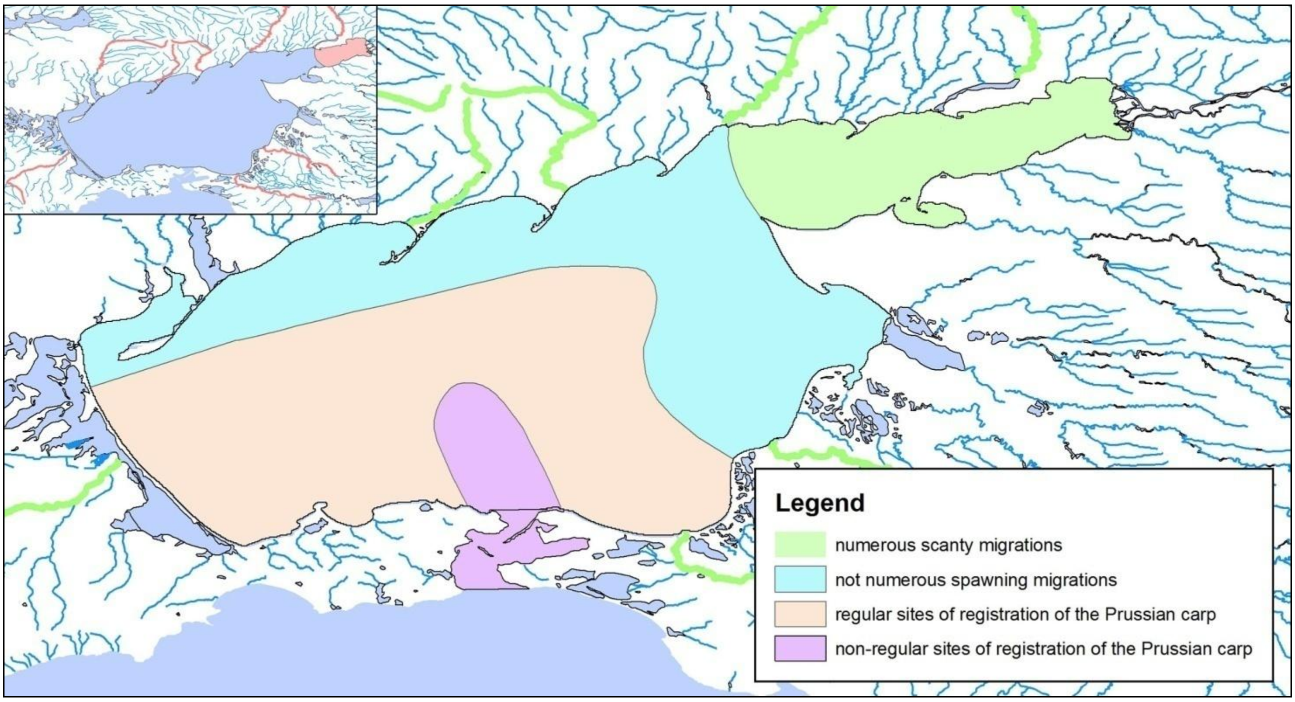


Figure 1.3.2. Distribution of the Prussian carp in water bodies of the Azov Sea during 2010-2011 and its main spawning migrations (see the inserted picture “A historical distribution range of the Prussian carp”).

Reptiles (Class: *Reptilia*)

Changes in distribution and range structure of the dice snake (*Natrix tessellata*).

Prior to the mid 20th century, according to the available data, the northern border of the dice snake (*Natrix tessellata*) distribution in Ukraine (Tarashchuk, 1959) went approximately at 48^{0} N, to the south of Dnipropetrovsk (Figure 1.3.3).

In the 1960s, single encounters of some southern species (Shcherbak, 1967) were registered northward of their range. For example, for the dice snake (*Natrix tessellata*) the extreme northern point of registration in Ukraine was at Ruzhin Village, Zhytomyr Region (about 49^{0} 45$^{\backslash}$ N).

According to other researchers, the northern distribution border of the dice snake almost coincides with +21^{0}C July isotherm (Kotenko at al., 2009). The authors assume that isolated populations along the northern distribution border are of relict character, and habitat conditions in them are determined by microclimate. According to some authors (Kotenko at al., 2011), in Kharkiv Region (the Don River Basin) the dice snake was recorded at the city of Zmiiv and villages of Horokhovatka and Haidary (Figure 1.3.3).

In summer 2012 (2 June – 8 July), in the framework of the enviroGRIDS project "Building Capacity for a Black Sea Catchment Observation and Assessment System Supporting Sustainable Development under the 7th Framework Programme of the European Union" it was undertaken an expedition to Kharkiv Region to clarify the northern border of the dice snake distribution range in Ukraine. During the expedition, the length of automobile route was about 470 km, and the following areas were investigated (Figure 1.3.3):

1. the site where Lopan River flows into Kharkiv River (within borders of Kharkiv City)
2. the shore of Travenske Reservoir near Liptsy Village (Kharkiv District),
3. a part of the right bank of Severskyi Donets River near Eskhar Village (Chuhuiv District),
4. the shore of Pechenezke Reservoir (Pechenehi District),
5. the shore of lake Liman and a part of the right bank of Severskyi Donets (Zmiiv District)

As a result it was confirmed a real existence of the population of the dice snake at the rivers Kharkiv and Lopan within borders of Kharkiv City (N $49^0 59^/ 14^{//}$ E $36^0 13^/ 32^{//}$).

In 2011, local herpetologists (Zinenko S., Korshunov A.) recorded 1 specimen in this region. However, it was supposed that this individual could be brought by nature lovers.

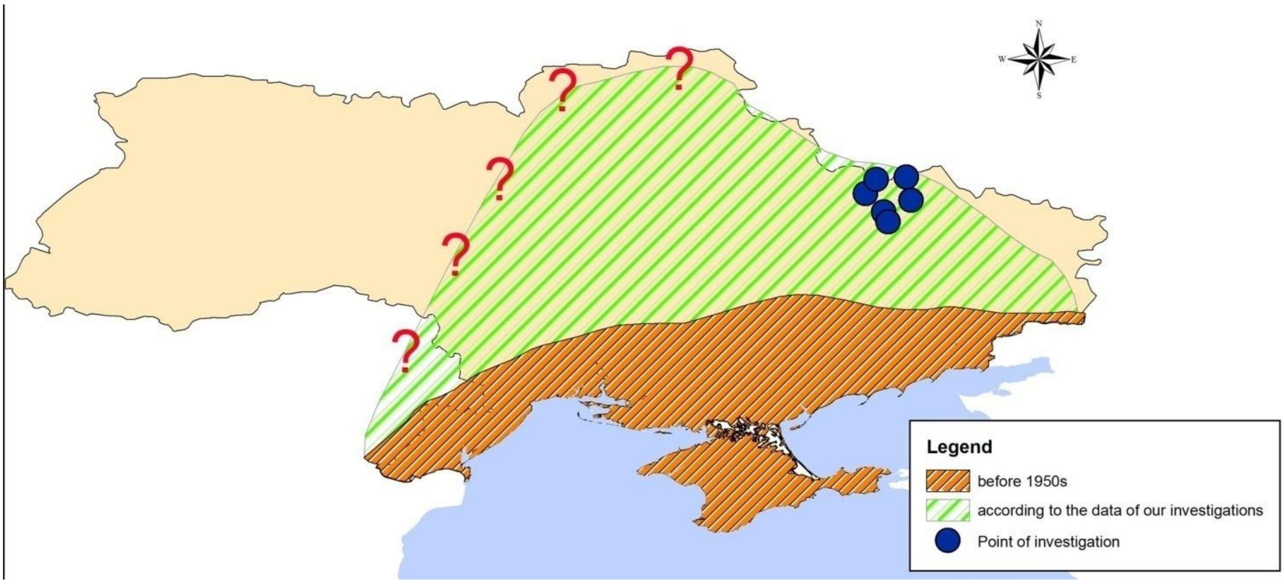


Figure 1.3.3. Distbribution of the dice snake (*Natrix tessellata*) in Ukraine

During our studies we revealed several specimens, both young and adult. This fact can be an evidence of existence of a stable population in these bodies of water. By now, it is the northernmost confirmed point of the dice snake distribution in Kharkiv Region. About 80% of recorded specimens were melanists.

As for origin of the dice snake population, discovered within limits of Kharkiv City, it is hard to say something reliable. It may be a relict or man-made population. Weather conditions (air temperature $+33^0$ …$+36^0$C, wind) and hard possibility of banks (dense thickets of riverine vegetation) did not allow to discover the species representatives in other points. However, at least we can claim that the Kharkiv population is viable (presence of specimens of different age), and climatic conditions are suitable for the species existence. A final decision of this question needs further research.

Birds (Class: *Aves*)

Changes in distribution of indicator species of waders in winter period

According to the published and author's data, some wader species in the last 2-3 decades noticeably increased the number of known wintering sites within the Black Sea region and adjacent areas. For example, this trend is observed for the avocet, oystercatcher, grey plover, kentish plover, dunlin, wood sandpiper, redshank, snipe, green sandpiper, jack snipe.

The avocet. Photo by Bogdan Przystupa

The example of the avocet (*Recurvirostra avosetta*) is a good illustration of a gradual broadening of the winter distribution area in the region from the south-west to the north-east for the last 35 years (Figure 1.3.4). The main wintering range of the avocet is located outside the Black Sea coast (chiefly, along the Atlantic coast of Europe and Africa and also in the Mediterranean in the territory of Tunisia, Algeria, Greece and Turkey). In the 1970s, within the Black Sea Region, regular wintering of this species were recorded only in Bulgaria (Figure 3.1.4A): on lakes Mandra, Atanasovsko, Varna and others along the Black Sea coast (Michev, Profirov, 2003).

In the 1980s the Avocet was for the first time registered during the winter period in Ukraine – in the Danube Delta (Zhmud,1998). In the 1990s, in Ukraine this species was also registered in winter at Tuzlovska group of limans in Odesa Region (Zhmud, 2000) and at Feodosia Bay (South Crimea). In the 2000s, the avocet began appearing during the winter period in Ukraine further to the north-east (Figure 3.1.4D) – in the vicinity of Odesa (Panchenko, Formanyuk, 2007), at Eastern Syvash and in the Azov area (Molochnyi Liman, Zaporizhzhia Region). At the same time, winter records of the avocet in the Danube Delta became more frequent, and in 2009 it was also recorded on wintering in Romania (Annual IWC Count Totals …).

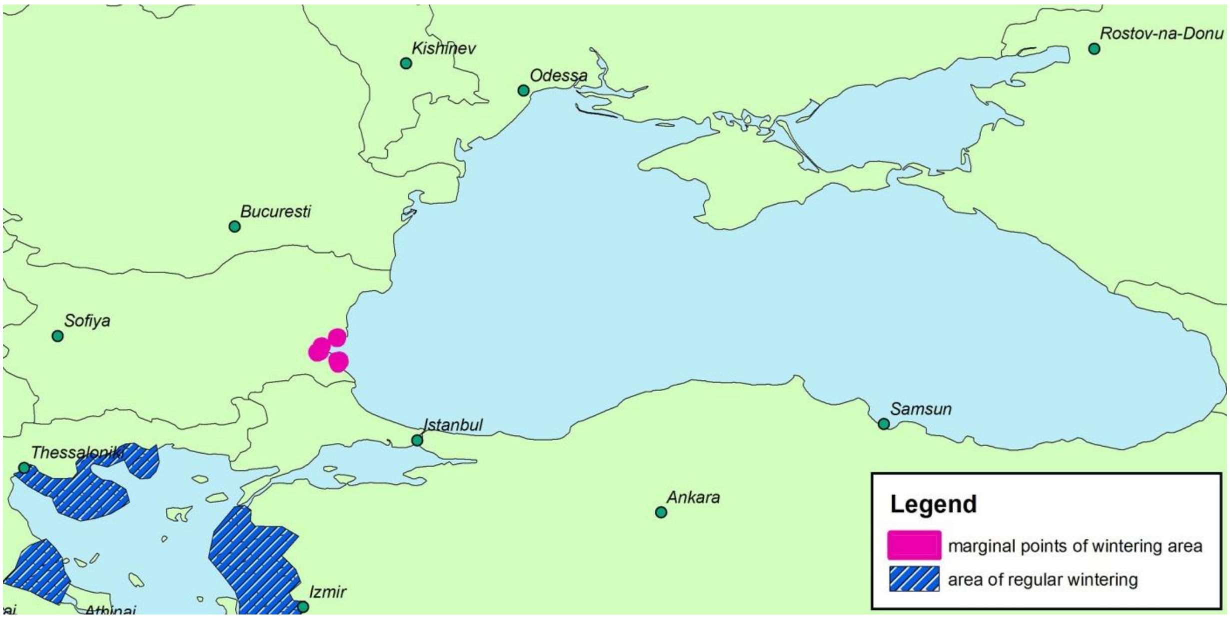


Figure 1.3.4A. Shifting of the border of the avocet (*Recurvirosta avosetta*) wintering area to the north-east in the Black Sea Region during the 1970s.

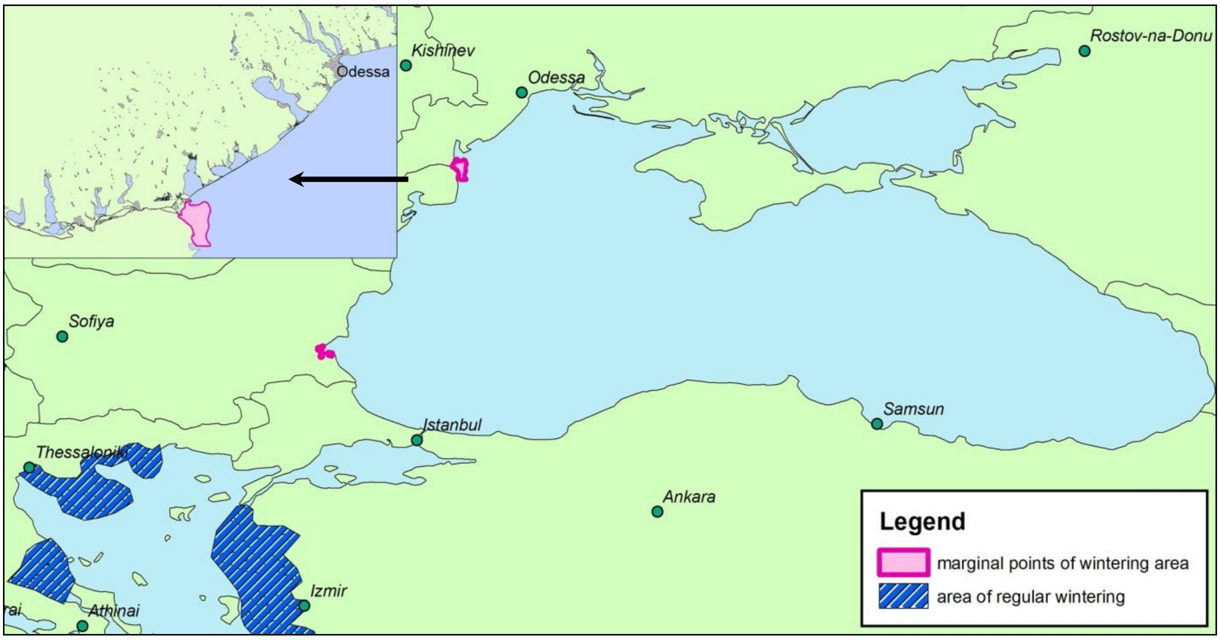


Figure 1.3.4B. Shifting of the border of the avocet (*Recurvirosta avosetta*) wintering area to the north-east in the Black Sea Region during the 1980s

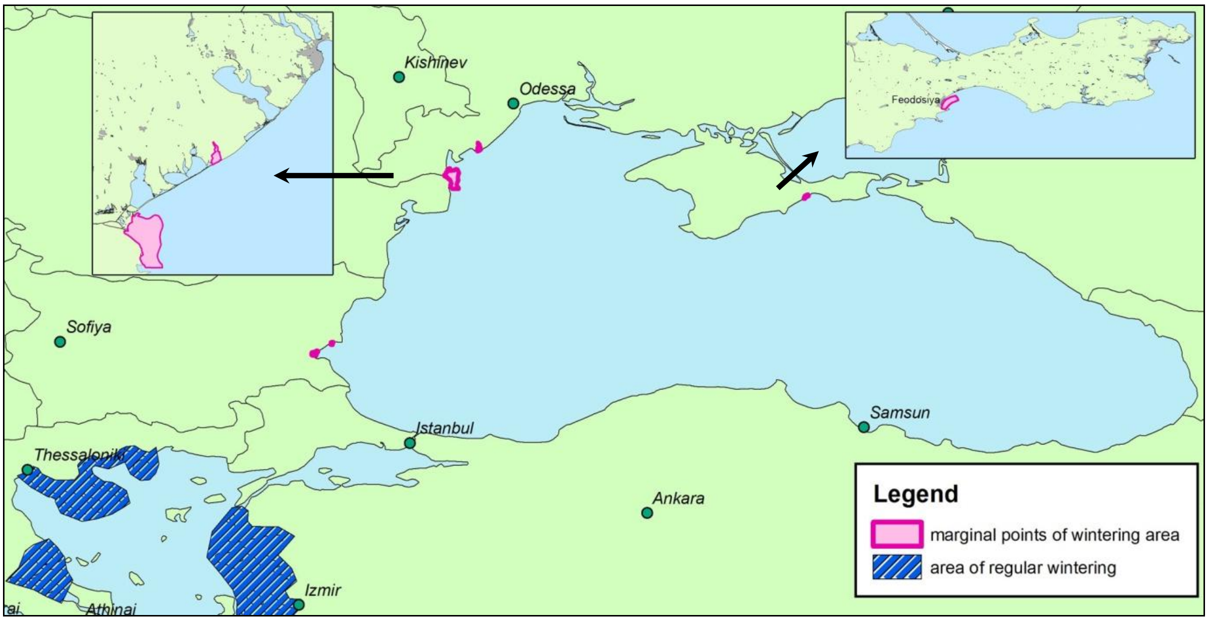


Figure 1.3.4C. Shifting of the border of the avocet (*Recurvirosta avosetta*) wintering area to the north-east in the Black Sea Region during the 1990s

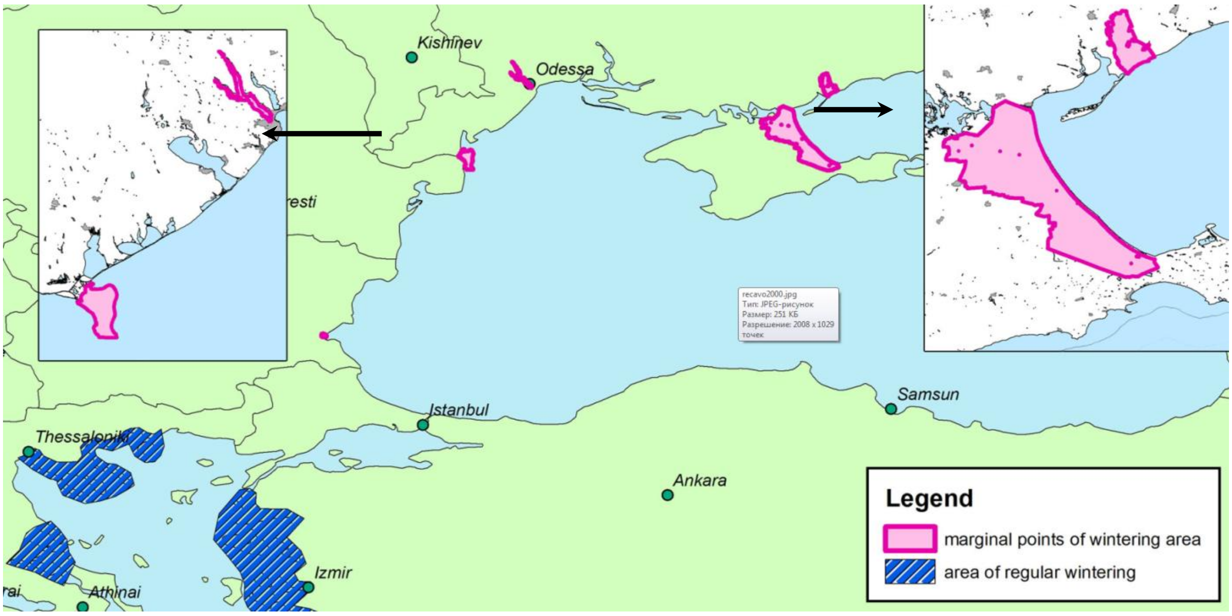
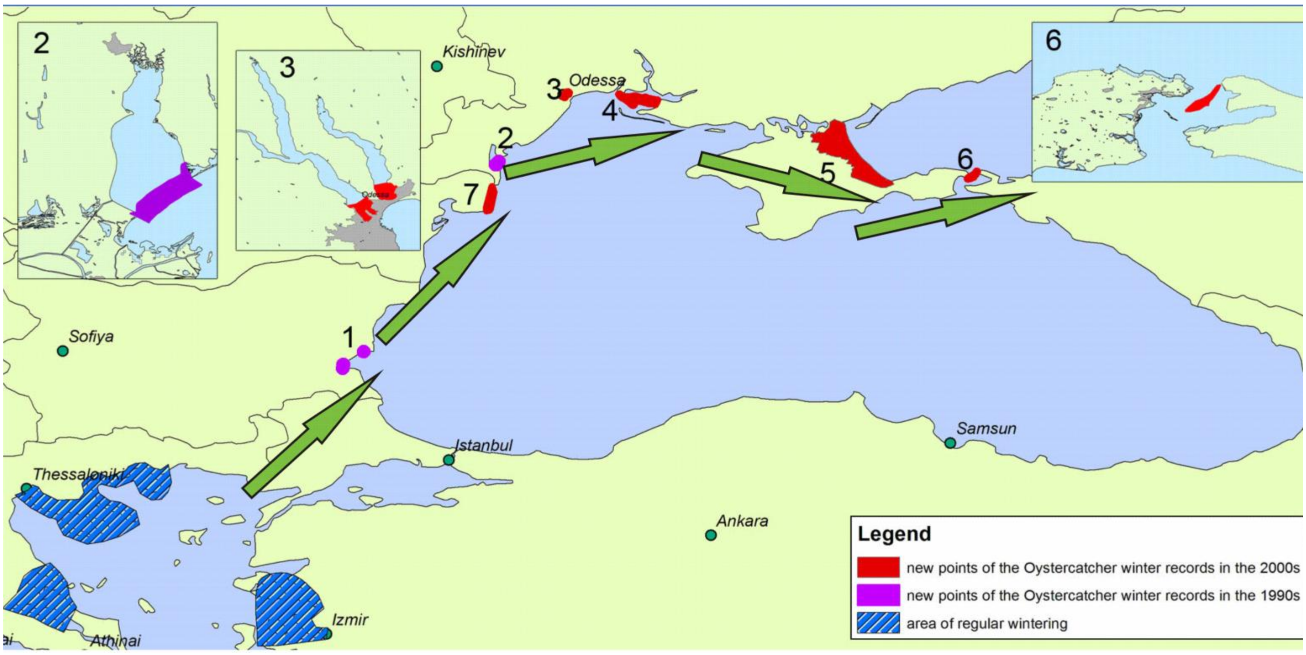


Figure 1.3.4D. Shifting of the border of the avocet (*Recurvirosta avosetta*) wintering area to the north-east in the Black Sea Region during the 2000s

Figure 1.3.4. Shifting of the border of the avocet (*Recurvirosta avosetta*) wintering area to the north-east in the Black Sea Region during the 1970s-2000s.

One of the examples of broadening the area of species winter registrations to the east for the last 2 decades is the oystercatcher (*Haematopus ostralegus*). Its main wintering range is located outside the Black Sea region (along the Atlantic coast of Europe and North Africa, and in the Mediterranean – mainly in Tunisia (Cramp S. & Simmons, 1983) and in Greece. In the 1990s, there were registered first cases of wintering of some oystercatcher individuals in Bulgaria, along its Black Sea coast (Michev, Profirov, 2003), and also at the Black Sea coast of Turkey (Figure 1.3.5). In January 1997, a wintering oystercatcher was for the first time recorded in the south-western part of Ukraine, at Sasyk Lake (Zhmud, 2000). In the 2000s, this species repeatedly wintered in Ukraine, in North Black Sea area along Kinburn Spit (Petrovich, Redinov, 2006) and in the vicinity of Odesa. In winter 2005, a small flock of oystercatchers was revealed further to the east of the region – in Eastern Azov area (Russia, Ciscaucasia) at the coast of Kerch Strait (Dinkevich et al., 2005).



1 – Lake complexes Pomorie and Mandra (Bulgaria); 2 – Lake Sasyk (Ukraine); 3 – Vicinity of Odesa (Ukraine); 4 – Kinburn Spit (Ukraine); 5 – Eastern Syvash (Ukraine); 6 – Kerch Strait, Chushka Spit (Russia); 7 – Romania, details are unknown

Figure 1.3.5. Extension of the area of the oystercatcher (*Haematopus ostralegus*) winter records in the Black Sea Region during the 1990s-2000s.

1.3.2 Numbers and productivity of indicator species

Productivity of the reed *Phragmites australis Trin. ex Steud*

The reed productivity was estimated in several model sites. These selected model sites were represented by mouth areas of one large river (the Danube) and several small rivers of the Azov area (Molochnaya, Berda and Malyi Utliuh). Selected small rivers had different degree of man-made transformation.

Ukrainian Danube Delta

The research on the condition and productivity of reedbeds was carried out from 1998 to 2012, according to standard methods of geobotanical studies (Aleksandrova, 1961, Mirkin, 1984). In 2011-2012 the research was undertaken in the framework of the project "Climate proofing the Danube Delta through integrated land and water management". The control of the vegetation cover on reed-harvesting plots is provided by making transects from an outer to inner part of the island each 500 m along the perimeter and by control mowing of vegetation in 1 m^2 on a route with different ecological conditions of growing.

There are two types of the reed in the Danube Delta: *Phragmites australis var. flavescens* and *Phragmites australis var. gigantissima*. To study the reed response to mowing we made experimental plots amidst the reed of different types. On Novostambulskyi Island the experimental plot is located in the reed *Phragmites australis var. Gigantissima*, others – in thickets of *Phragmites australis var. flavescens* (Zhebrianska Ridge, Kubanu Island, Stensivsko-Zherbrianski Plavni). Commercial reed harvesting is provided only on plots with the reed *var. flavescens*.

Morphometrical indices of the reed were studied on experimental, control and commercial plots. For the all observation period it was done over 780 descriptions of vegetation and 565 investigative mowings in 1 m^2, over 2,800 plants were measured, more than 9,000 morphometrical indices were taken: total weight of vegetation in $1m^2$ and weight of the reed, number of reed stalks, their height and diameter, number of the stalks blossoming or damaged by pests, etc. Thus, in 2011-2012 there were done 161 control mowings with description of vegetation and measurements of all possible morphological and other indices. The most attention was paid to Stensivsko-Zhebrianski Plavni (SZP) where 35 mowings were done in 2011, and 16 mowings – in 2012 with description of vegetation, detail procession and GIS mapping. In 2012, in addition to SZP and traditional areas of reed harvesting much attention was paid to delta islands: Bilhorodskyi, Ochakivskyi, Kubanskyi and Kubanu (control of action of the factor) (Figure 1.3.6) with the aim to reveal effect of fires on *plavni* vegetation (*plavni* – overflow areas in the delta).

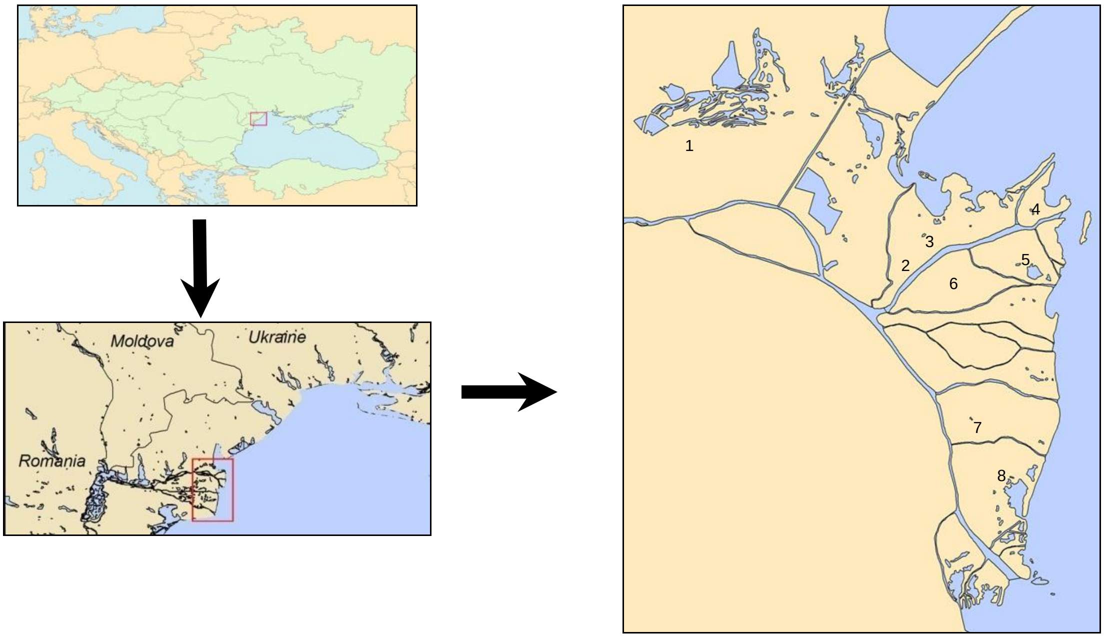


Figure 1.3.6. The model site for estimated reed – Ukrainian Danube Delta*:*
1 – Stensivsko-Zhebrianski Plavni; islands: 2 – Bilhorodskyi; 3 – Polunochne; 4 – Shabosh; 5 – Prorvin; 6 – Ochakivskyi; 7 – Kubanskyi; 8 – Kubanu.

Effects of different factors on the reed productivity. Two types of the reed differ in a multiple set of chromosomes and in size: average height of *Phragmites australis var. Flavescens* is up to 1.6-2.2 m and *Phragmites australis var. Gigantissima* is 3.0 to 5 m. Ecological conditions in areas of growing of both types of the reed are almost identical. Their interpenetration is often observed.

According to mowing results almost in all reed-harvesting plots the indices of phytomass and density were considerably higher than control indices. The diameter of plants was slightly smaller, but such indices as height, blossoming and seed productivity were higher in reed-harvesting plots. Perhaps, it is connected with lighting conditions of plots during spring.

In addition to lighting, the reed development in the Danube Delta is affected by winter temperature and high temperatures in summer, especially if they are intensified by low water level in the Danube and absence of precipitation. It results in more rapid growth of plants and transition from the vegetation stage to blossoming and fruiting.

Climate conditions of recent years and especially of the period 2010-2012 have showed that the climate factor is extremely important in the development of *plavni* vegetation and its action will be further intensifying. A prolonged winter with quite low temperatures caused mortality of wintering young reed sprouts and delayed vegetation start of the plants. The long cold winter and short spring were followed by a hot summer with infrequent rains. The vegetation of plants started 2-3 weeks later than average annual terms, and the phase of reed budding started in mid-August. Over the whole territory of the Danube Delta the reed came into a blossoming phase being much lower in height compared to all the preceding years.

Beside the temperature, the hydrological regime in *plavni* and fire have also provide a considerable impact on the reed. A high and long-lasting flood in spring delays the reed development and if the flood is absent or short-term the reed development accelerates.

In August-September 2011 the fires, caused by a draught season, destroyed thousands of ha of *plavni* vegetation. In these territories the reed development started 2-3 weeks after the fire. Before the beginning of December 2011, the reed had grown only to 0.3-0.5 m, and young wintering sprouts were not formed. Vegetation of the reed, suffered from summer fires, came out from deeper buds of roots that affected the number of stalks, their height, diameter and general productivity. Fires affected *plavni* vegetation in all the delta territories but most of all on Bilhorodskyi Island which is relatively higher than other delta islands and, because of low water level in the Danube in 2012 and low flood which did not reach natural levees of islands and did not penetrate in inner parts of the islands, Bilhorodskyi Island remained almost dry during all the vegetation period of plants.

The burn-out of died off vegetation matter in winter results in increasing lighting of the *plavni* area with preservation of root layer and seeds of plants. Winter fires lead to abundant growth of the sedge *Carex,* the cattail *Typha,* the rush *Scirpus* and other species of *plavni* vegetation. The percentage of marshy forbs increases and pyrophyte species appear which leads to general increase in biodiversity of *plavni* ecosystem. A the same time the fire eliminates thickets of the grey willow *Salix cinerea L*. and increases percentage of weeds on more elevated areas of levees.

The fires also result in reduction of the reed percentage in *plavni* vegetation, changes in the reed indices and general decline of the reed quality. This is a consequence of increase of amounts of nitrogenous compounds which penetrate into soil with ash. As a result, the reserves of useful raw material of the reed are reduced: the height and diameter are the same but weight of plants is smaller and the stalk is more fragile because of reduction of its thickness and adherity.

In ecosystems with man-made hydroregime (Stensivsko-Zhebrianski Plavni) a prolonged (more than 3 months) maintenance of water level in early spring 25-30 cm higher than the root layer of the reedbeds leads to mortality of young sprouts due to lack of oxygen. It brings about more sparse growth of reedbeds with formation of monospecies populations and in the end could lead to degradation of the reedbeds.

Characteristics of the reed development in the Danube Delta in 2007-2012

The year 2007 for the Danube Delta was characterized by a low water level, a spring flood was absent and for 4 months the precipitation was almost absent. As a result, the reed was developed in almost extreme conditions. Over all the delta territory it was observed the reduction of height and diameter of the reed irrespectively of winter reed harvesting or winter fire or absence of these factors.

The most considerable changes in the vegetation composition were on islands suffered from a 2006 winter fires and on areas of cattle grazing. First of all these are islands Ochakivskyi, Ankudinov, Prorvin and partly Kubanskyi, Kubanu and Stambulskyi. On them, the percentage of forbs increased 30% to 80%. In such areas the reed percentage is extremely small and in most cases it significantly differs in height and diameter of the stalk. On islands Prorvin, Shabosh, in the vicinity of Prymorske Village and in some parts of other islands the vegetation development went under substantial impact of grazing pressure.

Similar to the previous year, 2008 also had a low water level. The flood was rather insignificant but compensated by abundant rainfall. As a result, the development of *plavni* vegetation and, first of all, the reed went more evently compared to 2007. In 2008 we observed only a slight increase of the percentage of meadow vegetation among marshy complex of *plavni*.

In 2009 a rather unusual long-lasting summer flood was observed in the Danube Delta. Non-embanked islands of Kiliya Danube Delta were constantly underflooded throughout the summer. It stimulated the reed development.

In 2010 there was also a prolonged spring-summer flood in the Danube Delta. Non-embanked islands of Kilia Danube Delta were constantly underflooded almost throughout a half-year. It stimulated the development of the cattail and other hygrophytes, but, to some extent, delayed the reed development at the start of vegetation period. All this caused almost a month delay in all phases of the reed development. In areas of extreme development (coastal sand spits) the reed came into budding phase only in early August. The budding phase was very stretched in time, and the reed blossoming started in most areas in late August – early September. All this factors affected accumulation of nutrients in roots and formation of sprouts. Such a phenomenon has been never observed before 2010.

After an unusually prolonged spring-summer flood in the Danube which we observed in 2010, the year 2011 was very dry – *plavni* ecosystems were almost all the time without water. Only the areas totally or partially embanked, where some water retained in a central, the lowest, part of the island during almost all vegetation period, were suitable for the development of *plavni* vegetation. The latter has caused a greater fluctuation in the stalk indices (height and diameter).

The moisture accumulated in *plavni* in 2010 was sufficient for the vegetation development in 2011. The vegetation of plants started within average annual timing, and the budding phase started in last days of July. This is almost 2 weeks later than average timing in the last 5-7 years but 3 weeks earlier than in 2010.

The year 2012 in the Danube Delta was characterized by a severe prolonged winter with rather low temperatures and ice cover on the river, and after that a short spring followed by a hot summer already in late April-early May. The Danube flood was small and short-term with a low water level during the most part of the year. Only short wind-driven tides and rains contributed to watering of the lowest parts of the delta islands. All this affected development and productivity of *plavni* vegetation, which reduced over all the territory of the Danube Biosphere Reserve (see Tables 1.3.1 – 1.3.5).

A high water level in 2010 promoted the growth of hygrophytes (*Typha*, *Scirpus*, etc.) and meadow high grasses in levee areas of the islands composed of *Calamagrostis epigeios (L.) Roth*, *Inula salicina L.*, *Mentha verticillata L. Mentha aquatica L.*, *Euphorbia palustris L.*, *Iris pseudacorus L.*, etc., especially in cattle grazing areas. Such a high percentage of forbs in *plavni* vegetation also remained in 2011-2012 irrespectively of a small spring flood and rather hot and dry summer.

Characteristics of the reed condition in different areas. The reed development in Stensivsko-Zhebrianski Plavni went under constant underflooding of *plavni* ecosystem. However, climate characteristics of 2012 affected the reed by general reduction of all its indices (Table 1.3.1).

Table 1.3.1. Dynamics of the reed average indices on plots with permanent winter mowing in Stensivsko-Zhebrianski Plavni over the period 2007-2012.

Indices	2007	2008	2009	2010	2011	2012	average
Number of stalks per m^2	210	226	278	247	285	207	242.2
Phytomass in m^2, kg	3.150	2.950	3.4	3.62	2.94	2.15	3.035
Height of stalks, m	2.2	2.1	1.81	1.95	1.84	1.79	1.95
Diameter (average), mm	5.0	4.9	4.4	4.7	4.8	4.1	4.65

Bilhorodskyi Island is the second in size, after SZP, reed-harvesting area. Depending on climatic conditions of a year the island is underflooded during almost all the period. On the part of Bilhorodskyi Island from the side of Ochakivskyi Branch the cattle grazes permanently, that is why a strip 100-150 m wide is overgrown by meadow and marshy-meadow type of vegetation with small percentage of the reed (less than 25-40%).

Table 1.3.2. Dynamics of the reed average indices on plots with permanent winter mowing in Bilhorodskyi Island over the period 2007-2012.

Indices	2007	2008	2009	2010	2011	2012	average

Number of stalks per m^2	176	239	240	276	307	297	255.8
Phytomass in m^2, kg	2.28	3.15	2.95	3.10	2.99	2.79	2.88
Height of stalks, m	1.65	1.6	1.77	1.65	1.77	1.5	1.66
Diameter (average), mm	4.5	4.0	3.9	4.5	4.2	3.1	4.03

On analyzing average indices of the reed on Bilhorodskyi Island (Table 1.3.2) it should be noted that the general reed productivity is within average annual indices but it is at the expense of the reed from the areas which are closer to the see and are flooded during wind-driven tide from the sea. On a more elevated part of the island it is observed the reed degradation with productivity less than 1kg/m^2.

Table 1.3.3. Dynamics of the reed average indices of on plots with permanent winter mowing in Polunochne Island over the period 2007-2012.

Indices	2007	2008	2009	2010	2011	2012	average
Number of stalks per m^2	168	239	307	301	322	257.8	265.8
Phytomass in m^2, kg	2.33	2.66	3.5	3.45	3.713	2.684	3.056
Height of stalks, m	1.72	1.65	1.7	1.75	1.91	1.59	1.72
Diameter (average), mm	4.9	4.5	4.3	4.0	5.3	3.6	4.43

Table 1.3.4. Dynamics of the reed average indices on plots with permanent winter mowing in Shabosh Island over the period 2007-2012.

Indices	2007	2008	2009	2010	2011	2012	average
Number of stalks per m^2	366	245	314	334	303	195	292.8
Phytomass in m^2, kg	2.30	2.89	3.6	3.26	3.657	2.51	3.036
Height of stalks, m	1.6	1.7	1.67	1.65	1.72	1.7	1.67
Diameter (average), mm	4.0	3.9	4.13	3.8	4.9	4.88	4.27

On islands Polunochne and Shabosh (Table 1.3.3, 1.3.4) in 2011 the *plavni* areas were not constantly underflooded because there was no a spring flood at the Danube. But the *plavni* ecosystem was not as dry as in 2003-2004 and development of *plavni* vegetation went in favourable conditions. In 2012 these areas already had suffered from lack of moisture which affected reed productivity and its indices of density and height.

Island Prorvin (Table 1.3.5) is partly embanked due to formation of hydraulic fill maps and deposition of pulp during dredging works in Prorva Branch and Zyednuvalnyi (Soedininitelny) Canal. It very actively responses to wind-driven increase of water level, and in 2012 this fact favoured the development of *plavni* vegetation and general indices of the reed which were at the level of long-term indices. There is permanent grazing of horses and cows. Due to these two factors the island has one the largest meadows in Ukrainian Danube Delta. The latter influences the area of reedbeds.

Table 1.3.5. Dynamics of the reed average indices on plots with permanent winter mowing in Prorvin Island over the period 2007-2012**.**

Indices	2007	2008	2009	2010	2011	2012	average
Number of stalks per m^2	94	137	234	262	140	172	173.2
Phytomass in m^2, kg	2.25	1.91	2.90	2.78	2.47	2.25	2.43
Height of stalks, m	1.85	1.55	1.60	1.60	1.99	1.78	1.73
Diameter (average), mm	4.2	3.9	4.5	4.6	5.6	4.6	4.57

It is difficult to make more or less precise calculation of *plavni* productivity in 2012. However, in SZP, knowing that the reed harvesting is made on the area of 1,404 ha and the average reed productivity 3.04 kg/m^2, we can estimate the total productivity of the reed – 42,661.6 tons. Taking into account the surface area of water and other types of vegetation we have calculated the reed productivity in the *plavni* territories without winter harvesting of the reed and it constituted 51,599.1 tons.

Therefore, general productivity of SZP is 94,260.7 tons. This value is much lower than that calculated for 2011, and the reason of it is climate conditions of 2012.

A total area of Prorvin Island is 973 ha and *plavni* vegetation covers the most part of it. Almost a third of the island is covered with bushes, vegetation of salines, salt marshes and meadows, and the reed is almost absent there. The overall reed productivity on Prorvin Island in 2012, similar to SZP, had lower indices that those in 2011, but it dropped only by 8.9% and made up 8,776 tons.

Mouth areas of small rivers of the Azov area

Methods. Assessment of phytomass was done in November of 2010 and 2011. Monitoring indices were dry phytomass (in grammes), average height of sprouts (in cm), diameter of stalk (in mm) and projective cover of thickets (in %). Assessment of dry phytomass of the reed and average indices of height and diameter of sprouts was carried out in standard count plots 1 m^2 in size (1 m x 1 m). The spouts were mown at the height of 3-5 cm from soil surface and weighed by electronic scales with ±1 gr accuracy.

Berda River Mouth (Figure 1.3.7) is represented by continuous monodominant thickets of *Phragmites australis*. The phytomass in this model site in 2010 and 2011 was identical and constituted 162.8 hundredweight/ha for 5 mowing plots. However, compared to analogical phytomass data, which we had obtained on a neighbouring plot in February 2006, the resources of reed thickets decreased more than twice.

Analysis of dynamics of main climate factors (air temperature and sum of precipitation, Figure 1.1.11) for the period 2006-2010 in this region shows that in this particular case there is no “weather” background for a sharp decrease of reedbed phytomass. More likely, this sharp decrease in productivity of reed communities is connected with artificial regulation of the river runoff (there are several storage lakes upstream). Drain of water from storage lakes during floods, coinciding with the start of reed vegetation, essentially reduces the reed productivity. Retention of water in storage lakes during a draught period also adds to decrease of productivity (mouth areas are not watered). Such a situation completely levels a role of climate factors in formation of phytomass of reed communities.

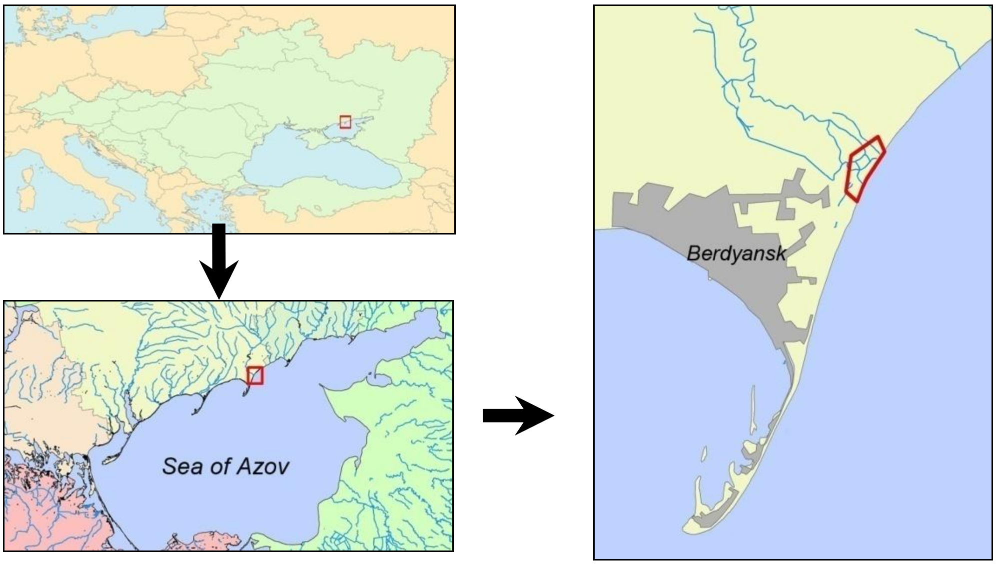


Figure 1.3.7. The model site for estimated reed – Berda River Moutn

Decrease of phytomass of reedbeds in this area is influenced by isolation of small floodplain water bodies from the main watercourse and their further drying up which leads to growth of general mineralization of water and soil. Increased salt content contributes to reduction of the stalk diameter and general height of sprouts (Nikolaevsky, 1961; 1963). Thus, in 2010 the average stalk diameter was 5.08 mm, but in 2011 it equalled to 4.8 mm. The height of reed and indices of its projective cover almost did not change for two years of observation and constituted 200-220 cm and 60-80% correspondingly.

Molochnaya River Mouth (Figure 1.3.8) is represented by continuous monodominant thickets of *Phragmites australis*. Contrary to the Berda River Mouth, the man-made regulation of the river runoff is practically absent there, and main factors impacting on productivity of reedbeds are, above all, climate factors (air temperature and amount of precipitation). Analysis of their dynamics shows a positive trend for the last 6 years.

Thus, compared to 2010, the phytomass of reed thickets in the Molochnaya River Mouth increased in 2011 by more than 4 hwt/ha and constituted 194.66 hwt/ha, and projective cover increased from 60-70% in 2010 to 60-80% – in 2011.

Morphometrical indices demonstrated analogical dynamics – average diameter of the stalk was 6.18 mm in 2010, and 6.36 mm in 2011. Height of sprouts increased from 250-270 cm in 2010 to 270-280 mm in 2011.

Due to minimal observation period of phytomass dynamics and morphometrical indices in this model site it is difficult to reveal trends of reed thickets. However, in case of increasing precipitation and air temperature we can reliably predict further growth of phytomass and morphometrical indices of the reed.

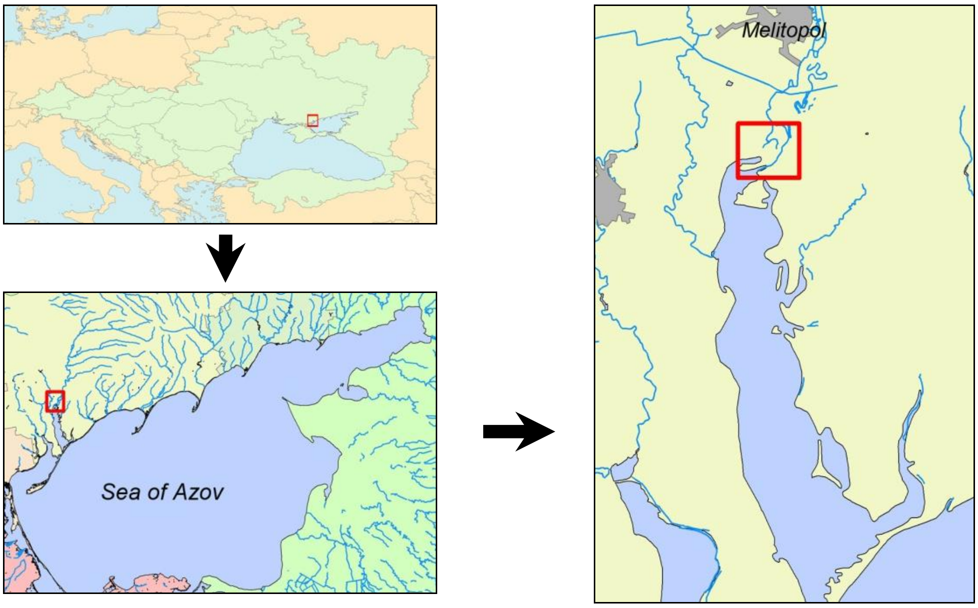


Figure 1.3.8. The model site for estimated reed – Molochnaya River Moutn

Lower reaches of Malyi Utliuh River (Figure 1.3.9) are represented by monodominant stripes of *Phragmites australis* thickets gradually transforming in continuous massifs due to weakening of the river flow and overgrowing of the watercourse.

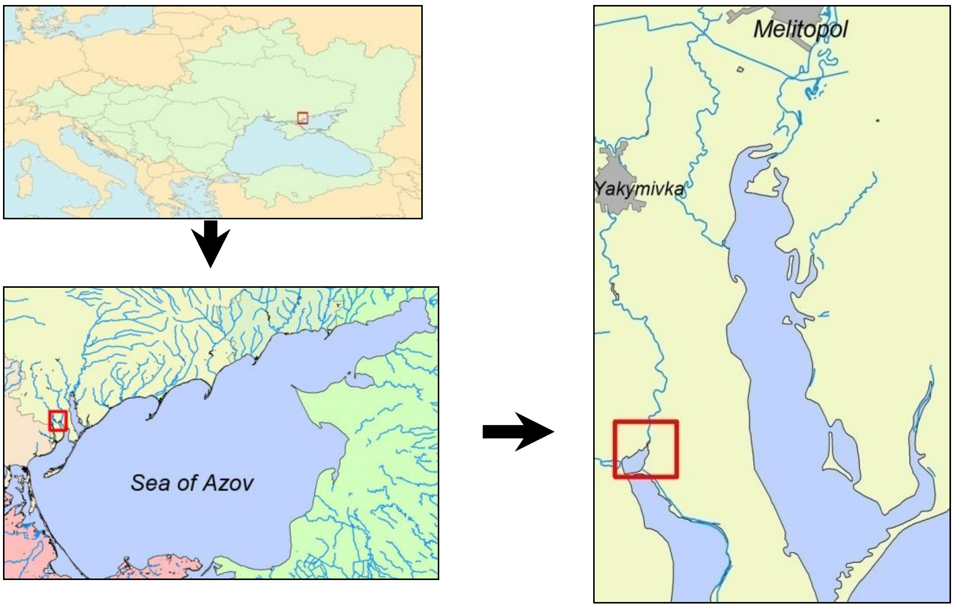


Figure 1.3.9. The model site for estimated reed – *Lower reaches of Malyi Utliuh River*

This area was watered during a major part of vegetation period which is evident from formed air roots in lower parts of sprouts. Dynamics of climate indices in this area is generally similar to those in Molochnaya River Mouth (Figure 1.1.10) and they determine the reedbed dynamics. Average phytomass in 2011 increased by 9 hwt/ha compared to 2010. The height of sprouts also increased from 200-220 cm in 2010 to 235-245 cm in 2011, and the stalk diameter increased from 4.7 to 5.4 mm correspondingly.

Possible decrease of precipitation in this area will lead to increasing mineralization of soil and water which will reduce qualitative parameters of the reed, and vise versa increase of precipitation will favour further growth of phytomass.

Number and productivity of indicator species of insects

Analysis of numbers of model species of insects and its relationship with climate parameters was carried out basing on results of monitoring works. The monitoring works were provided from the 2nd decade of May to the 3d decade of August 2010-2012. There were estimated the relationship of number dynamics of indicator species with air temperature and humidity during a season and per years. Monitoring objects were the seathorn hawk-moth (census by the method of attraction to a light source) and the Migratory Locust (census by the method of counting routes). The monitoring was implemented on two plots (Figure 1.3.10) wetland plot "**Spit**" (Stepanivska Spit of Molochnyi Liman) and forest plot "**Altahyr**" (Altahyr). The data were collected with intervals of two weeks under any weather conditions applying standard entomological methods.

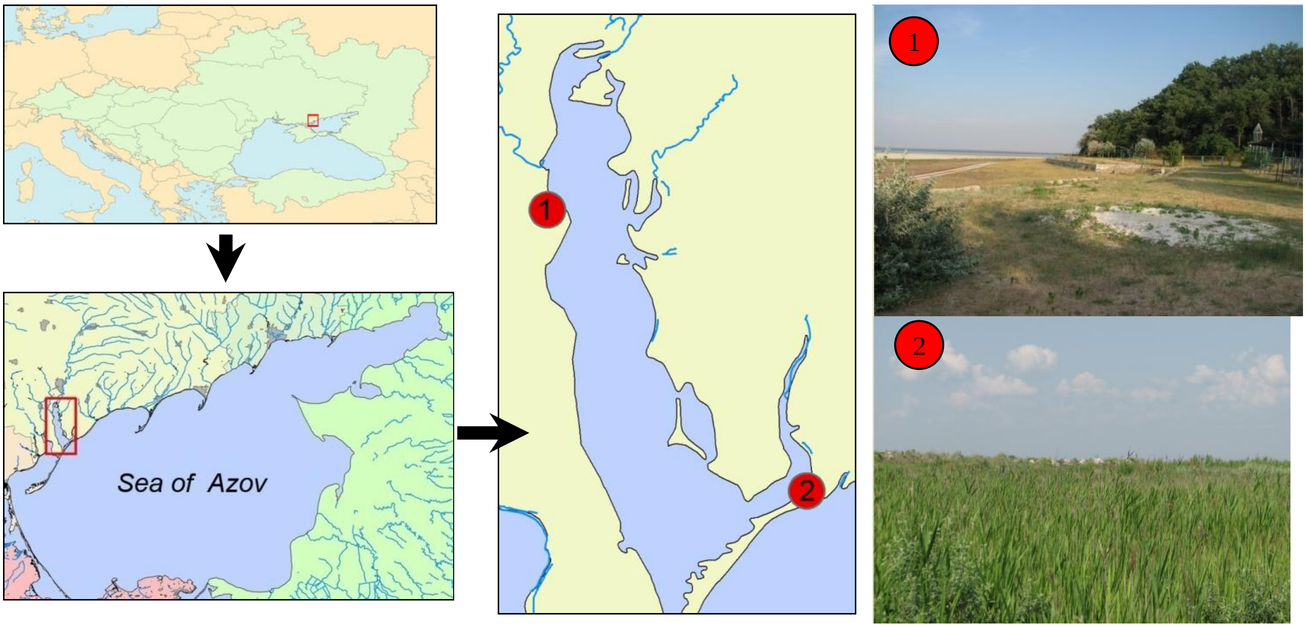


Figure 1.3.10. The model sites for estimated insects – forest plot "Altahyr" (1) and Stepanivska Spit of Molochnyi Liman (2).

the seathorn hawk-moth (caterpillar)

the migratory locust

As a result, it was found out that the numbers of both species during a season changed proportionally to a trend of increasing air temperature (Figure 1.3.11-1.3.14,A) and in inverse proportion to increase of humidity index (Figure 1.3.11-1.3.14,B).

In graphs below, the numbers of the seathorn hawk-moth is represented as the number of individuals flown to the light source per night; the number of the locust is represented by individuals counted per 100 m of the route (see details of the method in the project deliverable D5.1).

To compare data of different years it was selected the sum of positive temperatures for the field season 15.05 – 31.08 (109 days) (Σ t°C) as the main climate index, and average numbers of model species for the field season as the main quantitative index (S). It was calculated according to the formula $S = \frac{\sum N}{V}$, where N – for the seathorn hawk-moth is the sum of counted individuals of the species (flown at night to the light source during season); for the locust N – is the sum of the species individuals recorded during season, which were counted as number of ind. per 100 m of a fixed counting route; V – number of samples (n= 8 for all filed seasons for both monitoring plots). Obtained results are given in Table 1.3.6.

According to the sum of positive temperatures the warmest was the season 2010, the second place took the season 2012 with only a bit smaller quantitative index. The season 2011 turned out to be rather cool compared to other two seasons. However, it should be taken into account that the population dynamics of indicator species (and generally of most insects), besides a direct effect of temperature factor, is substantially influenced by the factor of humidity which is mostly determined by precipitation. Their combined effect is especially noticeable in the periods preceding to appearance of insects, and also at early stages of their development. That is why we searched for correlation between the sum of temperatures and average indices of indicator species numbers, taking into account humidity and amount of precipitation.

Seathorn hawk-moth – Stepanivska Spit

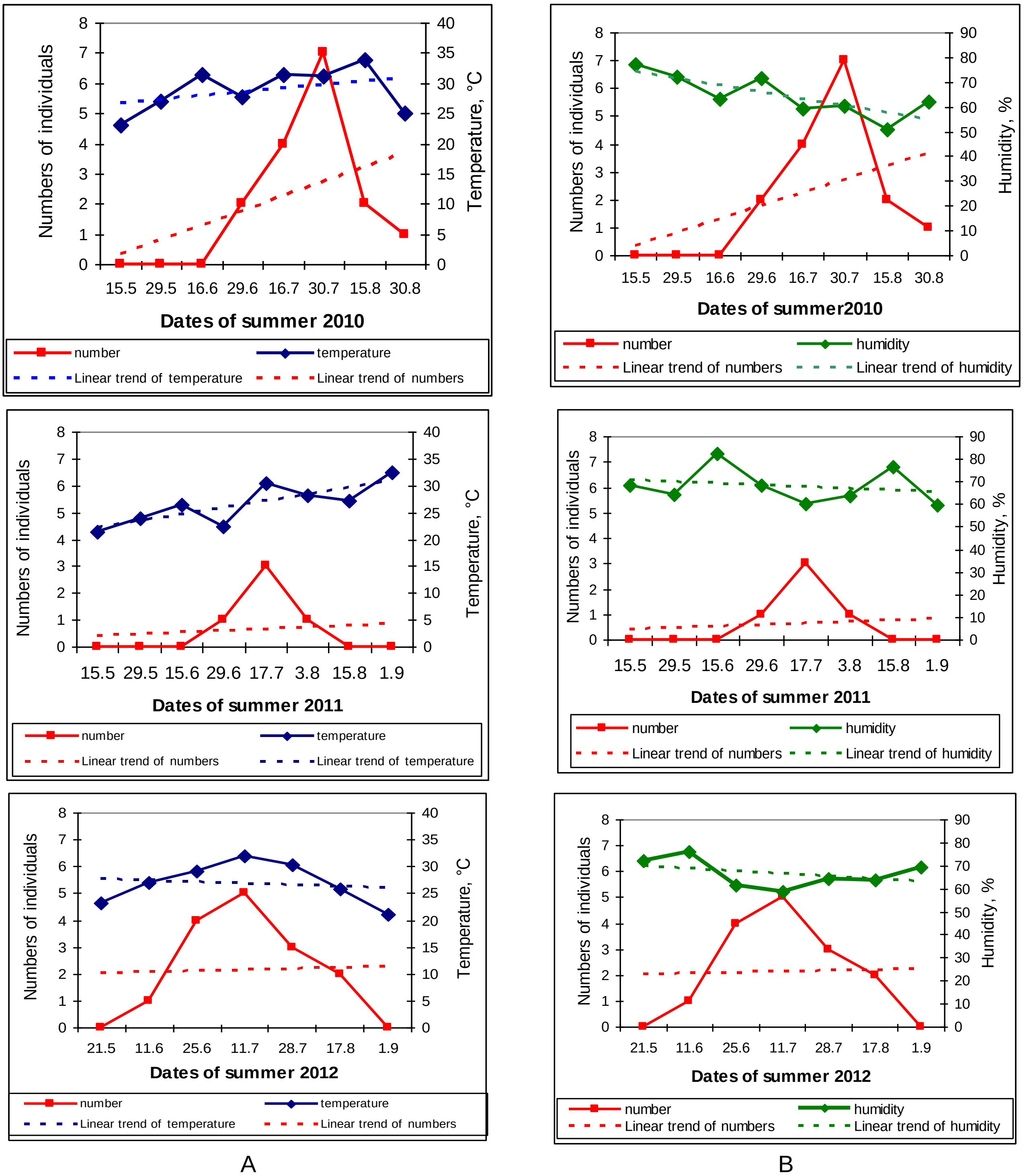


Figure 1.3.11. Dynamics of numbers of the seathorn hawk-moth and air temperature (A) and air humidity (B) on Stepanivska Spit during summer seasons 2010-2012

Seathorn hawk-moth – Altahyr Forestry

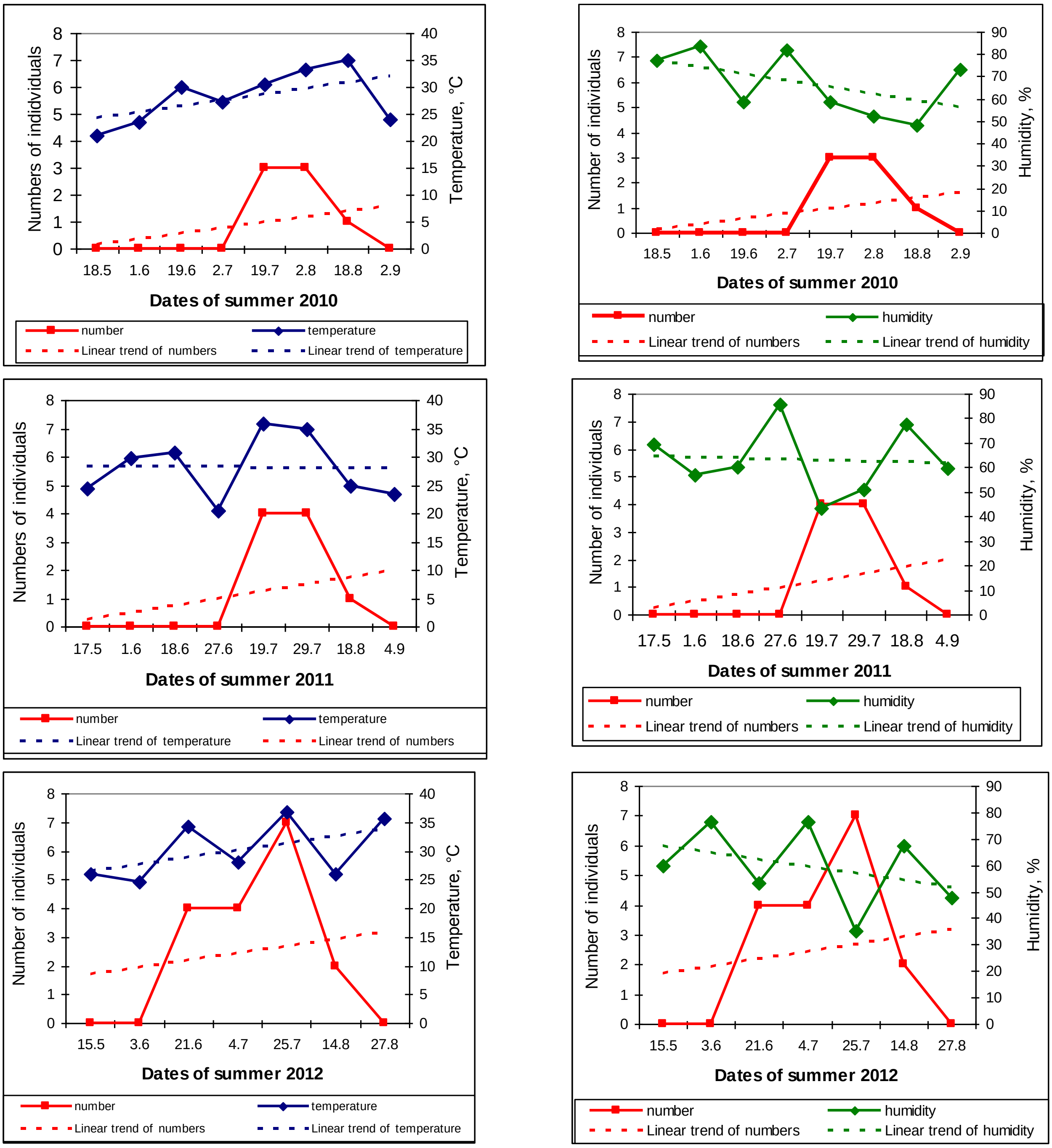
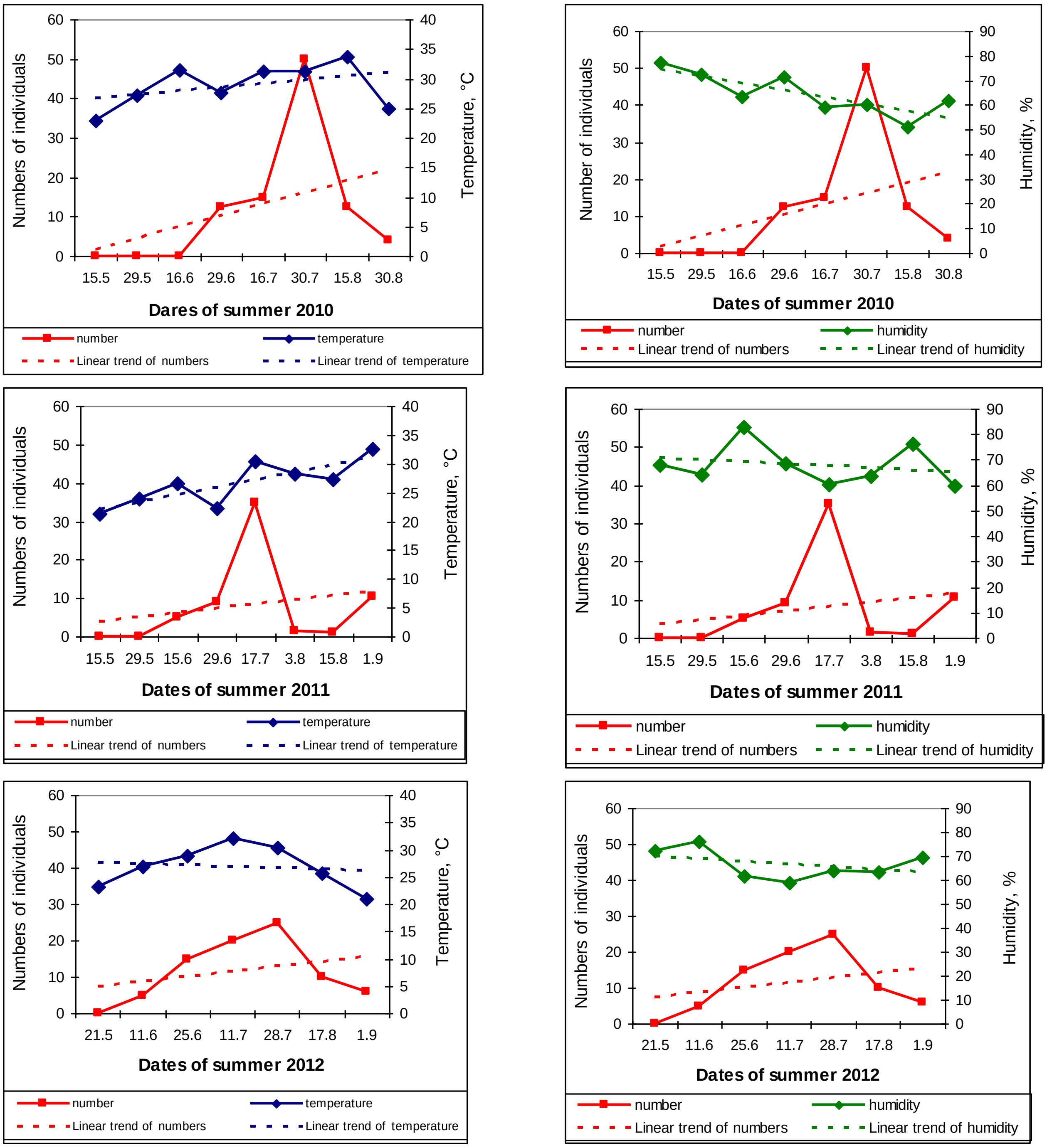


Figure 1.3.12. Dynamics of numbers of the Seathorn Hawk-moth and air temperature (A) and air humidity (B) in Altahyr Forestry during summer seasons 2010-2012

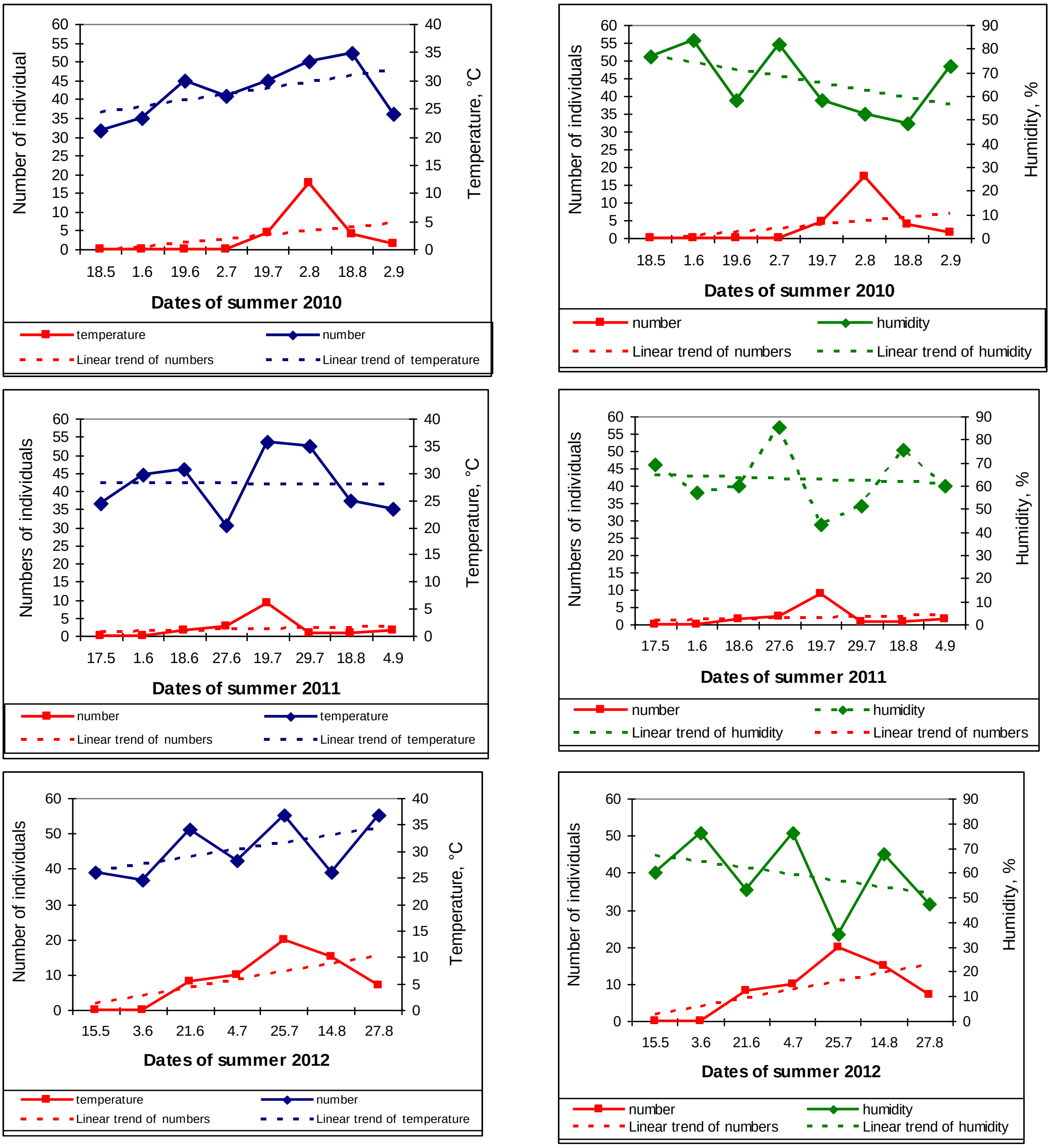
The migratory locust – Stepanivska Spit



A B

Figure 1.3.13. Dynamics of numbers of the migratory locust and air temperature (A) and air humidity (B) on Stepanovska Spit during summer seasons 2010-2012

The migratory locust – Altahyr Forestry



A B

Figure 1.3.14. Dynamics of numbers of the migratory locust and air temperature (A) and air humidity (B) in Altahyr Forestry during summer seasons 2010-2012

Table 1.3.6. Number dynamics of model species on main monitoring plots and dynamics of temperature during the study period in 2010-2012.

Monitoring plot	Species	2010		2011		2012	
		Sum of positive temperatures for field season ∑t	Average species numbers for field season S	Sum of positive temperatures for field season ∑t	Average species numbers for field season S	Sum of positive temperatures for field season ∑t	Average species numbers for field season S
"Altahyr"	seathorn hawk-moth	2647.6	0.9	2492.0	1.2	2621.1	2.1
	migratory locust		2.2		2		7.5
"Spit"	seathorn hawk-moth	2639.2	2	2510.0	0.5	2613.8	2.9
	migratory locust		11.8		8.2		12

On "Altahyr" plot the lowest numbers of the seathorn hawk-moth were recorded in 2010 in spite of maximal temperature indices for all seasons of observation. The reasons are prolonged showers in the first decade of June and the first decade of July which not only delayed the species appearance for 2-3 decades but essentially reduced its numbers until the very end of the season. At the same time, a sharp increase of temperature in mid summer 2010 induced a rapid emergence and growth of numbers of both seathorn hawk-moth and locust. The situation when these two biologically different species, occupying different ecological niches and belonging to different systematic groups, demonstrated synchronic growth of numbers in response to increase of air temperature has confirmed the accuracy of our selection of indicator species and monitoring direction.

The season 2011 was also not characterized by high indices of the seathorn hawk-moth numbers due to relative coolness of the seasons (compared to others) and due to abundant showers in the third decade in June. In spite of the fact that the showers were less intensive and less prolonged than in 2010, the situation almost repeated – the species emergence delayed for 2-3 weeks, and low numbers were registered throughout the season. Maximal numbers of the seathorn hawk-moth, essentially exceeding those of 2010-2011 seasons, was recorded in the last year of research. It was due to several key factors – an unusually early start of a warm season (3^{d} decade of April), a high sum of positive temperatures (only a bit smaller than the sum in 2010), absence of abundant and prolonged rainfall throughout the season (and especially at early stages of insect development). Thus, on "Altahyr" plot, according to a set of climate factors, the **2012** season was the most favourable for **the seathorn hawk-moth** which confirms the main hypothesis of the research.

A trend of number dynamics of the migratory locust per seasons on the monitoring plot "Altahyr" was similar to that of the seathorn hawk-moth. The difference was that minimal numbers were registered in a cool season of 2011. Besides, the factor influenced the species numbers in the 2011 season, similar to the seathorn hawk-moth, was precipitation in the third decade of June which delayed the species emergence for 2 decades and induced a serious negative impact on the locust numbers until the end of the season. In 2010, in spite of the highest sum of positive temperatures for the season, the species numbers were also slightly higher than in 2011, also due to abundant precipitation. The most productive for the migratory locust on the plot "Altahyr" turned out to be the year 2012 when the species numbers 3 times exceeded those for two preceding seasons.

On the plot "Spit" the lowest numbers of the seathorn hawk-moth was recorded in the coolest 2011; they were 4 times lower than in the hottest 2010. In 2010 it was registered the average (per years) index of numbers which is connected with abundant rainfall. Maximal numbers of the seathorn hawk-moth was recorded in 2012, and they 1.5 times exceeded those of 2010. As it was mentioned above, it was due to combination of favourable weather factors.

Therefore, maximal numbers of both indicator species were registered in 2012, along with maximal sum of positive temperatures for field season and minimal indices of humidity during key phenophases of mentioned species. Minimal average numbers of indicator species were recorded in a relatively cool 2011. This situation points at an extremely high correlation between the numbers of indicator species and indices of temperature and humidity.

Emergence of model species was practically always directly connected with the first in season considerable increase of temperature and decrease of humidity, and peak of numbers practically always coincided with maximal index of temperature and minimal index of humidity. In this situation we can say about a significant linear correlation between climate factors and quantitative indices of indicator species which is confirmed by trend lines.

Analysis of changes in weather conditions of seasons 2010-2012 and responses of indicator species has shown that climate factors can essentially shift terms of initial and final phases of development by prolonging or reducing duration of particular stages of annual cycle.

Abrupt climate changes, besides influence on number dynamics and phenology of indicator species, can also provoke changes in their behavior. A clear evidence of that was a mass movement of larvae of first ages of the locust (marching “clouds”) from accustomed drained biotopes to sites with higher humidity which was recorded by us in 2012 on the plot “Spit”.

In spite that during the two extremely hot seasons of 2010 and 2012 the transformation of the locust in gregarious form did not occur, we can assume with a high probability that this intra-population mechanism has been already launched and this may happen in the near future.

Number and productivity of indicator fish species

Number of freshwater fish species

A demonstrative example is increase in numbers of the Prussian carp in the Azov Sea. Trend of this process is shown in Figure 1.3.15 and illustrates increase of the Prussian carp in connection with decline of sea water salinity.

According to the field studies in 2011-2012 indices of occurrence of the Prussian carp in catches remained relatively stable. Thus, in 2011 the species occurred in 11.43% of catches, and in 2012 this index was equal 11.3%.

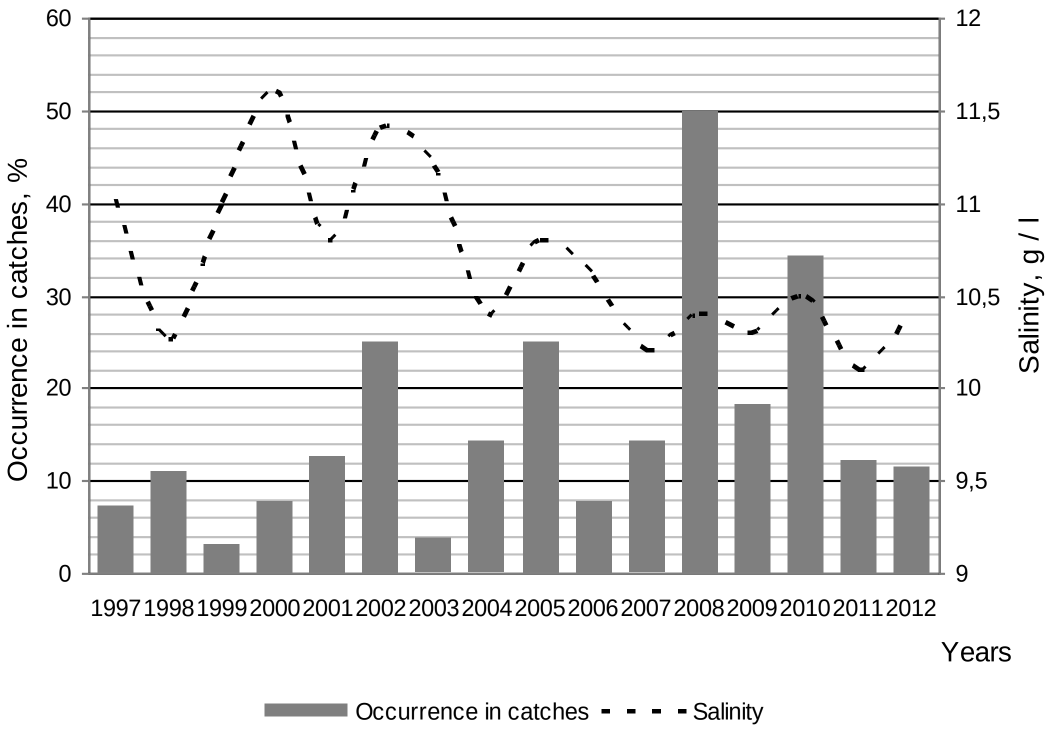


Figure 1.3.15. Occurrence of the Prussian carp in catches in water bodies of the Azov Sea

General indices of fish resources and volume of their catching in the Azov Sea

Analyzing a general dynamics of the fish yield in the Azov Sea from 1927 to 2010 it should be noted the considerable dynamics in the volume of annual catches (Figure 1.3.16.) Maximum catches were recorded in 1936 (275,570 tons), minimum – in 1993 (5,466 tons). Mean annual catches of all the commercial fish species for this period made up 102,904 ± 6,771 tons (Table 1.3.7).

A general trend of catching dynamics is a substantial decline of annual catches in the Azov Sea. A linear trend line shows the decline of 16.6 thousand tons per year (Figure 1.3.16). Unfortunately, it cannot illustrate a particular period in dynamics of catches. A polynomial trend line more obviously illustrates a general trend in the catching dynamics, and makes it possible to distinguish several major phases in a fishery history of the Azov Sea.

Table 1.3.7. Average fish catches in the Azov Sea in different periods

Species	1927-1951	1952-1986	1986-2011	1927-2011
Clupeonella cultriventris	49425	58202	15929	43187
Gobiidae	10050	24702	3963	14293
Engraulis encrasicolus	11504	11118	6793	9959
Liza haematocheilus	-	-	4534	4534
Percarina demidoffii	2047	2055	43	1723
Psetta torosa	6	613	171	308
Atherina pontica	735	615	164	549
Psetta maeotica	360	438	40	294
Mullus ponticus	269	438	23	224

Species	1927-1951	1952-1986	1986-2011	1927-2011
Mugilidae	129	61	39	79
Dasyatis pastinaca	25	5,1	2.4	14
Trachurus ponticus	4	50	7.4	16
Belone euxini	0.1	20	1.7	9
Sprattus phalericus	0	0	13	13
Scomber scombrus	0	30	0	30
Merlangius euxinus	0	0	2.4	2.4
Sander lucioperca	31800	5748	1508	12163
Abramis brama	19521	3150	538	7197
Rutilus rutilus	5558	3447	209	3115
Pelecus cultratus	3006	1270	128	1444
Cyprinus carpio	1976	537	121	969
Alosa pontica	1949	348	45	738
Acipenser stellatus	1654	485	149	596
Acipenser gueldenstaedtii	482	439	326	410
Siluridae glanis	806	87	12	358
Esox luceus	188	338	104	258
Vimba vimba	471	75	5,9	215
Huso huso	299	194	1.6	176
Alburnus leobergi	80	7,5	0	62
Carassius gibelio	0	0	166	166
Ballerus ballerus	0	310	0	310
Hypophthalmichthys molitrix, aristichthys nobilis	0	0	5.7	5.7
Total	147588	118113	34438	102171

The years 1927-1951 (1st period of intensification of fishery) are characterized by a significant increase in volume of catches at the expense of implementation of new methods and catching tools. However, because the breakdown of catching during the World War II there is no complete picture of fishery dynamics for this period. Averagely, for the period, the fish catches in the Azov Sea were maximum and made up 147,588 tons (Table 1.3.7).

The second period is connected with cardinal changes in the Azov Sea basin. Construction of Tsimliansk Hydrostaton in 1956 and after that the regulation in the Kuban River have twice reduced freshwater discharge into the sea (Hydrometeorology,… 1991). The second period (1952-1986) is characterized by great instability of commercial catches. Thus, the polynomial trendline demonstrates considerable fluctuations in annual catches of commercial fish species, averagely 118…113 tons (Table 1.3.7). In the preceding period the anadromous fish constituted a major part of general catches in the Azov Sea but the regulation of the river runoff contributed to isolation of most spawning areas.

The third period (1987-2010) was characterized by the decline of commercial catches in several times. The polynomial trend line demonstrates the second drop in catches (Figure 1.3.16). Indices of overall annual catches of fish in the Azov Sea in this period, averagely, were only 34,179 tons (Table 1.3.7).

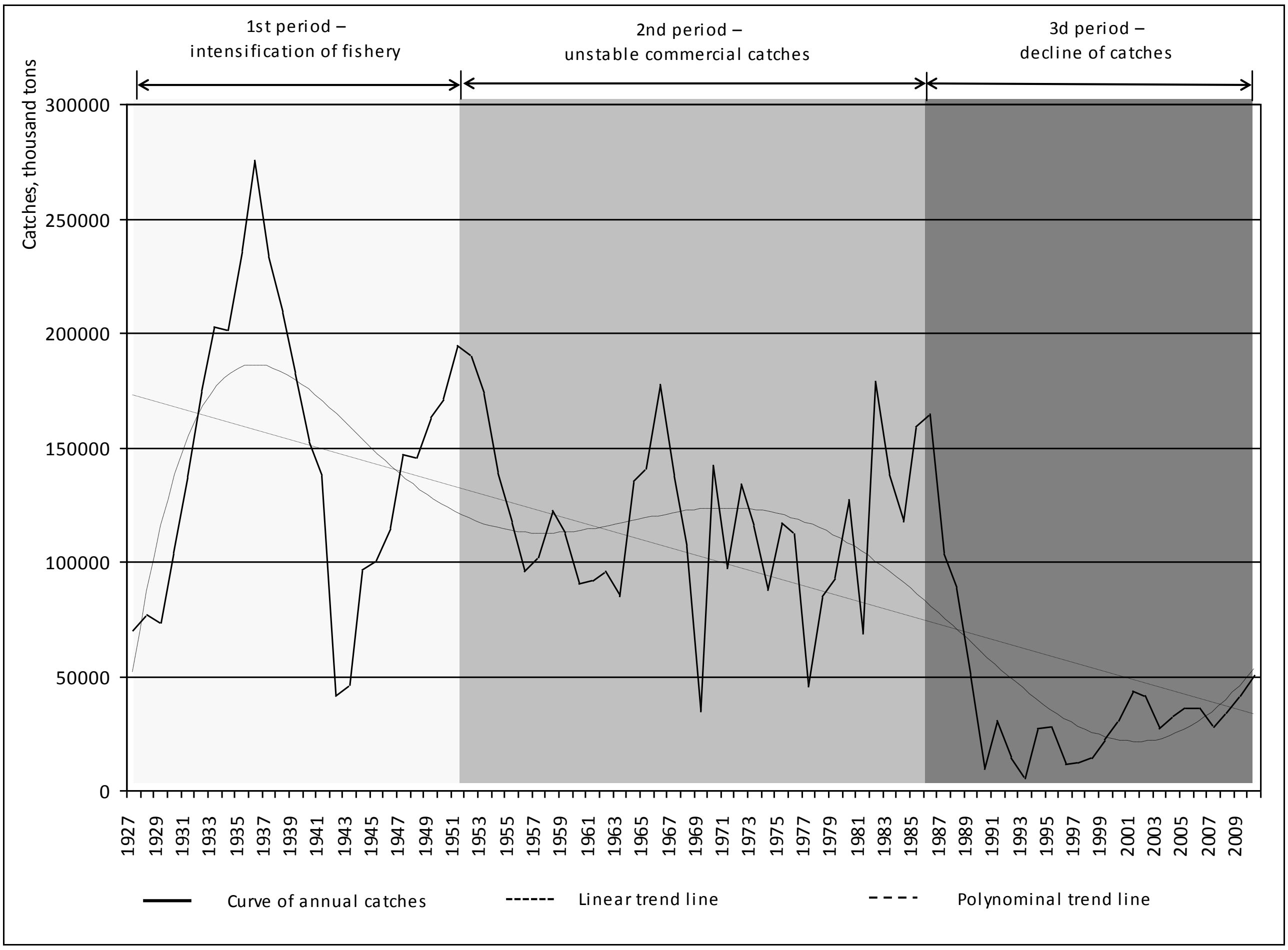


Figure 1.3.16. Long-term dynamics of commercial fish catches in the Azov Sea

Such low volume of fish catches in the sea is connected with a number of reasons, major of them are considered to be a negative impact of jellyfish organisms, appeared in the Azov Sea due to increasing salinity, on pelagic fish species (European anchovy and Azov Sea sprat), which are basic for commercial catches in the Azov Sea (Chashchin et al., 2011). Other main reason for the reduction of catches also was decline in works on artificial fish-breeding and flourishing of illegal fishery (poaching) (Statisitcs, 2000, Mezherin, 2008). However, it should be noted a certain trend of recent years (2008-2011) of increasing the overall volume of fish catches in the Azov Sea. Such an increase is, first of all, connected with a considerable growth in reserves of main commercial species – Azov Sea sprat, European anchovy and gobies.

To understand general long-term trends it is important to compare the volume of yield for different ecological fish groups. The Azov Sea is characterized by catches of both freshwater and marine fish species. Traditionally, the first group includes typical freshwater fish species which periodically come into the sea (the Prussian carp, silver carp, common carp, wels catfish), and anadromous and semi-anadromous species (starry sturgeon and other sturgeons, beluga, freshwater bream, pike-perch, sichel). The marine fish species include typical inhabitants of the Azov Sea (Azov Sea sprat, European anchovy, round goby, the Azov Sea turbot) and those, coming from the Black Sea (red mullet, whiting, Atlantic mackerel, European sprat, Black Sea turbot, etc.) Since 1992, the commercial species have added the So-iuy mullet, acclimatized in the Azov-Black Sea basin, which occupied a certain place in the overall aquatic commercial yield.

Analyzing the dynamics of commercial catches for freshwater and marine fish species it should be noted that the latter dominate in the Azov Sea (Figure 1.3.17).

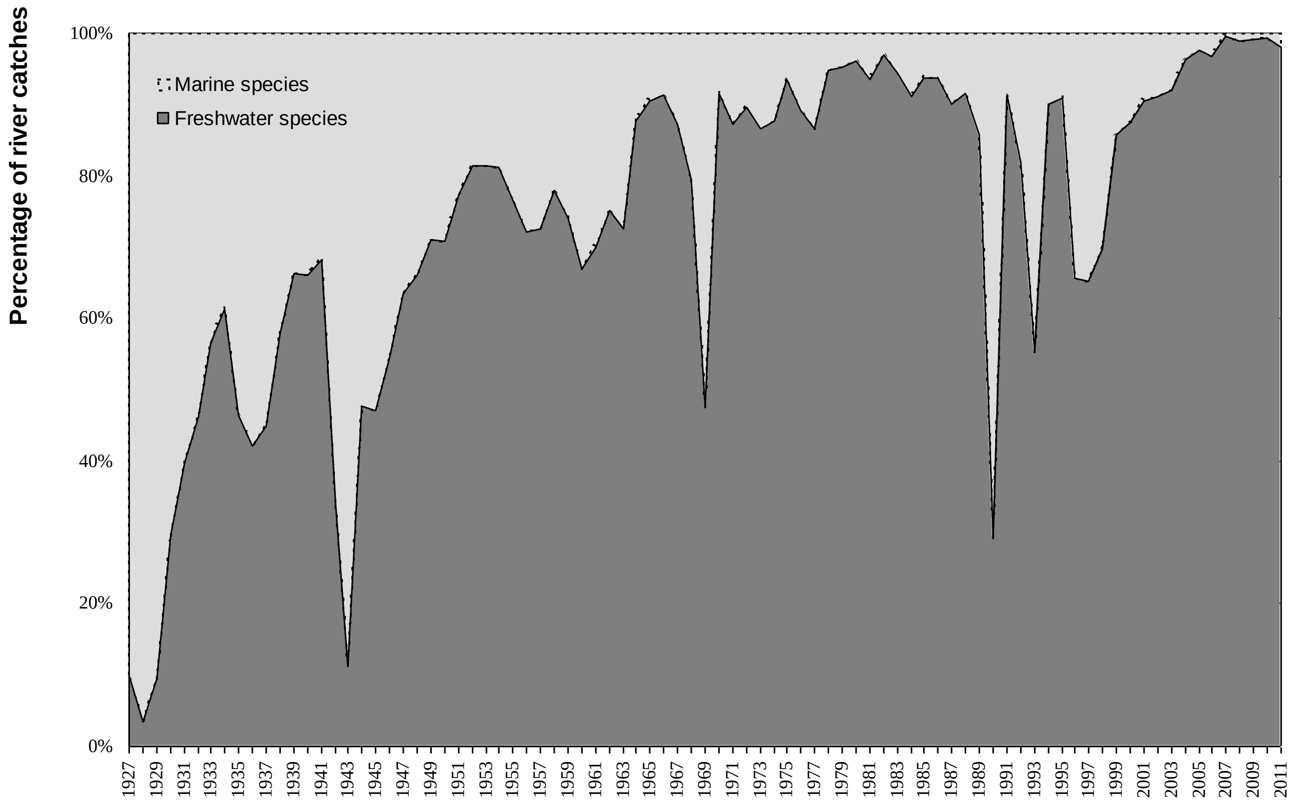
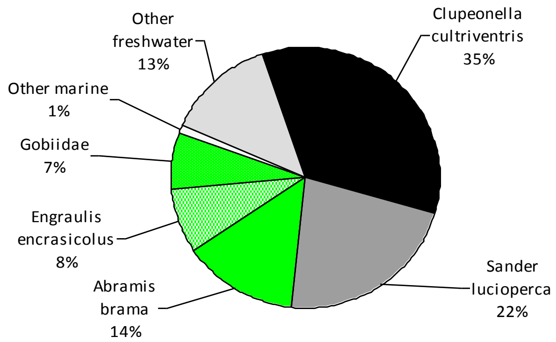


Figure 1.3.17. Dynamics of catches of freshwater and marine fish species in the Azov Sea

Averagely, the Sea of Azov is characterized by dominance of marine species in catches, though periodically the percentage of freshwater fish species was considerable. For the latter, the peak of catches was in 1936, with indices of 152,420 tons/year. The least indices are in the present period. In 2007 there was recorded the minimal yield of freshwater fish species for all the history of official fishery – 138 tons.

Analysing long-term dynamics of catches, it should be noted a gradual decline of the yield. The greatest breakdown was in 1937-1938. We assume that it was caused by overcatching of the valuable commercial fish species such as the pike-perch, sturgeon species, freshwater bream, etc. in 1936.



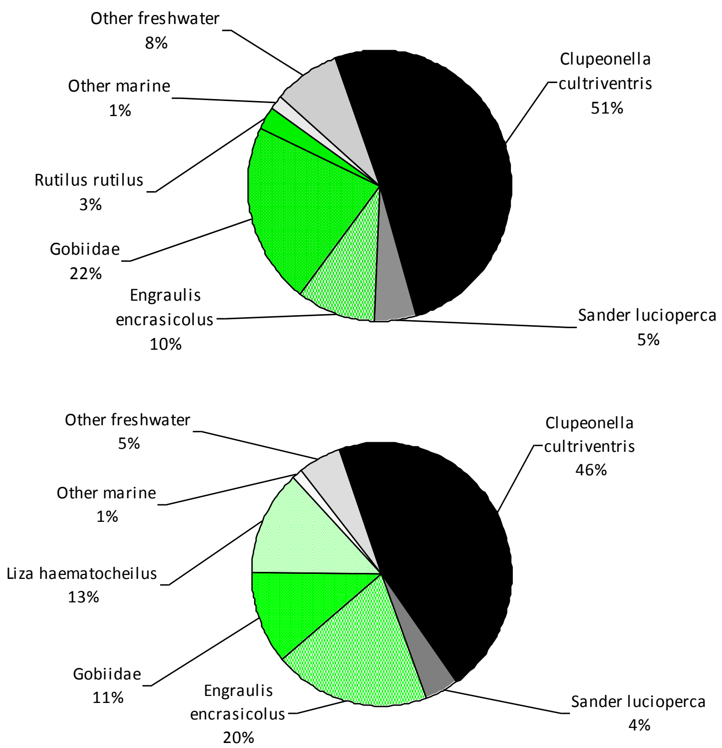


Figure 1.3.18. Ratio of major commercial fish species in catches in the Azov Sea per periods**:**

1 – 1927-1951, 2 – 1952-1986, 3 – 1986-2011.

Further gradual reduction in the volume of fish catches was caused by the regulation of freshwater spawning areas and sharp decline in numbers of freshwater fish species. Some artificial reproduction of valuable freshwater fish species allowed to maintain catches of this group at the level of 10-20 thousand tons. Nowadays, it should be noted that absence of the artificial reproduction system, weak efficiency of fishery management and poaching did not give a chance to restore populations of such valuable species as sturgeons, freshwater bream, pike-perch, etc.

Marine fish species are characterized by considerable fluctuations of annual catches. A major reason of such fluctuations is changes in spawning and fattening conditions along with overcatching of some fish species. The lowest yield of marine fish species was recorded in 1990 – 2,144 tons (Figure 1.3.17).

Comparison of species diversity of main commercial species is a good illustration for changes in the structure of commercial ichthyofauna of the Azov Sea. In all the periods, 4-5 species constituted circa 75% of yield being a base of the commercial fishery (Figure 1.3.18).

Thus, the first period was characterized by dominance of the Azov Sea sprat, pike-perch, freshwater bream, Azov type of European anchovy (Figure 1.3.18). They constituted 79% of yield, and there was no dominance of one particular species in the catches. In general, it should be noted that this period is characterized by a big list of freshwater and marine species which had rather high indices of annual yield.

The second period was characterized by a considerable dominance of the Azov Sea sprat (51%) and gobies (22%). Catches of the pike-perch and freshwater bream significantly reduced (Figure 1.3.18)

The present period is characterized by a considerable dominance of the Azov Sea sprat (45%). The number of the anchovy is restoring. The the So-iuy mullet – an acclimatized species from the Far East – started playing an important role in the structure in marine ichthyofauna. In 1992 it was included in the list of commercial species, and its catches in some years exceed 10,000 tons.

Numbers of the European mink (*Mustela lutreola* L.) in the Dniester Delta and characteristics of the species dynamics

A typical biotope of the European mink

Numbers of the European mink in the Dniester Delta was estimated during monitoring works in 5 plots with a total size of 7.5 km^2, in October-November and January-March of 2010-2011 and in January 2012. Periodicity of investigation for each plot was 5 to 10 days in winter and 10-30 days in autumn, the numbers was estimated as the number of individuals per 10 km of the riverbank or lake shore, and as average numbers per 10 km^2 of overflow (*plavni*) biotopes.

The European mink is an indigenous inhabitant of the delta and forms there an isolated core area, which allowed distinguishing it as a separate subspecies – "Transilvanian mink" (*Mustela lutreola transilvanika*). Its numbers in the 1950s-1960s made up 4-5 thouthand individuals (Abelentsev, 1968). The second half of the 20th century was characterized by low (not more than 2,000 ind.) but stable numbers of the species and relatively small human pressure. The highest numbers of minks in that period were recorded in some weak-developed parts of the delta. The last decades of the 20th century were crucial for the mink in the Dniester Delta; two factors provoked a drastic decrease in the species numbers: regulation of the Dniester runoff by two hydropower stations (substantial draining of inner floodplain lakes) and increased demand for fur. In that period the total numbers of the European mink in the Lower Dniester constituted 100 ind. (Volokh, Rozhenko, 1994). By the end of the 20th century the numbers had dropped to a critical point and the species was about to extinct (Rozhenko, 1999, 2006). A basic reason was destruction of habitats by draining a considerable part of *plavni* (overflow lands in the delta) (Volokh, 2004).

Over the period from 2000 to 2005 we registered only single individuals and some traces of activity of the European mink in the Dniester *plavni* (Figure 1.3.19)

Since 2007, basing on increased records of alive animals instead of dead, we can suppose a trend of numbers stabilization with a slight increase. In 2008, the numbers of the European mink amounted to circa 70 ind. (Volokh, Rozhenko, 2009). Precise reasons are not ascertained, but supposedly the growth of the European mink numbers (Figure 1.3.20) could be provoked by changes in hydrochemical composition of water discharge in the Dniester and optimization of the food base (frogs, molluscs, etc.) in the ecosystem. The latter could be connected with global changes of abiotic (climate) factors.

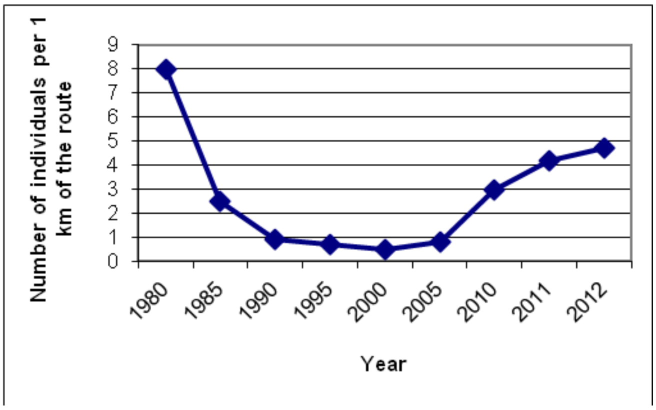


Figure 1.3.19. Density dynamics of the European mink since 1980

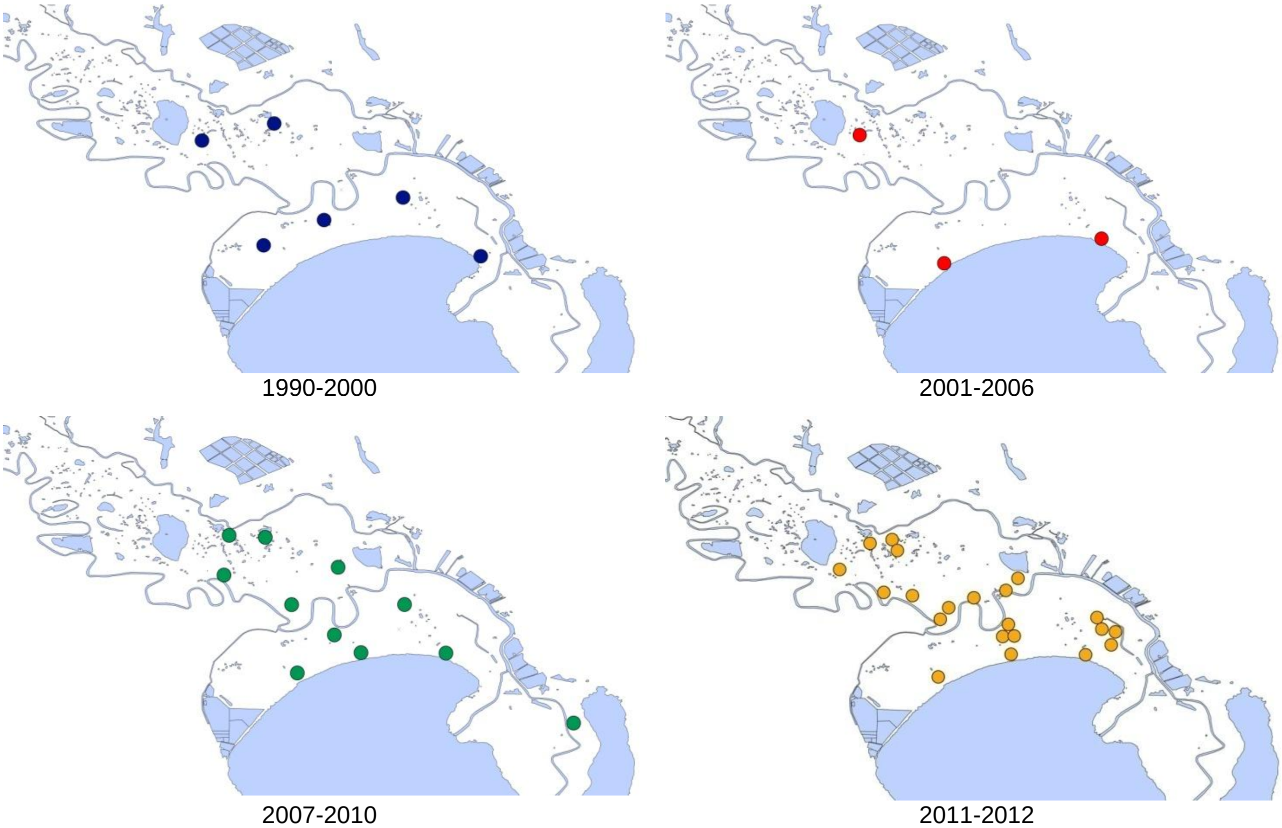


Figure 1.3.20. Distribution of the European mink in the Dniester Delta.

2011-2012 continue a trend of gradual growth of the European mink number, and it can be distinguished the most valuable biotopes where restoration of the population is ongoing. Availability of non-freezing parts of the river, channels and floodplain lakes provide a positive impact on survival of minks and improvement of their food base which, together with general warming of winter temperatures, can maintain positive trends of the mink numbers. At the same time, increase of summer temperatures and reduction of the river runoff, added by functioning of hydrotechnical constructions at the Dniester, have lead to substantial draining of vast areas of floodplain lakes and channels. As a consequence, the minks had to concentrate in the most watered and hard-to-access sites. These contrary-directed factors will determine further development of the situation with the mink numbers, which is still hardly to predict because of unclear climatic trends.

1.3.3 Phenology of annual life cycles of indicator species

Changes in timing of development of plants in terms of climatic characteristics of the year

Impact of climate changes on plant phenophases was studied in the Ukrainian part of the Danube Delta (Danube Biosphere Reserve – DBR). The duration and start of phenophases in plants of the Kilia Danube Delta, except climate conditions, is influenced by timing of start and end of flood, its height and duration, relief and characteristics of ecotopes. In general, the start of vegetation season for the majority of plant species on a major territory of DBR is observed from early February to mid-April, and for the spits, which are subject to the action of sea waves, it starts at the end of April – May, after finishing a period of heavy storms.

A phenological characteristic of plants in the territory of DBR is a big time interval (two weeks and more) between the dates of vegetation period in its northern section – Zhebrianska Ridge, dams of Yermakov Island and Stentsivsko-Zhebrianski Plavni, and in the southern (coastal) section. This is due to the microclimate created under the influence of the sea and the Danube waterway. In plants, developing after mid April – May, there are almost no differences in timing of phenophases in different parts of the delta.

Phenology of aquatic plants depends on water temperature, which in turn depends on the climatic characteristics of the year, and on the depth and flow of the water body. A particular feature of some hydrophytes is a significant difference in timing of their development in water and in periodically flooded areas. Thus, *Mentha aquatica* when being in water begins its development in February, and in the periodically flooded areas chiefly only in March-April (during flood). On the contrary, the reed *Phragmites australis* starts its vegetation period on well-warmed ground areas 2-3 weeks earlier than in water bodies.

A warm autumn period, observed in recent years, promotes secondary vegetation of plants. In addition to the reed *Phragmites australis*, in a warm late autumn period it is observed secondary vegetation of other airborne-aquatic species of plants (*Typha angustifolia*, *T. latifolia*, *Iris pseudacorus*, *Sparganium erectum,* etc.). However, in case of short-term light frosts their above-water parts dye off.

A bloom phase of plants in the Kiliya Danube Delta is long-continued which is determined by both prolonged period of positive temperatures and general climate warming observing in the last 10-15 years.

The most numerous are groups of species blooming in MAi-June and in August-September-October. The second peak of mass bloom of species is connected with secondary bloom of many ephemers and ephemeroids, which development is observed after the period of rains which are the most abundant in the second half of August-September. And in the last 3 years these groups of species were added with some tree-shrub species: *Amorpha fruticosa*, *Tamarix ramosissima*, *Robinia pseudoacacia* and other species including fruit trees.

Due to a dry summer period in 2011-2012, with high temperatures, the bloom of some species such as *Leucanthemella serotina*, *Mentha verticillata* and *Mentha aquatica L.*, *Tripolium vulgare*, *Taraxacum bessarabicum* started in September and lasted until November. And *Dianthus bessarabicus* starts blooming in June and finishes it, in case of a warm autumn, in November-December.

In recent years it is difficult to determine a precise trend of changes in timing of vegetation development because of unpredictable hydrological factor. The most sensitive species are orchids. There 4 species of them in the Danube Biosphere Reserve: *Orchis palustris*, *Epipactis palustris*, *Epipactis heleborine* and *Dactilorhyza majalis*. The most complete information, with retrospective data, is collected for *Orchis palustris* (from 1997 to 2012). This species grows over quite an extensive area in depressions of sand ridges. The table below shows the phenodates of the start of bloom for the indicator species *Orchis palustris*, conditions of its growing and other climatic and hydrological characteristics of vegetation periods from 1997 to 2012.

Table 1.3.8. Phenology of bloom of *Orchis palustris* and its connection with climatic and hydrological indices.

Year	Start of bloom	Conditions and density of growing	River hydrological regime	Climatic periods of seasons spring/summer
1997	28.05	Long-lasting small underflooding, density 5-7 plants/m² , max. 40 plants/m²	Higher than average, with long-lasting spring flood	Spring: 22.02-26.04 Summer: 27.04 – 15.11
1998	5.06	Dry; density 1-4 plants/m² , max. 23 plants/m²	Lower than average	Spring:09.02-02.04 Summer: 03.04 -27.10
1999	27.06-18.07	Long-lasting and high underflooding; density 3-8 plants/m², max. 31 plants/m²	High, with long-lasting spring flood	Spring: 21.02-25.04 Summer: 26.04 -15.10
2000	2.05	Dry; density 1-3 plants/m² , max. 18 plants/m²	Average, with long-lasting summer flood	Spring:27.02-04.04 Summer: 05.04-21.11
2001	5.06	Dry; density 1-2 plants/m² , max. 4 plants/m²	Lower than average, with small flood	Spring:05.02-4.04 Summer: 05.04-23.10
2002	28.05	Dry; density 1-2 plants/10m²	Lower than average, with small flood	Spring: 18.01-15.04 Summer: 16.04-27.10
2003	11.06; blooming up to 2 weeks	Dry; density 1-3 plants/per 100 m² in wet sites max. 3 plants/m²	Low, with small flood in early February	Spring: 03.03-19.04 Summer:20.04-04.11
2004	6.05	Sufficient moisture; density 1-7 plants/m², max. 18 plants/m²	Average, with flood in April-May	Spring:08.03-05.04 Summer:06.04-03.11
2005	19.05	Good moisture; density 1-7 plants/m² , max. 21 plants/m²	Higher than average, with long-lasting flood	Spring:12.03-09.04 Summer:10.04-27.10
2006	26.05; long-lasting bloom	Long-lasting and high underflooding; density 3-8 plants/m² , max. 37 plants/m²	High, with long-lasting 3.5 months flood	Spring:10.03-11.04 Summer:12.04-15.10
2007	12.05; short period of bloom	Dry; density 1-2 plants/m² , max. 14 plants/m²	Low, with small flood in late March	Spring:26.02-01.04 Summer:02.04-29.10
2008	13.05	Moisture of soil due to rains; density 3-4 plants/m²	Lower than average, with small flood in April	Spring:19.02-10.04 Summer:11.04-07.11
2009	04.05	Permanent and prolonged moisture of soil. bloom ≥2 months. density 3-5 plants/m² , max. 32 plants/m²	Higher than average, with 1 month flood	Spring:28.02-23.04 Summer:24.04-28.10

Year	Start of bloom	Conditions and density of growing	River hydrological regime	Climatic periods of seasons spring/summer
2010	14.05	Permanent and prolonged moisture of soil; bloom ≥2.5 months. density 5-8 plants/m² , max. 20 plants/m²	High, with long-lasting 7 months flood	Spring:11.02-13.04 Summer:14.04-21.11
2011	17.05	Small moisture density 7-10 plants/m² , max. 28 plants/m²	Low, with flood in January	Spring:12.03-16.04 Summer:17.04-23.10
2012	28.06; bloom up to 2 weeks	Very dry. The species was absent in some sites; density 1-2 plants/per 100m² in moistured sites max. 4 plants/m²	Very low, practically without flood. Abundant rainfall since 20.05, lasted 9 days	Spring:10.03-12.04 Summer: 13.04-29.10 Since 28.04 t≥ 20ºC

In the above-mentioned period of studies the year 1999 greatly differs from the previous years to the orchids. In 1999 the Danube water level for three months remained at almost a critical level, and in some days even exceeded critical values. It affected the development of plants in the delta, especially in depressions which were flooded for a prolonged period.

The vegetation period of orchids in 1999 turned out to be very stretched and shifted to summer season. Thus, in 1996-1998 the bloom of *Orchis palustris* started since the second decade of May and ended in the first dates of July with the bloom peak in the third decade of May – fist half of June, and in 1999 the bloom was recorded only since 27 May and ended in the second half of July. Maximum bloom was in the second half of June. After 1999 only some phenophases and density of growing were registered. However, having data of the Danube water level at Vilkovo and climatic indices of spring/summer we made an attempt to analyse the effect of these factors on the condition of *Orchis palustris*.

Results of monitoring and ecological reconstruction of integrated impact of factors have shown that only timing of summer start (see Figure 1.3.21) had a weak correlation (+ 0.3) with timing of start of bloom of this indicator species. At the same time, the start of summer period has a weakly-pronounced trend of shifting to earlier dates, contrary to the timing of the beginning of spring. Absolute values of temperature have little impact on bloom phenophase. It is the water regime of a particular season which is a determining factor in orchids development in the Danube Delta. In years with low water level and in dry years it is observed a general decline in orchids density and reduction of their bloom period. A high water level during spring-summer flood leads to increase of vegetation period and shift of bloom to summer season.

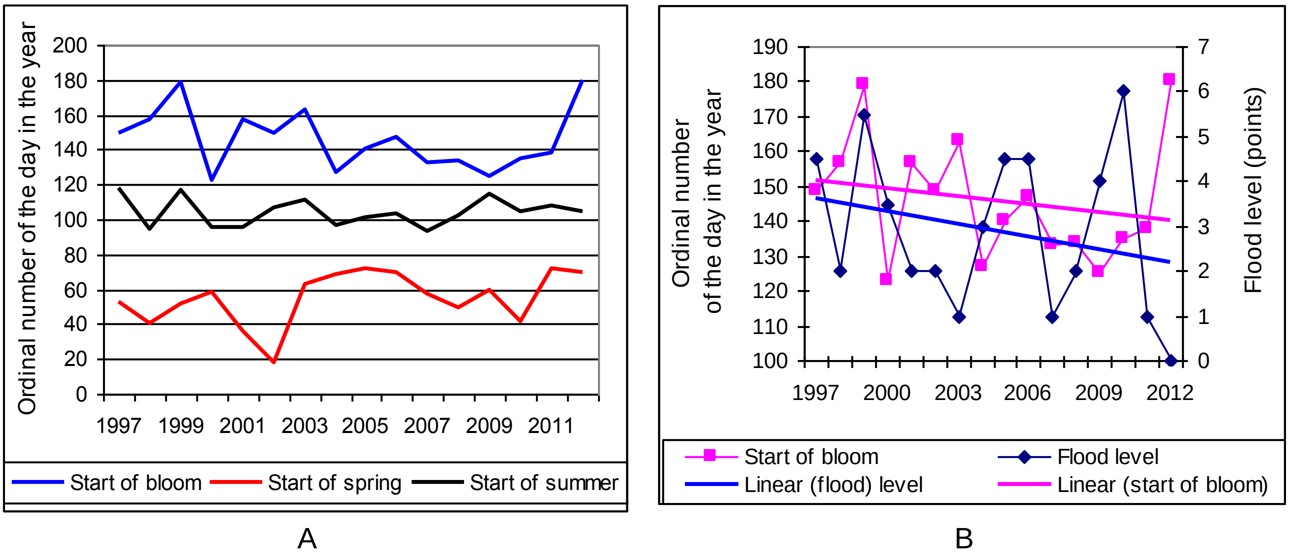


Figure 1.3.21. Blooming phenology of *Orchis palustris* and its relationship with climate (A) and hydrological (B) indices.

In dry years the orchids development goes predominantly in the deepest parts of depressions, and in over-moistured seasons – on the most elevated parts of their habitats. The highest density of the species was recorded in years following the year of maximum water level in the Danube which was observed in 1999, 2006 and 2010 (see Table 1.3.8).

Such substantial fluctuations in orchid numbers in the same places in subsequent years are possible only if there are significant reserves of "dormant" bulbs (roots). Because, due to peculiarities of orchids onthogenesis, they need many years to reach generative maturity. This is a very interesting phenomenon from the biological and ecological points of view.

Phenological indices of the European anchovy

The timing of migration of the European anchovy *(Engraulis encrasicolus)* from the Azov Sea to the Black Sea, across Kerch Strait, was selected as an indicator phenological index. The analysis has shown that for the period 1930-1977 the timing of migration shifted to later dates. It is caused by increase of water temperature and therefore a longer stay of the species in the Azov Sea during fattening (Figure 1.3.22.)

This trend had remained until the early 1970s. For that period, the behaviour of the anchovy population was directly or indirectly associated with water temperature (Figure 1.3.23). The start of migration was connected with two important factors: fat accumulation rate and air temperature.

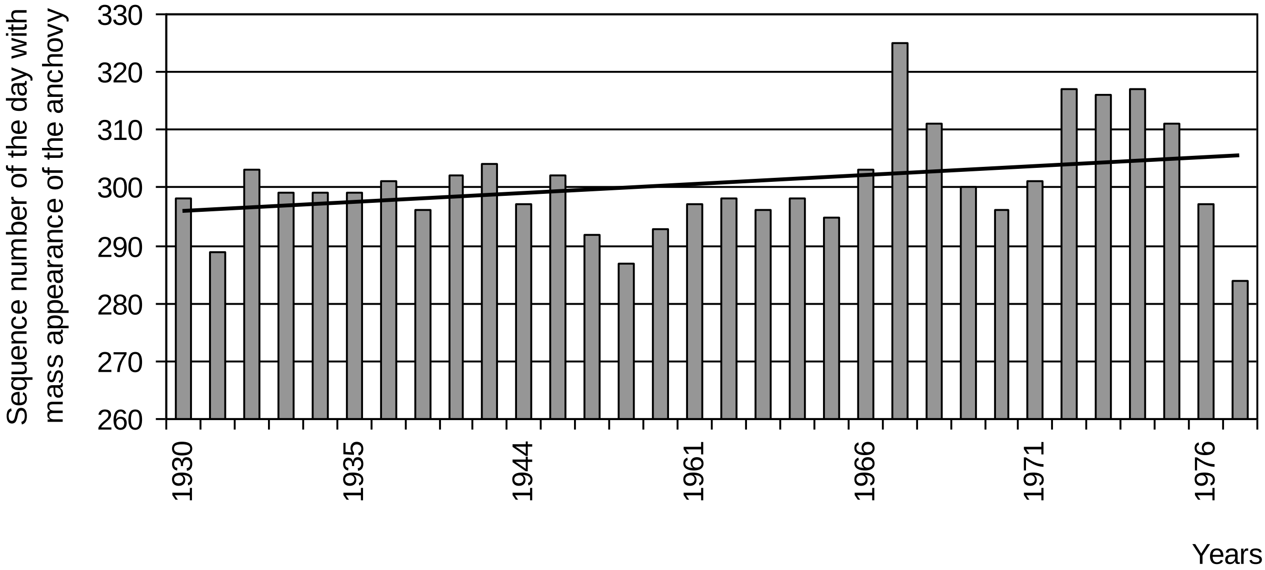


Figure 1.3.22. Dynamics of timing of migration of the European anchovy in Kerch Strait of the Azov Sea

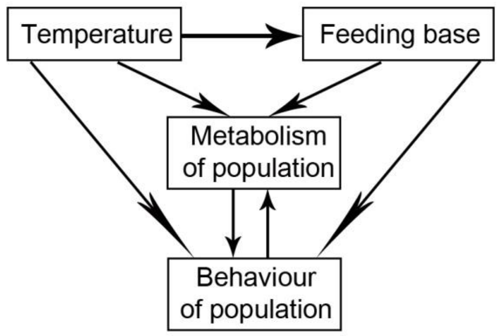


Figure 1.3.23. A scheme of influence of temperature and feeding base on biology of the anchovy until the late 1970s.

Since the early 1980s, this trend has changed due to a high feeding competition between the anchovy and the comb jelly (*Mnemiopsis leidyi*). Lack of feeding resources has led to a considerable decline of the anchovy numbers. As a result, since the early 1980s in the Azov Sea the concentrations of the anchovy have not been recorded, they do not form flocks or active shoals in Kerch Strait. Thus, the comb fish has crucially affected the situation in the Azov Sea. Only 2010 brought an increasing trend of the anchovy numbers in the Azov Sea. Most of experts predict further increase of the anchovy in the sea due to the improvement of the feeding base. In addition, a gradual increase of sea water temperature may lead to a longer fattening of the anchovy in the Azov Sea.

Changes in phenology of insects

During monitoring of indicator species, the changes in phenology of other species were also recorded. In this respect, 2012 was a demonstrative year. It was characterized by an unusually early start of a very warm season, since the last decade of April. Terms of imago emergence for a majority of night Macrolepidoptera, observed for all the three years of research (during counts of the hawk-moth *Hyles hippophaes Esp. (*Sphingidae, Lepidoptera*))*, in 2012 were ahead of normal time at least 14-16 days. Some representatives of this group demonstrated even more substantial time advance. Thus, emergence of the light crimson underwing *Catocala promissa* (Noctuidae;

Lepidoptera) in one of the monitoring plots was recorded 21.06.2012, while usually it is the second part of July – August. Similar results showed other representatives of this genus. Thus, imagoes of *C. nupta* and *C. Elocata* in 2012 emerged in early July, 14-20 days ahead of usual terms.

In addition to the early start of a 2012 warm season, the warm and dry weather was staying for long, until mid October. The effects could be easily seen for the underwing moths (large and bright moths, easy to observe) – their flying forms had been recorded until the second decade of October, almost 2-3 weeks longer than usually. In unusually early and hot summer the underwing moths, besides phenology changes, also demonstrated in other regions an abnormal diurnal activity and behaviour. According to A.Sviridov, a senior scientist of Moscow State University Zoological Museum and entomologist (cited by: Musolin, Saulich, 2012), "…..common in Moscow night moths – "underwing moths" – unusually occurred in daytime, and demonstrated untypical behaviour: did not hide in thickets but appeared in crowded places and sat straight on the way of pedestrians". The author suggests these behavior deviations are connected with abnormally high temperatures and absence of precipitation. In Russia, serious phenology changes were also recorded for Rhopalocera. Thus, at the Urals in late May was registered the mass emergence of *Aporia crataegi* (Pieridae; Lepidoptera), which is an agricultural pest. Such timing of this species appearance in the region is almost 1 month earlier than usual. Similar situation was observed in Tomsk Region. There, in the region of Kolarovo-Vershinino, July 6-7, the large concentrations of these butterflies were registered. Local experts assume that the reason of this phenomenon is an early and unusually hot summer.

These examples give an additional confirmation that phenological responses include not only a shift of insect development at the start of the season to earlier terms but further changes in phenology. Thus, phenophases, connected with the end of seasonal development, on the contrary, usually shift to later dates. It leads to prolongation of a period of active development, including that for pests, which can provide extremely negative socio-economic effects.

Phenology of annual life cycles of the sand lizard (Lacerta agilis)

Biological features (diurnal activity) of the sand lizard in the south of Ukraine were studied in 2012. It was found out that the duration of dAi-time activity depends on a season and seasonal temperature fluctuations. First specimens appear after winter hibernation in late March – early April. However, a constant activity was observed since mid April. In spring at + 14^{0}C air temperature, active lizards were seen on the surface. The highest activity was recorded in MAi-mid June. When heat season comes in the second half of June – August with +35^{0}C…+37^{0}C air temperature in the shadow, only single individuals could be seen on the surface. Supposedly, a majority of adult and half-adult lizards fall into summer hibernation because of critical for the species air temperatures (Figure 1.3.24; 1.3.25).

The diagrams show than for the last 12 years the duration of activity of the sand lizard in spring and autumn remained almost unchanged. In summer months the reduction of activity is recorded due to increase of dAi-time pause, which is supposedly explained by high day-time temperatures.

Month	Hours of the day														
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
IV															
V															

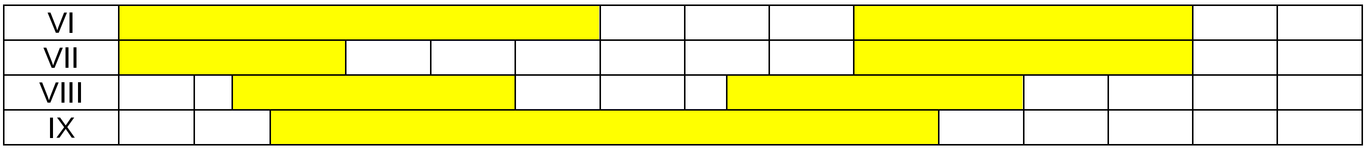


Figure 1.3.24. Diurnal activity of the sand lizard in the south of Zaporizhzhia Region in 2012.

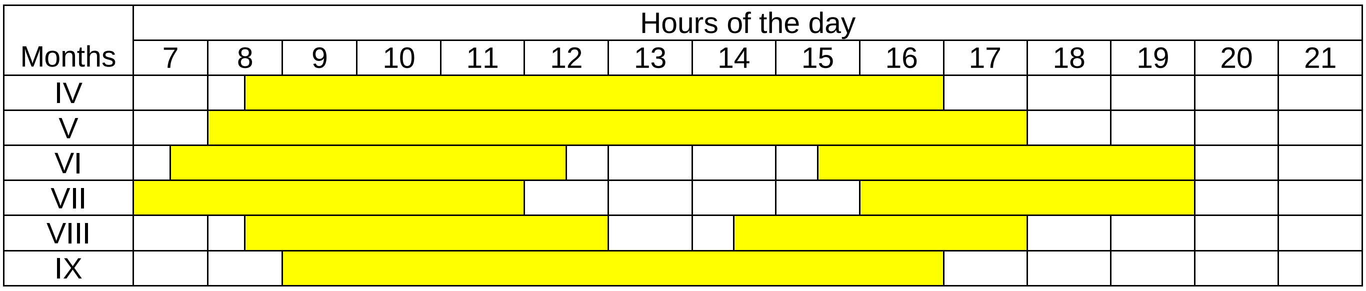


Figure 1.3.25. Diurnal activity of the sand lizard in the south of Zaporizhzhia Region in 2000.

In addition, an earlier emergence of young lizards was recorded in 2012. Thus, underyearlings of the sand lizard (*Lacerta agilis)* were recorded 6.07.2012 on the shore, near Lyman Lake (Zmiivka District, Kharkiv Region).

Such terms of appearance of young lizards are 2-3 weeks different to those registered on Molochnyi Liman (Zaporizhzhia Region) in the late 1990s.

Climate impact on phenology of seasonal migrations of birds

The bird species are conventionally divided into two groups: so-called “weather” migrants and those which timing of migration is genetically determined. It is the most logical to expect the impact of weather conditions and climate changes on timing of seasonal migrations for the first species group. As for waterbirds, we can include **short-distance migrants** in the first-group species. The wintering area of them is not far from their breeding grounds; they are some species of ducks, geese, gulls and waders.

In many cases it is the amplitude of arrival dates which clearly characterizes migration types of species: whether they relate to “weather” migrants or “endogenically regulated”. For instance, in Belovezhskaya Pushcha (Belarus), over the period 1947-1954, the amplitude of migration start for an Arctic species – the black-throated diver constituted only 5 days, while the amplitude of the arrival for a breeding garganey was 35, and for the herring gull – 43 days (Gavrin, 1957).

Climate changes differently reflects in migration phenology of the local species, territorially associated with biotopes, and the transit species which cross the region and use feeding and other resources of a biotope only for some period of time.

During the research carried out in the framework of EnviroGrids Project we have found out that a part of distant migrant species (Arctic waders and geese) also demonstrates a certain relationship between timing of migration and changed weather-climate factors. It is not always the dates of first registration which are a reliable criterion of a trend but rather the median of passage (departure) and physiological condition of the birds, the shift of terms of autumn arrival and the date of the species last registration in the region.

The indicator species suitable for the monitoring of migration phenology within the Azov-Black Sea Coast (both practically and theoretically) are the following: the white-fronted goose *Anser albifrons* (an inhabitant of Eurasian tundra), the ruff *Philomachus pugnax* (occurring at boreal latitudes from the forest zone to tundra zone) and the lapwing *Vanellus vanellus* (a part of this species populations breeds in the Azov-Black Sea Region and adjoining areas).

For some species such as white wagtail *Motacilla alba* and wheatear *Oenanthe oenanthe* it is known that timing of their passage depends on the NAO coefficient. This fact makes them more capable indicators of global changes in the atmosphere circulation (Sokolov, 2010).

There is a natural positive reaction on the spring warming for those species which timing of migration is determined by readiness of biotopes (ecosystems) to satisfy bird requirements in food, rest, etc. Short-distance migrants can benefit from a more prolonged stay on their breeding grounds (Grishchenko, 2010), males can occupy convenient nesting sites earlier. The data published for Belarus (Gavrin, 1957) supplement our assumptions on different reactions of birds on climate changes. The species, for which the selection and protection of their nesting site is principal, arrive in a wider temperature range then those, for which a limiting factor is the feeding base within the habitat. Thus, the air temperature amplitude at the day of arrival of the common crane was 13.5 ^{o} (from -9.2 to + 4.3), while for the swift – only 5.2 ^{o} (from +12.0 to +17.2), and for the common snipe – 5.8 ^{o} (from +1.8 to +7.6). At the same time the analysis of timing of breeding of waders in the Azov-Black Sea Region (the avocet *Recurvirostra avosetta L*.) has shown that the early arrival is not a determinant for the start of egg-laying or breeding dates of a core part of the population (Chernichko, 1988) and there are no benefits from the earlier start of breeding.

Due to these facts a better model group seems to be inhabitants of tundra zone – the geese (especially the white-fronted goose *Anser albifrons*) and waders (e.g. the ruff *Philomachus pugnax*) migrating across the Azov-Black Sea coast. During similar weather conditions effecting on local breeding species in the region at the same time, the reaction of long-distance migrants allows to distinguish some trends.

According to the data of our long-term research the time of migration peaks of the white-fronted goose can deviate $\pm$10-15 days from mean value. Actual dates of peak migration, with correlation of 0.8-0.9, can be an evidence of early or late start of spring. We have been recording the spring migration of the white-fronted goose at Molochnyi Liman since 1986. A valuable conclusion is that it is more important to estimate not the date of the first registration of the species but the term of passage for a half (median) of population numbers.

For the last 18 years (1986-2010) a migration peak for a main part of the white-fronted goose population tends to shift for later dates. At the same time, dates of the last registration of the white-fronted geese in the region demonstrate a contrary trend and are shifted for earlier dates (Figure 1.3.26)

There is an assumption that the geese react rather on weather conditions along their migration route or directly on breeding grounds than on local climate trends. It is also confirmed by the fact that autumn arrival of geese to the Azov-Black Sea coast has shifted to later dates. (Figure 1.3.27).

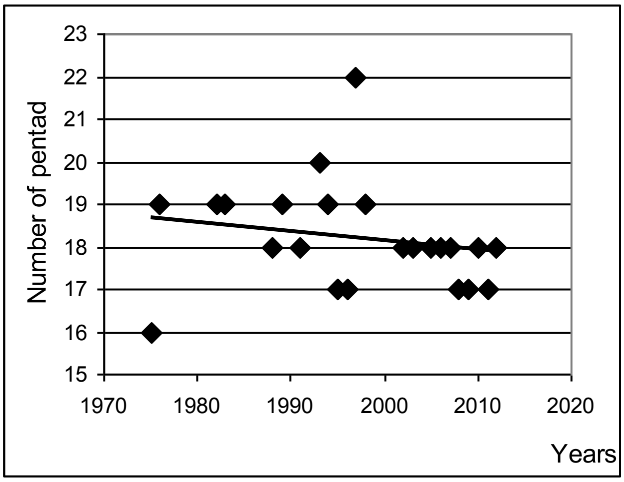


Figure 1.3.26. Changes in dates of the last registration of the white-fronted goose in spring at the Azov-Black Sea coast (pentads: 17.03-20.04)

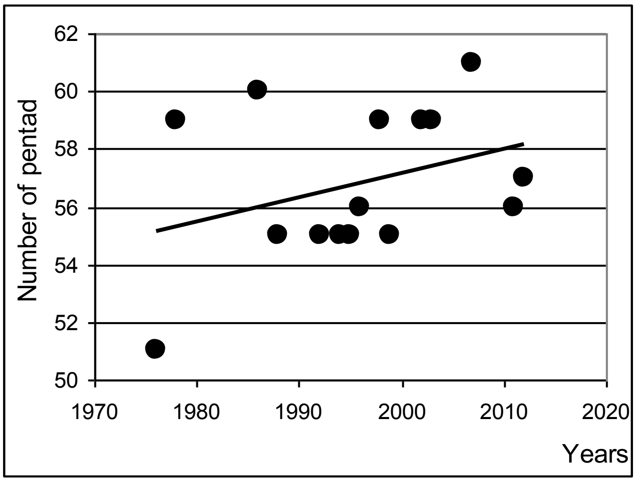


Figure 1.3.27. Changes in dates of the first registration of the white-fronted goose in autumn at the Azov-Black Sea coast (pentads: 11.09-24.10)

In this respect, it would be useful to fulfil a more detailed analysis of migration phenology for a key wader species – the ruff – which breeding grounds are located at high latitudes, and spring arrival, especially that of males, to the Azov-Black Sea region is relatively early and supposed to correlate with local weather conditions.

Thus, there were analysed the dates of the first species registration in the region for the over last 35 years (since 1975), and peaks of maximum numbers in April and May (n = over 800 000 ind.). Also, size measurements were analyzed (body condition index: weight to wing length ratio) for the ruff females (n=548) out of 1500 individuals captured in April and May for the period 1978-2007.

The spring passage of the ruff across the Azov-Black Sea coast of Ukraine in some years starts in mid-February (26 February in 1978 and 1991) but more frequently in mid-March. The diagram of the average bird number on count plots according to long-term data (Figure 1.3.28.) has two well-pronounced seasonal peaks. It is an evidence of synchronic passage, especially in spring.

The first flocks of the ruff in March include 90-95% of males (Figure 1.3.29.). By mid-April their percentage considerably reduces, and by late April it equals to the percentage of females. However, peak numbers in April are formed predominantly by males, and in May – by females. To make a more reliable analysis there were used catching data instead of approximate estimation of sex composition during counts.

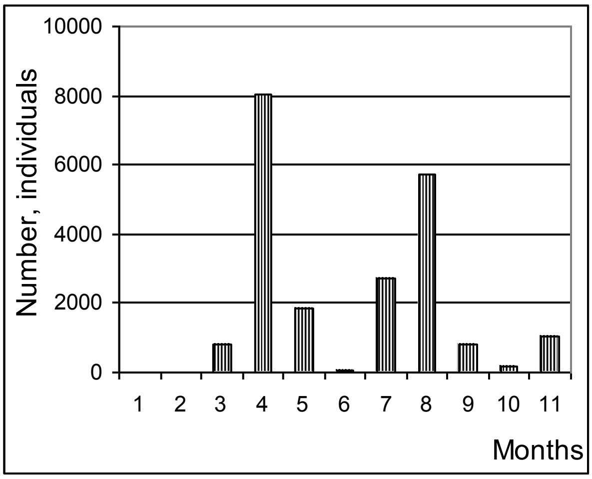


Figure 1.3.28. Average monthly numbers of the ruffs on count plots according to long-term data.

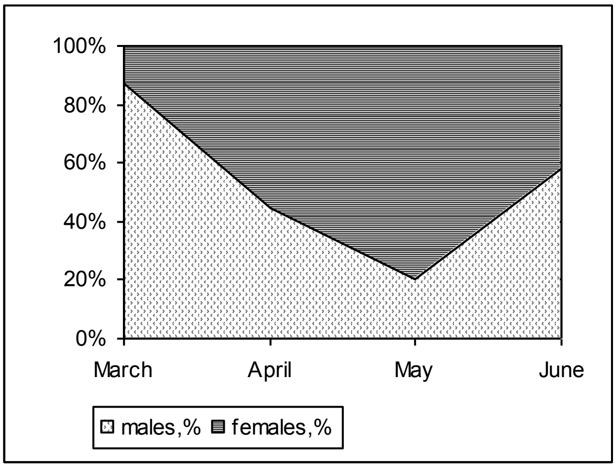


Figure 1.3.29. Percentage (%) of males and females among migrating ruffs in spring, according to the catching data during a period of counts.

There are no long-term reliable data for the Azov-Black Sea coast (for 100 years-period) relating to the date of the first spring registration. That is why we have analysed trends in the arrival date of the ruffs and some other wader species for a more northern area of Ukraine – Chernihiv Region (Marisova, et.al., 1992).

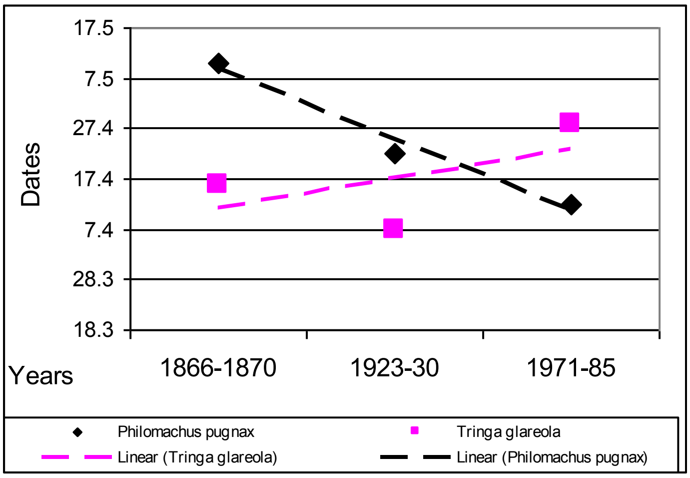


Figure 1.3.30. Changes in average dates of spring arrival of the ruff and common sandpiper to Chernihiv Region for the last 100 years (by Marisova, et al., 1992).

According to these data, for a majority of breeding wader species the average timing of arrival shifted to earlier dates (the lapwing *Vanellus.vanellus*, the common sandpiper *Actitis hypoleucos*, the Eurasian curlew *Numenius arquata*), except for the common snipe (*Gallinago gallinago*), which arrival, averagely, tends to be 1 week later. As for migratory wader species, affected by the same climate fluctuations, the situation is contrary. The ddunlin (*Calidris alpina*) and the wood sandpiper (*Tringa glareola*) arrive later (Figure 1.3.30.), and for the ruff a considerable shift to earlier dates is observed. Thus, for the interval of 1866-1870 the mean spring arrival date for the Ruff was 10 May, and during 1971-1985 the first registrations, averagely, shifted to 3 weeks earlier – 12 April. At the same time, standard deviation for the registration dates increased 4.5 times, which is a clear evidence of less stable terms of the migration start. Anyway, in inland area, the considered species demonstrate a pronounced positive trend of arrival dates for the last 100 years.

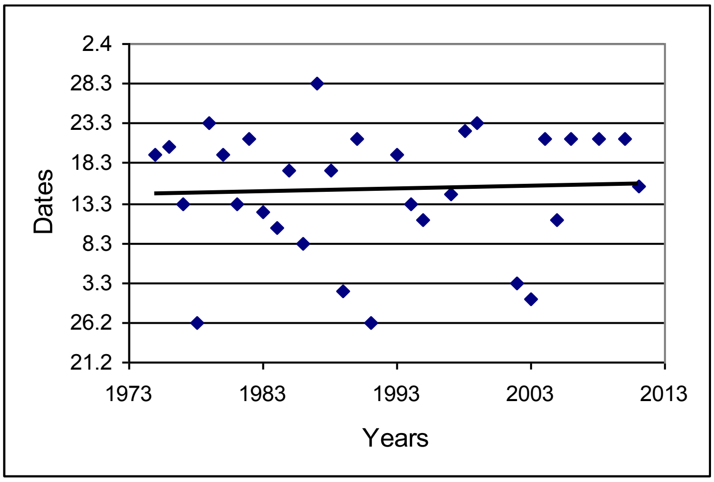


Figure 1.3.31. Dates of the ruff arrival to the Azov-Black Sea coast during 1975-2010.

According to the retrospective data, since 1975 the mean arrival dates demonstrate a very weak and low-reliable negative trend (Figure 1.3.31.) Therefore, in the south of Ukraine the timing of the ruff arrival for the last 35 years has little changed. At the same time, average monthly temperatures of February and March (data of meteostations of Odesa and Henichesk), that determine terms arrival of first birds, show a positive trend during the years of research (Figure 1.3.32). It was important to track the influence of weather conditions on the migration of a core part of population (peak dates, median of passage).

For this purpose we have analyzed the dates of peak numbers in April, when males still dominate in the region, and in May, when the percentage of females prevails. The dates of peak numbers in April (Figure 1.3.33.) for all the observation period since 1975 have demonstrated **slight** (unreliable) shifts to later dates compared to May peak concentrations (Figure 1.3.34) which started their **formation much earlier.**

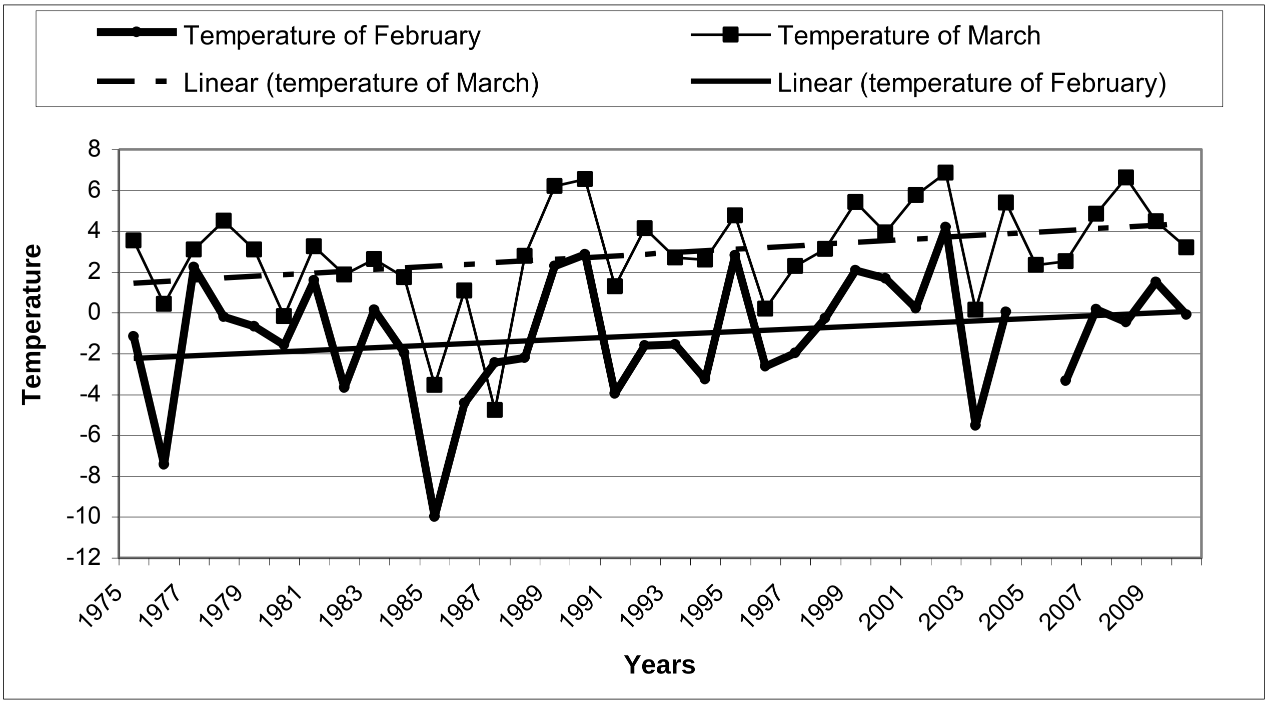


Figure 1.3.32. Trends of changes in average monthly temperatures of February and March at the Azov-Black Sea coast during 1975-2010 (data of meteostations of Odesa and Henichesk)

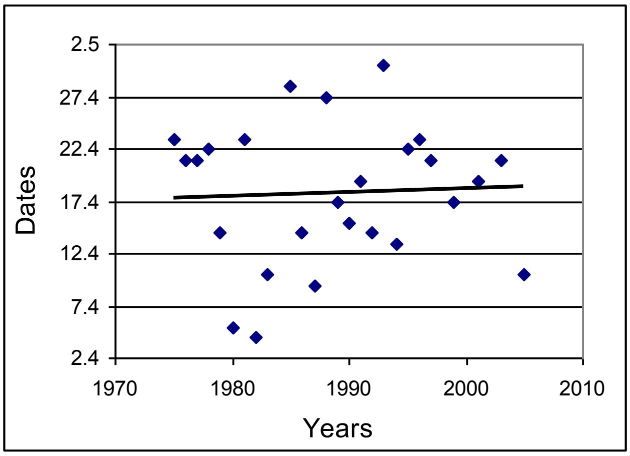


Figure 1.3.33. Dates of peak numbers of the ruffs (predominantly males) in April during 1975-2010.

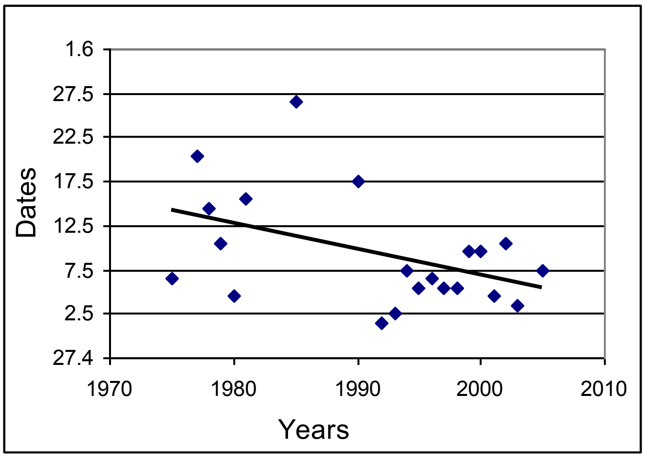


Figure 1.3.34. Dates of peak numbers of the ruffs (predominantly females) in May during 1975-2010.

In other words, the arrival dates of a majority of "vanguard" males and migration timing of a core part of the males in the population have weakly changed under the same weather-climate conditions in the region. However, females for the last 35 years are ready to migrate to their breeding grounds at earlier dates – averagely, 2 weeks earlier.

This fact made it necessary to check a migration condition also for females: average body condition index in April and May. In April, the data for different years did not show any significant trends. This is evidence that females arrive to water bodies of the region having approximately the same initial mass. However, in May the rate of weight growth was higher, and high departure masses were gained in more and more earlier terms (Figure 1.3.35).

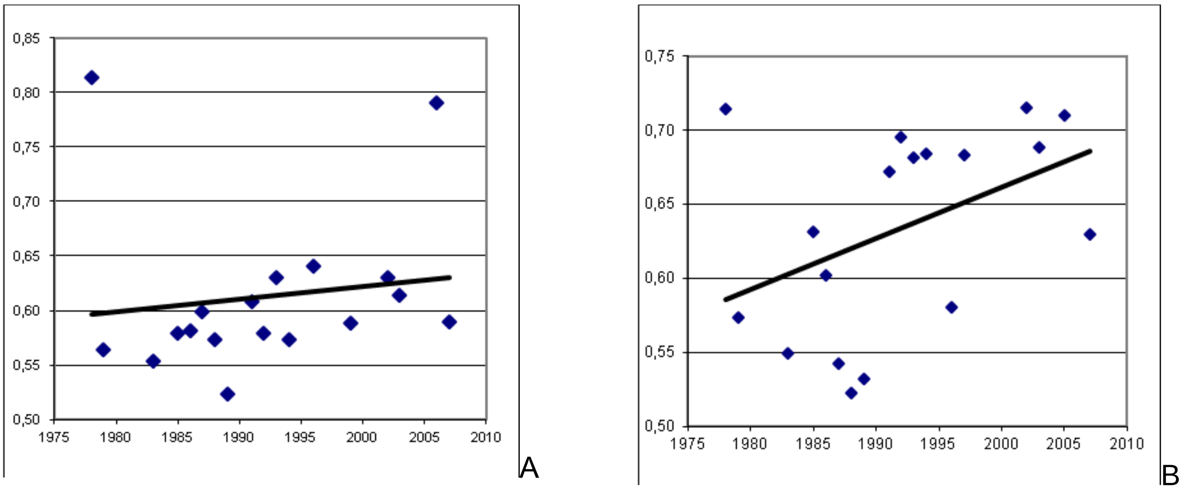


Figure 1.3.35. Changes of average monthly indexes of females' body condition in April (A) and May (B).

Therefore, the differences in trends of males and females can be explained as follows. Gradients of changes of spring temperatures are greatly depend on a geographic area of research. For instance, at the Azov-Black Sea, similar to other territory of Ukraine, they are pronounced not so strong compared to boreal and arctic areas. In Arctic the climate changes the most, approximately 2 times faster than averagely on the planet. For the last decades in different parts of Arctic the increase of average temperature in summer months was from 0.7 to 4ºC (Ippolitov et al., 2004; Sokolov, 2010). It leads to levelling of temperature zones in Siberia, accelerates melting of snow cover and defreezing of permafrost soils over a vast area.

In this situation it can be assumed that the ruff females, similar to white-fronted geese, give a more pronounced reaction on potential improvement of breeding conditions at high latitudes and therefore form readiness to the start of their spring migration in earlier terms already during their stay in the Azov-Black Sea Region.

Assessment of changes in phenology of wintering waders in the Azov-Black Sea Region of Ukraine

General trends of changes in phenology of wintering waders in the Azov-Black Sea Region of Ukraine. To reveal long-term trends in phenology the data for a long period should be compared, at least 30 years. That is why this analysis is based on the Crimea Peninsula area for which such long-term data are available. The latest registration dates of the species in late autumn-winter of the 1970s (by Kostin, 1983) and during 1990s-2000s (database of the Azov-Black Sea Ornithological Station, regional publications) were compared to reveal changes in duration of wintering in the region. The data for the last decade of February were not used to exclude overlapping between the end of wintering and start of spring migration.

During last two decades, for a number of species the latest registration dates in the Crimea have shifted from late October/November/first half of December to late December-January (Table 1.3.9). The lapwing, green sandpiper, sanderling, Eurasian curlew, woodcock and, presumably, dunlin, in relatively mild winters can stay for wintering even in February.

Table 1.3.9. Long-term changes in phenology of departure and wintering of waders in the Crimea

№	Species	The latest registration	
		In the 1970s	In the 1990s – 2000s
1.	*Pluvialis squatarola*	23.11.1975	19.01.2005
2.	*Charadrius hiaticula*	31.10.1973	31.12.1998
3.	*Eudromias morinellus*	23.11.1969	25.12.2010/2011
4.	*Vanellus vanellus*	9.12.1970	23.01.2000, 9-14.02.2001
5.	*Recurvirostra avosetta*	31.10.1974	23.01.1999
6.	*Tringa ochropus*	12.12.1970	22.01.2011, 10.02.2001
7.	*Tringa totanus*	4-19 December	5.01.2005
8.	*Calidris alpina*	9.12.1972	22.01.2001, 25.01.2006
9.	*Calidris canutus*	30.09.1971/1973	6.01.1993
10.	*Calidris alba*	15.11.1973	28.01-6.02.1996
11.	*Lymnocryptes minimus*	21.11.1975	15.01.2006
12.	*Numenius phaeopus*	1.11.1974	17.01.2005/2007

Notes: data for the 1970s are given according Yu.V.Kostin (1983); for the 1990s-2000s – by database of the Azov-Black Sea Ornithological Station, M.M.Beskaravainy (1999, 2008), Yu.A. Andryushchenko, V.M. Popenko (pers. comm.).

Indirectly, such a trend is traced in the whole Azov-Black Sea Region, though it cannot be reliably confirmed because of lacking long-term data of complete counts for different winter months. For example, in the 1960s, at the north-western coast of the Black Sea the dunlin and grey plover were recorded during winter only in December (Fedorenko, Nazarenko, 1965). The first winter record of the grey plover in the early 20th century also was in December (Kistiakivskyi, 1957). In the 1990s and 2000s the dunlin and grey plover started occurring on wintering in January (until the early February) at limans of Odesa Region and Azov Sea area, at the shores of Kinburn Spit, Yahorlytskyi and Tendrivskyi Bays of the Black Sea.

On the example of an indicator species – the dunlin – we review a gradual increase of wintering terms in the Azov-Black Sea Region in more details (Figure 1.3.36). An increasing trend of frequency of the species January registrations in the region in the 2000s, compared to the 1980s and 1990s, is shown (Figure 1.3.36a), as well as a gradual shift of the latest registrations to the end of January (Figure 1.3.36b). As a result, the regularity and duration of a winter stay of the species in the region are increasing.

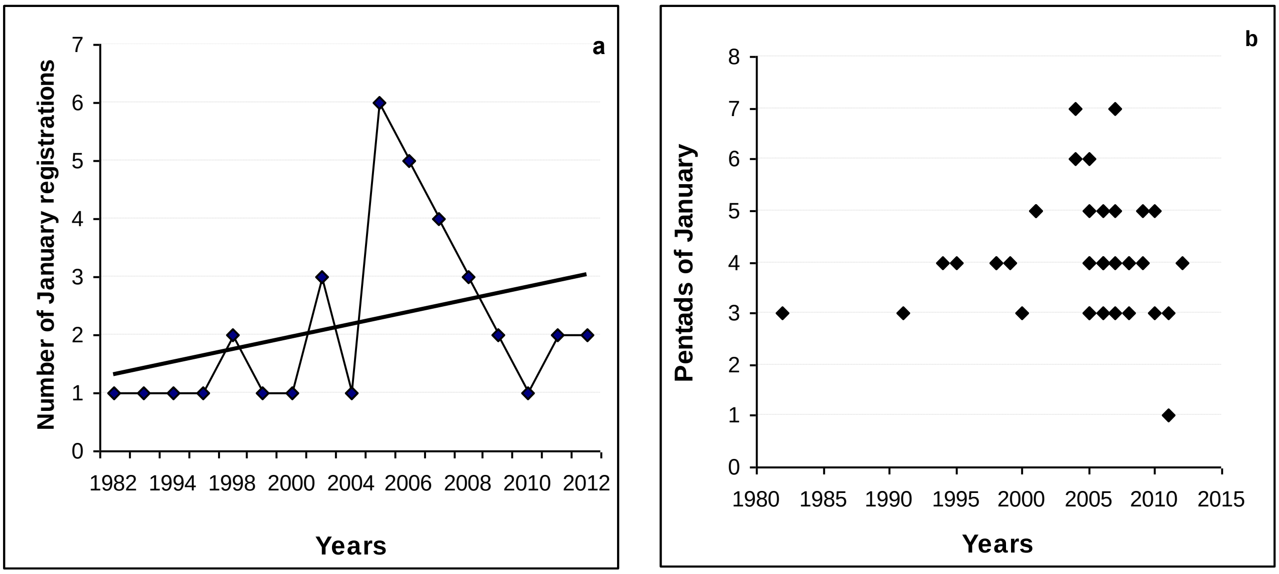


Figure 1.3.36. Increase of the number of the Dunlin winter registrations in January (A) and duration of wintering (B) in the Azov-Black Sea region of Ukraine during the 2000s.

Similarly, the avocet, for the first time appeared on wintering in the region in December 1980 in the Danube Delta (Zhmud, 2000), in the 1990s and 2000s began repeatedly occurring in December-January in the Danube Delta, at Danube limans and the southern coast of the Crimea, and also in new areas – at limans of Odesa Region and at Syvash (Table 1.3.10).

Table 1.3.10. Increase of the period and area of wintering for the avocet in the Azov-Black Sea Region of Ukraine for the last 30 years**.**

Years	Areas of winter observations in the region	Period
1980s	- Danube Delta (first winter registration in the region)	December 1980
1990s	- Danube Delta - Tuzlovski Limans (Odesa Region) - Southern Crimea, near Feodosia	- 27.12.1997 + 12.01.1998 - 05.01.1994 - 12.12.1999 + 23.01.1999
2000-e	- Danube Delta - Limans near Odesa - Eastern Syvash, Crimea - Azov Sea area, Molochnyi Liman (Zaporizhzhia Region)	- 17-18.01.2006 - December 2005 - December 2010 - 08.12.2004

Changes in wintering phenology of indicator wader species. Changes in wintering phenology of indicator wader species are considered in more detail for a central part of the Azov-Black Sea Region of Ukraine, in particular – for the North-Western Azov area, Crimea and Kherson Region (Left-bank Ukraine), since equivalent long-term data for the whole region are not available. Synchronized winter counts in the region and regular publication of their results have been carried out only after 1998 and cover not the whole winter period but only mid January. At the same time, the western part of the region (Right-bank Ukraine) noticeable differs in phenological indices of many species (earlier arrival dates, etc.). Therefore, if different areas are surveyed in different years, geographical variations between them can be more significant than those between years. As a result, we didn't succeed in finding the synchronized data collected by similar methods at least for several decades for the whole region.

In wetlands of the central part of the region the synchronized winter counts were carried out in the 2000s annually in January, and occasionally – in December and February. There are quite complete data on some winter seasons for the 1990s, and only data of irregular observations for the years before the 1990s. As a result, for particular years it is not possible to identify a reason of the data gap – whether it was connected with incomplete counts or with early departure of birds. That is why, wintering phenology was analyzed using only the data of those years when the species was registered in the considered territory during the winter period.

To characterize the wintering phenology of waders the main indices were the last registration date of the species in each season of wintering and a calculated, on its basis, duration of the species wintering in the considered area (number of days from the beginning of winter to the last registration date).

Our two-years observations on monitoring plots during all the wintering period have shown that if waders left control territories due to settled prolonged negative temperatures they did not come back until the end of wintering. In the few seasons when after being absent in late January-early February, the species appeared in the region the last decade of February, this date of returning was considered as a start of spring migration and was not taken into account in calculations of duration of wintering. On analysing long-term data we compared not years but winter seasons (i.e. December of the previous year and January-February of the next one was considered as a one single season).

Changes in the wader wintering phenology are shown on the example of four species. For these species there are data for a long-term period, i.e. they regularly winter in the region, and they are not associated with man-transformed landscapes (disposal fields, wells, waste discharges of heat stations). Such selection of species allows to find relationships between phenological and weather-climate changes.

The dunlins in the Molocny Liman.
Photo by Bogdan Przystupa

Dunlin (*Calidris alpina*). For the dunlin we managed to compile rather regular data on duration of wintering in the investigated territory for the period 1995-2012 (Table 1.3.11). Table 1.3.11 shows that since 2004, winter stay of the dunlin in the region becomes regular (annual) and lasts at least until the 2nd-3d decade of January.

A graphic image of wintering phenology of the dunlin for the period 1980s-2000s shows a general increasing trend of duration of wintering in the investigated territory (trend line in Figure 1.3.37). A similar relationship is also traced when the average duration of wintering is calculated in five-year periods, for the years with available data samples (Table 1.3.12).

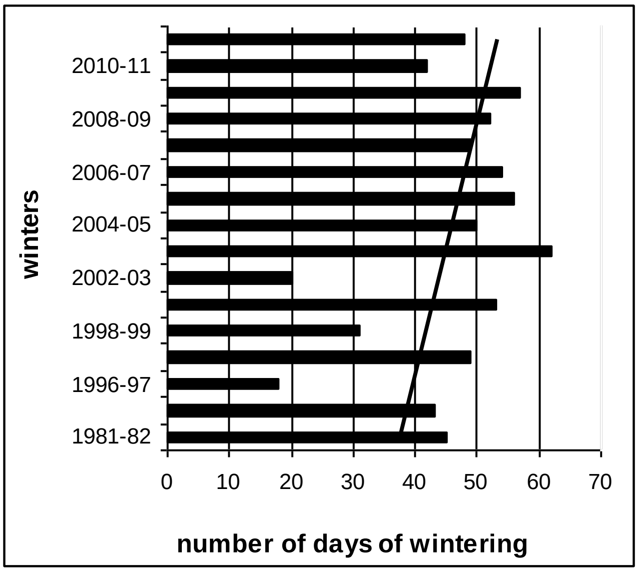


Figure 1.3.37. Duration of wintering of the dunlin in the North-West Azov area, Crimea and Kherson Region in the 1980s-2000s.

Table 1.3.11. Wintering phenology of the dunlin in the North-Western Azov area, Crimea and Kherson Region.

Winter season	Last registration date	Duration of wintering (days)	Number of birds
1981-82	14.01	45	1
1990-91	12.01	43	80
1996-97	18.12	18	20
1997-98	18.01	49	250
1998-99	31.12	31	10
2000-01	22. 01	53	70
2002-03	20.12	20	1
2003-04	31. 01	62	35
2004-05	19. 01	50	510
2005-06	25. 01	56	1
2006-07	23. 01	54	370
2007-08	18. 01	49	1
2008-09	21. 01	52	70
2009-10	26. 01	57	20

Winter season	Last registration date	Duration of wintering (days)	Number of birds
2010-11	11. 01	42	38
2011-12	17. 01	48	4

Table 1.3.12. Average duration of the dunlin wintering in the North-West Azov area, Crimea and Kherson region in 1995-2012.

Five year period (pentad)	Average duration of wintering in the region (days)	lim
Dec.1995 – Feb.2000	32.7	18-49
Dec.2000 – Feb.2005	46.3	20-62
Dec.2005 – Feb.2010	54.6	49-57

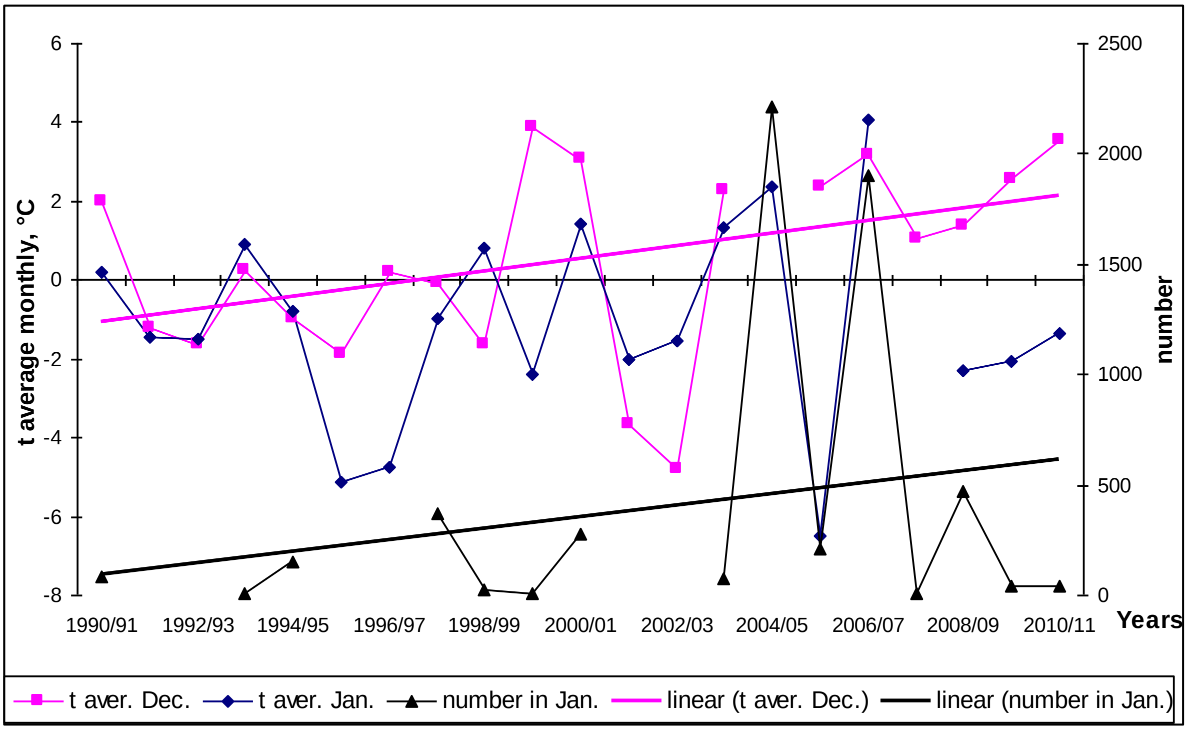


Figure 1.3.38. Long-term dynamics of January numbers of the dunlin in the Azov-Black Sea Region of Ukraine against the dynamics of average monthly temperatures of December and January

The number of wintering birds in our counts, in some years exceeding 200-500 individuals in the second half of January, indicates that the winter stay of the dunlin in this region is not accidental or occasional.

At the territory of Molochnyi Liman and Eastern Syvash, the January number of wintering dunlins for the period 1990-2011 shows a gradual increasing trend which grows parallel to the increase of average monthly temperatures of December.

In the whole Azov-Black Sea Region it is also traced an increasing trend of January numbers of wintering waders for the period 1990-2011 against a gradual increase of average monthly temperatures of December (Figure 1.3.38). For the considered period (1990-2011) in the dynamics of weather-climatic indices in this territory the following trends were revealed: average monthly temperatures of December shows an increasing trend; average monthly temperature of January has no pronounced trends; number of days with positive average daily temperatures has an increasing trend in December and in January. The dunlins continues wintering in January usually in those years when average monthly temperatures in December and January are higher than zero.

Eurasian curlew (*Numenius arquata*). For the Eurasian curlew the data on duration of wintering in the investigated territory were compiled for the period 1958-2012, and relatively regular – since 1990 (Table 1.3.13).

Table 1.3.13. Phenology of wintering of the Eurasian curlew in the North-West Azov area, Crimea and Kherson region.

Winter season	Last registration date	Duration of wintering (days)
1958-59	13.12	13
1964-65	15.01	46
1970-71	18. 01	49
1971-72	9.12	9
1976-77	21.01	52
1990-91	17. 01	48
1991-92	16. 01	47
1994-95	04.12	4
1996-97	20. 01	51
1997-98	20. 01	51
1998-99	28. 01	59
1999-2000	20. 01	51
2000-01	9. 02	71
2003-04	31. 01	62
2004-05	28. 01	59
2005-06	19. 01	50
2006-07	23. 01	54
2008-09	22. 01	53
2010-11	20. 01	51
2011-12	24. 01	55

A graphic image of wintering phenology of the Eurasian curlew, similar to the dunlin, shows a general increasing trend of duration of wintering for the period 1958s-2000s (trend line in Figure 1.3.39).

Similar to the dunlin data, which we gave earlier for Molochny Liman and Eastern Syvash (interim report, November 2011), the January numbers of wintering Eurasian curlews for the period 1990-2011 show a gradual increasing trend which grows parallel to the increase of average monthly temperatures of December. Also, it was noted, that Eurasian curlews more frequently continue wintering in those years when average monthly temperatures in December and in January are above zero.

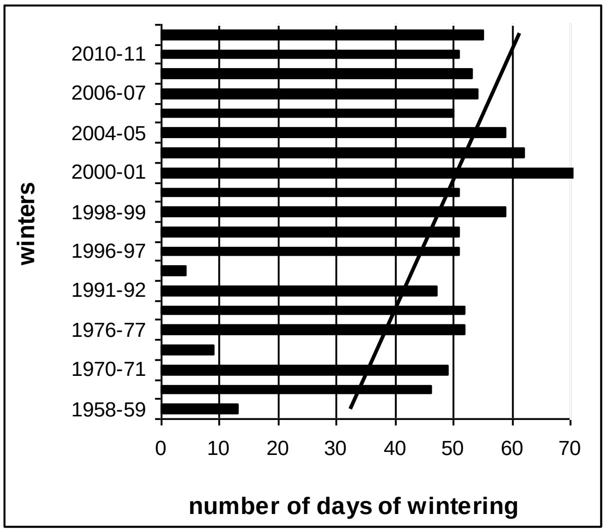


Figure 1.3.39. Duration of wintering of the Eurasian curlew in the North-West Azov area, Crimea and Kherson Region in the 1950s -2000s.

Lapwing (*Vanellus vanellus*). For the lapwing, the data on duration of wintering in the considered territory were compiled only since 1990s, and they are more fragmented (Table 1.3.14), presumably due to the fact that a part of birds winter in agrolandscapes which are less frequently covered with systematic winter counts.

Table 1.3.14. Wintering phenology of the lapwing in the North-Western Azov area, Crimea and Kherson Region.

Winter season	Last registration date	Duration of wintering (days)
1990-91	26.02	3
1995-96	6. 12	6
1996-97	18.01	49
1997-98	19.12	19
1998-99	3.12	3
1999-00	23.01	54
2000-01	14.02	76

Winter season	Last registration date	Duration of wintering (days)
2001-02	3.02	65
2003-04	18.02	80
2007-08	14.02	45
2010-11	24.12	24

Nevertheless, a graphic image of wintering phenology of the lapwing, similar to the two previous species, shows a general increasing trend of duration of wintering for the period 1990s-2000s (trend line in Figure 1.3.40).

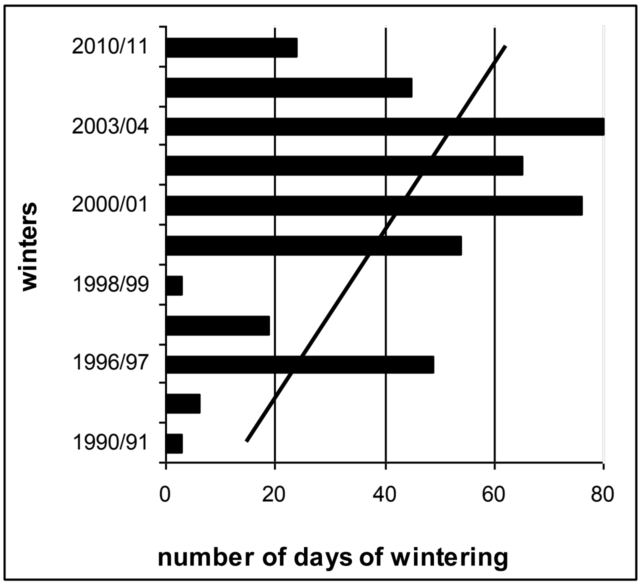


Figure 1.3.40. Duration of wintering of the lapwing in the North-West Azov area, Crimea and Kherson Region in the 1990s-2000s.

Grey plover (*Pluvialis squatarola*). Among four studied species, only the wintering phenology of the grey plover for the last 20 years (since 1990) is a bit different than a general trend (Table 1.3.15, Figure 1.3.41). Its duration of wintering also had been growing until 2005, and after that is slightly decreasing. There is the smallest phenological dataset available for this species. At the same time, it is more sensitive and reacts even on a short-term drop of average daily temperatures below zero. Both data gap or species sensitivity can be a reason of deviation from a general trend, and it needs further investigation.

At the same time, similar to other indicator species, since the mid-2000s wintering of the grey plover became regular (Table 1.3.15). As it was already noted, other indicator species have insufficient data for long-term analysis of wintering phenology.

Table 1.3.15. Wintering phenology of the grey plover in the North-Western Azov area, Crimea and Kherson Region.

Winter season	Last registration date	Duration of wintering (days)
1990-91	12.01	43
2004-05	19.01	50
2005-06	10.12	10
2006-07	23.01	54
2007-08	9.12	9
2010-11	21.12	21
2011-12	9.12	9

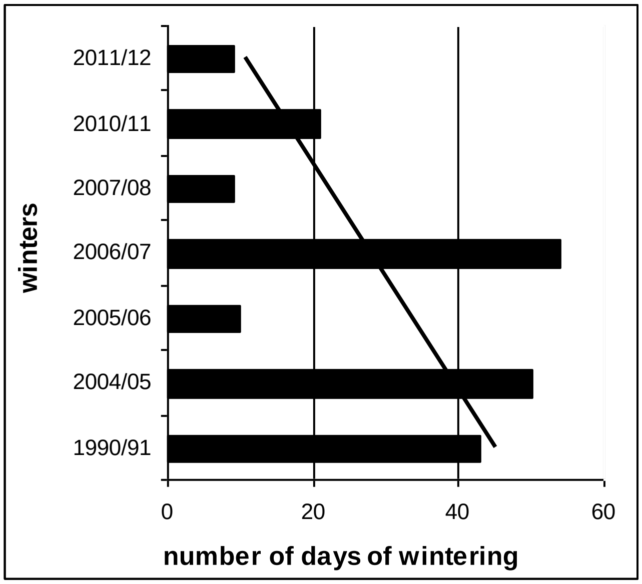


Figure 1.3.41. Duration of wintering of the grey plover in the North-West Azov area, Crimea and Kherson Region in the 1990s-2000s.

Therefore, it is recorded an influence of December-January weather-climate conditions on duration of winter stay in the region, regularity of wintering, phenology and numbers of particular wader species. There is an increasing period of winter stay in the Azov-Black Sea region and extension of wintering areas for example for the dunlin, avocet, grey plover, green sandpiper, redshank, knot. Taking into account a gradual increasing trend of average monthly temperature of December for recent decades, and influence of temperature on numbers of wintering birds, the observed changes in duration of wintering are very likely connected with weather-climate changes.

1.3.4 Population structure of some indicator species

Population (phenotypic) structure of the sand lizard

In the 1980s it was assumed that a direct impact of climate (temperature regime and humidity) on embryogenesis pholidosis formation (Roitberg, 1981; 1981a) could be one of the reasons of chronographic variability of the sand lizard.

Recent studies established that the temperature of egg incubation influences on stability of lizard's development (*Lacetrtidae*). To express the development stability the frequency of assymetric expression of a character or the asymmetry index is used (Zdanova, Zakharov, 2001; Zakharov et al., 2000). The development stability is considered as ability of an organism to form phenotype without ontogenic disorder. In laboratory studies it was established that the higher asymmetry index, the lower development stability which in turn can depend on temperature and environmental pollution rate during incubation. Thus, for the sand lizard the optimal temperature range is 25-27^{0}C. At this temperature the asymmetry index is 0.11-0.21 (Zdanova, Zakharov, 2001). If incubation temperature increases or decreases this value grows (Zdanova, Zakharov, 2001).

Phenotypical and physiological reactions as a response to environmental changes are influenced by biological features of reptiles: relatively small radius of individual activity, attachment to particular biotopes and, as a consequence, low rate of dispersion. It allows to use reptiles as biological indicators for a number of years.

Taking into account that one of indices of development stability can be a fluctuating asymmetry of pholidosis, the assessment of this index was made using the following characters:

- number of nasal shields (Nasalia)
- number of loreal shields (Loreale)
- number of upper labial shields until the subocular shield (Supralabialia)
- number of lower labial shields (Sublabialia)
- number of submandibular shields (Submandibularia)
- number of superciliary shields (Superciliary)
- number of supraocular shields (Supraocularia)
- number of granules between superciliary and supraocular shields (Granulae)
- number of femoral pores (pori femoralis)

Index of the fluctuating asymmetry is a sensitive indicator of environmental state, and the method allows to obtain integral estimate of condition of an organism with all the set of possible impacts.

Control studies were done in open areas to exclude influence of tree plantations on temperature regime during egg incubation.

In future, to obtain the data necessary for modeling of the ecosystem development it will be enough to collect information on permanent plots once in 3-5 years, and it will allow to predict further development of climate changes.

When making field studies it may be difficult to reveal what factor – natural or human – provides an impact on lizard's phenotype. To minimize human impact (disturbance, landscape changes, chemical pollution, etc.) the preference was given to the areas retained in the least transformed state. At the same time, if possible, open biotopes were chosen where the impact of temperature factor on animals is the highest.

As a result, pholidosis variability of the sand lizard was studied on five selected monitoring plots with different microclimate conditions (Figure 1.3.42, Table 1.3.16). Main characteristics of monitoring plots are presented below.

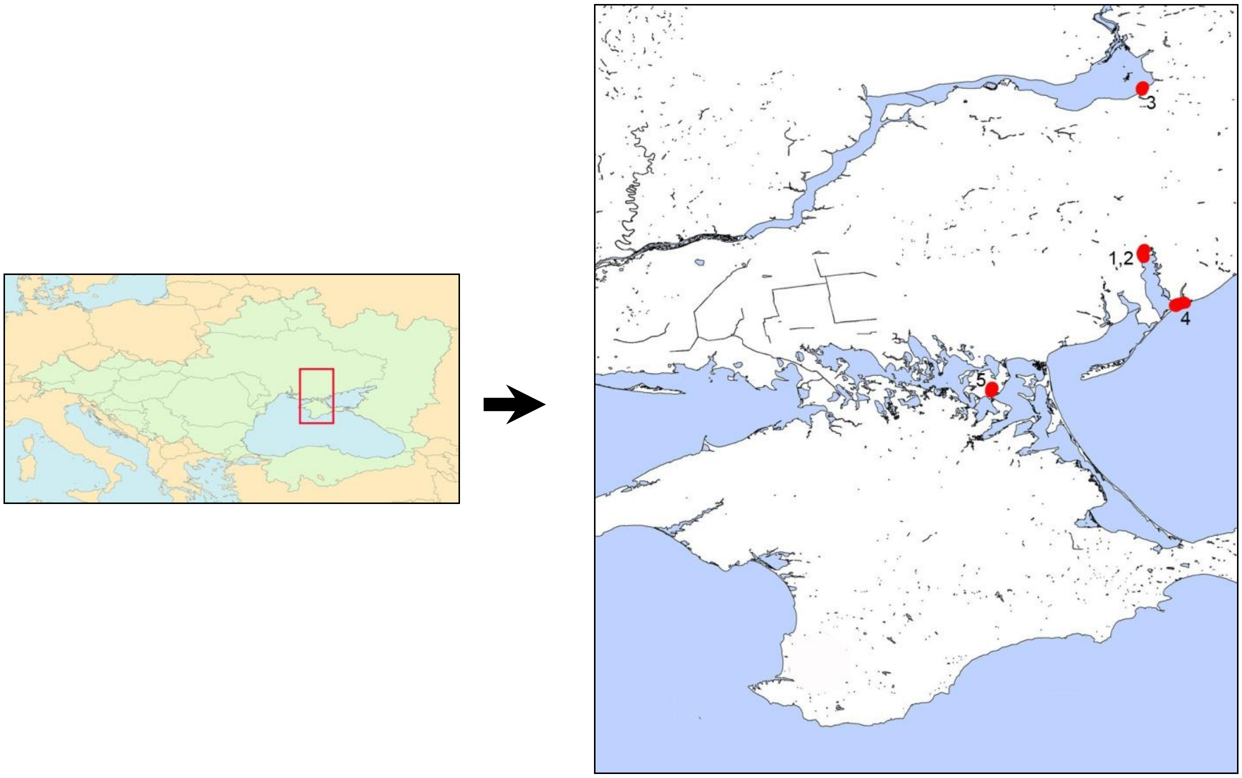
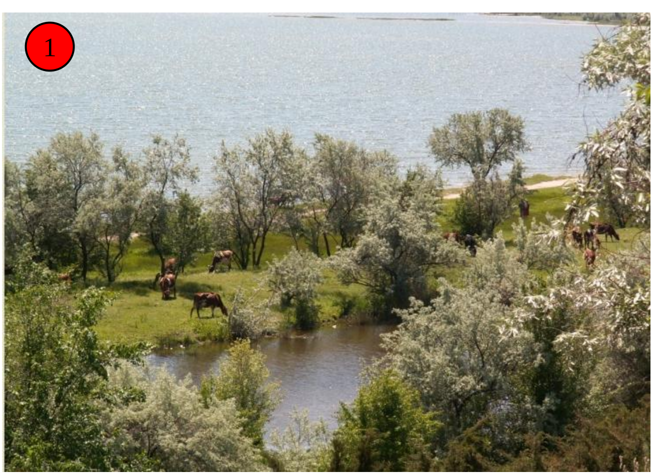


Figure 1.3.42. Location of monitoring plots for studying phenotype structure of sand lizard population.



1,2) Shore of Molochnyi Liman

Variety of conditions at the liman shore allowed us to organize two control plots.

An overall length of the control strip along Molochnyi Liman is 5-6 km, width is 200-300 m.

1) The northern plot is located in the territory of forestry (Altahyr). There are all conditions to choose the most optimal regime (temperature, humidity) for incubation of clutches.

2) The southern plot (Sheliuhivskyi Depression) is located at open terraced slopes with forbs-gramineous vegetation and has no significant tree plantations. There, reptile eggs during incubation period, possibly, can be subjected to increased temperature regime.

3) Shore of Kakhovske Reservoir (surroundings of Enerhodar)

The monitoring plot is 1.5-2 km long and about 500 m wide, located near Enerhodar City.

It is represented by areas of fixed sands with rarefied grassy vegetation and sparse tree stands. The plot is open to solar radiation and must reflect well all changes of thermal regime.

4) Stepanivska Spit.

The monitoring plot stretches along the Sea of Azov for 4 km and is about 100 m wide.

A characteristic feature is that along its whole length the spit is made of sandy-shell depositions with typical grassy vegetation. Small number of tree plantations allows the soil to be well-warmed which may influence on pholidosis of lizards.

5) Chonhar Peninsula

The monitoring plot is located between the highway Moscow-Simferopol and Syvash shoreline. It is about 3 km long and about 100-150 m wide.

This plot is characterized by extremely low humidity and high summer temperatures. Gramineous-wormwood associations with tree plantations along the roads dominate. The territory is mainly used as a pasture for sheep and cattle. Agriculture really is not practiced there, that allows researchers to exclude chemicals influence on phenotype formation of reptiles.

Table 1.3.16. Characteristics of monitoring plots

№	Administrative area	Description of biotope
1	Zaporizhzhia Region, Yakymivka District, Altahyr Forestry	Planted forest on sandy soils
2	Zaporizhzhia Region, Yakymivka District, Sheliuhivskyi Depression	Open area, wormwood-gramineous vegetation on loamy soils
3	Zaporizhzhia Region, surroundings of Enerhodar City	Forbs grasses with sparse tree plantations on sands
4	Zaporizhzhia Region, Pryazovie District, Stepanivska Spit	Open area, forbs-gramineous vegetation on sands
5	Kherson Region, Chonhar Peninsula	Verge of the highway with forest plantations on firm soils

Thus, among selected plots there are both areas deprived of tree plantations or with them. It allowed us to reveal how characteristics of biotope influence the lizard (*Lacertidae*) phenotype. It was assumed that in open biotopes without tree vegetation animals are in more extreme conditions and more rapidly react on increase of temperature in the environment during the period of egg incubation (Table 1.3.17).

Table 1.3.17. Estimation of development stability by pholidosis of the sand lizard *Lacerta agilis* (2009-2010)

Monitoring plot	Number of individuals	Index of asymmetry
Chonhar Peninsula	9	0.17 ± 0.05
Altahyr Forestry	30	0.17 ± 0.02
Sheliuhivskyi Depression	25	0.22 ± 0.02
Stepanivska Spit	20	0.24 ± 0.03
Surroundings of Enerhodar City	11	0.29 ± 0.05

The obtained data show that inhabitants of open biotopes (steppe, sandy coastal spits) are the most sensitive to changes in temperature regime during egg incubation which makes these areas the most promising for further investigations.

Index of development stability (asymmetry index) in these areas for the sand lizard is 0.22 to 0.29. In forested areas this index is considerably lower and is 0.17 which can be explained by more optimal choice for sites of clutches. Trees, to a certain extent, smooth the impact of high temperatures.

The asymmetry index can be also affected by man-made pollution (for example, radiation in the vicinity of Enerhodar, near the atomic station). Irrespectively of lower average monthly temperatures of June and higher humidity than those in the south of Zaporizhzhia Region (Altahyr, Sheliuhivskyi Depression) the asymmetry index is the highest there (0.29).

Analyzing average temperatures of June in the region of monitoring plots we recorded an increasing trend in all the studied localities: in Zaporizhzhia – from 19.2^{0}C (in 1992) to 23.0 ^{0}C (in 2010), in Melitopol – from +23.0^{0}C (in 1979) to +23.8^{0}C (in 2010), in Henichesk – from +22.8^{0}C (in 1995) to 23.4^{0}C (in 2010).

To confirm the influence of temperature factor on development stability (index of asymmetry) of the sand lizard there were used collection materials gathered in 1995-1998 in the same localities (Table 1.3.18).

Comparison of retrospective data with the data of 2009-2010, shown in Figure 1.3.43 and in Table 1.3.19, convincingly shows increase in the index of asymmetry in all the monitoring plots.

Table 1.3.18. Estimation of development stability by pholidosis of the sand lizard Lacerta agilis

Monitoring plot	Index of asymmetry in 1995-1998	Index of asymmetry in 2009-2010	Index of asymmetry in 2011
Chonhar Peninsula	0.11 ± 0.05 (n=13)	0.17 ± 0.05 (n=9)	No data
Altahyr Forestry	0.13 ± 0.02 (n=38)	0.17 ±0.02 (n=30)	0.16 ±0.04 (n=10)
Sheliuhivskyi Depression	0.12 ± 0.02 (n=20)	0.22 ± 0.02 (n=25)	0.24 ±0.02 (n=10)
Stepanivska Spit	0.12 ± 0.03 (n=20)	0.24 ±0.03 (n=20)	0.23 ±0.02 (n=16)
surroundings of Enerhodar City	0.18 ± 0.05 (n=5)	0.29 ±0.02 (n=11)	0.28 ±0.03 (n=10)

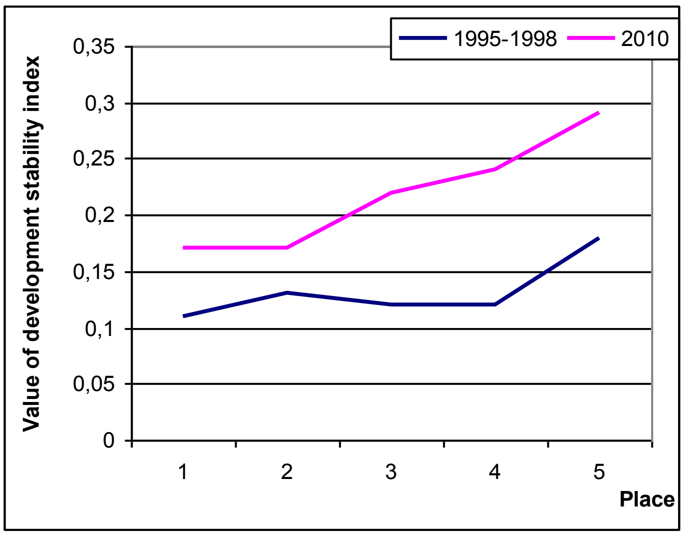


Figure 1.3.43. Changes in index of asymmetry for the sand lizard (*Lacerta agilis*) in 1995-2010.
1 – Chonhar; 2 – Altahyr; 3 – Sheliuhivskyi Depression; 4 – Stepanivska Spit; 5 – Enerhodar

The highest increase of the index of asymmetry is observed in open areas of Stepanovska Spit (0.24) and Sheliuhivskyi Depression (0.22) which allow to reveal and track recent changes in ecosystems.

According to literary data (Zhdanova, Zakharov, 2001), a zone of optimal temperatures for egg incubation of the sand lizard ranges from +25^0 C to +27^0 C. These values are corresponded by 0.11-0.21 index of asymmetry. In 1995-1998 on all areas the value of asymmetry index was from 0.11 (Chonhar) to 0.18 (Enerhodar) i.e was within limits corresponding to optimal values of incubation temperature. In 2009-2010 the index of asymmetry increased from 0.17 (Chongar) to 0.29 (Enerhodar). In all open biotopes there is observed the worsening of temperature-humidity impact on incubation regime (value of index increases to 0.22-0.29).

Basing on the fact that in warmer and drier areas the number of femoral pores in the sand lizard increases (Roitberg, 1981) we also investigated variability of this index in time (Table 1.3.19).

Table 1.3.19. Variability of number of femoral pores (Pori femoralis) of the sand lizard in time

Place	Year	Average number of pores	Year	Average number of pores
Chonhar	2002	29.2	2009	31.2
Altahyr	1996	29.4	2010	30.9
Sheliuhivskyi Depression	1994	29.4	2010	30.2
Stepanivska Spit	1998	29.2	2010	29.3

The obtained data on variability of femoral pores of the sand lizard may be an evidence of climate aridization for the last 10-15 years in the monitoring region. A smaller range of variability, recorded on Stepanivska Spit, may be connected with the fact that this plot is located between two water bodies: sea and liman, and therefore the aridity is smoothed by the influence of aquatic areas.

1.3.5 Morpho-phisyological characteristics of indicator species

Indices of growth rate and fattening of the round goby as an indicator of changes in hydrometeorological indices

The round goby (*Neogobius melanostomus (Pallas, 1814)* is a mass species in waterbodies of the study area. At the stage of a hutchling, it feeds on plankton, and at the adult stage eats benthos. Insufficient food base leads to a sharp decline in the rate of growth and fattening of this indicator species.

Some authors in their works told about a substantial negative impact of water salinity on primary production of organic matter in the Azov Sea (r=-0.47) (Gargopa, 2003) and explained that salinization of the sea leads to displacement of high-productive freshwater and brackish algoflora and fauna. Indicator parameters were the mean size of two-year specimens in spring period and mean fattening values by Fulton's coefficient.

Table 1.3.20. Volume of collected material

Catching site	2010	2011
North-western part of the Azov Sea	45	320
Eastern part of the Azov Sea	-	192
Southern part of the Azov Sea	-	37
Utliukskyi Liman	89	86

To check this factor, in 2010-2011 we have collected the material in catching sites with different salinity. The work was done in the framework of the enviroGRIDS project. The volume of the collected material is presented in Table 1.3.20.

Dynamics of the size characteristics of the round goby in the study period is shown in Figure 1.3.44.

As a result of field studies and use of long-term data (1997-2009) it was established that for the last 15 years it was observed an increasing trend of the round goby with 0.3 cm/year indices of linear trend. This trend coincides with trends of decreasing salinity in the Azov Sea and can be used as an indicative character to estimate climate impact on the species populations in the Azov Sea.

A similar dependence was also established for fattening index by Fulton's coefficient (Figure 1.3.45). Analyzing dynamics of indices according to the data of field studies we should note increase of fattening with years, which also corresponds to indices of decreasing salinity in the Azov Sea. So, mean annual values of fattening in a particular year can be used as indicator characters for revealing trends of climate changes in the Azov Sea Basin.

An important result of 2011 is confirmation of assumption that the fattening depends on salinity. Comparing Fulton's coefficient in several parts of the sea with different mineralization it should be noted a negative correlation of these indices. Thus, the highest indices of fattening were registered in the eastern part of the Azov Sea (Taganrog Bay) which is a relatively freshwater reservoir (Figure 1.3.45). The lowest indices of fattening were recorded in the southern part of the sea which still remains more salty.

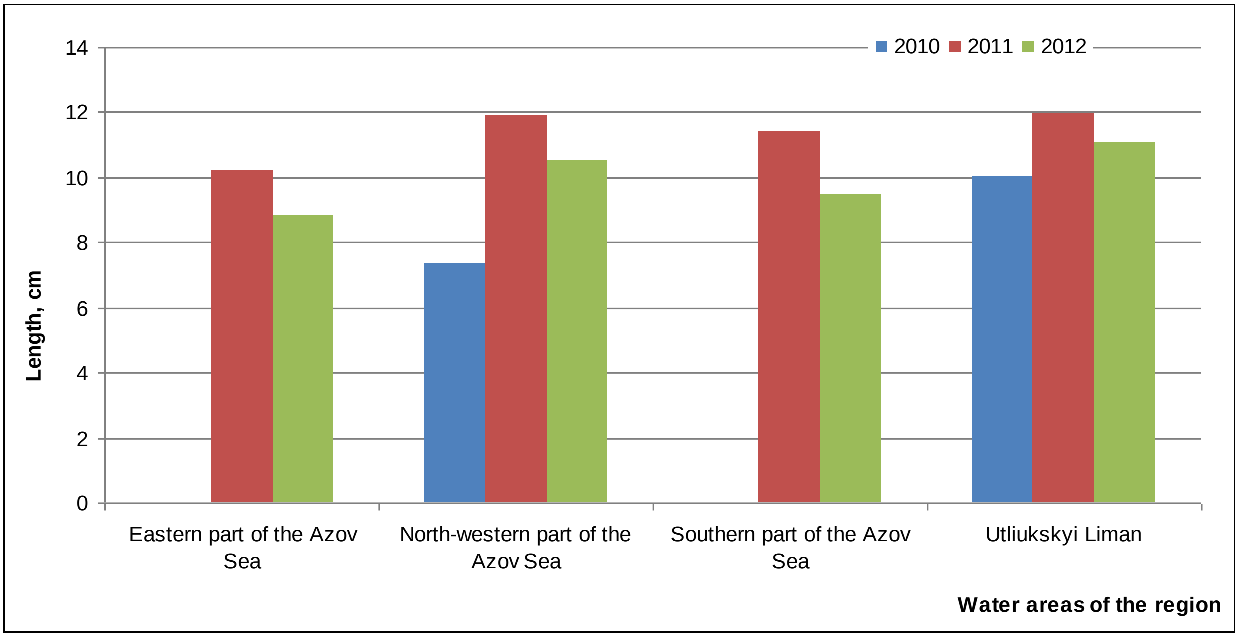


Figure 1.3.44. Dynamics of mean length of the round goby in the study area

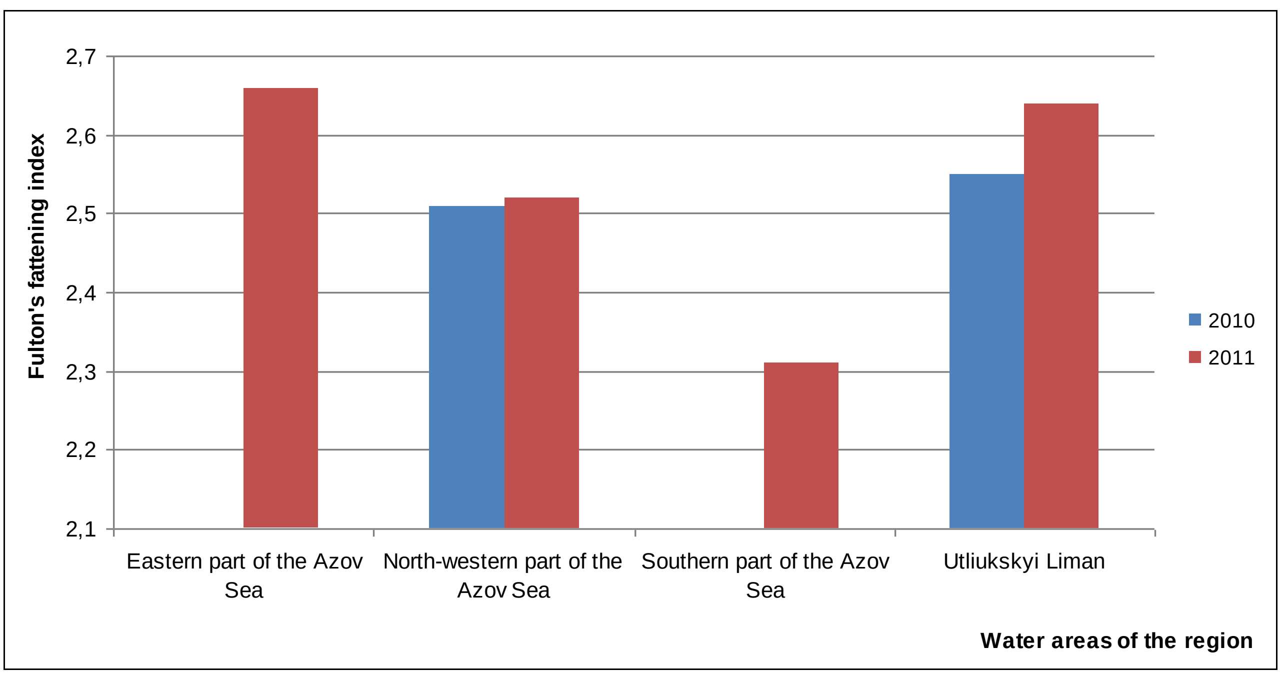


Figure 1.3.45. Fattening dynamics of the round goby by Fulton's coefficient in the study area

Changes in some morphological characteristics of indicator species of reptiles

Reptiles are cold-blooded animals and directly depended on the condition of the environment. For the first time the suggestion about possible impact of climate on herptofauna was told about 50 years ago (Shcherbak, 1962, 1964, 1966). It was established that colour, size and body proportion of some reptiles depend on ecological conditions. For example, the number of spots on the back of the Balkan wall lizard depends on xerotization of biotope (*Podarcis taurica*). A number of “sparse-spotted” animals increase from north to south and east to west, and in hot and dry areas (for example, in steppe) the specimens without any spots, with smaller body and shorter tail can be meet (Shcherbak, 1962). There are data that the number of the Balkan wall lizards within the Crimea increases in the south-west direction which is possibly connected with differences in thermic regime of habitats (Shcherbak, 1965).

The studies of 2010-2011 have confirmed the presence of phenotypical differences between representatives of populations in Kerch Peninsula and in surroundings of Sevastopol (Figure 1.3.46).

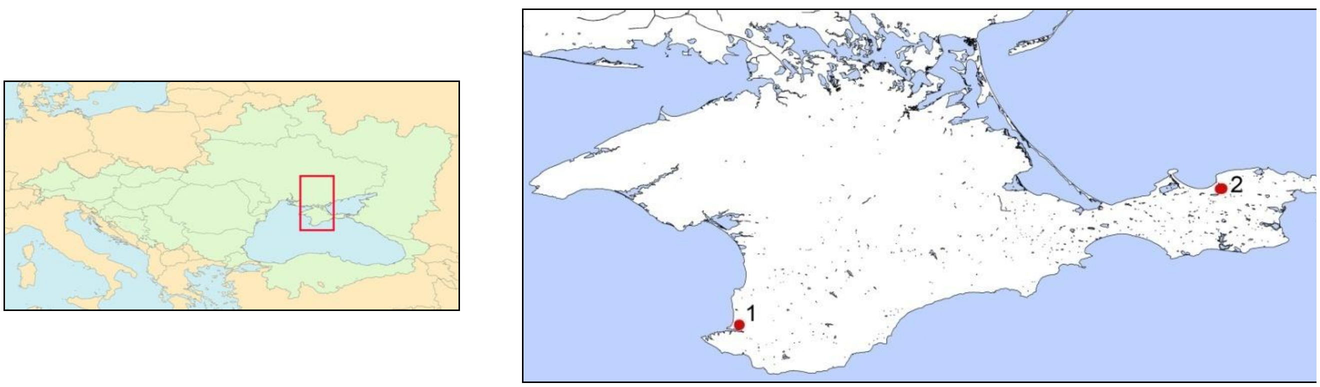


Figure 1.3.46. Points of observations of the Balkan wall lizard (*Podarcis taurica*) in the Crimea (1 – vicinity of Sevastopol (Mekenzievi Mountains); 2 – Kerch Peninsula, Chahany Cape).

The Figure 1.3.47 shows that the Balkan wall lizards from Kerch population have many dark spots on their back. These spots are elongated and form a “tiger” pattern. In contrast, representatives of the mountain population (surroundings of Sevastopol, Mekenzieve Forestry) have a pattern which looks like rare rounded spots.

It should be noted that the observation regions differ in some parameters. Thus, for example, the habitat on Kerch Peninsula is represented by an area of rocky steppe, practically almost deprived of tree vegetation and characterized by drier and hotter climate (Figure 1.3.48).

On the contrary, Sevastopol population is located in forest (Figure 1.3.49). The action of high temperatures in the period of egg incubation is leveled there by the presence of shady sites and different shelters where sufficient humidity retains and effect of high temperatures is mitigated.

The analysis of body size variability in the Balkan wall lizard has shown that the largest specimens occur in the Rocky Crimea. Body and tail length reduces in the north-east direction (Table 1.3.21).

Table 1.3.21. Body size variability of the Balkan wall lizard (*Podarcis taurica*) from the Steppe Crimea and Rocky Crimea

Sample (territory)	n Males/females	Character: length Lim (M±m)			
		body, males	tail, males	body, females	tail, females
Rocky Crimea	57/24	48-75 60.35 ±0.9	67-140 109.9 ± 2.6	51–67 59.1±0.9	89–113 97.4±1.9
Steppe Crimea (Bilohirsk)	13/8	49-60 53 ± 0.9	90-98 93.8 ± 1.4	48 – 64 57.4 ± 2.1	74 – 90 80.3 ± 4.9
Steppe Crimea (Kerch)	9/13	47-67 55.5 ± 2.3	90-107 95.5 ± 3.9	47 – 62 53.9 ± 1.2	79 – 97 88.7 ± 2.4

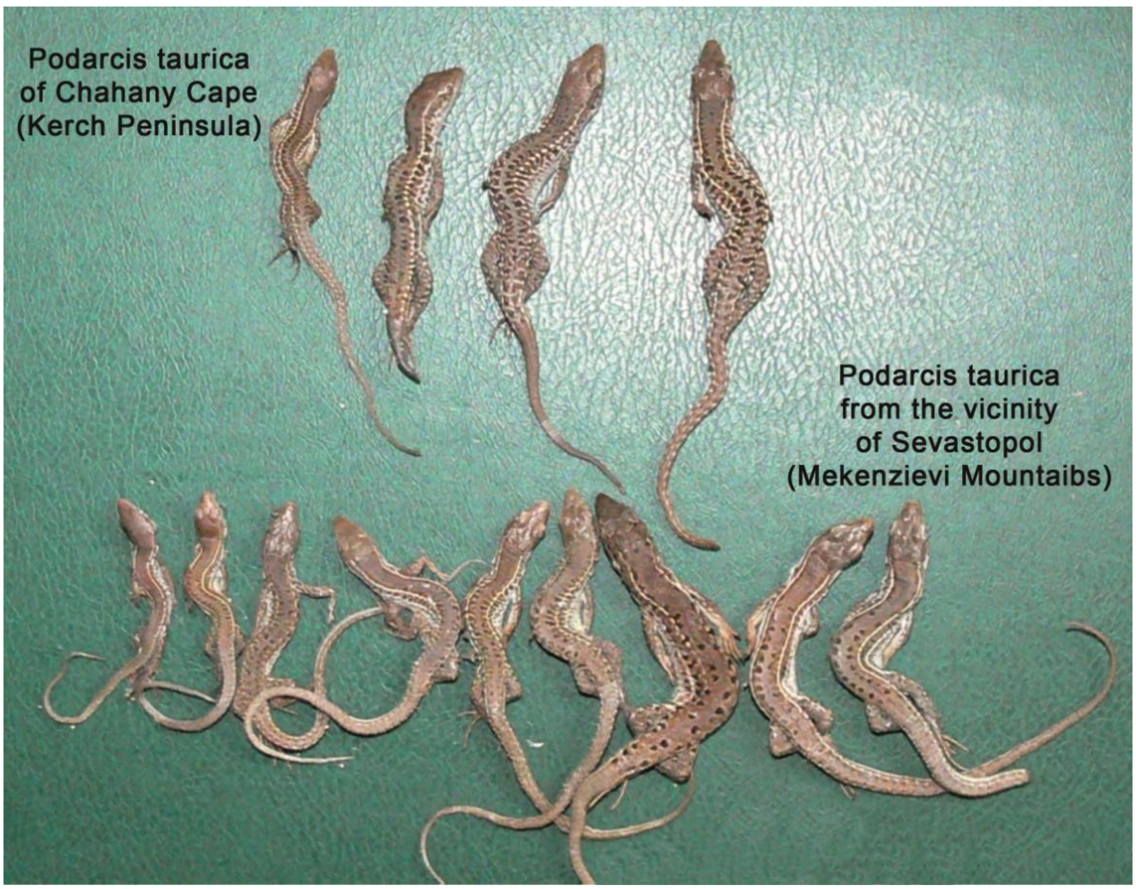


Figure 1.3.47. Phenotypic variability of the Crimean lizard (*Podarcis taurica*) from steppe and mountain populations.

Therefore, we can make an assumption that phenotypic diversity of the Crimean lizard is influenced by climatic and landscape conditions.

Decrease of body size in the north-east direction from the Rocky Crimea, according to N.N.Shcherbak (1996), can be also explained by increase of climate aridization in the steppe part.

Figure 1.3.48. Kerch Peninsula (Chahany), biotope of *Podarcis taurica*

Figure 1.3.49. Vicinity of Sevastopol (Mekenzievi Mountains), biotope of *Podarcis taurica*

Preliminary results were also obtained according to monitoring of snake's phenotype variability. The study of space-time distribution of different morphs of the dice snake *Natrix tessellata* has shown the increased percentage of melanists in Kakhovske Reservoir (Zaporizhzhia Region) and predominance of the latter in the population of the Lopan River (Kharkiv City) (Table 1.3.22).

Table 1.3.22. Space-time distribution of melanists of the dice snake (*Natrix tessellata)*

Year	Number (per 100 m of the shorebank line)			
	Kakhovske Reservoir (Zaporizhzhia Region)		Lopan River (Kharkiv City)	
	Common individuals	Melanists	Common individuals	Melanists
1993	3-4	0		
1997	7-8	1		
1999	5-6	0		
2000	6-7	0		
2003	7-8	0		
2007	6-7	3		
2010	8-9	5		
2012	-	-	7	5

The distribution analysis of different morphs of the dice snakes (*Natrix tessellata*) has shown that black specimens dominate in northern populations. At the same time their numbers in the south also increased during recent years. Precise data still were not received because of short-term works under the project but, more likely, these are some climatic conditions which influence on concentration of melanists.

1.3.6 State of particular natural processes: estimation of the state of wader's wintering in the region, trends and prognoses

The state of wader's wintering in the Azov-Black Sea Region of Ukraine has been analyzed for the period 1960s-2000s on the basis of published ornithological materials and the database of the Azov-Black Sea Ornithological Station including author's materials. Estimation of changes in wintering in the region was done simultaneously with analysis of trends in weather-climate conditions for the same period. For more detail investigation of impact of weather-climate conditions on winter distribution of waders in the winter periods 2010/2011 and 2011/2012 there were undertaken wader's regular counts (throughout the whole winter, with two-week intervals) on monitoring plots of South Ukraine (in the North-Western Azov area – Molochnyi Liman, Zaporizhzhia Region and in the North-Western Black Sea Region – the Danube Delta, Tilihulslkyi Liman, Odesa Region). Weather-climate conditions were estimated basing on primary data of Henichesk meteostation (Kherson Region), located in the central part of the seashore strip.

Characteristics of species diversity of wader's wintering community in the region and trends of changes. In ornithological literature there are very few facts of winter registration of waders in Ukraine from the late 19th century to the 1960s. There are single winter records of the green sandpiper *Tringa ochropus* and snipe *Gallinago gallinago* in the Crimea in the 19th century (Brauner, 1899). In the south of the Crimea and in the vicinity of Simferopol City for the same period there were known winterings of the woodcock *Scolopax rusticola* (Nikolsky 1891/1892; Senitsky, 1898). B.S.Valkh (1911) mentions single winter records of the woodcock, wnipe and jack snipe *Lymnocryptes minimus* in the steppe Dnieper area. Fundamental records of the 1950s on birds of Ukraine (Kistiakivskyi, 1957) and the former USSR (Dementyev, Gladkov, 1951) tell about two December registrations of the lapwing *Vanellus vanellus* in the Crimea and Askania-Nova Reserve (Kherson Region) and about rare winterings of the woodcock. There were known single observations of the wnipe, Eurasian curlew and dotterel *Eudromias morinellus* at the Dniprovskyi Liman in the first half of December, and records of the jack snipe and grey plover *Pluvialis squatarola* (Kistiakivskyi, 1957) in Askania-Nova Reserve. In the late 1950s in the Black Sea Reserve and on Dzharylhach Island (Kherson Region) in the warmest seasons the lapwing and Eurasian curlew *Numenius arquata* stayed for winter (only in December) (Ardamatskaya, 1973; 1996). Therefore, biodiversity of wintering waders in the Azov-Black Sea Region prior to the 1960s, according to literary data, included 8 species – the lapwing, green sandpiper, grey plover, dotterel, woodcock, snipe and jack snipe.

In the 1960s at the northern coast of the Black Sea (Odesa and Kherson region of Ukraine) the following species were registered on wintering: the lapwing, redshank *Tringa totanus*, woodcock, Eurasian curlew, and also (only in December) – grey plover and dunlin *Calidris alpina* (Fedorenko, Nazarenko, 1965; Ardamatskaya, 1983; 1996; Ardamatskaya, Rudenko, 1996). In the late 1960s a single winter record (14.02.1969) of the dunlin in the Crimea is known (Kostin, 1983).

As a result, before 1970 on the south of Ukraine there were registered 10 species of waders (Table 1.3.23).

In the 1970s only in the Crimean Peninsula in winter season there were recorded 12 species of waders – the dunlin, ruff *Philomachus pugnax*, snipe, woodcock, black-tailed godwit *Limosa limosa*, purple sandpiper *Calidris maritima*, Eurasian and slender-billed curlews *Numenius tenuirostris*, and also (in December) the lapwing, green sandpiper, greenshank *Tringa nebularia* and redshank (Kostin, 1983).

In the Black Sea Reserve (Yahorlytskyi and Tendrivskyi Bays of the Black Sea) 7 species were recorded on wintering: the lapwing, redshank, jack snipe, snipe, woodcock, Eurasian curlew and whimbrel *Numenius phaeopus* (Ardamatskaya, 1983); in the vicinity of Odesa at Khadzhibeiskyi Liman the jack snipe was registered on wintering (Zhmud, 2000).

In a total, in the south of Ukraine in the 1970s there are references of winter records for already 14 species of waders (Table 1.3.23). For the first time in winter period in the region there were recorded the greenshank (9-11.12.1970), ruff (December-February), black-tailed godwit (16.02.1971, 17.01.1975), purple sandpiper (17-18.02.1971), whimbrel (December-January) and slender-billed curlew (12.01.1971).

Table 1.3.23. Changes in the species composition and distribution of waders in winter period in the Azov-Black Sea Region of Ukraine for the last 50 years

№	Wader species	Number of sites where the species stay in winter				
		Prior to 1970	1970s	1980s	1990s	2000s
1.	*Pluvialis squatarola*	2	-	1	3	5
2.	*Pluvialis apricaria*	-	-	-	2	3
3.	*Charadrius hiaticula*	-	-	-	1	3
4.	*Charadrius alexandrinus*	-	-	1	-	3
5.	*Eudromias morinellus*	1	-	-	-	1
6.	*Vanellus vanellus*	4	2	2	11	13
7.	*Vanellochettusia leucura*	-	-	-	-	1
8.	*Arenaria interpres*	-	-	-	1	1
9.	*Himantopus himantopus*	-	-	-	-	1
10.	*Recurvirostra avosetta*	-	-	1	3	4
11.	*Haematopus ostralegus*	-	-	-	2	3
12.	*Tringa ochropus*	1	1	1	4	6
13.	*Tringa nebularia*	-	1	-	-	1
14.	*Tringa totanus*	1	2	2	-	5
15.	*Tringa erythropus*	-	-	-	-	1
16.	*Actitis hypoleucos*	-	-	-	-	1
17.	*Philomachus pugnax*	-	2	-	2	3
18.	*Calidris minuta*	-	-	-	-	2
19.	*Calidris ferruginea*	-	-	-	-	1
20.	*Calidris alpina*	2	1	2	6	14
21.	*Calidris maritima*	-	1	-	-	1
22.	*Calidris canutus*	-	-	1	4	3
23.	*Calidris alba*	-	-	1	3	5
24.	*Lymnocryptes minimus*	2	2	1	2	6
25.	*Gallinago gallinago*	2	3	3	7	15
26.	*Gallinago media*	-	-	-	-	2
27.	*Scolopax rusticola*	5	2	4	5	10
28.	*Numenius tenuirostris*	-	1	-	-	-
29.	*Numenius arquata*	3	3	2	11	13
30.	*Numenius phaeopus*	-	1	2	-	3
31.	*Limosa limosa*	-	1	1	-	2
Total, species		10	14	15	16	30

In the 1980s in the Ukrainian Danube Delta in winter months there were registered 13 species of waders (Zhmud, 1998). Eight of these species (grey plover, lapwing, dunlin, sanderling *Calidris alba*, woodcock, whimbrel and Eurasian curlew, black-tailed godwit) could stay in this area for the whole winter. For the first time the following species were registered in winter period: the Kentish plover *Charadrius alexandrinus*, avocet *Recurvirostra avosetta*, knot *Calidris canutus*, sanderling.

In the 1980s at the southern coast of the Crimea, from Alushta to Feodosia, there were recorded 4 species of wintering waders – the lapwing, dunlin, snipe, woodcock (Beskaravayny, Kostin, 1999). Besides, the green sandpiper, snipe and jack snipe were recorded on wintering in the vicinity of Odesa.

In general, in the Azov-Black Sea Region of Ukraine during these years 15 wader species occurred on wintering (Table 1.3.23). For the first time for the whole region there were recorded wintering Kentish plover (17.12.1986), avocet (December 1980), sanderling (December-February), knot (16.12.1983).

In the 1990s in the Ukrainian Danube Delta there were registered 13 wader species in winter period. The species, new for this area, appeared – the oystercatcher *Haematopus ostralegus*, golden plover *Pluvialis apricaria* (began occurring repeatedly on wintering), green sandpiper, jack snipe (Zhmud, 2000).

In the south of the Crimea in this period, in addition to earlier recorded species there were registered in winter the ringed plover *Charadrius hiaticula*, avocet, turnstone *Arenaria interpres*, green sandpiper, knot, sanderling (Beskaravayny, 1999; Kostin et al., 1998).

In the 1990s in the North Azov area (mostly at Molochnyi Liman) we recorded 7 species of wintering waders: the lapwing, grey plover, dunlin, sanderling, knot, Eurasian curlew and snipe (Kinda et al., 2006).

A total of 16 wader species were recorded on wintering in the whole region during the 1990s. For the first time in winter period there were revealed the ringed plover (31.12.1998), golden plover (December 1998), oystercatcher (15.01.1997), turnstone (5.02.1996).

In the 2000s in the Ukrainian Danube Delta 15 waders species were recorded in winter period. In 2001 in this area the following species appeared on wintering for the first time: the greenshank (11.01.2001), spotted redshank *Tringa erythropus*, little stint *Calidris minuta*. Species composition of waders each winter was determined by weather conditions. The most common and regularly wintering in the delta species, which occur in small numbers even in severe winters right up to complete freezing of water bodies, are the Eurasian curlew, dunlin and sanderling. The most tolerant to low temperatures is the Eurasian curlew; it is the only species which remains in especially cold winters. In mild seasons (according to weather conditions) 9 species occurred throughout the whole winter: grey plover, golden plover, lapwing, dunlin, sanderling, knot, snipe, woodcock, Eurasian curlew. For other species (such as the avocet, greenshank, spotted redshank, little stint, jack snipe, black-tailed godwit) there are known only 2-3 records.

On Kinburn Peninsula (Mykolaiv Region) and the adjacent shore of Yahorlytskyi Bay in the 2000s there were registered 16 species of waders in winter period (Petrovich, Redinov, 2006; Redinov et al. 2008; Petrovich, Redinov, 2011). Among them such rare species on wintering in the whole region as the oystercatcher, ringed plover, Kentish plover, turnstone, purple sandpiper, knot, sanderling. Species composition of waders depended on winter-climate conditions of the winter: in case of significant falls of temperature waders leave this area, and only the species the most tolerant to low temperatures occur regularly– the Eurasian curlew, dunlin, grey plover and, perhaps, the woodcock (Petrovich, Redinov, 2006).

In the 2000s (Figure 1.3.50) in the North Azov area (Mlochnyi Liman) we counted 11 wader species in winter months, in the Crimea (Syvash) – 15 species (Kinda et al., 2006; Andryushchenko, pers.comm.), at Odesa Limans – 19 species (Panchenko, Formanyuk, 2005; 2006; 2007; 2008, pers.comm.)

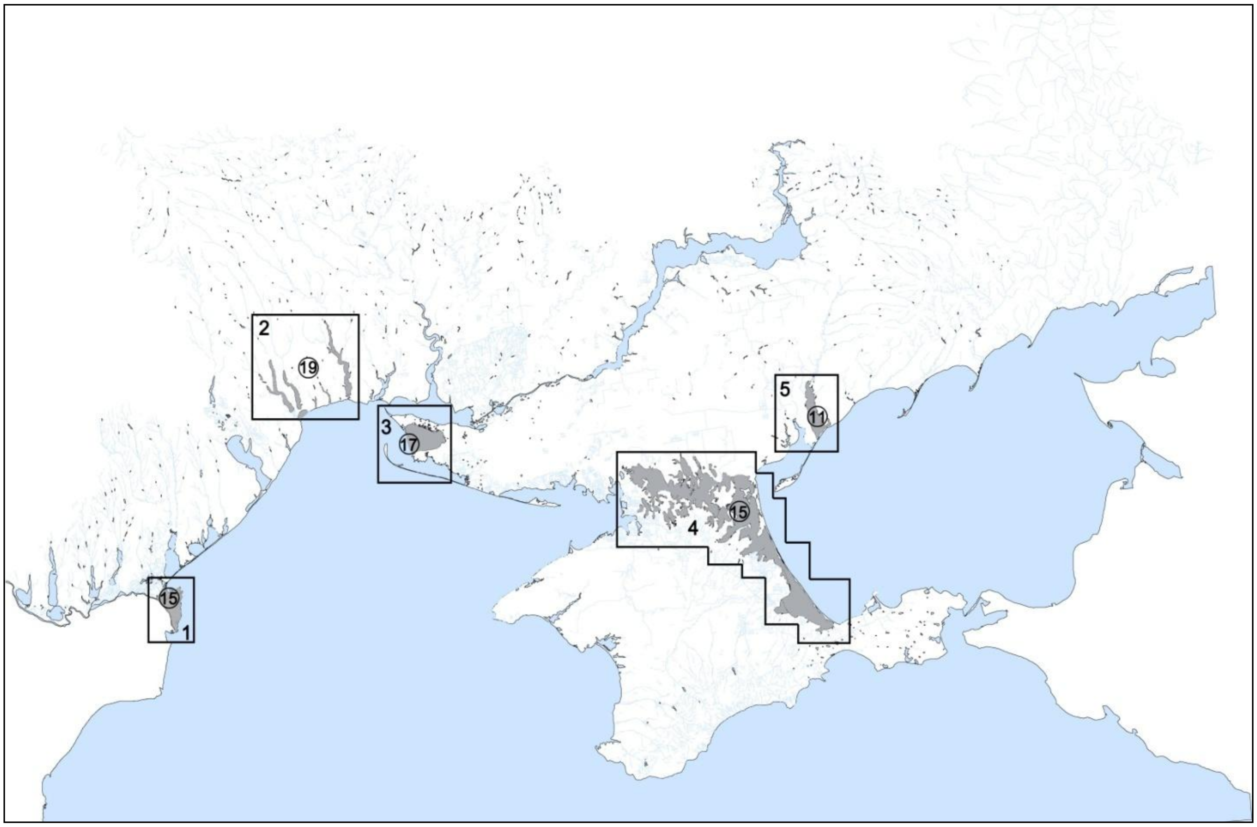


Figure 1.3.50. Species diversity of waders during winter period and main wintering sites in the Azov-Black Sea Region of Ukraine in the 2000s.

Figure in the circle – number of wintering species of waders, 1- Danube Delta (15), 2 – Odesa Limans (19), 3 – Kinburn Spit and Yahorlytskyi Bay (17), 4 – Syvash (15), 5 – Molochnyi Liman (11).

Thus, for the recent decade biodiversity of waders, regularly and sporadically wintering in the Azov-Black Sea Region of Ukraine has increased the most substantially – up to 30 species. In the 2000s the following species were registered on wintering in the region for the first time: the black-winged stilt *Himantopus himantopus* (December-February 2005-2007, Odesa Limans), white-tailed plover *Vanellochettusia leucura* (19.01.2001, Crimea), spotted redshank (21.01.2001, Danube Delta), common sandpiper *Actitis hypoleucos* (25.12.2004, lower reaches of the Dnieper), curlew sandpiper *Calidris ferruginea* (8.12.2004, Azov Sea region), little stint (11.01.2001, Danube Delta) and great snipe *Gallinago media* (January 2005, 2007, Odesa Limans, Black Sea Reserve).

Main trends in changes of species diversity of waders

Increase in the number of wintering species of waders in the Azov-Black Sea Region of Ukraine for the last 50 years (from 10 to 31 species, Figure 1.3.51), more likely, is connected with warming of first winter months. Also, we cannot exclude man-made transformation of biotopes. Coverage of the studied area has only a partial impact on the results. The closest regular wintering areas of the considered group of species are located in the Mediterranean, North Africa, Transcaucasia, and South Asia. That is why, movement of their wintering range to the north, in the Black Sea area, is quite probable with the climate warming. A similar trend is observed in Bulgaria – increase of species diversity of waders at the expense of the species which wintering range lies much further to the south (Nankinov, 1989; Dimitrov et al., 2005).

The trend of increasing species diversity of waders is traced by us also in some monitoring wetlands – in the Danube Delta, at Syvash and Molochnyi Liman (Figure 1.3.52).

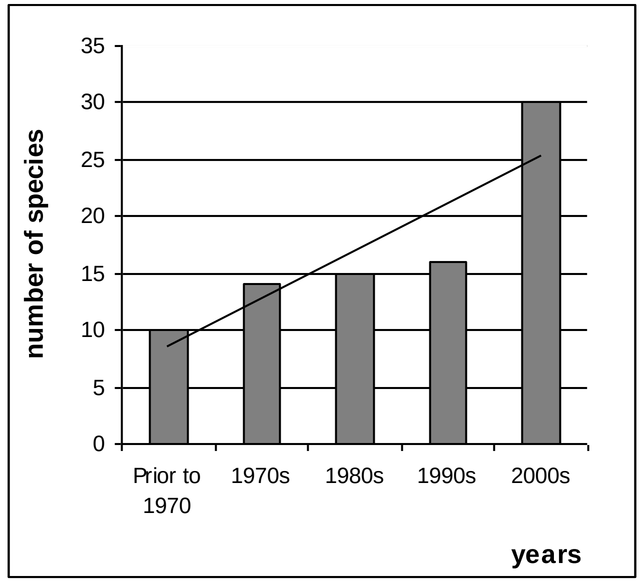


Figure 1.3.51. Increase of species diversity of wintering waders in the Azov-Black Sea Region of Ukraine during the last 50 years.

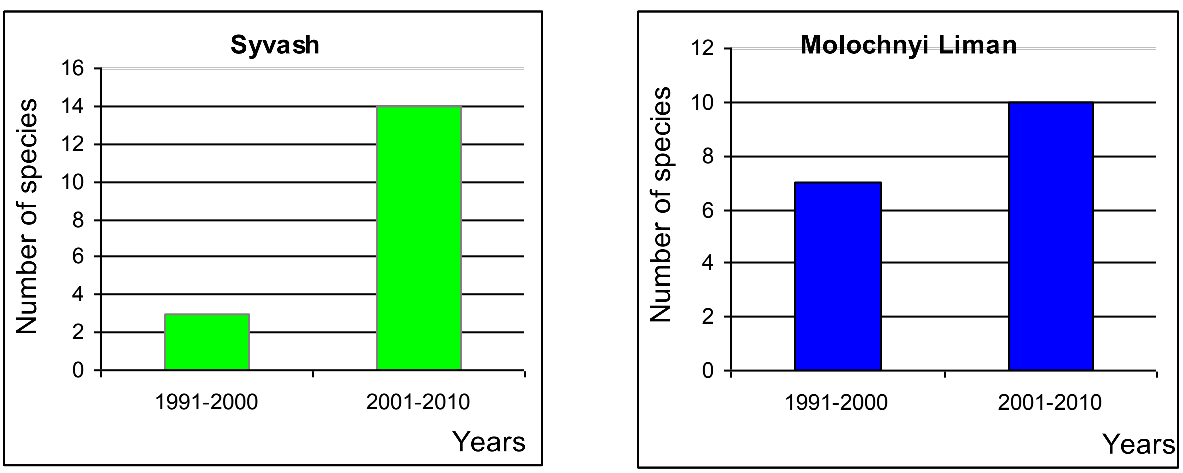


Figure 1.3.52. Increase of species diversity of wintering waders at Syvash and Molochnyi Liman over the period of 20 years (1991-2010).

Only the Eurasian curlew can bear severe winters. Among other species, the most resistant to prolonged falls of temperature and their consequences, are the dunlin, in lesser extent – the grey plover, and in the coastal zone – the sanderling. These species winter in the region the most regularly and dominate in numbers (Kinda et al., 2006). The man-made water bodies are the most frequently used as wintering sites by the green sandpiper, jack snipe, black-winged stilt.

In mild winters not only the overall number of registered wader species increases but also the number of species which stay in the region throughout all the winter or during its major part (until late January-February). For the last two decades there is observed increase in the period of winter stay in the region for a number of species (see Chapter 3.3), and, as a result, the species diversity of the wader's wintering community in the region is gradually growing.

Prognoses of changes in the wader's wintering in the region.

With gradual climate warming in winter period the species diversity of wintering waders in the Azov-Black Sea coast of Ukraine may increase at the expense of movement of Mediterranean wintering ranges of many wader species in the Azov-Black Sea direction. The first will be those new species Nankinov, 1989) which in recent decades already began winter non-regularly in Bulgaria.

The wader species, sporadically wintering in the region, may become stable wintering in the near decades. The species, currently occurring only in December-January may stay in the region, during mild winters, for the whole winter period (for example, the grey plover, avocet, redshank).

In addition, it is expected broadening of the wintering area for particular species at the expense of using new wetlands within the region and increase of total numbers of some regularly wintering species in the region (for example, the dunlin, Eurasian curlew, grey plover, snipe). In the near decades in the south of Ukraine the appearance of stable wintering sites of waders is the most probable, first of all, for the Danube Delta, Tuzlovska group of limans, at Syvash and Lebiazhi (Swan) Islands.

As a result, it may increase the value of wetlands in the region as the wader's wintering area, including rare and protected species. The competition pressure on more southern wetlands, in particular the Mediterranean wetlands, will be lower in winter period. This will promote conservation of some wader species at the global scale.

In case if the trend of climate warming continues we can expect the following changes in the wader winter fauna of South Ukraine **by 2050**:

- species, which are common at the present time (the dunlin, sanderling, woodcock and Eurasian curlew), undoubtedly, will retain their status, and the dunlin, more likely, will be a mass wintering species;
- species, which are rarely wintering now (grey plover, lapwing, redshank and snipe) will become common species;
- a number of species which occur now only sporadically (the Kentish plover, avocet, black-winged stilt, green sandpiper, little stint, whimbrel and black-tailed godwit) will change their status into rare wintering species, and the ruff will be common on wintering;
- the appearance of new wintering species is highly probable (the little ringed plover, wood sandpiper, Temminck's stint, bar-tailed godwit). The Temminck's stint may become common, the little ringed plover and wood sandpiper – rare and the bar-tailed godwit – a sporadically wintering species.

Thus, by 2050 the winter fauna of waders in the south of Ukraine will probably include 33 species, of them 10 common species, 9 – rare wintering species and 14 – sporadically recorded.

By 2100, the most probably, the following changes in the wader winter fauna of South Ukraine can be expected:

- species, which are common at the present time (the dunlin, sanderling, woodcock and Eurasian curlew), undoubtedly, will retain their status, and the dunlin and sanderling, more likely, will be mass wintering species;
- species, which are rarely wintering now (grey plover, lapwing, redshank and snipe) will become common and may be even mass wintering species;
- absolute majority of sporadically wintering species will be either rare (the golden plover, ringed plover, Kentish plover, turnstone, black-winged stilt, oystercatcher, greenshank, spotted redshank, common sandpiper and curlew sandpiper), or even common on wintering (the avocet, green sandpiper, ruff, little stint, whimbrel and bar-tailed godwit);
- the appearance of new wintering species is highly probable (the little ringed plover, wood sandpiper, Terek sandpiper, Temminck's stint, bar-tailed godwit). The wood sandpiper and Temminck's stint may even become common, and the terek sandpiper and bar-tailed godwit will, more likely, remain sporadically wintering species.

Thus, by 2100 the winter fauna of waders in the south of Ukraine will probably include 34 species, of them 12 common species, 10 – rare wintering species and 7 – sporadically recorded.

Table 1.3.24. Wintering of waders in the south of Ukraine: current status and prognosis

№	Species	Current status	Prognosis by 2050	Prognosis by 2100
Actually registered species				
1.	*Pluvialis squatarola*	R	C	C
2.	*Pluvialis apricaria*	S	S	R
3.	*Charadrius hiaticula*	S	S	R
4.	*Charadrius alexandrinus*	S	R	R
5.	*Vanellus vanellus*	R	C	C
6.	*Vanellochettusia leucura*	S	S?	S?
7.	*Arenaria interpres*	S	S	P
8.	*Himantopus himantopus*	S	S	P
9.	*Recurvirostra avosetta*	S	R	C
10.	*Haematopus ostralegus*	S	R	P
11.	*Tringa ochropus*	S	R	C
12.	*Tringa nebularia*	S	S	P
13.	*Tringa totanus*	R	C	C
14.	*Tringa erythropus*	S	S	P
15.	*Actitis hypoleucos*	S	S	P
16.	*Philomachus pugnax*	S	C	C
17.	*Calidris minuta*	S	R	C
18.	Calidris ferruginea	S	S	P

№	Species	Current status	Prognosis by 2050	Prognosis by 2100
19.	Calidris alpina	C	C	C
20.	Calidris canutus	S	S	E
21.	Calidris alba	C	C	C
22.	Lymnocryptes minimus	S	S	E
23.	Gallinago gallinago	R	C	C
24.	Gallinago media	S	S	E
25.	Scolopax rusticola	C	C	C
26.	Numenius tenuirostris	S	S?	E?
27.	Numenius arquata	C	C	C
28.	Numenius phaeopus	S	R	C
29.	Limosa limosa	S	R	C
Total, species		C- 4; R – 4; S-21	C-9; R-7; S-13	C-14; R-10;S-5
	Expected species			
30.	*Charadrius dubius*	-	R	O
31.	*Tringa glareola*	-	R	O
32.	*Xenus cinereus*	-	-	E
33.	*Calidris temminckii*	-	C	O
34.	*Limosa lapponica*	-	S	E
Total, species		C-4; R-4; E-21	C-10; R-9;S-14	C-17; R-10;S-7

Note: C – common; R – rare; S – sporadic records

1.4 Expected socio-demographic (socio-economical) effects of biodiversity changes caused by a complex of factors, prognoses and scenarios to mitigate negative effects

Target investigations on impact of climate changes on particular characteristics of key ecosystems of the Azov-Black Sea coast, undertaken within the enviroGRIDS project "Building Capacity for a Black Sea Catchment Observation and Assessment System Supporting Sustainable Development under the 7th Framework Programme of the European Union", with extensive use of retrospective data, have allowed to work out scenarios of prognosticated consequences for various life spheres and economical activity of people using biological resources in the south of Ukraine.

As for a particular direction of climate changes they vary in different geographical regions and relevant literature sources have no clear and unambiguous opinions of it. Moreover, the on-going climate changes are frequently added with human interference in nature systems that complicates a precise identification of causal relationships.

This work is based on the monitoring observations for the period 2009-2012 along with available retrospective data for the Azov Sea ecosystem and changes in the sea ichtyocoenoses and for an intrazonal ecosystem of the Danube Delta especially the productivity of the reed (a key, landscape-forming species). The survey of the coastline dynamics under climatic and human factors was carried out at the marine edge of Kiliya Danube Delta to forecast expected effects both for delta systems and for recreational and economical use of the territory by local people.

Some geobotanical surveys were done in 2010-2011 on monitoring plots in zonal (meadow and steppe) vegetation communities of the Azov area, and prognoses were made. For some ecotone ecosystems of the Azov area, the current entomological monitoring was compared with retrospective data, and the prognosis of pests dynamics was made.

Ecosystems of the Azov Sea

The changes of basic parameters (Chapter 1.1) have provoked successional dynamics of main hydrobiological ecosystem indices.

The analysis of hydrometeorological data in the Azov Sea Basin allows to expect several scenarios of climate changes in the region 1) increase of temperature and increase of precipitation; 2) increase of temperature and decrease of precipitation 3) decrease of temperature and increase of precipitation.

Water ecosystems have more composite schemes of impact on the ichthyofauna. Thus, for example, increase of precipitation influences the volume of river runoff, and the drainage, in its turn, is a major determinant of salinity. Mineralization of sea water influence the fish productivity, forming their food base – this relationship is very typical for the Sea of Azov. In recent decades, increase of sea salinity resulted in the appearance of the comb jellyfish (*Mnemiopsis leidyi)* which greatly undermined zooplankton biomass and affected the productivity of most short-cycle fish species (European anchovy, Azov Sea sprat).

For the Azov Sea, we can expect several variants for fish communities and fish productivity as well as socio-demographic effects within the three above-mentioned scenarios.

Figure 1.4.1. The gobies at the beaches of the city of Berdiansk (from http://www.brd24.com)

The first scenario will entail decrease of salinity due to the increase of river runoff. It should be noted that this scenario is the closest to present conditions. Increase of air temperature will entail increase of water temperature. As it was mentioned above, this trend will lead to further desalinization of the Azov Sea. Currently, the sea salinity is 10.2 g/l which is typical for a natural (before the construction of Tsymlyansky Hydrocomplex) condition of the sea. In case of further increase of precipitation the salinity may decrease to 9.5-10 g/l. It will not lead to any considerable changes in ichthyofauna structure. The European anchovy and Azov Sea sprat will remain dominating commercial species and a current trend of their number growth will continue. The increase of stocks of these fish species will assist to improvement of socio-demographic situation in the industry. The increase of their catch will promote the growth of work places in extractive and processing fish industries.

An important element of the development of fish-extraction enterprises will be a possibility to catch fish using a fixed net in coastal waters without special vessels and trawls. It can assist to the development of small business in the coastal villages. However, decrease of salinity, lower than 9 g/l, will be critical for the Azov Sea ecosystem and may provoke substantial changes in the ichthyocoenoses structure and negative effects for fish productivity.

A considerable freshening of the sea will, to some extent, be compensated by the increasing temperature, due to evaporation from water surface. Especially strong evaporation may be observed in mouth zones of Molochny Liman and Syvash. Intensively evaporating, these water bodies will bring a great part of salts into salt balance of the sea.

An important consequence of increase of temperature will be the increase in frequency and size of suffocation phenomena. Combination of high summer temperatures and calm waters leads to water stratification and rapid decline of oxygen dissolved in lower water layers (less than 3 mg/l) and, therefore, mass mortality of bottom fish species – mostly gobies (round goby, bullhead, goad goby, Syrman goby, etc.) As for the socio-economical situation in the region, acceleration of such phenomena will lead to the following negative consequences: reduction of fish resources of bottom fish species; decrease of fish industry profitability due to worsening of the production quality, since even alive gobies captured in pre-suffocation period are lower in price; worsening of recreational potential due to mass discard of dead fish onto beaches of the region (Figure 1.4.1.) According to the Azov Special Fish Protection Service for the period of 10 years there is an increasing trend for the duration of suffocation phenomena and the volume of dead fish (Figure 1.4.2, 1.4.3, 1.4.4).

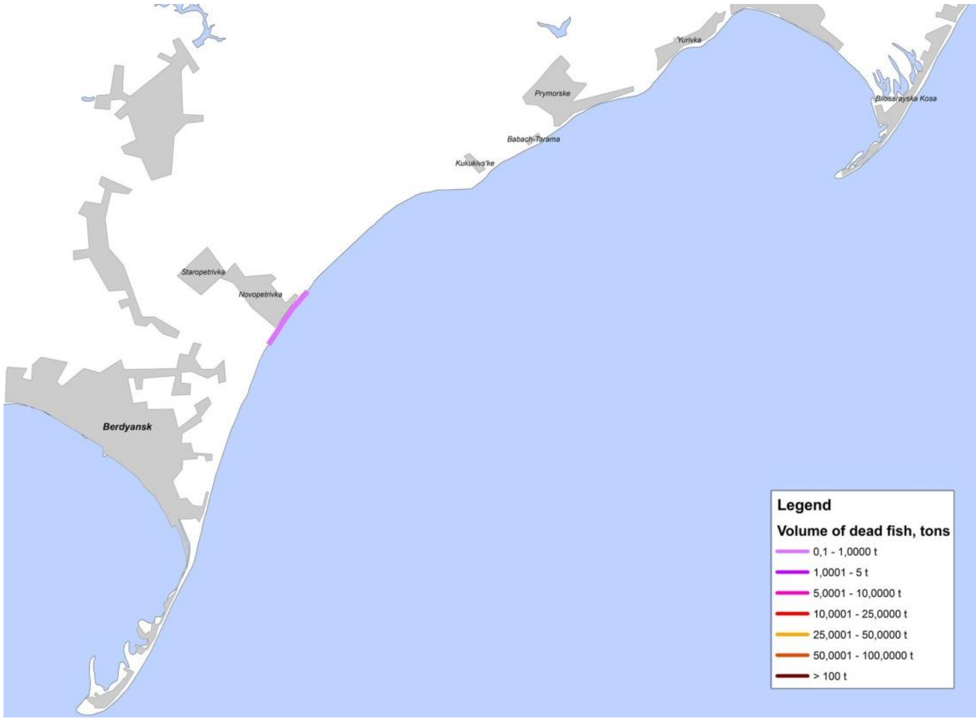


Figure 1.4.2A. Fish mortality in the north-western part of the Sea of Azov in 2002

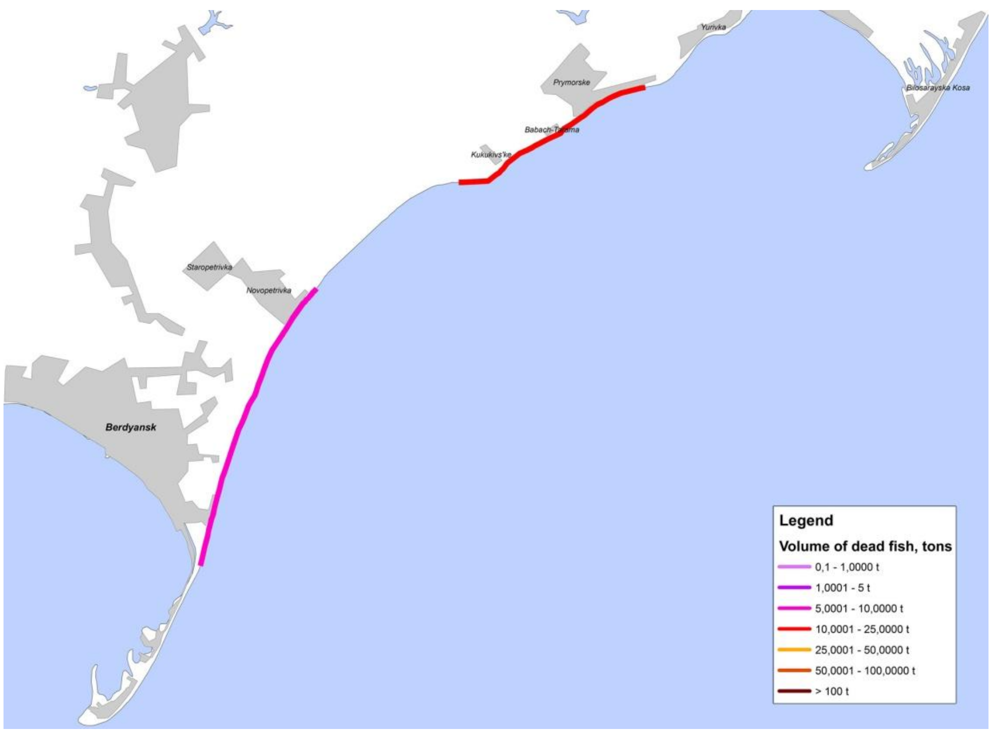


Figure 1.4.2B. Fish mortality in the north-western part of the Sea of Azov in 2004

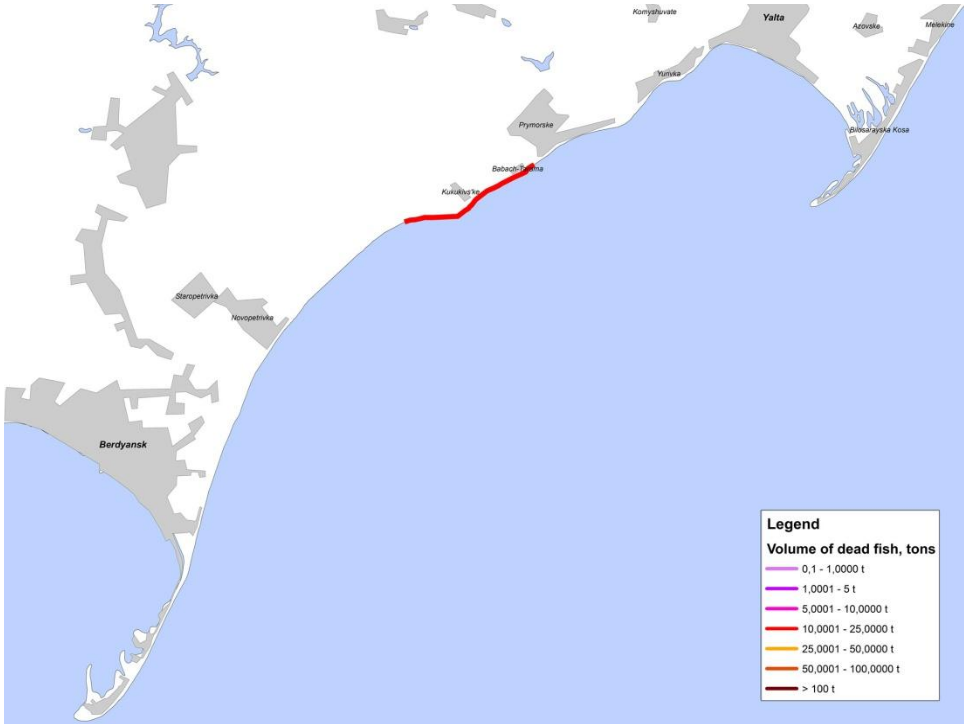


Figure 1.4.2C. Fish mortality in the north-western part of the Sea of Azov in 2006

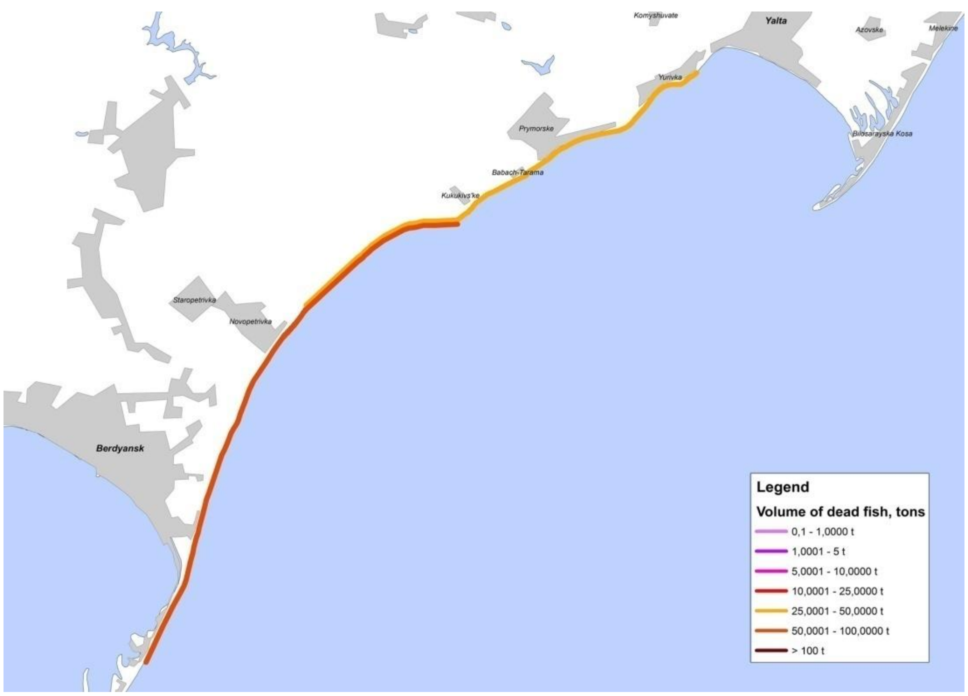


Figure 1.4.2D. Fish mortality in the north-western part of the Sea of Azov in 2007

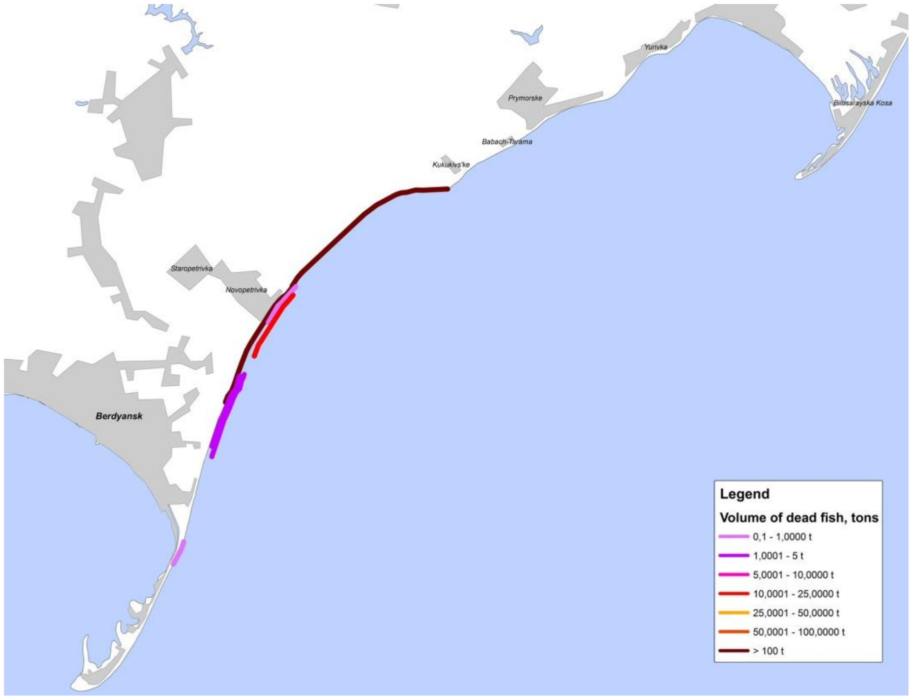


Figure 1.4.2E. Fish mortality in the north-western part of the Sea of Azov in 2008

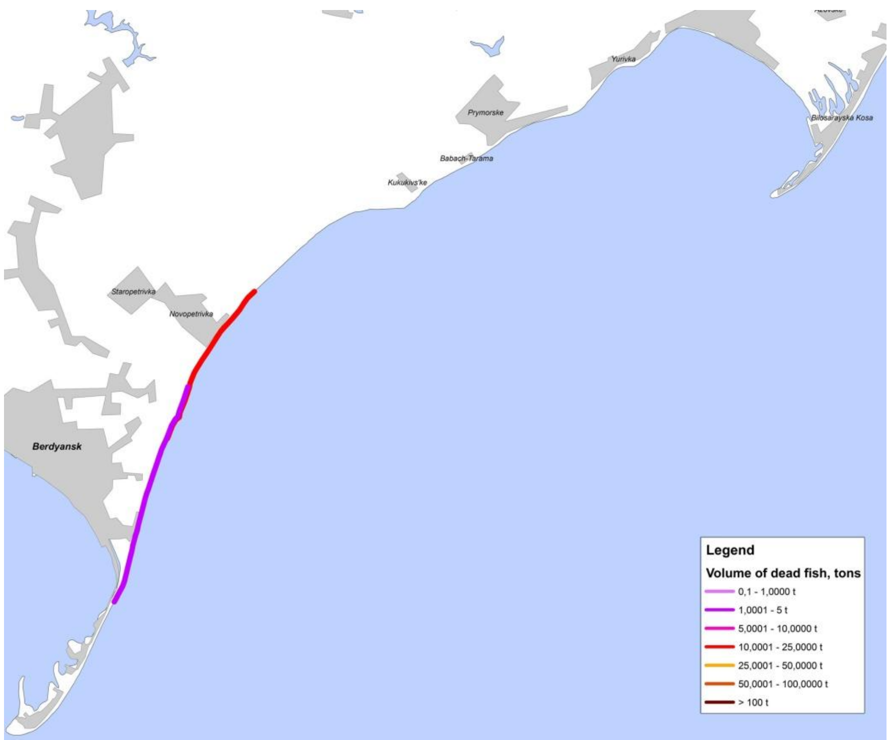


Figure 1.4.2F. Fish mortality in the north-western part of the Sea of Azov in 2009

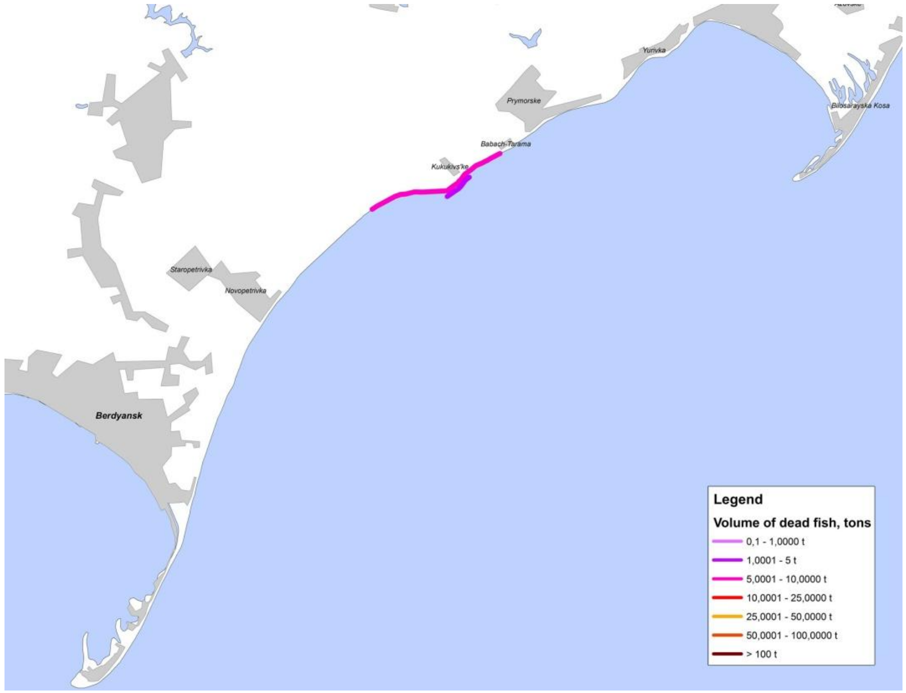


Figure 1.4.2G. Fish mortality in the north-western part of the Sea of Azov in 2010

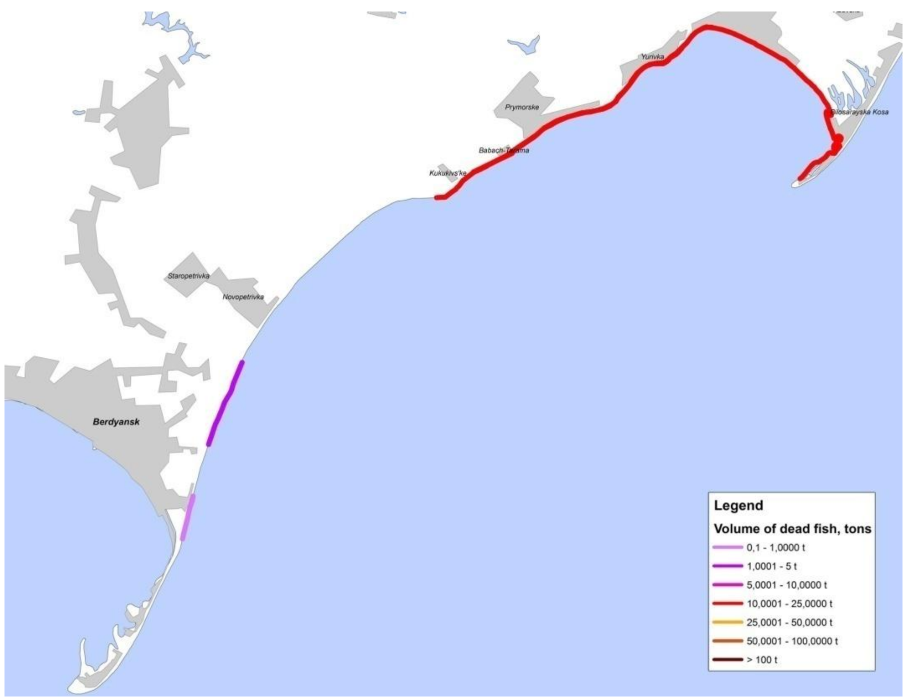


Figure 1.4.2H. Fish mortality in the north-western part of the Sea of Azov in 2011

Figure 1.4.2. Dynamics of fish mortality in the north-western part of the sea

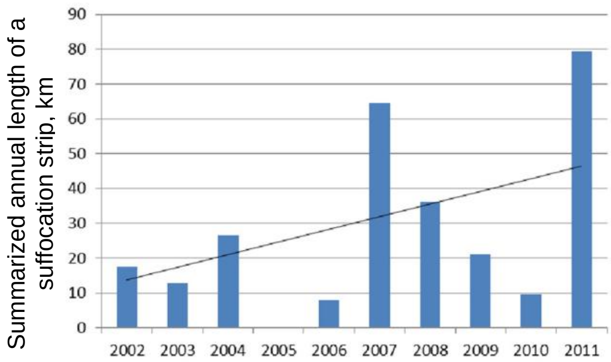


Figure 1.4.3. Summarized annual length of a suffocation strip in the Azov Sea

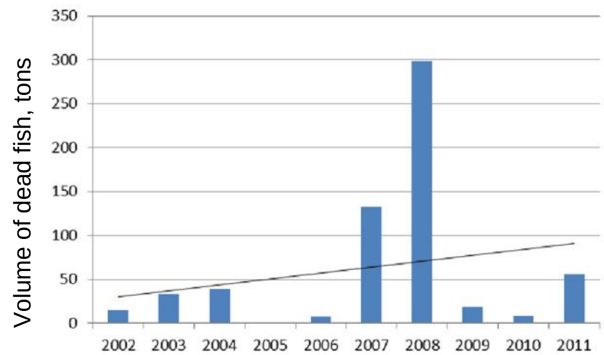


Figure 1.4.4. Summarized volume of dead fish from suffocation in the Azov Sea

The second scenario will provoke increase of salinity owing to reduction of river runoff and rise of evaporation from water surface. This condition of the sea already was observed during the 1960-1980s. The only difference of that period was that the reduction of river runoff had anthropogenic reasons. In that period the sea salinity reached 14 g/l which is again possible in case of decrease of precipitation and increase of temperature in the region. In this situation, a negative role of the jelly-like organisms in formation of food zooplankton will grow which will further result in reduction of stocks of the anchovy and Azov Sea sprat. In these conditions, work places in fish-extracting and fish-processing industries will considerably reduce because of decrease in fish catches. An alternative commercial species may be the so-iuy mullet (it is an euryhaline species and in case of increasing salinity its number can grow). However, it should be noted that the number of work places connected with the so-iuy mullet catching is fewer than in case of catching and processing of the anchovy and Azov Sea sprat. That is why this scenario will apparently bring about the tension in fish industry of the region.

The third scenario will lead to decrease of salinity and water temperature. This scenario for the Azov Sea will be similar to the first scenario, because a leading factor is the salinity level.

It should be noted that the transformation of major commercial fish species groups has been already traced in the recent decade. Valuable sturgeons have been lost, the zander, turbot and many freshwater species are depressed in numbers. At the same time, reducing salinity and, therefore, declining numbers of jelly-like zooplankton organisms entails increase of the anchovy and Azov Sea sprat. Numbers of the round goby also demonstrate a positive trend.

Intrazonal ecosystems of the Danube Delta

Monitoring of the reed quality and the size of reedbed areas in the Danube Delta for the last 4-5 years (2009-2012) has revealed some trends which can have socio-economic effects for the subregion. Reed harvesting in the Ukrainian Danube Delta is an important economical activity in the region. The reed is harvested in winter when a part of the local people becomes unemployed and for them this type of activity acquires a crucial importance.

Observation of the reed condition in 2011-2012 allows to make a very cautious prognosis on the implementation of this type of activity. In 2011 and 2012 the flood level in the Danube Delta was so low that water could not penetrate into inner parts of islands and reedbeds stayed without water almost all the time. Only Stensovko-Zhebriansky Plavni were watered during all the period of reed vegetation. This fact affected the reed development and general productivity. This factor was also added by other climate features of the year 2012. A prolonged winter with quite low temperatures caused mortality of wintering young reed sprouts and delayed vegetation start of the plants. The long cold winter and short spring were followed by a hot summer with infrequent rains. The vegetation of plants started 2-3 weeks later than average annual terms, and the phase of reed budding started in mid-August. Over the whole territory of the Danube Delta the reed came into a blossoming phase being much lower in height compared to all the preceding years. Changes touched also the reed diameter and density per 1 sq.m. All above-mentioned factors affected the reed productivity over the whole territory of the Danube Delta. In August-September 2011 fires destroyed thousands of ha of *plavni* (overflow lands) vegetation on a considerable part of delta islands. In these territories the reed development started 2-3 weeks after the fire. Before the beginning of December 2011 the reed had grown only to 0.3-0.5 m. Young wintering sprouts were not formed and the reed indices in the areas of 2011 summer fires were even worse that in those where there were no fires at all or they were in winter. Over the all territory, vegetation of the reed in 2012 came out from deeper buds of roots that affected the number of stalks, their height and diameter.

The reed winter harvesting is a reasonable exploitation of the delta resources and useful for the ecosystem. However, climate changes can have an essential impact on the development of this activity.

The anticipated rise of Black Sea level and more frequent water level fluctuations due to wind-driven tides may result into rise of water level in the secondary delta of Kiliya Branch of the Danube, reduction of reedbeds and increase of cattail-reed associations. Decreasing trends of flood water level in the Danube will result in extending areas of saline meadow and marshy-meadow communities with low percentage of the reed.

Due to a hot summer the increase of fire frequency is expected. It will lead to changes in vegetation and formation of a marshy-meadow type. This process of meadowfication of *plavni* is already observed on considerable areas of the Danube Delta. The fires will provoke changes in the cell wall structure of the reed due to accumulation of ash constituents in soil. They make parenchyma thinner, and the stalk will be more fragile. The latter will substantially reduce its commercial value.

Increase of temperature of summer months even by 1.5-2.0 º C will bring about the shifts in timing of the reed development, especially its transition into a winter phase. During the last 3-4 years, especially in winter 2011, the phase of leaf fall was practically absent and this substantially broke the terms of starting the reed harvest. It started only in early December, and the work was more expensive because of additional costs connected with cleansing the stalks from leaves when sorting and packing the reed for export.

As for positive trends in reed communities in terms of the reed harvest it should be noted only the increase of the ecosystem mineralization due to the rise of the Black Sea level. The reed, growing in brackish areas, ripens more quickly and its stalks are more strong and adherent which increases its commercial value.

Taking all the above-mentioned into account, we can make the following conclusions on the climate impact on socio-economical life of local communities, in terms of reed harvesting. Not stable qualitative characteristics of the reed require a manual labour to sort out the stalks. Therefore the use of woman's work and especially elderly people will grow.

Increase in the demand for manual labour will extend a working season for almost the whole year.

Shortening of the harvesting period in *plavni* as a result of delaying leaf fall and considerable water level fluctuations will allow to survive only powerful harvesting companies equipped with "Seiga" combines. Increase of a percentage of the cattail-reed communities will result in appearance of a new activity of local people – winter cattail harvest. This tendency is already observed at the labour-market.

Changes in zonal ecosystems

Monitoring of steppe and meadow vegetation communities was conducted during 2010-2011, from the 3^{d} decade of June to the 3^{d} decade of October. To obtain reliable results there were selected areas without traces of grazing or haymaking. The phytomass of vegetation communities was estimated on *sample plots*, 30-100 m^2 in size. The plots were described according standard geobotanical methods.

In spite of short-term monitoring, it was found a meadowfication trend of steppe communities at the expense of increasing phytocoeniotical role of *Elytrigia repens* and *Cynodon dactylon* (on dark- and light-chestnust soils with low fertility). Besides, according to retrospective data for the period 1952-2011 it can be seen a clear trend of increasing phytomass of steppe communities with the dominance of *Stipa capillata.* The phytomass increase is a direct consequence of increase of precipitation and air temperature. If this trend of increasing precipitation and air temperature continues it can lead to meadowfication of southern steppes.

As for meadow vegetation communities, changing in their structure, taking into account their insignificant total size within the studied area of the coastline, cannot have any serious economical consequences. However, at the local level, changes in the meadow communities productivity can have an essential impact on the productivity of pastures and hayfields. Thus, for the two years of observation, the phytomass of meadow communities with the dominance of *Elytrigia repens* on monitoring plots demonstrated a positive trend from 4.2 to 22.0%. In case of the 2nd scenario (increase of air temperature and decrease of precipitation) the productivity of *Puccinellia gigantea* meadows can decrease 2-3 times. Correspondingly, heads of grazing cattle or volume of haymaking will be also 2-3 times reduced. With average productivity of these vegetation communities as 40-50 kg/ha of green mass and market price of hay in the region as 1 UAH, loss because of lack of forage (for a single mowing) would be equal 500 to 520 thouthand UAH a year (monitoring plot at the right coast of Molochnyi Liman). In meadow communities of *Elytrigia repens* the productivity may reduce 6-7 times, and the loss will be 80,000 UAH.

In case of the 1nd scenario (increase of air temperature and increase of precipitation), the productivity of meadow coenoses can rise by 20-30%. In this case the overall commercial volume of hay can rise from 600 to 750-800 thou. UAH/year (in a total for two monitoring plots – Molochnyi Liman and Syvashik Liman).

At the present time, a major profitable type of activity in steppe areas is the cattle raising. In case of the above-mentioned 2nd scenario (increase of air temperature and decrease of precipitation) and dominating processes of desertification, the productivity of steppe areas can reduce 4-5 times in feather grass-fescue and fescue-feather grass communities. Respectively, heads of grazing cattle or volume of haymaking will be also 4-7 times reduced. With average productivity of feather grass-fescue and fescue-feather grass communities as 200-300 kg/ha of green mass and market price of hay in the region as 1 UAH, loss because of lack of forage (for a single mowing) would be equal from 450 to 550 thou. a year (control plot "Novopetrovsky") and 850-950 thou./year for the monitoring territory of Syvash.

These consequences will be especially actual in Syvash region where the haymaking is a major type of using natural resources. According to our observations, the mowing takes place two times a vegetation season (MAi-June and the second half of August). In this case, we cannot exclude a possibility of steppe areas to be ploughed up as an alternative for haymaking or there may be transition to sheep grazing which can successfully feed on low productive pastures. The sheep grazing will be even more destructive than the ploughing and will greatly accelerate desertification.

Reducing productivity of steppe areas will probably be compensated by up-to-date techniques of the crop-growing including green forage crops (lucerne, esparcet, etc.). In connection with it (on the example of Novopetrovsky control plot) an other variant can be also allocation of low productive steppe areas for building country cottages and recreation facilities.

In case of the 1st scenario (increase of air temperature and increase of precipitation) and dominating processes of meadowfication, the productivity of feather grass-fescue and fescue-feather grass communities can rise nearly 2 times due to their transformation in couch grass and reach to 5600-5800 kg/ha. Respectively, heads of grazing cattle or volume of haymaking will become also 2 times greater. In this case the overall commercial volume of hay can rise to 1300 thou. UAH/year (control plot "Novopetrovsky") and to 2000 thou. UAH/year for the control plot of Syvash.

Insects of ecotone systems

The situation, observed in recent years, connected with extreme high temperatures in the spring-summer period, is leading, in addition to direct increase of air temperature and drought of soil, to the considerable reduction of the size of watering area of near-water habitats and creates very favourable conditions for transformation of the locust *Locusta migratoria L. (Acrididae, Orthoptera)* in the gragarious (invasion) form. This situation is worsened by embankment and regulation of most rivers flowing into the limans of the Azov and Black Seas.

River banks, lake shores and sea coasts with reed and sedge thickets (particularly *Phragmites australis*) are the main habitat for this species. Such sites are often surrounded by the steppes and agrocoenoses which turn to be in the most potentially dangerous situation. Long-term observations shows that potentially the most dangerous localities of the locust in Ukraine are the Danube River Delta and lower reaches of the rivers entering into the eastern part of the Azov Sea.

The solitary form of the migratory locust is a rather narrow oligophage which prefers wild crops (eg. the reed and *Elytrígia*). Gregarious forms during the first few days after hatching start to form concentrations ("clouds") which density can reach to 80,000 larvae/m² for the 1st age and 7,000 larvae/m² for the 5th age. These clouds can move for a relatively large distances (marching "clouds"). In case of rare vegetation cover, the clouds of 5th age larvae can cover up to 3 km a day. The gregarious imagoes form swarms circa in 10 days after getting winged. In spite of the single form, the individuals of the gregarious form can eat plants of many families and far from their breeding area. Every individual of the locust eats 300 to 500 g of green forage during its life, and they include practically all agricultural crops, fruit trees, hayfileds and pastures in their diet.

In 2012 the locust invasion has seriously damaged agricultural lands in Stavropol Territory and in Rostov and Kemerovo Regions of the Russian Federation (Musolin, Saulich, 2012), and appearance of the locust reproduction in the territory of Ukraine is the question of the near future. Experts of the authoritative agency of agricultural prognoses “AgroInsurance.com” assume that the situation with increasing risks connected with the locust invasion will continue, firstly due to climate changes (weather risks). The situation with its harm to agriculture is worsened by imperfection of means of struggle against the locust, above all different pesticides. Transition to up-to-date, high effective chemical (hormonal) and biological means against the locust will also entail the rise of financial costs for the harvest protection.

In Russia, serious phenology changes were also recorded for Rhopalocera. Thus, at the Urals in late May was registered the mass coming out of *Aporia crataegi* (*Pieridae; Lepidoptera*), which is an agricultural pest. Such timing of this species appearance in the region is almost 1 month earlier than usual. Local experts assume that the reason of this phenomenon is an early and unusually hot summer.

These examples give an additional confirmation that phenological responses include not only a shift of insect development to earlier terms but further changes in phenology, prolongation of a period of active development, above all for pests, which can lead to extremely negative socio-economic effects.

Development of recreation in the Kiliya Branch of the Danube Delta

Recreational services is one of main socio-economic activities for local comminites of small coastal settlements such as Primorske Village and Vilkovo City located in the region of the Kiliya Danube Delta (Figure 1.4.5)

The seacoast is a major type of recreation resources in the region; its value is determined by a qualitative and quantitative combination of resort-recreational resources – climatic and balneological values, landscape, sea beaches and coastal sea waters.

Active recreational development in the Kiliya Danube Delta is possible only on the limited section of the coastline from Sasyk Liman to Zhebrianska Bay. It is explained by a functional zonation of the Danube Biosphere Reserve (Figure 1.4.5) and frontier location of the region. The border between Ukraine and Romania lies in the waterway of Kiliya and Starostambulsky Branches of the Danube. Thus, monitoring and prognoses for further development of exogenic processes, connected with formation or degradation of beaches, is very important for the recreational activity in the Kiliya Danube Delta. Such studies are especially crucial due to seasonal characteristics of the seashore recreation and due to the fact that for a majority of local people the tourist services are the main source of their profits.

Figure 1.4.5. Zonation of the Kiliya Danube Delta.

The most impact on modern processes of the formation of the marine edge of the delta (MED) has the decrease of sediment drainage of the Danube, redistribution of runoff between Tulcha and Kiliya Branches, the rise of the Black Sea level.

Last years the runoff of Ochakov Branch dropped the most intensily; it was induced by the reduction of water content in Kiliya Branch and stop of dredging works in Prorva Branch and Soedinitelny Canal. Supposedly, it provokes the deficit of sediments in the northern part of Kiliya Delta, especially in low water years.

Field surveys of 2011-2012 revealed intensification of erosion processes at Zhebrianska Bay and on northern spits of Kiliya Delta in the mouth of Potapovsky Branch.

The shore of Zhebrianska Bay from the southern part of the dyke of Sasyk Liman and to Badyk Bay (Badika) is mostly represented by clean beaches and areas overgrown by the silverberry, tamarisk and annual grasses. The marine edge in this section is essentially changing: spits are developing, joining to the shore and then eroding. Deepening and shallowing of the coastal zone can take place several times a year. During a year the marine edge in some areas moves as far as more than 50 m.

Analysis of MED dynamics, based on satellite images from 1984 to 2011, has shown that in the considered region the most dynamic is Zhebrianska Spit. It is forming mostly at the expense of a longshore current of sediments. This spit is adjacent to the resort zone of Prymorske Village and is the most promising for the development of recreational infrastructure both at the present time and in the near future.

Pereboyna Spit (Figure 1.4.5) in recent years is subject to washing out and moving to the coastal side. In the mouth of Polunochny Branch the coast predominantely consists of *Mia arenaria* shells discarded by the sea onto a shallow coast, on top of black mud. The coast is retreating there; the evidence is a great number of remnants of reed roots at the depth of 40-60 cm as far as 30 m of the coastline. Spits in the region of Polunochny Kut Bay (Durnoy Kut), the mouth of Shabash Branch, western shore of Shabash Island are subject to erosion and displacement to the south.

The climate warming will undoubtedly lead to the rise of the Black Sea level. It, in its turn, will intensify processes of coastal erosion (washing out), flooding and under-flooding of islands and will cause important changes in ecosystems of the Danube Delta. The scale of these processes will depend on the rate and height of increasing sea levels. According to various scenarios of climate changes the Black Sea level can rise 22 to 115 cm.

In case of the scenario with a 115 cm rise of level by the year 2100, the most negative effects are anticipated in the mouth of Ochakovsky Branch, with its current deficit of sediments, and high potential of wave power. In spite of continuous replenishment of the recreational beach of Primorskoe Village and Zhebrianska Spit with a longshore drift of sediments we can predict damages and flooding for most objects of economical and recreational infrastructure which are presently located almost at sea level. The most impact on the coastal zone will be produced by winter storms, causing a wind-driven increase of water level. Frequency and intensity of such phenomena may also increase due to climate changes in the region.

Thus, exogenic processes, associated with the formation and erosion of the marine edge of the delta and by-delta spits and observed during monitoring of 2011-2012, can have negative and positive impacts for the development of recreational infrastructure in the Danube Delta. However, with further climate changes and the sea level rise, negative effects more likely will dominate.

Expected socio-economical and nature conservation effects of changes in winter bird complexes in terms of hunting resources of the Danube Delta

Current climate changes have a trend of evident warming, though in different geographic regions and in different seasons of the year their scale is distinct. As for hunting species of waterbirds, the most crucial is the warming in autumn-winter periods. Thus, in a spring-summer breeding period a few degree increase of temperature will be not significant for birds. However, in a winter period, when the temperature in the Danube Delta ranges about 0^oC, such increase of temperature means that the bodies of water will stay without ice cover for a longer period of time, and feeding areas of geese and mallards will be also stay longer without snow cover. It is known that the state of ice and snow is a main determinant for wintering waterbirds. It means that more hunting species and more individuals of this waterbird group will spend a longer time in the Danube Delta before their departure to wintering areas. More and more birds of this group, especially the mallard and greylag goose will simply stay for winter in the delta region and not depart. Below we consider socio-economical and nature conservation effects of this fact.

Traditionally, the hunting for waterbirds starts in Ukraine on the second Saturday of August. During this period, especially in the south of Ukraine, still remains high air temperatures, and they will rise with further climate warming. As a result, a breeding period for many species will be longer and by the beginning of August there still will remain many immature young birds. Also, the moult of adults will be characterized with some delay. It will reduce trophy characteristics and aesthetical value of hunting. In addition, due to high August temperatures it will be almost impossible to preserve hunted birds from being spoiled. So, the hunting will lose their main advantages – good trophies, aesthetical value and recreation.

The climate warming in an autumn-winter season will considerably increase the species composition and numbers of waterbirds in the region for this particular period of the year. It will give a unique opportunity to shift the waterbird hunting for later terms, especially in coastal areas.

Traditionally, the waterbird hunting in the Ukrainian Danube Delta is a kind of green tourism and recreational activity associated with aesthetical and emotional pleasure. To support these objectives, and taking the climate warming into consideration, the following measures are recommended:

1. To start the waterbird hunting not earlier than the first Saturday of September. By that time, the decreased daily air temperature will allow to preserve the morning trophy until evening hours. As it was mentioned above, in case of earlier start of hunting the trophy qualities and aesthetical value of hunted birds will be minimal, and with further prolongation of a breeding season under the climate warming these characteristics will be deteriorate.

2. Due to expected decline in waterbird resources, also connected with the climate warming and drying of wetlands, the hunting norms should be reduced as much as 20-70% of the present norms. Especially it concerns geese, above all the greylag goose (*Anser anser*) which populations in the south of Ukraine have considerably decreased by now.

3. Make relevant changes in 'the Law on Hunting and Hunting Economy and restore strict limits for hunting in economical zones of protected areas.

4. The waterbird hunting in Ukraine (except for geese) is finished in late December while geese hunting lasts until mid-January. It should be reasonable to extend the hunting season for the mallard *Anas platyrynchos* (a key species of wintering ducks) until mid-January. With the climate warming, more and more mallards are staying for winter in the coastal part of the delta. For people, such prolongation of the mallard hunting will, to some extent, compensate a later start of the hunting season. In addition, in terms of biology, resources and nature conservation the wintering of geese in the region has no principal differences with the mallard and thus it will also make easier to control observance of hunting rules.

1.5 Recommendations for the organization of monitoring of indicator species and communities

Two-three year period of monitoring of indicator species and communities within the project allowed to specify some details of its organization, selection of monitoring plots, observation system, to specify indices. Below, we have collected the recommendations which complement or make changes in the system of monitoring of species and communities for the estimation of climate impact and impact of other factors on biodiversity.

Experience of the organization of monitoring of insects indicator species

Analysis of monitoring results in 2010-2012 allows to recommend several key approaches to the organization of monitoring.

The most important monitoring index for the seathorn hawk-moth within Ukraine is its dispersion and gradual shift of its range to the north, under the influence of temperature factor. Further monitoring of the expected broadening of the seathorn hawk-moth range in the north direction will be the most reasonable in Gomel Region (Belarus) and Bryansk Region (Russia). The most optimal time to carry out research in recommended territories will be the 3^{d} decade of June, 1st decade of July – 3^{d} decade of August, 1st decade of September. Methods for the data collection to estimate the number of this species in the wild is described in other chapters of this deliverable.

Long-term monitoring of other indicator species, the migratory locust, has shown that the most dangerous sites of species concentrations are river banks, lake shores and sea coasts with thickets of the reed and sedge. They are the Danube river delta and lower reaches of rivers entering into the eastern part of the Azov Sea. These sites are densely surrounded by steppe areas and agrocoenoses that require regular monitoring research. In the south of Ukraine, during the studied period, nymphs of the locust started occurring 11-29 June, and last imagoes were recorded 1-4 September. Therefore, we can recommend the 2nd, 3d decade of June -1st decade of September for the monitoring studies of the locust in the south of Ukraine. Methods for the data collection to estimate the number of this species in the wild is described in the previous deliverable of AZBOS (D5.1).

Additions to monitoring of bird migration phenology

During research within the project we have found out that a part of species – long-distance migrants (Arctic waders and geese) demonstrate a certain relationship between timing of migrations and changed weather-climate factors. Dates of the first registration not obligatory should be considered as a reliable criterion of this trend but rather the criterion is the migration median (time of passage of main part of the population) and also the physiological condition of birds, shift of spring dates of departure to breeding areas, shift of autumn arrival to stopovers and dates of the last species registration in the region.

The indicator species suitable for the monitoring of migration phenology within the Azov-Black Sea Coast (both practically and theoretically) are the following: the white-fronted goose *Anser albifrons* (an inhabitant of Eurasian tundra), the ruff *Philomachus pugnax* (occurring at boreal latitudes from the forest zone to tundra zone) and the lapwing *Vanellus vanellus* (a part of this species populations breeds in the Azov-Black Sea Region and adjoining areas, and others are widely distributed within Eastern Europe and West Asia).

An optimal network of monitoring points would be the geographical transect stretching from the seacoast of Bulgaria and Romania, through Zmiinyi Island and major wetlands of the Ukrainian coast until the Eastern Azov area in Russia. In addition to traditional observation methods of migration phenology it is advisable to implement, as wide as possible, a radar system of automatic registration of migration intensity. Estimation of the physiological state and formation of weather-dependent migratory condition of long distance migrants is possible only when organizing necessary catches and intravital procession of individuals of indicator species.

A promising direction of monitoring of migration phenology will be the estimation of correlations between NAO indices in winter-spring period and timing of migration of a selected group of indicator bird species. For example, for such species as the white wagtail *Motacilla alba* there are data that timing of their passage depends on the NAO coefficient. However, the accurate estimation of migration dates of this species requires a very wide sample of monitoring points, with several radar registration points. In this case it is real to obtain in future the information about the relationship between migration phenology and global changes in the atmosphere circulation.

Recommendations for the organization of wintering monitoring of waders

Periodicity of survey of monitoring territories. Since the birds are extremely mobile objects, there is proposed to investigate monitoring territories at least twice a month throughout all the winter period. If possible, the best will be to carry out researches each decade, at similar dates every year. It makes easier the further statistical analysis of long-term data. At the same time, if drastic changes in weather conditions are expected (strong drop of temperature, stormy wind, etc.) the next count, within a decade, will be preferable to carry out before and after this extreme situation.

Duration of monitoring works. Since climate trends and phenological changes can be traced only by analysis of single-type data for the long-term period (as a rule, at least 25-30 years) it is desirable for monitoring works also to cover the period of many years. Thus, the comparison of successive 10-year or 5-year periods according to the same indices can give a quite demonstrative picture.

Selection of monitoring territories. Taking into account the above-mentioned aspects, it is recommended to select the monitoring territories with a long row of retrospective data already available (meteorological and ornithological). The monitoring territory should represent characteristics of a particular wetland as much as possible: include areas with different types of biotopes, anthropogenic pressure, key feeding sites. More or less synchronized survey of several key monitoring territories within the region is encouraged.

Model species. To study the influence of weather-climate factors it is recommended to choose those model species which mostly winter in natural biotopes. They are, for example, the dunlin, Eurasian curlew, grey plover, sanderling, or the species which only recently started wintering at the Azov-Black Sea coast of Ukraine: the avocet, knot, ringed plover. If the estimation of human impact on formation of wintering areas is required, we recommend to include in the list of model species the waders which mostly winter at man-transformed biotopes (on biological filtration fields, canals and wells of irrigation systems, etc. or on agricultural lands). These, for example, are the green sandpiper, jack snipe, black-winged stilt, partly – the lapwing and golden plover.

Estimation of non-climate factors. Since the impact of weather-climate factors is often difficult to differentiate from simultaneous impact of other groups of factors it is recommended, for each monitoring territory, to identify the most important non-climate factors and decide the method of their estimation during counts. For instance, it may be the surface area of available feeding sites, water level during counts, drying-out of temporary water bodies, extent of flooding of rice paddies, etc.

Methodical aspects of survey in the territories*.* The optimal method of monitoring counts is combination of surveying all the territory of a wetland by motor vehicle (if possible, with fixed stop-points for bird counts) and fixed pedestrian count routes in key parts of the territory. Telescopes of 30x magnification should be used for bird counts because many wader species in winter plumage is not easy to identify. The counts should be carried out in morning and/or evening hours when birds are the most active. After the count, it is recommended to fill standard count forms and mark on GIS-maps the route, points of waders registrations (per species) and borders of the coastline at the moment of the count. The use of GPS devices will make this work easier. In addition, it is necessary to receive daily weather data from the meteorological station of the studied region for all the winter period and make notes of weather conditions (including precipitation, ice cover percentage on water bodies, presence of snow cover) at the moment of count.

Control of changes in ichthyofauna at the level of indicator species and communities

A systematic control of ichtyological indices in the Azov-Black Sea Region will allow to reveal main changes in ecosystems and the role of climate factors in this transformations. The latter is possible if select particular indices both at the level of fish species and at the level of ichtyocoenoses which will react on changes of hydrometeorological characteristics in a waterbody.

The main **goal** of the proposed monitoring is *to control the state of populations and fish communities in the Azov-Black Sea region as indicators of climate changes, for the selection of scenarios of ecosystems management.*

Objectives of this monitoring are the following:

- Estimation of the actual state of indicator fish species;
- Control of fish community structure;
- Estimation of possible ecological, economical and social risks;
- Information support for making effective management decisions;
- Development of management scenarios for water ecosystems of the Azov-Black Sea region

Subjects of monitoring and monitoring plots should give possibilities to receive objective data from the whole Azov-Black Sea region. Major monitoring subjects from Ukraine can be the following:

- Institute of Biology of Southern Seas of National Academy of Sciences of Ukraine (Sevastopol)
- Odesa Branch of the Institute of Biology of Southern Seas, NAS of Ukraine (Odesa)
- Odesa National University (Odesa)
- Danube Biosphere Reserve (Vilkovo)
- Black Sea Biosphere Reserve (Hola Prystan)
- Southern Scientific-Research Institute of Mariculture and Fishery (Kerch)
- Scientific-Research Institute of the Azov Sea (Berdiansk);
- Karadah Nature Reserve (Feodosia)
- Interdepartmental Laboratory for the Monitoring of Ecosystems of the Azov Sea (Melitopol)

Distribution of proposed monitoring plots in the Azov-Black Sea region is shown in Figure 1.5.1.

Figure 1.5.1. Location of proposed monitoring plots at the Azov-Black Sea coast of Ukraine

Monitoring objects inlude two groups of indices: *ecosystem* and *demecological*

As ecosystem indices there were selected:

- **Structure of ichtyocoenoses***.* For this index it is used the percentage of freshwater species out of the number of all fish species recorded in a monitoring plot. The percentage of warm-loving species or saline water species can be also used as indices.
- **Number of particular fish species, of different ecological groups***.* For example, the Prussian carp (*Carassius gibelio*) was used for the Azov Sea.

As **demecological indices** of monitoring we have selected the following:

- **Growth rate of short-cycle fish species***.* For the Azov-Black Sea region it was selected the round goby*.* At the stage of a hutchling, it feeds on plankton, and at the adult stage eats benthos. Insufficient forage base leads to a sharp decline in the rate of growth, and the forage base is very sensitive to changes of climate indices.

- **Timing of mass migrations***.* These indices are connected with temperature trends. These indices have been recorded for some commercial species for more than 50 years which will allow to demonstrate the correlation between these factors on long-term basis. For the Azov Sea the achnovy was selected (*Engraulis encrasicolus*).
- **Fattening of specimens***.* For monitoring in the Azov Sea it was selected the Fulton's fattening index (*Neogobius melanostomus).* Fattening index characterizes the supply of indicator species population with forage resources. For the Black Sea such index can be the fattening of the sprat.

Main methods are:

- Estimation of fish species composition;
- Estimation of absolute and relative numbers of fish species;
- Complete biological analysis of specimens of model fish species (identification of fattening, age, growth rate).

We propose **3 stages** for the realization of monitoring (Figure 1.5.2):

- **Estimation of the actual state of indicator species and ecosystem indices** (I stage). Works should be done in all monitoring plots of the Azov-Black Sea Region (Figure 1.5.1).
- **Assessment of risks induced by changes in the state of the environment** (II stage). This monitoring stage is important to reveal the consequences of changes in ecosystems. Ecological risks include the assessment of consequences of new fish species invasion and further fortune of invasion species. Assessment of ecological risks is connected with reduction of commercial catches of fish species and decline in general sea productivity. Social risks are related to decrease in profitability of fishery, closure of some kinds of fishery and loss of jobs.
- **Information support for the preparation and making of decisions to improve quality** *of the environment and ensure the ecological safety* (III stage). The final stage of monitoring is selection of a scenario for the ecosystem management. To make the work at the 3d stage more effective it is necessary to fill the automatized information system. Main elements of this system are: prognostic-diagnostic system, geoinformation system, system of integrated interpretation of data; data processing system.

To fulfill the above-mentioned tasks of monitoring it is extremely desirable to implement simultaneous hydrological and hydrochemical monitoring.

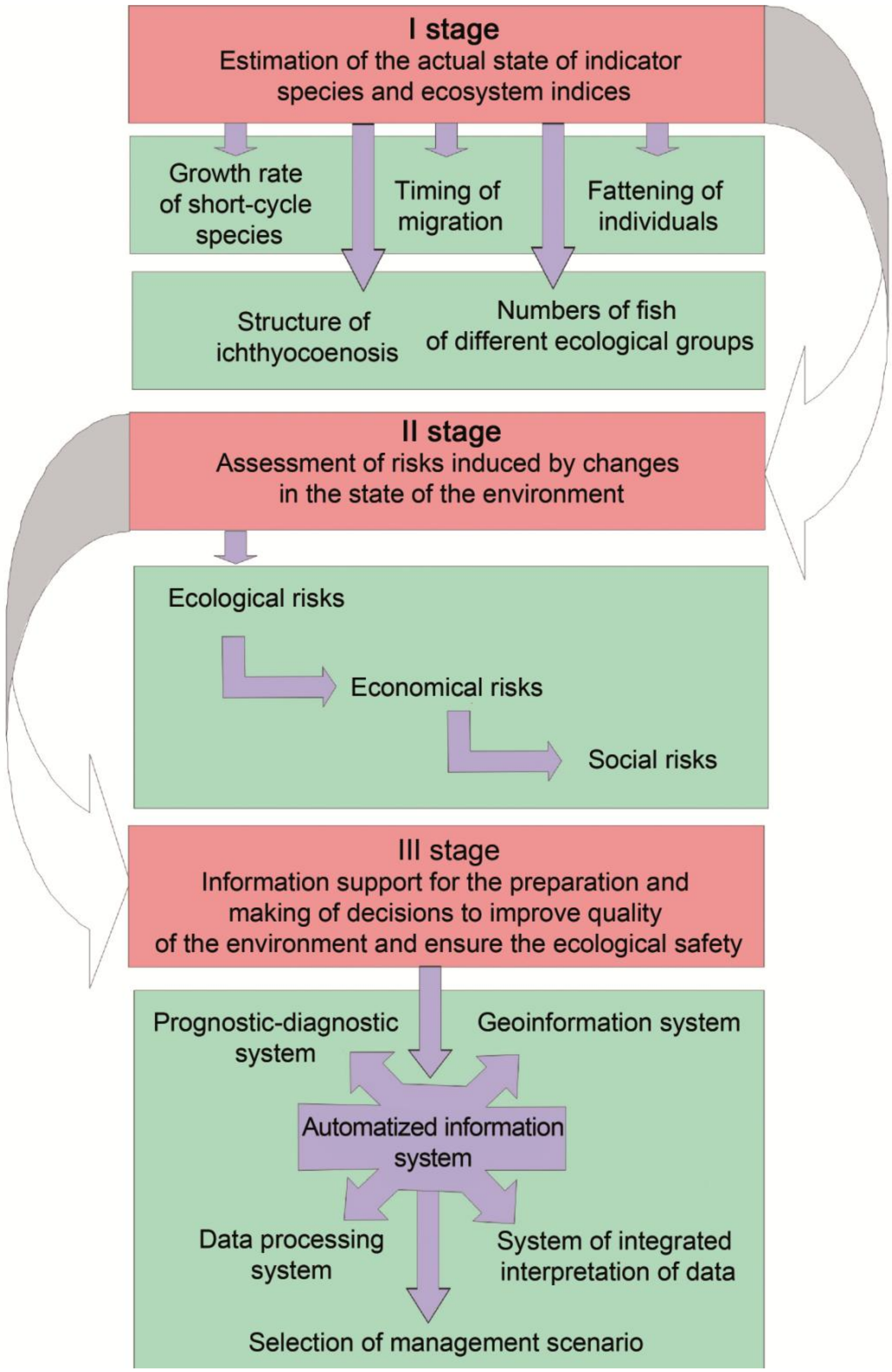


Figure 1.5.2. Monitoring scheme of the state of fish populations and communities in the Azov-Black Sea Eegion.

2 Assessment of biodiversity in the İğneada forest (ITU)

2.1 Introduction

2.1.1 Purpose and scope

“Flooded (longos/alluvial/floodplain) forests are forests in which the water table is usually at or near the surface, and the land is covered periodically or at least occasionally with shallow water” (Čermák et al. 2001, Pivec 2002, Tepley et al. 2004, Paal et al. 2007, Kavgaci et al., 2011). Because of their ecological, biological, environmental and economic importance longos forests have a multiple role in the landscape (Kavgaci et al., 2011). As a result of excessive use and destruction of natural resources, ecosystems are damaged and therefore are in danger and pressure of extinction. In The Bern Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), they were defined as habitat under threat.

The coverage of flooded forests has decreased (Wenger et al. 1990, Glaeser & Volk 2009) because of heavy anthropogenic pressures such as intensive cutting, construction of hydroelectric power stations and regulation of rivers (Čermák & Prax 2001). All over the world flooded forests are under negative human pressure (Müller 1995, Müller 1998). Because of this reason, sustainable natural conservation and management very important for flooded forests (Jackson 1990, Tockner & Stanford 2002).

There is an urgent need to examine these ecosystems and define their function, (Wenger et al. 1990). Many studies of floodplain forests have been conducted to elaborate biodiversity, function and their importance (Wildi 1989, Döring-Mederake 1990, Pietsch et al. 2003, Turner et al. 2004, Özyavuz, 2008, Bektas Balcik et al., 2011a, Bektas Balcik et al., 2011b, Bektas Balcik et al., 2011c, Bozkaya, 2013). Floodplain forests have rich biological and ecological diversity (Schnitzler et al. 2005) and, if they are protected, they build an important part of biological richness on a regional scale (Schuck et al. 1994; Kavgaci et al., 2011). However, the floodplain forests in Europe are less biodiverse, because of the effects of the last glaciation (Schnitzler et al. 2005, Kavgaci et al., 2011). From this point of view, Thrace and Anatolia perform important tasks since they hosted many species that disappeared from Europe at the time of the glaciations and found refuge here or species that settled here during the subsequent re-colonization of the Balkan Peninsula (Kavgaci et al., 2011). There are three floodplain forests in the northern Turkey (İğneada Longos, Sakarya Karasu Acarlar Longos and Sinop Sarıkum Longos) and they played an important role in these processes and knowledge of them is very crucial. These riverine and floodplain forests, some of which have already been studied in terms of ecology, biology and planning of biosphere reserve (Pamay 1967, Kutbay et al. 1998, Çiçek 2002, Özyavuz, 2008, Başkent et al. 2008).

Our research took place in floodplain forest in North West of Turkey, in the well-known İğneada Region, one of the important plant areas in Turkey (Özhatay et al. 2003). İğneada and the surrounding environment have been recognized as an important biodiversity hotspot due to their unique flora and fauna characteristics. Because the area houses different sensitive ecosystems, the parts of it were previously protected as Nature Protection Park, Natural Site, and Wildlife Protection Area. In order to promote a wider scale (3155 ha) comprehensive protection, the area has been announced as a national park by the Board of Ministers in 11/03/2007. Its biological richness has already been elaborated (Kavgacı 2007a, Kavgaci, 2007b, Kavgacı et al. 2007, Özyavuz, M., 2008, Tecimen & Kavgacı 2010, Kavgacı et al. 2010) and two European Union supported projects have taken place there: GEF II and Yıldız Dagları (Istranca) Mountains Biogenetic Reserve project. Despite its ecological sensitivity and importance, the İğneada area has been under serious threats such as İstanbul Water Board Authority project to supply drinking water to İstanbul, a harbor project, a nuclear power station and a coastal road project. The announcement of the national park is expected to contribute to the sustainable development of the area. In addition, great variety of urban pressures is evident in the area such as expansion of summer houses on and around wetlands, increasing recreational uses on coastal line (mainly off-road racing), and wetland pollution due to sewage. These ongoing pressures and their consequences should be taken into account for sustainable management of İğneada protection area.

The main goal of this document was to present a review of the biodiversity (flora and fauna) of İğneada and associated environment based on the published project reports, thesis and articles. Conservation methods and conservation zones were highlighted as a part of this project. Therefore, variety of threats the selected region faces were introduced in the document. Land cover and use information are very important components of sustainable conservation and management. Remote sensing technology was used to determine reliable and updated land use and land cover information. Detection of land use change enables sustainable resource management. Supervised classification and on screen digitizing were applied for the year of 1984, 1990, 2000 and 2010 to analyze the land cover and land use differences by using two change detection methods. Elaboration of historical urban development plays an important role in understanding the types of pressures these sensitive ecosystems are being subjected to. According to the results of land cover change detection, the area is in a stationary state. The results show that a little increase in the barren and urban lands occured in İğneada. According to change matrix, the rate of change in residential areas is the highest. Owing to its similar reflectance values the urban and built-up class was mixed up with the agricultural class and bare areas and so the obtaining of accurate classes was obstructed. Consequently, examination of past and current situation by using remote sensing is very important to reach the aim of sustainable environment.

2.2 Study Area

İğneada is a sub-district located in the province of Kırklareli in the northwest of Turkey. The İğneada Longos Forests National Park located on the Black Sea coast far from 15 km from the Turkish-Bulgarian border (Figure 2.2.1).

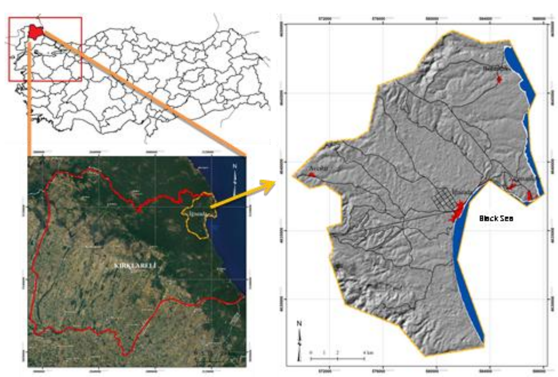


Figure 2.2.1. Study area.

The study region lies on an area that is approximately 5757 ha located between the northern latitudes 41°44 '43'' and 41 °58 '27'' and the eastern longitudes 27°44'52'' and 28°39 '17''. Elevation in the study area ranges from sea level to approximately 800 m above sea level. The average annual rainfall is about 800 mm and the average temperature is 13°C. The hottest month is August and the coldest month is February (Anon. 2006). The research area has a humid and mesothermal sea climate. Table 2.2.1 shows basic meteorological information. The bedrock is mainly formed by sedimentary rocks, including alluvial, calcareous rocks, non-calcareous and pliocene sedimentary rocks, dunes and siltstone flysch-schists (Kantarcı 1979, Sevgi 2005).

Table 2.2.1. Meteorological data for Kırklareli.

Kırklareli	Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec
	Average Values (1970 – 2011)											
Average Temperature (°C)	3,1	4	6,9	12	17,2	21,6	23,9	23,2	19,1	13,8	8,7	4,9
Max. Temperature (Average) (°C)	6,7	8,2	11,8	17,5	23,1	27,8	30,5	30,2	25,9	19,4	13	8,3
Min. Temperature (Average) (°C)	0,2	0,6	2,9	7,1	11,5	15,4	17,7	17,4	13,8	9,7	5,3	2,1
Mean Sunshine Duration (Hourly)	2,5	3,5	5,1	6,4	8,5	9,2	10,2	10,2	8	5,1	3,5	2,2
Average Number of Rainy Days	10,5	8,9	9,5	10,5	9,8	8,5	4,9	3,9	4,8	7,6	9	11,1
Average Monthly Total Precipitation Amount (kg/m2)	51,6	45,1	46,3	42,9	48,7	48,3	28,9	22	33,1	53,5	69	62,8
	Minimum and Maximum Values (1970 – 2011)											
Max. Temperature (°C)	18,3	21	25,7	29,4	34,6	39,8	42,5	40,4	37	37,4	25,6	21,6
Min. Temperature (°C)	-15,8	-15	-11,8	-3	1,4	5,8	8,8	10,2	3	-3,4	-7,2	-11,1

İğneada, district in Kırklareli province, is the largest settlement in the study area. The region has different kinds of ecosystems and a wide range of biodiversity with nature and wildlife conservation areas on the Thracian Black Sea coast. İğneada flooded (alluvial /longos) forests with associated aquatic and coastal ecosystems include seawater, sand dunes, freshwater and saline lakes, wetlands, mixed forests of deciduous tall trees, and riparian ecosystems (Figure 2.2.2). Because of endemic and rare species, the Iğneada Flooded Forests and surrounding environments show a rarity and diversity on an international scale (Şişman and Özyavuz, 2010). The area houses different kinds of ecosystems and a wide range of biodiversity; the parts of it have previously protected as Nature Protection Park, Natural Site, and Wildlife Protection Area (Özhatay et all. 2003). The region host 194 bird species, 310 insect species, 46 mammal species, 28 fish species, 11 reptile species and 6 amphibian species. According to the flora report prepared as part of GEF-II (Global Environment Facility) project which is carried out by the Ministry of Forestry, 21 of 592 plant species in İğneada are rare species, and also 4 of those are endemic species.

The area is one of the most important representatives of ash-oak-alder mixed populations and it is "IMPORTANT BIRD AREA" (Özyavuz, 2008). The area was declared a national park in 2007, but cultural pressures have gradually increased. A unique mix of alluvial forests, coastal dunes and wetlands are valued for scenic, aesthetic and recreational purposes and provides an opportunity for ecological interpretation and education.

Figure 2.2.2. İgneada and surrounding environments with national park boundaries.

There are five lakes in the selected area (Figure 2.2.2). Among them Lake Erikli is adjacent to the north part of the İğneada, that is not linked with the sea during the summer season. Lake Mert is located at the southern part of the region where Çavuşdere stream reaches at the Black Sea. The smallest of all, Lake Saka, is at the south part of the selected area and it lies between the forest and sand dunes. There are three longos forest in the region (Lake Erikli, Lake Mert and Lake Saka Longos Forest). The coverage of the longos forests, lakes and sand dune are given in Table 2.2.2 (Bozkaya, 2013).

Table 2.2.2. Coverage of Natural Resources of İgneada (Wetlands, Lakes and Longos Forest)

Area (ha)	Erikli	Mert	Saka	Pedina	Hamam	Sea
Lake	6	39	5	10	21	6
Wetland	81	238	43	-	-	-
Longos	722	271	494	-	-	-
Length of Coast: 15 km and Area of Sand Dune: 131 ha						

Despite its ecological sensitivity and importance, İğneada has been under serious threats. Upstream forests and water resources are critical to maintain the delicate balance of the alluvial forest and wetland ecosystem of İğneada. Supplying drinking water project to İstanbul using upstream water sources is one of the important threats. Coastal dunes provide a barrier to retain freshwater in the alluvial forest and prevent saltwater intrusion. Therefore, these areas are home to several rare and endemic plant species and are sensitive to human use. In fact Black Sea coastal dune ecosystems are among the most threatened in Europe and are a top priority under the European Union Habitats Directive (Bozkaya, 2013). Despite this, coastal dunes are under the pressure of uncontrolled sand extraction. In the region, forests and wetlands are under the threat of uncontrolled grazing cattle and illegal hunting. Also, the forests are under the threat of supplying fuel wood and other forest products. Burning and cutting reeds before, and/or during, the breeding season of bird species leads to the destruction of the food chain and a reduction in the number and variety of birds established in the wetland ecosystem. Over-hunting is an additional cause of destruction to the ecological balance of wetlands.

The most important income sources for people in the region are forestry, fishery, livestock breeding, and tourism. Agricultural areas are rather poor within the study region. However, there are many farms in the area because of both fertile soils for agriculture and lush cover from herbaceous plants. The alluvial forests have reduced in size, as the value of the timber species grown in them and the fertility of the agricultural land that is produced by clearing them are high (Ok, 2006).

2.3 Biodiversity of İğneada

2.3.1 Introduction

İğneada region is very valuable, in terms of ecosystem diversity. There are many ecosystem types in the region like, flooded forests, mixed forests, lakes, swamps around the lakes and a large coastal sand dune (Figure 2.3.1) (Bozkaya, 2013).

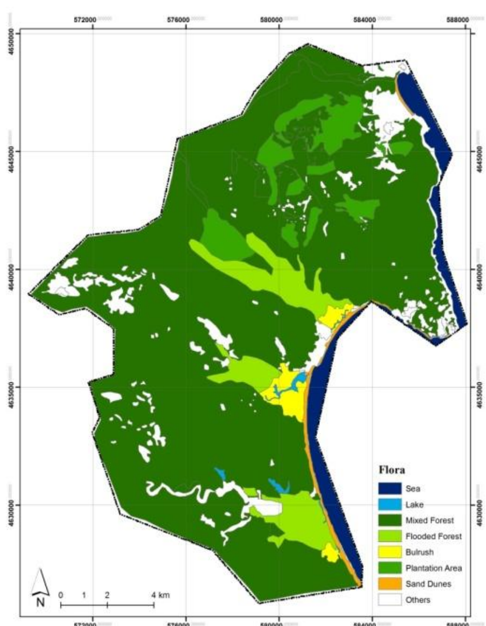


Figure 2.3.1. Different ecosystems in İğneada.

2.3.2 Flora

In addition to the floodplain forests called Saka, Mert and Erikli, there are also lakes, swamps, scrub communities and sand dunes (Özhatay et al. 2003; Kavgacı 2007a; Kavgacı 2007b ; Kavgacı et al., 2007; ÇOB, 2007) in the region with very rich flora. Table 2.3.1 shows vegetation species of İğneada that belongs to International Union for Conservation of Nature (IUCN) Red Data Book List (Demir, 2011).

Table 2.3.1. Flora from IUCN Red Data Book List.

Species	Endemic	Danger Category
Acer pseudoplatanus	-	VU
Aurina uechtritziana	-	VU (Vulnerability) + Bern List
Centaurea areneria	-	VU
Centaurea kilaea	+	EN (Endangered) + Bern List
Crambe maritima	-	VU + Bern Listesi
Crepis macropus	+	LR (Low Risk)(lc)
Cyclamen coum	-	VU+Bern List
Digitalis viridiflora	-	VU
Euphorbia amygdaloides var. Robbiae	-	NT (Near Threatened)
Galanthus nivalis subsp. nivalis	-	VU + Bern List
Jurinea kilaea	-	VU
Leucojum aestivum	-	VU
Ophrys aestrifera	-	VU
Pancratimum maritimum	-	EN+ Bern List
Polycnemum verrucosum	-	VU
Pseudanum obtusifolium	-	VU
Ruscus aculeatus	-	VU + Bern List
Salvia nutans	-	VU
Salvinia nutans	-	VU + Bern List
Sideritis romana subsp. Romana	-	EN
Stachys angustifolia	-	VU
Silene Sangaria	+	VU + Bern List
Trapa natans	-	VU + Bern List
Trifolium boccenei	-	DD (Data Deficient)
Verbascum degenii	+	CR (Critically Endangered) + Bern List

2.3.2.1 Sand dune vegetation

The coastal dunes of Igneada host the most sensitive ecosystems in the region and in Turkey that have been relatively less affected by environmental conditions. Most of the known endemic plants in Igneada and its vicinity are found in the coastal dunes. Two different plant communities are found in Igneada coastal dunes *(Leymus racemosus–Centaurea kilaea communities, Otanthus maritimus–Pancratium maritimum communities)*. In this area, Igneada physically separates the coastal dunes into two zones. Coastal dunes located to the north of Iğneada cover an area from the east of Lake Erikli to Iğneada. Coastal dunes to the south of Iğneada cover an area from the channels connecting Lake Mert and the sea to south of Lake Saka; the width of these dunes approaches 50 to 60 m in some places. Many interesting plant species grow on these dunes. **Leymus racemosus-Centaurea kilaea community** constitute *Centaurea kilaea, Centauera arenaria, Silene sangaria, Matthiola fruticosa, Crambe maritima, Cyperus capitatus, Eryngium maritimum* (Figure 2.3.2), *Leymus racemosus, Salsola* *tragus, Xanthium strumarium* subsp. *Cavanillesii, Elymus elongatus* subsp. *elongatu, Peucedanum obtusifolium, Cionura erecta* (Kavgaci et al. 2011).

Figure 2.3.2. Leymus racemosus-Centaurea kilaea community.

Otanthus maritimus-Pancratimum maritimum community host *Centaurea kilaea, Leymus racemosus* subsp. *sabulosus, Elymus elongatus* subsp. *elongatus, Ammophila arenaria* subsp. *arundinace, Teucrium polium, Jurinea kilaea* in dunes between Lake Hamam and south of Lake Saka (Figure 2.3.3). Table 2. 3. 4 gives information about vegetation types in İgneada sand dunes.

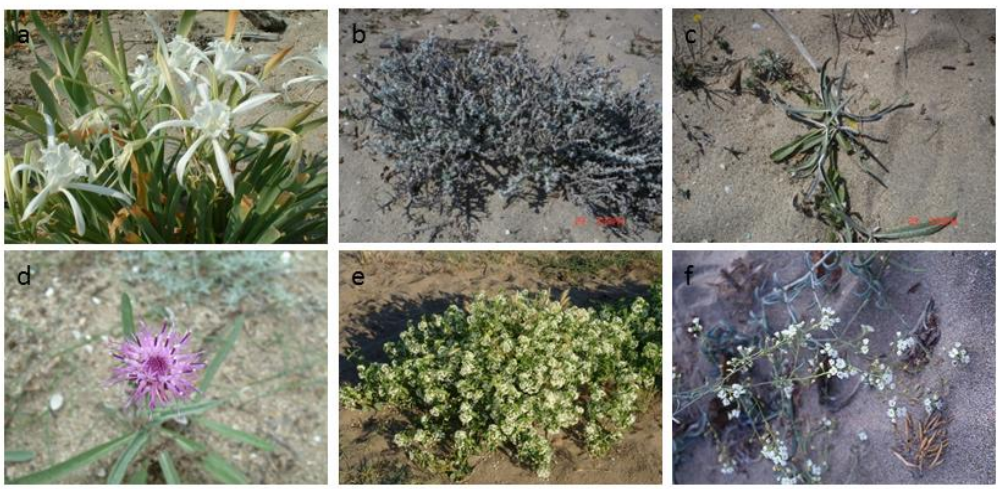


Figure 2.3.3. a) Pancratimum maritimum b) Otanthus maritimus c) Jurinea kilae d) Jurinea kilae flowering e) Cionorua erecta f) Aurinia uechtritziana.

Table 2.3.4. The endemic and rare and the other vegetation species of İgneada Sand Dunes.

Sand Dune Vegetation	Transition between sand dune and wetland
Silene sangaria (Endemic)	*Crataegus monogyna*
Centaurea kilaea (Endemic)	*Cornus sanguinea*
Crepis macropus (Endemic)	*Ulmus glabra*
Aurinia uechtritziana (Rare)	*Phillyrea latifolia*
Centaurea arenaria (Rare)	*Quercus robur*

Sand Dune Vegetation	Transition between sand dune and wetland
Crambe maritima (Rare)	*Paliurus spina-christii*
Pancrtimum maritumum (Rare)	*Asparagus acutifolius*

Rare species are under the conservation based on BERN. Jurinea kilaea, Peucedanum obtusifolium, Aurinia uechtritziana Centaurea arenaria, Crambe maritima, Polycnemum verrucosum and Pancratimum maritimum are not endemic but they are rare in the region (Özyavuz, 2008).

2.3.2.2 Wetland and grass vegetation

Different sizes of Lagoons between longos forests and coastal sand dunes and inland lakes are comprised the wetlands of İgneada. The marsh and meadow vegetation surrounding lakes Mert, Erikli, Saka, Hamam and Pedina give rise to a rich flora, including ***Schoenoplectus lacustris–Phragmites australis*** (lakeshore bulrush–common reed) ***and Bolboschoenus maritimus–Cladium mariscus*** (cosmopolitan bulrush–swamp sawgrass) **communities** (General Directorate of Nature Conservation and National Parks, 2005a).

Schoenoplectus lacustris- Phragmites australis community consist of *Schoenoplectus lacustris* subsp. *tabernaemontanii, Phragmites australis, Thypha domingensis* and *T. Angustifolia* (Özyavuz, 2008). This community grows in the lake where depth of water is 50-100 cm.

Bolboschoenus maritimus – Cladium mariscus community includes *Bolboschoenus maritimus* var. *maritimus, Cladium mariscus*, *Juncus heldreichanus* subsp. *heldreichanus, J. littoralis, Sparganium erectum* subsp*. erectum, Atriplex patula*, *Chenopodium chenopodioides*, *Spergularia bocconi*, *Leucujum aestivum, Limonium gmelinii*, *Cirsium creticum* subsp*. creticum*, *Polypogon viridis*, *Cucubalus baccifer*, *Lavatera thuringiaca*, *Althaea officinalis*, *Dipsacus laciniatus* (Özyavuz, 2008).

Trapa natans- Nymphaea Alba Community

Hamam and Pedina Lakes host Trapa natans vegetation communities (Figure 2.3.4). This community is located in the list of Bern as well as Red Book of Turkish Plants as “Vulnerability”. Hamam and Pedina lakes ecosystem is one of the most valuable fresh water systems in the region due to this fragile vegetation community. In addition, Nymphaea alba L. were distributed in Lake Hamam.

Figure 2.3.4. a) Cladium mariscus b) Trapa Natans.

2.3.2.3 Longos forest vegetation

The composition of flora in the Longos forests of lakes Erikli, Mert, and Saka are quite similar to each other. These Longos forests resemble tropical forests in appearance, growing on acidic soils with high organic content. They are completely covered with water in the winter and spring and partly inundated because of the high water table in the summer and fall. This type of ecosystem is rarely found in Turkey because of climatic characteristics.

There are three different in Turkey and İgneada Longos is the largest (approximately 1800 ha) alluvial forest of the Europe (Kavgaci et al., 2011). The best-conserved, natural Longos forests in the project area are the **Lake Mert, Lake Erikli, and Lake Saka Longos forests.** These types of ecosystems are rare in Turkey because they are very sensitive to environmental conditions, losing their main characteristics if the water table lowers. The habitats of the Longos forests in the project area have not yet been degraded and, therefore, are composed of a rather tall (8 to 15 m) mixed forest (Figure 2.3.5). The dominant plants are *Fraxinus angustifolia* subsp. *oxycarpa, Fagus orientalis, Quercus robur* subsp. *robur, and Carpinus betulus* (General Directorate of Nature Conservation and National Parks, 2005a).

Figure 2.3.5. Longos forest of Igneada.

There are nine different vegetation communities in alluvial forest of İgneada such as Fraxinus angustifolia community, Fraxinus angustifolia-Quercus robur-Acer campestre community, Quercus robur-Fagus orientalis-Carpinus betulus community, Fraxinus angustifolia-Fagus orientalis community, Quercus robur-Carpinus betulus community, Fraxinus angustifolia- Acer campestre-Fagus orientalis community, Fraxinus angustifolia-Quercus robur-Carpinus betulus community, Carpinus betulus-Tilia argentea community, Carpinus betulus community (General Directorate of Nature Conservation and National Parks, 2005a). Table 2.3.3 gives a short list some of the vegetation types.

Table 2.3.2. Vegetation types in longos forest.

Longos Trees	**Wrapping Plant**
Fraxinus angustifolia	*Hedera helix*
Fagus orientalis	*Tamus communis* subsp. *cretica*
Quercus robur	*Periploca graeca*
Carpinus betulus	*Humulus lupulus*

Longos Trees	**Wrapping Plant**
Quercus petraea	
Acer campestre	
Acer platanoides	
Sorbus	
Tilia argentea	
Alnus glutinosa* subsp. *Glutinos	
Ulmus laevis	
Shrubs	**Grass**
Ruscus aculeatus subsp. angustifolia	*Iris pseudacorus*
Mespilus germanica	*Nectaroscordum siculum*
Crateagus monogyna Jacq.* subsp. *monogyna)	*Leucojum aestivum*
Cornus mas	*Galanthus nivalis*
Sambucus nigra	*Primula vulgais* subsp. *vulgaris*
Sorbus torminalis	*Juncus littoralis*
	Ornithogalum sigmoideum

2.3.2.4 Forest vegetation

In general, deciduous mixed forest vegetation is found in the area outside of the longos forests, and these forests have similar floristic composition with the longos forests. However, slopes are rather steep in the area where these forests are found; therefore, the water table is well below the surface. One plant community has been identified in this vegetation type, which is composed mostly of mixed oak species. *(Q. robur– Q. petraea–Q. frainetto communities)* (General Directorate of Nature Conservation and National Parks, 2005).

Quercus robur-Q. petraea-Q.frainetto community includes *Quercus petraea* subsp. *petraea, Q. frainetto, Q cerris, Q. robur* subsp. *Robur, Fraxinus ornus* subsp. *ornus, Carpinus orientalis, C. betulus, Fagus orientalis, Acer campestre, A. pseudoplatanus, Sorbus aucaparia, Populus tremula, Tilia argentea, Alnus glutinosa* subsp. *glutinosa, Juglans regia, Sambucus nigra, Cornus mas, Ulmus laevis, Crataegus pentagyna, C. monogyna, Pyrus elaeagnifolia* subsp. *elaeagnifolia, Mespilus germanica.*

In addition, *Malus sylvestris* subsp. *orientalis, Cornus mas, Prunus spinosa, Prunus x domestica, Rubus sanctus, R. tereticaulis, Mespilus germanica, Crataegus pentagyna, C. monogyna, C. orientalis, Vitis sylvestris, Juglans regia* can be seen in the region (Figure 2.3.6)***.***

Figure 2.3.6. Carpinus orientalis from Mix Forest in İgneada.

2.3.3 Fauna

The different ecosystems in the area provide a diverse living environment for the fauna in the region. Nearly half (194) of the 454 bird species constituting the bird diversity of Turkey are seen in this area during the year. The *Phalacrocorax pygmeus, Haliaetus albicilla, and Falco naummani*, which are endangered or likely to be endangered according to the criteria of the International Union for Conservation of Nature Red List of Threatened Species, are 3 indicator bird species, which represent the healthy ecosystem of this area. According to the Bern Convention, 184 bird species, which rest or live in this region, are in the category ''endangered.''

In the region Lake Mert and Lake Erikli and surrounding environment are very important living space for different fauna (Figure 2.3.7) . There are 11 fish species and 60 bird species in the lake Mert and 62 bird species in Lake Erikli. Recent studies showed that there are 89 bird species from 33 families in Lake Mert and Erikli (Kaya, 1998). In the region 184 (133 bird specious in SPFS (Strickly Protected Fauna Species and 51 bird specious in PFS (Protected Fauna Species)) bird specious under danger based on Bern List category. Half of the 454 bird specious can be seen in İğneada in different season. The region is very important especially for migratory birds. There are many waterfowl and raptor in the region such as *Haüaeetus albicilla, Ciconia nigra, Picus canus, Parus majör, Motaciha alba, Falco naumanni, Anser albifrons, Egretta garzetta, Anas querquedula, Fulica atra, Phaiacrocorax pygmeus.*

Figure 2.3.7. Some examples of İğneada Fauna.

In addition, mammals such as *Apodemus flavicolis, Cervus elaphus, Capreolus capreolus, Sus scrofa, Canis lupus, Vulpes vulpes, Canis aureus, Felis silvestris, Martes martes, Meles meles* and *Lutra lutra* are observed in the area based on recent research studies and GEF (Global Environment Facility) II Project (Ozyavuz, 2008).

Eight fish species that live in these lakes and their streams are in the Bern List category ‘‘Protected Fauna Species’’ (PFS): *Chalcalburnus chalcoides, Syngnathus abaster, Neogobius fluviatilis, Apius aspius, Alburnoides bipunctatus, Rhodeus amarus, Cobitis taenia*, and *Chondrostomanasus* (General Directorate Of Nature Conservation and National Parks, 2005b). Therefore, in Lake Mert, Lake Erikli and Lake Saka host *Mugil cephalus* and *Atherina boyeri* because of the connection between fresh water lake and sea.

There are 310 insect species in İğneada and surrounding environment. Some of them such as Cerambyx cerdo and Lycaena are in The International Union for Conservation of Nature (IUCN) Red List of Threatened Species.

2.4 Natural Conservation

Turkey is one of the countries where three floristic regions and biodiversity hotspots meet. In Turkey there are 9,200 defined plant species, and this number has reached 11,000 with the number of species and one third of plant species are endemic. This species-richness is not available in any European country. In this aspect, Turkey has the plant diversity of a continent, given that the number of species in Europe is 12,500. The number of legally declared national parks in Turkey is 40 and it is located on the bird migration routes.

Preservation of many cultural and historical assets has been included in various laws such as those on Forests, National Parks, Preservation of Natural and Historical Assets, Environment, Coasts, and the Bosphorus. The concept of protected area management and conservation in Turkey started as early as 1937 when Land Hunting Law (number 3167) was enacted. Among institutional structures responsible for protected areas of Turkey, the Ministry of Forestry and Water affairs (URL 1), the Ministry of Food, Agriculture and Livestock Affairs (URL 2), the Ministry of Culture and Tourism (URL 3), and the Ministry of Environment and Urban Planning (URL 4) play important roles. During the planning process, the latest technology and state of the art is used as well as involvement of stake holders.

The İğneada longos forests are among the rare areas in Turkey and Europe with an intact ecosystem, of which the biodiversity is approved under the GEF-2 project. The area houses different kinds of ecosystems and a wide range of biodiversity; the parts of it have previously protected as Nature Protection Park (southern part of the region about 1345 ha), Natural Site, and Wildlife Protection Area (about 5399 ha) (Özyavuz and Yazgan, 2010). Different conservation categories were declared in different dates for different parts of the region (Bozkaya, 2013).

- Hunting and Wildlife Protection Area (1978-5399 ha)
- Lake Saka Longos Natural Protection Area (1988-1345 ha)
- Lake Erikli 1st degree natural site (1991)
- Lake Saka Longos 1st degree natural site (1991)
- The Area Between Lake Erikli and Black Sea 2nd degree natural site (1994)
- Lake Mert 1st degree natural site (1994)
- The northern part of the Lake Mert 3rd degree natural site (1994)
- The Longos Forests National Park (2007)

The area is one of the most important representatives of ash-oak-alder mixed populations and it is “Important Bird Area” (Özyavuz, 2008). The area was declared a national park in 2007, but cultural pressures have gradually increased. Conservation status in the study area is given in Figure 2.4.1 and Table 2.4.1.

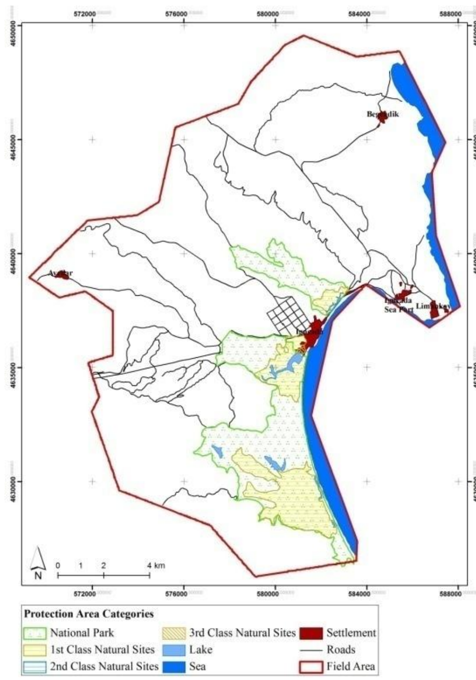
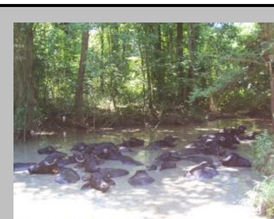


Figure 2.4.1. İgneada Conservation Zones and its surroundings.

Table 2.4.1. Conservation Status in İgneada.

Natural Conservation Area	Conservation Status	Photographs
İgneada Longos Forest	National Park	
Lake Erikli	2 nd degree natural site	
Lake Mert	2 nd degree natural site	

Natural Conservation Area	Conservation Status	Photographs
Lake Saka	1 st degree natural site	

Faults in the planning for the areas of these species has resulted in great damage even though these areas are protected by law. They stay continuously under pressure because the management and planning of natural protection areas are not accomplished efficiently, the local population cannot play a role in this management, and the management does not allow sustainable activities for economical interests.

Table 2.4.2 shows the strengths, weakness, opportunities and threats (SWOT) to determine the impact of social, economic and cultural pressures on natural resources in the region (Özyavuz, 2008) based on scientific research and knowledge of the governmental and non-governmental organizations such as stakeholders, municipality, …etc. According to the result of interview with villagers, the most important problem in the region is limited income sources (Field work, 2010).

Table 2.4.2. Results of SWOT Analysis.

Strengths	**Weakness**
• Flora, • Fauna, • Natural Resources, • Rich water ecosystems	• Lack of Awareness, • Unemployment, • Lack of social services, poverty and the associated migration • Different government agencies have jurisdiction over protected areas
Opportunities	**Threats**
• Undestroyed environment, • Different opportunities for eco-tourism, • Board, camp sites and village houses, • Support of public about activities relating to the conservation area • Against of hunting by public • Opportunities for forestry	• Overgrazing • Solid waste • Illegal cutting of forest • Unregular sea tourism • Unregulated sand extraction • Water pollution from untreated sewage • Illegal cutting of marshes • Illegal hunting • Lack of water because of upstream diversion for agricultural and municipal uses • Planning a dam project for supplying water to Istanbul • Planning a highway project • Urban areas are very close wetlands

Table 2.4.3 shows threats and opportunities for natural resources of four different ecosystems such as Sand Dune Ecosystem, Wetland Ecosystems, Flooded (alluvial/longos) Forest Ecosystems, Forest Stream Ecosystems.

Table 2.4.3. Ecological units with threats and opportunities.

Ecologic Units	Threats	Opportunities
Sand Dune Ecosystems	• Degradation of sand dune community because of grazing and recreational activities • Large scale sand extraction	• Possibility to find alternative solutions
Wetland Ecosytems	• Construction on Mert lake • Water pollution from untreated sewage • Illegal hunting • Lack of water because of upstream diversion for agricultural and municipal uses	• Public awareness of sewage problem. • Sentiment against construction for aesthetic and recreational reasons
Longos Ecosytems	• Illegal cutting for hundicrafts • Illegal Hunting • Solid Waste • Extention for enlarging agricultural areas within core zone	• Reduce grazing pressure through improved pasture management. Farmers are willing to discuss. • Hunting and cutting undercontrol by forest guards • Municipality attaches great importance to tourism.
Forest Stream Ecosystems	• Dam project • Lack of water because of agriculturaland plantations activities • Water pollution from pesticides • Sand extraction • Illegal hunting and cutting	• Nongovernmental Organizations and Universities against dam • Plantations area will be close

2.5 İğneada Case Studies; Change Detection Based On Remotely Sensed Data

2.5.1 Introduction

Flooded forests are one of the most fragile and threatened ecosystems in the world (Murphy and Lugo 1986). With the urgent need for sustainable monitoring and conservation strategies, the assessment of flooded forests using geospatial technologies has become a research priority (Sánchez-Azofeifa et al. 2005). Current effort includes developing remote sensing techniques for evaluating extent, structure, and composition of flooded forest types and common vegetation. Furthermore, determining land cover changes occurred in flooded forest and surrounding environment has important role for conservation and management of biodiversity. On the other hand, a flooded forest as a forest reserve is one of the most important components to identify the biodiversity.

The second step of the project mainly demonstrates the impact of land use/land cover changes in sensitive natural area using the İğneada flooded (alluvial/longos) forest as a case study based on remote sensing technology. It is possible to provide economic, accurate, temporal, reliable and updated information from remotely sensed data especially for large geographic areas. In this project, two different change detection techniques were applied to freely available temporal Landsat TM data set to determine the land cover/use changes that occurred in selected region. Supervised classification and Principle Component based change detection methods were applied to data set. Therefore, different vegetation indices were calculated and ANOVA analyses were applied to find which remotely based vegetation indices is the best for flooded forest discrimination. For three case studies mainly 1984, 1990, 2000 and 2010 dated Landsat 5 TM data were used in the study. The Landsat 5 TM sensor data detects the earth from the altitude of 705 km with seven spectral bands from blue to thermal infrared wavelength regions. It has four spectral band in visible (0.45 – 0.52 µm, 0.52 – 0.60 µm, 0.63 – 0.69 µm, 30 m), two spectral band in near – infrared (0.76 – 0.90 µm, 1.55 – 1.75 µm, 30 m), a spectral band in mid- infrared (2.08 – 2.35 µm, 30 m). The spatial resolution of the data is 30 meter, except in the thermal band, which has a resolution of 120 meter. Approximate scene size is 170 km north-south by 185 km east-west.

2.5.2 Case study 1: Change detection based on supervised classification

In this study, **Image pre-processing** was conducted to eliminate atmospheric distortions, sensor problems and geometric distortions. Figure 2.5.1 gives the main steps of image pre-processing. Detailed information about image processing can be found in **deliverable 2.4** EnviroGRIDS remote sensing data use and integration guideline, 2009. Before starting determining coverage of different land cover categories, the original digital numbers (DN) of the Landsat 5 TM images were converted to exo-atmposhperic reflectance based on the methods provided by Chander and Markham, 2003.

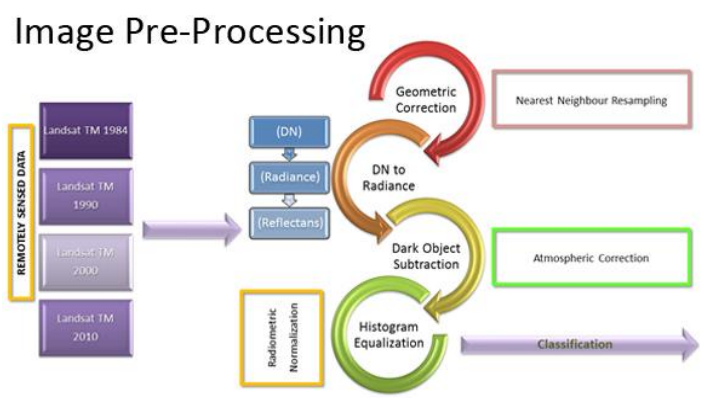


Figure 2.5.1. Image pre-processing steps and data used in the study.

A “dark object subtraction” (DOS) method was used to correct for atmospheric scattering in the path. The method is an image-based approach that assumes dark objects exist within an image and these objects should have values very close to zero (such as water bodies) (Moran et al, 1992). The pixel values are selected for each individual band with the histogram method and subtracted from all pixel values for the corresponding band across an image (Liang 2004) to remove the atmospherical effects from the image. To employ this method, brightness values were examined in an area of shadow or for a very dark object (such as a large clear lake) and the minimum value was determined. The correction is applied by subtracting the minimum observed value, determined for each specific band, from all pixel values in each respective band. Because scattering is wavelength dependent the minimum values will be different from band to band, therefore each band must be evaluated independently.

There are both systematic and non-systematic geometric errors in remotely sensed imagery. The detailed information about the effects is given by (Richards, 1993). Systematic distortions can be corrected by using mathematical formulas during image preprocessing and non systematic errors can be only corrected statistically by using the Ground Control Points (GCPs). The Landsat 5 TM images were rectified to the UTM projection system (ellipsoid= WGS 84, datum= WGS 84, zone = 35 North) using ground control points, primarily road intersections, evenly distributed across the images. Root Mean Square Error (RMSE), which represents a measure of deviation of corrected GCP coordinate values from the original reference GCPs used to develop the correction model. A first order polynomial model was used for the rectification by using nearest neighbor resampling algorithm. The RMSEs were less than 0.50 pixels (15 m) for each of the images.

Geometrically corrected images were classified by using unsupervised and supervised classification methods to derive land cover categories of İğneada (Figure 2.5.2). Classification is the process of grouping pixels of images into patterns of varying gray tones or assigned colors that have similar spectral values to transfer data into information for determining earth resources.

Iterative Self-Organizing Data Analysis (ISODATA) is the most commonly used unsupervised classification technique and also used in this study with the supervised classification methods. In the first step, pixels are grouped into the number of clusters that user defined previously. These groups are called spectral classes. Classified groups are then labeled with user expertise, if the result classes are satisfactory then result classified image is used for further analysis. In supervised classification, spectrally similar areas on an image are identified by creating 'training' sites of known targets and then extrapolating those spectral signatures to other areas of unknown targets (Schowengerdt, 1997). As a supervised classification Maximum Likelihood (ML) classifier is selected in this study. The ML classifier assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless a probability threshold is selected, all pixels are classified. Each pixel is assigned to the class that has the highest probability. If the highest probability is smaller than a threshold, the pixel remains unclassified. For 1984 dated image, 653 training area; for 1990 dated image, 640 training area; for 2000 dated image, 638 training area and for 2010 dated images 670 training area were selected and used in classification.

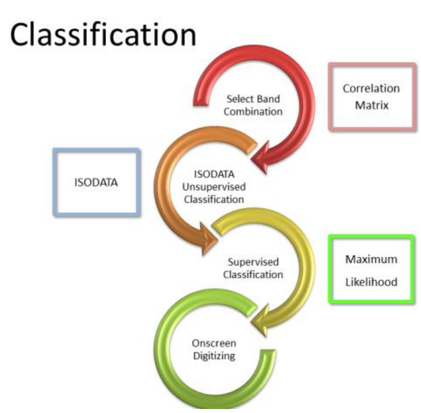


Figure 2.5.2. Flow chart of classification

With maximum likelihood method, all images were classified and land use / land cover maps were obtained by using Erdas Imagine 9.1. As a result, we got nine different land use classes: water, forest, flooded (longos) forest, wetland / bulrush, plantation area, agriculture / bare ground / grassland, sand dunes, settlement / road, and cloud. Water class includes lake, river and sea. The forest class is mixed forest, it includes pine trees, oak trees, beech trees, poplar trees, ash trees etc. Settlement means mainly city centers and artificial surfaces that include concrete and asphalt areas and roads. Agriculture category includes hay, cereals or other kind of crops. Bare ground is without any cover and any use.

To evaluate the thematic accuracy of the classified images Kappa statistic and overall accuracy were calculated based on error matrix. Because of the mixed pixel problem the accuracy of the resultant images need to be improved. In order to solve this problem and improve the accuracy rates, on-screen digitizing method was used. The derived data from digitization entegrated with classification results. Thus, land use/cover base maps with high accuracy were obtained for four years (Figure 2.5.3 and Table 2.5.1).

Table 2.5.1. Supervised Classification statistical results for 1984, 1990, 2000 and 2010.

Classes	1984 Area (ha)	1990 Area (ha)	2000 Area (ha)	2010 Area (ha)
Water	137	136	106	141
Forest	15046	15900	16643	16554
Flooded Forest	1497	1513	1536	1589
Bulrush	369	379	365	357
Plant Plantation Area	2190	1906	1378	1449
Bareground/Grassland/Agriculture	2532	1940	1705	1584
Sand Dunes	196	178	187	213
Settlement	54	67	97	128
Road	716	719	720	723
Total	22737	22737	22737	22737

Change detection applied by comparing these base maps using **from-to** analysis. According to change matrix, the rate of change in residential areas is the highest. 1984 dated supervised classified image has overall accuracy of 92 % and Kappa value of 91 %, 1990 dated classified image has overall accuracy of 97 % and Kappa value of 96 %, 2000 dated classified image has overall accuracy of 98 % and Kappa value of 98 % and 2010 dated classified image has overall accuracy of 97 % and Kappa value of 96 %.

The results showed that major damage occurred on bareground/grassland/agriculture areas of the selected region. The area was 2532 ha in 1984 and it was 1584 ha in 2010. The area of flooded forest was 497 in 1984 and it was 1589 in 2010 because of new plantations in the region. Mix Forest and flooded forest categories converted to bare land and plantation area.

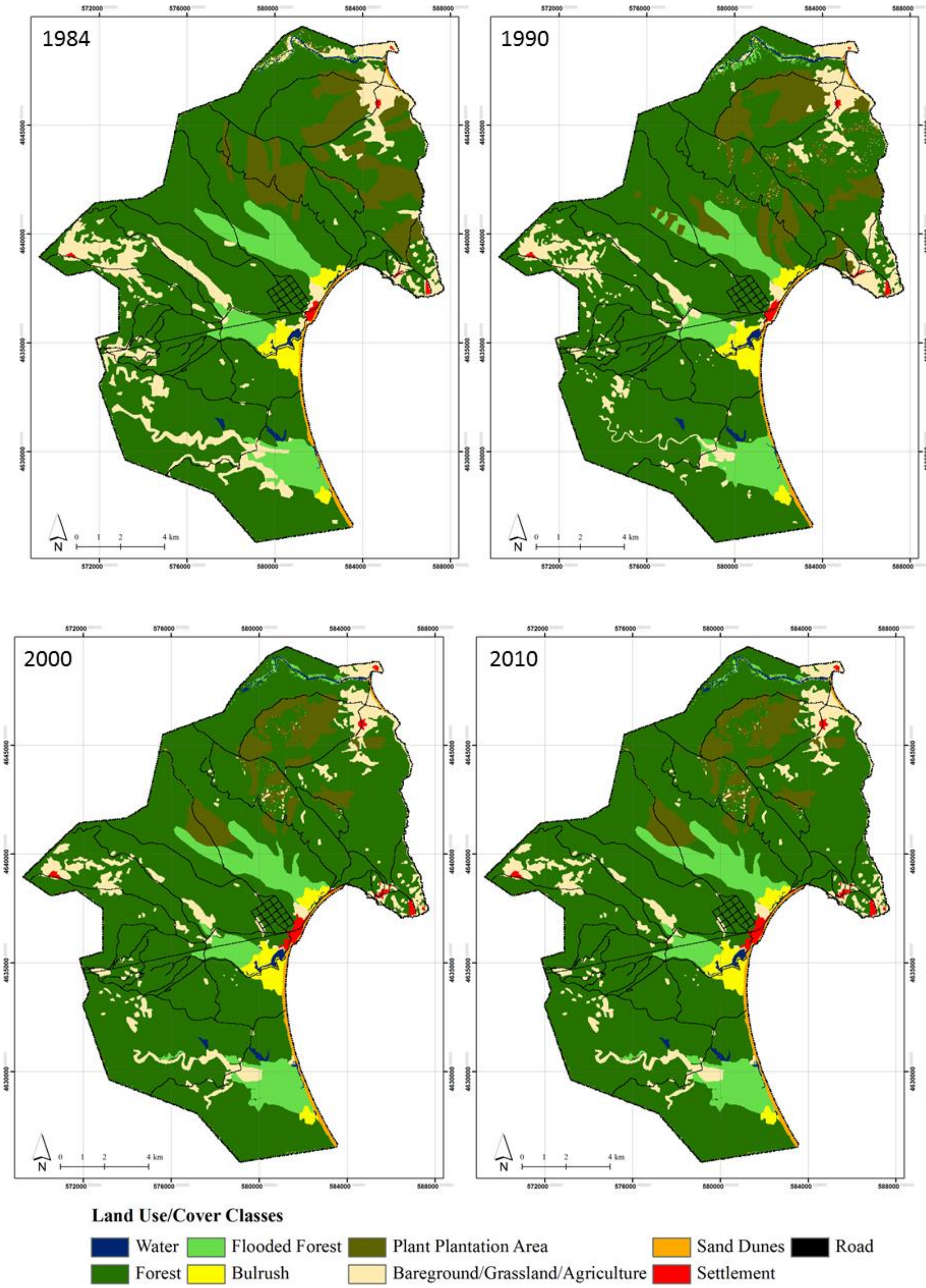


Figure 2.5.3. Supervised classification results of 1984, 1990, 2000 and 2010.

Figure 2.5.4 illustrates that land cover classes have changed over the 1984 and 2010 years. Results showed that some land cover types converted to some other land cover classes. According to the gain- loss charts, the highest change in forest, bareground, agriculture, grassland and plantation area.

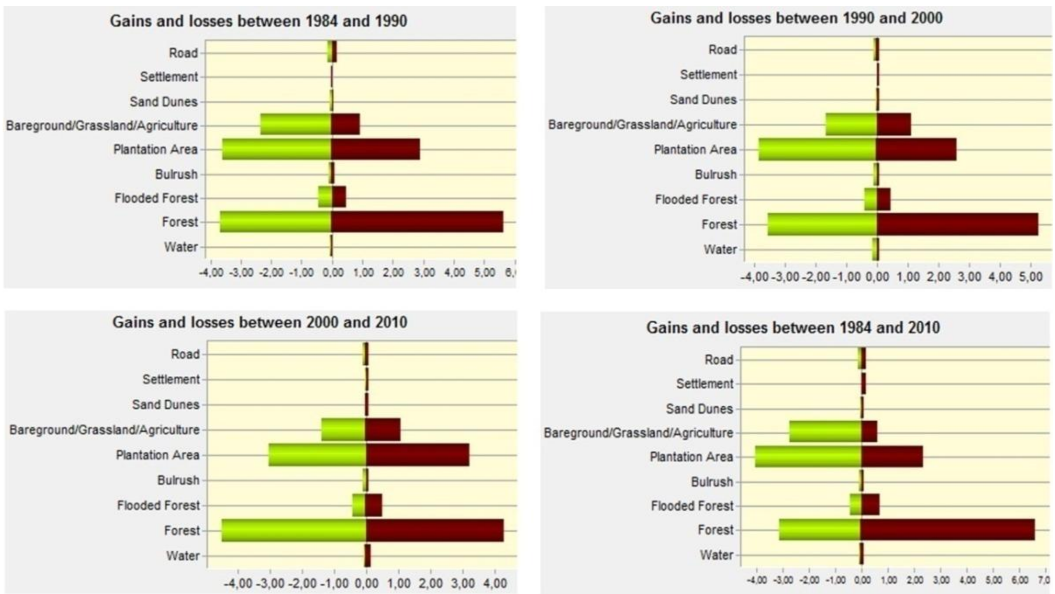


Figure 2.5.4. Gain and Losses between four different years.

Settlement, road and forest land cover types are increasing and bareground, grassland and agriculture area is decreasing in all the combinations. The changes in other land cover types are almost same in terms of gains and losses.

Consequently, examination of past and current situation by using remote sensing techniques is important for sustainable environment. For effective management, this kind of monitoring should be done in certain periods as a rapid approach.

2.5.3 Case study 2: PCA based change detection based on hybrid classification

Change detection methods help to provide a better understanding about interactions and relationships between human and natural phenomena. However, change detection capabilities are limited by the spectral, spatial and temporal resolution of the remotely sensed data in environmental applications to characterize changes for better management and use of resources (Bektaş Balçık, 2010).

The objective of this study is to develop a methodology to detect and identify land use land cover changes on the basis of a time series of land cover maps derived from Landsat 5 TM (30 m) data set. In this study, image preporcessing steps were applied to 2000 and 2010 dated Landsat TM images. Pre-processing, before change detection analysis, is essential and more demanding to minimize radiometric differences and remove errors between temporal image set. This stage includes calibration to radiance and/or at-sensor reflectance, atmospheric correction, geometric correction, and normalization, respectively. Figure 2.5.5 shows the detailed information about pre-processing.

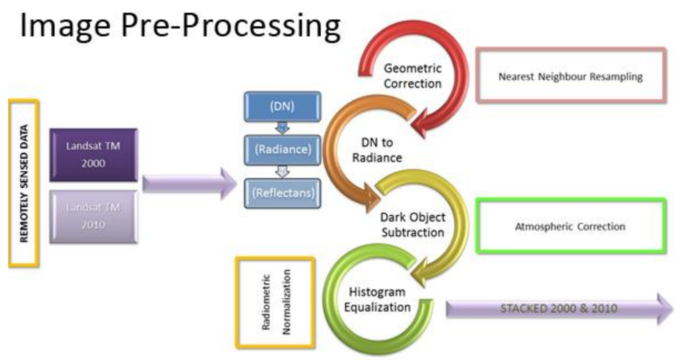


Figure 2.5.5. Pre processing steps of Principal Component Analysis based application.

Different dated images were stacked to store multitemporal data in one image and the principal component analysis (PCA) was used to enhance the change information from stacked multitemporal data. Figure 2.5.6 shows the methodology of the PCA based change detection. PCA is used to reduce the dimensionality of a dataset consisting of a large number of interrelated variables, while still retaining the maximum information of the variation present in the dataset (Deng et al. 2008).

Pre-classification spectral change-detection methods, such as PCA, actually enhance the change information from original images, they have difficulty in labelling and obtaining 'from-to' change class information. In fact, classification intrinsically impacts the whole accuracy of change detection. In this study, a hybrid classification process combining unsupervised and supervised approaches is performed on the PCA-enhanced multitemporal change image. Hybrid method combines the benefits of both techniques. This hybrid classifier has the potential to produce class signatures that are numerically separable in feature space and land-use classes that are meaningful to the analyst to increase the change detection map accuracy. The results from hybrid classifier were decomposed and labelled into different land uses for 2000 to 2010 (Figure 2.5.7) and from-to conversion matrix given in Table 2.5.2.

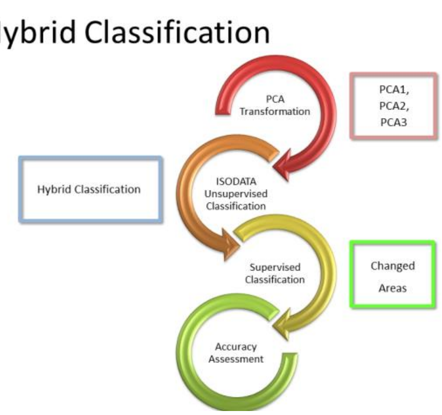


Figure 2.5.6. Methodology of the PCA based change detection.

An error matrix was used to assess classification accuracy. Although many methods of accuracy assessment have been discussed in the remote sensing literature (Jensen 1996) the most widely used method for assessing the accuracy of a classification is the error (or confusion) matrix (Foody 2002). As a simple cross-tabulation of the mapped class label against that observed on the ground or in reference data it provides an obvious foundation for accuracy assessment. For the PCA based change-detection accuracy assessment at least 50 reference points were selected for all categories. Although errors and confusion exist because of mixing problem, PCA method showed satisfying results with an overall accuracy to be 87.50% and 84.32 % and 0.85 and 0.81 for the Kappa coefficient, respectively.

The results depicted that major damage occurred on mix forest I and II of the selected region. 387 ha green area was converted to bare land and 62.19 ha of the mix forest I area was changed to bare land in the study region. On the other hand, 1472 ha bare land area was converted mix forest I. The above change statistics gives an explanation on the question of where land use and land cover changes occurred between the years of 2000 and 2010. According to results coverage of the water, sand dune, wetlands and flooded forest were same during ten years. For sustainable management, this kind of monitoring should be done in certain periods as a rapid approach.

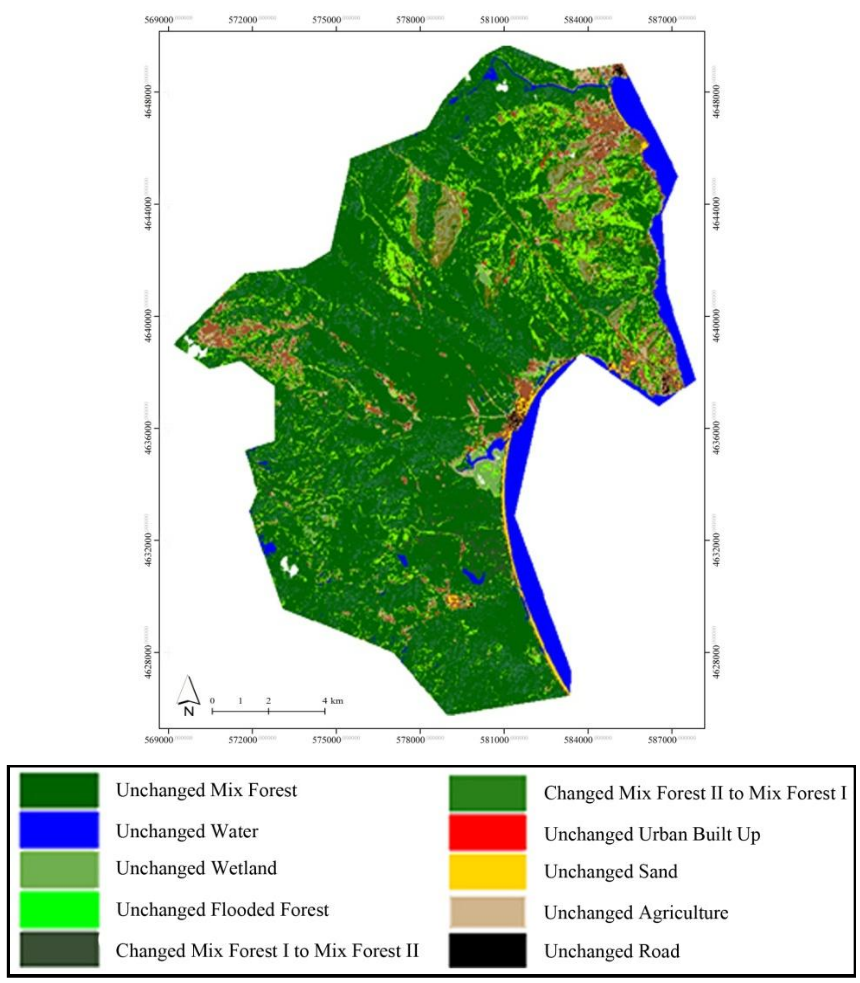


Figure 2.5.7. Change detection by PCA and hybrid classification.

Table 2.5.2. From-to change detection results.

Area (ha)	W	MF I	MF II	B	Ag	U	FF	S	w
Water	1193								
Mix Forest I		14707	1944	62.19					
Mix Forest II				387					
BareLand		1472		624					
Agriculture					570				
Urban						115			
Flooded F							1228		
Sand								163	
Wetland									289

2.5.4 Case study 3: Vegetation indicies and statistical analysis

İğneada area includes different kinds of ecosystems and a wide range of biodiversity. This study is conducted to evaluate the potential of remote sensing indices to discriminate alluvial flooded forest (longos) from mixed forest and wetland in İgneada. Before vegetation indices were calculated image pre-processing steps were applied to temporal Landsat TM images. 2010 dated satellite data from three different seasons (spring, summer and autumn) were used to perform Intrinsic-based vegetation indices and soil line-based vegetation indices using two band wavelength combinations (Table 2.5.3). The most common indices are generally ratio and soil-based indices that are based on discrete red and near infrared bands. This is because vegetation reveals distinctive reflectance properties in these bands. Ratio based indices are often preferred to soil-based indices as the soil spectral characteristics needed to establish soil line (Darvishzadeh et al., 2008). The soil line defined by Richardson and Wiegand is a linear relationship between the near-infrared and red reflectance of bare soils and is defined by the slope and intercept of this line (Richardson and Wiegand, 1977). The soil line properties (slope ‘a’ and intercept ‘b’) were calculated from Landsat 5 TM derived pure soil pixels.

Table 2.5.3. Vegetation Indices (L=0.5, a=slope and b=intercept)

Vegetation Index	Acronym	Equation	Reference
Normalized Difference Vegetation Index	NDVI	(NIR-RED) / (NIR+RED)	Rouse et al. (1973)
Ratio Vegetation Index	RVI	NIR/RED	Jordan (1969)
Perpendicular Vegetation Index	PVI	(NIR-a*RED-b) /(1+a^2)	Richardson and Wiegand (1977)
Soil Adjusted Vegetation Index	SAVI	(NIR-RED)*(1+L)/ (NIR+RED+L)	Huete (1988)
Modified Soil Adjusted Vegetation Index	MSAVI	(2*NIR+1-((2*B4+1)^2-8*(B4-B3))^ $^{1/2}$)/2	Qi, Chehbouni, Huete, Kerr & Sorooshian (1994)

Transects from different land cover categories such as flooded (longos) forest, mixed forest and wetlands were derived for statistical analysis. In order to determine the discrimination ability one-way Analysis of Variance (ANOVA) analysis were used with a post-hoc Scheffé test at each image based collected transects for the individual class pair. ANOVA describes if the remote sensing signal is statistically different for the various categories of land cover types in İğneada. In this study, two different research hypotheses were analysed based on means of the reflectance between the pairs of flooded forest and each one of the co-existing categories (mixed forest and wetlands) were significantly different for three seasons and for five vegetation indices. ANOVA was applied with two confidence levels: a 99% confidence level ($p < 0:01$), and a 95% confidence level ($p < 0.05$) to compare different vegetation indices based on seasons and vegetation indices.

Hypothesis 1:

The null hypothesis Ho: $\mu1 = \mu2$, $\mu1 = \mu3$ versus the alternate hypothesis Ha: $\mu1 \neq \mu2$, $\mu1 \neq \mu3$ where $\mu1$ is the mean reflectance values from longos transect (winter) and $\mu2$, $\mu3$ are the mean reflectance values from longoz transect (spring and autumn), respectively. That hypothesis also applied for the wetland and mixed forest transects with longos transect.

Hypothesis 2:

The null hypothesis Ho: $\mu1 = \mu2$, $\mu1 = \mu3$, $\mu1 = \mu 4$, $\mu1 = \mu5$ versus the alternate hypothesis Ha: $\mu1 \neq \mu2$, $\mu1 \neq \mu3$, $\mu1 \neq \mu4$, $\mu1 \neq \mu5$ where $\mu1$, is the mean reflectance values from longoz transect (NDVI) and $\mu2$, $\mu3$, $\mu4$, $\mu5$ the mean reflectance values from longoz transect (PVI,RDVI,SAVI and MSAVI), respectively. That hypothesis also applied for the wetland and mixed forest transects with longos transect.

Three transects were selected from each image based on land cover categories such as longos forest, wetlands and mixed forest for each vegetation index and for each season. Totally 45 transects were derived to test two research hypothesis. One – way ANOVA only shows that there is a significant difference in the mean reflectance of longoz forest than the other categories but it does not show which pairs are different. A post hoc Scheffe test were executed in order to establish differences between each pair.ANOVA results indicate that for the first hypothesis there is significant difference in the mean spectral reflectance between all the class pairs with a 99% confidence level ($p < 0:01$) and the 95% confidence level ($p < 0:05$). The p value was calculated 0.00 for each pairs. For the second hypothesis, results indicated that the mean reflectance for NDVI is significantly different from those obtained by PVI, RDVI, SAVI and MSAVI ($p < 0.05$). The p value was calculated 0.00 for each pairs for all vegetation indices. Results show that there are significant differences between vegetation indices. This means that it is possible to classify flooded forest by using different vegetation indices. These results and analyses can be used for effective resource management of sensitive regions.

2.6 Conclusion

Devastating and uncontrolled land use land cover changes have occurred in the natural areas for urbanization purposes as a result of population increase. In order to ensure the sustainability of ecological sensitive areas, these areas are declared as “protected area”. However, several problems encountered, due to the deficiencies and differences on the protection status. It is very important to make retrospective analysis of natural resources for their sustainable utilization, conservation and development.

İgneada flooded forest and its surrounding environment are very sensitive and valuable ecosystems for local, regional and global scale. It is one of the 122 Important Plant Areas and 184 Important Bird Areas of Turkey. This area is a valuable site because of being both a core-site within WWF (World Wildlife Fund) Global 200 eco-region and a potential Natura 2000 site. The announcement of the national park is expected to contribute to the sustainable development of the area. In addition, heavy urban pressures are evident in the area and these ongoing pressures and their consequences should be taken into account for sustainable management of İğneada protection area. Thus, latest technology such as remote sensing should be used for the sustainable resource use in İğneada.

Scientific research studies and projects have important roles for effective management of natural areas. With the support of the EnviroGRIDS project a master thesis was conducted to determine the land use and land cover changes of the İgneada. In the same thesis, the land cover and land use were modeled for the year of 2030 with support of TUBITAK funded project "110Y015: Detection of Historic Urban Growth Pattern and Modeling Future Urban Development in İğneada Protection Area" for the İğneada study area.

Consequently, examination of past and current situation by using remote sensing and GIS techniques and for the future land use and land cover prediction using appropriate urban forecasting models are important for sustainable environment.

3 Assessment of biodiversity in the Yalta mountain forest (TNU)

3.1 Landscape and ecological characteristics of the Yalta Mountain Forest Nature Reserve

3.1.1 Geographical position and boundaries, main activity

Yalta Mountain Forest Nature Reserve (Yalta MFNR) is located in the south-western part of Crimea and occupies a southern macroslope of the Main Ridge of the Crimean Mountains (Figure 3.1.1). It was created February 20, 1973.

The territory of the Yalta Mountain Forest Nature Reserve in accordance with the state administrative-territorial division is part of the 9 local councils of Greater Yalta – 7 townships: Foros, Simeiz, Koreiz, Gaspra, Livadia, Massandra and Gurzuf and 2 towns: Alupka and Yalta.

Currently Yalta NFNR total area is 14,523 hectares and it consists of 4 forestries:
- Gurzuf forestry (area is 3,967 ha);
- Livadia forestry (4,836 ha);
- Alupka forestry (2,619 ha);
- Opolznevoe forestry (3,101 ha).

Forest lands are 11,296 hectares, including covered by forests areas – 11,090 ha, non-forest lands – 3,227 ha, including arable lands – 4 ha, hayfields – 73 ha, built-up lands – 30 ha, water – 7 ha, roads – 155 hectares.

Figure 3.1.1. The territory of Yalta Mountain Forest Nature Reserve.

Reserve stretches along the Black Sea on 40 km from the settlement Foros in the west to settlement Gurzuf in the east. The maximum width (from the north to the south) is 23 km. In general reserve is within the altitude 380-1200 m above sea level in some places falling to the sea. The highest points of reserve are mounts: Lapata (1406 m) and Ai-Petri (1320 m above sea level). The upper boundary of the reserve stretches in some places along the cliffs yaila (plateau), capturing in the area of Ai-Petri plateau. The lower boundary of the reserve runs along the highway from Sevastopol to Yalta, in places down to the coast, sometimes leaning toward yaila breaks.

About 75% occupy coniferous and broadleaf forests of the Submediterranean and Central European type. At flat top of the Main Ridge of forests are replaced by mountain-steppe, meadow and tomillares by the communities occupying about 20% of the area of reserve. Flora of the reserve accounts 1363 species of vascular plants that makes 65% of species of Crimean Mountains or 28% of species of all Ukraine.

The reserve territory consists of a series of large areas and small areas, separated by numerous settlements and roads. The close proximity to the sanctuary is home to about 140 thousand people, and in the summer at the "peak" of recreational load the maximum lump sum in the Big Yalta population is more than 200 thousand people.

The Yalta MFR is state establishment for research and nature protection of nation-wide status, is part of natural-reserved fund of Ukraine and is protected as national property. For Nature Reserve the special regime of protection is established. The territory of Yalta MFNR with all natural resources has been completely excluded from economic land use according to the current legislation of Ukraine. At present time the great problem is that there is no buffer zone that protects the reserve area against transboundary negative influences.

On the territory of the reserve any economic and other activities which contradict the special purpose are forbidden, for example activities which break the natural development of processes and the phenomena, cause threat of harmful influence on its natural complexes and objects (like construction of buildings and roads, linear and other objects of transport and communication; bonfires, parking of transport, pasturing, prospecting works, gathering of plants, hunting, military activity, etc.).

The protection of the reserve includes a system of legal, organizational, economic, and educational instruments focused on preservation, restoration and sustainable use of resources according to the regulations of the nature protection legislation of Ukraine. Protection of reserve is assigned to service of the state forest protection which is part of the state protection service of natural-reserved fund of Ukraine.

Activity on development of ecological tourism in YMFNR is conducted under the direction of the Scientific Department of Reserve and the Protection Service which develops ecological trails, and monitors a level of carrying capacity. Ecological tourism in the reserve is based on the use of existing roads and trails. The Reserve is annually visited by 30.000 up to 50.000 visitors. The reserve offers not only hiking on the ecological trails, but also automobile, speleological, bicycle and horse tracks, as well as ski and sledge routes in winter. One route is the passenger aerial ropeway "Miskhor – Ai-Petri".

3.1.2 Geology and soils

Geological structure of the Yalta MFNR area is represented by rocks of the lower and upper floors of the structure of the Crimean Mountains. The lower structural level consists of rocks of Upper Triassic-

Lower Jurassic (T_3-J_1) complex of terrigenous sediments, known as the Taurian series, and layer of the Middle Jurassic (J_2) deposits. The upper structural stage of the Crimean Mountains includes the Upper Jurassic (J_3) and Pliocene-Quaternary ($N_{2\text{-}3}$-Q_1) deposits. The general scheme of geological structure of area is shown on Figure 3.1.2.

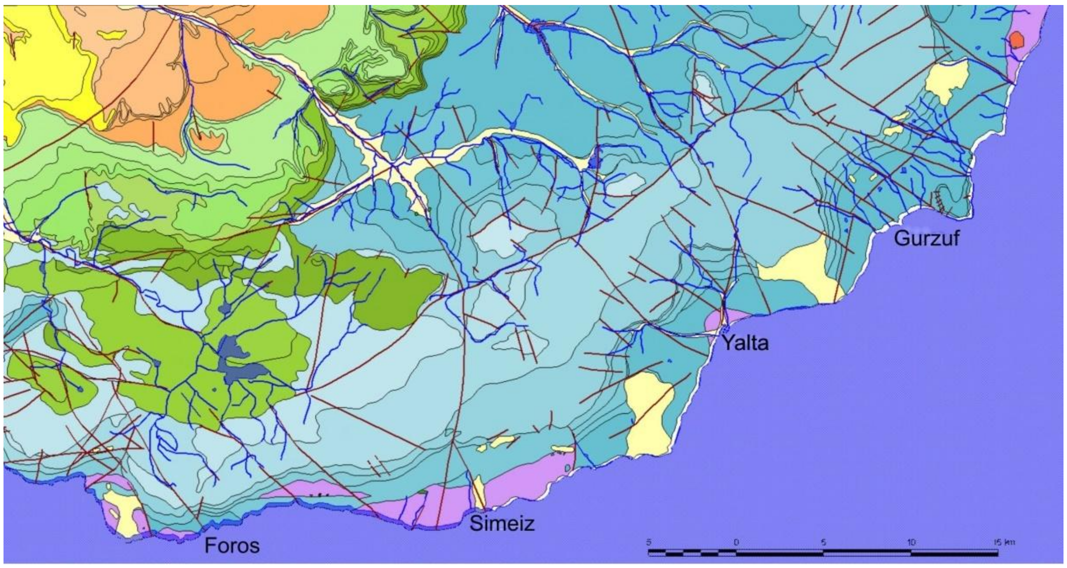


Figure 3.1.2. Geological map of the South-Western part of the Mountain Crimea. Produced from GIS "Karst of Crimea" (UISK). Digitization of the Geological Map of the Crimea scale 1:50000 (Vanina et al, 1986, 1988).

The Taurian series is presented by a thick sequence of alternating dark argillaceous mudstone (hardened clay) with layers of dense quartz siltstone and sandstone. Deposit width of Taurian series reaches several thousand meters.

Middle Jurassic sediments are the second most common in the Yalta reserve. They are elongated strip on top of the macroslope of the Main Ridge of Crimean Mountains. Middle Jurassic deposits of volcanic rocks are observed on the ridge of the Ai-Yuri (Dragon). Among them are the shales, alternating with layers of sandstone, volcanic and tuffaceous strata; layers of conglomerates.

Upper Jurassic limestone deposits form the upper structural level of the Main Ridge of the Crimean Mountains. In reserve they compose the Yailas (surface of the plateau), its cliffs and separated large limestone blocks.

According to Russian soil classification on the territory of Yalta MFNR the following types and subtypes of soils are presented: 1) mountain-meadow and mountain-meadow chernozem, 2) brown mountain forest soils, 3) brown mountain forest podzolic soils, 4) brown typical and calcareous soils (terra rossa).

All these soils are rocky, on the slopes are often eroded. Mountain-meadow chernozem soils have in A horizon 6-10% of humus.

Brown soils of dry forest and scrub that were formed in submediterranean landscapes (typical for dry

Mediterranean). The humus content in the A horizon of brown soil is usually not more than 4%.

3.1.3 Climate

The climate of the lowest part of the reserve is similar to that of the Mediterranean, and becomes more moderately cold and moist on the tops of yailas. In accordance with the climatic zoning, mountainous part of the reserve lies within the West Yayla division, which is characterized as very wet cool to moderately cold winters. Land Reserve on southern coast of the slope, located at altitudes above 500 m in the western district of southern slope of the main ridge of the humid, warm climate and mild winters, but below the 500-meter mark – to the Western South Coast region with a subtropical Mediterranean dry, hot climate and moderately warm in the winter.

The climate of this territory is formed by three atmospheric processes: heat, moisture cycle and atmospheric circulation. However, these processes are directly dependent on a number of geographical factors, which include latitude, altitude, topography, and surface.

Latitude has a great influence on the heat exchange processes within the reserve, which forms its radiation regime. The arrival of solar radiation largely depends on the duration of sunshine. The annual sunshine duration in different parts of the reserve varies between 2180-2470 hours. The maximum duration of the solstice is observed in July (320-360 hours). For long-term observations of the total quantity of radiation per year is in the range of values 120-125 Kcal/cm^2 (Ai-Petri – 120.6 Kcal/cm^2; Yalta – 122.5 Kcal/cm^2). Extreme values range from 17.2 Kcal/cm^2 in July to 3.0 Kcal/cm^2 in December. The radiation balance for the year is positive – the average 54 Kcal/cm^2. In connection with the position of the South Coast in relatively low latitudes, about 40% of the total solar radiation falls on summer, 30% – on spring, 20% – on autumn and 10% – on winter.

The influence of solar radiation on the formation of the temperature field can be enhanced or limited by such geomorphological factors as steepness of slopes. For the Crimea annual amounts of direct solar radiation as possible on the southern slopes of 30° is about 125%, and the slope of 10° – about 115% relatively to amounts on a horizontal surface (100%). For the northern slopes of the same steepness the amount of direct radiation is reduced relatively to 55 and 83%. Calculations show that during the cold period the steep slopes facing south get 2 times more heat than the surface of the plateau as a whole, and 4-5 times more than the steep slopes of the eastern, western and northern exposures. Thus, in a sufficiently dissected terrain of the reserve there is a large diversity of characteristics of radiation, causing the complex pattern of temperature distribution.

The value of hydrothermal coefficient (the ratio of precipitation to the possible evaporation of moisture) on the reserve area is 0.52. This ratio characterizes the conditions of summer moisture as insufficient.

The wind regime is determined by the general synoptic processes, proximity to the sea, terrain features. In the cold period of the year the north-eastern and eastern winds dominate (24% and 25% relatively), the frequency of western winds is slightly lower (18%). Often during the cold period the winds blowing from the mainland, are changed by strong winds from the sea, which are connected with cyclones from the Mediterranean Sea. These winds are milder than north-eastern and bring the warming with the heavy rainfall. Increased frequency of the wind from the sea (eastern and southern direction) is observed during spring period. In summer, the local circulation is prevailing (up to 50% of days per month). In summer there is a strong storm wind from east. Since October the north-western winds dominate. For the western part of the Southern Coast of Crimea mostly the small wind speed is characterized. The average wind speed is 3-6 m/sec. Strong winds are registered during 20-25 days. During the cold period the severe and prolonged

storms may have the speed of the eastern wind from 15 to 40 m/sec. In general, for the year in this region the eastern (38%) and western (25%) winds dominate.
The main climatic parameters for territory of Yalta MFNR according to "Yalta" (coastal zone) and "Ai-Petri" (mountain plateau) meteorological stations presented in the Tables 3.1.1 and 3.1.2.

Table 3.1.1. Microclimatic characteristics of the coastal areas of the Yalta MFNR, the average long-term value on "Yalta" meteorological station.

Parameters	Months												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Air temperature, °C	3.5	3.6	5.7	10.2	15.8	20.5	24.0	24.5	19.2	14.3	8.8	5.7	13.0
Wind speed, m/sec	3.0	3.1	3.2	2.6	2.3	2.3	2.4	2.7	3.1	3.0	3.0	3.0	2.8
Precipitation, mm	71	69	47	29	17	48	52	21	33	39	50	60	536
Relative humidity, %	90	85	84	77	76	64	62	60	60	73	76	83	74
Sunshine duration, hours	76	83	140	187	242	288	328	310	241	179	103	73	2250
Total solar radiation, MJ*month/m^2	134	189	360	486	662	737	763	675	511	327	168	122	5134
Intensity of UV radiation, W/m^2	22	30	40	50	55	57	55	50	41.5	32	23	17	
Seawater temperature, °C	8.6	7.7	7.7	9.4	13.5	17.9	21.2	22.8	20.6	17.0	13.7	10.6	14.2

Table 3.1.2. Microclimatic characteristics of the coastal areas of the Yalta MFNR, the average long-term value on "Ai-Petri" meteorological station.

Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Air temperature, average °C	-3.5	-3.6	-1.1	4.1	9.6	13.1	15.4	15.2	11.0	7.1	2.5	-1.2	5.7
Max air temperature, °C	2.1	1.5	3.5	9.5	13.0	16.7	19.7	19.1	15.0	12.4	8.2	3.9	-
Min air temperature, °C	-10.3	-9.9	-7.5	-0.5	5.1	10.2	12.8	12.5	6.9	0.8	-3.9	-5.3	-
Soil temperature, °C	-4	-4	-2	7	15	19	21	20	14	7	2	-2	-
Number of cloudy days	19	13	16	7	5	9	2	1	2	5	14	17	110
Humidity, mm Hg	3.1	3.1	3.3	4.5	6.3	8.2	9.2	9.0	7.2	5.5	4.6	3.7	5,6
Humidity, %	84	86	80	73	70	71	68	69	74	76	80	81	76
Moisture deficit, mm Hg	0.6	0.6	1.1	2.2	3.1	3.6	4.8	4.6	3.0	2.1	1.4	1.0	2,3
Precipitation, mm	160	129	92	50	52	73	60	49	49	71	109	158	1052
Precipitation (daily max), mm	176	76	75	77	75	178	95	117	186	83	61	215	215
Wind speed, m/sec	7.4	7.6	6.7	5.9	4.7	5.1	5.2	5.1	4.9	5.5	5.9	6.5	5.8

Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Evaporation, mm	10	12	27	40	81	97	87	55	31	23	13	10	486
Potential evaporation, mm	10	12	42	67	100	110	125	114	78	60	23	12	753
Evaporation from water surface, mm	-	-	-	32.8	98.5	100.1	121.0	116.5	73.3	45.5	-	-	587.7
Evaporation from the snow surface, mm	14.2	14.3	18.6	12.0	-	-	-	-	-	-	13.0	20.0	92.1
Evaporation from the soil surface, mm	-	-	-	30.8	82.0	111.4	86.5	41.0	32.6	21.9	9.1	-	415.3

3.1.4 Flora of the Yalta Mountaine Forest Nature Reserve

Data for this review were provided by Ya. P. Didukh, N. Kornilova, I. V. Kriukova, N. I. Rubtsov, Yu. R. Sheliag-Sosonko, A. V. Yena etc., and also originate from the author’s research (Sheliag-Sosonko, Didukh, 1980, Didukh,1992, Yena, 2012).

The rich and original flora of Crimean Mountains always drew attention of biologists. The history of its studying has old traditions and totals about 200 years. For this period over 500 works on various questions of flora and vegetation of this unique corner of our nature were published. More than half of works to some extent are related to flora and reserve vegetation.

The Crimean Mountains, as a geobotanical district, belong to Crimean Mountains underprovince and Evksinsky province of the Mediterranean area. The reserve territory occupies the western part of the Yalta-Sudak geobotanical area of *Querceta* and *Pineta pallasianae* communities and an insignificant southwest part of High-mountainous geobotanical area of *Carpineta betulii* and *Fageta orientalis* communities, and also the western part of Yaila geobotanical area of meadow steppes. Its vegetative cover reflects all basic lines peculiar to a vertical profile of vegetation of a southern macroslope of the Main Crimean Ridge, and rather fully characterises the general laws of vegetation of all Crimea Mountains underprovince.

Flora of the reserve is representing 1363 species of vascular plants, from 509 genera and 100 families. Some numerous examples of the following representative plant groups: Asteraceae (12.2%), Fabaceae (9.4%), Poaceae (8.3%), Brassicaceae (5.7%), Rosaceae (5.6%), Lamiaceae (5.2%), Apiaceae (4.2%). The perennial herbs are prevailing here (54,8%). Other places are represented by next groups: annual plants (34.3%); shrubs, semi-shrubs and small shrubs (only 10.9%), and among them only one endemic genus – Rumia. About 8% of species are endemic (some flowers and trees) (on data Sheliag-Sosonko, Didukh, 1980). In the reserve 183 moss’s species (60% of Crimean flora) and 154 species of lichens are found.

Flora of the reserve most fully represents all variety and riches of flora and vegetation of the Crimean Mountains, the mountains caused by a geographical position and the big variety of ecological conditions. One of the leading factors which define the common character of distribution of vegetative communities is the height above sea level. It causes formation of high-rise zones of vegetation. Within zones of vegetation differentiation is caused by steepness and an exposition of slopes, character of ecological conditions and, as a consequence of these factors, climate change and capacity of a soil cover. In the most common terms in connection with height increase above sea level the vegetative cover of reserve is differentiated on four zones of vegetation (Figure 3.1.3).

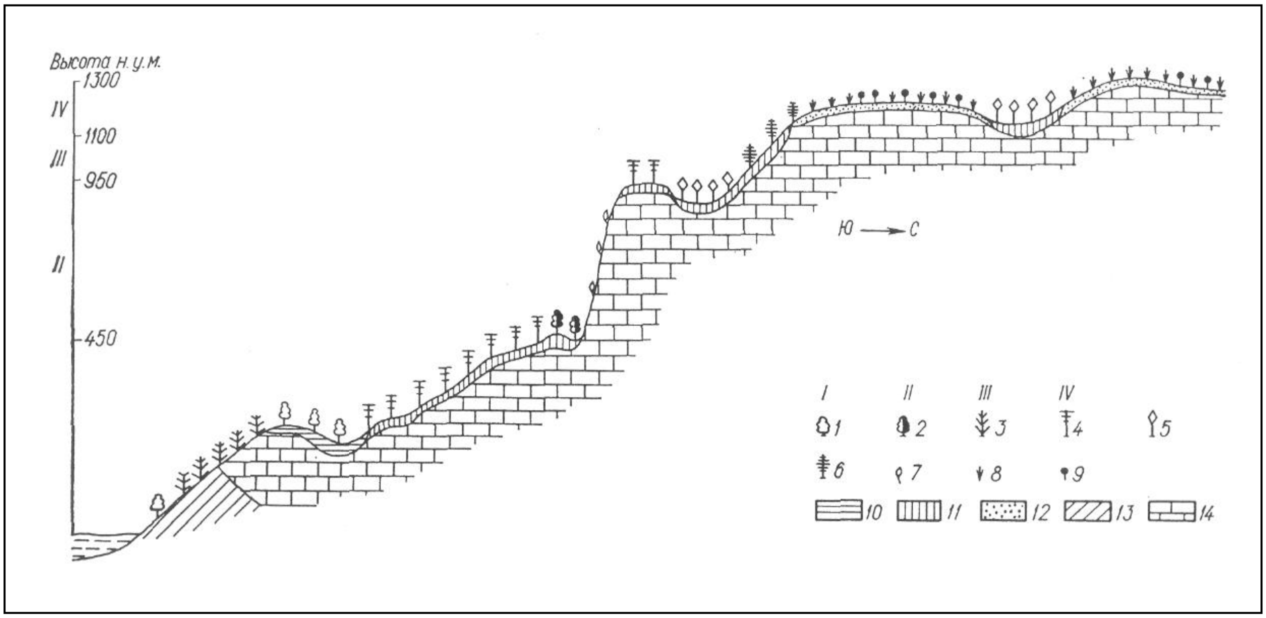


Figure 3.1.3. The zones of vegetation of Yalta Mountain Forest Nature Reserve (Didukh, 1992):
I – zone Junipereta excelsae and Querceta pubescentis communities; II – zone Pineta nigrae with participation Querceta petraeae communities; III – zone of Carpineta betulii and Fageta orientalis with Pineta sylvestris communities; IV – zone of tomillares and mountain steppes; 1 – Quercus pubescens; 2 – Q. petraea; 3 – Juniperus excelsa; 4 – Pinus nigra ssp. pallasiana; 5 – Carpinus betulus and Fagiis orientalis; 6 – Pinus sylvestris ssp. hamata; 7 – Petrofity; 8 – Carex humilis; 9 – Festuca rupicola; 10 – cinnamonic soils; 11 – brown forest soils; 12 mountain-steppe soils; 13 – slates of Taurian (Triassic-Jurassic) geological group; 14 – Upper Jurassic limestones.

The first zone occupies a strip from coast to height of 400-450 m above sea level also is characterised by domination in the richest soil cover conditions of the Submediterranean forests of *Quercus pubescens* and *Carpinus orientalis*. On the driest, well warmed southern slopes completely deprived of soil cover, forest changes from *Quercus pubescens* formations to *Juniperus excelsa* light forests. The moderate-warm Mediterranean climate, in which forests of this zone grow, has a maximum of precipitations during the winter-spring period that causes distribution of the evergreen and summergreen species wintering with open buds of renewal. The part from them does not stop vegetation and in the winter even blossoms. In Juniperus forests the species wintering with green leaves make 2.2%, species with open buds of renewal – 50%, and with closed – 17.8%. *Junipereta excelsae* and *Querceta pubescentis* formations in comparison with others were exposed to the greatest changes under the influence of economic activities of the people. Therefore it is frequent on their place are distributed bushland the thickets named “shiblyak”, or grassy groupings from ephemerals and ephemeroids, forming savannoids and dry grasslands vegetation.

The second zone occupies an average part of a macroslope at height from 400-450 to 800-950 m above the sea level. Here prevail forests of the Submediterranean type from *Pinus pallasiana*. In these forests in the lower part of a zone the second layer forms *Quercus pubescens*, and within heights of 600-850 m above the sea level of Central European species – *Quercus petraea*. Less often on richer and damp brown soils it is replaced with typical nemoral (forest) species of *Carpinus betulus* and *Fagus orientalis*. Unlike forests of the lower zone, in these forests the increase in quantity of the species wintering with closed buds of renewal and leaves falling down for the winter is observed. Here they make already 42,5% of total number of species.

The third zone occupying rather narrow strip from 800-950 m to 1000-1300 m above the sea level, is in conditions of a moderate-cool and damp climate and is characterised by forests of Central European type. Gentle slopes and hollows with well developed soils are covered by beechen, hornbeam-beechen and hornbeam forests, and abrupt mainly southern slopes in east part of reserve – forests from pine (*Pinus sosnovskyi*). In the western part of reserve on the abrupt rocky slopes forest from *P. pallasiana* gets into this zone to Yaila.

The fourth zone occupies top of the Main Ridge. It is presented by the mountain meadow steppes from formations formed by species *Zerna cappadocica, Festuca rupicola, Carex humilis*, etc. They occupy rather steep (to 30°) slopes of a various exposition, equal sites with mountain-steppe soils capacity 50-60 sm. More abrupt mainly southern slopes with badly developed, often washed off soils are covered tomillares by the communities representing thickets of semi-shrubs and low shrubs (species of *Thymus, Teucrium, Helianthemum, Cytisus, Genista*, etc.). In small on the area relief falls the meadow vegetation is formed. Sometimes in the deepest falls of a relief it is possible to meet small sites of low oppressed beechen forests. In connection with negative temperatures of winter on yaila species with the compelled winter rest – 86.4% prevail.

The vegetation of the reserve has some peculiarities. One of them – the predominance of the reserve forests of Pinus pallasiana, which constitute 30% of its forests and over 50% of these forests of the Crimea. One more feature – domination and sodomination in various communities of some the evergreen Submediterranean species which do not have the period of winter rest: *Arbutus andrachne*, *Cistus tauricus, Ruscus ponticus* and *Hedera taurica*. In reserve territory at height about 500 m above sea level there passes border of continuous distribution (except for *Hedera taurica*) these species. At the same time on reserve territory do not come a number of steppe species, such as *Artemisia caucasica, Astragalus rupifragus, A. suprapilosus, A. subuliformis, Ceratoides papposa, Salvia scabiosifolia, Stipa lessingiana, S. capillata, S. pontica*, and others, growing to the east of Alushta. This results from the fact that to the east of Alushta the winter rain maximum is replaced by the summer. This climatic barrier interferes with distribution of some species and is border between southwest (Yalta) and southeast (Sudak) areas.

The vegetative cover of reserve is presented by five types of vegetation: forests (formations of *Junipereta excelsae, Pineta pallasianae, Pineta sosnovskyi, Querceta pubescentis, Querceta petraeae, Carpineta betulii and Fageta orientalis*), steppes (*Zerneta cappadocicae, Festuceta rupicolae, Cariceta humilis, Stipeta lithophilae*), savannoids (*Hordeeta bulbosi, Hordeeta leporini, Aegilopseta biuncialis, Achnathereta bromoidis,* etc.), tomillares (*Teucrieta chamaedri, Teucrieta jailae, Helianthemeta stevenii, Thymeta callieri, Thymeta taurici,* etc.), meadows (*Alopecureta pratensis, Arrhenanthereta elatii, Brizeta australis, Alchemilleta,* etc.).

Juniper forests (Figure 3.1.4) represent forests with the lowest productivities and a crown density on the most well remained sites to 0.4-0.,6. Trees at the age of 70-200 years have, as a rule, strongly bent trunks in height of 5-8 m. Together with *Juniperus excelsa* grow *Pistacia mutica, Arbutus andrachne, Quercus pubescens,* and in a rather thin underbrush – *Juniperus oxycedrus, Cistus tauricus, Jasminum fruticans, Paliurus spina-christi* and other species. The grassy cover usually not dense (to 60%) also is characterised strong mosaic. The total area occupied by Juniper forests, makes less than 1% of the area of reserve (Green book, 2009).

Figure 3.1.4. *Uniperus excelsa* in the Yalta Mountain Forest Nature Reserve.

In structure of the Juniper forests of reserve forests following subformations are allocated: *Junipereta excelsae, Querceto-Junipereta, Pistaceto-Junipereta.* From them the greatest area is occupied by two first: last is presented fragmentary on the areas to some hundreds of square metres.

Subformation Junipereta excelsae depending on a prevailing species in underbrush is presented by a number of groups association: *Junipereta juniperosa (oxycedris), Junipereta jasminosa, Junipereta ruscosa* and *Junipereta cistosa*. Last group of associations meets fragmentary only along coast of Black Sea, without rising in mountains above 300 m above sea level. More widespread is *Junipereta ruscosa*, taking the lowered shaded places with the rather well developed soil. It is a link with forests from *Quercus pubescens* (Red book of Ukraine. Plantage, 2009).

Forests of group of associations *Junipereta juniperosa (oxycedris)* are in reserve the most widespread and the least broken. They occupy southern, southwest and southeast slopes with a steepness 10-30° with poorly developed brown stony soils on slates or limestones. The rarefied (0.2-0.4) underbrush forms Juniperus oxycedrus. In herbage the following species prevail: *Poa sterilis, Carex hallerana, Achnatherum bromoides,* rarely *Festuca callieri, Zerna cappadocica* or *Elytrigia nodosa*. The Most typical and widespread association of considered group is *Juniperetum juniperoso-poosum (sterilis)*. The growing stock of forests of this association at the age of 80-100 years has height of 5-8 m and diameter of trunks 18-24 sm. The crown density of trees are 0.4-0.6. In the tree layer except Juniperus excelsa occasionally meets *Pistacia mutica, Quercus pubescens* and evergreen red smooth trunks *Arbutus andrachne*. The rare underbrush consists from *Juniperus oxycedrus* with an impurity as evergreen *Cistus creticus, Jasminum fruticans,* and summer-green *Paliurus spina-christi, Coronilla emeroides, Colutea cilicica*. The herbage, which projective covering approximately 40-60%, is characterised by alternation of more dense stains on sites with the generated soil cover and less dense on the rocks deprived of a layer of soils. Except dominating Poa sterilis (20-40%) in herbage formation accept considerable participation (projective covering is 5-20%) *Festuca callieri, Elytrigia nodosa, Carex halleri, Zerna cappadocica,* and in places with the washed off soil – *Teucrium chamaedrys Thymus dzevanovskyi. Botriochloa ischaemum, Inula ensifolia, Onobrychis miniata, Teucrium polium* play the smaller role (1-5%). With a small covering (to 1%) as a part of this association more than 100 species are noted, from which *Asparagus verticillatus, Campanula taurica, Dorycnium herbaceum, Dianthus humilis, Fumana procumbens, F. arabica, Poterium polygamum, Veronica multifida, Anthyllis taurica*, etc meet the most constantly. Characteristic feature of flora of these forests with wide circulation of the species having bulbs and tubers is: *Allium rupestre, Muscari racemosum, Scilla autumnalis, Crocus sussianus,* or tomentous leaves, for example *Alyssum rostratum, Convolvulus cantabrica, Jurinea sordida, Inula oculus-christi, Fibigia clypeata*. Their presence is caused by the fact that they are more adapted for transferring adverse for development of plants of the period of a summer drought, than other vital forms. The same reason it is necessary to explain presence in flora of the *Juniperus oxycedrus* forests of many annual plants, as, for example, *Coronilla scorpioides, Briza humilis, Crupina vulgaris, Helianthemum salicifolium, Trifolium scabrum, T. leucanthum, Sedum hispanicum, S. pallidum.*

On sites with more developed soils association *Juniperetum juniperoso-caricosum (halleranae)* is formed. Its herbage has a projective covering of 25-35% and in comparison with the previous is less broken and more mesophytic, though the majority of species at them are common. But in this association is pointed the increasing role of such species, as *Paeonia daurica, Dictamnus gymnostylus, Laser trilobum*, whereas *Elytrigia nodosa, Fumana procumbens, F. arabica, Inula oculus-christi, Teucrium polium* and the majority annual plants are rare or absent at all. On the steeper slopes with a thinned stand of trees under the influence of economic and recreational activity of man is formed an herbage with a predominance of *Elytrigia nodosa, Festuca callieri, Achnatherum bromoides*.

Forests of group of *Junipereta jasminosa* associations occupy more abrupt (to 40°) southern slopes with strongly washed off brown rubble-stony soils. Their stand of trees as a whole on specific structure did not differ from a stand of trees of the previous group of associations, but, as a rule, has a smaller crown density of trees. The shrubage is formed by Jasminum fruticans with individual participation *Juniperus oxycedrus, Cistus tauricus* and *Celtis glabrata*. The grassy cover also is mosaic, its covering fluctuates from 20 to 80%. On it in various associations prevail *Poa sterilis, Carex hallerana, Teucrium chamaedrys, Elytrigia nodosa,* etc. The distinctive feature of this group of associations from previous is the big role of annual plants, first of all such, as *Briza humilis, Helianthemum salicifolium, Sedum hispanicum, S. pallidum, Hippocrepis ciliata* and others. That explains big anthropogenous influence which strengthening conducts to change Juniperus forests groupings to shiblyak and savannoids vegetation, which is formed as well on a place of oak forests from *Quercus pubescens*.

Querceta pubescentis forests represent a link between Mediterranean evergreen and Central European broadleaf forests, reaching the greatest variety on the Balkans. The Crimean forests from *Quercus pubescens* (Figure 3.1.5) dominate in the lower zone of vegetation of southern and northern macroslope of the Main Ridge, and also foothills where occupy mainly southern, eastern and western slopes which are very dry, more rare on fresh brown and red-brown soils capacity 20-80 sm. Outside of the zone they leave only separate sites on the warmest slopes with developed enough soils, reaching heights of 600 m above sea level. Above 400-450 m above sea level on abrupt stony slopes and on rocks with an undeveloped soil cover and a thin soil layer they are replaced with pine forests from *Pinus pallasiana*, and within a zone of pine forests on less steeper slopes with well generated forest soils – forests from *Quercus petraea*. Forests from *Quercus pubescens* occupy 17% of the area of reserve. Their stand of trees coppice and seldom exceed age 80 years. In optimum ecological conditions at this age trees reach no more than 15 m of height. The most widespread are forests 60-80-year age, having height of a stand of trees of 8-12 m.

In YMFNR the territory of *Quercus pubescens* forests are presented by following subformations: *Querceta pubescentis, Carpineto (orientalis)-Querceta, Pistaceto-Querceta Junipereto-Querceta*. The forests of first two subformations are most widespread. They occupy about 90% of the area of forests of all zones. Forests of last two subformations occupy the insignificant areas, mainly in the lower part of a zone. Ecologically and floristically they represent transitive communities from *Quercus pubescens* to *Juniperus oxycedrus* to forests with which have the general dominant in grassy cover: *Poa sterilis, Elytrigia nodosa* and *Achnatherum bromoides.*

Forests of subformation *Carpineto-Querceta* are the most widespread in Yalta MFNR (Figure 3.1.6). *Carpinus orientalis* plays the role of co-edificator in them, which crown density is 0.7 that testifies, obviously, about disturbance. These forests are presented by following associations: *Carpineto (orientalis)-Querceta, Carpineto-Querceta ruscosa, Carpineto-Querceta juniperosa (oxycedris)* and *Carpineto-Querceta cornosa*. From them the greatest area (to 70% of forests of formation) is occupied with forests of group of associations *Carpineto-Querceta* and *Carpineto-Querceta ruscosa*. As a whole, these groups of associations develop in more or less similar eco-coenotic conditions and are presented by a number twin associations: *Carpineto-Quercetum ruscoso-caricosum (halleranae)* and accordingly *Carpineto-Quercetum caricosum (halleranae), Carpineto-Quercetum ruscoso-lithospermosum* and *Carpineto-Quercetum lithospermosum, Carpineto-Quercetum ruscoso-caricosum (cuspidatae)* and *Carpineto-Quercetum caricosum (cuspidatae), Carpineto-Quercetum ruscoso-achnatherosum* and *Carpineto-Quercetum achnatherosum, Carpineto-Quercetum ruscoso-dentariosum (quinquefoliae)* and *Carpineto-Quercetum dentariosum (quinquefoliae).* In the summer herbage of two last associations dies off, therefore many researchers allocate them as *Carpineto-Quercetum ruscoso-sparsiherbosum* and *Carpineto-Quercetum sparseherbosum*. The Most typical for fluffy-oak forests are the two first twin associations from which in reserve forests of the first association have the greatest area (Kriukova, 2005).

Figure 3.1.5. The Crimean forests from *Quercus pubescens.*

Forests of association *Carpineto-Quercetum ruscoso-caricosum (halleranae)* are distributed mainly in the bottom part of the bottom forest zone (to 400 m above sea level) on slopes of eastern, western and southern expositions a steepness to 20° with the developed brown soil. Their stand of trees has middle age of 60 years and height of trunks of 8-12 m. Except *Quercus pubescens* with a crown density 0,4-0,7 and *Carpinus orientalis* – 0.2-0.6 as a part of a stand of trees in a small amount meet *Acer campestre, Cerasus mahaleb, Juniperus excelsa, Fraxinus angustifolia*, etc. In an underbrush prevails *Ruscus ponticus* with a density 0.2-0.8. Except it occasionally meet *Crataegus curvisepala, C. microphylla, C. orientalis, Rosa canina, R. corymbifera, Mespilus germanica, Pyracantha coccinea, Ligustrum vulgare, Euonymus verrucosa*. Sometimes considerable participation is accepted by the lianas twisted highly on trunks of trees: *Hedera taurica* (to 40%) and *Clematis vitalba* (to 20%).

In some places *Carpinus orientalis* and *Ruscus ponticus* form the dense almost impassable thickets almost deprived of herbage. Except dominating *Carex hallerana* (20-50%) sometimes form rather big covering (5-20%) *Dentaria quinquefolia* and *Lithospermum purpureo-caeruleum*. With projective coverings of 1-5% and III—V classes of constant there are typical species of the broadleaf Submediterranean forests, such as *Althaea cannabina, Asparagus verticillatus, Calystegia sylvestris, Carex cuspidata, Luzula forsteri, Corydalis paczoskii, Crocus sussianus.* Less than 1% occupies *Dictamnus gymnostylis, Lathyrus laxiflorus, L. rotundifolius, Primula vulgaris, Ornithogalum fimbriatum, Scilla bifolia, Veronica umbrosa, Viola sieheana, Lapsana intermedia*. Characteristic feature is the relative abundance of Orchids: *Cephalanthera rubra, C longifolia, C damasonium, Epipactis helleborine, E. microphylla, Limodorum abortivum, Neottia nidus-avis, Orchis romana, O. pallens, O. mascula, O. provincialis, O. simia, Ophrys oestrifera, O. taurica, Platanthera chlorantha*. Often in these forests grow rare species: *Lathyrus digitatus, Paeonia daurica* and *Geranium tauricum*.

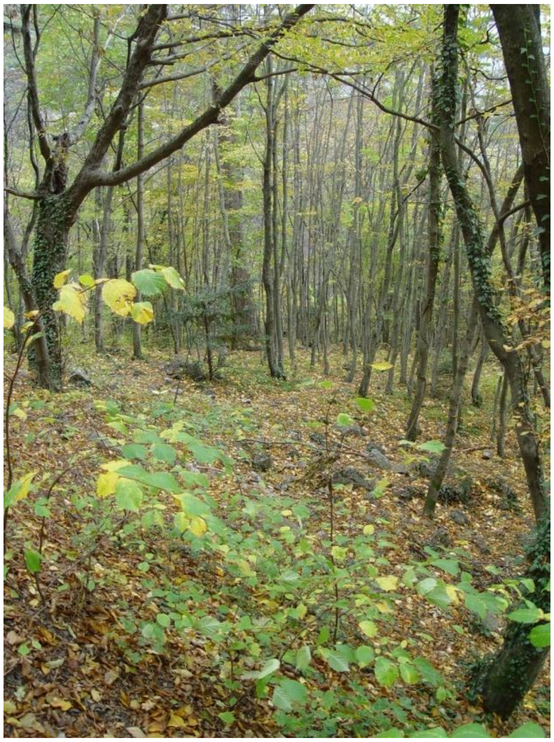


Figure 3.1.6. Forest of subformation *Carpineto-Querceta.*

Forests of association *Carpineto-Quercetum ruscoso-lithospermosum* are formed in more damp, less broken ecotope, than previous. As a whole the dense stand of trees and underbrush have the same characteristic features and specific structure, as in the previous association. In a grassy cover (40%), except dominating *Aegonychon purpureocaeruleum* (L.), *Holub (Lithospermum purpureo-caeruleum)* (20-30%) have a considerable covering (5-15%) *Carex hallerana, Dentaria quinquefolia* and *Luzula forsteri.* By a small covering (to 1%), but a high class of a constancy are characterised *Arum elongatum, Cephalanthera rubra, Epipactis microphylla, Geum urbanum, Geranium tauricum, Lathyrus laxiflorus, Lapsana intermedia, Paeonia daurica, Primula vulgaris, Viola sieheana* and other Submediterranean species.

Forests of association *Carpineto-Quercetum ruscoso-achnatherosum* are distributed in the lower part of a zone on southern slopes of various steepness with washed off very dry brown or is brown-red soils. Their stand of trees is rarefied and formed mainly by *Carpinus orientalis* and *Quercus pubescens.* It alternates with shiblyak thickets and the open glades occupied by savannoids with communities. In places shrubage forms *Ruscus ponticus* (to 0.2) with participation *Paliurus spina-christi, Rosa canina.* Enough dense (to 70%) the grassy cover forms *Achnatherurn bromoides*. In it typical species are mainly species of the *Juniperus oxycedrus* forests and savannoids vegetation: *Asparagus verticillatus, Asperula galioides, Convolvulus cantabrica, Dianthus marschallii, Eryngium campestre, Elytrigia nodosa, Galium verum, Medicago falcata, Ornithogalum fimbriatum, Teucrium chamaedrys,* etc.

Twin associations in which *Ruscus ponticus* is absent, are characterised by more dense grassy cover (to 60%), combined by the species mentioned above. They are distributed basically in an average and top part of the bottom zone where *Ruscus ponticus* does not rise any more.

The group associations *Carpineto-Querceta juniperosa (oxycedris)* is presented by association *Carpineto-Quercetum juniperoso-caricosum (halleranae).* Forests of this association are distributed in the western part of reserve (Opolznevoe and Alupka forest areas), where occupy dry southern slopes (to 30°) with limestones or slates on deep 20-40 sm from surface. They are characterised by the sparse stand of trees (0.6 0.8) formed except dominant *Quercus pubescens* and *Carpinus orientalis* by species, peculiar as *Quercus pubescens* to forests (*Acer campestre* and *Cerasus mahaleb*), and *Juniperus oxycedrus* (*Arbutus andrachne, Juniperus excelsa, Pistacia mutica*). An underbrush in these forests is rather thin (0.3). It is formed by *Juniperus oxycedrus* (0,2) with insignificant impurity *Colutea cilicica, Coronilla emeroides, Crataegus curvisepala, C. microphylla, Cornus mas, Rhus coriaria, Rosa canina, Jasminum fruticans, Ruscus ponticus*. Herbage is usually dense. Except dominating *Carex hallerana* (20-50%), the most constant species with a covering about 1-5% are *Brachypodium rupestre, Dactylis glomerata, Poa sterilis*, and less than 1% – *Cephalanthera rubra, Calystegia sylvestris, Crocus sussianus, Cirsium laniflorum, Elytrigia nodosa, Galium mollugo s. L, G. verum s. 1., Aegonychon purpureocaeruleum, Lathyrus laxiflorus. Lapsana intermedia, Ornithogalum ponticum, Veronica umbrosa, Viola siehana*, etc. There are very seldom orchids from the «Red Data Book of Ukraine»: *Comperia comperiana, Himantoglossum caprinum, Ophrys apifera, O. taurica* and *O. oestrifera*.

Forests of group of associations *Carpineto-Quercetum cornosum* occupy gentle slopes of northern and western expositions with the most damp forests well developed soils, and also valleys of the rivers with considerable deluvial deposits. There are they separate stains within all bottom zones, rising sometimes to border with hornbeam-beechen forests. To this group belong associations *Carpineto-Quercetum cornoso-caricosum (halleranae), Carpineto-Quercetum cornoso sparseherbosum, Carpineto-Quercetum cornoso-mercurialosum.* In the bottom part of the zone are distributed twin associations in which *Ruscus ponticus* forms the big density (to 0.4).

Association *Carpineto-Quercetum forests cornoso-mercurialosum* is most mesophytic among forests of a formation and in the ecology and floristic structure is close already to forests from *Quercus petraea.* The stand of trees and underbrush of the listed associations are characterised by higher crown density, than forests of the previous group of associations. In them do not meet any more most ksero- and termophilous formation of species, such as *Pistacia mutica, Juniperus excelsa, Arbutus andrachne, Cistus tauricus, Jasminum fruticans* and others, and appear, though and in a small amount, typical mesophytes. In a stand of trees it – *Fraxinus excelsior, Quercus petraea*, and in an underbrush – *Corylus avellana, Euonymus europaea, Berberis vulgaris* which together with *Juniperus oxycedrus, Crataegus curvisepala* and others are added to dominating *Ruscus ponticus* and *Cornus mas*. Considerable participation in these forests is accepted by lianas, especially *Hedera taurica* and *Clematis vitalba*. Grass stands rather thin. Its characteristic feature is presence along with photophilous species of a considerable quantity of shade plants, such as *Arum albispathum, Brachypodium sylvaticum, Geum urbanum, Lapsana intermedia, Primula vulgaris, Mercurialis perennis, Paeonia daurica, Polygonatum odoratum, Viola sieheana.*

Forests of subformation *Querceta pubescentis* in the reserve are distributed only on rather sloping slopes with well expressed soil cover. They have narrower eco-coenotic amplitude and occupy considerably smaller areas, than forests of subformation *Carpineto-Querceta*. Obviously, the last were generated basically on their place as a result of activity of the person. In this connection both subformations in ecological and floristic relations have many common features. Difference between forests of subformation *Querceta pubescentis* consists mainly in higher site classe of their stand of trees, the best crown density and absence of such species, as *Achnatherum bromoides, Elytrigia nodosa,* and some annual plants. The subformation is presented by following groups of associations: *Querceta ruscosa, Querceta juniperosa (oxycedis)* and *Querceta jasminosa*. From them forests of the first are distributed fragmentary among forests of subformation *Carpineto-Querceta* and do not occupy the considerable area. In the floristic structure they are very close to forests of group of associations *Carpineto-Querceta ruscosa*.

Forests of group of associations *Querceta juniperosa (oxycedris)* (Figure 3.1.7), presented by two associations are more widespread: *Quercetum juniperoso-caricosum (halleranae) and Quercetum juniperoso-brachypodiosum (rupestris)*. They occupy dry slopes of the top part of the bottom zone, in places of contact *with Pinus pallasiana* forests where it is noted basically for lower heights, and, unlike association *Carpineto-Quercetum caricosum (cuspidatae),* occupy less steeper slopes with more powerful soils and it is characterised by more close and productive layer from *Quercus pubescens*. In a stand of trees of the second association having a density 0.8, constant companions of *Quercus pubescens* are *Carpinus orientalis* and *Acer campestre*. The shrubage (0.2) forms of *Juniperus oxycedrus* among which are scattered individual or small groups of *Cornus mas, Coronilla emeroides, Mespilus germanica, Rosa canina, Sorbus aucuparia*. Grass stand is rather dense.

The role of *Brachypodium rupestre* (20-40%) is well expressed; the covering of other species does not exceed 1%. Among them are constant the typical species *of Quercus pubescens* forests: *Carex hallerana, Aegonychon purpureocaeruleum, Crocus sussianus, Lathyrus nissolia, Viola sieheana* and many others, and also species of *Pinus pallasiana* forests: *Campanula bononiensis, Cirsium laniflorum, Laser trilobum, Teucrium chamaedrys,* etc.

The group of associations *Quercetum jasminosum* is presented only by association *Quercetum jasminoso-poosum (sterilis)* which forests are dated for less developed soils, than the previous association of the bottom and average part of the bottom zone. The stand of trees has a low crown density (0.6). Except *Quercus pubescens,* in it *Carpinus orientalis, Fraxinus angustifolia, Pinus pallasiana* meet*.* The shrubage is rather dense, but has a non-uniform covering as thickets *Jasminum fruticans* alternate with open places. A grassy cover is dense (60-70%). Its usual species except *Poa sterilis* (40-60%) are A*llium rupestre, Asperula galioides, Alyssum tortuosum, Carex hallerana, Convolvulus cantabrica, Dorycnium herbaceum, Dactylis glomerata, Dictamnus gymnostylis, Elytrigia nodosa, Galium mollugo s. 1., Fibigia clypeata, Lathyrus laxiflorus, Sedum hispanicum, Teucrium chamaedrys,* etc.

Figure 3.1.7. The association *Querceta juniperosa* and *Juniperus excelsa.*

Forests of subformation *Pistaceto-Querceta* are distributed only in the bottom part of the bottom zone of vegetation on southern very dry and well warmed up slopes with developed enough brown soils. They are presented by two associations: *Pistaceto-Quercetum elytrigiosum (nodosae)* and *Pistaceto-Quercetum achnatherosum*. These forests are, on the one hand, a link between *Quercus pubescens* forests and Mediterranean evergreen maquis in this connection represent in Crimea the most thermophilic variant of oak forests, and with another – an extreme link succession of some the pistachio-oak forests, binding these forests with shiblyak and savannoids. The stand of trees of forests of these associations low also is strongly rarefied (0.4-0.6). Except *Quercus pubescens* and *Pistacia mutica* into it enter *Acer campestre, Carpinus orientalis, Juniperus excelsa* and *Arbutus andrachne*. The layer of bushes is not expressed. There are only individual shrubs *Paliurus spina-christi, Jasminum fruticans, Ruscus ponticus, Juniperus oxycedrus* and other Submediterranean species. Herbage dense is 60-70%. Its characteristic feature is well expressed role of the dominant *Achnatherum bromoides* and *Elytrigia nodosa*. Except them, *Althaea cannabina, Asparagus verticillatus, Asperula galioides, Eryngium campestre, Festuca callieri, Galium verum, Medicago falcata, Ornithogalum fimbriatum, Teucrium chamaedrys, T. polium, Xeranthemum cylindraceum* and many other species, including species of savannoids vegetation are constantly meet here.

Very often forests of formation *Querceta pubescentis* under the influence of concentrated activities of the person strongly thin. *Quercus pubescens* and *Carpinus orientalis* get undersized the bush form, forming low to 2 m of thicket with participation *Paliurus spina-christi, Rosa corymbifera, R. canina, Cistus tauricus,* etc. They alternate with sites savannoids vegetation. In the literature such thickets are known under the name «shiblyak». Further at stronger influence of the anthropogenous factor when forest and shrub species any more in a condition to be restored, «shiblyak» it is replaced by savannoids vegetation.

In reserve savannoids are dated for the bottom zone of vegetation where forests have been shown. Their area makes 3-4% of the area of reserve. Characteristic feature of savannoids is prevalence of ephemeroids and ephemers (in most cases cereals), developing in the spring and in the autumn. These communities usually have dense herbage with a projective covering to 80 and even 100%, in height 20-90 sm and consist of two or three sublevels. The first in height to 60-90 sm is formed by one or several species of perennials: *Hordeum bulbosum, Achnatherum bromoides* and *Elytrigia nodosa*. Second and third denser of a sublevel consist from annual plants: *Aegilops biuncialis, A. triuncialis, Bromus squarrosus, Hordeum leporinum, H. muricatum, Avena trichophylla, Poa bulbosa, Vulpia ciliata, Zerna sterilis, Trifolium leucanthum, T. scabrum, Vicia bithynica, Xeranthemum annuum*, etc. Most frequent except the specified species in savannoids groupings with a covering nearby 1% are the grassy perennials: *Anthemis monantha, Convolvulus cantabrica, Dianthus humilis, D. marschallii, Dactylis glomerata, Dorycnium herbaceum, Eryngium campestre, Medicago falcata, Poterium polygamum,* and also a great number Mediterranean annual plants: *Bombycilaena erecta, Crupina vulgaris, Linum lutecium, Medicago arabica, M. agrestis. Trigonella gladiata, Trifolium angustifollum, T. lappaceum, Hippocrepis ciliata,* etc. On stony exposures with not developed soils in savannoids vegetation groupings of stony steppes and tomillares are interspersed. The most usual dominants of stony steppes are *Festuca callieri* and *Stipa lithophila*, and tomillares – *Thymus callieri, Th. tauricus, Helianthemum stevenii*. The communities formed by them are characterised by rarefied grassy or shrubs (to 60%) by a layer in which structure there are the same grassy perennials, as in savannoids whereas annual plants any more do not play the big role.

Forests from a crimean pine (*Pineta pallasianae*) (Figure 3.1.8 a, b) are distributed in the East Mediterranean. In the Western Balkans and the Alpes these forests are replaced with forests from close species *P. nigra*, stretched in the north to the south of Austria. These forests in Central Asia rise to height of 1600 m, in east Alpes and the Balkans – to 1500 m and in Crimea – to 1200 m above sea level.

In Crimean Mountains the northern border of distribution of *Pinus pallasiana* forests in Ukraine are passes. In reserve they form the continuous well expressed average zone from Simeiz vill. to Krasnokamenka vill. within heights from 400-450 to 800-950 m above sea level, rising separate languages to most yailas.

They are known for stony, often steep slopes with skeletal low developed brown soils and rocks on which grow in their crevices, forming low productivity light forests. On conditions of humidifying they occupy dry and fresh soils.

a b

Figure 3.1.8. The *Pinus pallasiana* forests.

Outside of reserve these forests meet only in rather small separated files. After cabins and fires they are badly restored, therefore their area in Mountain Crimea is reduced. At the bottom border of distribution *Pinus pallasiana* forests on dry stony habitats are replaced by Juniperus oxycedrus, and in places with more developed soil cover – *Quercus pubescens* forests. At the top border in eastern part of reserve they are changed by forests from *Pinus sosnovskyi*, and on other part – hornbeam-beechen forests are observed. Forests of *Pinus pallasiana* are most distributed and make more than 35% of the area of reserve or 4% of all forests of Crimea. Prevail among them 100-120-year a stand of trees in height to 20 m and a crown density – 0.7-0.8; there are sites with majestic 200-230-year trees in height of 23-28 m.

Pinus pallasiana forests are various enough and depending on co-dominants breeds can be carried to six subformations: *Pineta pallasianae, Querceto (pubescentis)-Pineta, Querceto (petraeae)-Pineta, Carpineto (betulii)-Pineta, Fageto (orientalis)-Pineta and Acereto (stevenii)-Pineta*. In character of their distribution the following general law is traced. Forests of the first subformation are formed on the poorest and least developed soils mainly an average part of a zone where they form the basic background of forests of a formation, getting into the bottom and top parts of a zone in the form of separate files. On more powerful and dry soils of the bottom part of a zone they are replaced by forests of subformation Querceto (pubescentis)-Pineta, and in the top part of a zone – *Querceto (petraeae)-Pineta*, and then with height increase above sea level and the general humidity of conditions of growth *Carpineto-Pineta, Fageto-Pineta* and *Acereto-Pineta*.

From them forests of subformation *Pineta pallasianae*, components about 70% of the area of forests of a formation are most distributed. They are presented by four groups of associations: *Pineta pallasianae, Pineta cotinosa, Pineta juniperosa (oxycedris)* and *Pineta cornosa*. In an ecological number the first group of associations occupies the central position. In comparison with it on drier soils forests Pineta cotinosa, and more low on warmer slopes – forests *Pineta juniperosa* are formed. In more damp conditions forests of *Pineta cornosa* grow.

The greatest area in reserve is occupied with forests of the first group of associations the central position among which belongs to association *Pinetum forests brachypodiosum (rupestris),* growing in optimum ecological conditions. They are marked for the bottom and average part of a zone where occupy the habitats most typical for a formation whith slopes of a various exposition a steepness to

40° and their tops with brown detritus soils capacity of 20-50 sm and exits on a surface of fragments of rocks are. The stand of trees of these forests has middle age of 80-120 years, height of 20-24 m and a crown density 0.7-0.9. Sometimes there are 250-year-old plantings of park character. The first layer is formed exclusively by *Pinus pallasiana* under which bed curtains there are in strong a depression individual trees *Quercus pubescens, Q. petraea, Carpinus betulus, Fagus orientalis, Acer campestre*. The underbrush, as a rule, is not generated. In it the separate scattered shrubs or small trees *Cotinus coggygria, Crataegus curvisepala, C microphylla, Ligustrum vulgare, Rosa canina, R. tschatyrdagii, Sorbus graeca, S. torminalis* grow only. From lianas occasionally meet *Hedera taurica* and *Clematis vitalba*. Herbage usually dense also has a projective covering of 70-80%. The grass stand is formed by *Brachypodium rupestre* (30-60%) with considerable, places to 20%, participation *Inula ensifolia*, *Teucrium chamaedrys* and *Pteridium tauricum*. Constants for these forests are the Submediterranean species: *Cirsium laniflorum, Dorycnium herbaceum, Inula conyza, Carex cuspidata, Laser trilobum, Laserpitium hispidum, Lithospermum purpureo-caeruleum, Vincetoxicum laxum, Viola sieheana* and others, including petrophytes: *Allium saxatile, Asperula galioides, Bupleurum exaltatum, Centaurea declinata, Inula aspera, Pimpinella lithophila.* For forests of this association are characteristic and endemic species: *Campanula taurica, Cytisus wulfii, Elytrigia strigosa, Galium tauricum, Genista albida, Jurinea sordida*. In insignificant flat depressions with more powerful soil layer the considered forests are replaced with *Pinetum pteridosum* forests association (Figure 3.1.9) in which the role of petrophytes decreases, and the role of nemoral species, such *as Convallaria majalis, Euphorbia amygdaloides, Potentilla breviscapa, Polygonatum odoratum, Primula vulgaris, Platanthera chlorantha, Salvia glutinosa, Viola odorata* increases too. Characteristic feature of its herbage well expressed prevalence *Pteridium tauricum*, which is forming a continuous background.

In the top part of a zone on abrupt (to 40°) slopes with less powerful soil layer in dry conditions of humidifying association *Quercetum forests laserosum*, and in more damp – *Quercetum physospermosum* are formed. As well as in the previous associations, the crown density of these forests are high and makes 0.8-1.0. Characteristic feature of their stand of trees is appreciable participation *Quercus petraea* that connects them with subformation *Querceto (petraeae)-Pineta*. In not expressed layer of underbrush meet individual *Crataegus curvisepala, Cornus mas, Rosa canina, R. tschatyrdagii, Sorbus aucuparia*. In a rather thin grassy cover except dominating *Laser trilodum* and *Physospermum cornubiense* along with the Mediterranean species the big participation is accepted also by species European broadleaf forests: *Clinopodium vulgare, Cephalanthera rubra, Euphorbia amygdaloides, Laserpitium hispidum, Hypopitys monotropa, Polygonatum odoratum, Viola mirabilis,* etc.

In the uppermost part of a zone, on a crest and slopes adjoining to them with low-power brown soils on limestones association *Pinetum forests caricosum (humilis)* which comes into an overlying zone is formed. These are old 180-200-year forests with height of a stand of trees 18-25 m and rather low crown density (0.6-0.8). In their forest stand insignificant participation accept *Fagus orientalis, Carpinus betulus* and in east part of reserve (Avinda) – *Pinus sosnovskyi*. In not generated underbrush occasionally *Crataegus curvisepala, Rosa canina, R. tschatyrdagii, R. spinosissima, Sorbus graeca, S. aucuparia is* met.

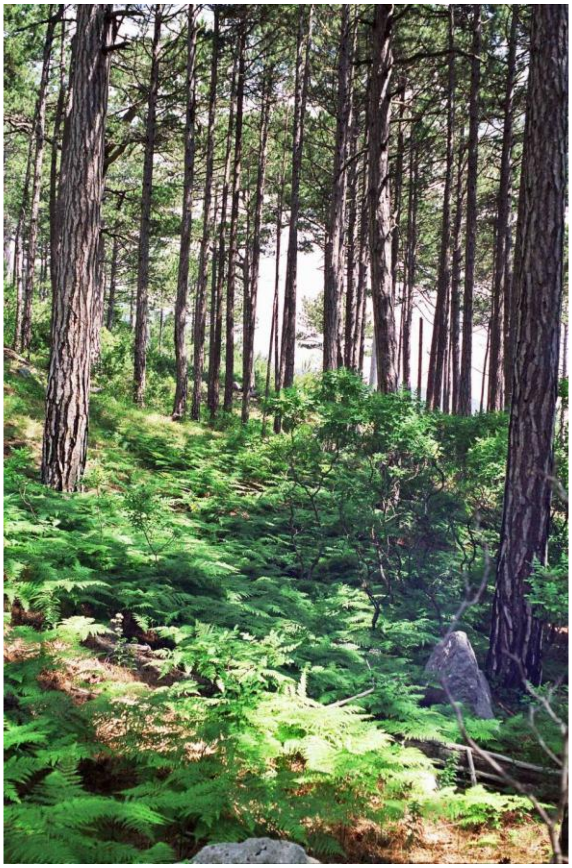


Figure 3.1.9. *Pinetum pteridosum* forest association.

In dense herbage *Carex humilis* (50%) prevails. In its structure a number widespread at lower heights of the Submediterranean species (*Carex hallerana, C cuspidata, Lithospermum purpureo-caeruleum, Dorycnium herbaceum, Viola sieheana*) are absent. Photophilous species of meadow steppes and stony exposures, such as *Filipendula vulgaris, Asphodeline lutea, Alyssum rostratum, Androsace taurica, Aster amelloides, Cephalaria coriacea, Anthericum ramosum, Geranium sanguineum, Ferulago taurica, Hypericum linarioides, Peucedanum tauricum, Pulsatilla taurica, Pedicularis sibthorpii, Scabiosa columbaria, Sideritis taurica*, etc. start to play the leading part. Appear also not meeting in low levels boreal species: *Orthilia secunda, Pyrola chlorantha, Goodyera repens*.

Forests of group of association *Pineta cotinosa* occupy very abrupt (to 40°) rocky slopes. They are characterised concerning narrow eco-coenotic by amplitude and presented by association *Pinetum cotinoso-brachypodiosum*. Its tree layer has rather low crown density (0.5 0.7). In a layer of an underbrush except dominating *Cotinus coggygria* (0.2-0.6) grow also *Pyracantha coccinea, Cotoneaster integerrima, Coronilla coronata, Rhus coriaria, Crataegus curvisepala, C. microphylla, Sorbus aucaparia, S. graeca*, etc. In a grassy cover dominate *Brachypodium rupestre* (40-70%). Together with it most constantly meet *Bupleurum exaltatum, Cephalaria coriacea, Elytrigia strigosa, Inula ensifolia, Teucrium chamaedrys, Boromopsis cappadocica* and a number of others. Some usual for the first group of associations species (*Centaurea declinata, Galium verum, Filipendula vulgaris, Primula vulgaris, Platanthera chlorantha*, etc.) do not meet here.

Forests of group of associations *Pineta cornosa* occupy the most flat for this formation slopes of the bottom and top part of zone on which are formed depending on insignificant increase in humidity of soils of association *Pinetum cornoso-brachypodiosum, Pinetum cornoso-lithospermosum, Pinetum cornoso-physospermosum*. They have a various density a stand of trees (0.6-1.0) with appreciable participation (to 0.2) *Quercus pubescens, Q. petraea* and a dense underbrush which form *Cornus mas* (0.3-0.7) with insignificant participation *Crataegus curvisepala, Sorbus aucuparia, Ligustrum vulgare, Euonymus verrucosa, E. europaea, E. latifolia, Rosa canina*. In rare herbage (25-35%) except prevailing in corresponding associations of the dominant species are *Brachypodium rupestre, Lithospermum purpureo-caeruleum, Physospermum cornubiense*. Characteristic species for twin associations *Pinetum brachypodiosum, Pinetum lithospermosum, Pinetum physospermosum*, such as *Carex digitata, Euphorbia amygdaloides, Goodyera repens, Lapsana intermedium, Neottia nidus-avis, Paeonia daurica, Viola sieheana,* etc are usual here.

In the bottom part of a zone in the driest for formation conditions of slopes of a southern exposition with undeveloped brown soils forests of group of associations *Pinetum juniperosum (oxycedris)*, being a link with *Juniperus oxycedrus* forests with which they pull together by a generality of floristic structure and rather small ecological distinctions are distributed fragmentary. Their stand of trees has a low density (0.6-0.7). As an exception can be met *Juniperus excelsa*.

In rare underbrush from *Juniperus oxycedrus* sometimes *Cotoneaster integerrima, Cotinus coggygria, Rhus coriaria, Coronilla emeroides, Jasminum fruticans, Ligustrum vulgare, Rosa spinosissima,* and also shrub forms *Quercus pubescens* and *Carpinus orientalis* meet. In dense herbage dominates *Brachypodium rupestre* (60%) except photophilous species both forest, and open places are richly presented: *Asperula galioides, A. stevenii, Centaurea sterilis, C. declinata, Cirsium laniflorum, Dorycnium herbaceum, Inula aspera I. ensifolia, Galium tauricum, Poa sterilis, Teucrium chamaedrys, Thymus callieri, Carex cuspidata, Lithospermum purpureo-caeruleum, Bromopsis cappadocica*.

Forests of subformation *Querceto (pubescentis)-Pineta* grow in the bottom part of zone within heights of 400-600 m above sea level, occupying, as well as the previous group of associations, the driest and warm for forests of a formation slopes with brown, but more developed soils capacity 30-60 sm. They are presented by four groups of associations forming a number, similar to groups of associations of the considered subformation: *Querceta-Pineta, Querceto-Pineta cotinosa, Querceto-Pineta juniperosa, Querceto-Pineta cornosa.*

The first most widespread group of associations is presented by association *Querceto-Pinetum brachypodiosum.* It, as well as forests of other groups of associations, has a two-story stand of trees with the general crown density 0.9-1.0. In the first layer in height of 20-25 m undividedly dominates *Pinus pallasiana*, and in the second low (6-12) and less close layer – Quercus *pubescens, Carpinus orientalis.* The underbrush as a layer is not expressed. In it there are the separate shrubs noted for the previous group of associations. In very dense herbage with prevalence *Brachypodium rupestre* (40-80%) are most usual typical Submediterranean species: *Cirsium ianiflorum, Dictamnus gymnostylis, Dorycnium herbaceum, Geranium tauricum, Laser trilobum, Laserpitium hispidum, Lithospermum purpureo-caeruleum, Limodorum abortivum, Paeonia daurica, Physospermum cornubiense, Viola sieheana* and others, and also species of stony exposures: *Asperula galioides, Inula ensifolia, Thymus callieri, Teucrium chamaedrys.*

Other groups of associations having insignificant distribution, as a whole are similar to groups of associations of subformation *Pineta pallasianae* from which differ mainly by presence of well generated second layer of a stand of trees and bigger degree of participation in formation of herbage species of the *Quercus pubescens* forests. The last in these forests, except for *Carex cuspidata*, do not dominate, and meet as an impurity to group of associations *Brachypodium rupestre*.

Forests of subformation *Querceto (petraeae)-Pineta*, the zones distributed in the top part where occupy slopes of a various steepness and an exposition with rather developed brown soils. They are formed by the same number of groups of associations, as well as at the previous subformation in which certain law in formation of forests of a formation is shown. These are following groups of associations: *Querceto (petraeae)-Pineta, Querceto-Pineta cotinosa, Querceto-Pineta cornosa*.

The group of associations *Querceto (petraeae)-Pineta* occupies in an ecological number, as well as similar groups of associations of the previous subformations, the central position and is the most widespread. It is presented by associations *Querceto-Pinetum brachypodiosum, Querceto-Pinetum laserosum* and *Querceto-Pinetum physospermosum*. In comparison with the first, second and third associations are formed in slightly more damp conditions. All associations have a two-story stand of trees with a high crown density (0.9-1.0). The first more close layer in height forms of 20-28 m *Pinus pallasiana*, and the second low layer (5-15 m) – *Quercus petraea* with small impurity *Carpinus betulus*, *Fagus orientalis, Acer campestre*. In underbrush there are single shrubes *Cornus mas, Cotinus coggygria, Euonymus europaea, E. verrucosa, Rosa canina, R. tschatyrdagii, R. spinosissima, Mespilus germanica, Sorbus graeca*. In herbage of the first association dominates *Brachypodium rupestre.* In comparison with herbage of two other associations it is denser (40-60%) also is characterised by the best expressiveness of a dominant rolet. Therefore other species, which overwhelming majority grow and in two mentioned associations, meet here not often. These are *Laser trilobum, Physospermum cornubiense*, dominating in these associations, and also *Cirsium laniflorum, Carex cuspidata, C. hallerana, Dictamnus gymnostylis, Dactylis glomerata, Euphorbia, amygdaloides, Laserpitium hispidum, Platanthera chlorantha, Polygonatum odoratum, Primula vulgaris, Scabiosa columbaria, Teucrium chamaedrys, Viola mirabilis, V. reichenbachiana, V. alba, V. odorata, V. sieheana.*

Forests of group of associations *Querceto (petraea)-Pineta cotinosa* occupy steeper slopes with exits of calcareous rocks. They are presented by association *Querceto-Pinetum cotinoso-physospermosum* which from twin associations of the previous group of associations differs basically by well expressed dense layer of underbrush formed by low thickets *Cotinus coggygria* with insignificant participation *Crataegus curvisepala, Cornus mas, Piracantha coccinea, Rosa canina, R. tschatyrdagii, Sorbus aucuparia, S. graeca,* etc. Herbage rather is rare. Its projective covering does not exceed 30% and is formed almost completely by a dominant. Other species meet individually: *Brachypodium rupestre, Dictamnus gymnostylis, Galium verum, Lithospermum purpureo-caeruleurn, Laser triloburn, Paeonia daurica, Teucrium chamaedrys, Viola mirabilis, V. reichenbachiana, V. alba* etc.

Forests of group associations *Querceto-Pineta cornosa* occupy gentle slopes and insignificant falls with brown soils capacity 40-60 sm are presented by association *Querceto-Pinetum cornoso-lithospermosum* which stand of trees of forests, unlike a stand of trees of forests of the previous group of associations, is characterised by higher degree of a crown density of the second layer, than the first. The underbrush dense and on the specific structure almost does not differ from described above. Changes only the cenotic role of *Cornus mas*, having a density 0.4-0.6. Herbage of this association is very rare. Except a dominant, which projective covering does not exceed 15-20%, in it with a covering less than 1% there are typical species of the Submediterranean and European forests, such as *Brachypodium rupestre, Convallaria majalis, Carex digitata, Dictamnus gymnostylis, Laser trilobum,* *Laserpitium hispidum, Neottia nidus-avis, Paeonia daurica, Physospermum cornubiense, Viola alba, V. mirabilis, V. odorata, V. sieheana,* etc.

Forests of subformations Fageto-Pineta, Carpineto-Pineta, Acereto (stevenii)-Pineta, distributed fragmentary in a strip of contact of pine forests with beechen, hornbeam and maple. They are characterised by two-story stand of trees in which the second layer form broadleaf forests. Herbage in these forests is very rare. In it the leading part is played by not exactly Submediterranean species and usual species of broadleaf forests: Asperula odorata, Mercurialis perennis, Convallaria majalis. In the spring in their herbage the continuous carpet dominates Dentaria quinquefolia, forming on separate sites.
Forests from the Sessile oak (*Querceta petraea*) are distributed to territories of the Central Europe up to southern Scandinavia. In the Alpes and on the Balkans they rise to height of 1200 m above sea level. In Crimea on northern macroslope of the Main Ridge they form zone of *Quercus petraea* forests, 550-750 m located within heights above sea level (Figure 3.1.10). In YMFNR they are dated for an average and top part of an average forest zone (600-850 m above sea level), where occupy slopes of a various exposition with steepness to 20 and 30° with brown more or less well generated soils capacity 40-120 sm. The degree of humidifying of a condition in which these forests grow is fresh and damp. Probably that in territory of reserve they were generated on a place of the mixed oak-pine forests as a result of cutting down and fires of the last. On border of average and top zones in more damp conditions these forests are replaced by mixed hornbeam-oak and beechen-oak forests. Rock-oak forests occupy about 2% of the area of reserve. They have middle age of 50-60 years, height of trunks of 14-16 m, a crown density 0.7-1.0.

These forests are presented by a small number of associations from which the most widespread is *association Quercetum poosum (sterilis),* characteristic for eastern part of the reserve where the basic files of forests of a formation are concentrated. Forests of this association are dated to rather sloping (to 20°) to slopes of a various exposition and their tops with well developed brown soils. Their stand of trees has a crown density 0.9-1.0 and is formed by Quercus petraea with small impurity *Acer campestre, Carpinus betulus, Pinus pallasiana,* is more rare *Fagus orientalis, Pyrus communis, Cerasus avium*. The underbrush layer is very rare or is not expressed. Occasionally in it meet *Mespilus germanica, Cornus mas, Cotinus coggygria, Crataegus curvisepala, C. microphylla, Rosa canina, Sorbus aucuparia.* Often there is *Hedera taurica* rising on trunks on height to 10 m. The herbage is dense. Its projective covering fluctuates from 40 to 80%. In its formation except a dominant of *Poa sterilis* (with a projective covering 1-10%) there is appreciable participation of *Carex cuspidata, Luzula forsteri, Lithospermum purpureo-caeruleurn* and *Vicia cassubica*, a smaller role play *Lathyrus laxiflorus, L. rotundiiolius, L. aureus, Orchis romana, Clinopodoium vulgare, Carex digitata, Dactylis glomerata, Dentaria quinquefolia, Hieracium gentile, Lapsana intermedia, Neottia nidus-avis, Platanthera chlorantha, Primula vulgaris, Veronica officinalis V. umbrosa, Viola mirabilis, V. odorata, V. reichenbachiana, V. siehean*a, both other Submediterranean and Central European species of deciduous forests.

Figure 3.1.10. The *Quercus petraea* forest.

Association *Quercetum forests lathyrosum (aurii),* formed in more damp conditions have considerably smaller distribution. Their stand of trees differs from described above only by bigger density and better expressed role of *Carpinus betulus*. The underbrush layer is not formed; meeting separate shrubs belong to same species, as at the previous association. In herbage dominates *Lathyrus aureus*, it is not dense (30-40%). It differs from herbage of the previous association by strengthening role of mesophytes *Euphorbia amygdalioides, Physospermum cornubiense, Potentilla breviscapa, Tamus communis, Bromopsis benekenii* and even presence of hygromesophytes (*Carex sylvatica*) and reduction of role of xero-mesophytes. For example, in these forests there are no almost met *Carex cuspidata, Lathyrus laxiflorus* and *Lithospermum purpureo-caeruleum*.

Forests of subformations *Carpineto-Quercetum, Fageto-Quercetum* occupy the insignificant space. They are characterised by very close shady stand of trees with participation to 50-60% from the general structure of stand of trees *Carpinus betulus* or *Fagus orientalis*. Occasionally meet also *Fraxinus excelsior, Populus tremula, Acer campestre*. In underbrush it is possible to meet separate shrubs far scattered from each other of *Euonymus europaea, E. latifolia* and *Rosa canina*. In rare herbage dominates *Lithospermum purpureo-caeruleum* in the summer and *Dentaria quinquefolia* in the spring. Other species have a projective covering less than 1%. There are *Brachypodium sylvaticum, Carex digitata, Cephalanthera rubra, Colchicum umbrosum, Convallaria majalis, Mercurialis perennis, Lathyrus rotundifolius, Euphorbia amygdaloides, Physospermum cornubiense, Salvia grandiflora, Veronica umbrosa, Viola sieheana, V. odorata*, both other Central European and Submediterranean species broadleaf forests.

Next types are forests of *Fagus orientalis* (Figure 3.1.11) and *Carpinus betulus*. The first are distributed in mountains of East Submediterranean at height of 800-2000 m above sea level. In the Western Europe *Fagus orientalis* it is replaced with close species *F. sylvatica*, the border of areas between which passes through Balkan Peninsula and Crimea. Forests from *Carpinus betulus* have area in general similar to area of beechen forests. They are secondary and were generated on place of hornbeam-beechen and hornbeam-oak forests. In Crimean Mountains the beechen forests and hornbeam forests on northern macroslope of the Main Ridge form the top forest zone at height of 700-1300 m above sea level.

Figure 3.1.11. The *Fagus orientalis* forest.

In reserve these forests grow basically in east part on brown and dark-brown soils capacity of 20-150 sm, in hollows, gorges and on northern rather sloping slopes of the top part of the macroslope at height of 800-1300 m above sea level, and also in the most lowered landlocked elements of land forms of yaila. Except pure beechen forests in reserve the considerable areas occupy hornbeam-beechen forests in which *Carpinus betulus* forms the second layer. Beechen and hornbeam-beechen forests occupy about 7% of the area of reserve, and hornbeam forests – 5%. The first have age of 80 90 years, height to 20-22 m and a crown density 0.9-1.0, and hornbeam – 60-80 years, height of 12-18 m and the same crown density.

Beechen and hornbeam-beechen forests are presented by twin associations: *Fagetum sparsaeherbosum* and *Carpineto-Fagetum sparsaeherbosum, Fagetum mercurialosum* and *Carpineto-Fagetum mercurialosum, Fagetum asperulosum* and *Carpineto-Fagetum asperulosum*.

The central in an ecological number and the most widespread in the first pair twin are the associations formed in optimum for beechen and hornbeam-beechen forests conditions of growth with well generated powerful and damp brown soils. Except *Fagus orientalis* and *Carpinus betulus*, forming in hornbeam-beechen forests the second layer with a crown density 0.2-0.6, constantly meet also *Fagus sylvatica, Acer stevenii, Populus tremula.* The underbrush layer is absent. In it sometimes meet only *Taxus baccata, Euonymus europaea, E. latifolia, Rosa canina.* In herbage it is plentifully presented *Dentaria quinquefolia*, forming in places a continuous covering in the spring. At this time are flowering *Corydalis paczoskii, Galanthus plicatus, Scilla bifolia*. To the beginning of summer these species die off also herbage strongly thins. Its projective covering does not exceed 10% in the summer and is formed *Asperula odorata, Arum elongatum, Convallaria majalis, Cephalanthera rubra, C.*

damasonium, Euphorbia amygdaloides, Lathyrus aureus, Mercurialis perennis, Neottia nidus-avis, Polygonum odoratum, P. polyanthemum, Poa nemoralis, Paeonia daurica, Physospermum cornubiense, Platanthera chlorantha, Viola mirabilis V. odorata, Bromopsis benekenii, etc.

In the top part of a zone close to yaila slopes with brown soils and exits of limestones association *Fagetum forests mercurialosum* and *Carpineto-Fagetum mercurialosum* are formed. The layer of their stand of trees on specific structure does not differ from a stand of trees of the previous associations, but considerably concedes to them on productivity (in biomass) and, as a rule, has the smaller crown density equal 0.8-0.9. The underbrush layer is absent. In rather dense and well generated and much richer species, than at the previous association herbage, dominates *Mercurialis perennis* (20-40%). Usual besides specified above spring species also are *Asperula odorata, Allium auctum, Anthriscus sylvestris, Delphinium pallasiana, Euphorbia amygdaloides, Dactylis glomerata, Galium mollugo, Geum urbanum, Mycelis muralis, Lamium laevigatum, Salvia glutinosa, Symphytum tauricum*, etc.

In the most lowered negative sites of a relief (karstic funnels, hollows) association *Fagetum forests asperulosum, Carpineto-Fagetum asperulosum* are distributed. They grow in richer, than the previous association, conditions and are characterised by more productive stand of trees with higher crown density. In dense enough herbage besides dominant is *Asperula odorata* (20-50%), appreciable participation accepts *Mercurialis perennis* (5-20%), and in the spring *Dentaria quinquefolia* (20-40%). More light-requiring species, noted for the previous association, such as *Allium auctum, Galium verum, Vincetoxicum scandens*, drop out of herbage, and there are more shade-requiring – *Corailorhiza trifida, Dryopteris filix-mas, Hypopitys monotropa, Ranunculus constantinopolitanus*.

Hornbeam forests in comparison with the beechen occupy a little drier condition. They were generated on a place of hornbeam-beechen forests and from the last differ by a single-tier stand of trees, participation of *Fagus sylvatica*, not exceeding 10% of its structure, and more constant presence of *Quercus petraea*. In their herbage prevail *Mercurialis perennis, Asperula odorata* with participation of characteristic species for beechen forests.

In a complex with beechen forests there are also small sites of forests from *Acer stevenii* with the herbage formed by species typical for beechen forests. Obviously, these forests were formed on a place of beechen as a result of cabins.

Forests from pine Sosnovsky (*Pineta sosnovskyi*) are characteristic for mountains of all Submediterranean. In the Alpes, the Balkans they grow at height of 800-1500 m, in Asia Minor – above 1400 above sea level. In the Crimean Mountains they are distributed in the form of narrow often faltering strip at height of 1000-1300 m above sea level, replacing at these heights with more frigid climate in poor soil conditions forest from *P. pallasiana* through formed in transitive conditions of *Pineto (pallasianae)-Pinetum (sosnovskyi) forests*.

In reserve these forests are distributed only in its eastern part where occupy convex southern, east or western slopes of the top forest zone within heights of 900 1300 m above sea level. In richer and damp soil conditions they are replaced by beechen, forming in transitive conditions of *Fageto-Pineta (sosnovskyi) forests*. Forests from *P. sosnovskyi* occupy over 3% of the area of reserve. They have the big age equal to 100-250 years, height of trees of 16-26 m, a crown density 0.5-0.9. With increase in absolute height the density of stand of trees go down. On border with yaila it already sparse croocked forests with prevalence in herbage of yaila species.

Forests of a considered formation grow on dry and fresh low-power brown and dark-brown carbonate soils. They are presented rather by a small number of associations, the most widespread and typical from which are *Pinetum caricosum (humilis), Pinetum brachypodiosum (rupestris)* and *Pinetum laserosum.*

Forests with domination in herbage *Carex humilis* occupy convex well warmed up slopes with dark-brown dry soils. Obviously, they are the rests of pleystocenic pine forests which had in a glacial age a wide circulation in Europe and Asia. The stand of trees of these forests has a crown density 0.7-0.9 and is formed almost by one *P. sosnovskyi*. Only occasionally meet still *Acer stevenii* and *Fagus orientalis*. The underbrush layer is not formed. In it only thickets of *Rosa tschatyrdagi* and single exemplars of *Rosa canina, R. spinosissima, Crataegus curvisepala* are growing. In dense enough (40-70%) herbage prevail *Carex humilis* (40-60%). Together with it with a projective covering of 1-10% grow *Brachypodium rupestre, Convallaria majalis, Dactylis glomerata, Potentilla breviscapa, Laser trilobum* and *Teucrium chamaedrys*, is more rare – *Alopecurus vaginatus, Antennaria dioica, Aster amelloides, Bupleurum exaltatum, Carex cuspidata, Carlina vulgaris, Cirsium laniflorum, Euphorbia amygdaloides, E. glareosa, Filipendula vulgaris, Leontodon asperus, L. hispidus, Inula ensifolia*, etc. Characteristic for herbage and mostly endemic species peculiar to yaila vegetation: *Adenophora taurica, Androsace taurica, Campanula taurica, Galium tauricum, Cerastiurn biebersteinii, Elytrigia strigosa, Ferulago taurica, Pulsatilla taurica, Sideritis taurica*, etc.

On more abrupt and less warmed up slopes are formed forests with domination in herbage of Laser trilobum. They, as a rule, have less close stand of trees with very rare underbrush in which along with the species listed for the previous association meet *Cornus mas, Rubus tauricus, Sorbus graeca, S. taurica*. The grassy cover is slightly rarer. Its constant species except dominant *Laser trilobum* with the projective covering which is not exceeding 30%, are *Brachypo-dium rupestre, Cirsium laniflorum, Campanula bononiensis, Clinopodium vulgare, Coronilla varia, Dactylis glomerata, Euphorbia amygdaloides, Galium mollugo, Mercurialis perennis, Origanum vulgare, Physospermum cornubiense, Salvia glutinosa, Scabiosa columbaria, Teucrium chamaedrys, Viola sieheana, V. odorata, V. mirabilis*.

In the bottom part of a zone on border with forests from *Pinus pallasiana* association *Pinetum brachypodiosum (rupestris)* forests, and in transitive conditions *Pineto (pallasianae)-Pinetum (sosnovskyi) brachypodiosum* are formed. The stand of trees of these forests differ by the big specific riches. It forms *P. pallasiana*, a component at last association to 50% of quantity of trees, *Carpinus betulus, Fagus orientalis*, and also species, characteristic for underlaying zones *Quercus petraea* and *Acer campestre*. The underbrush also very rare is presented by the same species, as at the previous association. The grassy cover is enough dense. In it with a projective covering of 30-60% dominates *Brachypodium rupestre*. Appreciable participation on separate sites accepts also *Carex humilis, Dactylis glomerata, Laser trilotum, Physospermum cornubiense.* From the species meeting in a scattered way, the majority are in common with the previous association. Distinction consists only in occurrence of a small number of species, characteristic for forests of midle zone *Cephalanthera rubra, Dictamnus gymnostylis, Salvia grandiflora* and absence of some species of the near yaila forests: *Alopecurus vaginatus, Antennaria dioica, Aster amelloides, Elytrigia strigosa*, etc.

Forests of subformation, formed on richer soils, occupy the small space. They are characterised by a crown density, absence of a layer of underbrush and as a whole more expressed role of species, characteristic for beechen forests. In their rare herbage *Mercurialis perennis* prevails.

Thus, in reserve territory a high-rise number of distributions of forest formations are finished by forests from *Pinus sosnovskyi*, and on separate sites from *Fagus orientalis*. At flat tops of the Crimean Mountains as it already was marked, forests are replaced by grassy vegetation.

In a vegetative cover of the Ai-Petri yaila the mountain meadow steppes prevail. On stony exposures they pass in tomillares, and in depressions with their mountain-meadow soils capacity to 150 sm are replaced by meadows. Characteristic feature of yaila vegetation is its polydominance, mosaic and complexity that is defined by a variety of a relief, a climate and soils. As a result of that, frequent phytocoenosis has the insignificant sizes that complicates typification and the characteristic.

In the reserve territory under meadow steppes on sites with aligned relief are formed mountain-steppe little- and medium chernozems, and on slopes by a steepness (to 20°) – humus-carbonate soils. Meadow steppes are presented mainly by formations *Zerneta cappadocicae, Festuceta rupicolae, Cariceta humilis.*

Meadow steppes of formation *Zerneta cappadocicae* are most mesophytic. They occupy superficial both flat falls and the bottom parts of gentle slopes with leached mountain-steppe chernozems soil and directly contact to meadows. Their herbage has height of 40-50 sm and very dense. Almost always its projective covering exceeds 90%. Vertically it is dismembered on poorly expressed three sublevels: the first in height to 50 sm; the second – 20-30 and the third – 3-10 sm. The first densest layer forms the dominants which projective covering makes 30-60%. In its formation, and also the second and third sublevels a considerable role play co-dominant which in various associations are *Festuca rupicola, Filipendula vulgaris, Hypericum linarioides, Onobrychis jailae, Thymus callieri, Th. dzevanovskyi, Teucrium chamaedrys*. From other species which projective covering does not exceed 1-5%, constantly meet *Galium verum, Medicago falcata, Clematis integrifolia, Ranunculus illyricus, Scabiosa columbaria, Trifolium alpinum, Allium saxatile, Centaurea declinata, Inula ensifolia, Potentilla depressa, Pimpinella lithophila, Polygala major*, etc. Characteristic feature of herbage is considerable participation of meadow species like: *Leucanthemum vulgare, Lathyrus pratensis, Lotus corniculatus, Prunella vulgaris, Rhinanthus major, Stellaria graminea, Veronica gentianoides* and many other things.

Meadow steppes of formation *Festuceta rupestris* in comparison with previous are more widespread and occupy drier ecotope, mainly tops and rather sloping slopes of ridges with the washed off or well developed mountain-steppe chernozems capacity 20-80 sm. They contact directly to formations both *Zerneta cappadocicae* and *Cariceta humilis* and were generated under the influence of intensive unnormous pasturage. The grass stand of these steppes is dense (80-100 %), but not high. In most cases its height does not exceed 20-30 sm. *Festuca rupicola* has a projective covering of 40-70%, and each of co-dominant – 20-40%. In various associations they are *Carex humilis, Bromopsis cappadocica (Zerna cappadocica), Filipendula vuigaris, Medicago falcata, Teucrium chamaedrys, T. ailae, Hypericiim linarioides, Thymus dzevanovskyi*. From species with a small projective covering usually *Asperula caespitans, Carex michelii, C. tomentosa, Galium verum, Potentilla depressa, Koeleria lobata, Trifolium ambiguum Allium jailae, Aiopecurus vaginatus, Anthyllis biebersteinii, Ajuga orientalis, Alyssum rostratum, Hieracium malacotrichum, H. tephropodum, Phiomis taurica, Scabiosa columbaria, Scorzonera crispa, Trifolium alpestre, Thesium brachyphyllum, Campanula taurica, Potentilla angustifolia, Veronica taurica*, etc. In comparison with the previous formation herbage as a whole floristically is poorer. Meadow species for it are not characteristic and meet seldom.

Steppes of formation *Cariceta humilis* are the most widespread and typical for reserve, and also floristically the richest. They occupy slopes with steepness to 30° and tops of ridges with mountain-steppe low-power chernozems, often forming most various micro- and mezokombinations with tomillares. Their herbage is rarer. Its projective covering fluctuates within 70-90%, and the height from 10 to 40 sm. In it three sublevels are located, but, unlike the previous formations, the most expressed is the third, formed by *Carex humilis*, the sublevel in height 5-10 sm. From co-dominant species for a formation along with *Festuca rupicola, Bromopsis cappadocica* are characteristic numerous petrophytes: *Helianthemum stevenii, Asperula caespitans, Genista albida, G. depressa, Cytisus polytrichus, Thymus callieri, Th. dzevanovskyi, Th. tauricus, Teucrium jailae*, etc. Appreciable role in a herbage structure (5-20%) play *Elytrigia strigosa, Filipendula vuigaris, Koeleria lobata, Medicago falcata, Teucrium chamaedrys*. Considerably smaller projective covering (to 1%), but a high class of a constancy have *Alopecurus vaginatus, Androsace taurica, Alyssum rostratum, Anthyllis biebersteinii, Allium saxatile, Bupleurum exaltatum, Campanula taurica, Galium verum, G. tauricum, Hieracium malacotrichum, H. tephropodum, Potentilla depressa, P. angustifolia, Pulsatilla taurica, Pimpinella lithophila, Paronychia cephalotes, Sideritis taurica, Scorzonera crispa, Trinia glauca, Trifolium ambiguum, Veronica taurica*, etc.

On stony exposures of southern slopes (the steepness 15-30°) sometimes small sites extend steppes of formation *Stipeta lithophilae*, concerning stony steppes. They are presented only by two associations of co-dominant species one of which is *Carex humilis*, and another – *Helianthemum stevenii*. Except them appreciable participation accept *Elytrigia strigosa, Thymus dzevanovskii, Teucrium chamaedrys* and *T jailae*. Other species have a projective covering less than 1%. In overwhelming majority there are obligate petrophytes: *Asphodeline lutea, Jurinea sordida, Melica monticola, Ferulago taurica, Ornithogalum flavescens, Seseli dichotomum, Sideritis taurica, Alyssum rostratum, Erysimum cuspidatum, Scorzonera crispa, Pimpinella lithophila, Genista albida, G. depressa, Cytisus polytrichus, Convolvulus tauricus, Draba cuspidata,* etc. All these species are peculiar to tomillares that specifies their similarity.

Tomillares are distributed mainly in mountains of the Ancient Mediterranean. On plain their fragments meet in Steppe and Forest-Steppe zones. They are the azonal-zone type of the vegetation generated in the conditions of an arid climate and the dismembered relief with exits on a surface of stony breeds.

In the reserve tomillares are distributed in the bottom zone and on the yaila. They occupy stony exposures of slopes, tops of ridges and narrow crests with strongly washed off soils. In physiognomic they represent rare communities (40-80%) in height to 25-30 sm, in which semishrubs, low shrubs and semilow shrubs with participation grassy perennials, characteristic for steppes and stony exposures, dominate. In their vertical structure two sublevels are allocated: the first rarer (20-30%) height 30-40 sm and the second denser (30-60%) height 5-10 sm.

In lower zone of tomillares meet fragmentary among light forests of Juniperus and savannoids. With the last they often form the mixed groupings. Dominating species in communities of tomillares are *Thymus callieri, Teucrium chamaedrys, Helianthemum stevenii* and some other.

They are accompanied by typical Submediterranean species, such as: *Convolvulus cantabrica, Dianthus marschallianus, D. humilis, Festuca callieri, Poterium polygamum, Elytrigia strigosa, Botriochloa ischaemum, Poa sterilis, including annual plants: Aegilops biuncialis, A. triuncialis, Briza humilis, Coronilla scorpioides, Crucianella oxyloba, Linum lutecium, Medicago arabica, Trifolium lappaceum, T. angustifolium, Vulpia ciliata, Xeranthemum annuum, X. cylindraceum*, etc. The geophytes *Allium rupestre, Muscari racemosum, Scilla autumnalis*, etc are also frequent.

Considerably big area occupy tomillares on the yaila, where they are presented by communities with prevalence of *Helianthemum stevenii, Teucrium chamaedrys, T. jailae, Thymus callieri, Th. dzevanovskyi, Th. tauricus, Genista albida*, etc. It is frequent these species together with dominants of meadow steppes form difficult polydominant dynamic communities.

Communities with prevalence *Teucrium chamaedrys* are formed in the most damp for tomillares conditions which flat stony slopes with the washed off soil cover capacity 5-10 sm the sites deprived of a soil cover, they are replaced by communities with prevalence of *Teucrium jailae, Thymus dzevanovskyi, Th. tauricus*, and on sites with more powerful layer of soils – meadow steppes. Characterised communities have two sublevels with the general projective covering of 70-80%. From them of 20-40% it is necessary on *Teucrium chamaedrys*, together with which in various associations with a projective covering of 10-30% co-dominant are *Bromopsis cappadocica, Festuca rupicola, Thymus callieri, Th. dzevanoskyi,* etc. Except the named species with a projective covering of 1-5% meet *Polygala major, Asperula caespitans, Helianthemum stevenii, Hypericum linarioides, Teucrium jailae*. Smaller role play *Alopecurus vaginatus, Sideritis taurica, Koeleria lobata, Galium verum, Alyssum rostratum, Potentilla angustifolia, P. depressa, Scabiosa columbaria, Carex tomentosa, C. humilis, Medicago falacata, Allium saxatile, Paronychia cephalotes, Inula ensifolia, Trifolium ambiguum, Leontodon asperus, Helichrysum graveolens, Hieracium malacotrichum*, and also Crimean endemics *Cerastium biebersteinii* and *Veronica taurica*.

Communities, in which endemic Crimean species *Helianthemum stevenii* dominate, are ones of the most widespread. They are dated to more xerophytic conditions, than previous, and occupy rather sloping slopes of the various expositions which surface is combined from small fragments of limestone. Their grass-low shrubs cover has a projective covering of 60-80% and consists of two sublevels in height of 3-10 sm and 20-30. Co-dominant species in various associations are: *Thymus callieri, Th. dzevanovskyi, Th. tauricus, Genista albida, Teucrium jailae,* etc. Smaller participation (a projective covering of 1-5%) accepts *Koeleria lobata, Festuca rupicola, Carex tomentosa, Paronychia cephalotes, Polygala major, Hieracium malacotrichum*. From species with an insignificant covering it is possible to name *Centaurea declinata, Inula ensifolia, Scorzonera crispa, Potentilla angustifolia, Asperula galioides, Hypericum linarioides, Galium mollugo, G. verum, Pimpinella lithophila, Medicago falcata, Ajuga orientalis, Alyssum rostratum, Adonis vernalis, Filipendula vulgaris, Draba cuspidata, Asphodeline lutea, Asperula stevenii, Thesium brachyphyllum, Teucrium chamaedrys*, and also numerous endemic species: *Senecio tauricus, Cerastium biebersteinii, Anthyllis biebersteinii, Androsace villosa subsp. taurica, Elytrigia strigosa, Sideritis taurica, Pulsatilla taurica, Veronica taurica,* etc (Figures 3.1.12–3.1.16).

Communities from *Thymus callieri, Th. tauricus* are formed on exposures of limestone. They have identical with communities *Helianthemum stevenii* structure and almost same floristic structure.

As have shown numerous researches, the area occupied tomillares in Mountain Crimea now under the influence of anthropogenic activities extends.

Flora

Within the reserve we have observed five adventive species: *Ambrosia artemisifolia* L., *Bupleurum fruticosum* L., *Erigeron canadensis* L., *Lonicera caprifolium* L. and *Mahonia aquifolia* Nuff.

Many species of plants and plant communities of the Yalta MFNR are rare and are under protection. Lists of protected species and rare communities are listed in tables 3.1.3 and 3.1.4.

Table 3.1.3. Plant communities included in the Green Data Book of Ukraine.

Acereta stevenii	*Fageta taxosa*
Junipereta exelsae	*Fageta sylvaticae*
Pineta pityusae	*Junipereta hemisphericae*
Pineta pallasianae	*Stipeta lithophilae*
Pineta kochianae	*Stipeta pulcherrimae*
Pistacieta muticae	*Stipeta tirsae*
Querceta (pubescentis)-juniperosa (oxycedri)	*Asphodelineta luteae et tauricae*
Quercetum (petraeae) cornoso-physospermosum	*Paeonieta tenuifoliae*
Querceta (petraeae) cornosa	*Cariceta humilis*
Cisteta taurici	*Saturejeta tauricae*

Table 3.1.4. List of protected plant species.

Latine name	Red Data Book of Ukraine	The Bern Convention	European Red List	CITES
1. *Adenophora taurica* (Sukacz) Juz.	+		R	
2. *Adiantum capillus-veneris* L.	+			
3. *Adonis vernalis* L.	+			
4. *Anacamptis pyramidalis* (L.) Rich.	+			+
5. *Arbutus andrachne* L.	+			
6. *Arum albispathum* Stev. ex Ledeb.	+			
7. *Asphodeline lutea* (L.) Reichenb.	+			
8. *Asplenium adiantum-nigrum* L.	+			
9. *Atropa belladonna* L.	+			
10. *Botrychium lunaria* (L.) Sw.	+			
11. *Cardamine graeca* L.	+			
12. *Centaurea rubriflora* Illar.	+			
13. *Cephalanthera damasonium* (Mill.) Druce	+			+
14. *Cephalanthera longifolia* (L.) Fritsch	+			+
15. *Cephalanthera rubra* (L.) Rich.	+			+
16. *Cerastium biebersteinii* DC.	+		I	
17. *Cheilanthes persica* (Bory) Mett. et Kuhn.	+			
18. *Cistus tauricus* C. Presl	+			
19. *Colchicum umbrosum* Stev.	+			
20. *Comperia comperana* (Stev.) Aschers. et Graebn.	+	+		+
21. *Corallorhiza trifida* Chatel.	+			+
22. *Crocus speciosus* Bieb.	+			
23. *Crocus tauricus* (Trautv.) Puring	+			
24. *Dactylorhiza iberica* (Bieb. ex Willd.) Soo	+			+
25. *Dactyiorhiza incarnata* (L.) Soo	+			+
26. *Dactylorhiza romana* (Seb. et Mauri) Soo	+			+
27. *Delphinium pallassii* Nevski	+			

Latine name	Red Data Book of Ukraine	The Bern Convention	European Red List	CITES
28. *Epipactis helleborine* (L.) Crantz.	+			+
29. *Epipactis microphylla* (Ehrh.) Sw.	+			+
30. *Epipactis palustris* (L.) Cranlz.	+			+
31. *Eremurus tauricus* Stev.	+		R	
32. *Fumana thymifolia* (L.) Spach ex Webb	+			
33. *Galanthus plicatus* Bieb.	+		V	+
34. *Genista scythica* Pacz.	+			
35. *Gladiolus italicus* Mill	+			
36. *Glaucium flavum* Crantz	+			
37. *Goodyera repens* (L.) R. Br.	+			+
38. *Gymnadenia conopsea* (L.) R. Br.	+			+
39. *Heracleum pubescens* (Hoffm.) Bieb.	+		I	
40. *Himantoglossum caprinum* (Bieb.) C. Koch	+	+	R	+
41. *Juniperus excelsa* Bieb.	+			
42. *Lamium glaberrimum* (C. Koch) Taliev	+		R	
43. *Limodorum abortivum* (L.) Sw.	+			+
44. *Listera ovata* (L.) R. Br.	+			+
45. *Neottia nidus-avis* (L.) Rich.	+			+
46. *Onosma polyphylla* Ledeb	+	+	R	
47. *Ophrys apifera* Huds.	+			+
48. *Ophrys oestrifera* Bieb.	+	+		+
49. *Ophrys taurica* (Agg.) Nevski	+	+		+
50. *Orchis fragrans* Pullini	+			+
51. *Orchis mascula* (L.) L.	+			+
52. *Orchis militaris* L.	+			+
53. *Orchis pallens* L.	+			+
54. *Orchis palustris* Jacq	+			+
55. *Orchis picta* Loisel	+			+
56. *Orchis provincialis* Balb.	+	+		+
57. *Orchis purpurea* Huds.	+			+
58. *Orchis simia* Lam.	+			+
59. *Orchis tridentata* Scop.	+			+
60. *Orchis wanjkowii* E. Wulf	+			
61. *Paeonia daurica* Andr.	+			
62. *Paeomia tenuifolia* L.	+	+		
63. *Pistacia mutica* Fisch. et Mey.	+			
64. *Platanthera bifolia* (L.) Rich.	+			+
65. *Platanthera chlorantha* (Cust.) Relchenh.	+			+
66. *Pulsatilla taurica* Juz.	+		I	
67. *Ruscus hypoglossum* L.	+			
68. *Silene jailensis* N.I.Rubtzov	+		V	
69. *Silene viridiflora* L.	+			
70. *Sobolewskia sibirica* (Willd.) P.W. Ball	+			

Latine name	Red Data Book of Ukraine	The Bern Convention	European Red List	CITES
71. *Sternbergia colchiciflora* Waldst. et Kit.	+			+
72. *Steveniella satyrioides* (Stev.) Schlechtelr	+	+		+
73. *Stipa lithophila* P. Smirn.	+		R	
74. *Stipa tirsa* Stev.	+			
75. *Taxus baccata* L.	+			
76. *Tilia dasystyla* Stev.	+		V	
77. *Thymus dzevanovskii* Klok. et Schost.			I	
78. *Tulipa schrenkii* Regel	+			
79. *Viola alba* Bess	+			
80. *Viola oreades* Bieb.	+		R	

Crimean endemics in Yalta Mountain Forest Nature Reserve (endemics reaveled after Yena, 2009):
Aceracee
Acer hyrcanum Fischer et C.A. Meyer *subsp. stevenii* (Pojark.) E. Murray
Alliaceae
Allium nathaliae Seregin
Amaryllidaceae
Galanthus plicatus M. Bieb.
Apiaceae
Heracleum ligusticifolium M. Bieb.
Rumia crithmifolia (Willd.) Koso-Pol.
Seseli lehmannii Degen
Trinia biebersteinii Fedoronczuk
Asteraceae
Anthemis dubia Steven
A. jailensis Zefir.
A monantha Willd.
A. sterilis Steven
Centaurea alba L. *subsp. sterilis* (Steven) Mikheev
C. fuscomarginata (K. Koch) Juz.
C. semijusta Juz.
C. steveniana Klokov
C. vankovii Klokov
Cirsium laniflorum (M. Bieb.) M. Bieb.
Hieracium uczanssuense Ueksip
Jurinea sordida Steven
Lagoseris purpurea (Willd.) Boiss.
Senecio tauricus Konechn.
Tephroseris jailicola (Juz.) Konechn.
Brassicaceae
Alyssum kotovii A. Iljinskaja
Sobolewskia sibirica (Willd.) P.W. Ball

Campanulaceae
Campanula sibirica L. *subsp. taurica* (Juz.) Fed.
Caryophyllaceae
Cerastium biebersteinii DC.
Dianthus marschallii Schischk.
Minuartia adenotricha Schischk.
M. euxina Klokov
M. hirsuta (M. Bieb.) Hand.-Mazz.
M. taurica (Steven) Graebn.
Silene jailensis N.I. Rubtzov
Cistaceae
Helianthemum stevenii Rupr. ex Juz. et Pozdeeva
Convolvulaceae
C. sericocephalus Juz.
Dipsacaceae
Cephalaria demetrii Bobrov
Scabiosa praemontana Privalova
Fabaceae
Anthyllis taurica Juz.
Genista taurica Dubovik
G. verae Juz.
Lotus tauricus Juz.
Onobrychis jailae Czernova
O. pallasii (Willd.) M. Bieb.
Lamiaceae
Lamium glaberrimum (K. Koch) Taliev
Salvia demetrii Juz.
Satureja montana L. *subsp. taurica* (Velen.) P.W. Ball
Sideritis syriaca L. *subsp. catillaris* (Juz.) Gladkova
S. s. subsp. taurica (Steph. ex Willd.) Gladkova
Teucrium montanum L. *subsp. jailae* (Juz.) Soo
Thymus dzevanovskyi Klokov et Des.-Shost.
Linaceae
Linum pallasianum Schult.
Poaceae
Agropyron cristatum (L.) Beauv. *subsp. ponticum* (Nevski) Tzvelev
Elytrigia caespitosa (K. Koch) Nevski *subsp. nodosa* (Nevski) Tzvelev
E. strigosa (M. Bieb.) Nevski *subsp. strigosa*
Koeleria biebersteinii M. Kaleniczenko
K. taurica M. Kaleniczenko
Stipa eriocaulis Borb. *subsp. lithophila* (P. Smirn.) Tzvelev
Primulaceae
Androsace villosa L. *subsp. taurica* (Ovcz.) Fed.
Primula veris L. *subsp. intermedia* Hricak (+) ;
Ranunculaceae
Pulsatilla halleri (All.) Willd. *subsp. taurica* (Juz.) K. Krause
Ranunculus brutius Ten. *subsp. crimaeus* (Juz.) A. Jelen.
Rosaceae

Alchemilla buschii Juz.
A. camptopoda Juz.
A. crebridens Juz.
A. exuens Juz.
A. hirsutissima Juz
A. jailae Juz.
A. languescens Juz,
A. phegophila Juz.
A. tytthantha Juz.
Cotoneaster tauricus Pojark.
Crataegus ceratocarpa Kossych
C. sphaenophylla Pojark.
Potentilla depressa Willd. ex Schlecht.
Sorbus tauricola Zaikonn.
Rubiaceae
Asperula supina M. Bieb. *subsp. caespitans* (Juz.) Pjatunina
Saxifragaceae
Saxifraga irrigua M. Bieb.
Scrophulariaceae
Euphrasia taurica Ganesch. ex Popl.
Scrophularia exilis Popl.
S. goldeana Juz.
Veronica incana L. *subsp. hololeuca* (Juz.) A. Jelen.
V. taurica Willd. *subsp. taurica*
V. taurica Willd. *subsp. bordzilowskii* (Juz.) A. Jelen.

At all 82 species from 117 endemics revealed to Crimea by Yena (2009).

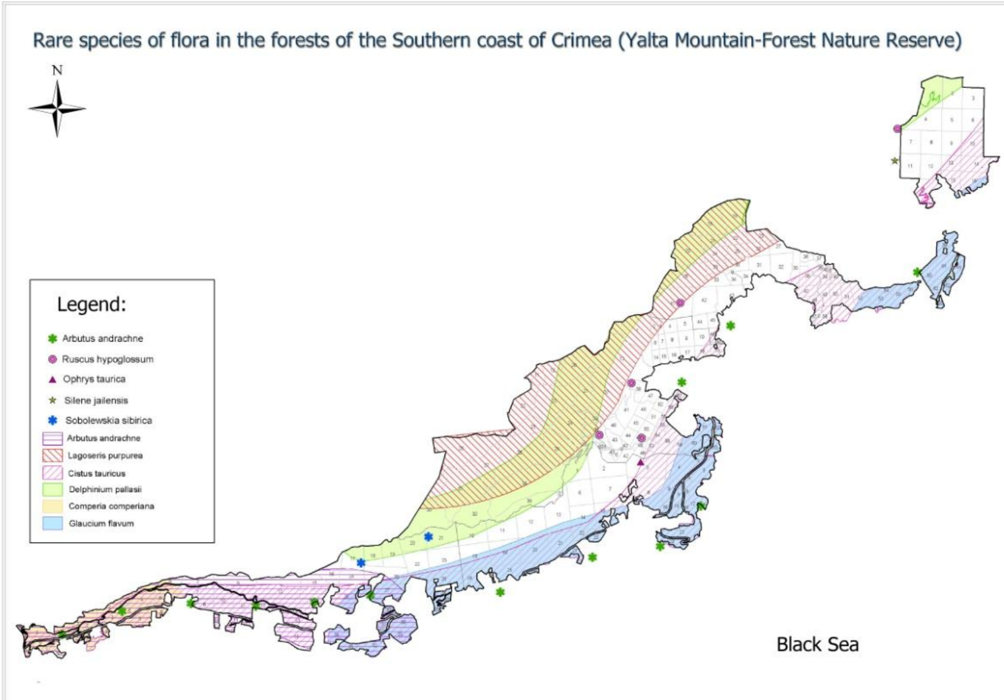


Figure 3.1.12. Rare species of flora in the forest of the Southern coast of Crimea (Yalta Mountain Forest Nature Reserve).

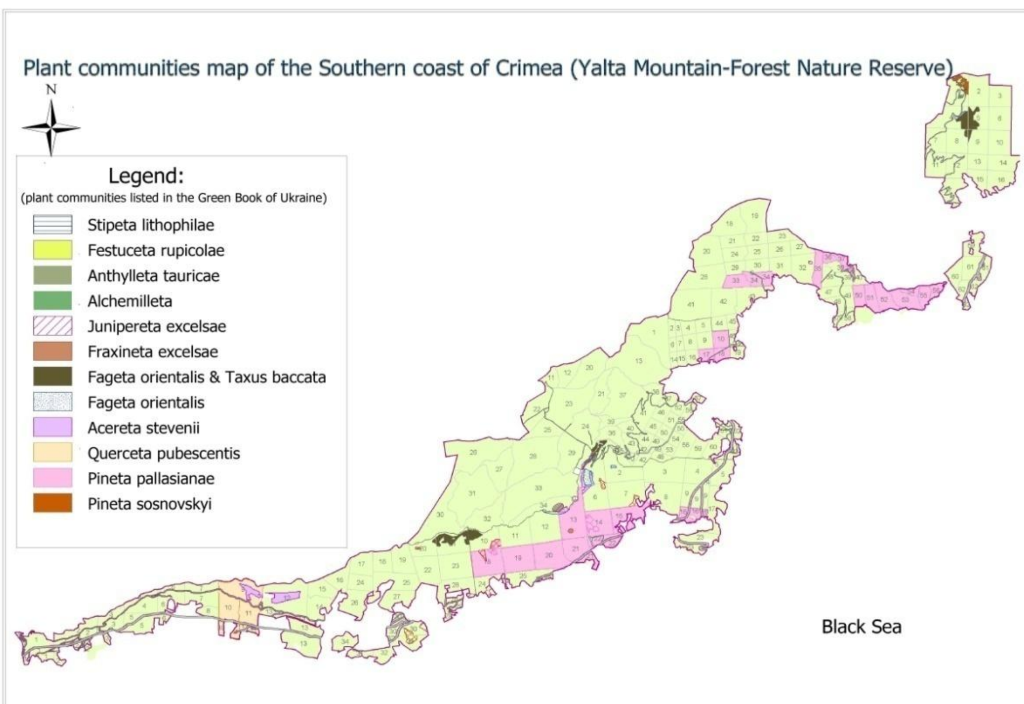


Figure 3.1.13. Plant communities map of Southern coast of Crimea (Yalta Mountain Forest Nature Reserve).

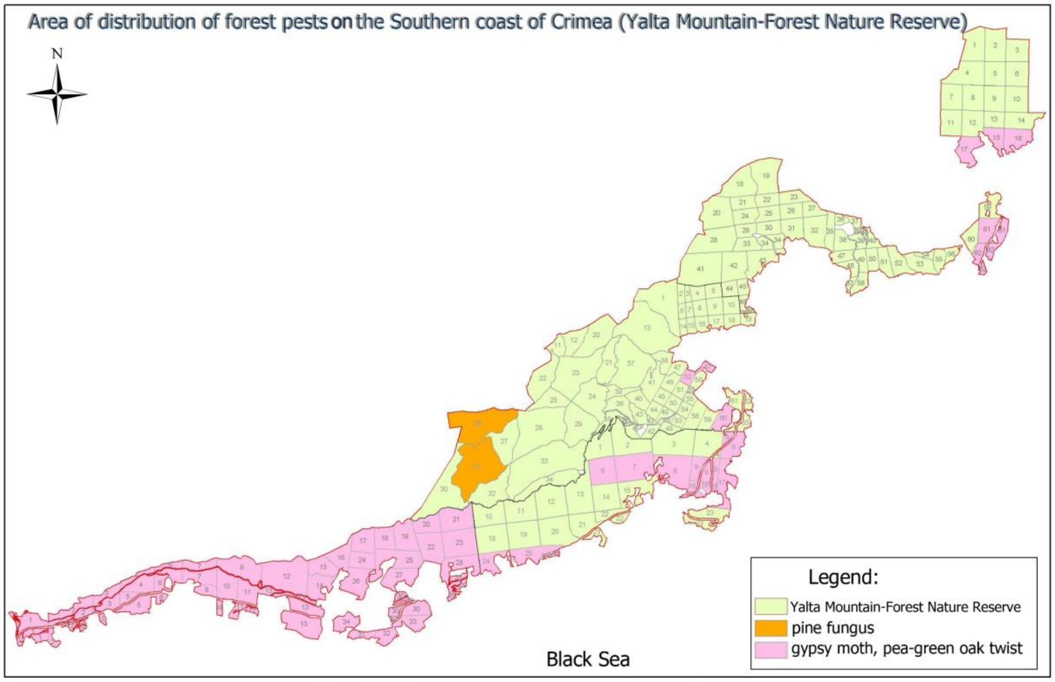


Figure 3.1.14. Area of distridution of forest pests on the Southern coast of Crimea (Yalta Mountain Forest Nature Reserve).

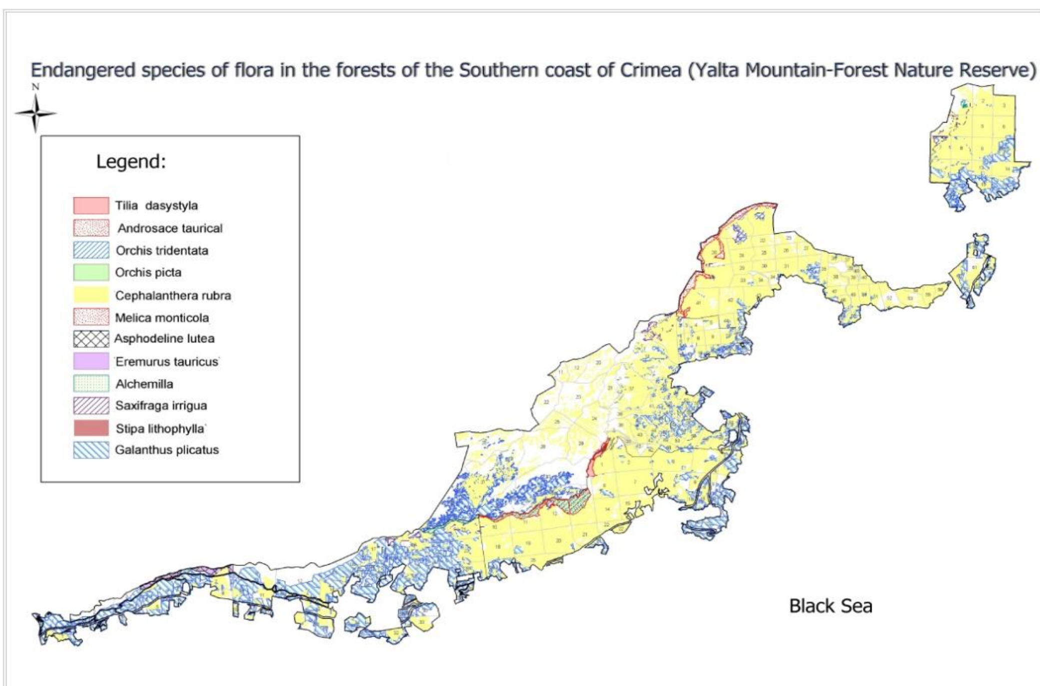


Figure 3.1.15. Endangered species of flora in the forests of the Southern coast of Crimea (Yalta Mountain Forest Nature Reserve).

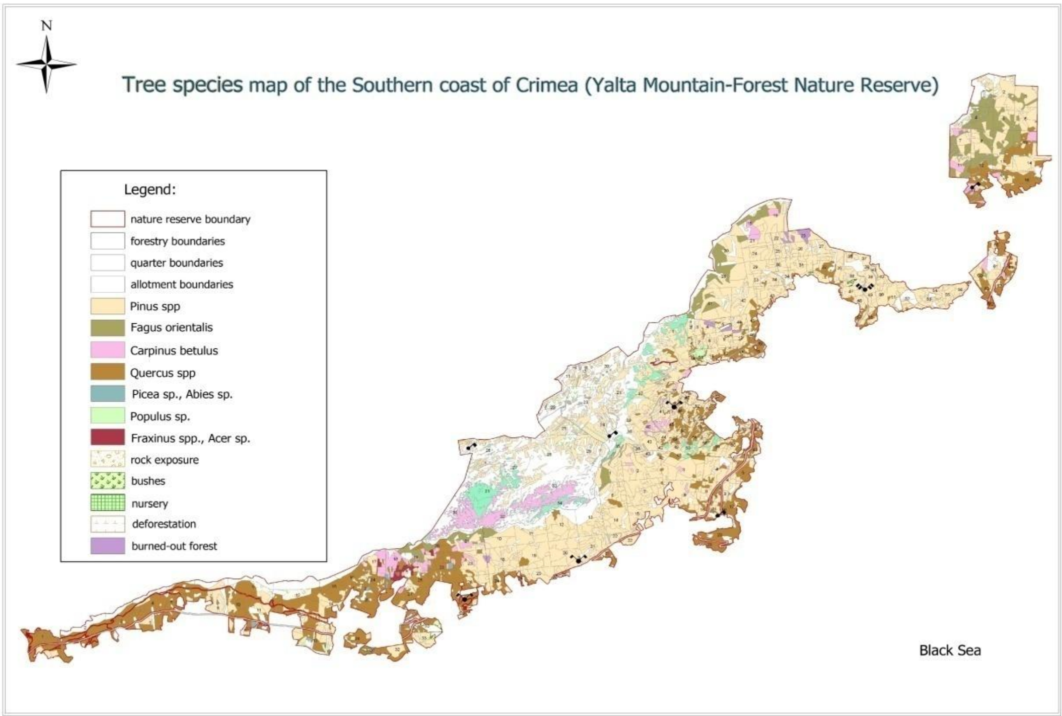


Figure 3.1.16. Tree species map of the Southern coast of Crimea (YMFNR).

3.1.5 Fauna of the Yalta Mountain Forest Nature Reserve

Data for this review were provided by A.F. Bartenev, A.A. Baydashnikov, K.A. Efetov, S.Y. Kostin, N.M. Kovbluk, O.V. Kukushkin, S.V. Leonov, S.A. Mosyakin, A.A. and S.V. Petrusenko, V.N. Popov, G.V. Popov, V.B. Pyshkin, S.V. Stukalyuk, N.N. Tovpinets, A.V. Fateryga, etc., and also originate from the author's research.

The **invertebrate fauna** of reserve is diverse; it is represented by species of various origin and ecology. Earthworms are presented mainly by family *Lumbricidae* species. 12 oligochete species were recorded: *Nicodrrilus roseus* Sav., *N. caliginosus* Sav., *N. dubiosus* Oerl. And *N. handlirschi* Rosa., *Dendrobaena schmidti* Mich., *D. mariupolienis* Wys., *D. octaedra* Sav., *D. veneta* Rosa., *Eisenia nordenskioldi* (Eis.), *Octolasium lacteum* Oerl., *O. transpadanum* Rosa., *Eiseniella tetraedra* Sav.

The fauna of land molluscs of the reserve includes 65 species. Common are *Monacha fruticola* (Kryn.), *Helix albescens* Rossm.) and representatives of genera *Brephulopsis, Xeropicta, Helicopsis*. *Quercus pubescens* forests are inhabited by *Oxychilus deilus* Bourg., *O. diaphanellus* (Kryn.), endemic species *Mentissa gracilicosta* (Rossm.), *M. canalifera* (Rossm.), *M. velutina* (Baid.). In juniper forest *Brephulopsis cylindrica* (Kryn.) is common.

In *Pinus pallasiana* forest zone dominants are small species living in litter or under bark, such as *Cochlicopa* spp., *Truncatellina* spp., etc. *Clausiliidae* and *Acanthinula aculeata* (Müll.) predominate in *Carpinus betulus* and *Fagus orientalis* forests.

Yaila zone is inhabited by *Cochlicopa lubrica* (Müll.), *C. lucbricella* (Rossm.), *Vallonia pulchella* (Müll.), *V. costata* (Müll.), *Peristoma rupestre* (Ross.), *Pyramidula rupestris* (Drap.), etc. Endemic species are *Peristoma merduenianum* Kryn., *Thoanteus gibber* (Kryn.) (Figure 3.1.17), *Ramusculus subulatus* (Kryn.).

Crustaceans are poorly studied. Isopoda species are: *Armadillidium pallasii* Br., *Armadillo erythroleucus* B.-L., *Cylisticus rotabilis* B.-L., *Leptotrichus tauricus* B.-L., *Porcellio lamellatus* B.-L., *P. obsoletus* B.-L., *P. uljanini* B.-L., *Porcellionides approximatus* (B.-L.), etc.

Ligidium fragile Budde-Lund and *Ligidium tauricum* Verh are found at banks of mountain streams. Amphipoda live in the rivers and streams: *Gammarus balcanicus* Schäf., *Niphargus* spp.

About 200 species of spiders inhabit the reserve area. Some of them are endemic: *Drassyllus crimeaensis* Kovbl., *Gnaphosa taurica* Thor., *Malthonica podoprygorai* Kovbl., *Zelotes kukushkini* Kovbl., etc.

Euscorpius tauricus (Koch) and *Galeodes araneoides* (Pall.) are recorded from the zone of oak and juniper forests.

Myriapoda are badly studied. The most common is *Scolopendra cingulata* Latr. and *Scutigera coleoptrata* L. The important ecological role in biocenoses is played by millipedes. *Pachyiulus varius* (Berl.) (= *flavipes* (C. L. K.)) assimilates 13.9-22.8% of the entire energy of cellulose destruction. In addition, millipedes play important roles in the turnover of calcium, which is accumulated in the cuticle (Petrusenko, 1975).

Insect fauna of the reserve is very diverse. Due to landscape and vegetation diversity, insects of various ecological groups and faunal assemblages found refuge in it. One of the factors affecting the formation of the insect fauna is the height above sea level. Species diversity falls with rising altitude (Figure 3.1.18).

Order Embioidea is represented by a hiddenly living relict *Haploembia solieri* Ramb. *H. solieri* lives in the litter and under stones in the Sub-Mediterranean forests of *Quercus pubescens* and *Juniperus excelsa* light forests.

Figure 3.1.17. *Thoanteus gibber* – the endemic species from Yalta MFNR.

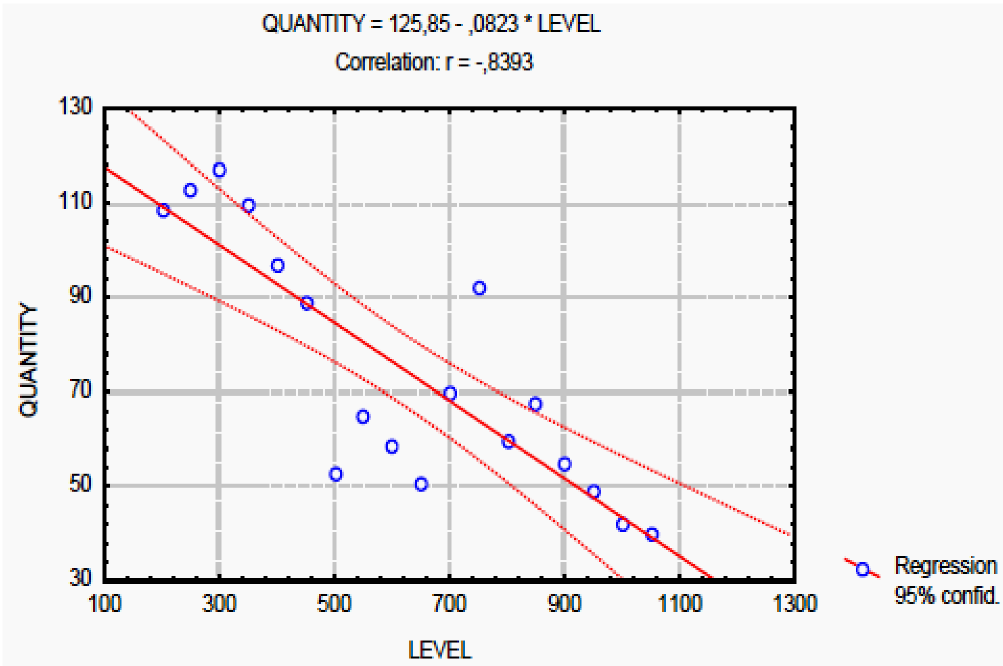


Figure 3.1.18. Number of insect species (QUANTITY) vs. altitude (LEVEL) (m above sea level). (Rybka, 2008).

Order Orthoptera is characterized by considerable diversity. Tettigonioidea are represented by *Saga pedo* Pall. (Figure 3.1.19), *Philidoptera pustulipes* F-W. *Poecilimon boldyrevi* Mir. *Aandrymadusa retowskii* Adel., *Poecilimon schmidti* (Fieber), *Poecilimon pliginskii* Mir., *Poecilimon kuznetzovi* Mir. *Poecilimon tauricus* Ret., *Izophya taurica* Ret., *Tettigonia viridissima* L. and *Tettigonia caudata* Ch., etc. Acridoidea are represented by *Tetrix bolivari* (Saul.), *Uvarovitettix depressa* (Bris. de Barn.), *Calliptamus italicus* (L.), *Acrida ungarica* (Herbst), *Oedipoda coerulescens* (L.), *Acrotylus longipes* (Charp.), *Sphingonotus coerulipes* (Uvar.), *Aiolopus strepens* (Latr.), *Eremippus costatus* (Tarb.), *Stenobothrus* spp., etc.

Order Mantodea is represented by six species. They are: *Hierodula transcaucasica* Br., *Mantis religiosa* L., *Ameles heldreichi* Br., *Empusa fasciata* Brull., *Iris polystictica* F.-W. (Figure 3.1.20) and *Bolivaria brachyptera* Pall.

Order Coleoptera is represented by about 3000 species. Of particular interest is the carabid fauna of the reserve (Unakov, 2003).

In meadow-steppe assemblages of the yaila over 40 carabid species are recorded. The dominant species are *Pterostichus sericeus* Fisch., *Calathus fuscipes* Goeze, *Zabrus spinipes* F., and common *Carabus campestris* Fisch., *C. bosphoranus* Fisch., *Poecilus cupreus* L., *Calathus melsnocephalus* L., *Cymindis angularis* Gyll.

European species, mainly tending to forest or near-water landscapes, are common in Crimean mountain wood zone: for example, *Nebria brevicollis* F., *Bembidion saxatile* Gyll., *Pterostichus* *anthracinus* Ill., *Calathus fuscipes* Gz., *Amara ovata* F., *Chlaenius vestitus* Pk., *Panagaeus bipustulatus* F., *Brachinus crepitans* (L.), etc.

Figure 3.1.19. *Saga pedo* Pall., one of the protected species of Yalta MFNR.

Figure 3.1.20. *Iris polystictica* F.-W., one of the rarest species.

In forest plantations lighted by windfalls, with well-developed grass cover, 52 carabids species are found, of which the most widespread are: *Calosoma inquisitor* (L.), *Carabus gyllenhali* F.-W. (Figure 3.1.21), *Pterostichus niger* (Schall.), *P. melanarius* (Ill.), *Calathus fuscipes* (Goeze), and ordinary *Carabus campestris* F.-W., *C. scabrosus tauricus* Bon., *Pterostichus nigrita* (Payk.), *P. anthracinus* (Ill.), *Laemostenus venustus* (Dej.), *Harpalus rufipes* (De Geer).

The most common species of forest glades are *Pterostichus melanarius* (Ill.), *Calathus fuscipes* (Goeze), *Amara aenea* (De Geer), *Harpalus rufipes* (De Geer), *Calosoma inquisitor* (L.), *Carabus gyllenhali* F.-W., *Ophonus puncticollis* (Payk.).

Along shorelines of brooks and springs common are *Nebria brevicollis* (F.), *Bembidion saxatile* Gyll., *B. deletum* Serv., *Platynus assimile* (Payk.), *Carabus granulatus* L., *Asaphidion flavipes* (L.), *Bembidion tetracolum* Say.

Endemic species are *Carabus gyllenhali* F.-W., *Bembidion iphigenia* Net., *Pristonychus jailensis* Breit., *Pristonychus koeppeni* Motsch., *Ophonus jailensis* Schaub., *Cymindis vagemaculata* Breit., *Carabus* (*Procerus*) *scabrosus tauricus* Bon.

Figure 3.1.21. *Carabus gyllenhali* F.-W., the endemic species from Yalta MFNR.

The Cerambycidae fauna of reserve is characterized by a considerable diversity. In the inferior part of the reserve, width 6–8 km and characterized by the warmest climate at Crimean peninsula, the complex of sawyer beetles has a Mediterranean character; it is represented by *Aegosoma scabricornis* (Scop.), *Rhamnusium testaceipenne* Pic, *Vadonia unipunctata* (Fabr.), *Vadonia bipunctata mulsantiana* Plav., *Hesperophanes sericeus* (Fabr.), *Trichoferus holosericeus* Rossi, *T. griseus* (Fabr.), *Stromatium unicolor* Oliv., *Cerambyx cerdo acuminatus* Motsch., *C. nodulosus* Germ., *Rosalia alpina alpina* L. (Figure 3.1.22), *Gracilia minuta* (Fabr.), *Penichroa fasciata* (Steph.), *Nathrius brevipennis* (Muls.), *Stenopterus rufus* (L.), *S. ater* (L.), *Callimus femoratus* (Germ.), *Phymatodes lividus* (Rossi), *Isotomus comptus* (Mannerh.), *Dorcadion sericatum* Sahlb., *Calamobius filum* (Rossi), *Tetrops gilvipes* (Fald.), *Phytoecia praetextata* (Stev.) *Rosalia alpina alpina* L., etc.

The sawyer beetles, which development is connected with pine forests, were recorded: *Rhagium inquisitor* (L.), *Oxypleurus nodieri* Muls., *Arhopalus rusticus* (L.), *A. ferus* (Muls.), *Pogonocherus perroudi* Muls., *Acanthocinus aedilis* (L.), *A. griseus* (Fabr.), etc.

Oak, beech and hornbeam foresta are inhabited by *Megopis scabricornis, Prionus coriarius, Purpuricenus budensis* (Gotz), *Molorchus umbellatarum* (Schreb.), *Ropalopus lederi* Ganglb., *Phymatodes alni* (L.), *Saperda scalaris* (L.), *Dinoptera collaris* (L.), *Leptura maculata* (Poda), *Stenurella melanura* (L.), *S. nigra* (L.), *Strangalia attenuata* (L.), etc.

Figure 3.1.22. *Rosalia alpina* L., one of the rarest species of sawyer beetles.

Developing larvae of the following species of jewel beetles were found in deciduous forests: *Acmaeoderella circassica* (Rtt.), *A. flavofasciata* (Pill. et Mitterp.), *Dicerca berolinensis* (Herbst), *D. chlorostigma* Mannh., *Anthaxia bicolor* Fald., *A. brevis* Gory et Laporte, *A. cichorii* (Oliv.), *A. fulgurans* (Schrank), *A. hungarica* (Scop.), *A. millefolii* (Fabr.), *A. olympica* Kies., *A. podolica* Mannh., *A. rossica* Daniel, *A. signaticollis* Kryn., *Chrysobothris affinis* (Fabr.), *Agrilus olivicolor* Kiesw., *A. roscidus* Kiesw., *A. sulcicollis* Lac.

Conifers are populated by: *Anthaxia mamaji* Plig., *A. quadripunctata* (L.), *Phaenops cyanea* (Fabr.) and *Chalcophora mariana* L.

On blackberries (*Rubus* spp.) and rosehips (*Rosa* spp.) *Coraebus rubi* (L.) and *Agrilus cuprescens* Ménétr. were recorded. Development of larvae of some species is associated with herbaceous plants: *Capnodis tenebricosa* (Oliv.), *Anthaxia hypomelaena* (Illig.), *A. sericans* Kiesw., *Coraebus elatus* (Fabr.). The leaf miner of arbours, bushes and bindweed (*Convolvulus*) is *Trachys minuta* (L.).

37 species of bark beetles (Scolytidae) were found under the bark and in a bark of deciduous trees. They are: *Scolytus multistriatus* (Marsh.), *S. orientalis* (Egg.), *S. kirschii* Skal., *S. pygmaeus* (Fabr.), *S. ensifer* Eich., *S. jaroschewskii* Schev., *S. scolytus* (Fabr.), *S. sulcifrons* Rey, *S. laevis* Chap., *S. mali* (Bechst.), *S. intricatus* (Ratz.), *S. carpini* (Ratz.), *S. rugulosus* (Mull.), beetles: *Hylesinus toranio* Dant., *H. crenatus* (Fabr.), *H. varius* (Fabr.), *Pteleobius kraatzi* (Eich.), *P. vittatus* (Fabr.), *Chaetoptelius vestitus* Muls. et Rey, *Carphoborus perrisi* (Chap.), *Liparthrum genistae georgi* Knot., *Hypoborus ficus* Erich., *Ernoporus tiliae* (Panz.), *Ernopocerus caucasicus* Lind., *E. fagi* (Fabr.), *Trypophloeus rybinskii* Rtt., *T. granulatus* Ratz., *Phloeotriobus caucasicus* Rtt., *Ph. muricatus* Egg., *Ph. rhododactylus* (Marsch.), *Ph. brevicollis* Kol., *Phloeocinus serrifer* Wich., *Ph. thujae* (Perr.), *Lymantor coryli* (Perr.), *Taphrorychus bicolor* (Herbst), *T. villifrons* (Duf.), *Dryocoetes villosus* (Fabr.), *D. alni* (Georg). In the interior of wood live *Trypodendron domesticum* (L.), *T. signatum* (Fabr.), *Xyleborus dispar* (Fabr.), *X. cryptographus* (Ratz.), *X. eurigraphus* (Ratz.), *X. monographus* (Fabr.), *X. dryographus* (Ratz.), *X. pfeilii* (Ratz.) и *Xyleborinus saxesenii* (Ratz.) (Mosiakin, Popov, 1995).

Kissophagus hederae (Schmidt) occurs on ivy (*Hedera helix*), *Xylocleptes bispinus* (Duft.) on clematis (*Clematis vitalba*).

On coniferous trees the following species develop: *Tomicus minor* (Har.), *T. piniperda* (L.), *Hylugus ligniperda* (Fabr.), *Phloesinus aubei* (Perr.), *Hylastes ater* (Payk.), *H. attenuatus* Erich., *H. angustatus* (Herbst), *Crypturgus cinereus* (Herbst), *C. pusillus* (Gyll.), *Dryocoetes autographus* (Ratz.), *Pityophthorus pityographus* (Ratz.), *P. lichtensteinii* (Ratz.), *Pityogenes bistridentatus* (Eich.), *P. calcaratus* (Eich.), *Ips acuminatus* (Gyll.) *I. sexdentatus* (Boern.), *Orthotomicus proximus* (Eich.), *O. erosus* (Woll.), *O. suturalis* (Gyll.), *O. laricis* (Fabr.), *Pityokteines curvidens* (Germ.).

Small number of species of the Crimean bark beetles (Scolytidae) live in caulises of herbaceous plants (*Thamnurgus caucasicus* Rtt., *T. euphorbiae* Kust., *T. delphinii* (Rosen.)).

Among other groups of xylophagous beetles from the reserve it is worth to mention representatives of the families Bostrychidae and Anobiidae. In the wood and under bark of deciduous trees the following species were found: *Psoa vienensis* Hbst., *P. dubia* Rossi, *Dinoderus minutus* F., *Stephanopachys quadricollis* Mars., *Bostrychus capucinus* L., *Schistoceros bimaculatus* Ol., *Scobicia chevrievi* Villa., *Enneadesmus forficula* Fairm., *Synoxylon perforans* Schrnk., *S. senegalense* Karsch., *Xylonites retusus* Ol.

Of the 45 species of Crimean Anobiidae, 25 are xylophagous: *Ptinomorphus rosti* Pic, *P. imperialis* L., *Hedobia pubescens* Oliv., *Driophilus anoboides* Chevr., *Grynobius planus* F., *Xestobium rufovillosum* De Geer, *A. costatum* Gene., *A. fulvicorne* Sturm., *Hemicoelus rufipes* Fabr., *Oligomerus brunneus* Oliv., *O. retowskii* Schil., *O. ptilinoides* Woll., *Gastrallus immarginatus* Mull., *Ptilinus pectinicornis* L., *P. fuscus* Geoffr., *Xyletinus ater* Creutz., *X. fibvensis* Lund., *Mesothes ferrugineus* Muls. et Rey., *Dorcatoma chrysomelina* Sturm.

On the territory of Yalta Reserve 160 species of leaf beetles (Chrysomelidae) were found. Depending on the type of forest the composition of the leaf beetles fauna and the number of species change. 88 species were recorded in oak forests, 36 in beech forests, 23 species in pine and juniper forests.

For the forest glades and other open areas the characteristic genera are: *Smaragdina, Cryptocephalus, Clytra, Labidostomis, Phylotreta, Longitarsus*. Vast species diversity was found in biotopes of willow bushes and river banks. Only here the following species were found: *Labidostomis cyanicornis* Germ., *Pyrrhalta lineola* F., all species of the genera *Plagiodera* Redt. and *Chrysomela* F.; in addition, a number of species prefer these habitats: *Smaragdina cyanea* Fald., *Cryptocephalus bicolor* Esch., *C. bipunctatus* L., *C. flavipes* F., *Clytra quadripunctata* L. Thickets of mint (*Mentha* sp.) along the banks of rivers are preferred by *Chrysolina herbacea* Duft., *Longitarsus lycopi* Foudr. and *Cassida viridis* L.

Species preferring open, illuminated areas live at yaila. They are: *Cryptocephalus sericeus* L., *C. moraei* L., *Celegantulus* Grav., *Chilotoma erytrostoma* Fald., *Antipa macropus* Ill., *Chrysolina morio* Kryn., representatives of genera *Longitarsus* Latr., *Altica* F., *Derocrepis* Wse. and *Batophila* Foudr. Here species associated with woody vegetation live: *Cryptocephalus bicolor* Esch., *C. bipunctatus* L., *Clytra quadripunctata* L., *Smaragdina hypocrite* Lac., *Luperus xanthopoda* Schrank. Under the stones the representatives of endemic species (*Chrysolina pliginskii* Redt.) can be found (Figure 3.1.23).

Figure 3.1.23. *Chrysolina pliginskii* Redt., an endemic species from Yalta MFNR.

The southern coast of Crimea is characterized by *Labidostomis tridentate* L., *Luperus armeniacus* Kiesw., *Aphtona sarmatica* Ogl., *Longitarsus nasturtii* F., *Cassida canaliculata* Laich.

Of 160 species of leaf beetles of the reserve, 10 species are rare and need protection. They are: *Donacia impressa* Pk., *Antipa macropus* Ill., *Clytra atraphaxidis* Pall., *C. valeriana taurica* L. Medv., *Cryptocephalus bicolor* Esch., *C. coronatus* Sffr., *Timarcha tenebricosa* F., *Chrysolina pliginskii* Rtt., *Ch. oricalcia* Mull., *Ch. susterai* Bech. (Cherney, 2005).

Hymenoptera of the Yalta Reserve represent the most diverse group of insect species. The total number of species of Hymenoptera inhabiting the reserve can be estimated at about 1000-1500 species (Fateriga,2004).

Most a multiple group of Hymenoptera is parasites of insects. Smallest of them (the genera *Aphidius*, *Trichogramma*, *Monodontomerus*, *Melittobia*, *Telenomus*, *Asolcus*, etc.) parasitize on adult plant louses, larvae and eggs of other insects.

On yaila it is possible to meet some species of bees of the genera *Ceratina*, *Halictus* and *Lasioglossum*. As a fodder habitat yaila use *Xylocopa violacea* (L.) and *Xylocopa valga* Gerst. Here bumblebees are ordinary: *Bombus humilis* Ill., *Bombus lucorum* (L.) and *Bombus sylvarum* (L.). From ants are noted *Lasius alienus* Först., *Tapinoma ambiguum* Em., *Formica pratensis.* From the wasps to meet on yaila *Katamenes flavigularis* (Blüth.), *Stylbum cyanurum* Först., *Vespula germanica* (F.), *Megalodontes kohli* Kon. etc.

In a zone of beechen forests of reserve *Dolichovespula sylvestris* (Scop.), representatives of genus *Ectemnius*, occasionally *Scolia hirta* Schranck are recorded. The beechen forest is characterized by such species as wild bees *Anthophora* (*Clisodon*) *furcata* Panz., *Megachile willoughbiella* (Kirby), *Megachile circumcincta* (Kirby), bees of genera *Andrena* and *Lasioglossum*, and also bumblebees: *Bombus lucorum* (L.), *Bombus silvarum* (L.) and *Bombus hortorum* (L.).

In the area of pine forests the following species of wasps are: *Ancistrocerus nigricornis* (Curt.), *Eumenes coronatus* (Panz.), *Vespula rufa* (L.), *V. vulgaris* (L.), *Dolichovespula sylvestris* (Scop.), *D.*

media (Retz.), *D. sylvestris* (Scop.), *Trypoxylon figulus* (L.), *Psenulus pallipes* (Panz.), species of genera *Ectemnius* and *Crossocerus*, etc.

Bees of pine forests are dated mainly for glades. Here live different representatives of the genera *Hylaeus*, *Andrena* and *Nomada*. Bees of family Megachilidae are represented by *Megachile lagopoda* (L.) and *M. octosignata* Nylander. Here there are brood-parasites of these bees – *Coelioxys conoidea* (Illiger) and *C. inermis* (Kirby). Here there are *Anthidiellum strigatum* (Panz.) and bumblebees: *Bombus terrestris* (L.), *Bombus haematurus* Kriechb., *Bombus lucorum* (L.) and *Bombus pascuorum* (Scop.). From ants most typical are: *Crematogaster schmidti* Mayr, *Formica gagates* Latr. and *Lasius emarginatus* Oliv. From phytophagous Hymenoptera are noted *Sirex noctilio* F. and *Tremex fuscicornis* F.

In light oak forests of the reserve the greatest diversity of Hymenoptera is concentrated. Vespidae wasps in a zone of oak forests are represented by 25 species. The most common are: *Polistes dominulus* (Christ), *Vespula vulgaris* (L.), *Vespula germanica* (F.), *Vespa crabro* L. The fauna of the solitary wasps includes many Mediterranean species, such as *Alastor bieglebeni* G. S., *Syneuodynerus egregius* (H-Sch.), *Euodynerus dantici* (Rossi), *Parodontodynerus ephippium* (Klug), *Ancistrocerus auctus* (F.), *Eumenes dubius* Sauss., *Eumenes pomiformis* (F.), *Leptochilus alpestris* (Sauss.), *Katamenes flavigularis* (Blüth.), *Celonites abbreviatus tauricus* Kostylev.

The oak forests are characterized by Scoliidae, including *Scolia maculata* Dr. and *S. hirta* Schr., digger wasps, like *Podalonia hirsuta* (Scop.), *Ammophilla sabulosa* (L.), *Sceliphron destillatorium* (Ill.), *Sphex flavipennis* F. and *S. rufocinctus* Brullé. From single wasps live here *Psenulus pallipes* (Panz.), *Trypoxylon figulus* (L.), *Bembicinus tridens* (F.), *Cerceris arenaria* (L.), *Philanthus triangulum* (L.) and others. Very rare species is *Larra anachema* (Rossi). From the Pompilidae family in oak forests can be found *Cryptocheilus rubellus* (Evers.) and *Cryptocheilus annulatus* (F.).

Throughout last several years in terrain of oak forests of reserve the invader from Southern Europe *Sceliphron curvatum* Smith. is marked.

Bees of oak forests are very diverse. Besides numerous representatives of earthen bees of the genera *Andrena*, *Halictus*, *Lasioglossum*, *Eucera* and *Anthophora*, here are *Hylaeus*, *Ceratina*, *Anthidium*, *Heriades*, *Osmia*, *Megachile*, *Hoplitis* and others. Here live bees-cuckoos *Nomada*, *Coelioxys*, *Stelis*, *Thyreus*. From the most original elements of fauna are *Chalicodoma parietina* (Geoffroy) *C. lefebvrei* L., *Xylocopa violacea* (L.), *X*. *valga* Gerst, *X. iris* Christ.

The most common bumblebees in oak forests are: *Bombus terrestris* (L.), *Bombus haematurus* Kriechb., *Bombus pascuorum* (Scop.) and *Bombus subterraneus* (L.), less common *Bombus argillaceus* (Scop Less often.), *Bombus vestalis* (Geoffroy) and *Bombus bohemicus* Seidl.

Ants in oak forests are represented by 8 species. Most numerous are *Leptothorax parvulus* Schenck, *Formica gagates* Latr. and *Crematogaster schmidti* Mayr. Herbivorous hymenoptera are represented by *Calameuta idolon* (Rossi) and *Urocerus sah* Mocs.

The fauna of butterflies of the yaila is extremely diverse. Of the Rhopalocera it is worth to mention *Aglais urticae* L., *Vanessa atalanta* L., *Coenonympha glycerion* Brkh., *Hipparchia fagi* Scop., *H. pellucida* Stgr., *Hyponephele lycaon* Rott., *Satyrus virbius* H.-S., *Proterebia phegea* (Borkh.), *Gonepteryx rhamni* L., etc. Among rare species *Meleageria (Polyommatus) daphnis* Den. et Schiff. can be noted.

Family Zygaenidae is represented in Yalta Reserve by *Adscita geryon* (Hbn.), *A. albanica* (Nauf.), *Jordanita budensis* (Spr. et Spr.), *J. globulariae* (Hbn.), *J. subsolana* (Stgr.), *Zygaena carniolica* (Scop.), *Z. loti* (Den. et Schiff.), *Z. viciae* (Den. et Schiff.), *Z. filipendulae* (L.), *Z. lonicerae* (Schev.), *Theresimima ampellophaga* (B.-Bar.), etc.

The reserve is inhabited by a number of species and subspecies of butterflies endemic to the Crimean Mountains: *Pseudochazara euxina* (Kusn.), *Agrodiaetus damone* (Ev.), *Proterebia afra krymaea* (Shelj.), *Coenonympha glycerion korshunovi* Nekrut., *Melitaea aurelia petricola* Nekrut., *Zygaena ephialtes taurida* Hol. et Shelj.

It is necessary to mention another group of butterflies: species causing significant damage to forestry: *Lymantria dispar* (L.) and *Tortrix viridana* L.

Diptera fauna of the area is very original and is characterized by presence of Mediterranean xerophilic species. Families Asilidae, Bombyliidae Syrphidae, etc. are very indicative in this respect. The most studied dipteran groups in Yalta Reserve are hoverflies and bulb flies.

Common are *Eupeodes lundbecki* (Soot-Ryen) and *Pipiza lugubris* (Fabr.), *Volucella zonaria* Poda. The most rare species are *Eumerus tauricus* Stack., *Paragus cinctus* Schin. and Egger, *P. hyalopteri* Marc.-Garc. And Rojo, *Eumerus argyropus* Loew and *E. tauricus* Stack.

20 species of mosquitoes were recorded: *Anopheles maculipennis* Meigen, 1818; *An. claviger* Meigen, 1804; *An. hyrcanus* Pallas, 1771; *An. plumbeus* Stephens, 1828; *Aedes annulipes* Meigen, 1830; *Ae. caspius* Pallas, 1771; *Ae. geniculatus* Olivier, 1791; *Ae. pulchritarsis* Rondani, 1872; *Ae. vexans* Meigen, 1830; *Ae. punctor* Kirby, 1837; *Ae. cataphylla* Dyar, 1916; *Ae. krimmontanus* Alekseevii, 1986; *Ae. rusticus* Rossi, 1790; *Ae. cantans* Meigen, 1818; *Culex pipiens* Linnaeus, 1758; *C. hortensis* Ficalbi, 1889; *C. territans* Walker, 1856; *C. torrentium* Martini, 1925; *Culiseta annulata* Schrank, 1776; *C. longiareolata* Macquart, 1838.

Of great interest is a complex of freshwater invertebrates. Despite the relatively low species richness, it is distinguished by a considerable extant of endemism. The endemic species are: *Electrogena braaschi* (Sowa), *Leuctra crimeana* Zhiltz., *Agapetus ajpetriensis* Mart., *Plectrocnemia intermedia* Mart. and *Silo alupkensis* Mart., *Prosimulium nigritum* (Rubz.), *Simulium acutiphallus* (Rubz.), *Cnetha taurica* (Rubz.), *Tabanus smirnovi* Ols.

Vertebrate fauna of the Yalta MFNR is largely depleted due to the nature of the island territory. Amphibians of the reserve are represented by following species: *Triturus karelini* (Str.), *Pelophylax ridibundus* (Pall.), *Bufo viridis* (Laur.) and *Hyla arborea* (L.). In Yalta reserve there are 11 species of reptiles. They are: *Emys orbicularis* (L.), *Mediodactylus kotschyi danilewskii* (Str.), *Pseudopus apodus* (Pall.), *Lacerta agilis tauridica* Such., *Podarcis tauricus* (Pall.), *Darevskia lindholmi* (Lantz et Cyr.), *Natrix natrix* (L.), *N. tessellata* (Laur.), *Dolichophis caspius* (Gmel.), *Zamenis situla* (L.) и *Coronella austriaca* (Laur.) (Figure 3.1.24). Among them one endemic species is, *D. lindholmi*.

Avifauna of biotopes is distributed unevenly. Belt juniper-oak forests are inhabited by *Fringilla coelebs*, *Chloris chloris*, *Carduelis carduelis*, *Anthus trivialis*, *Parus major*, *Aegithalos caudatus*, *Lanius collurio*, *Turdus merula*, *Cuculus canorus*, *Phoenicurus phoenicurus*, *Garrulus glandarius*, *Sylvia atricapilla*, *Sylvia communis*, *Coccothraustes coccothraustes*, *Dendrocopos major*, *Corvus monedula*, *Jynx* *torquilla*, *Emberiza cia* etc. Remarkable birds of prey are: *Otus scops*, *Athene noctua*, *Falco tinnunculus*, *Buteo buteo*, *Accipiter nisus*, *Falco peregrinus*.

Pine forests are inhabited by *Loxia curvirostra*, *Spinus spinus*, *Regulus ignicapillus*, *R. regulus*. The dominant species is *F. coelebs*. Here we meet *Erithacus rubecula*, *Parus caeruleus*, *P. major*, *P. ater*, *Phylloscopus sibilatrix*, *Turdus philomelos*, *T. merula*, *C. canorus*, *P. phoenicurus*, *G. glandarius*, *Troglodites troglodites*, *Muscicapa striata*, *Prunella modularis*, *Certhia familiaris*, etc. Sometimes you can see *Accipiter nisus*, *Accipiter gentilis*, *B. buteo* and *Strix aluco*. In the upper part of the zone of pine and beech *Turdus viscivorus*, *Scolopax rusticola*, *Columba oenas*, *Circaetus gallicus*, *Aquila heliaca* are seen (Kostin et all, 1999).

Figure 3.1.24. *Coronella austriaca* (Laur.), one of the rarest species in Yalta MFNR.

In the zone of rocky habitats *Apus melba*, *Apus apus*, *Sturnus vulgaris*, *Corvus corax*, *Columba livia* live. It is a home to birds of prey such as *Falco tinnunculus*, *F. peregrinus*, *F. cherrug*.

Birds of yaila habitats are: *Alauda arvensis*, *Anthus campestris*, *Oenanthe oenante*, *Perdix perdix*, *Coturnix coturnix*, *Crex crex*, etc (Dulitskiy, 2001).

Species recorded during migration are: *Ciconia nigra*, *C. ciconia*, *Pandion haliaetus*, *Circus cyaneus*, *C. aeruginosus*, *C. macrourus*, *C. pygargus*, *Buteo lagopus*, *B. rufinus*, *Hieraaetus pennatus*, *Aquila chrysaetos*, *A. rapax*, *A. clanga*, *A. pomarina*, *Haliaeetus albicilla*, *Grus grus*, etc. (Security category, 2005).

Representatives of the mammalian fauna and their distribution by biotopes are indicated in Table 3.1.5. A significant number of species recorded in the Yalta Reserve is listed in the Red Data Book of Ukraine. A list of these species is presented in Table 3.1.6.

Table 3.1.5. Distribution of mammal species in habitats of YMFNR.

№	Taxon	Juniper-oak forests	Pine forests	Beech f orests	Wetland habitats	Yaila
	Insectivora					
	Erinaceus concolor	+	+		+	
	Sorex minutus	+	+	+		
	Neomys anomalus				+	
	Crocidura suaveolens	+	+	+	+	+
	Crocidura leucodon	+				
	Chiroptera					
	Rhinolophus hipposideros					+
	Rhinolophus ferrumequinum					+
	Myotis nattereri					+
	Myotis emarginatus					+
	Barbastella barbastellus					+
	Pipistrellus nathusii	+		+		+
	Pipistrellus kuhlii	+				+
	Hypsugo savii	+				
	Nyctalus leisleri	+	+	+	+	
	Nyctalus noctula	+	+	+	+	
	Lagomorpha					
	Lepus europaeus	+		+		+
	Rodentia					
	Sciurus vulgaris	+	+	+	+	
	Rattus norvegicus	+			+	
	Rattus rattus	+				
	Mus musculus				+	
	Sylvaemus uralensis	+	+	+	+	
	Sylvaemus arianus				+	+
	Sylvaemus tauricus	+	+	+	+	
	Microtus obscurus	+	+	+	+	+
	Carnivora					
	Vulpes vulpes	+	+	+	+	+
	Mustela nivalis	+	+	+	+	+
	Martes foina		+	+		+
	Meles meles	+	+	+		+
	Artiodactyla					
	Sus scrofa		+	+	+	+
	Capreolus capreolus	+	+	+	+	+
	Cervus elaphus	+	+	+		+
	Ovis musimon		+	+		+

Table 3.1.6. List of species of the reserve from the Red Data Book of Ukraine.

№	Latin species name	№	Latin species name
1.	*Barbastella barbastellus*	46.	*Empusa fasciata*
2.	*Myotis bechsteini*	47.	*Ascalaphus macaronius*
3.	*Myotis emarginatus*	48.	*Saga pedo*
4.	*Myotis nattereri*	49.	*Poecilimon boldyrevi*
5.	*Nyctalus leisleri*	50.	*Poecilimon schmidti*
6.	*Pipistrellus kuhli*	51.	*Aandrymadusa retowskii*
7.	*Pipistrellus savii*	52.	*Euchloe ausonia volgensis*
8.	*Rhinolophus ferrumequinum*	53.	*Hipparchia statilinus*
9.	*Rhinolophus hipposideros*	54.	*Iphiclides podalirius*
10.	*Mustela (Putorius) eversmanni*	55.	*Papilio machaon*
11.	*Neomys anomalus*	56.	*Libythea celtis*
12.	*Aegolius funereus*	57.	*Polyommatus daphnis*
13.	*Bubo bubo*	58.	*Proterebia phegea*
14.	*Aegypius monachus*	59.	*Pseudochazara euxina*
15.	*Gyps fulvus*	60.	*Zegris eupheme*
16.	*Aquila clanga*	61.	*Zerynthia polyxena*
17.	*Aquila pomarina*	62.	*Acherontia atropos*
18.	*Aquila chrysaetos*	63.	*Daphnis nerii*
19.	*Circaetus gallicus*	64.	*Marumba quercus*
20.	*Falco cherrug*	65.	*Proserpinus proserpina*
21.	*Falco peregrinus*	66.	*Sphingonaepiopsis gorgoniades*
22.	*Hieraaetus pennatus*	67.	*Callimorpha quadripunctaria*
23.	*Buteo rufinus*	68.	*Catocala fraxini*
24.	*Aquila rapax*	69.	*Catocala sponsa*
25.	*Pandion haliaetus*	70.	*Coranus griseus*
26.	*Circus cyaneus*	71.	*Calosoma sycophanta*
27.	*Ciconia nigra*	72.	*Carabus hungaricus*
28.	*Grus grus*	73.	*Procerus scabrosus tauricus*
29.	*Monticola saxatilis*	74.	*Ocypus olens*
30.	*Regulus ignicapillus*	75.	*Alaus parreyssi*
31.	*Lanius excubitor*	76.	*Cerambyx cerdo*
32.	*Ophisaurus apodus*	77.	*Dorcadion equestre*
33.	*Mediodactylus kotshyi danilewskii*	78.	*Rosalia alpina*
34.	*Coluber jugularis*	79.	*Lucanus cervus*
35.	*Elaphe situla*	80.	*Calameuta idolon*
36.	*Coronella austriaca*	81.	*Scolia maculata*
37.	*Batracobdella algira*	82.	*Cryptocheilus rubellus*
38.	*Potamon tauricum*	83.	*Sphex flavipennis*
39.	*Euscorpius tauricus*	84.	*Sphex rufocinctus*
40.	*Galeodes araneoides*	85.	*Larra anachema*
41.	*Scutigera coleoptrata*	86.	*Megachile rotundata*
42.	*Calopteryx splendens taurica*	87.	*Bombus argillaceus*
43.	*Haploembia solieri*	88.	*Xylocopa valga*
44.	*Iris polystictica*	89.	*Xylocopa violaceae*
45.	*Bolivaria brachyptera*	90.	*Xylocopa iris*

3.1.6 Landscapes of the Yalta Mountain Forest Nature Reserve

Landscapes organisation specificity of the southern coast of Crimea, in whole and the key area is Yalta Mountain Forest Nature Reserve in particular, is defined by its original locating in diverse geographical contacts zones: a land and a sea contacts; at the differentiated elevations of mountain part of Crimea and Black Sea depressions zones; at the zones of a contacts and an interpenetration sub boreal and the Mediterranean floras. These factors have defined formation ***of a southern coast landscape macroecotone*** – boundary landscape system which is characterised by a diversity of tectonics, diversity of lithology, complexity of a geomorphological structure, macro-, meso- and microclimatic contrasts of situations, a diversity of a soil-vegetative covering, complex and mosaic space-time structure of landscapes, and also high dynamics of landscape processes development. The modern landscape organisation of a southern coast landscape macroecotone is formed at active impact of an anthropogenic factor. Economic activities have considerably variated natural landscape and landscape processes of this area.

The height above sea level is the factor of landscape differentiation, having background value. Fall of temperature with height and simultaneously increase of relative humidity and the sum of precipitation defines change of humidifying and character of vegetation in various altitudinal belts.

Two altitudinal layers are formed: meso- and low-mountain. The border between them passes at height of 400-600 m (subject to conditions of a vegetation locality, bound to height, an exposition, surface slope, depth of loose deposits).

Low-mountain altitudinal layer includes one ***landscape belt*** which is presented ladder-shaped and slope-denudation-landslide low-mountain with ancient landslide forms on Taurian flysch, dismembered by river valleys, ravines and small flat-bottom valleys, complicated by limestone outlier massifs and intrusive massifs (0-400-600m above sea level) it is characterised by domination of various shiblyak[1], bushes and forest community with evergreen shrub layer, xerophyte – cereals and hemixerophyte forest of *Quercus pubescens* in some areas (up to 450-600 m above sea level), juniper and pistachio submediterranean vegetation (up to 450 m above sea level) on dry and very dry cinnamon break stone soils. Natural landscapes disappear or degrade in connection with the big anthropogenic impact on low-mountain zones. There are bushes thickets, secondary shiblyak and savanna community are occupying considerable areasthat were formed on a pubescent oak forest and submediterranean vegetation places. The most part of natural landscapes has turned in agricultural, seliteb areas, parks and so forth.

Middle-mountain altitudinal layer includes two ***altitudinal landscape zones***: ***mountain pasture structural-denudation*** **middle-mountain** ***plateau zone (900-1300*** m above sea level***)*** on upper Jurassic karst limestone under mountain-meadow steppe and a petrophyte-xeropolum, with plantation of a *Pinus nigra* ssp. *pallasiana* and *Pinus sylvestris* ssp. *hamata* on mountain meadow chernozem-like (mountain-steppe soil) and rendzina break stone soils; ***ladder-shaped and slope-denudation rocks near mountain pasture middle-mountain zone (600-900-1000 m above sea level)*** with dominance of downhill and steep slopes, complicated by taluses on limestones, sandstones and conglomerates of middle Jurassic and Taurian flysch under durmast oak and hornbeam-oak forests,

[1] Shiblyak – Thermophilous deciduous or semi-deciduous scrub of the Balkans and the Black Sea area resulting from long-term grazing and forest degradation. Shiblyak may be composed or dominated by a variety of shrubs, notably *Carpinus orientalis, Paliurus spina-christi, Prunus tenella, Quercus pubescens* and others (Bergmeier, Petermann, Schröder, 2010).

pine-oak forests (500-900 m above sea level), beech forests (800-1300 m above sea level) and pine forests (*Pinus nigra* (Simeis – M. Mayak) 450-900 m above sea level, *Pinus sylvestris* (Yalta-Alushta) 900-1300 m above sea level) and submediterranean vegetation on dry cinnamon and brown forest soils.

The altitudinal zone differentiation of a southern macro slope of the Main Ridge of Crimean Mountains has no accurately borders between zones. Borders have gradual, diffuse character, and their high-altitude position varies. This is due to the several causes: 1) erosive ruggedness of macro slope creates a considerable quantity of the various locations different on exposure-insolation and exposure-circulation conditions that leads to formation of distinctions in the conditions of high-altitude position and to shift (upwards-downwards) borders between zones; 2) wide development of sliding, gravitational, erosive and torrent processes promotes formation of paradynamic and paragenic systems with strong intersystem relationship (are directed from top to down) and diffuse of high-altitude borders; 3) the openness of river valleys, ravines and small flat-bottom valleys to the sea promotes deep penetration breeze circulation deep into to terrain and smoothing as the thermal contrasts bound to distinction insolation expositions, and high-altitude thermal distinctions.

The landscape differentiation in zones is defined by heterogeneity of a relief, lithology and exposition distinctions. Allocation is bound to it in high-altitude landscape zones of different rank landscape complexes.

The southern slope of the Main Ridge of Crimean Mountains is separated from northern slope by a line of fault of an upper Jurassic limestone layer. It begins straight hanging rocks and steep slopes was formed by limestone massif in fractures and on ledges collects petro-clastic materials was stirred with soft land waste and soil mass. Zigzag lines of a line of fault of an upper Jurassic limestone, lithology features of a constitution majority of a southern macro slope (flysch of Taurian series), wide development erosive and landslide processes have caused formation of the amphitheatres representing occluded with three parties by watershed ridges and open on south to the sea a lobby. Each of such amphitheatres has a characteristic bioclimatic and landscape feature that gives the grounds to consider them as individual landscape types.

Within Yalta Mountain Forest Nature Reserve area **5 individual landscape types** are excreted: Ai-Petri mountain pasture (yaila) landscapes, Simeiz landscapes, Yalta and Livadia landscapes, Foros landscapes, Gurzuf landscapes (Figure 3.1.25; Table 3.1.7.).

Ai-Petri mountain pasture (yaila) landscapes is formed within Ai-Petri yaila and located at height of 1000-1300 m above sea level (Figure 3.1.26). Geological constitution and erosive processes has great exerted on formation of Ai-Petri yaila relief. Southern yaila slopes almost everywhere are steep and northern – long and graded. The main geomorphological elements are hump-shaped eminences and hills, karst cavities and sluggy, hollows and small flat-bottom valleys. Elevations on yaila are characterised by an easy grade and downhill slopes which rate of grade does not exceed – 20-25^{o}. As a rule, northern slopes rather easy grade and flat. Southern slopes are abrupt and steep, broken by numerous fractures on separate terraces at which karst cavities and sluggy are often formed.

Figure 3.1.25. Ai-Petri mountain (yaila) landscape (photo V.Gorbatiuk).

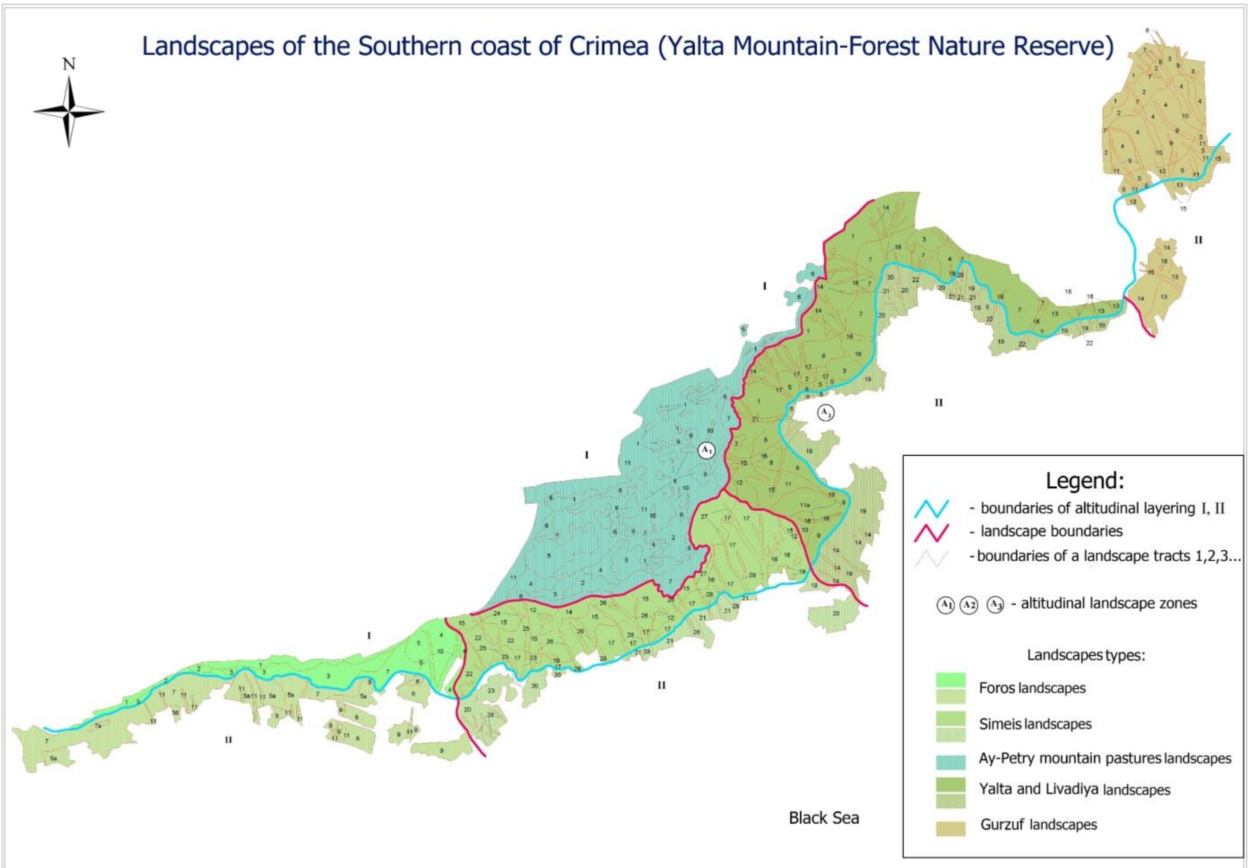


Figure 3.1.26. Landscapes of the Southern Coast Crimea (Yalta Mountain Forest Nature Reserve) (Bobra, 2010).

Table 3.1.7. Legend of landscape structure of the Yalta Mountain Forest Nature Reserve

Altitudinal layering	
I. Middle-mountain altitudinal layer (400-450-1300m above sea level)	***II. Low-mountain altitudinal layer (0-400-450m above sea level)***
Altitudinal landscape zones	
A1.Mountain pasture structural-denudation middle-mountain plateau zone (900-1300 m above sea level) on upper Jurassic karst limestone under mountain-meadow steppe and a petrophyte-xeropolum, with plantation of *Pinus nigra* and *P. sylvestris* on mountain meadow chernozem-like and rendzina break stone soils	
Ai-Petri mountain pasture (yaila) landscapes	
Boundaries of a landscape tracts 1. Outcrop of limestones with fragmentary petrophyte vegetation and lichens. 2. Ladder-shaped slopes with outcrop of limestone gently dipping on the south, under petrophyte, festuceta-brachypodiosum steppe association with dwarf semishrub vegetation on mountain meadow chernozem-like soils 3. Convex-concave and gently dipping and downhill slopes, open on the south, with outcrop of bedrocks in the form of steps under beech-hornbeam (*Fagus sylvatica* + *Carpinus betulus*) forests, on brown forest soils 4. Surfaces flat convex and slopes between kettle flat ridges under hornbeam-beech (*C. betulus* + *F. sylvatica*) second growth wood, on brown forest soils 5. Slopes between kettle flat ridges convex, sloping on the north and the northwest under hornbeam-beech (*C. betulus* + *F. sylvatica*) second growth wood, on brown forest soils 6. Slopes and bottoms of karstic kettles under petrophyte and pratal steppe and shrub with pine (*Pinus nigra*) plantation, on meadow chernozem soils 7. High limestone rocky steeps, breaking on the south and the south-southeast, with fragmentary petrophyte vegetation and the solitary low growing trees of pine (*Pinus sylvestris*), and Arabis caucasica in crevices 8. Near mountain pasture slopes very steep and steep, concave, breaking on the south with pine (*P. sylvestris*) and hornbeam-beech (*C. betulus* + *F. sylvatica*) forests, on brown forest soils 9. Kettle hills and ridges with sloping and convex-concave slopes under petrophyte, festuceta-brachypodiosum steppe association with dwarf semishrub vegetation, on mountain meadow chernozem-like soils	

10. Small and middle flat-bottom valleys, hollows with short sloping and gentle slopes, with narrow bottoms under festuceta-bromosum association on mountain meadow chernozem-like soils 11. Hollows and intermountain depressions with flat convex-concave slopes under petrophyte steppe festuceta-bromosum association, on mountain meadow chernozem-like soils	
Altitudinal landscape zones	
A2. Ladder-shaped and slope-denudation rocks near mountain pasture middle-mountain zone (600-900-1000 m above sea level) with dominance of downhill and steep slopes, complicated by taluses on limestones, sandstones and conglomerates of middle Jurassic and Taurian flysch under *Querceto (petraea)* and *Carpineto-Quercetum* forests*, Pineta -Quercetum* forests (500-900 m above sea level), *Fagus sylvatica* forests (800-1300 m above sea level) and pine forests (*Pinus nigra ssp. pallasiana* (Simeiz – M. Mayak) 450-900 m above sea level, Pinus sylvestris ssp. hamata (Yalta-Alushta) 900-1300 m above sea level) and submediterranean vegetation on dry cinnamon and brown forest soils.	A3. Low-mountain altitudinal layer includes one landscape belt which is presented ladder-shaped and slope-denudation-landslide low-mountain with ancient landslide forms on Taurian flysch, dismembered by river valleys, ravines and small flat-bottom valleys, complicated by limestone outlier massifs and intrusive massifs (0-400-600 m above sea level) it is characterised by domination of various shiblyak, bushes and forest community with evergreen shrub layer, xerophyte-cereals and hemixerophyte forest of *Quercus pubescens* in some areas (up to 450-600 m above sea level), juniper (*Juniperus excelsa*) and pistachio (*Pistacia mutica*) submediterranean vegetation (up to 450 m above sea level) on dry and very dry cinnamon break stone soils.
Simeiz landscapes	
<u>Boundaries of a landscape tracts</u> 12. Relict mountain watershed convex surfaces with pine forests, on brown forest soils and limestone and flysch eluvium 13. Small flat-bottom valleys watershed surfaces and slanting slopes, southern exposition, with limestone rocky fragments under pine forests with participation of Quercus, Acer and Populus, on brown forest soils 14. The Main Ridge slopes (top parts of near mountain pasture) sloping and steep, southern exposition, under forests second growth wood of *Fagus sylvatica* and *F. sylvatica* with *Carpinus betulus*, on brown forest soils 15. The Main Ridge slopes (top parts of near mountain pasture) sloping and concave, southern-southeast and southeast exposition, under forests of P. sylvestris and F. sylvatica, on brown forest soils 16. Outcrop of limestones, forming steps on a slope of the Main Ridge	***<u>Boundaries of a landscape tracts</u>*** 20. Small flat-bottom valleys watershed surfaces and slopes complicated by landslips, gently dipping and sloping on the south and south-southeast, under *Quercus pubescens* and *Carpinus orientalis* shiblyak, with *Pinus nigra* and *Juniperus excelsa*, with evergreen species of undergrowth, on brown and cinnamon soils, on sandstone-argillite-siltstone deposits of Taurian flysch 21. Small flat-bottom valleys watershed surfaces and slopes, complicated by landslips, gently dipping on the south, under pine (*P. nigra*) forests, on cinnamon soils 22. Small flat-bottom valleys watershed surfaces flat-convex, gently dipping on the south-southeast, under *Quercus spp.* forests, forests of *Q. pubescens* with *C. betulus* and forests of *Q. pubescens* with *Fraxinus excelsior*, on brown and cinnamon soils

17. Small flat-bottom valleys watershed ridges and flat convex gently dipping slopes, southern exposition, under pine (*P. sylvestris*) and low-stemmed oak (*Quercus petraea*) forests, on brown forest soils 18. Small flat-bottom valleys watershed ridges and flat convex gently dipping slopes, southern exposition, under pine (*P. sylvestris*) forests, on brown forest soils 19. Terrace artificial on gently dipping slopes, south-southwest exposition, with a dump occupied 24. Upper of small flat-bottom valleys, narrow, deeply runs, V-shaped, filled by detrital rocks of limestone, with steep and gently dipping angle of depression on the south, forests of *F. sylvatica* with *C. betulus* and *P. sylvestris*, on brown forest soils 25. Small flat-bottom valleys (middle parts), deeply runs, with gently dipping and steep slopes, falling of the bottoms on the south and south-southeast, under *Quercus spp*. forests and forests of *Q. pubescens* with *C. betulus*, on brown forest soils 26. Small flat-bottom valleys and ravines, narrow, deeply runs, with gently dipping slopes, ladder-shaped bottoms dropping on the south-southeast, under pine (*P. nigra*) forests, on brown forest soils 27. Small flat-bottom valleys, deeply runs, with gently dipping and convex slopes, narrow bottoms dropping on the south, with pine (*P. nigra*) forests, on brown forest soils	23.Flat slopes (places planed) and small flat-bottom valleys surfaces, flat, southern exposition, under vineyards 28. Bottom of small flat-bottom valleys, average width, with gently dipping and convex slopes, under low-stemmed *Quercus pubescens* and *Q. pubescens* with *Juniperus excelsa* forests, *Q. pubescens* and *Carpinus orientalis* shiblyak, on cinnamon and meadow-cinnamon soils
Yalta and Livadia landscapes	
Boundaries of a landscape tracts 1. Slopes and watershed surfaces, steep and gently dipping, convex, the southeast and southern macro exposition, deeply runs were dismembered by small flat-bottom valleys, under beech (*F. sylvatica*) forests with *P. sylvestris, C. betulus* and *Fraxinus excelsior* in the second layer, on brown forests soil 2. Steep and gently dipping slopes, convex, southeast exposition, treeless 3. Slopes and watershed surfaces, gently dipping, flat-convex, the southern and south-southwest exposition, occupied by burnt wood on a place of pine forests, on brown forests soil 4. Interfluvial watershed ridge slopes, gently dipping, convex, southern and southeast exposition, under low-stemmed *Q. petraea* forests with *P. sylvestris* and *J. excelsa*, on brown forests soil 5. Small flat-bottom valleys watershed surfaces and slopes, ladder-shaped and gently dipping, under oak-ash (*Q. petraea* + *F. excelsior*) forests, on brown forests soil 6. Watershed ridges slopes, gently dipping, flat-convex, southern and south-southeast exposition, under pine forests, on brown and cinnamon soils	***Boundaries of a landscape tracts*** 19. Watershed ridges slopes, gently dipping, southeast, southern and east exposition, under low-stemmed *Q. pubescens* forests with pine (*P. nigra*), on cinnamon soils 20. Small flat-bottom valleys watershed surfaces and slopes, gently dipping, flat-convex, under pine (*P. nigra*) forests with low-stemmed oak (*Q. pubescens*), on cinnamon soils 21. The bottoms of river valleys, narrow 22. The bottoms of small flat-bottom valleys, with *Q. pubescens* shiblyak and *P. nigra*

7. Small flat-bottom valleys watershed surfaces and slopes, gently dipping, flat-convex, south-southeast and southeast exposition, under pine (*P. sylvestris*) forests, on brown and cinnamon soils 8. Small flat-bottom valleys watershed ridges slopes, flat and sloping, convex, east and east-northeast and northeast exposition, under pine-oak (*P. sylvestris* + *Q. petraea*) forests, on brown and cinnamon soils 9. Small flat-bottom valleys watershed ridges slopes, gently dipping, ladder-shaped, east-southeast exposition, under pine (*P. sylvestris*) forests with low-stemmed oak (*Q. petraea*), on brown and cinnamon soils 10. Relict mountain watershed slopes, gently dipping, convex, east exposition, under pine (*P. sylvestris*) forests with *C. betulus*, on brown forests soil 11. Small flat-bottom valleys watershed ridges slopes, gently dipping and flat, convex, northeast and north-northeast exposition, under *Q. petraea* forests with *P. sylvestris*, on brown forests soil 12. The top parts of a macroslope of the Main Ridge, gently dipping, east exposition, under hornbeam (*C. betulus*) forests, on brown forests soil 13. Small flat-bottom valleys watershed ridges surfaces and slopes, gently dipping, convex, southern exposition, under pine (*Pinus spp*.) forests, on brown and cinnamon soils 14. Upper of small flat-bottom valleys, deeply runs, V-shaped, with steep and gently dipping slopes, under *F. sylvatica* and *F. excelsior* forests with *C. betulus, P. sylvestris* and *Acer campestre*, on brown forests soil 15. Upper of small flat-bottom valleys, deeply runs, V-shaped, under hornbeam (*C. betulus*) forests, on brown forests soil 16. The bottoms of small flat-bottom valleys, narrow, places with steep slopes, northeast and east orientation, under pine (*P. sylvestris*) forests with *C. betulus, Q. petraea, F. excelsior*, on brown forests soil 17. The bottoms of small flat-bottom valleys, deeply runs, southeast orientation, under long-boled *Q. petraea* forests with *F. excelsior, A. campestre* and *Populus tremula*, on brown forests soil 18. The bottoms of small and middle flat-bottom valleys, with gently dipping slopes, east and south-southeast orientation, under pine forests, on brown and cinnamon soils	

Foros landscapes	
1. Near mountain pasture slopes of limestone, steep, complicated by collapses and taluses, southern exposition 2. Near mountain pasture slopes of limestone, steep, southern exposition, with fragments of petrophyte steppe and rare species (*Asphodeline lutea, Eremurus tauricus*), on sod-carbonate soils 3. Slopes of the Main Ridge, structural-denudation, rocky, steep and gently dipping, southern exposition, with fragmentary petrophyte vegetation and forest of bushes 4. Small flat-bottom valleys watershed surfaces, flat-convex, gently dipping slopes, south-southeast and southern exposition, under hornbeam (*C. betulus*) forests with *Q. petraea* and *P. sylvestris*, on brown and cinnamon soils 5. Ladder-shaped landslide slopes, gently dipping, southern exposition, under pine (*P. nigra*) forests, on brown and cinnamon soils 6. Relict mountain of limestone, rocky (Isary, etc.) 10. Upper of small flat-bottom valleys, deeply runs, short slopes, under hornbeam xyliums with *Q. pubescens*, on brown forests soils	5a. Ladder-shaped landslide slopes, gently dipping, southern exposition, under pine (*P. nigra*) plantation, complex with Q. pubescens shiblyak, on cinnamon soils 7. Ladder-shaped landslide slopes, gently dipping, dismembered deeply runs by small flat-bottom valleys and ravines, southern, under oak-pistachio (*Q. pubescens* + *Pistacia mutica*) and oak-juniper (*Q. pubescens* + *J. excelsa*) shiblyak, on cinnamon soils 7a. Ladder-shaped landslide slopes, gently dipping, southern, under *Querceto (pubescentis) xyliums*, on cinnamon soils 8. Ladder-shaped landslide slopes, gently dipping, dismembered deeply runs by small flat-bottom valleys and ravines, southern, under oak-pistachio (*Q. pubescens* + *P. mutica*) and oak-juniper (*Q. pubescens* + *J. excelsa*) shiblyak with fragments of pine (*P. nigra*) plantation, on cinnamon soils 9. Ladder-shaped landslide slopes, gently dipping, dismembered deeply runs by small flat-bottom valleys and ravines, southern, under forest of bushes and shiblyak, on cinnamon soils 11. Small flat-bottom valleys and ravines, gently dipping and steep slopes, deeply runs, open on the south, under oak-pistachio (*Q. pubescens* + *P. mutica*) shiblyak, with pine (*P. nigra*) plantation, on cinnamon soils
Gurzuf landscapes	
1. Mountain pasture slopes (Babugan Mnt), formed by laminated limestone, abrupt and steep, complicated by taluses, dismembered by upper river valleys and small flat-bottom valleys, southeast and southern exposition, with pine (*P. sylvestris*) forests, on sod-carbonate soils 2. Interfluvial watershed and small flat-bottom valleys ridges and slopes, gently dipping slopes, southeast orientation, under *F. sylvatica* forests with *C. betulus* on brown forests soils 3. Interfluvial watershed and small flat-bottom valleys ridges and slopes, gently dipping and steep slopes, southern orientation, under *P. sylvestris* forests with *F. sylvatica* and *F. excelsior*, on brown forests soils	13. Small flat-bottom valleys watershed surfaces flat-convex and gently dipping short slopes, under oak (*Q. pubescens*) forests, with *P. nigra* on brown and cinnamon soils 14. Watershed ridges slopes, gently dipping, convex, southeast exposition, under pine (*P. nigra*) and oak (*Q. pubescens*) forests, on brown and cinnamon soils 15. Small flat-bottom valleys and bottoms of river valleys, developed into flysch, under *Querceto (pubescentis) xyliums*, on brown and cinnamon soils 16. Ponds

4. Interfluvial watershed and small flat-bottom valleys ridges, flat-convex, wide, southeast and southern orientation, with short gently dipping slopes, under beech (*F. sylvatica*) and pine (*P. sylvestris*) forests, on brown forests soils 5. Interfluvial watershed and small flat-bottom valleys ridges, flat-convex, southeast and southern orientation, with short gently dipping slopes, under oak (*Q. petraea*) forests with *P. sylvestris*, on brown and cinnamon soils 6. Upper river valleys and small flat-bottom valleys, narrow, deeply runs into limestone slopes of yaila, detrital sediments filled, with petrophyte vegetation, fragmentary with *P. sylvestris* and *F. sylvatica*, on sod-carbonate soils 7. The bottoms of river valleys and small flat-bottom valleys, narrow, deeply runs, gently dipping and steep short slopes, under *F. sylvatica* forests with *C. betulus* and *F. excelsior* on brown forests soils 8. The bottoms of river valleys and small flat-bottom valleys, narrow, deeply runs, gently dipping and steep short slopes, under pine (*P. sylvestris*) forests with *F. sylvatica* and *F. excelsior*, on brown forests soils 9. Small flat-bottom valleys developed into flysch, narrow, with beech (*F. sylvatica*) and pine (*P. sylvestris*) forests, on brown forests soils 10. The bottoms of river valleys, deeply runs, with abrupt and steep slopes (Avunda, Putamish), with beech (*F. sylvatica*) and pine (*P. sylvestris*) forests, with *Q. petraea*, on brown forests soils 11. Small flat-bottom valleys developed into flysch, narrow, with oak (*Q. petraea*) forests with *P. sylvestris*, on brown and cinnamon soils 12. The bottoms of river valleys, narrow, with oak (*Q. petraea*) forests with *P. sylvestris* on brown and cinnamon soils	

Simeiz landscapes is formed in area between the Koshka mountain, the cape Ai-Todor and the Mogabi ridge which watershed surfaces it is possible to consider as its borders. Prominent feature is that middle-mountain zone within this landscape the widest, considerable heights (1200 m above sea level), the Main Ridge breaking on the south by steep rocky ledges. The distance between coastline and a foot of the Main Ridge steeps is 6–6.5 km. Height of edge yaila steeps 1100–1200 m. All orographic elements of a landscape form system of a large mountain ridge – Mogabi, branch off the Main Ridge to the sea and coming to an end to several large capes, for example, cape Ai-Todor.

The landscape was formed within the Yalta anticline. Now in a landscape prevalence of tectonic blocks with the tendency to lowering is observed. The anticline bedrock composing does not participate almost in formation of landscape complexes as heavy covered by loose sediments of the Massandra series. These are yaila limestone massif fragmentation with incorporation of very large displaced blocks from upper Jurassic limestone.

They form mountains Ai-Nikola, Krestovaia, etc. (Figure 3.1.27, 3.1.28). Mountain-outliers create shape of a mountain relief. Core of anticline consist of sandy-argillaceous flysch of Taurian series (T_3-J_1).

On separate areas they form the narrow crests dividing an erosive lobby or landslide cirques. On the majority areas bedrock is covered by loose Quaternary sediments. Among them are prevail upper Quaternary and Modern dealluvial grey loams, dark grey or yellow loams with sandy gravel and fragments of sandstones, siltstones, limestones. They cover slopes of watershed ridges, ravines and small flat-bottom valleys. Thickness of modern slide-rocks is from 0.5 to 6 meters. The wide spread occurrence of the Massandra accumulations, are characterized by good water penetration, was reflected on insignificant watering areas in comparison, for example, with the next Yalta and Livadia landscapes.

Closeness of a landscape area from the north – high rocky steeps of the Main Ridge, from the east and the west – high watersheds of the Mogabi and the Koshka ridges and at the general southern macro exposition is created by conditions for formation of the warmest on western part of southern coast of Crimea.

The natural cover of a landscape is presented juniper-oak, pine and beech forests with undergrowth of a savin, oriental hornbeam and rockrose or often without undergrowth. The natural vegetation is almost destroyed as a result active buildings or very much degraded as a result chaotic recreational activities on coastal areas.

Dominant landscape complexes are interfluvial ridges, wide and sloping (6-11°), with the tendency to tectonic sinking and weak behaviour erosion- denudation and landslide processes, under juniper-oak forests and with areas oak, pine and juniper middle close forests.

Landscape complexes of a landslide terraces occupies rather small space in a landscape. It is, for example, a large abrasion landslip the Golden Beach. Thickness of it deposits is reach 30 m, length of a landslip – 840 m. Active motion of this landslip has passed in 1969. Landslide massif the Oreanda is formed by system of landslips. Their dimensions: length – from 70-80 to 270 m, thickness of their deposits – 2-3 m, slope – 21-25 °. Landslip activity is observed.

Landscape complexes of small flat-bottom valleys watershed ridges (which form a large displaced limestone blocks with rocky slopes and flat summit plane, covered juniper and pine forests) are interest.

Simeis landscape areas under anthropogenic load for a long time. There and then are settlements, recreational complexes and farm lands. At the same time there are: large woodland, the Sun Path (more than 6 km at length), sanatorium parks, the Haraksky park-monument of landscape architecture.

Unfortunately, the large industrial and economic area (including of open mines, concrete product plant, depots, etc.) was created in the vicinity of Gaspra. Contaminants cause quality degradation of recreation southern coast resources.

Yalta and Livadia landscapes are formed within the central part of Southern coast of Crimea in basins of the Vodopadnaya and the Bystraya Rivers. Their outer boundaries are: from the west – the Mogabi Ridge, from the east – the Nikitsky Cam, from the north – high wall (1350 m above sea level) of steep slopes of the Main Ridge. Steeps of the Main Ridge are removed from seashore from 5 km to 6-7 km. Thus, Southern Coast of Crimea within the Yalta and Livadia landscapes reaches the greatest width and differs from other landscapes lower hypsometric marks (Figure 3.1.29).

Figure 3.1.27. Simeiz landscapes (mountain Ai-Nikola).

Figure 3.1.28. Simeiz landscapes (mountain Krestovaia).

In orography the Yalta and Livadia landscapes are formed by two amphitheatre lobby. They are divided by a large ridge which levels goes down to the sea. One of its lowest grade levels is within the bounds of the Yalta – the Darsan Mountain (144 m above sea level).

Figure 3.1.29. Yalta and Livadia landscapes.

This area has general slope landscape seaward and centripetal streams on the drainage systems – the Vodopadnaya and the Bystraya rivers, to the river outlet parts of these rivers in the central part of the city (area between hotel "Oreanda" and the seaport buildings). In the top areas of the river valleys (where numerous lateral inflows form the branching erosive network) the thalwegs has backward direction to the basic direction of macroslope falling of an amphitheatre. The Yalta and Livadia landscapes have general lowering, graded relief and high steepness of slopes.

Tectonic basis of this area is the Yalta anticline. Now the whole of amphitheatre is tectonic lowering zone that does not forward processes activation of a denudation, erosion, abrasion, sliding. Core of anticline consist of sandy shale of the Taurian series (bedrock) crop out and form the special natural complexes.

Figure 3.1.30. Pine plantation on the Darsan Hill.

The natural vegetation is almost destroyed as a result active buildings or very much degraded as a result chaotic recreational activities. The pine and oak forests have remained on hills and river valleys. Public gardens (the Gagarinsky, etc.), parks (the Livadia, the Massandra, the Nikita Garden), pine plantation (for example, on a hill of the Darsan) are created on a place of natural vegetation (Figure 3.1.30).

Dominant landscape lands: small flat-bottom valleys ridges (8), active landslide terraces (13, 14), wide river valleys (17).

Small flat-bottom valleys ridges were form in sandy-argillaceous flysch of Taurian series. They usually narrow with many-stage watershed crests and steep slopes. Slopes of ridges are covered by dealluvial loams which easily are exposed processes of a denudation, erosion and sliding. The vegetation of small flat-bottom valleys ridges is transformed by man. There are only remains of a natural sylva: oak and oak-juniper forests which are in phase of intensive digression.

Active landslide terraces subdivided on: abrasion, located in a seaside part (Livadiysky, Heltyshevsky, Chukurlarsky, Massandrovskaya Sloboda, Seljam-Magarachsky) and streamside erosion (landslips – Mogabi, Gnezdyshko). Landslide terraces of abrasion origin are characterised by the average dimensions (200 – 400 m) and rate of grade (12-20°). Among them there are landslips of frontal type which reach width to 350 m (Massandrovskaya Sloboda) and linear form (Chukurlarsky, Seliam-Magarachsky). The surface relief of landslide differs multistep. Often, landslide terraces are the whole system of different genesis landslips – abrasion, artificial, mixed (for example, Livadijsky). All of them are located on high-rise marks from 0 to 100-150 m.

Erosive landslips form landslide terraces in the form of huge streams landslide loams. So, Mogabi landslips reach length more than 2 km and width to 400 m, an average rate of grade 9-10° and thickness of deposits – 5-10 m.

The lands of wide river valleys are excreted in the Yalta and Livadia landscapes only. Throughout 1.5-2 km their average width compounds 300-440 m, reaching a maximum to 600-700 m in river outlet parts. Above on flow river valleys are narrowed to 50-70 m and less.

The bottoms of river valleys compose modern proluvial-alluvial overburdens – blocks, debris, detritus, lightly gravel with loamy and clay sand filler thickness from 5 to 15 m. In river outlet parts of the Vodopadnaya and the Bystraya rivers thickness of deposits reaches 40-45 m.

There are small flat-bottom valleys lands are widely presented. These are small and large flat-bottom valleys with proluvial and dealluvial-proluvial sediments filling their bottoms, with steep talus sideboards (Figure 3.1.31).

Gurzuf landscapes are formed by basins and small flat-bottom valleys (Avunda, etc.) within the Gurzuf amphitheatre (Figure 3.1.32, 3.1.33). This amphitheatre deeply runs into southern edge Gurzuf and Babugan Yailas. It outer boundaries is: from west – prong of Nikitsky Yaila which has height of 1270-1470 m, and from the east – ridge which stretch in a southwest direction from height of 1256 m to mountain Aiu-Dag. The Gurzuf amphitheatre on the geological framework and character of crust has no sharp differences from Yalta amphitheatre. There are widespread limestone-clay dealluvial sediments, and at mountain Aiu-Dag it is formed mixed slide-rocks from cank and flysch of Taurian series. The complex mosaic of the relief is supplemented by modern landslips. These phenomena are observed along coast, on slopes river valleys and small flat-bottom valleys were formed by clay slates. Destructive activities of landslips are observed in the region of Alupka, Simeiz, Yalta and Gurzuf.

Figure 3.1.31. Small deep valley with a V-shaped bottom.

Figure 3.1.32. Landscapes of Gurzuf amphitheatre.

Figure 3.1.33. Upper reaches of the river valley Avunda.

3.2 Research Forest Ecosystems of Mountain Crimea.

3.2.1 Materials and methods of scientific research on forest ecosystems

Research and analysis of vertical and spatial structure, biodiversity, ecological state of forest ecosystems of the mountain area and the area of landscape organization, monitoring of forest condition, composition and location of threats to biological diversity of forest landscapes and ecosystems have relied on special **information and geographical software.**

1. Library materials:
• Schemes of natural forest management of the territory of Yalta Mountain Forest Nature Reserve schemes of land management of agricultural enterprises, which are located around the reserve and directly next to it;
• Materials of YMFNR Annals of Nature.

2. Data of state socio-economic statistics:
• The current state of the main branches of industry and agriculture of the Soutern Coast of the Crimea;
• The status of surface water and groundwater in the region;
• The current use of the region for recreational purposes;
• The characteristics of hunting and forestry.

3. Materials of field research:
• Geobotanical description of basic types of vegetation (geobotanical site), the quantitative and qualitative account of fauna;
• Identification of areas of rare species of plants and animals;
• overlay of contours of plant communities on forest management and land management schemes in order to further adjust the boundaries of districts (forest inventory units);
• Implementation of field mapping of landscapes;
• Organizing data of monitoring points (incorporated with GPS-receivers) to create a GIS database.

Methods of detecting the horizontal and vertical structure of different types of forest communities in the test areas were based on the works of A.A.Molchanov (1960, 1961), Principles of Forest ... (1964), Yu.Ross (Ross, 1963), Yu.L.Rauner (1972), M.A. Kotchkin (1967), Y.P. Didukh (1992), T.V. Bobra (2005).

During the field research was conducted the description of ecobiomorphemic, phenophases, tiers of the vertical structure of plant communities and phytometric measures of various parameters. Among these, special attention was paid to the spatial distribution of green biomass, leaf area index (LAI), the amount of tree crown space, phytomass density (LAD).

Landscape-ecological studies were conducted in each type of characteristic landscapes, and more detailed observations of the regime of their operation were carried out in semi-stationary and stationary points, where changes of landscape and geophysical parameters were fixed (see Figure 3.2.5). To analyze the spatial differentiation of the total phytomass profiling transects, regular and irregular network of observation points were used. These results are recorded in the GIS database.

4. Devices, advanced software and GIS technologies:
• use of the software ArcGIS 10, ERDAS IMAGINE, ENVI 4, representing opportunities for the collection, storage, space-time analysis and visualization of geographic data;
• For the analysis in the mountain forests of Crimea were used satellite images SPOT4, NOAA, Landsat 7-ETM and their interpretation for the territory of the Yalta Mountain Forest Nature Reserve, as well as aerial photographs (1: 12 000, 1: 40 000) for test sites of Karadag Nature Reserve were produced.

Remote sensing data (RSD) and various methods of their interpretation were used for the following purposes:
• mapping of land cover and landscape organization;
• monitoring the status and dynamics of forest ecosystems;
• forest fire detection and mapping of forest areas traversed by fire;
• analysis of phytopathological status and damage assessment of forest plantations, caused by massive insect pests.

The use of satellite images clarified the forest management scheme and the scheme of the modern use of the territory.

Boundaries of forest communities identified in expeditionary studies were applied to satellite images and linked to the existing forest management scheme.

In the analysis of the horizontal structure of forest vegetation commonly used were methods of geo-modeling based on interpretation of remote sensing and aerial photography.

With the aid of ground positioning GPS (GARMIN) the boundaries of forest ecosystems were clarified, test grounds and monitoring points (coordinates were determined by GPS) were laid.

5. *Creation of GIS databases.*
Geographic information database and visualization were performed using the program ARCGIS 10 and are placed at GeoServer TNU http://envirogrids.crimea.edu/ and http://80.245.119.241/geoserver/web/.

Table 3.2.1. GIS databases of the Yalta Mountain Forest Nature Reserve.

	Data name	Information	Format
1.	Altitudinal_landscape_zones_YMFNR	Landscapes of the Yalta Mountain Forest Nature Reserve. Altitudinal landscape zones	Shape
2.	Boundaries_of_altitudinal_layering_YMFNR	Landscapes of the Yalta Mountain Forest Nature Reserve. Boundaries of altitudinal layering.	Shape
3.	Boundaries_of_landscape_tracts_YMFNR	Landscapes of the Yalta Mountain Forest Nature Reserve. Boundaries of landscape tracts.	Shape
4.	Endangered_species_YMFNR	Endangered species of flora in Yalta Mountain Forest Nature Reserve	Shape
5.	Fires2000_2009_YMFNR	Fires in Yalta Mountain Forest Nature Reserve, 2000-2009	Shape
6.	Forest_pests_YMFNR	Forest Pests in Yalta Mountain Forest Nature Reserve	Shape

	Data name	Information	Format
7.	Landscapes_YMFNR	Landscapes of the Yalta Mountain Forest Nature Reserve	Shape
8.	Rare_species_flora_YMFNR	Rare species of flora in Yalta Mountain Forest Nature Reserve (Points)	Shape
9.	Rare_species_of_flora_YMFNR	Rare species of flora in Yalta Mountain Forest Nature Reserve (Areas)	Shape
10.	Tree_species_YMFNR	Tree species in Yalta Mountain Forest Nature Reserve	Shape
11.	YMFNR_boundaries	Yalta Mountain Forest Nature Reserve boundaries	Shape

3.2.2 Identification and study of vertical and horizontal structure of the different types of forest ecosystems

The structure of radiation, thermal and water regimes, balance of mineral substance is substantially connected to horizontal and vertical structures of a forest covering. The great importance for character of absorption and dispersion radiation has density and vertical allocation of leafage and branches. Detention of an atmospheric precipitation by forest canopy depends on crown density and quantity of leaves, their geometry and roughness of trunks. The water balance structure is defined also by character of a forest floor and grass cover.

Features of a plant community's geometry are characterised by size of the relative area of phytomass (the area of the vegetative mass which is in a certain layer) which in the foreign literature is defined as ***leaf area index (LAI) – a leaf index***, and also by size ***of density of phytomass (LAD).***
Size LAI is defined according to the formula:
$LAI = \int (l_1 + l_2)\, dz$; (1) where
$l_1 = d\omega_1 \backslash dz$; $l_2 = d\omega_2 \backslash dz$ – the relative area of phytomass in an individual layer accordingly for green mass – ω_1 and the non- leaf part ω_2.

Phytometric characteristics of forest associations were studied on several test sites located in the major forest types of the mountain area of Crimea. The most detailed analysis was performed on the test site located near the Karadag background ecological monitoring station of the meteorological mast, as well as Karadag landscape and ecological station (KLES), located in south-eastern macroslope of the ridge Besh-Tash (Figure 3.2.1).

The experimental valuation area №1 is located in the middle part of the northeast macroslope (an azimuth 45°) on the Svyatay Mountain. Research of plant community's was caried out on a field with the area 40 to 40 metres (160 m^2). The valuation area is at height of 185 m above sea level, on sloping (10-15°) direct part of a macroslope of the Sviataia Mountain.

Here at the quality of locality – 4 grow oak (*Quercus pubescens*) forests with cornelian cherry (*Cornus mas*) undergrowth.

The vertical structures of investigated phytocenosis are presented by several layers: arboreal, a layer of underwood, herbaceous and a forest floor layer (Figure 3.2.2, 3.2.3).

Cinnamonic low calcareous soil is of middling thickness, loamy, rubble. The regular structure of flora is presented by 32 families. In ecology and geographical aspect of flora the phytocenosis comes nearer to the Mediterranean type: the Mediterranean core of flora compounds 47.5 % from total kinds of phytocenosis.

The height of an arboreal layer compounds 10-12 meters (average height of an arboreal layer of 8-9 meters). It is presented, mainly, by *Quercus pubescens*, *Acer campestre* and *Fraxinus excelsior* (the formula of a forest: 8 *Quercus*, 2 *Acer*, single specimens of *Fraxinus*). Density of crown spaces of an arboreal layer is 4-7 metres (height of the inferior border crown spaces of 3-4 metres). The averages distance between trees is 2.5-4 metres. The stand of trees is characterised by following stratum data: general density 0.7-0.8; average height of 8 metres, average diameter at breast level – 20-22 cm, structure of a stand of trees – 244 *Q. pubescens*, 23 *A. campestre*, 4 *F. excelsior*, 3 maple.

Underwood is expressed well and consists basically of *Cornus mas*, *Crataegus* spp., *Sorbus torminalis*, *Carpinus orientalis* and *Cotinus coggygria*. According to stratum data within an valuation area: 81 – *C. mas*, 16 – *Crataegus*, 14 – *Carpinus orientalis*, 12 – *Sorbus torminalis*, 3 – *C. coggygria*. The height of underwood is from 1 to 4 metres, different within the area and on the average compounds a density 0.3-0.4.

The undergrowth (seed renewal) (H – 0,5-1) is expressed poorly, in it meet a *A. campestre*, *F. excelsior*, *Crataegus* sp.), seed renewal of *Q. pubescens* practically isn't noted.

The field layer is rarefied and heterogeneous, the projective coating on the average compounds 20 %, H_{avg} – 15 cm. The field layer in places where the wood density is insignificant (in wood windows), and also on forest border is more expressed. In a field layer species composition are *Festuca* sp., *Dactylus glomerata*, *Carex humilis*, *Dictamnus gymnostylus*, *Galium aparine* and others.

On the soil surface the forest floor by average thickness 2-3 cm is formed, and in microfalls – to 5-6 cm.

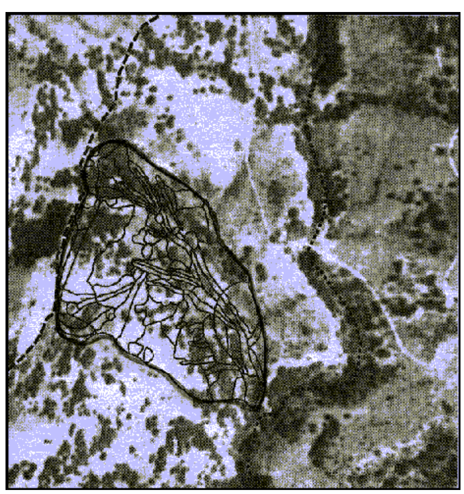


Figure 3.2.1 The valuation area on a southeast macroslope of the Besh-Tash ridge (Karadag landscape ecological station (test sites) – KLES).

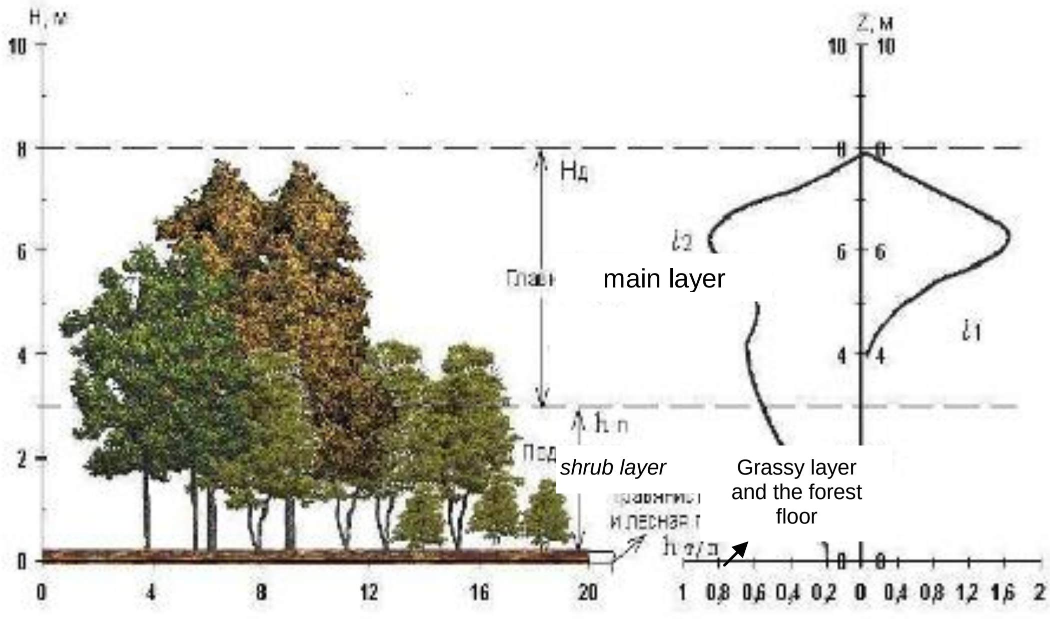


Figure 3.2.2. Vertical structures of oak (*Quercus pubescens*) forests.

Figure 3.2.3 Allocation of green mass and nonleaf skeletal part for oak trees (*Q. pubescens*) forests.

Types of ecobiomorf of studied phytocenosis are presented by trees, bushes, perennia and eutherophyte herbaceous. The role of trees and bushes – dominant in association structure in biomass and projective coating is especially great. In structure of above-ground propagules overtop semirosellate plants. In a relative positioning of propagules there are speciesl of two and three shoots (38.7 %). In renewal type overtop sympodial plants (57 %). In recurrence of development monocarpic propagules prevail di- and polycyclic (63 %). in means of diffusion of fruits and seeds in the first place stand barochore, in the second – hemianemochore and in the third – ballistics. But as a whole the leading place in diffusion of seeds belongs to the wind.

In relation to water regime mesophytes and xeromesophytes (40-53 %) prevail. In relation to light status are 40 % comprise scioheliophytes and 25 % – heliosciophytes.

The maximum of vegetation species is marked from 2nd decade of April till June, the minimum – from 2nd decade of August till 2nd decade of October. In character of an overwintering prevail aestisilvae species (37 %), but also wintergreen species comprise to 20 %. Leading position comprise species which the bud renewal is partial or complete referring to vegetative sphere of propagule only in the autumn of the next year.The maximum vegetation species is observed from 2nd decade of August till 2nd decade of October.

In phytocenosis the first blossoming species appear in the first decade of February, the last – in the 1st decade of August. The maximum of blossoming species is marked in the 2nd decade of the May, blossoming – in the 1st decade of the June, fading – in the 2nd and 3rd decades of June, fructify and fruit ripening stage – in the 2nd decade of the July, finishing fruit ripening stage and dissemination – in the 3rd decade of July, and the end of dissemination – in the 3rd decade of September.

Arboreal ecobiomorf (*Q. pubescens*, *A. campestre*, *F. excelsior*) is the leader in the given phytocenosis. The height of trees varies from 4 to 12 metres, the distance between them comprises 2-4 m.

The phytocenosis basis is compounded by an oak. Both solitary trees and their clump growth (on 4-6 individuals) meet. Tree trunks have direct and slightly bent form. An interrelation of diameters of tree trunks at level of breast and on the middle of the trunk allow to say that the form quotient compounds basically 0,6-0,7. The state of arboreal ecobiomorf of *Q. pubescens* is normal (a gain of top propagule – 20-22 cm). However, seed renewal of *Q. pubescens* is not practically revealed.

Shrub ecobiomorf is presented basically by a *C. mas* and *Crataegus* spp., the *Ligustrum vulgare* and *Cotinus coggygria* are more rare. It is concentrated in a layer of underwood. The height of bushes varies from 1 to 4,5 metres. Bushes have good enough development, normal vegetation and at the moment of the description were in a fructification stage.

On Figure 3.2.3 differential curve of allocations of green mass and non-leaf skeletal part for oak stand of trees are shown. The curve of allocation of a leaf area of an oak (*Q. pubescens*) stand of trees in phytocenosis finds in the main layer a maximum at height of 6.5 m from which to the inferior and top parts crown spaces are decreasing, and to the inferior part of a crone are decreasing faster which is possibly bound by the fact that the most part of new propagules with leafage is concentrated in the top part of crown spaces.

The allocation curve of non-leaf area of oak stand of trees marks the main maximum which practically coincides with a maximum $\mathbf{l_1}$. At height 3-3,5 m are marked the second, less expressed maximum which coincides with a place where branching of trunks begins and branches are thicker than in middle and top parts of the crone (Table 3.2.2).

Table 3.2.2. Vertical allocation of a relative surface of phytomass and leaf area index at a stand of *Q. pubescens* trees (majorant).

z	$\mathbf{l_1}$	$\mathbf{l_2}$
0.05	0.40	0.018
0.10	0.94	0.045
0.20	1.52	0.08
0.30	0.80	0.072
0.40	0.42	0.054
0.50	0.12	0.060
0.60	0.01	0.048
0.70	0.00	0.037
0.80	0.00	0.030
0.90	0.00	0.020
	$\sum$ 4.21	0.464
LAI = 4.684		
$\mathbf{H_{avg}}$= 8 m		
$\mathbf{H_{avg}}$ = 3 m		

Under natural conditions crones of many foliaceous breeds and in particular *Q. pubescens* have well-marked spindle-shaped form. A line which is bending around crones in vertical section is possible to be approximated by a curve of second or higher order. A characteristic kind of the curve is possibly the ellipse, eccentricity of which is considered as an indicator of an interrelation of depth **H – h** and width of a crone of tree **r**. The volume of crown spaces in this case corresponds to ellipsoid rotations, that is to rotation of an ellipse round an erect axis **z**, coinciding with a fulcrum axis:

$$\nu = 4 \backslash 3\pi (H-h)_1 r_1^{\,2} = \pi \backslash 6 r^{\,2} \text{ (H – h)} \approx \text{ 0,5r}^2 \text{ (H – h), (2)}$$

where r_1=r\2; (H – h) $_1$ = H – h\2 – small and big semiaxes of an ellipse.

Then the phytomass density in some layer will be defined by an interrelation:

$$\text{LAD} = (\omega \backslash \Delta V = \int (l_1 + l_2) dz \backslash \Delta V \text{ (3)}$$

Using the formula (2), it is possible to calculate ***volume crown spaces*** of average *Q. pubescens*, making the basis of the studied phytocenosis:

The volume of crown space of *Q. pubescens* comprises:

$$\text{V} = 0{,}5 \times 2{,}5^2 \times (8-3) = 15{,}6 m^3,$$

then ***LAD =*** 0,29/m^3.

The horizontal structure of vegetation can be reflected through regional differentiation of the plant communities, different layers on a panel in vertical profile (quantity, thickness) and height of the top layer (Figure 3.2.4).

On a test area 1 most complex vertical structure assemblages from an *Q. pubescens* in height 10-12 m which forms the first arboreal layer, the second arboreal layer is comprised by *A. campestre*, *F. excelsior* in height to 6-10 m, a layer of underwood *C. mas*, *C. orientalis*, *S. torminalis*, the field layer has no continuous projective cover and is presented by *Carex* sp.*, Dactylus glomerata, Festuca* sp. These communities have the greatest density (till 0.7-0,8) and biomass.

A high percent of the test area occupy shrub with assemblages of a different density and herbaceous grassland and gramineae steppe assemblages (on Figure 3.2.4 these assemblages have height of the top layer from 1 to 6). This results from the fact that the test area is settled in the region of ecotone.

Spatial analysis of landscape and ecology forest conditions was carried out on the basis of the complex approach: studying of a spacing of landscape and geophysical parameters (temperature and air humidity, temperature and humidity of soil, quantity of phytomass and so forth) with use of possibilities of GIS-technologies; detailed analysis of results of field landscape mapping, decription and analysis of aerial photographs.

The landscape and ecology differentiation on the KLES is bound to distinctions of situations of connatural complexes on different elements of mesoforms of a relief. Three landscape complexes of rank complex natural boundaries are secured: gully bottom, slopes of a ridge of the Besh-Tash and watershed surface of a ridge of the Besh-Tash. In them the landscape differentiation is defined basically by exposition distinctions and different steepness of slopes that finds the reflection in character of humidifying, change of plant community's etc.

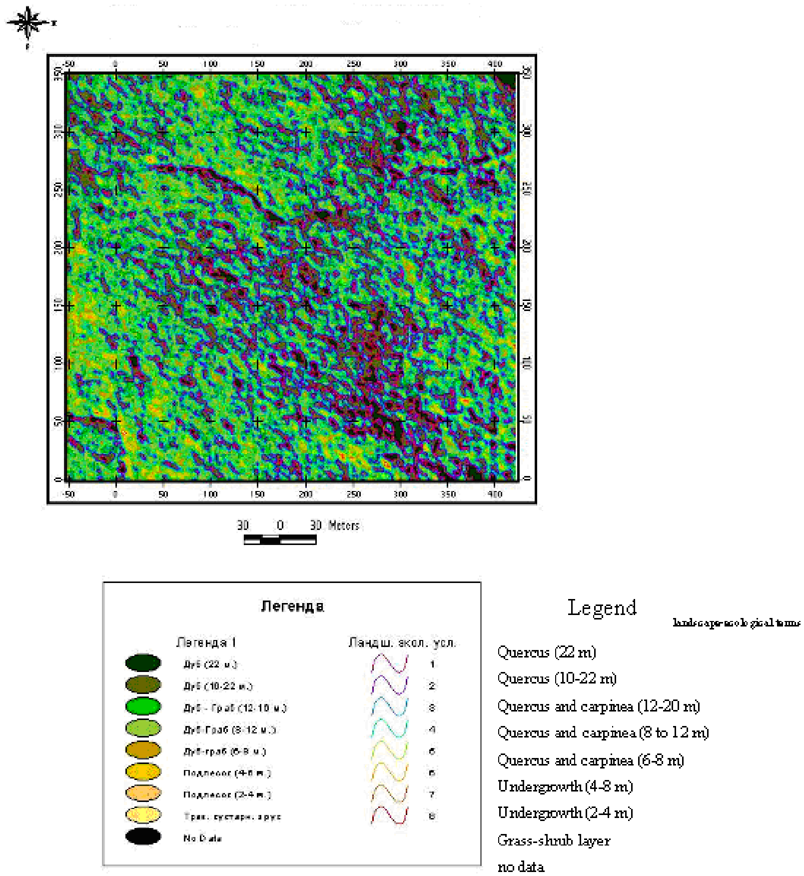


Figure 3.2.4. Spatial analysis of forest ecosystems. Forest communities with different vertical structure (test sites, fragment).

Different poles of landscape and ecology conditions on the KLES, defining amplitude of regional differentiation and contrast, are geotop formed on the one hand, on the watershed surface by limestone with a rubbly-loamy sediments under petrophyte steppe and xerophytic assemblages on cinnamonic low thickness rubbly loamy soils, on the other hand – in the bottoms of the gully developed on flysch rocks by middle Jurassic period and steppe, wheatgrass-shrub and forest communities in moderately brown loamy soils.

Landscape complexes are formed in the conditions of insufficient humidifying within eight months. This circumstance also defines the small areas of xyliums. Xyliums are dated basically for northeast slopes, the bottoms of hollows and gully.

Field landscape and ecology research on KLES was made in each characteristic phylum of landscape complexes, and more detailed supervision over a mode of their functioning were carried out in semiportable and stationary points in which changes of landscape and geophysical parameters were fixed (Figure 3.2.5). Detailed research in this area testifies that high degree of regional differentiation of landscape and geophysical conditions here takes place (Figure 3.2.6, – regional change of temperature conditions).

The range of temperatures (on supervision of 9.08.2004, 13 hours) fluctuates from 24°C to 40°C, the amplitude compounds 16°. The lowest values of temperatures (24-26°) are observed in forest canopy curtains geotop 1 and 3 phylums with the high degree of closeness (0.9 – 0.6), the gully is marked for the bottoms, hollows, and also gully slopes of northeast and northern exposition. Mapping of landscape and ecology structure and regional differentiation of temperature conditions allows saying that regions with greatest contrasts of landscape, ecology and temperature conditions practically coincide.

As an integrated indicator of change of landscape and geophysical conditions the indicator of total phytomass as it is the indicator of many processes proceeding in a landscape is used, and it well correlates with other landscape characteristics. Phytomass measurement was carried out on fourteen transect profiles. As an example results of measurements are resulted for several profiles (Figure 3.2.7).

On the presented profiles ranges of the maximum gradients of regional change of quantity of phytomass which fix boundary regions of geotop with different landscape and ecology conditions are noted. These regions are dated not to narrow and linearly extended water separate and thalweg complexes, but to slope surfaces. It happens because landscape and ecology conditions there are more homogeneous, than on slopes adjoining them. The sharpest change is undergone here by direction (divergence-convergence) of sublateral streams while on slopes considerable change of variety of processes and parameters (from topographical height to components structure) take place.

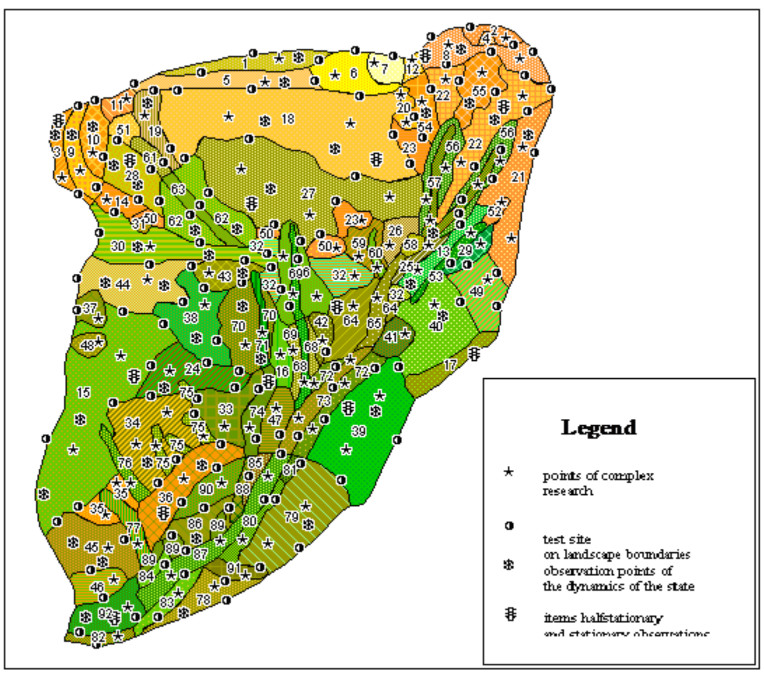


Figure 3.2.5 Landscape organisation of the territory KLES with an irregular network of observation points (Bobra, 2005).

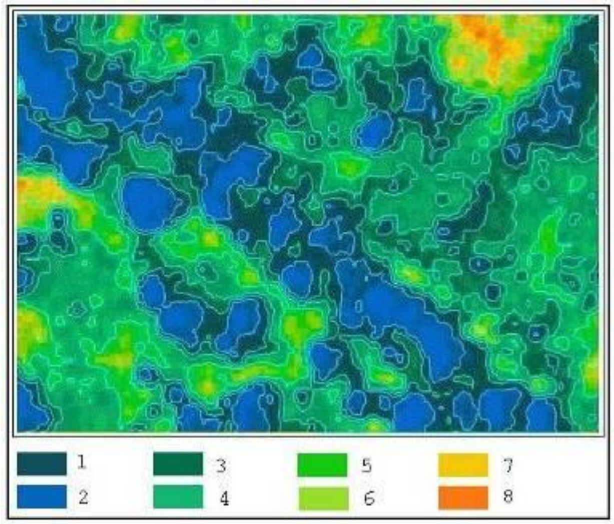


Figure 3.2.6 Spatial differentiation of temperature conditions on the test site (fragment):
1 – 24°-26°; 2 – 26°-28°; 3 – 28°-30°; 4 – 30°-32°; 5 – 32°-34°; 6 – 34°-36°; 7 – 36°-38°; 8 – 38°-40°.

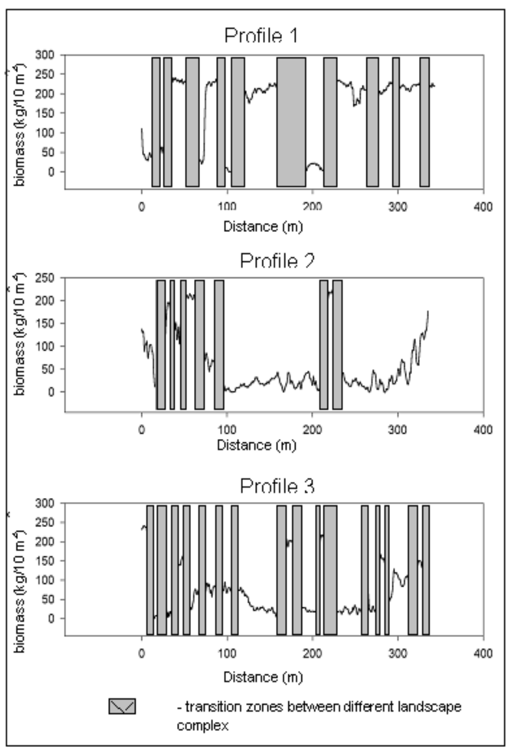


Figure 3.2.7. Changes in phytomass along the lines of cross sections, laid through the territory KLES (showing zone ecotones, topological level).

1 – Landscape-ecological conditions, characterized by vegetation of the xeromezopholious *Carpineto (orientalis)* – *Quercetum communities*, in most cases confined to the upper floors of bars and adjacent gullies and near – braced slopes of the eastern and the north-eastern exposure, with brown medium-detritus and sometimes stony-loamy soils. The density of the tree layer is 0.8 to 0.9, the height of the

forest stand is up to 10 m. In the undergrowth, as the second tier, grows *C. mas* and *C. orientalis*, having here the form of trees. The grass cover consists mainly of mesophytes (umbrofits), early-spring ephemerals and ephemeroids. In most of the densed herb coverage, the cover is between 1% to 10%,and only during the spring it can reach 30%. These are the most humid and cool conditions, with the least amount of incoming solar radiation. The density of phototone on the image ranges from 0 to 16 units for these areas (the most shaded parts of the picture).

2 – Landscape-ecological conditions, characterized by vegetation of the lighter low-stemmed, of up to 4 m, *Querceto (pubescens) – Carpinetum (orientalis)* forest communities.
The *C. orientalis* (dominant species) creates a second wooden substage and dense undergrowth with a projected cover of up to 90%. The density of the main tier of the forest stand, formed by the *Q. pubescens*, sometimes mixed with *Pistacia mutica*, does not exceed 0.4. In the undergrowth, except for the *Q. pubescens*, grows *C. coggygria*, and in the thinned herbage dominate xeromesophytes and mesophytes. The density of phototone on the image, ranges from 16 to 32 units for these areas.

3 – Landscape-ecological conditions, are characterized by vegetation of the most common to the community station – *Q. pubescens* forests with thorny shrubs. They make up about 30% of all timber groups the station. These communities are to be of the island type, in the form of small curtains or spots of various sizes and configurations, alternating with grassy and shrubby coenosis. They are strongly attached to the slopes of different exposures, often eastern and northeastern, as well as in small hollows and depressions. Larger areas are found along the slopes of beam, the ravines. Individual groups of trees are typical for the distinctive forest species in the herbaceous cover under the canopy. The height of the forest stand, which consists of the *Q. pubescens*, *P. mutica*, and sometimes *A. campestre*, is less than 10 m, the crown density is 0.6-0.8. In the floor of thorny shrubs, which has a projective cover of 20% or less, most common are *Rosa corymbifera, Paliurus spina-christi*, mores rare – *Prunus spinosa* and species of the *Crataegus* genus. Projective cover of grass varies from 20 to 60% of its composition, and is dominated by *Elytrigia maeotica*, as well as mesophilic and xeromezophilious herbs – *Teucrium chamaedrys, Lithospermum purpureo-caeruleum, Geum urbanum, Arum elongatum, Viola alba, V. odorata, Thalictrum minus*. The density of phototone on the image, ranges from 32 to 64 units for these areas.

4 – Landscape-ecological conditions, characterized by the vegetation of shrub communities, which occupy about one-tenth of the area of the station, are presented by *Paliureta spinae-christi, Rosaeteta corymbiferae, Pruneta spinosae, Rubeta taurici.* Apparently, just as their wooden community predecessors, they are placed along the beam, tend to ravines, depressions of the relief, but come on level areas and slopes (the shrub invasion here is interrupted by wild hogs). The projective cover of shrubs tier in these communities is from 40 to 100%. The grass cover consists of long-rhizomatous cereals, herbs and annuals, which are often of the weed nature, such as *Torilis arvensis, Tordylium maximum, Galium aparine, Xeranthemum cylindraceum*, etc. In the most humid habitats (along the bottom of the joists) under the canopy of shrubs, there are common mesophytes (*Melissa officinalis, Rumex crispus, Carex otrubae, C. polyphylla*), as well as the gigrofit *Mentha longifolia*. In the continuous scrubs, the projective cover of grass is minimal – 3%. It is based on ephemers and ephemeroides. Density of the phototone varies from 64 to 96 units.

5 – Landscape-ecological conditions, characterized by the grassy vegetation communities of meadow nature (10% of the total area of herbaceous communities in a hospital/station). They are located along the beam, on the bottoms of ravines and gullies, in depressions, occupying the spaces between shrubs and tree groups. Density of the phototone varies from 96 to 128 units

6 – Landscape-ecological conditions, characterized by meadow-steppe vegetation, represented by the communities *Alopecureta vaginatii, Stipeta pulcherrimae et ponticae, Elytrigieta intermedii et trichophorae*, and located on not steep, often somewhat concave slopes of the northern and north-eastern exposure. Density of the phototone varies from 128 to 156 units

7 – Landscape-ecological conditions, characterized by vegetation of various communities *Festuceta valesiacae, Bothriochloeta ischaemii, Agropyreta pectinatii, Stipeta ponticae (et pulcherrimae), Elytrigieta nodosae, Alopecureta vaginatii*, relating to this (typical) steppes, are formed on the gentle and an average steepness slopes of the eastern exposure, as well as on the flat areas. Density of the phototone varies from 156 to 222 units.

8 – Landscape and environmental conditions, characterized by the vegetation of petrophyte-steppe communities are confined to the convex surface topography, interhollow and interdepression watersheds, and steep slopes. Density of the phototone varies from 215 to 256 units (Figure 3.2.8).

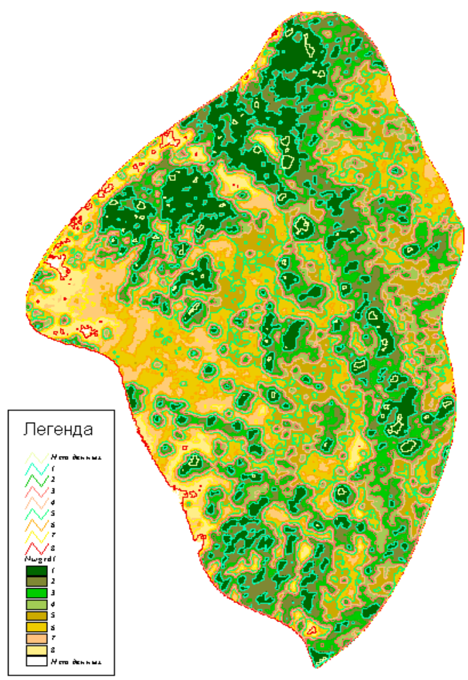


Figure 3.2.8 Types of geotops with different landscape-ecological and conditions for the growth of forest (KLES) (Bobra, 2005, 2011).

The most common, are geopots with landscape and ecological conditions that allow xeromezophytous communities *Carpineto (orientalis) – Quercetum* to grow with brown medium-rubbly and stony soils in places. The density of the tree layer is 0.8 to 0.9, the height of the forest stand is 10 meters. The smallest areas are occupied by geotops with *Festuceta valesiacae, Bothriochloeta ischaemii, Agropyreta pectinatii, Stipeta ponticae (et pulcherrimae), Elytrigieta nodosae, Alopecureta vaginatii* communities, relating to this (typical) steppes, which are formed on the flat and gently rolling slopes of the most eastern exposure, as well as on the flat areas.

Spatial analysis showed, that forest communities with a higher forest stand and a complex vertical structure, are located on the bottoms of beams and the bottom of the closed basin slopes of ravines and gullies (longitudinal trend of the slopes).

Taking the advantages of GIS-technology Arc GIS 9.2 – Spatial Analysis, indicators were calculated that could quantitatively characterize the compactness of the tree-shrub layer, and constructed maps showing the spatial variation of canopy forest communities (!), and the spatial differentiation of the forest in height, and difficulties of the vertical structure.

Indicators of density are obtained by calculating the distance from the centroid point, from each previously selected on the grounds of deciphered circuit of the plant community to the periphery (the border), taking into account the overlapping of crowns. Spatial variation of the density in forest communities within the test site in Old Crimea UTC, is shown in Figure 3.2.9. The density level varies from 0 to 10 (full density). On the picture, light tone displays communities with the largest density – 7.5.

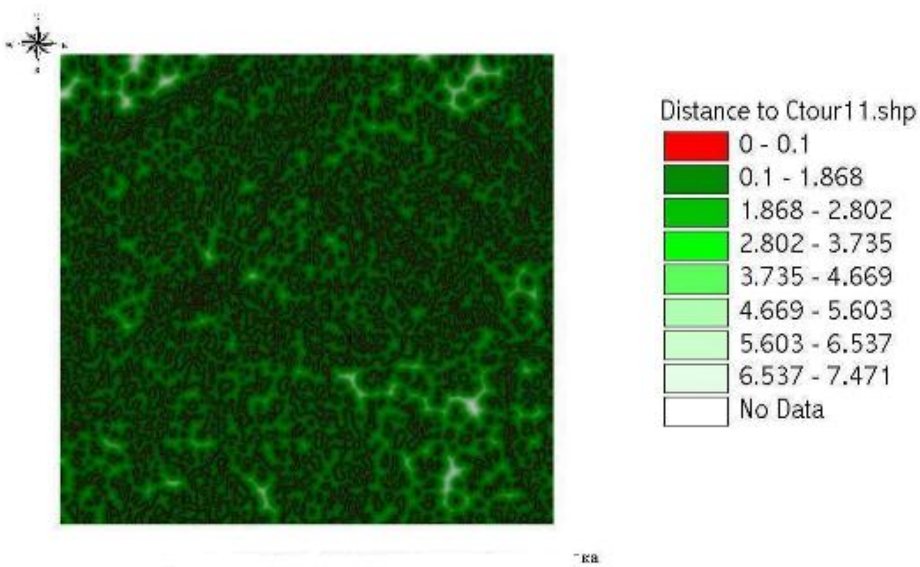


Figure 3.2.9 Spatial variation of the forest density on the test site (fragment) (Bobra, 2007, 2011).

The conducted researches have shown significant spatial differences in the nature of the vertical structure, height and layers thickness in different forest types (Figure 3.2.10*).* The biggest density of the forest stand is observed in *beech* (*Fagus sylvatica*) *forests*. Projective cover of the grass sods, varies from 40 to 60%. Thickness of litter in this type of forest is 5-10 cm

Durmast oak (*Quercus petraea*) *forests are* also characterized by the high closeness of the stand, but have a lower height and lower leaf mass. Projective cover of grass is quite high, often reaching 70%, the thickness of forest litter is 5-15 cm

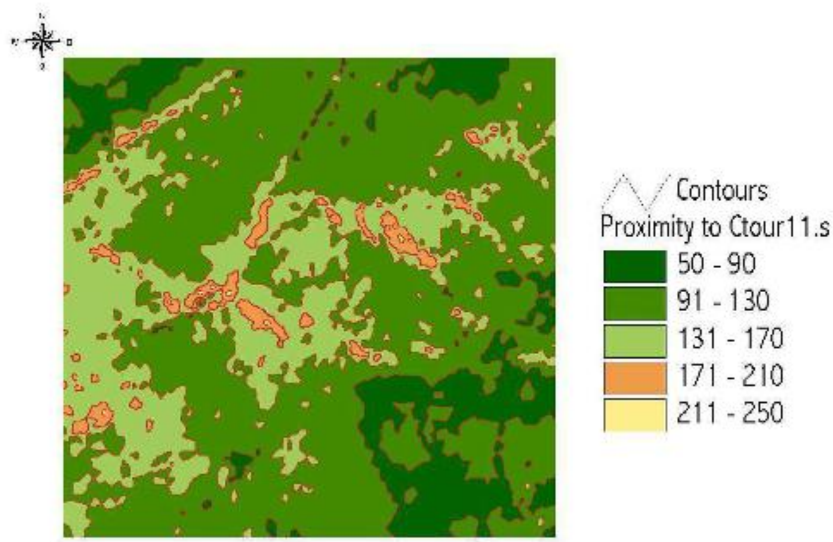


Figure 3.2.10 Spatial Differentiation of forest according to the vertical structure on the test site (fragment) (Bobra, 2007, 2011).

In the pubescent oaks (*Quercus pubescens*) forests, there is a much greater spatial differentiation and heterogeneity: significantly vary the stocking of tree stand, projective cover of the grass layer, and litter thickness. Pubescent oaks communities, grow in the lower altitude zone (up to 400-450 m asl), where a considerable relief and ruggedness of a large mosaic of habitats and locations (site conditions) is observed. In this regard, there are more significant differences in horizontal and vertical structure of forest and shrub-forest communities

3.3 Environmental Policy of Ukraine for Specially Protected Areas (Nature Reserve Fund Lands). General Legal Approaches to the Nature Protection And Biodiversity Conservation.

After the independence of Ukraine declared in 1991, the Government of Ukraine has developed environmental policy aimed at an optimal model for environmental management. The key elements of Ukrainian environmental policy are:

- environmental standards, permitting and compliance;
- pollution fees and environmental funds;
- environmental reviews.

A number of legal documents elaborated and adopted in the last years provides basis for nature protection and conservation in a direct way and in this way defines the legal framework for nature management. Among them the most important is 1991 Law of Ukraine on Environmental Protection, which has become the legislative base for nature protection in Ukraine. In accordance with this law, nature protection and conservation has become a matter of state concern. The Law regulates different relations in the sphere of environmental protection, use and restoration of natural resources, ensuring ecological safety, prevention and liquidation adverse impact of economical activity on environment, conservation of natural resources, living nature genetic fund, landscapes and other natural complexes, unique territories and objects, connected with historical-cultural heritage. According to the law all entities of the plant and animal world of the country are subjects of the state protection, and any special use of living natural resources should be based on the principles of compensation and special permits.

Other environmental acts of general importance are:

Law of Ukraine on Nature Reserve Fund, 1992. The law defines precisely the background for creation, designation, management and rational use of the Nature Reserve Fund of Ukraine. The NRF includes lands and water areas, natural complexes and sites of high natural, scientific, recreational and other assets. These are set aside with the aim of protection of both landscape and biological diversity, maintenance of ecological balance (sustainability) and providing basic environmental monitoring.

Land Code of Ukraine, 2001. Its objects are regulation of land relations to create conditions for sound use and protection of lands, for equal development of all forms of property on lands and all types of human activities, conservation and restoration of soil fertility, improvement of environment, and protection of rights of the citizens, establishments and organizations on the land.

Law of Ukraine on Environmental Expertise, 1995. Environmental expertise in Ukraine is a type of scientific practical activity performed by specially authorized state bodies, expert agencies in the field of ecology. It is based on inter-field environmental researches, analyses of projects, programmes, designs with regards to its compatibility with the nature conservation, prevention of undesirable negative changes in the environment, and ensuring sustainable use of nature resources.

Forest Code of Ukraine, 2006. Legislative regulation to ensure increase of productivity, protection and restoration of forests, enhancement of their useful properties, satisfaction of society needs in forests resources on the scientifically justified sound utilization are objects of the Forest Code of Ukraine.

Water Code of Ukraine, 1994. According to the Water Code, all water objects on the territory of Ukraine are of national property, the ones of natural bases of economical development and social welfare. Water resources provide conditions for human, animals' and plants' existence and are limited and sensitive natural objects. The Code provides mechanism for sustainable use of water resources.

Law of Ukraine on Flora, 1999. The Law on Plant Kingdom (Flora) regulates social relations in the sphere of protection, use and restoration of wild and other non-agricultural vascular plants, algae, lichens, fungi, their communities and habitats.

Law of Ukraine on Fauna, 1993. Animal Kingdom (Fauna) is one of the main components of environment, national wealth of Ukraine, source of spiritual and ethic self-enrichment and upbringing of people, object of scientific research and important resource of industrial and medical raw-materials, foodstuff and other material values. The law regulates use of animals for different purposes such as hunting, fishery, scientific research, farming, agriculture etc. They provide base for the protection of endangered and rare species of animals. Special consideration is given to the migratory animals.

Law of Ukraine on Hunting, 1999, ensures sustainable use of hunting animals, regulates relations between hunting associations, and provides mechanism for establishing limits and sharing quota for hunting etc.

Law of Ukraine on the Red Data Book of Ukraine, 2002, deals with the preservation and protection of rare, threatened and endangered species of plants and animals. The regulation has taken recommendations of the European Economic Commission of the UN (Former Experts Group on Flora, Fauna and Habitat) and international conventions for protection of biodiversity.

Laws of Ukraine on National Program of Forming of National Ecological Network of Ukraine on 2000-2015 (2000) and on Ecological Network (2004). The laws define the background for creation, designation, management and rational use of the territories that are included to the ecological network of Ukraine as part of Pan-European econet. The econet includes such elements as core areas, ecological corridors, buffer zones that are the lands, natural and semi-natural complexes and sites of high natural, scientific, recreational and other assets.

Legal act "*Regulations on the Green Data Book of Ukraine*" (1997) covers typical and rare plant communities which should be preserved.

Besides these laws, nature conservation is (directly) regulated also by Decrees of the President of Ukraine. In particular, in these decrees lands can be reserved for protection, this means that in future protected areas can be established, without the need for the Government to buy the land. Besides the laws mentioned above, Ukrainian legal system of environmental protection and management includes by-laws which regulate the specific types of activities in the field. The system comprises regulations, rules, Government resolutions, standards, methodologies and and recommendations.

In 1995, the Sofia Ministerial Conference on Environment of the European states under the auspices of the Council of Europe and the UN European Economic Commission approved the Pan-European Strategy for Biological and Landscape Diversity Strategy, the basic direction of the implementation of which was the establishment of the Pan- European ecological network. The network would combine the existing centers of natural diversity of European values into a single territorial system, stretching from the Urals to the Iberian Peninsula.
A
ccording to the Pan-European Strategy for the conservation of biological and landscape diversity, the basic elements of ecological networks are natural habitats (core) to store various types of ecosystems and habitats (ecotopes), species of plants and animals and landscapes of European importance, ecological corridors (transition zone) for providing the links between natural habitats, restoration of areas of damaged ecosystems, buffer zones for protection of natural focus from adverse external influences. And to the natural homes of the Pan-European ecological network are primarily environmental or nature-protected areas that meet the criteria of international (global, European and regional) conventions and agreements and are recognized by them. The integrity of the ecological network is ensured by establishing, where appropriate, continuous eco – corridors or continuous "transition zones", which contribute to the settlement or migration of species between natural focus. In many cases, the binding function of eco – corridors are to be linked to some forms of economic activity in the territory.

Legal basis for an ecological network in Ukraine were laid in the Law of Ukraine "On Environmental Protection" (1991), which states that natural areas and sites subject to special protection, form a

single territorial system and include the territories and objects of natural-reserve fund, spa and therapeutic, recreational, waterproof, field and other types of sites and facilities, which are determined by the Ukrainian legislation.
Relations associated with the formation, conservation and use of an ecological network, governed by the laws of Ukraine "On the nature reserve fund of Ukraine", "On Flora", "On Fauna", "The Red Book of Ukraine", "On the Protection of Cultural Heritage, the Land , Water, Forest Code, the Code "On Subsoil" and the Law "On the General Scheme of Planning in Ukraine" (2000) and the Law "On the Planning and Development of Territories" (2002).

In September 2000, Ukraine adopted a special Law "On the formation of a national program of the National Ecological Network of Ukraine for 2000-2015." And in 2004 Parliament approves the law "On Ecological Network in Ukraine", which consists of sections and paragraphs of articles revealing the program of conservation, protection and development of national ecological network. Ukraine National Econet is a complex multi-functional natural system, the main functions of which are conservation, stabilization of the ecological balance, increase productivity of landscapes, environmental improvement, to ensure balanced and sustainable development of the state.

Natural focus of high-level are natural reserves, protected areas of national parks and biosphere reserves and buffer zones around nature reserves and recreation areas in national parks and natural buffer zones in biosphere reserves (reserves) is essentially the buffer zones.

The main natural homes of the national ecological network, due to their conservation and recovery are: the Carpathian mountain country, with Precarpathian Opolie, Crimean mountainous country, the Western Polesie, the Dnieper Polesie, Eastern Polesie, Podolsk Upland, Donetsk Ridge and Azov Upland. Significant role in the national ecological network play branched river networks of the Dnieper, Dniester, Southern Bug, the Western Bug and Northern Donets, the Ukrainian coast of the Azov and Black Seas.

According to the "National Program of formation of the National Ecological Network of Ukraine for 2000-2015 years.", 29 national parks, 7 biosphere reserves should be created, the 3 natural and 3 biosphere reserves, 5 national parks should expand their borders. In general, the area of nature reserve fund of Ukraine should increase more than doubled to reach 10% of the area of Ukraine.

Formation of an ecological network involves changes in the structure of land fund of Ukraine by referring to the categories of land subject to special protection to ensure the integrity of the ecological network.

The program provides for the implementation of a series of events:

- expansion and optimization of the network object of natural reserve fund;
- formation of cross-border conservation areas;
- creation of protective forest plantations, shelter belts, etc.;
- reclamation of disturbed lands and their renaturalization;
- ensuring the protection of wetlands;
- providing conditions for the preservation and reproduction of the variety of plant and animal species;
- special measures to ensure that migration animals;
- implementation of measures to prevent negative effects on natural ecological network core.

The program provides an inventory of special and scientific research, establishment of centers for

artificial breeding of rare and endangered plant and animal species, awareness raising, implementation of activities arising from international obligations.
The nationwide program of the formation of a national ecological network provides for the preparation of applications for recognition of the values of natural areas of Ukraine, primarily within its nature reserve, at the international level, a national inventory of natural heritage. Presentation will be prepared for the international recognition of new biosphere reserves, made were the proposals to the List of Wetlands of International Importance and the World Network of Biosphere Reserves, the Emerald Network in Europe and for awarding the European Diploma for protected areas.

Following the adoption of the Law "On the formation of a national program of the National Ecological Network of Ukraine for 2000-2015 years." began to adopt programs to promote regional environmental networks. In September 2008 the Decree of the Verkhovna Rada of the Autonomous Republic of Crimea on 17.09.2008 № 968-5/08 approved program of formation of a regional ecological network in the Autonomous Republic of Crimea in 2015, under which developed and adopted is a scheme of regional ecological network in Autonomous Republic of Crimea (the Scheme), recognized by the Ministry of Environment and Natural Resources the best in Ukraine. According to the approved scheme 36 objects local to the area of 51 324 hectares are reserved for further commandments. With the implementation of relevant activities under nature protection scheme percent in the ARC will be 17.4%.

The main elements of a regional ecological network as a part of the National Ecological Network of Ukraine in the Crimea are:
- Regional Ecocentres (Core areas, or Biocentres) - formed to natural areas that have high biological and andscape diversity (here included alta Mountain forest reserve of natural, Karadag nature reserves, Crimea Mountain forest reserve of natural wetlands of international alue created by the territory of the National Natural Park Tarkhankut", etc.). Core areas are the most valuable areas, mainly represented by large (more than 500 ha in the steppe and more than 1000 hectares of forest ecosystems) objects nature reserves and other areas requiring special protection (East Syvash, Karalarsky, Karkinitsky, Sasyksky " etc.);
- Ecological Corridors – connecting area, which form parts of the natural landscape of varying shapes and sizes, providing appropriate conditions for the migration of flora and fauna;
- Buffer Areas – protect key and connecting areas from human influence. These areas are the transitional zones between nature areas and areas of economic use;
- Restored Areas – provide a spatial integrity of the ecological network, for their formation the priority measures concerning reconstruction of the primary natural state should be made.

Under the proposed scheme as a result of the formation of a regional ecological network of the Autonomous Republic of Crimea, which includes 21 environmental center and 20 ecological corridors, the area of facilities of regional ecological network will be more than 38% of the total territory of the republic. The share of the objects of nature reserve fund will be about 10%. The remaining 28% of the area that is occupied by the objects of the ecological network, will have regulated and controlled level of protection depending on the functional purpose. environmental and biological values, the nature of economic activities, etc.

The Law of Ukraine on Nature Reserve Fund of Ukraine (1992).
According to the Law of Ukraine on Nature Reserve Fund (the Nature Protection Areas) of Ukraine is a part of dry land and water space, which natural complexes and objects have special environmental, scientific, aesthetic, recreational and other value and are singled out with the purpose to preserve

natural variety of landscapes, flora and fauna genofund, maintenance of general ecological balance and ensure environment background monitoring. Nature reserve fund shall be protected as a national inheritance. A special protection, reproduction and use regime shall be set as regards to it. Ukraine considers this fund as a component part of world system of natural territories and objects which are under special protection.

To nature reserve fund the Law refers:

- natural territories and objects (natural reserves, biosphere reserves, national natural parks, regional landscape parks, game reserves, natural monuments, unique terrain feature reserves;
- artificial objects (botanical gardens, dendrology parks, zoological parks, parks which are monuments of park and garden planning).

In the Article 3 of the Law there is a classification of protected areas.
The Law sets ownership forms for the territories and objects of nature reserve fund.

Article 7 of the Law sets legal regime of nature reserve fund lands. Any activities which negatively influence or may negatively influence on natural and historical cultural complexes condition and prevent their purposeful use shall be prohibited on the lands of environmental protection and historic and cultural purpose.

The territories and objects of nature reserve fund may be used for:

- environmental;
- scientific investigation;
- health care and recreation;
- education and bringing up;
- needs of environmental monitoring.

Chapter II of the Law regulates the issues of management in the sphere of organization, protection and use of natural reserve fund. Specially authorized body of state management in the sphere of natural reserve fund organization, protection and use is a central body of executive power in the sphere of environment.

The Law sets regime of nature reserve fund territories and objects. The regime of nature reserve fund territories and objects is a totality of scientifically grounded ecological requirements, norms and rules which determine legal status, destination of these territories and objects, character of permissible activities on them, procedure of their natural complexes protection, use and recreation.

The Law stipulates creation of territories and objects of nature reserve fund protection zones. These buffer zones shall be created to ensure the necessary regime of nature reserve fund objects protection and prevention of negative influence of economic activity on them. In protection zones it is not allowed to build industrial and other objects, to develop economic activity which can cause negative influence on nature reserve fund territories and objects. Such influence shall be evaluated on the basis of ecological assessment.

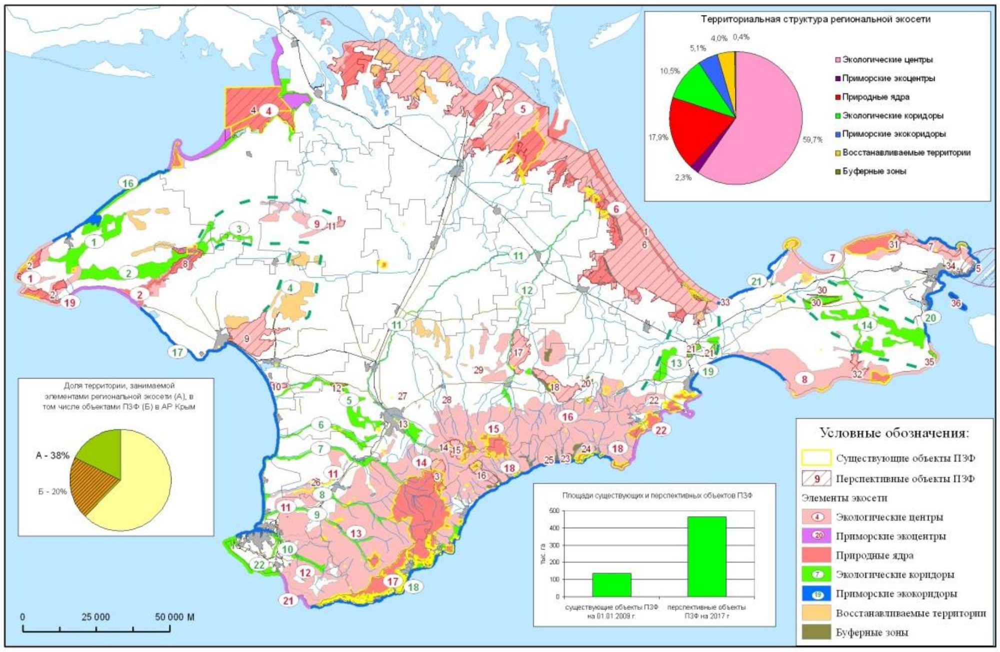


Figure 3.3.1. The Scheme of the Regional Ecological Network of the Autonomous Republic of Crimea (Development of Scheme ..., 2008).

Chapter V of the Law is devoted to scientific investigation work on the nature reserve fund territories and objects.

According to Article 43 of the Law, the main form of summarizing the results of scientific research and observations of conditions and changes pertaining to natural complexes that are carried out by Nature Reserve Fund objects shall be *Nature Chronicles* (*Litopysy pryrody*).

According to Article 44 of the Law effective organization and functioning of natural reserve fund is ensured on the basis of the following economic measures:

- natural reserve fund economic grounded organization and development;
- economic evaluation of the natural reserve fund territories and objects, keeping of their cadastre;
- differentiated determination of sources and norms of natural reserve fund organization and functioning;
- granting tax and other privileges to enterprises, establishments and organizations that ensure functioning of natural reserve fund;
- compensation in the set procedure of losses caused by the violation of the legislation on natural reserve fund.

Measures on the natural reserve fund territories and objects shall be financed at the expense of the State budget, local budgets, charity funds, enterprises, institutions, organizations and citizens funds. Special purpose ecological funds of natural reserves, biosphere reserves, national natural parks, regional landscape parks, botanical gardens, dendrology parks and zoological parks may be created to finance measures on environmental protection.

Article 46 of the Law defines the list of territories and objects of the nature reserve fund of national importance, the financing of measures regarding is effected by using funds of the State Budget of Ukraine. It includes: nature reserves, biosphere reserves, national nature parks, botanical gardens, dendrological parks, and zoological parks.

The Law provides for the procedure of natural reserve fund territories and objects creation and announcement.

According to Article 56 of the Law the state cadastre of the natural reserve fund territories and objects is a system of necessary and reliable information about natural, scientific, legal and other characteristics of the territories and objects which refer to nature reserve fund. The state cadastre of the natural reserve fund territories and objects shall be kept by the central body of executive power in the sphere of environmental protection and by its local bodies at the state budget expense.

Financial and economic aspects.
The partial financial support for biodiversity conservation is provided through institutions and organizations, the State Budget of Ukraine, regional and local budgets, extra-budget conservational funds (e.g., the Vidrodzhennya Foundation) and other sources. Available financial support is directed mostly to improvement of the system of protected territories, urgent measures and actions for protection and rational use of land resources, development of field-protecting forests and forest shelter belts, conservation and restoration of species and populations of plants and animals, environmental monitoring, development of information and education systems, etc.

Nature protection improvement.
Although the regulatory system for the protection of living natural resources and biodiversity is constantly improving, previously adopted laws and new legal acts are being revised as the social/economic situation changes. New legislation related to biodiversity conservation has been developed in Ukraine. Verkhovna Rada of Ukraine adopted the Main directions (Strategy) of National Environmental Policy of Ukraine on 2010-2020. According to this Strategy the Government developed The National Environmental Action Plan on 2010-2015. There are proposals for updating national legislation in terms of promoting development of ecological network in Ukraine and integrated coastal zone management. It is planned to increase gradually the total area of protected territories. Sometimes the effectiveness of enforcement is low and caused by existing problems specific to economy in transition period, and also lack of ecological consciousness. To improve this broad public awareness activities are necessary. Further development and improvement of both enforcement mechanism and environmental legislation are envisaged.

Development of international co-operation is considered to be the most important tool in resolving of the problems of the conservation of biological and landscape diversity at the both national and international levels. The main priorities in this field in Ukraine can be as follows:
- to set up national, regional, and sectoral programmes for the restoration of rare plants and animal species as well as for management of introduced alien species especially where they adversely affect local biodiversity;
- participation of Ukraine in the permanent bodies of the conventions, to which it is a Party, implementation of the international commitments already taken, and co-operation in the process of accession to other important ecological treaties and agreements;
- broad participation of both governmental and non-governmental organizations in implementation of the international project aimed to resolve global and European problems related to nature protection;

- improvement of informational exchange relevant to biodiversity conservation;
- support of establishment and functioning of the national and regional systems of protected areas and further integration it to the European Network;
- the monitoring of species and ecosystems and the compiling of a species cadastre as prerequisites for any management policy;
- carrying out the national surveys on threatened or rare species and habitats (in particular those which fall under international agreements);
- systemic investigation and analysis of international experience in the field of biodiversity conservation, conducting of scientific flora, workshops, and meetings together with foreign colleagues, training of Ukrainian specialists in the field of ecological management, ecological education and public awareness, promotion in establishment in Ukraine of international scientific and other centers related to nature protection;
- development of ecological tourism;
- elaboration and implementation of action plans aimed at conservation of endangered and threatened species of wildlife.

Given to the gradual integration of Ukraine into European structures and communities, the European environmental legislation and initiatives are taken into account when elaborating new legal acts, programmes and action plans in Ukraine, including EC Habitat (92/43/EEC) and Bird (79/409/EEC) Directives, EC Regulation 338/97 relevant to international trade of endangered species of plants and animals, and others.

Structure of protected territories.
On the 01/01/2011 the Nature Protection Areas of Ukraine include 7,739 territories and objects of 3,744 thousand hectares, which amounts to 5.7% of the area of Ukraine. The Nature Protection Areas of Ukraine consist of 19 nature and 4 biosphere reserves, 47 national natural parks, 2922 reservates (zakazniks), 3245 nature monuments, 28 botanical gardens, 12 zoological parks, 54 dendrological parks, 58 regional landscape parks, 547 park-memorials of landscape art of national and local importance, and others.

The main categories of Nature Reserve Fund of Ukraine:
- Biosphere Reserves (Zapovedniks, Preserves, or Reservates).
Biosphere Reserves (colloquially biosphere zapovedniks) are environment-protected scientific-research institutions of international status that are created with the intent for conservation in a natural state the most typical natural complexes of biosphere, conducting background ecological monitoring, studying of the surrounding natural environment, its changes under the activity of anthropogenic factors. Biosphere Preserves are created in the established order the World Network of Biosphere Reserves in the UNESCO framework "Man and the Biosphere Programme".

- Nature Reserves (Zapovedniks, Preserves, or Reservates).
Nature Preserves (colloquially nature zapovedniks) are environment-protected, scientific-research institutions of statewide status that are created with the goal of conservation in natural state typical or unique for a given landscape zone nature complexes with the entire collection of their components, studying of natural processes and phenomena that occur in them, developing scientific foundation for protection of the surrounding natural environment, efficient use of natural resources as well as ecological safety.

Plots of land and water area with all the natural resources are completely withdrawn from commercial use and granted to Reserves in order established by the Law of Ukraine.
The main objective of the nature reserves is conservation of nature complexes and objects on their territories, conducting scientific research and observations after the state of the surrounding natural environment, development on their basis environment protective recommendations, dissemination of environmental awareness, facilitation in preparation of scientific personnel and specialists in the field of protection of the surrounding natural environment and nature preservation.

The Nature Preserves are also responsible for coordination and carrying out scientific research on territories of nature reservates, nature monuments and other protected areas in a region.

- National Nature Park.
National Nature Parks are environment-protected, recreational, culture-educational, and scientific-researching institutions of a statewide status that are created with the goal of conservation, restoration, and effective use of natural complexes and objects that have special environment-protected, health-oriented, historic-cultural, educational, aesthetic value.

Plots of land and water area with all the natural resources and objects are withdrawn from commercial use and granted to the National Nature Parks in order established by the Law of Ukraine.

The composition of the territories of the National Nature Parks may include plots of land and water area of other landowners and land users.

The National Nature Parks are vested implementation of such fundamental tasks:
- conservation of valuable natural and historic-cultural complexes and objects;
- creating conditions for organized tourism, recreation, and other outdoor activities in natural conditions in compliance with the regime of protection of preserved natural complexes and objects;
- conducting scientific research of natural complexes and their changes under the conditions of recreational use, development scientific recommendations on the protection of the surrounding natural environment and effective use of natural resources;
- implementation of environmental education work.

- Regional Landscape Park.
Regional landscape parks are environment-protected recreational institutions of local or regional status that are created with the goal of conservation in natural state typical or unique natural complexes and objects as well as providing the conditions for organized recreation for the population.

Regional landscape parks are organized with withdrawal or without withdrawal of land plots, water, and other natural objects from their owners or users.

In the event when the withdrawal of land plots, water, and other natural objects is necessary for the needs of the regional landscape parks, it is conducted in order established by the legislation of Ukraine.
On regional landscape parks relies the implementation of such objectives:
- conservation of valuable natural and historical-cultural complexes and objects;
- creating conditions for effective tourism, recreation, and other types of outdoor activities in natural conditions in compliance with the regime of protection of preserved natural complexes and objects;
- promoting environmental education work.

- Nature reserves (zakazniks).
Nature reserves (colloquially zakazniks) are declared natural territories (aquatic areas) with the goal of conservation and restoration of natural complexes or their separate components.
Declaration of reservates (zakazniks) is conducted without withdrawal of land plots, water, and other natural objects from their owners or users.

Nature monuments.
Nature monuments are separate unique natural creations that possess special environment-protected, scientific, aesthetic, educational, and cultural status. They are declared with the goal of conservation them in natural state. Their declaration is conducted without the withdrawal of land plots, water, and other natural objects from their owners or users.

Structure of Nature Reserve Fund of Autonomous Republic of Crimea (ARC).
On 01 January 2010 there are 153 territories and objects of 144,965 hectares, which amounts to 5.6% of the area of Autonomous Republic of Crimea (without Sevastopol region). At 2009 in Crimea the «Magic Harbour» National Nature Park (10,900 ha) was created, so the percent of protected areas in ARC increased from 5.2 % to 5.6 % (tab. 3.3.1).

Nature Reserves (or Nature Zapovedniks, or Preserves) are environment-protected, scientific-research institutions of statewide status that are created with the goal of conservation in natural state typical or unique for a given landscape zone nature complexes with the entire collection of their components, studying of natural processes and phenomena that occur in them, developing scientific foundation for protection of the surrounding natural environment, efficient use of natural resources as well as ecological safety.

Plots of land and water area with all the natural resources are completely withdrawn from commercial use and granted to preserves in order established by the Law of Ukraine.

The main objective of the nature preserves is conservation of nature complexes and objects on their territories, conducting scientific research and observations after the state of the surrounding natural environment, development on their basis environment protective recommendations, dissemination of environmental awareness, facilitation in preparation of scientific personnel and specialists in the field of protection of the surrounding natural environment and nature preservation.

Table 3.3.1 Structure of Nature Reserve Fund of Autonomous Republic of Crimea (01.01.2010).

Categories of Nature Reserve territories and objects	Number	Square, hectares
Nature Reserves (Zapovedniks)	6	63855,07
Biosphere Reserves	-	-
National Nature Parks	1	10900
Regional Landscape Parks	5	23395
Reservates (Zakazniks) of national importance	13	35457,7
Reservates (Zakazniks) of local importance	16	5658,8
Nature monuments of national importance	13	639
Nature monuments of local importance	56	2760,1803
Natural landmarks	8	1217,43
Botanical gardens of national importance	1	876,6
Botanical gardens of local importance	1	33,16
Dendrological parks of local importance	1	3,2

Categories of Nature Reserve territories and objects	Number	Square, hectares
Zoological parks of local importance	1	2,4276
Park-monuments of landscape art of national importance	10	276,2
Park-monuments of landscape art of local importance	21	291,779
Total	**153**	**144965,4556**
% square of Nature Reserve lands to square of ARC		5,6

The Nature Reserves (e.g., Yalta Mountain Forest Nature Reserve) have the most core protection regime
The Nature Preserves are also responsible for coordination and carrying out scientific research on territories of nature reserves, nature monuments, protected tracts in a region.

According to the Statute of the Yalta Mountain Forest Nature Reserve (approved by the Order of the Ministry of Environment and Natural Resources of Ukraine from 18.12.2000 № 255) the reserve was created:

- to preserve the natural state of a unique mountain-forest nature complexes and objects of the southern part of the mountain area of Crimea with the totality of its components,
- to conduct the research and observations for studying the natural processes and phenomena, the restoration of the forest ecosystems,
- to develop of scientific bases of environmental protection, efficient use of natural resources and environmental safety,
- to improve water and soil conservation, recreational and aesthetic qualities of mountain forests,
- to protect the forest complexes from fire, pests and diseases;
- to maintain the overall environmental balance in the region;
- to develop the environmental education and outreach work.

According to the article 60 of the Law on the Nature Reserve Fund of Ukraine, the organization of the territory protection of the Yalta Mountain Forest Nature Reserve is carried out by the State Security Service of Nature Reserve Fund of Ukraine. Local councils, local state administrations should promote to protect the territory of Yalta mountain-forest nature reserve. In addition to the government control also the public control for protection of the territory of Yalta Mountain Forest Nature Reserve is established. Public control is carried out by Public Inspectors of Environmental Protection, which activity is carried out in accordance with the Regulation on public inspectors of environment protection (Order of the Ministry of Environment of Ukraine № 88 from 27.02.2002).

State Security Service of Nature Reserve Fund has the following tasks:
- Provides protection of natural systems of nature reserves;
- Provides protection of wild animals and their places of residence in the territories and objects of natural reserve fund;
- Provides the use of natural resources;
- Ensures compliance with the requirements for attendance areas and objects of natural reserve fund;
- Prevents damage to forest complexes as a result of illegal logging;
- Implements the measures to prevent the occurrence, spread of fires and other emergencies and elimination;
- Informs the government authorities about emergencies;
- Implements of prevention and protection of natural systems of pest and diseases in the territories and objects of natural reserve fund;

- Maintains the state of signs, information boards, quarterly and district posts, as well as fire prevention facilities.

According to Article 17 of the Law of Ukraine on Environmental Protection the List of activities related to nature protection measures approved by the Cabinet of Ministers of Ukraine (decree № 1147 from 17 September 1996).

Environmental education and outreach activity of Yalta Mountain Forest Nature Reserve is carried out in accordance with the on environmental and educational activities of reserves and national parks (Order of Ministry of Environment of Ukraine № 140 from 21.09.1998). In accordance of these

Regulations the main activities are:
- Conducting of the outreach activity according to the objectives Yalta MFNR, it values, needs for protection of natural and historical heritage, the general ideas of conservation among the local population and visitors;
- Training, research, practical and methodical work with pupils and students through the creation and implementation of environmental education programs, projects, agreements, plans, activities with various environmental government and nongovernmental organizations;
- Organization of environmental education activities dedicated to special dates: Ukrainian Environment Day (the third Saturday of April), International Earth Day (April 22) and March for Parks, World Environment Day (June 5), International Day for Biological Diversity (22 May), The Day of the forest (21 September), Birthday of Reserve (February 20, 1973);
- Cooperation with local communities, public and international environmental and educational organizations.

The Museum of Nature Reserve works in Central Office, established in 1987 on an area about 150 m^2. The museum contains zoological, botanical and geological exposure. Since 2002 the update of the hall "Fauna" and mineral collection started in the Museum of Nature Preserve.

On the territory of Yalta MFNR the network of ecological trails established. The Taraktashskaya, Koreizskaya trails, Shaitan-Merdven trail to Baydarskaya valley (an ancient Roman road of the 1st century AD) and “Romanov Road” of 19^{th} century et al are the most popular. The increasing recreational press forces to develop certain modes of operation of trails and effective methods of environmental education activities.

Ukraine has signed all international nature conservation conventions and agreements. International projects are carried out jointly with the neighboring countries of the European Union, the Black Sea basin (for example, Danube Delta National Park, The Carpathians protected areas). They are promoting the objects of Nature Reserve Fund of Ukraine. Unfortunately, nowadays Yalta MFNR not takes part in international nature conservation activity. One of the ways to start international activity is organization of scientific and environmental education conferences, seminars and expeditions with invitation of foreign scientists, as well as creation of advertising of nature reserve in the scientific community and among environmental NGO.

3.4 Ecological Monitoring of the Crimean Mountains Forests

Not changed or weakly changed biota is the unique component capable to stabilize and restore natural ecological balance in a geographical cover, compensating consequences of anthropogenic influence. This position is a basis of modern most progressive global strategy and concepts ecologically safe development (strategy of "total cleaning"; strategy of a restriction consumption; concepts of a sustainable development etc).

Forest biocoenosis – play especially important role as a most powerful regulator of the maintenance of a carbonic gas in atmosphere of the Earth and a regulator of a temperature mode.

Forests carry out not only environment and resources reproducing functions but also environmental control (water conservation, water regulating) and recreational functions and also a basic link of ecological networks and centres of a biodiversity **on regional scale**.

In a more comprehensive sense it is possible to say that forests promote maintenance of regional ecological, social and economic balance.

Forests occupy **270 thousand hectares (about 10 % of the area)** of Crimea and are concentrated in a mountain part. They are on border of their existence area.

At the same time, it is difficult to overestimate an ecological role of the Crimea mountain forests for the region, all industrial south of Ukraine and also for southern Europe. It is because they are: factor of formation and regulation of water balance; possess high potential of self-cleaning and neutralize polluting substances infused with transboundary transport in the course of biological circulation; South European centre of a biodiversity and gene pool as unlike the Mediterranean forests they have in a greater degree kept a natural condition.

In Crimea oak forests are concerning low growth class (3, 4, 5 growth classes) prevail. Forests are mostly second growth. The factors defining an **ecological condition** of the Crimean forests are:

1. Lack of a moisture within 6-7 months that does not promote natural renewal by a seed way;
2. Periodic mass damage of leaves and young plants by entomofauna, mouse rodents and hares, and as eating of seeds and shoots other animals;
3. Frequent repeatability of fires;
4. Long (throughout 2-3 centuries) anthropogenic impact: deforestation, trampling down of soils, grasses and undergrowth;
5. High recreational load.
6. Now one of the most scale factors influencing an ecological condition of forests in Ukraine and Crimea is atmospheric air pollution (*in Crimea basically by means of transboundary transport!).*

In this connection ecological monitoring of forests is one of the most important directions in structure of complex ecological monitoring in Ukraine as in whole and in Crimea as in particular.

In 1989 *(Ukraine scientific production association «Forest», observations in 12 regions and in Crimea)* works on the organisation of a monitoring forests network in framework of the International joint program by an estimation and monitoring of air pollution influences on the forests, the Convention founded by the Executive office on global pollution of atmosphere at the European Economic commission of the UNO have been initiated. Departmental ecological monitoring of forests is carried out by following divisions (Figure 3.4.1) in Ukraine and in Crimea.

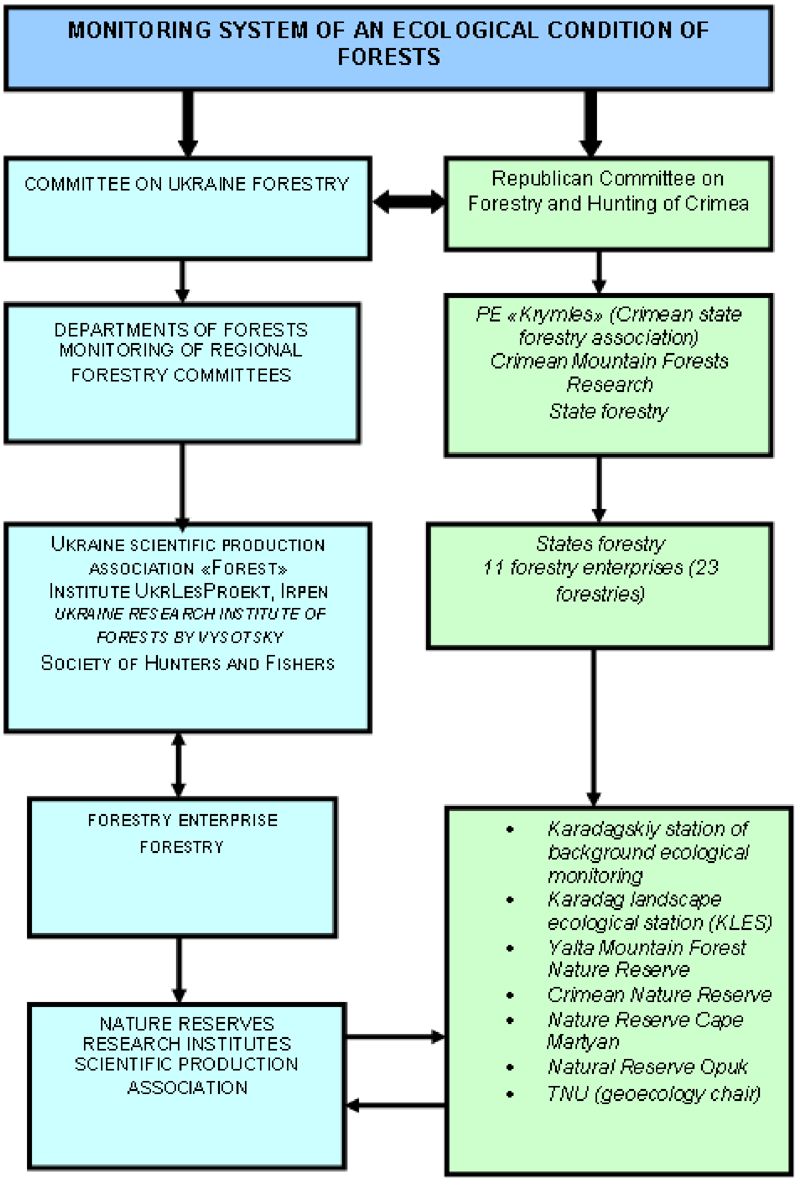


Figure 3.4.1 Monitoring system of ecological condition of forests in Crimea.

These factors were fixed according to «Temporary recommendations…» (1990) and international method of forest monitoring – «Manual on methodologies and criteria for harmonised sampling, assessment, monitoring and the effects of air pollution on forest» (1986) in process of observations: 1) forestry indicators (a breed, a shapes, age, growth class, a stock, an undergrowth, an underbrush – annually; 2) morphological and bioindicator – annually; 3) chemical indicators – sulphur maintenance in assimilative bodies; pH – once per 5 years; 4) radiological – an exposition dose at height of 1 meter and on soil.

In Crimea constant observations are conducted by Crimean Mountain Forests Research Station on test forest valuation area. However they are focused basically on revealing biotic factors of forests digression (pests, diseases). Observations are conducted on test forest valuation area. The report forms are the summary tables characterising a condition of basic forest breeds.

Stationary, semiportable and field researches of an ecological condition of forests are conducted by scientific departments of the Karadagskiy Nature Reserve (NR), the Crimean NR and the Yalta Mountain-Forest NR, the «Cape Martyan» NR (results are fixed in annual «Chronicle of the nature»).
In system State Committee on Hydrometeorology on some meteorological stations are conducted observations: maintenance in atmospheric air CO_2, SO_2 and dust; condition of an ozone layer and ground ozone; chemical composition of precipitation.

However the existing system of monitoring in Crimea does not allow receiving presentable data of an ecological condition of the forest ecosystems, meeting the requirements Conventions of 1989.

Lacks of an existing departmental network of an ecological monitoring of forests:
1. The network points of monitoring are imperfect and does not consider feature of individual regions. In particular, in Crimea at the organisation of such network it is necessary to consider geography of various types of forest (oak, pine, beech, hornbeam, ash and juniper – 96 % of the area);
2. Fixed factors concern basically biotic indicators;
3. The special geochemical observations connected with revealing of the maintenance pollutants in different environments are conducted irregularly. In these connection authentic conclusions about influence of pollution on an ecological condition of forests it is impossible to receive!
4. Level of instrument base and automation of gathering, storage and processing of the ecological information is low;
5. Out-of-date methodical base and absence of early diagnostics methods of an ecological condition of forest ecosystems;
6. Superficial analytical data processing, absence of balance models that does not give possibility to leave on authentic forecasts of change of an ecological condition of forests and operatively to make corresponding administrative decisions.

In this connection the special attention is given to observations of an ecological condition of the forest ecosystems that were conducted since 1993 by geoecology TNU scientists jointly with employees of scientific department of the Karadagskiy Natural Reserve in framework of problems of Karadagskiy station of background ecological monitoring and the Landscape and ecological stationary with the same name (KLES). Elements of ecological monitoring of forest ecosystems are shown on Figure 3.4.2.

Ecological researches and monitoring of change of geosystem conditions and including forest geosystems are notable for complexity and regularity. They include monitoring and analysis: 1) biological parameters of forests (phytometric, bioindicator, phenological); 2) geophysical parameters (for different components and environments); 3) some geochemical parameters.

KLES are conducted on new methods of gathering, analysis and interpretation of the ecological information on a condition of forest ecosystems and also methods of the spatial analysis.

One of such methods is t*he complex approach* based on a combination of methods:

- Land field research based on special traditional techniques on key test sites.
- Computer decoding satellite and aerial photographs (the universal decoding scale is made, allowing to allocate on species composition, height and density of various forest biocenoses).
- The spatial analysis, interpolation and extrapolation of data by GIS and also computer modelling and mapping.

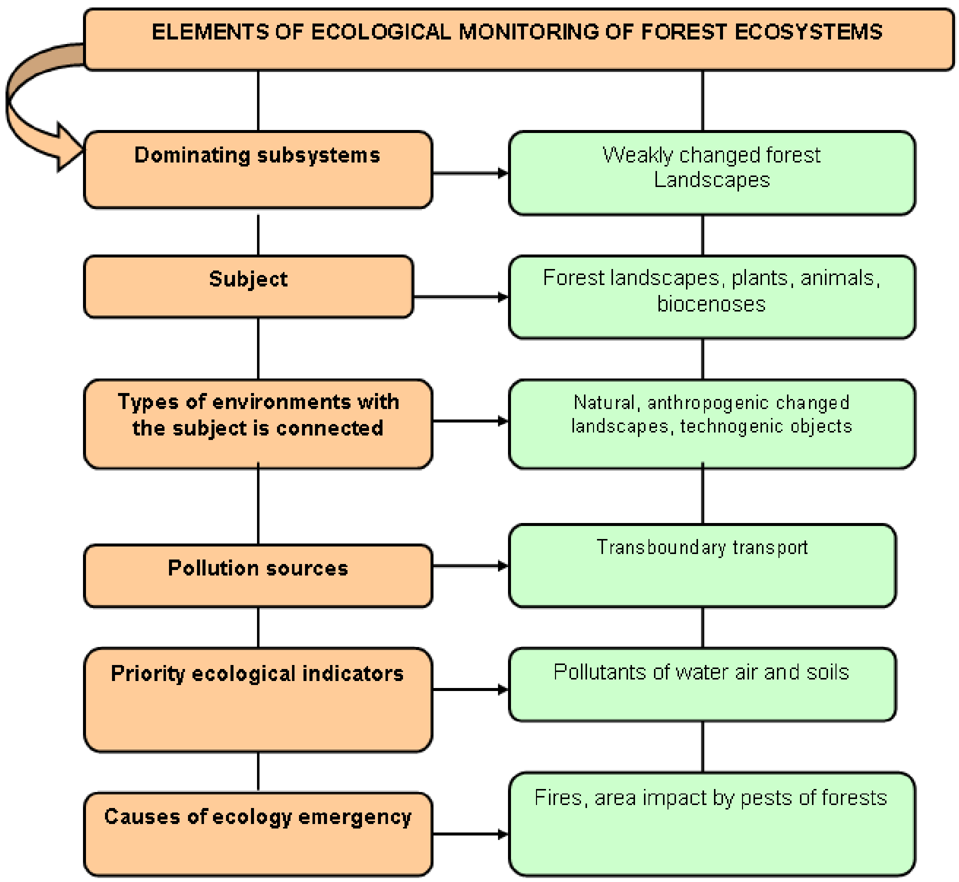


Figure 3.4.2 Elements of ecological monitoring of forest ecosystems.

The most significant limiting factor for growth of the Crimea forests of east part of the southern coast is humidifying. It defines an urgency of water and thermal conditions of the Crimean forests studying.

The atomated system for collecting data on water and thermal conditions of forest ecosystems is functioning at Karadag station of background ecological monitoring.

3.5 Analysis of Threats to Landscape and Biological Diversity

To analyze the possible further changes to the landscape and biological diversity of the Yalta

Mountain Forest Nature Reserve (Yalta MFNR) territory is necessary to determine the main threats to natural complexes of the reserve.

The various natural systems are exposed to different effects of various factors. There are 31 significant threat factors (tab. 3.5.1) that have influence to the biodiversity of Nature Reserve.

They can be divided into 5 main groups: 1) factors that change the water-salt regime; 2) mechanical impact on biodiversity; 3) biological influence; 4) change of soil and geology basis; 5) chemical pollution. Each of these factors is characterized by the complex influence (eg, recreation – the damage for plants, disturbance of animals, soil degradation, landfills, etc.).

Certain factors also have a positive value. For example, pits afforestation, strengthening of slopes, increasing of forest cover – generally necessary actions that improve the existing state and functioning of ecosystems, stabilization of climate parameters. But now we consider only negative aspects of the influence – threats for biodiversity.

As can be seen from the table, the largest number of threats (28) is recorded for the sub-Mediterranean vegetation zone of the South Coast. Further, there is a sharp decline in the number of negative factors: for the coastal zone – 19, for Mountain Meadows and Yaila Steppes – 16, and for Midland Pine and Oak Forests – 13 factors.

For all zones the width of distribution of factors is related to recreation, poaching and biological contamination (invasion of exotic species). For all zones the regional scale of influence marked for erosion and recreation, while other factors act as regional for single zones, or have a local impact.

By the force of impact in each area are leading different factors: fire has the strong impact in the pine forests of the southern coast; unauthorized use of lands, urbanization and recreation – in the coastal zone.

This matrix of the threats and their assessment at the zonal and local level must be a basis for monitoring, decision-making and planning aimed at their prevention and reduction.

So, the ecosystems of Southern Coast of Crimea is exposed to the most comprehensive set of the threatening factors in Crimea, and it has already led to the destruction of much of its natural ecosystems. Despite the high level of direct threats such as fire, grazing and removal of plants and animals, the ecosystems of the Mountain Meadows and Yaila Steppes and the middle mountain forest zone of the Crimean mountains are still the most valuable – both in terms of biodiversity, and in terms of degree of disturbance of nature complexes.

The most vulnerable from presented threats are fires in the pine and xerophytic Submediterranean forests of the Southern coast of Crimea. The chart of cases and areas of forest fires that occurred in the Yalta MFNR during 1973-2012 (Figure 3.5.1) shows that more than 1100 cases were fixed for this time, or an average of 25 per year. The total area of fires exceeded 2300 ha.

In the vast majority (80-95%) the causes of the fires have not been identified. Probability of occurrence of forest fires is determined by a complex of factors, both natural (the dynamics of moisture and properties of fuel material, the relative humidity and air temperature, solar radiation activity, wind speed, local features of terrain, phenological phases of vegetation), and anthropogenic (access to the protected area, not extinguished fireplaces and butts, arson, etc.). Most often fire occur in the summer-autumn period, during the recreation season (Kobechinskaya, 2010). On the maps of fires (Figure 3.5.2, 3.5.3) that distributed by the forest quarters and land plots of Yalta MFNR (during 1997-2002 and the last 2011-2012) we can see that almost all red-colored plots are located near settlements and the roads Alushta–Yalta–Sevastopol and Yalta-Bakhchisaray.

Table 3.5.1 Factors (threats) and level of their impact to landscapes in different zones of Yalta Mountain Forest Nature Reserve (Priority-setting in Conservation: A new approach for Crimea, 1999; with corrections of authors).

Factors (Threats)	Zones			
	I Mountain Meadows and Yaila Steppes	**II Midland Pine and Oak Forests of the Southern Slope of the Crimean Mountains**	**III Submediterranean Vegetation of the South Coast**	**IV Coastal Zone of Black Sea**
1. Decline of Salinity				1B
2. Rising Groundwater			1B	1B
3. Desiccation	1B			
4. Overgrazing	3B		2B	
5. Recreation Pressure	2B	1B	4A	3A
6. Fires	1B	4B	2B	
7. Forest Felling		1B	1B	
8. Medicinal Plant Collection	3A	2B	3B	1B
9. Poaching	2B	1B	2B	2B
10. Urbanization			4B	4B
11. Afforestation	3B		1B	
12. Land Cultivation			2A	
13. Sewage Emissions			3A	2B
14. Garbage Dumps	1B		3B	2B
15. Transportation	1B		3B	1B
16. High-voltage Wires		1B	1B	
17. Industrial Pollution			2B	2B
18. Agricultural Pollution			2A	2B
19. Military Pollution	1B		1B	1B
20. Hydrological Construction			1B	2B
21. Erosion	1A	2B	2A	
22. Open-pit Mining		1B	1B	
23. Desertification			1B	1B
24. Mud Flows		1B	3B	
25. Landslides			3B	
26. Wave Erosion				2B
27. Soil Removal	1B		1B	1B
28. Biological Pollution	1B	1B	3B	2B
29. Genetic Contamination	1B		1B	
30. Disturbance	1B	1B	3B	1B
31. Squatter-occupied Land	2B	1B	3B	3B

***Values:** The force of the impact on the biota: 1 – poor; 2 – average; 3 – severe; 4 – very strong. The spatial scale: A – total (regional) and B – local impact.*

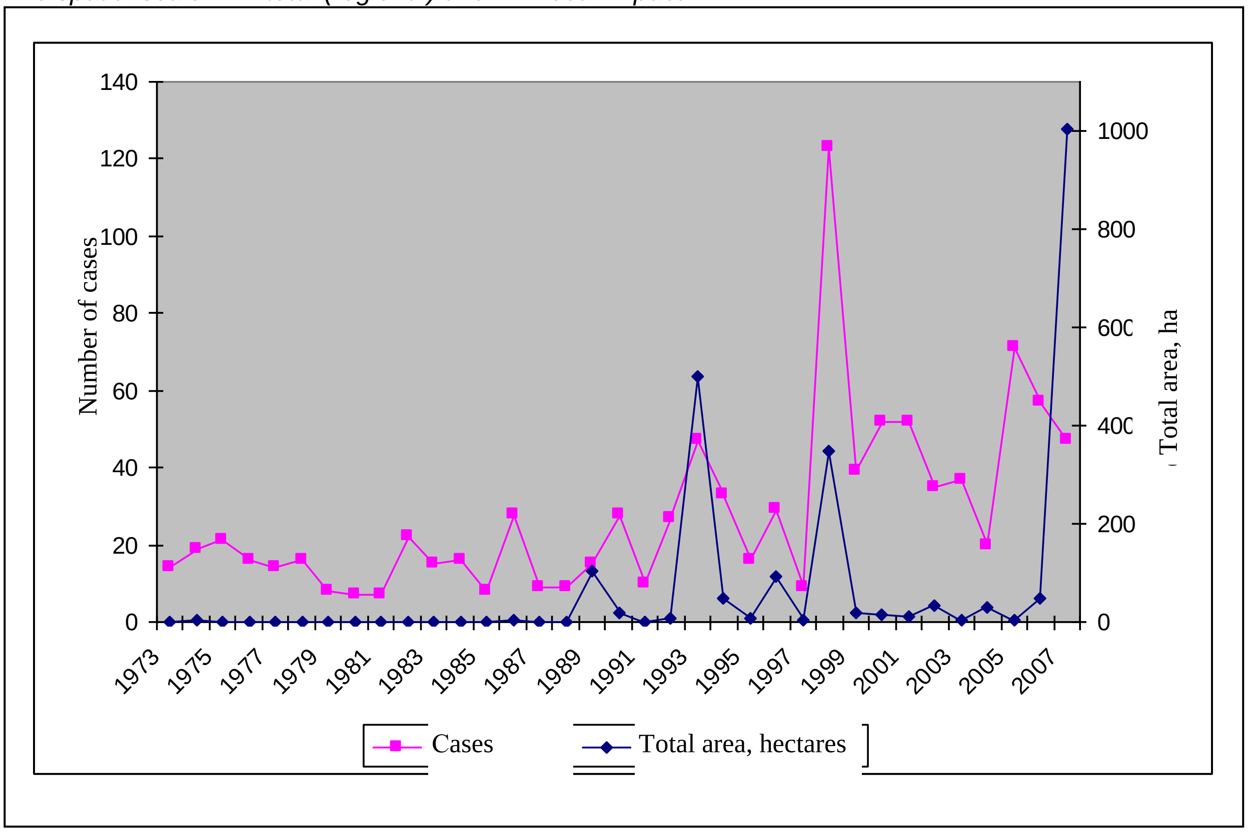


Figure 3.5.1 Forest fires in Yalta MFNR during 1973-2007
(red – number of cases, blue – total area, ha).

The biggest fires on the territory of Yalta MFNR were registered in 1993, 1998 and 2007, when 498.6 ha, 347.54 ha and 973 hectares of the unique Crimean forests had been destroyed. In 1998 the number of fires achieved 123 cases. The most terrible is the crown fire. During 1991-2012 years the crown fire destroyed more than 387 hectares.

For last years the most significant is the fire of August 24, 2007 on the territory of the Alupka forestry in the 11th quarter. Here, the area of one fire was slightly less than the total area for the period 1991-2006 (1,169.99 ha), and amounted to 973.0 hectares, including 274.1 ha of crown fire. The cause of the fire is bonfire left by tourists. The spread of fire occurred spontaneously on the steep slopes of mountain-forest areas with sufficiently strong wind, and therefore failed to put out the fire in the early stages.

In the nature reserve the fire management plan is developed, the specialized forest fire departments – forest fire stations are created, where there are 9 of combat vehicles and two trucks. Of course, this is not enough to uniquely difficult terrain within the reserve area of 14.5 thousand hectares.

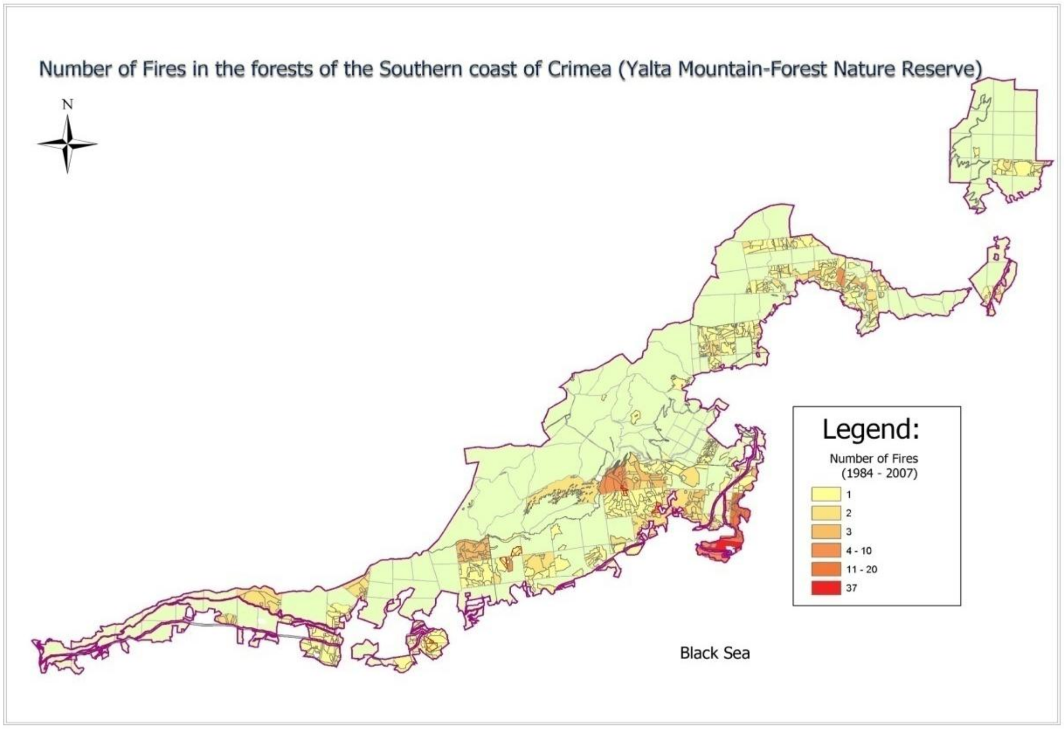


Figure 3.5.2. Number of fires that distributed by the forest quarters and land plots in the forests of the Southern coast of Crimea (Yalta Mountain Forest Nature Reserve, 1984–2007).

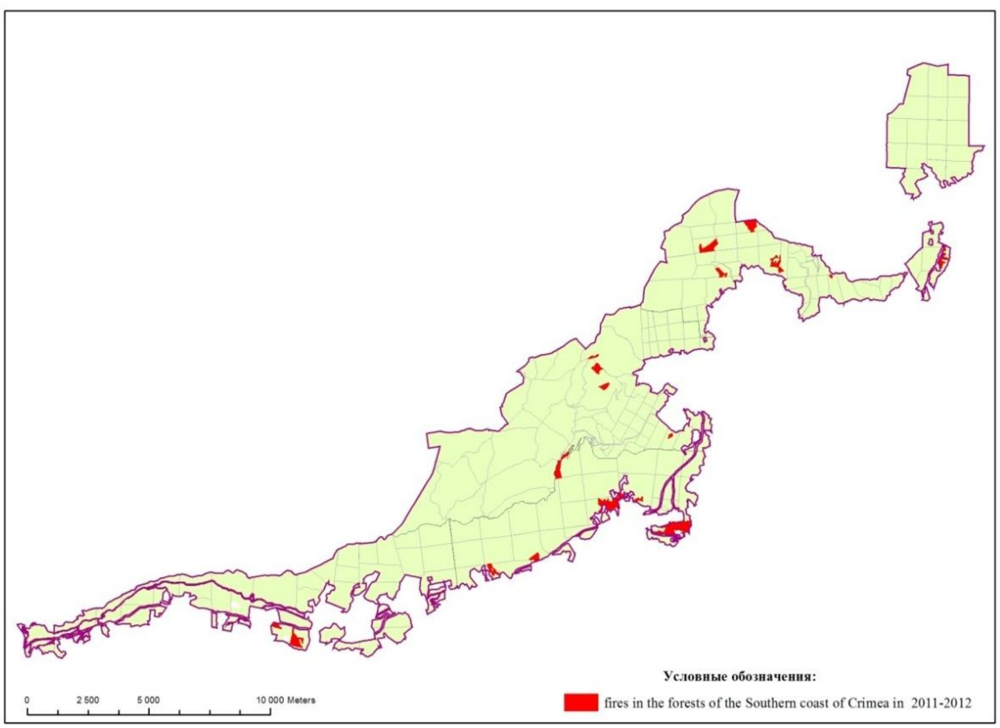


Figure 3.5.3. Fires in the forest quarters and land plots of Yalta Mountain Forest Nature Reserve, 2011-2012.

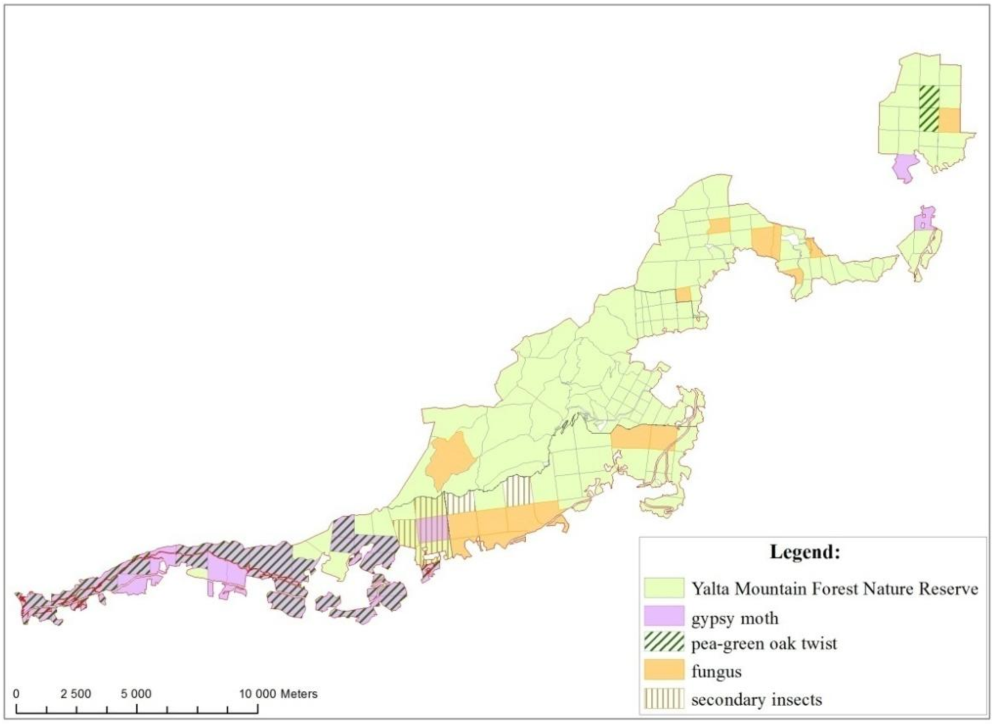


Figure 3.5.4. Pests and diseases that distributed in the forest quarters of Yalta Mountain Forest Nature Reserve, 2012.

Also big damage to the forest and shrub ecosystems of the Southern Coast of Crimea is affected by pests and diseases. Distribution of the pests and diseases by the forest quarters of Yalta Mountain Forest Nature Reserve is presented on the figure 3.5.4. The pine forests were the most affected by gypsy moth and root fungi and xerophytic Submediterranean forests – by the oak leaf roller. The Yalta MFNR and the State Agency of Forestry Resources of Ukraine are monitoring this specific pests (oak leaf roller, gypsy moth), and fungi. They also use sampling systems developed to predict damage by defoliators. Typically pest management techniques such as ground and aerial application of biological or chemical insecticides are carried out in the face of major outbreaks of damaging forest pests.

3.6 Regional Management of Forest Ecosystems

The Yalta Mountain Forest Nature Reserve has the IUCN Category Ia. Strict Nature Reserve: protected area managed mainly for science. Category Ia are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring (Dudley, 2008). But the current situation with active development of recreation activity near and on the territory of “strictly” protected area allows some researchers to concern it to the Category II – National Park (Bergmeier et. all, 2010).

From positions of protected area governance the Yalta MFNR is related to *Type A: Governance by government (at state level).* A government body (State Forest Resources Agency of Ukraine) holds the authority, responsibility and accountability for managing the protected area, determines its conservation objectives, develops and enforces its management plan and owns the protected area's land, water and related resources.

Analysis of the status of protected areas (Davey, 1998) shows that:
- effective management of protected areas is provided only in the case of matching it with the management of surrounding areas;
- sustainable development of protected areas is possible in the case when they perform a wide range of social functions;
- conflicts in nature use and its management cannot be stopped just because the lands have received the protected status;
- variety of approaches in the creation of protected area leads to the fact that their boundaries usually coincide with the boundaries of land ownership but not of natural geosystems.

The management effectiveness of the reserve is depends on its territorial and functional organization. The management structure of the Yalta MFNR has all common features of forestry that does not quite meet the modern requirements of strict nature protection in the highly developed recreational region.

The territory of the Yalta Mountain Forest Nature Reserve is divided into 4 Forestry and 60 protection go-rounds for ensuring the nature protection regime. The average area of visiting rounds is 240 hectares per 1 forester (in Nature Reserves – inspector of the state service of nature protection). For summer period of high recreation season, together with high level of breaking of protection rules, there checkpoints at all entrances and ranger patrols are created. The state service of nature protection of the Yalta MFNR coordinates its activity together with public inspectors and local policemen. Similarly, for prevention of pine trees cutting the ranger patrols are usually organized for Christmas and New Year days.

However, the situation with reduction of forest cordons, forest fires, expanding urbanization and tourist activity on the ecological trails and attractive nature sites requires the new approaches to nature protection and visitor management, to the territorial and functional organization of the reserve.

The Yalta MFNR has the 10-year management plan – The Project of organization of territory of Yalta Mountain Forest Nature Reserve and protection of its nature complexes (last developed at 2006). This document was worked out with current developments of foreign and Ukrainian scientists (On the way to National Park in Crimea, 2000; Kukurudza, 2003, and others). The main directions of environmental management of the Yalta MFNR include:

1. *Maintaining the nature balance.* For effective management it is necessary to determine the state or changing stages of the ecosystems, what mechanisms (geological, geomorphological, climatic or anthropogenic) ensure their stability or lead to instability. And in some cases, we should pay attention to conservation of the "secondary" (succession) ecosystems for conservation of some rare and endangered plant species (belladonna, etc.).

2. Protection of ecosystems and processes, maintenance of ecosystem services.
In general, the ecosystem services (provisioning, regulating, supporting and cultural) – the benefits people obtain from nature. Protecting the ecosystems of nature reserve, we receive goods, services and other benefits for our human well-being abroad the protected area.

Effective protection of species is, first of all, the preservation of their habitats, all natural components and processes. Intrusion to the natural processes may be permissible in the case of:
- Restoration of natural landscape features and natural vegetation that have changed during previous human activities;
- Restoration of the destroyed sites by the visitors.

3. *Management of states of animals and plants populations*. It includes:

a) Development of management plans, especially for species from the European Red List, the Red Data Book of Ukraine, in the lists of international conventions. Since many of these species and make them immediately is not possible, you need to select the highest priority, as well as to identify groups of related species for which management plans will be the same type;

b) Development of regional management plans for migratory species and species with wider area than protected area has;

c) Strengthened protection of habitats of endangered species;

d) Maintaining of habitats – enlargement and protection of migration ways, ecocorridors and natural breeding sites, feeding places, etc;

e) Regulation of invasive species that can compete, disturb or inhibit native species (e.g., *Bupleurum fruticosum*, gypsy moth *Lymantria dispar*, etc.);

f) Organization of key research and monitoring of animals and plants populations;

g) Organization of breeding centers and resettlement from other areas.

4. *Management of natural resources.* Any use of natural resources on the territory of nature reserves is prohibited by law, except to ensure conservation, restoration of damaged ecosystems, scientific research, prevention and response to natural and man-made disasters, fires.
The possible use of natural resources is strictly limited by the Ministry of environment and nature resources of Ukraine. Permission to use and limits (kind of use, amount, area, time) for natural resources is annually approved. In Yalta MFNR it includes:
- Collection of herbarium specimens;
- Collecting seeds of pine *Pinus nigra subsp. Pallasiana* and downy oak *Quercus pubescens*;
- Haying (for employees only);
- Grazing cattle (for employees only);
- Visiting of ecotrails and caves;
- Sanitary cuttings.

5. *Protection of historic, cultural and aesthetic values of the territory.* On the territory of nature reserve dozens of archaeological sites from the Paleolithic to the Middle Ages, monuments of cultural heritage, places visited by famous people are located. It includes a big set of activities on nature and cultural heritage protection: archaeological investigations, corrective and ongoing maintenance of ecotrails, sites and monuments, integrating into the landscape of buildings, constructions and communications, vandalism control management.

6. *Protection of water resources* (surface and groundwater): Drainage and waste water treatment of recreational facilities, from roads near and around of the reserve area. This is especially important for water catchments of yayla karst massifs where wellsprings are arranged for drinking water supply of Southern Coast of Crimea settlements. The surface boundaries does not coincide with the real watershed such karst sources (Hasta-Bash, Shahan-Kaya, etc.). So water protection should include all territory of yayla mountain karst massifs (especially the area of the upper cable car station, "Okhotnichie" settlement, not only area of Yalta MFNR).

Administration of Yalta MFNR should sign the appropriate "protection agreement" with water supply enterprise of Yalta on the use of water wellsprings on the territory of nature reserve.

7. *Air protection.* It includes identification of potential sources (most of them – external for nature reserve) of air pollution, light and noise impacts, organizing monitoring and regulation of their activities. Focus is the highways, crossing the area of the Yalta MFNR.

8. *Visitor Management.* The basic efforts of management plans aimed directly at the organization of visitors activities of the reserve. The annual amount of the Yalta MFNR visitors can exceed 300,000–500,000 people. The effective management allows reducing the number of violations of protected regime, the number of accidents and fires. And on the contrary, poorly organized visitor management can discredit the idea of the Reserve.

One of the fundamental concepts of visitor management is defining of the recreational load (number of users per unit area per unit time). For different types of ecosystems at certain seasons of year it is necessary to calculate the allowable and critical load values. Separately, we note that the relationship between visitors and the state of ecosystems in nature reserve is determined not only acceptable levels of use, but the logic and objectives of the organization of recreational and eco-educational activity (Blaga, Rudyk, 2002, Rudyk, 2011).

The visitor management includes a lot of sub-systems of management (development and technical maintenance of eco-trails, guide service, system of signs and wayside exhibits, visitor safety, entrance fees, litter and garbage control, advertising, etc).

Management logically follows the process of planning, design and establishment of structure and boundaries of protected area, and in many cases the main reason of the management difficulties can be found in the initial planning errors. So, when the Yalta Mountain Forest Nature Reserve in 1973, there was no any analysis of the current state of the structure, land use regime in the region. The entire territory of the Yalta forestry has been transferred into the nature reserve. Till current days the nature reserve includes the lands with water supply facilities (catchment sources, clean water reservoirs), with some recreation and storage areas, quarries of limestone for road construction Yalta-Sevastopol. The Gaspra limestone quarry has been turned into the city landfill. So, simultaneously, the organization of the nature reserve was already established the deep environmental conflicts between protected area and economic activity, urban and recreation development of Yalta.

Functional zoning is an essential tool for land and resource management of protected areas that allows setting the optimal ratio of special use and protection of these areas. Functional zoning determines what best management practices ensure the most effective protection activity on different protected areas. The current legislation of Ukraine does not provide the functional zoning of nature reserves. However, for large, spatially and functionally heterogeneous system of the Yalta MFNR we propose the "internal" functional zoning and relevant system of environmental planning and management (Rudyk et al, 2005).

Planning structure of protected areas defined by the relationships of several types of spatial structures (nature and anthropogenic infrastructures) on the same territory. Elements of one type of infrastructure can be both element of other. For example, drained water sources are part of the ecosystem, monitoring, educational, economic, and fire prevention infrastructures. And on the basis of the existed elements we can develop the elements of new infrastructure, e.g. the visitor centers and monitoring stations, requiring constant oversight, are established on the forest cordons.

For development of management plan in the "Project organization of the Yalta MFNR" (2006), we distinguished 6 types of infrastructures. The first – the ecosystem infrastructure – includes elements of ecological network: core areas, ecological corridors, buffer zones, ecoducts, and refuges, breeding and nesting sites, caves and other underground ecosystems, nurseries, etc.

Other types of infrastructure in the Yalta MFNR were artificially formed to maintain the protection regime:

1. State Guard Service of Protected Areas: Forestry and cordons, checkpoints, control routes, forest roads, information signs.

2. Research: research and monitoring stations, hydrological stations, nurseries, seed plots, etc.

3. Recreational and Educational: visitor center, museum of nature, ecotrails and facilities, information exhibits and signs, viewing places, monuments, souvenir shops, destinations, fences and bridges, other elements of trail equipment.

4. Fire prevention: fire stations, helicopter pad, fire ponds, information signs, fire breaks, clearings, roads, observation towers, etc.

5. Economic: the settlements and cordons of nature reserve, repairs and garage, public and forest roads, water wells and pipelines, dams and ponds, pipelines, power lines, nurseries, orchards, pastures, hayfields, open pit (closed and active), radio transmitters, etc.

The especial question of effective management is partnership of Administration with local authorities, environmental education of local people and their involvement in the activities of the nature reserve. Protected area managers need to make ongoing efforts to communicate with all stakeholders. Only with the broad support of the community the nature protection management will be successful in the long term.

In conclusion we underline that “good management needs to be rooted in a thorough understanding of the individual conditions related to a protected area, be carefully planned and implemented and include regular monitoring, leading to changes in management as required” (Hockings et al, 2006).

4 Invasive Alien Species (SPSU, OBIBSS, SPCB, AZBOS, IBISS)

4.1 Trends of changes in the situation with invasive species in the Black Sea Region

Invasive alien species (IAS) are plants, animals, fungi and microorganisms whose introduction and/or spread outside their natural past or present ranges pose a risk to biodiversity or have other unforeseen negative consequences. IAS have been recognised as the second most important threat to biodiversity at the global level (after direct habitat loss or destruction) (CBD 2001; MA 2005). They also represent a serious impediment to conservation and the sustainable use of biodiversity, and have significant adverse impacts on the goods and services provided by ecosystems, both globally and in the European Union (EU) (EEA 2012).

Recognizing the need for robust action to control biological invasions and thus mitigate their impacts on biodiversity, ecosystem services and human activities, the European Commission issued a Communication presenting policy options for an EU Strategy on Invasive Species four years ago (EC 2008). This communication highlighted the magnitude of the impacts of biological invasions in Europe and the urgent need to take action. The EU Biodiversity Strategy (EC 2011) stresses the need to combat invasive alien species (IAS) through its Target 5: "By 2020, IAS and their pathways are identified and prioritized, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS". Currently, a dedicated legislative instrument is being developed by the Commission (to be launched in 2013) as dictated by Action 16 of the Biodiversity Strategy. European countries and their relevant institutions have or will have, under the developing EU legislative instrument, obligations and commitments under both the European and global frameworks in respect to IAS. These include prioritising pathways for prevention, identifying the most harmful species for responses, enforcing effective early warning and rapid response mechanisms, developing indicators of trends and responses, and other management strategies (Katsanevakis et al. 2013).

Human-mediated introductions of IAS is an increasing environmental pressure for the Black Sea region, which needs to be properly estimated and relevant management actions should be implemented at the regional and national levels. On the regional level, the issue of IAS introductions has been also recognized and addressed in relevant regional agreements.

Specifically, the regional Convention on the Protection of the Black Sea Against Pollution (1992) adopted in 2002 the Black Sea Biodiversity and Landscape Conservation Protocol, which require from Contracting Parties (Article 5 of the Protocol, http://www.blacksea-commission.org/_convention-protocols-biodiversity.asp): 1) to take all appropriate measures to regulate an intentional introduction and prevent an accidental introduction of non-indigenous species or genetically modified organisms to the wild flora and fauna and prohibit those that may have harmful impacts on the ecosystems, habitats or species; 2) to implement all appropriate measures to eradicate or reduce to an possible level species that have already been introduced when it appears that such species cause or are potentially causing damage to ecosystems, landscapes, habitats or species in the area to which this Protocol applies. Also, within the Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea adopted in 2009 (SAP 2009), one of Long-term Ecosystem Quality Objectives (EcoQOs) includes efforts to reduce and manage human mediated species introductions (EcoQO 2c).

IAS are considered also as a serious issue within activities of the Convention on Cooperation for the Protection and Sustainable use of the Danube River (Danube River Protection Convention, http://www.icpdr.org/main/icpdr/danube-river-protection-convention, and http://www.icpdr.org/main/issues/invasive-species), and the Danube River Basin Management Plan (2009) includes a chapter on invasive species (2.1.5.2. Invasive species in the DRBD – a possible pressure).

In order to address these issues and contribute to relevant capacity-building on the regional level, within EnviroGRIDS project we collected relevant information on aquatic and terrestrial invasions in the Black Sea catchment area. This information is stored in relevant databases, including those hosted by the The Regional Euro-Asian Biological Invasions Centre (see in section 5.3), and conducted analysis of trends in IAS introductions for selected aquatic and terrestrial ecosystems, which is present in this report. Other results of these activities, including the developing risk assessment based Decision Support System (DSS) for management of introductions of invasive alien species for the Black Sea basin and case studies for early warning, are present in related project deliverables EnviroGRIDS_D5.4 and EnviroGRIDS_D5.10.

4.2 Aquatic Invasive Species

The Black Sea catchment area is linked with other parts of Europe via complex network of navigable inland waterways, with main river basins (Danube, Dniepr and Don basins) serving as important southern parts of European inland invasion corridors (Panov et al. 2009; 2010; Figure 1). The current invasion corridors and the projected future developments of the European network of inland waterways may highly facilitate the transfer of aquatic IAS across European inland waters and coastal ecosystems. Appropriate risk assessment-based management options are required to address risks posed by human-mediated introductions of these species (Panov et al. 2009). Also, there is an urgent need for open information on IAS in the Ponto-Caspian area (Panov 2004), and, specifically, for relevant Decision Support System for the Black Sea area (Panov et al. 2012).

As part of EnviroGRIDS project activities, we developed database on alien species records in the Black Sea catchment area, based on analysis of published data and results of our own field studied. Information stored in this database was further used for estimation of relevant IAS-related environmental indicators for main assessment units within the Black Sea catchment area, including Black Sea itself, and river basins of three main tributaries to the Black Sea, Danube, Dnieper and Don rivers (Figure 4.2.1). The European Environmental Agency (EEA) 'Typology of indicators' and the Driving forces–Pressures–State–Impact–Response (DPSIR) framework was used to structure estimated environmental indicators in the socio-economic context (Panov et al. 2009, 2012). Detailed description of these indicators is provided in project deliverable EnviroGRIDS_D5.10. In this report we are presenting of our analysis of important indicator of "Pressures"**-** *Trends of alien species invasions,* which is recognized as main IAS-related environmental indicator for Europe (EEA 2012). Trends of alien species invasions were estimated for non-native fish and invertebrates for the Black Sea (Ukrainian part), Danube, Dnieper and Don river basins. This indicator is useful both for assessment of the ecosystem state in regard of IAS introductions, and as indicator of the effectiveness of preventive management options.

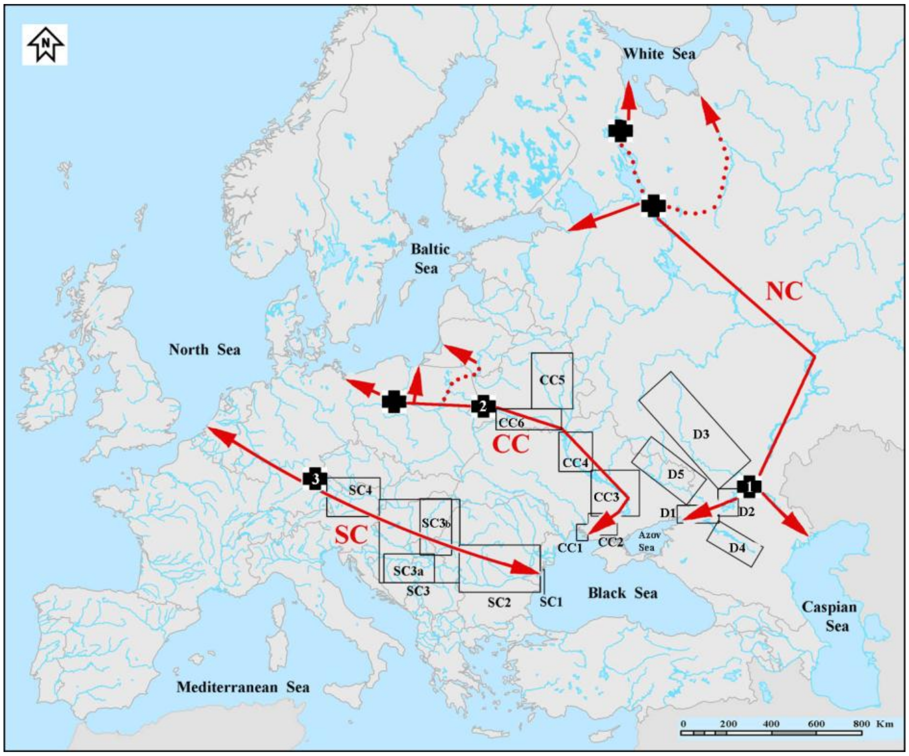


Figure 4.2.1 Main invasion corridors in Europe, related to the Black Sea Catchment area:

NC – Northern invasion corridor, CC – Central invasion corridor, SC – Southern invasion corridor (after Panov et al. 2009, modified). Black crosses indicate main canals: 1 Volga-Don Canal, 2 Bug-Pripyat Canal, 3 Ludwig Canal and Main-Danube Canal. Boxes indicate Assessment Units within main river basins. Assessments units within the Don River basin: D1 – Lower Don River, D2 – Tsymlyansk Reservoir, D3 – Upper and Middle Don River basin, D4 – Manych River basin, D5 – Severskii Donets River basin. Assessments units within the Dnieper River basin: CC1 – Dnieper-Bug Liman, CC2 – River Dnieper Delta and Kahovka Reservoir, CC3 – Zaporozhje, Dneprodzerzhinsk and Kremenchug reservoirs, CC4 – Kanev and Kiev Reservoir, CC5 – upper Dniepr River, CC6 – Pripyat River. Assessments units within Danube River basin: SC1 – River Danube Delta, SC2 – lower part of River Danube, SC3 – middle part of River Danube, SC3a – River Sava, SC3b – River Tisa, SC4 – upper part of River Danube).

4.2.1 Trends in alien species in the Black Sea (Ukrainian part)

Black Sea is particularly heavily affected by non-native species invasions. During last decade, number of recorded alien species in the sea is rapidly increasing: the list of alien species released in the 2007 in Transboundary Diagnostic Analysis by Black Sea Commission averaged 217 alien species (TDA 2007), by May 2010 this list included already 254 species (Aleksandrov 2010), and in the next 2 years total number of registered alien species in the sea reached 265 species, with maximum number of alien species (173) recorded in Ukrainian waters (Aleksandrov et al. 2013).

Our analysis of collected information on records of aquatic alien species indicated, that during last two decades rates of new species introductions in Ukrainian waters of the sea increased substantially: biological contamination rates during last decade doubled (Figure 2). Number of new records of alien species for 2001-2012 in Ukrainian waters of the sea averaged for this period 24 new introductions of invertebrate species and 8 new non-native fish introductions, compare to 11 and 8 introductions during the previous decade (Figure 4.2.2).

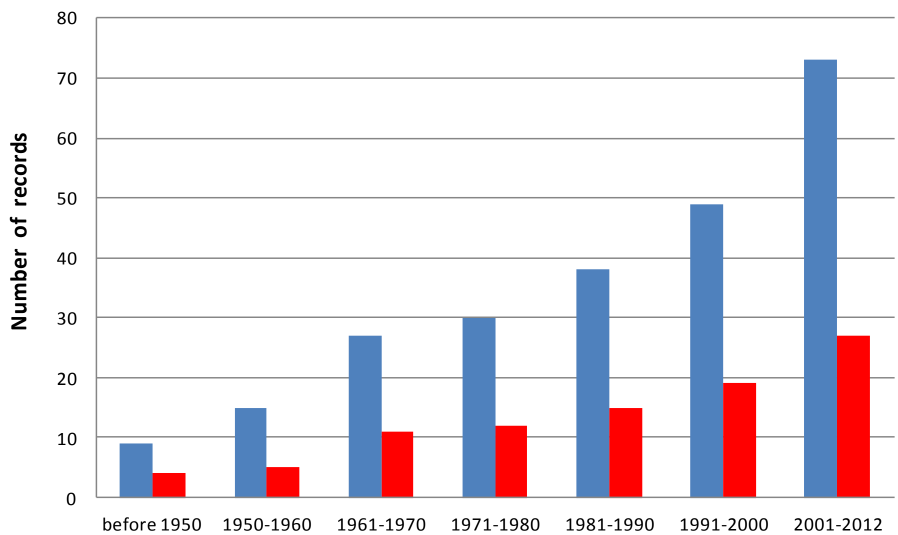


Figure 4.2.2. Trends in new records of alien species of fish (red bars) and invertebrate species (blue bars) in Ukrainian part of the Black Sea. Source: Aleksandrov et al. 2013

Increasing shipping activities in the sea during last 2-3 decades are considered as one of main reasons of this drastic increase. In case if no relevant management options implemented, by 2020 more than 80 new alien species can invade the Black Sea ecosystem (Aleksandrov 2010). However, at this stage coastal countries are not implementing yet relevant management options, recommended by the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM 2004). This Convention is not yet into force, and at this stage, among Black Sea countries, only Russian Federation amended the accession of Convention on 24 May 2012.

In the meantime, negative ecological and economic consequences of continuing introductions of IAS in the Black Sea can be significant. Most impacting IAS for the Black Sea include North American ctenophore *Mnemiopsis leidyi*, which invaded sea at the end of last century with ballast waters of ships (Vladymyrov et al. 2011, for details see also EnviroGRIDS_D5.10).

4.2.2 Trends in alien species in Danube River basin

The Danube River basin is a part of the European Southern inland water Invasion Corridor (Black Sea – Danube-Main/Danube Canal – Main-Rhine – North Sea waterway), one of Europe's four most important routes for invasive species (Figure 4.2.1). The river is therefore exposed to intensive colonisation of invasive species and further spreading in both north-west and south-east directions throughout the basin.

Extensive literature survey indicated drastic increase in new records of alien species of fish and macroinvertebrates in Danube and its tributaries during last decade (Figure 4.2.3), which is most likely can be related to intensive shipping along this inland waterway of international significance (Zoric et al. 2013; Paunovic et al. unpubl. data).

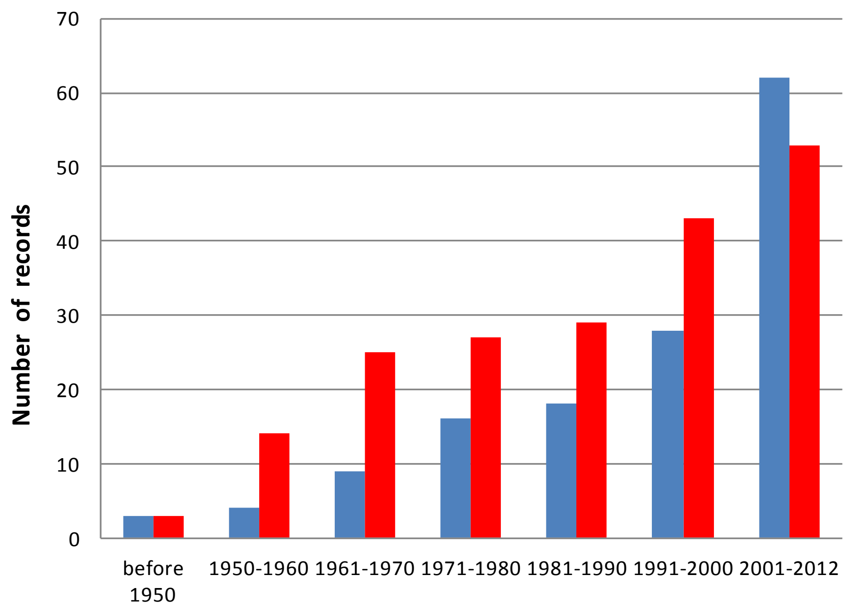


Figure 4.2.3. Trends in new records of alien species of fish (red bars) and macroinvertebrate (blue bars) species in Danube River Basin (all new records for Lower, Middle and Upper Danube, Tisa and Sava rivers). Source: Zoric et al. 2013; Paunovich et al. unpubl.

Results of the Join Danube River Survey 2 (JDS 2), conducted in 2007, revealed that invasive species have become a major concern for the Danube and that their further classification and analysis is vital for effective river basin management. During JDS 2 the most frequent invasive macroinvertebrates were Asian clams (*Corbicula fluminea*) observed at 93% of sites sampled along the Danube River. Another ubiquitous Invasive macroinvertebrates are the Caspian mud shrimp (*Corophium curvispinum*) and killer shrimp *Dikerogammarus villosus* observed at 90% and 69% of all sampled JDS 2 sites, respectively. The JDS 2 found that macroinvertebrate invasive species reached 100% abundance in specific river stretches in the Middle Reach of the Danube. In the Upper Reach, the invasives accounted for up to 90% of specimens observed at some sites. The Asian clams were often one of the only species found at many sites, given their ability to survive the current and bottom conditions there. Within the macrophyte study of the JDS 2, the presence of water hyacinth (*Eichhornia crassipes*), most likely resulting from human impacts (aquarium release), was observed. This invasive plant is considered one of the worst aquatic weeds in the world, and timely eradication of this species should be considered (Danube Watch 2008).

4.2.3 Trends in alien species in Dnieper River basin

The Dnieper River basin is a part of the European Central inland water Invasion Corridor (Black Sea – Dnieper River – Pripyat River – Bug/Pripyat Canal – Bug River – Baltic Sea waterway), and serves also as Europe's important route for IAS (Figure 4.2.1). As other European navigable waterways, assessment units of the Dnieper River are vulnerable to IAS colonization and play an important role in spreading of non-native species. Analysis of trends in introductions of non-native species in assessments units of this area revealed rather high rates of non-native fish and invertebrate species introductions during last decades, averaging 6 fish species and 10 invertebrate species introductions per 10 years (Figure 4). Some of these non-native species, recently invaded and spreading within the basin, include such highly invasive species as killer shrimp *Dikerogammarus villosus*, Chinese mitten crab *Eriocheir sinensis,* North American white-fingered mud crab *Rhithropanopeus harrissi* and Amur sleeper *Percottus glennii* . These species are known as able to cause severe negative impacts on natural biodiversity, and urgent management options should be developed to control them (Semenchenko et al. 2013a). As a result of successful establishment of IAS in the Pripyat River, many locations of this assessment unit were found as biologically contaminated at high extent (Semenchenko et al. 2013b).

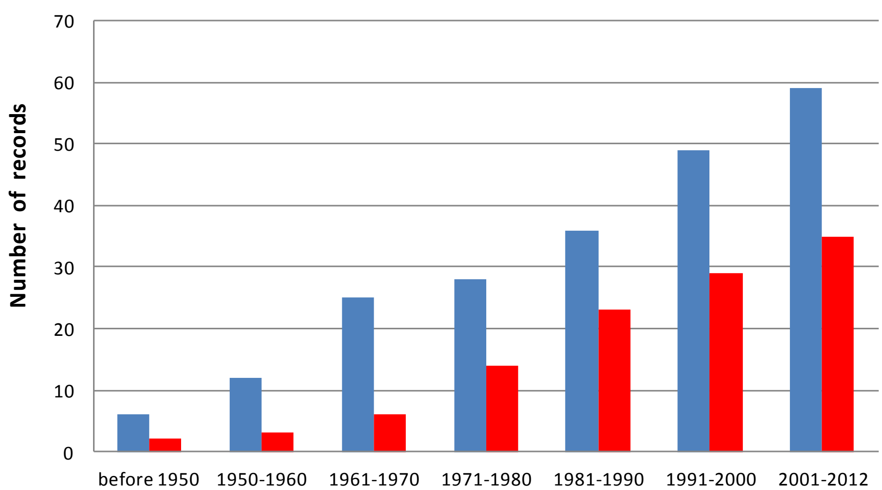


Figure 4.2.4. Trends in new records of alien species of fish (red bars) and macroinvertebrate (blue bars) species in the Dnieper River Basin (all new records for Dnieper-Bug Liman, River Dnieper Delta and Kahovka Reservoir, Zaporozhzhia, Dneprodzerzhinsk and Kremenchug reservoirs, Kaniv and Kiev Reservoir, upper Dniepr River, Pripyat River). Source: Semenchenko et al. 2013a

4.2.4 Trends in alien species in Don River basin

The Don River basin is a part of the European Northern inland water Invasion Corridor (Black Sea – Azov Sea – Don River – Volga-Don Canal – Volga River – Volga-Baltic Canal – Lake Onega- Lake Ladoga – Neva River – Baltic Sea waterway and Black Sea – Azov Sea – Don River – Volga-Don Canal – Volga River – Caspian Sea waterway, Figure 4.2.1). Assessment units of the Don River basin were also found as vulnerable to colonization by non-native species. Analysis of trends in introductions of non-native species in assessments units of Don River basin revealed drastic increase in rates of non-native fish and invertebrate species introductions during last decades, peaking 9 fish species and 23 invertebrate species introductions during last 12 years (Figure 4.2.5). Most likely, this is a consequence of intense ship traffic and climate changes.

Most invasive species, currently spreading in the basin and able to affect negatively natural biodiversity of the area include: Caspian amphipod *Dikerogammarus caspius* and Asian fish stone moroko *Pseudorasbora parva* (Prokin et al. 2013a). Our special biological survey conducted on the Don River in August 2011 relealed high level of biological contamination of many locations in the river (Prokin et al. 2013b).

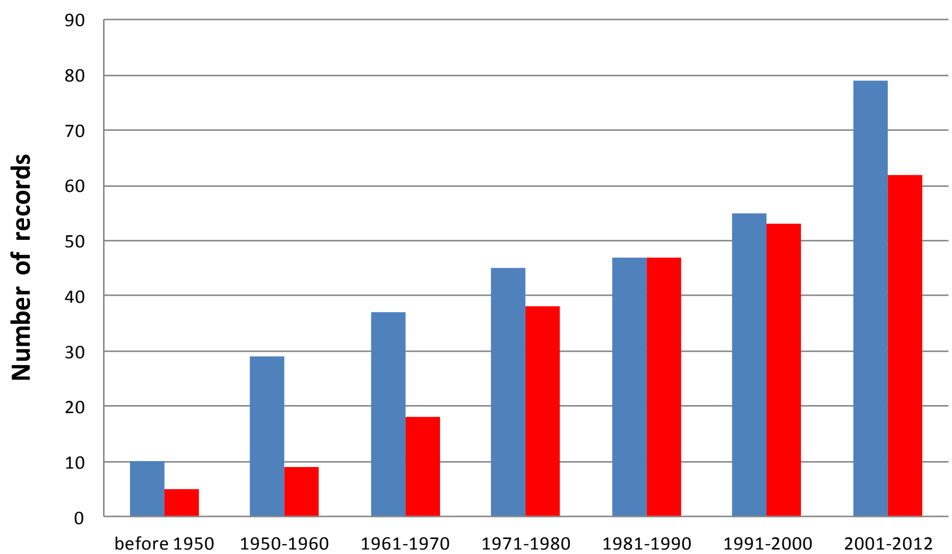


Figure 4.2.5. Trends in new records of alien species of fish (red bars) and macroinvertebrate (blue bars) species in the Don River Basin (all new records for Lower Don River, Tsymlyansk Reservoir, Upper and Middle Don River Basin, Manych River Basin, Severskii Donets River Basin). Source: Prokin et al. 2013a

4.3 Terrestrial Invasive Species

4.3.1 Non-native insect species

In the recent decade, invasion of insect species in the south of Ukraine have become a burning issue. Increase of air temperature, mildening of winters, “blurring” of borders between seasons have considerably intensified the number of successful invasions, and in some cases – expansions of thermophilic species into temperate latitudes. According to the published data (Russian journal of biological invasions…) from the late 19th century to the 1990s, averagely, every 22 months it was found a new alien species of phytophagous insects. But now, the rate has accelerated: a new species appears approximately every 12 months.

Under a general global trend of a shift of ranges of many species to the poles, one of main reasons of penetration and further naturalization of alien species in the south of Ukraine is increase of air temperature. Already now, general trends of shifting ranges of south-originated insects to northern latitudes can be traced on specific examples. Penetrations of invasion species in indigenous communities of the south of the country are of different type, sometimes neutral but in a number of cases they have negative effects.

Expansion of the seathorn hawk-moth *Hyles hippophaes Esp. (Sphingidae, Lepidoptera)*, started in the early 1980s, is a vivid illustration of a relatively neutral penetration and fixation of the Mediterranean species in Ukrainian fauna. It is first of all connected with the fact that with increasing temperatures (especially winter months), the hawk-moth has penetrated far to the north assimilating earlier introduced forage plants as a trophic resource – the sea buckthorn (*Hyppophae rhamnoides*) and the silverberry (*Eleagnus argentea*) grown in the area of its origin (the Mediterranean, Balkans, Western Asia). At the same time, the hawk-moth almost did not come in competition with indigenous species.

However, more frequently the situation is contrary, and invasion species have to assimilate representatives of indigenous fauna as food objects, coming into a tense inter-species competition with local enthomofauna. An example of the negative effect of a phytophagous invader on indigenous flora and fauna is the white peach scale *Pseudalacaspis pentagona* Targioni-Tozzetti (Homoptera; Diaspididae) originated from Eastern Asia. With the planting stock, it penetrated into Europe in the late 19th century, and further in Ukraine. In recent years, during to global warming, this species shows itself as an aggressive pest of decorative and fruit plants in countries with temperate climate (Kozarzhevskaya, 1990). The white peach scale prefers introduced plants in the diet but in the process of naturalization also assimilated many components of our indigenous fauna since it is a classical polytrophic species and, according to recent data, includes 121 genera of 54 families of plants in its diet! Besides danger to decorative and fruit trees, the extent of the species competition with indigenous insect species and number of these species is being estimated (Kozarzhevskaya, 1990).

As for predatory insect species of southern origin, occupying the territory of Ukraine, there is a bright example of expansion of the ascalaphid owlfly *Libelloides macaronius* (Ascalaphidae; Neuroptera) from the Crimea to southern inland areas of the country. The species is listed in the Red Data Book of Ukraine as ‘vulnerable’, and therefore experts are rather careful to changes of its range. Until recently the natural range of the ascalaphid owlfly in Ukraine lain within the Southern Transcarpathians and south/south-east of the Crimean Peninsula. The northern edge of a temperature range of the species went along the border of the mountainous and steppe Crimea. In the early 2000s, due to climate warming which is apparently favous to successful development of pre-imago phases of the ascalaphid owlfly, it distributed all over the Crimea, until Tarkhankut Peninsula in the west and Chongar Isthmus in the north. Using the latter as a kind of ecological corridor, the species penetrated to coastal areas of Zaporizhzhia Region where for the first time was registered in 2007 in the north-western part of Molochnyi Liman (Yakymivka District, Zaporizhzhia Region) (Karmyshev, 2009). At present, the ascalaphid owlfly has occupied practically all the right coast of Molochnyi Liman and large areas at the coast of Utliukskyi Liman. At the same time, with every year the species is considerably expanding its range and increasing its number on newly occupied territories. Thus, in 2011, the species numbers at the right shore of Molochnyi Liman reached 300 ind. per 100 m of a census route which had never been registered by the author in indigenous biotopes of the species in Crimea. Therefore, it is an evidence of fixation the species and its accelerating expansion. The effects of the ascalaphid owlfly integration into the southern coastal areas of continental Ukraine are dubious. On the one part, this protected species occupies new areas, increases the number, i.e. flourishes. In addition, it is extremely useful for human economical activity since being a predator in all phases of its development it brings apparent benefit to agriculture. On the other part, after penetrating into a new area the ascalaphid owlfly will inevitably start competition with other neuropterans both for food resources and for bitopes suitable to larvae development which coincide for these species. In the mentioned territories these species are the ant-lions *Acanthaclisis occitanica* and *Myrmeleon formicarius* (Myrmeleontidae; Neuroptera), unique representatives of rarefied maritime steppes and coastal littoral biotopes, listed in European Red List (K-category). Being attached to unstable and limited in size species-specific biotopes, having scanty numbers and extremely low ecological plasticity, these species are subject to extinction (*Acanthaclisis occitanica* had been considered as extinct in Ukraine for a number of years) (Chopik et al., 1988), and with appearance of numerous and aggressive competitor their survival changes can be reduced.

There are few examples, when the whole way and mechanisms of penetration and fixation of invasive species are well-studied. Above all, it is due to the fact that many invaders have penetrated into new areas only recently while the monitoring of shift of their ranges, identification of causal mechanisms and assessment of their possible impacts on indigenous communities requires a considerable period of time. The south of Ukraine is not exclusion from this rule. For example, collecting field material under this project on Biriuchyi Island (Henichesk District, Kherson Region) the author captured one butterfly specimen– the grayling *Hipparchia pellucida* (Satyridae; Lepidoptera). Earlier the range of this species was limited to mountainous areas of the Crimea and the Crimean southern coast. Taking into consideration general trends of dislocation of ranges of many southern species (in this case, Mediterranean-Turan species) to the north, it is assumed that the grayling had penetrated inland using the same ecological corridor as the ascalaphid owlfly. However, confirmation of this assumption requires specially organized monitoring.

Taking into account trends of further changes in temperature and humidity, the following changes are expected in enthomofauna of Southern Ukraine: the number of invasion species will steadily grow, and this can provide an extremely negative impact on natural species diversity of insects. First of all, it is determined by the fact that actively occupying our territory and resources, as a rule, aggressive species with a wide ecological plasticity will start competition with communities of indigenous species. And the number of invasive species will be not possible to compare with the number of depressed and displaced species of indigenous fauna. The most vulnerable will be endemics and relicts, and also highly specialized species with restricted adaptability which are always the most unique and valuable components of fauna. Thus, urgent management efforts are needed to tackle this problem in Ukraine.

4.3.2 The jackal (*Canis aureus* L., 1758) invasion in the south of Ukraine. Case study

Appearance of the jackal in Ukraine, a new species for the fauna of this territory, brought up a lot of questions for researchers connected with argumentation of invasion facts as a zoogeographic phenomenon. Analysis of some characteristics of expansion in the south of Ukraine will allow deeper understanding of occupation mechanism of new areas and its reasons.

According to paleozoological studies the jackal has never occurred in Ukraine earlier. In the first half of the 20th century it was recorded in Europe in such countries as Albania, Bulgaria, Greece and former Yugoslavia. From these territories there are known accidental visits of some animals to Hungary, Romania and even to Moldova. However, in spite of such geography of records the jackal range was reducing and the hunting for these species in the above-mentioned countries was banned. Soon after that the numbers of the jackal sharply increased and it began occurring regularly in the early 1980s in Hungary, since 1987 in Italy and Austria, since 1989 in Macedonia and Romania, and since 1998 in Ukraine (Volokh, 2004).

The presence of the jackal in Ukraine for the first time was established on 13th March 1998 in the Dniester Delta in bordering with Moldova Biliaivka District of Odesa Region. It was the animals died under car wheels. Since that time it was started the control of the development of the south-eastern core of the species habitation. Initially, at least two jackal pairs penetrated in the Dniester Delta, and nowadays within Odesa Region the jackal occurs in Biliaivka, Bilhorod-Dniestrovskyi, Kiliya, Reni, Sarata, Shyriayeve, Kominternivske Districts, and its total numbers constitute at least 350-400 individuals.

The other core of the jackal habitat close to Ukrainian borders was the Caucasus. In 1950-60s the numbers of the jackal in the Caucasus also declined (Volokh, 2003) but in the 1970s this process changed into a very rapid growth. From their, according to a game manager Bahtiyar Kuliev (Kerch City), the jackals crossed Kerch Strait in winter walking on ice and penetrated into the Crimea on Tuzla Spit. Since the very first days of their appearance the beasts became hunting for poultry, and in April 2002 suffocated 26 lambs in the sheep-pen. One of the animal was killed; it was an adult well-fed male.

From the Caucasian core the jackal penetrated into the lower Don, and some migrants into the lands of Artemivsk District (Donetsk Region). There, in February 2002, according to A.A.Dobrov, two jackals were killed during wolf hunting. At the present time the jackal intensively distributes over valleys of the rivers Siret and Prut and can appear on neighbouring areas of Ukraine (Volokh, 2003; Rozhenko and Volokh, 2010).

Taking into account that the jackal is the second in size predator in southern Ukraine, its impact on local fauna will be substantial. The most negative effect on wildlife this species will have in territories of the hunting associations specializing in game-breeding. Thus, in the spring period the presence of jackals in the lands with intensive game-breeding (pheasant, grey partridge) may lead to extremely negative consequences. Preliminary results of studies on competition relations of the jackal show its clear dominance over the fox and the raccoon dog. It should be taken into account that the jackals readily visit baits and the organization of them in sites of the jackal habitation can be an important tool both for management of this species behaviour and for regulation of the jackal number by taking out from nature a certain number of them.

5 Approaches to inform decision-makers about biodiversity changes, possible threats to biodiversity and socio-demographic consequences of biodiversity changes (AZBOS, SPSU)

5.1 The Regional Waterbird Monitoring Service as the state form of dissemination, exchange and use of information about biodiversity

The only stable-existing state system of dissemination and exchange of information in the field of environmental protection is the State System for Environmental Monitoring and its regional subdivisions. However, within this system, the biodiversity monitoring is almost absent. The information either about the general condition of biodiversity or about its particular components (for example, red-listed species of flora and fauna protected at the national or international level) is not collected. Correspondingly, there is no stable exchange and dissemination of biodiversity information.

In the framework of “enviroGRIDS” project, where one of major tasks was to trace changes in the general biodiversity of key ecosystems at the level of indicator species, it is important to elucidate the organization measures directed at improving the situation with monitoring of species biodiversity at the state level.

The first attempt to establish the monitoring system for certain components of biodiversity was initiated in Zaporizhzhia Region by Melitopol State Pedagogical Institute (to be more precise, by its subdivision – the Institute of Biodiversity of Water and Land Ecosystems). We speak about **the State Regional Waterbird Monitoring Service (RWMC).** Its **Regulations** and acting **Procedure** of automatized data exchange were approved by the special decision of the State Administration in Zaporizhzhia Region in 2009.

The Regional Waterbird Monitoring Service was organized as the scientific-production unit of the Scientific Research Institute of Biodiversity, the interdepartmental Azov-Black Sea Ornithological Station of Melitopol Pedagogical University and Schmalhausen Institute of Zoology.

The main activity of RWMC is monitoring of waterbirds at key water bodies and generally in the region. Another important activity is monitoring of rare and vanishing species of waterbirds in the region. This activity will include informing of territorial bodies of the State Forestry Committee of Ukraine and the Ministry for Environmental Protection in Zaporizhzhia Region as well as users of hunting lands about the state of hunting species resource to make decisions for their sustainable use, and also informing about the state of waterbirds as indicators of wetlands in the region.

Main objectives of RWMC activity are as follows:

- conduction of waterbirds counts and estimation of waterbirds resource in the region;
- development and management of monitoring databases, preparation of GIS-based cartographic information for further prognosis of the state of hunting resources of waterbirds at wetlands and in hunting farms;
- submission of monitoring indices of waterbirds biodiversity to the State Department of the Ministry for Environmental Protection in Zaporizhzhia Region, according to the developed and approved **Procedure of Interactions** between users and customers of the monitoring;

- preparation of the analytical information about the state of the resource for the current biodiversity resource monitoring system (as a component of the environmental monitoring in Zaporizhzhia Region);
- zonation of lands according to their use by waterbirds (night and day roosting sites, feeding sites, migratory stopovers) and identification of important areas of bird seasonal distribution (spring and autumn migrations, breeding, wintering);
- methodical and scientific-practical assistance to hunting farms for the organization and conducting of bird counts;
- preparations of recommendations to justify limits of hunting pressure for different areas and different seasons of the year;
- identification of the most valuable lands for the feeding and conservation of birds to create reproduction areas.

At the regional level the following organizations are involved into the sub-system of waterbird monitoring (as a part of the environmental monitoring system in Zaporizhzhia Region):

- the State Department of the Ministry for Environmental Protection in Zaporizhzhia Region;
- Zaporizhzhia Regional Department of Forestry and Hunting Economy;
- other state agencies, scientific and public institutions which carry out monitoring research within Zaporizhzhia Region and in the territories of wetlands of international importance.

All the waterbirds are subject to **monitoring** especially rare and vanishing species, as well as hunting and commercially important. Most of bird species which are subject to monitoring will be identified in the field only by expert ornithologists or trained workers of hunting farms. The object of monitoring is also the waterbird quarry shot by hunters.

5.2 ROM programme (regional ornithological monitoring) – an example of a public form of information dissemination and exchange

Until recently, in spite of long-term and close collaboration between experts in ecology, management and conservation of terrestrial and aquatic ecosystems in the Azov-Black Sea Region, there was a lack in specially designed and well-working forms of information dissemination and exchange.

To solve the problem, in 2001 we developed a specialized monitoring programme ROM (the author is I.I.Chernichko). The ROM (Regional Ornithological Monitoring) is focused at organization of stable ornithological monitoring on the fixed plots and census routes in any region and provides an express method of results exchange.

The programme is based on the standardization of sites, synchronized terms, unified methods of monitoring and data procession including the use of remote sensing and GIS analysis.

The ROM is a long-term programme and organized as an interdepartmental network of expert ornithologists from different institutions of Ukraine, Russia, Belarus, Moldova, united by Memorandum on Collaboration or on voluntary basis. In some years, the programme involved experts from distant regions and other countries (Italy).

Methodically, the programme is targeted at the organization of bird monitoring in different seasons except the winter. Monitoring of wintering birds is coordinated at the national level by IWC and therefore is an independent part of monitoring works in the region. The ROM is specially focused on the coordination of monitoring of waterbird migratory concentrations and on breeding counts. Annual duration of the migration period did not allow yet to provide monitoring of all migration waves both in spring and autumn, and at this initial level the ROM programme selected the monitoring of bird concentrations in summer/autumn migration period: first half of August.

The results of the programme are published in the ROM Bulletin. Nowadays it is the most assessable and needed form of the scientific information dissemination and exchange. In addition to a hard copy, the Bulletin materials are also available at the website of the Azov-Black Sea Ornithological Station, and in future it is planned to organize the web portal presenting the ROM outputs.

For all the period of the ROM implementation 7 issues have been published. In addition to materials of IWC winter counts, they contain the results of several, ROM-traditional, waterbird counts in August, during summer/autumn period.

The ROM Bulletin is not only a tool of information exchange between scientists but also informs regional authorities and decision-makers about resource capacity of lands, the most valuable areas for local and migratory birds, rare and protected bird species, etc.

5.3 Information and Decision-support systems on invasive alien species

Open informational resources are important for support of decision making on invasive alien species (IAS). Before start of EnviroGRIDS project, the open information resources on invasive alien species IAS in the Black Sea Basin countries were limited to the regional *Mnemiopsis leidyi* database (Vladymyrov et al. 2011), the database of aquatic invaders of Belarus (Mastitsky et al. 2010) and the Ukrainian node of the GloBallast programme (GloBallastUkraine 2011). Development of the Black Sea *Mnemiopsis leidyi* database is supported by the regional Black Sea Commission, but mechanisms of regular updates of this database with new information are lacking and only 5-years old species record data are available in open access.

With the support of the *enviroGRIDS* project, during 2009-2012 we developed demonstration version of the regional risk assessment-based Decision Support and Early Warning System on IAS for the Black Sea basin, which is based on online information management tools available at the REABIC information system (Panov et al. 2012; Panov et al. 2013).

The Regional Euro-Asian Biological Invasions Centre (REABIC, http://www.reabic.net/) is an independent regional data centre for invasive alien species (IAS) serving as an international repository of geo-referenced record data on IAS, and currently focusing on elaboration of effective mechanisms of online open access to the datasets of geo-referenced IAS monitoring data. Specifically, REABIC provides services for data holders in the protection of their author rights on IAS related information via timely publication of their papers in the international open access thematic journals *Aquatic Invasions, BioInvasions Records*, and *Management of Biological Invasions* established by REABIC (http://www.reabic.net/journals/). These thematic journals include a peer-reviewing system as the mechanism of quality control of IAS data, available after their publication in the online information system of REABIC. These scientific journals, as part of the information system of REABIC, serve to provide a unique opportunity to develop early warning systems, based on the most recent geo-referenced records of IAS (Panov et al. 2011; Lucy and Panov 2012; Panov et al. 2012; Panov et al. 2013). In combination with other REABIC-based online services, including the European Research and Management Network on Aquatic Invasive Species (ERNAIS) experts database (http://www.reabic.net/ZnExp.aspx), REABIC also provides a virtual platform for linking the international research community and general public, managers and decision-makers. REABIC is registered as GEOSS component, and is serving as a partner organisation and data provider for the Global Biodiversity Information Facility (GBIF) and developing European Alien Species Information Network (EASIN, http://easin.jrc.ec.europa.eu/Partners).

References

Abelentsev V.I. 1968. Fauna of Ukraine. Mustelidae. – P.75-118 [in Ukrainian]

Aleksandrov B. 2010. Modern tendencies of the Black Sea biological pollution. Nauk. zap. Ternopol. ped. univ.- Ser. “Biology”. - T. 3 (44).- P. 3-5.

Aleksandrov B, Gvarishvili T, Khalvashi M, Mikashavidze E, Moncheva S, Öztürk B., Raykov V, Selifonova J, Skolka M, Son M, Stefanova K, Surugiu V. 2013. Checklist of alien species of the Black Sea. Aquatic Invasions 8 (in press).

Aleksandrova V.D. 1969. Classification of vegetation. – L.: Nauka. – 275 p. [in Russian]

Anikin V. 1975. Enroachment on sands/ In.: Earth and people (popular geographical annual edition). – M.: Mysl’. – P. 91-97. [in Russian]

Annual IWC Count Totals: African-Eurasian Waterbird Census // www.wetlands.org/WatchRead/Currentpublications

Anon., 2006: The data of Kumkoy Meteoroloji Station. Istanbul.

Apostolov L.G., Bokov V.A., Dulitsky A.I. 1988. Concepts “biological diversity” and “landscape diversity” //Issues of development of the Crimea: scientific-practical discussion collection of papers. Issue 11: Biological and landscape biodiversity of the Crimea: problems and prospectives. – Simferopol: SONAT. – P.4-7. [in Russian]

Ardamatskaya T.B. 1973. Breeding waders in the North Black Sea region // Fauna and ecology of waders: Proceedings of the conference. March 29-30, 1973 – Moscow: Moskow University Press. – Issue 2. – P.5-10. [in Russian]

Ardamatskaya T.B. 1996. Change in the status and number of rare birds of Dzharylgach Island under the influence of human transformation of the landscape // Important Bird Areas in Ukraine – IBA Program: Proceedings of the conference. – Kyiv. – P. 5-15. [in Russian]

Ardamatskaya T.B. 1983. Wintering waders of the Black Sea Reserve / / Bulletin of MOIP. – Volume 88, Issue 1. – P.64-66. [in Russian]

Ardamatskaya T.B., Rudenko A.G. 1996. Birds // Vertebrates of the Black Sea Biosphere Reserve (annotated lists of species). – Bulletin of Zoology. – № 1 (special issue). – P.19-47. [in Russian]

Başkent, E. Z., Terzioğlu, S. & Başkaya, Ş. 2008. Developing and implementing multiple-use forest management planning in Turkey. Environmental Management, 42:37–48.

Bektaş Balçık, F. 2010. Mapping And Monitoring Wetland Environment By Analysis Of Different Satellite İmages And Field Spectroscopy. PhD thesis, İstanbul Technical University.

Bektaş Balçık, F., Bozkaya, A. G., Göksel, Ç., Doğru, A. Ö., Uluğtekin, N. N. & Sözen, S. 2011c. İğneada Arazi Örtüsü ve Kullanımı Değişiminin Uzaktan Algılama ve Coğrafi Bilgi Sistemleri ile Belirlenmesi. *HKM Jeodezi, Jeoinformasyon ve Arazi Yönetimi Dergisi*. 106(3), 70-74.

Bektaş Balçık, F., Göksel, Ç., Bozkaya, A. G., Doğru, A. Ö., Uluğtekin, N. N. & Sözen, S. 2011a. Ecosystem monitoring using digital change detection method; example of İğneada wetland forest. *Open Water Symposium and Workshops at UNESCO-IHE*. Delft, Netherlands, 18-19 April. (Extended Abstracts).

Bektaş Balçık, F., Göksel, Ç., Eşbah Tunçay, H., Bozkaya, A. G., Doğru, A. Ö., Uluğtekin, N. N. ve Sözen, S. 2011b. Performance of Different Vegetation Indices for Igneada Flooded Forest Mapping. *16th International Symposium on Environmental Pollution and Its Impact on Life in the Mediterranean Region*. Ioannina – Greece, 24-27 September. (in CD).

Bergmeier E., Petermann J., Schröder E. 2010. Geobotanical survey of wood-pasture habitats in Europe: diversity, threats and conservation Biodivers Conserv. – 19 – P. 2995–3014.

Bergmeier E., Petermann J., Schröder E. 2010. Geobotanical survey of wood-pasture habitats in Europe: diversity, threats and conservation Biodivers Conserv. – 19 – P. 2995–3014.

Beskaravayny M.M. 1999. Wintering birds in South-Eastern Crimea // Winter counts of birds in the Azov-Black Sea coast of Ukraine. Collection of scientific works. – Melitopol-Odessa-Kiev: Wetlands International. – Issue 2. – P.10-20. [in Russian]

Blaga N.N.., Rudyk A.N. 2002. Methodological aspects of the definition of standards of permissible recreational pressure in the natural reserve fund // Culture of Peoples of Black Sea Region. – № 34. – P.168-170. [in Russian]

Bobra T.V. 2007. Collection of scientific articles and essays on organization of geospace, geoecotones and ecotonization. – Simferopol: TNU Publishing House. – 160 p. [in Russian]

Bobra T.V. 2005. Landscape boundaries: detection, analysis, mapping. Scientific monograph. – Simferopol. – 168 p. [in Russian]

Bozkaya, A. G., 2013. İğneada Koruma Alanının Uzaktan Algılama ve Coğrafi Bilgi Sistemleri ile Zamansal Değerlendirilmesi ve Geleceğe Yönelik Modellenmesi (Temporal Assessment of İgneada Conservation Area with Remote Sensing and Geographic Information Systems and Modeling the Future), MSc Thesis, İTÜ, Fen Bilimleri Enstitüsü, Istanbul, 161pp. (in Turkish)

Brauner A. A. 1899. Notes on birds of the Crimea. – Notes of Novorossiysk Society of Natural Science. – Volume 23, Issue 1. – P.1-45. [in Russian]

BWM. 2004. International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. http://www.imo.org/About/Conventions/ListOfConventions/Pages/Default.aspx

CBD. 2001. Status, impacts and trends of alien species that threaten ecosystems, habitats and species, Convention on Biological Diversity (http://www.cbd.int/doc/meetings/sbstta/sbstta-06/information/sbstta-06-inf-11-en.pdf)

Cermák, J. & Prax, A. 2001. Water balance of a Southern Moravian floodplain forest under natural and modified soil water regimes and its ecological consequences. Ann. For. Sci. 58: 15–29.

Čermák, J. Kučera, J., Prax, A., Bednářová, F. T. & Nadyezhdin, V. 2001. Long-term course of transpiration in a floodplain forest in southern Moravia associated with changes of underground water table. Ekológia 20: 92–115.

Chander, G., & Markham, B. L. 2003. Revised Landsat-5 TM radiometric calibration procedures, and post-calibration dynamic ranges. IEEE Transactions on Geoscience and Remote Sensing, 41, 2674−2677.

Chashchin A.K. 2011. Impact of jellyfish invasive hydrobionts on populations of Azov pelagic fish and perspectives of fisheries / A. K. Chashchin, V.E. Dubovik, S.A. Negoda et al. // Fishery of Ukraine. – № 1. – P. 10-18. [in Russian]

Cherney L.S. 2005. Darkling beetles (Coleoptera, Tenebrionidae) // Fauna of Ukraine. V 19: Beetles. Issue 10. – Kiev: Naukova Dumka. – 434 p. (Cherney, 2005 – in Russian)

Chernichko I.I. 1988. The Avocet // Colonial hydrophilic birds of South Ukraine: Charadriiformes. – Kyiv: Naukova dumka. – P.90-101. [in Russian]

Cheroy A.I. 2009. Runoff of water, sediments and morphological processes in the Danube river mouth: dissertation of Cand.of Geography: 11.00.07. – Odessa. – 174 p. [in Russian]

Chopik V.I., Shcherbak N.N., Ardamatskaya T.B. et al. 1988. Rare and endangered plants and animals in Ukraine: Ref. / Ed. Sytnik KM – Kiev: Naukova Dumka, 256 pp (in Russian)

Çiçek, E. 2002. Adapazarı-Süleymaniye Subasar Ormanında Meşcere Kuruluşları ve Gerekli Silvikültürel Önlemler, PhD Thesis, İstanbul Üniversitesi Fen Bilimleri Enstitüsü, 138 pp.

ÇOB, 2007. İğneada Longoz Ormanları Bitkileri Resimli Tanıma Kılavuzu, *Çevre ve Orman Bakanlığı Doğa Koruma ve Milli Parklar Genel Müdürlüğü,* Biyolojik Çeşitlilik ve Doğal Kaynak Yönetimi Projesi, İstanbul.

Cramp S. & Simmons K.E.L. (eds.). 1983. The Birds of the Western Palearctic. Vol.III. Waders to Gulls. – Oxford – New York: Oxford University Press. – 913 p.

Danube Watch. 2008. Invasion of the Danube. Danube Watch 2008, 3. http://www.icpdr.org/main/publications/invasion-danube

Darvishzadeh, R., Skidmore, A., Atzberger, C., van Wieren, S. 2008. Estimation of vegetation LAI from hyperspectral reflectance data: Effects of soil type and plant architecture. International Journal of Applied Earth Observation and Geoinformation, 10 (3), pp. 358-373.

Davey, A.G. 1998. National System Planning for Protected Areas. – Gland, Switzerland and Cambridge, UK: IUCN. – X + 71 pp.

Deliverable 2.4 EnviroGRIDS remote sensing data use and integration guideline, 2009

Dementiev G.P., Gladkov N.A. 1951. Birds of the Soviet Union. – Moscow: Sovetskaya Nauka. – Vol.3. – 680 p. [in Russian]

Deng, J. S., Wang, K., Deng, Y. H., Qi, G. J., 2008. PCA-based land-use change detection and analysis using multitemporal and multisensor satellite data. International Journal of Remote Sensing. Vol. 29, pp. 4823-4838.

Derzhavets Yu.A. 1984. Overview of hawkmoths system (Lepidoptera, Sphingidae) with a list of species of the USSR fauna / / Entomological Review. – Volume LXIII, № 3. – P.604 – 620. [in Russian]

Development of Scheme of Regional Ecological Network of the Autonomous Republic of Crimea. 2008. – Simferopol: TNU. [in Russian]

Didukh Ya. P. 1992. The vegetation cover of the Crimean Mountains (structure, dynamics, evolution, and conservation).- Kiev: Naukova Dumka. – 256 p. [in Russian]

Dimitrov M., Michev T., Profirov L., Nyagolov K. 2005. Waterbirds of Bourgas Wetlands. Results and Evaluation of the Monthly Waterbird Monitoring 1996-2002. – Sofia-Moskow: Bulgarian Biodiversity Foundation and Pensoft Publishers. – 160 p.

Dinkevich M.A. Mnatsekanov R.A., Tilba P.A., Korotky T.V. 2005. Oystercatcher and Redshank – new wintering species of the Ciscaucasia// Strepet. – Volume 3. – Issue 1-2. – P.118-119. [in Russian]

Döring-Mederake, U. 1990: Alnion forests in lower Saxony (FRG), their ecological requirements, classification and position within Carici elongatae- Alnetum of Northern Central Europe. Vegetatio 89: 107–119.

Dudley, N. (Editor). 2008. Guidelines for Applying Protected Area Management Categories. – Gland, Switzerland: IUCN. – X + 86 pp.

Dulitskiy A.I. 2001. Biodiversity of the Crimea. Mammals: History, status, security, prospects . – Simferopol: "Sonat". – 208 p. [in Russian]

EC. 2008. Towards an EU strategy on invasive species. COM/2008/789, European Commission, Brussels, 10 pp

EC. 2011. Our life insurance, our natural capital: an EU biodiversity strategy to 2020. COM/2011/244, European Commission, Brussels, 16 pp

EEA. 2012. Trends of alien species invasions. Invasive alien species indicators in Europe A review of streamlining European biodiversity (SEBI) Indicator 10. European Environment Agency Technical report 15, Luxembourg: Publications Office of the European Union, pp 44

Efetov K.A., Budashkin Yu.I. 1990. Butterflies of the Crimea (Lepidoptera; Heterocera): Handbook. – Simferopol: Publishing House "Tavria". – 112 p. [in Russian]

Fateriga A.V. 2004. Wasps of Eumeninae subfamily (Hymenoptera: Vespidae) as indicators of areas with high levels of biodiversity in the Crimea / / Issues of development of Crimea. Scientific-practical and analytical collection. Issue 15. Inventory Problems of Crimean biota. – Simferopol: Tavria plus. – P. 105-110. [in Russian]

Fedorenko A. P, Nazarenko L.F. 1965. New data on wintering birds at the north-western coast of the Black Sea // Terrestrial vertebrates of Ukraine (ecology, distribution, history of fauna). – Kyiv: Naukova Dumka. [in Ukrainian]

Foody, G. M. 2002. Status of land cover classification accuracy assessment. Remote Sensing of Environment. Vol. 80, pp. 185-201.

Gargopa Yu.M. 2003. Large-scale changes of hydrometeorological conditions of bioproductivity formation in the Azov Sea. – Theses for Dr. of Georgraphy degree. Speciality 25.00.28 "Oceanology" / Yu.M. Gargopa. – Murmansk. – 51 p. [in Russian]

Gasso V.Ya. 1998. Ecological-biochemical characteristics of interaction of the sand lizard (Lacerta agilis) with technogenic environment in the steppe Dnieper area: dissertation abstract for a degree of Candidate of Biology: Dniepropetrovsk: Publishing House DDU. – 17 p. [in Ukrainian]

Gavrin V.F. 1957. Seasonal migration of birds in Belovezhskaya Pushcha and the surroundings // Proceedings of the Second Baltic Ornithological Conference. Moscow. – P.108-130. [in Russian]

General Directorate of Nature Conservation and National Parks, Republic of Turkey Ministry of Environment and Forestry 2005. Iğneada Flora and Vegetation Final Report: Biological Diversity and Natural Resources Management Project (GEF-II). Ankara, Turkey

Geographical encyclopaedia of Ukraine: in 3 volumes. 1990. / Edited by O.M.Marynych et al. – Kyiv: “Ukrainian Soviet Encyclopaedia” named after M.P.Bazhan. – Volume 2. – 480 p. [in Ukrainian]

Glaeser, J. & Volk, H. 2009: The historical development of floodplain forests in Germany – a review. Allgemaine Forsts- und Jagdzeitung 180: 140–151.

GloBallastUkraine. 2011. GloBallast Programme in Ukraine web site. http://www.globallast.od.ua

Golubev V.N., Korzhenevsky V.V. 1985. Methodical recommendations on geobotanical survey and classification of vegetation of the Crimea. – Yalta: GNBS. – 37 p. [in Russian]

Gopchenko E.D., Cheroy A.I. 2006. Dynamics of the marine edge of the Danube Delta and bottome of its estuarial seashore // Ukrainian Hydrometeorological Journal. – No1. – P.163-169. [in Russian]

Green Book of Ukraine. 2009. / Edited by. Ya.P. Didukh – К.: Alterpress, 2009. – 448 p. [in Ukrainian]

Grishchenko V.N. 2010. Changes in timing of bird migrations in Kaniv Reserve // Branta: Transactions of the Azov-Black Sea Ornithological Station. – Issue13. – P.33-39. [in Russian]

Guskov E.P. 1975. On the phenotypical variations in coloration of subspecies of the grass snake (Natrix natrix)// Zoological journal. - Volume 54(8). – P.1266-1267. [in Russian]

Hockings, M., Stolton, S., Leverington, F., Dudley, N. and Courrau, J. 2006. Evaluating Effectiveness: A framework for assessing management effectiveness of protected areas. – 2nd edition. – Gland, Switzerland and Cambridge, UK: IUCN. – XIV + 105 pp.

Hydrology of the Danube Delta. 2004. / edited by V.N.Mikhailov. – M.:GEOS. – 448 p. [in Russian]

Hydrometeorological conditions of seas of Ukraine. 2009. - Vol. 1: Sea of Azov/ [Ilyin Yu.P., Fomin V.V., Dyakov N.N.Gorbach S.B.]. – Sevastopol: NVC "EKOSI-Hydrofizika". – 402 p. [in Russian]

Hydrometeorology and hydrochemistry of the seas of the USSR. 1991. – Saint-Petersburg: Gidrometeoizdat. – T. V. Sea of Azov. – 234 p. [in Russian]

Ippolitov I.I., Kabanov M.V., Komarov A.I., Kuskov A.I. 2004. Current nature-climatic changes in the Siberia: dynamics of average annual surface temperatures and pressure // Geography and Natural Resources, 3.- P. 90-96. [in Russian]

Jackson, B. D. 1990: Identification and Inventory of the International Forested – Wetland Resource: Conference Summary. Forest Ecology and Management 33/34: 1–4.

Jensen, J. R., 1996. Introductory Digital Image Processing: a Remote Sensing Perspective, Second ed, Prentice Hall, Saddle River, NJ, 316 pp.

Kantarcı, M. D. 1979. Kuzey Trakya Dağlık Orman Yetişme Bölgesinin Yöresel Sınıflandırması. İst. Üni. Orman Fak. Der. A/29(2): 42–71.

Kashkarov D.N. 1938. Essentials of animal ecology. – Moscow.-Leningrad.: Medgiz. – 601 p. [in Russian]

Katsanevakis S, Genovesi P, Gaiji S, Hvid HN, Roy H, Nunes AL, Aguado FS, Bogucarskis K, Debusscher B, Deriu I, Harrower C, Josefsson M, Lucy FE, Richards G, Trichkova T, Vanderhoeven S, Zenetos A, Cardoso AC. 2013. Implementing the European policies for alien species – networking, science, and partnership in a complex environment. *Management of Biological Invasions* 4: in press

Kavgaci, A. 2007a. Demirköy-İğneada longoz ormanlari ve çevresinin bitki toplumlari ve kuruluş özellikleri. PhD thesis, İÜ. Fen Bilimleri Enstitüsü, Istanbul, 215 pp.

Kavgacı, A. 2007b. Sand-Dune Vegetation of İğneada Coast in the Thracian Part of Turkey. Hacquetia 6(2): 171–182.

Kavgacı, A., Čarni, A., Tecimen, B. & Özalp, G. 2010. Diversity and Ecological Differantiation of Oak Forests in NW Thrace (Turkey). Archives of Biological Sciences 62(3):705–718.

Kavgaci, A., Čarni, A., Tecimen, H., Özalp, G. 2011. Diversity of floodplain forests in the Igneada region (NW Thrace – Turkey). Hacquetia, 10 (1), 73-93.

Kavgacı, A., Özalp, G. & Özhatay, N. 2007. Flora of Igneada floodplain forests (longozes) and their surroundings. İst Üni Orman Fak. Der. A/57(2): 61–90.

Kaya, M. 1998. Mert ve Erikli Göllerinin (Kırklareli/ İğneada) Kuş Faunası Açısından Önemi ve Ekolojik Sorunları, Ekoloji Dergisi, Cilt 7, Sayı 27, Sf 15-18, İzmir.

Kinda V.V., Beskaravayny M.M., Diadicheva E.A., Chernichko I.I., Chernichko R.N., Formanyuk O.A. 2006. Spatial distribution and abundance of waders in winter period in the Azov-Black Sea Region // Branta: Transactions of the Azov-Black Sea Ornithological Station. – Issue 9. – P.150-183. [in Russian]

Knowler D. 2005. Reassessing the costs of biological invasion: Mnemiopsis leidyi in the Black Sea. Ecological Economics 2: 187-199

Kobetchinskaya V.G., Svolynskiy A.D., Svolynskiy M.D., Kapitonov V.V. 2010. Leading human-induced factors that violate the stability of the ecosystems of the Yalta Mountain Forest Nature Reserve / / Ecosystems, their optimization and security. – Simferopol : TNU. – Issue 2. – P. 58-74. [in Russian]

Kostin Yu. V., Dulitskiy A. I., Kostin S. Yu. 1999. Ecological and geographical characteristics of the zonal-biotopic stand out and the composition of their fauna / / Issues of Crimea: Scientific- Practical analytical collection. Issue 11: Biological and landscape diversity of the Crimea: problems and prospects. – Simferopol: Sonat. – P. 35-54. [in Russian]

Kostin Yu.V. 1983. Birds of the Crimea. – Moscow: Nauka. – 240 p. [in Russian]

Kotenko T.I., Shaitan S.V., Starkiov V.G.. Zinenko O.I. 2009. The northern limit of the distribution of the dice snake (Natrix tessellata) over the territory of Ukraine and the Don River basin in Russia //15th European Congress of Herpetology & SHE Ordinary General Meeting. – Kusaadsi – Aydin, Turkey. – P. 26.

Kotenko T.I., Shaitan S.V., Starkiov V.G.. Zinenko O.I. 2011. The Northern Range Limit of the Dice snake (Natrix tessellata) in Ukraine and the Don River Basin in Russia //MERTENSIELLA, number 18. – P. 311 – 324.

Kovalenko E.E. 2001. Methodological problems of bioindication // Issues of herpetology. Proceedings of the 1st session of herpetological society named after A.M.Nikolsky 4-7 December 2000, Pushchino-on-Oka. – Pushchino-Moscow. – P. 124-126. [in Russian]

Kozarzewski E.F., Konstantinov G.N. 1990. Beetle – pests of fruit and ornamental plants. – Moscow: Agropromizdat, 156 pp. [in Russian]

Kriukova I.V. 2005. Botanical tours of Mountain Crimea . – K.: Stylos. – 156 p. [in Russian]

Kukurudza M.M. 2003. National Parks Management: Manual. – Lvivi: LNU Publishing House named after Ivan Franko. – 127 p. [in Ukrainian]

Kutbay, H. G., Kılınç, M. & Kandemir, A. 1998: Phytosociological and Ecological Structure of Fraxinus angustifolia forests in the Central Black Sea Region. Turk J Bot 22: 157–162.

Kistyakivsky O.B. 1957. Fauna of Ukraine in 40 volumes. Volume 4. Birds. – Kyiv.: Publ.House of USSR Academy of Sciences. – 432 p. [in Ukrainian]

Li, X., Yeh, A. G. O., 1998. Principal component analysis of stacked multi-temporal images for the monitoring of rapid urban expansion in the Pearl River Delta of Hong Kong, Pokfulam Road, Hong Kong. International Journal of Remote Sensing. Vol. 19, no. 8, pp. 1501-1518

Liang S. 2004. Quantitative Remote Sensing of Land Surfaces, John Wiley and Sons, New Jersey, USA.

Lucy F.E., Panov V.E. 2012. BioInvasions Records: A new international journal on biological invasions. BioInvasions Records, Volume 1, Issue 1: 1-4

MA (Millenium Ecosystem Assessment). 2005. *Ecosystems and human well-being. Biodiversity Synthesis*. World Resources Institute, Washington, DC, 100 pp.

Magurran, A. E. 1988. Ecological diversity and its measurement. Princeton University Press, Princeton, 179 pp.

Magurran, A. E. 2004. Measuring biological diversity. Blackwell Publishing, 256 pp.

Marisova I.V., Samofalov M.F., Bobko V.M. History of research and migration phenology of birds in Chernihiv Region // Seasonal migrations of birds in the territory of Ukraine. – Kyiv: Naukova dumka, 1992. – P. 221-240 [in Russian]

Mastitsky SE, Karatayev AY, Burlakova LE. 2010. Aquatic invaders of Belarus: Alien species database. Available at: www.aliensinbelarus.com

Mezherin S.V. 2008. Animal Resources of Ukraine in terms of the sustainable development strategy: an analytical reference book / S.V. Mezherin – K.: Logos. – 282 p. [in Russian]

Michev T., Profirov L. 2003. Midwinter numbers of waterbirds in Bulgaria (1977-2001). Sofia: Pensoft. – 160 p.

Mirkin B. M. 1984. Anthropogenic dynamics of vegetation // Results of science and technology. Series: Botany. – Moscow. - Volume 5. - P.139-232 [in Russian]

Moran, M. S., Jackson, R. D., Slater, P. N., & Teillet, P. M., 1992. Evaluation of simplified procedures for retrieval of land surface reflectance factors from satellite sensor output. Remote Sensing of Environment. Vol. 41, pp. 169– 184.

Mosyakin S.A., Popov V.N. 1999. Ecological and geographical structure of the fauna of leaf beetles (Coleoptera, Chrysomelidae) of Crimea // Pontida. – №1. – P. 30-40. [in Russian]

Müller, N. 1995: River dynamics and floodplain vegetation and their alterations due to human impact. Arch. Hydrobiol. Suppl. 101(3/4): 477–512.

Müller, N. 1998: Effects of natural and human disturbances on floodplain vegetation. In: Müller, N., Okuda, S. & Tama, N. (eds.): Proceedings of International Symposium for River Restoration, Tokyo, 209 pp.

Murphy, P. G. and A. E. Lugo. 1986. Ecology of tropical dry forest. Annual Review of Ecology and Systematics 17:66-88.

Musolin D.L., Saulich A.Kh. 2012. Responses of insects on current climate changes: from physiology and behaviour to shift of ranges // Entomological outlook. – Vol.91., No1. – P.3-35. [in Russian]

Nankinov D. 1989. The status of waders in Bulgaria // Wader Study Group Bull. – N.56. – P.16-25.

Nikolsky A.M. 1891/1892. Vertebrates of the Crimea // Notes of the Royal Academy of Sciences: Annex № 4 to Volume 68. – St. Petersburg. – 484 p. [in Russian]

Odum Yu. 1975. Issues of ecology. – Moscow: Mir. – 740 p. [in Russian]

Ok, K. 2006. Multiple Criteria Activity Selection for Ecotourism Planning in Igneada. Turk. J. Agric. For., 30, 153-164.

On the way to National Park in Crimea. 2000. / Bokov V.A., Yena V.G., Rudyk A.N.and others. – Simferopol. – 80 p. [in Russian]

Özhatay, N., Byfield, A. & Atay, S. 2003. Türkiye'nin Önemli Bitki Alanlari, Doğal Hayati Koruma Vakfi (WWF Türkiye) yayini, 88 pp.

Özyavuz, M. & Yazgan, M. E. 2010. Planning of İğneada Longos (Flooded) Forests as a Biosphere Reserve. Journal of Coastal Research: Volume 26, Issue 6: pp. 1104 – 1111.

Özyavuz, M., 2008. Yıldız Dağları'nın İğneada – Demirköy arasında yer alan bölümünün biyosfer rezervi olarak planlanması (Planning of İğneada-Demirköy Part of Yıldız (Istranca) Mountains as a Biosphere Reserve). Ankara University, Ph.D. thesis, 173pp.

Paal, J., Rannik, R., Jeletsky, E.M. & Prieditis, N. 2007: Floodplain forests in Estonia: Typological diversity and growth conditions. Folia Geobotanica 42: 383–400.

Pamay, B. 1967. Demirköy – İğneada longoz ormanlarının silvikültürel analizi ve verimli hale getirilmesi için alınması gereken silvikültürel tedbirler üzerine araştırmalar. Orman Genel Müdürlüğü Yayınları, No. 451/43, İstanbul, 174 pp.

Panchenko P.S., Formanyuk O.A. 2007. Regional news: Ukraine // Information materials of Wader Study Group. – Moscow. – Issue 20. – P. 14-15. [in Russian]

Panov V, Aleksandrov B, Boltachev A, Gubanova A, Karpova E, Lucy F, Paunovich M, Prokin A, Pulenko N, Semenchenko V, Shestakov V, Shiganova T, Son M. 2013. Illustrated pilot case studies for the Black Sea catchment Disaster Early Warning System. Deliverable D5.10. to European Commission EnviroGRIDS project. Part 1 "Invasive Alien Species"

Panov V, Alexandrov B, Boltachev A, Gubanova A, Karpova E, Lucy F, Paunovich M, Prokin A, Pulenko N, Semenchenko V, Shestakov V, Shiganova T, Son M (2012) Risk Assessment Toolkit and DSS. The online Risk Assessment Toolkit and Decision Support System for introductions of invasive alien species for the Black Sea catchment. Deliverable D5.4. to European Commission EnviroGRIDS project, 21 pp

Panov V, Alexandrov B, Boltachev A, Gubanova A, Karpova E, Lucy F, Paunovich M, Prokin A, Pulenko N, Semenchenko V, Shestakov V, Shiganova T, Son M. 2013. Risk Assessment Toolkit and DSS. The online Risk Assessment Toolkit and Decision Support System for introductions of invasive alien species for the Black Sea catchment. Deliverable D5.10. to European Commission EnviroGRIDS project

Panov VE. 2004. Internet-based information resources on aquatic alien species relevant to the Ponto-Caspian Region. In: H.J. Dumont, T.A. Shiganova and U. Niermann (eds), Aquatic Invasions in the Black, Caspian, and Mediterranean Seas, Kluwer Academic Publishers, pp 257-269

Panov VE, Alexandrov B, Arbačiauskas K, Binimelis R, Copp GH, Grabowski M, Lucy F, Leuven RSEW, Nehring S, Paunović M, Semenchenko V, Son MO. 2009. Assessing the risks of aquatic species invasions via European inland waterways: from concepts to environmental indicators. Integrated Environmental Assessment and Management, Volume 5, Issue 1: 110–126

Panov VE, Alexandrov B, Arbačiauskas K, Binimelis R, Copp GH, Grabowski M, Lucy F, Leuven RSEW, Nehring S, Paunović M, Semenchenko V, Son MO. 2010. Risk Assessment of Aquatic Invasive Species Introductions via European Inland Waterways. Atlas of Biodiversity Risk. Pensoft. Sofia, pp 140–143

Panov VE, Gollasch S, Lucy F. 2011. Open-access journal Aquatic Invasions: An important part of the developing European information and early warning system on invasive alien species. Aquatic Invasions, Volume 6, Issue 1: 1-5

Petrovich Z.O., Redinov K.O. 2011. Purple Sandpiper (Calidris maritima) in Ukraine / / Branta: Transactions of the Azov-Black Sea Ornithological Station. – Issue. 14. – P.151-153. [in Ukrainian]

Petrovich Z.O., Redinov K.O. 2006. Records of waders in winter period at Kinburn Peninsula // Branta: Transactions of the Azov-Black Sea Ornithological Station. – Issue. 9. – P.191-194. [in Ukrainian]

Petrusenko A.A., Petrusenko S.V. 1975. On entomogeografical zoning of Crimea by studying of distribution of ground beetles (Coleoptera, Carabidae) // Zoological Bulletin. – № 5. – P. 57-62. [in Russian]

Pietsch, S. A., Hasenauer, H., Kuèera, J. & Èermák, J. 2003: Modelling effects of hydrological changes on the carbon and nitrogen balance of oak in floodplains. Tree Physiology 23: 735–746.

Pisanets E.M. 2007. Amphibians of Ukraine (reference book on amphibians of Ukraine and adjacent areas). – Kyiv.: Zoological museum of NNPM NAS of Ukraine. – 312 p. [in Russian]

Pivec, J. 2002: A short-term response of floodplain and spruce forests to evaporation requirements in Moravia in different years. Journal of Forest Science 48(7): 320–327.

Plyushch I.G., Sheshurak P.N. 1997. Lepidoptera Heterocera of Chernivtsi region of Ukraine. – Kyiv: Publ. Company "International Financial Agency". – 4.2 – 126 p. [in Russian] Aleksandrov B, Boltachev A, Kharchenko T, Lyashenko A, Son M, Tsarenko P, Zhukinsky V (2007) Trends of aquatic alien species invasions in Ukraine. Aquatic Invasions, Volume 2, Issue 3: 215-242

Problems of organization, maintenance and protection of the NRF in the Crimea – http://www.arhus.crimea.ua.

Project of organization of the territory of the Yalta Mountain Forest Nature Reserve. 2006. / Crimean branch of the Research Center for Research on Reserves of Ministry of environment and nature resources of Ukraine. – Simferopol. [in Russian]

Prokin AA, Son MO, Demchenko VN, Khlyzova NY, Silina AY, Shokhin IV, Grabowskyi M, Konopacka A, Nabozhenko MV, Zhivotova EN, Sayapin VV, Panov VE. 2013a. Non-native aquatic species of the Don River basin: a review. Aquatic Invasions 8 (in press)

Prokin AA, Son MO, Dubov PG, Grabowski M, Konopacka A, Panov VE. 2013b. Assessment of biological contamination of Don River: results of biological survey in August 2011. Management of Biological Invasions 4 (in press)

Puzanov I. I. 1927. Materials to the knowledge of terrestrial molluscs of Crimea. Part III. Composition, distribution and origin of the Crimean malacofauna / / Bull. MOIP Dep. Biology.– V. 35.– P. 221-282. [in Russian]

Red Book of Ukraine. Plantage. 2009. / Edited by Ya.P.Didukh — К. : Globalconsulting.– 900 p. [in Ukrainian]

Red Book of Ukraine. Wildlife. 2009. / Edited by I.A. Akimov. – К.: Globalconsulting. – 600 p. [in Ukrainian]

Redinov K.A., Petrovich Z.O., Formanyuk O.A. 2008. News from the regions: Ukraine / / Information materials of Wader Study Group. – M. – № 21. – P.14-15. [in Russian]

Richards, J. A. 1993. Remote Sensing Digital Image Analysis: An Introduction. Verlag Berlin Heidelberg: Springer.

Richardson, A.J., Wiegand, C.L. 1977. Distinguishing vegetation from soil background information. Photogrammetric Engineering and Remote Sensing 43, 1541–1552.

Roitberg V.S. 1981. Analyis of intra- and interpopulational differences by meristic characters of pholidosis in Lacerta agilis and L. strigata of Daghestan // Issues of herpetology (abstracts of reports). Proceedings of 5th Soviet herpetological conference, Ashkhabad, 22-24 September 1981. – Leningrad: Nauka. – P. 115-116. [in Russian]

Roitberg V.S. 1981. Chronographical and interpopulational variability of characters of pholidosis in Lacerta agilis and L. strigata of Daghestan // Issues of herpetology (abstracts of reports). Proceedings of 5th Soviet herpetological conference, Ashkhabad, 22-24 September 1981. – Leningrad: Nauka. – P. 178 [in Russian]

Rowell T. A. 1996. Ecological indicator for nature conservation monitoring. Joint Nature Conservation Committee Report № 196. – Peterborough.

Rozhenko M.V. 1999. The current state of the population of predatory mammals in the Lower Dniester // Biodiversity conservation of the Dniester Basin: Proceedings of the international scientific conference Kishinev. – P.199-200. [in Russian]

Rozhenko N, Volokh A. 2010. The golden jackal (*Canis aureus* L.,1758) as a new species in the fauna of Ukraine. Beitrage zur Jagd -und Wildforschung. Bd.35. 237-246 pp

Rozhenko N.V. 2006. Vulnerability of predatory mammals in Ukrainian Black Sea region and their protection. – Vinnitsia. – P. [in Ukrainian]

Rudyk A.N. 2010. Management of recreational load on the territory of NRF // Natural Reserve territories: functioning, monitoring, protection. Proceedings of the International Scientific Practical Conference dedicated to 30th anniversary of Carpathian National Natural Park) (Yaremche, 25.11.2010). – Yaremche. – P. 105-107. [in Russian]

Rudyk A.N. 2008. The environmental management of protected areas // Geography in information society. Зб scientific works. – К.: VGL Obrijiї. – V.2. – P. 237-239. [in Russian]

Rudyk A.N. 2011. Valuation of ecosystem services – a new approach in the management of protected areas in the Crimea / / Reserves of Crimea. Biodiversity and nature conservation in the Black Sea region. Proceedings of the VI International Scientific Conference (Simferopol, 20-22.10.2011). – Simferopol. – P. 120-128. [in Russian]

Rudyk A.N., Prokopov G.A., Yepihin D.V. 2005. Application of GIS in the development of the project for the territory of Yalta Mountain Forest Nature Reserve // Scientific notes of TNU. A series of "Geography". – V. 18. – № 1. – P. 109-114. [in Russian]

Rybka T.S. 2008. Entomocomplexes as indicators of state and diversity of ecosystems of the Southern Coast of Crimea. / Thesis for PhD degree in Biology in the specialty 03.00.16. – Ecology. – Dnepropetrovsk National University, Dnepropetrovsk. – 20 p. [in Ukrainian]

Sanchez-Azofeifa, G. A., M. Quesada, J. P. Rodriguez, J. M. Nassar, K. E. Stoner, A. Castillo, T. Garvin, E. L. Zent, J. C. Calvo-Alvarado, M. E. R. Kalacska, L. Fajardo, J. A. Gamon, and P. Cuevas-Reyes. 2005. Research priorities for neotropical dry forests. Biotropica 37 (4):477-485.

SAP. 2009. Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea 2009. Available at http://documents.blacksea-commission.org:88/Downloads/SAP2009_ver_09Apr09.pdf

Schnitzler, A., Hale, B.W. & Alsum, E. 2005: Biodiversity of Floodplain forests in Europe and eastern North America: A comparative study of the Rhine and Mississipi Valleys. Biodiversity and Conservation 14: 97–117.

Schowengert, R. A. 2007. Remote Sensing: Models And Methods For Image Processing. (3. Baskı). Burlington, MA: Elsevier.

Schuck, A., Parviainen, J. & Bücking, W. 1994: A review of approaches to forestry research on structure, succession and biodiversity of undisturbed and semi-natural forests and woodland in Europe. European Forest Institute Working Paper 3, Joensuu, 64 pp.

Security categories of the Ukrainian fauna. 2005. / I.Yu. Parnikoza, E.V. Godlevskaya, M.S. Shevchenko, D.N. Inozemtseva / Edited by I.V. Zagorodnuk. – K.: Kiev Ecological AND Cultural Center. — 60 p. [in Russian]

Semenchenko VP, Son MO, Novitsky RA, Panov VE. 2013a. Non-native macroinvertebrates and fishes of the Dnieper River Basin. Aquatic Invasions 8 (in press)

Semenchenko VP, Vezhnovetz VV, Lipinskaia TP, Panov VE. 2013b. Assessment of biological contamination of Belarusian part of the Dnieper River basin: results of biological survey in August 2011. Management of Biological Invasions 4 (in press)

Senitsky A. 1898. Birds of Tarkhan-Sunak: Experience of collecting materials for ornithology of the Crimea. – Simferopol: Veresotskaya Publ.Office. – 101 p. [in Russian]

Sevgi, O. 2005. Soil Characteristics of Different Sites In Stranja (Yildiz) Mountain. In: Chipev, N. (ed.): UESCO-BAS-MOEW Bulgarian – Turkish Workshop on Challenges of Establishment and Management of a Trans-Border Biosphere Reserve between Bulgaria and Turkey in Strandzha Mountain, 151 p.

Shcherbak N.N. 1967. About northern border of the distribution range of some reptiles of Ukrainian fauna // Vestnik zoologii, Issue 6. – P. 76-77. [in Russian]

Shcherbak N.N. 1966. Amphibians and reptiles of the Crimea. – Kyiv: Naukova Dumka. – 240 p. [in Russian]

Shcherbak N.N. 1962. On the ecology of the Balkan wall lizard // Issues of herpetology. Volume 6. – P. 176-178. [in Russian]

Shcherbak N.N. 1965. Origin of Crimean herpetofauna // In: Terrestrial vertebrates of Ukraine. – Kyiv: Naukova Dumka. - P.107-121 [in Ukrainian]

Shcherbak N.N. 1964. Reptiles as a model for studying changes of animals in the process of acclimatization // Issues of herpetology. Proceedings of herpetological conference, 12-14 October 1964. – Leningrad: Publ.House of Leningrad State University. – P.78-79 [in Russian]

Shelag-Sososnko Yu. R., Didukh Ya. P. 1980. Yalta Mountain-Forest National Park. – K.: Naukova Dumka. – 184 p. [in Russian]

Şişman, E. E., Özyavuz, M. 2010. Assessment of Ecological Units of Important Nature Conservation Area of Thrace Region. Journal of Coastal Research: Volume 26, Issue 4: pp. 615 – 621.

Sokolov L.V. 2010. Climate in the life of plants and animals. – St.Petersburg: TESSA. – 344 p. [in Russian]

Tarashuk V.I. 1959. Fauna of Ukraine. Volume 7 // Amphibians and reptiles. – Kyiv: Publ.House of AS USSR. – 246 p. [in Ukrainian]

TDA. 2007. Black Sea Transboundary Diagnostic Analysis. Black Sea Commission, 263 pp (available at http://81.8.63.74/Downloads/BS-TDA_may2007.pdf)

Tecimen, H.B. & Kavgacı, A. 2010. Comparison of soil and forest floor properties of floodplain and surrounding forests in Igneada, Turkey. Journal of Environmental Biology 31: 129–134.

Tepley, A.J., Cohen, J.G. & Huberty, L. 2004: Natural community abstract for floodplain forest. Michigan Natural Features Inventory, Lansing MI. 14 pp.

The Danube River Basin Management Plan (2009) ICPDR / International Commission for the Protection of the Danube River (Available at http://www.icpdr.org/participate/danube_river_basin_management_plan)

The third, fourth and fifth national communication of Ukraine on issues of climate changes. 2009. – Kiev. – 366 p. [in Russian]

Tockner, K., & Standford, J.A. 2002: Riverine flood plains: present state and future trends. Environmental Conservation 29: 308–330.

Turner, M.G., Gergel, S. E., Dixon, M.D. & Miller, J.R. 2004: Distribution and abundance of trees in floodplain forests of the Wisconsin River: Environmental influences at different scaled. Journal of Vegetation Science 15: 729–738.

Url-1 http://www.ormansu.gov.tr/osb/AnaSayfa.aspx?sflang=tr, the Ministry of Forestry and Water affairs

Url-2 < http://www.tarim.gov.tr/>, the Ministry of Food, Agriculture and Livestock

Url-3 < http://www.kultur.gov.tr/>, the Ministry of Culture and Tourism

Url-4 http://www.csb.gov.tr/turkce/index.php, the Ministry of Environment and Urban Planning

Vladymyrov V, Kideys AE, Myroshnychenko V, Slipetsky D, Shiganova T, Abolmasova G, Bingel F, Tezcan D, Ak Y, Anninsky B, Bat L, Finenko G, Gorbunov V, Isinibilir M, Kamburska L, Mihneva V, Birinci Ozdemir Z, Romanova Z, Sergeyeva O, Stefanova K, Xalvashi M. 2011. A basin-wide Black Sea *Mnemiopsis leidyi* database. Aquatic Invasions, Volume 6, Issue 1: 115-122

Volokh A.M. 2004. Distribution and numbers of the European mink in Ukraine / / Bulletin of Lviv National University. Biology. – Issue 38. – P. 118-128 [in Ukrainian]

Volokh A.M. Rozhenko N.V. 2009. The European mink (Mustela lutreola L. 1766) / / Red Data Book of Ukraine. Animal World. – Kyiv: Globalconsulting. – 2009. – 540p. [in Ukrainian]

Volokh A.M. Rozhenko N.V. 1994. Red Data Book of Ukraine. Kyiv. "Ukrainian Encyclopedia" [in Ukrainian]

Volokh AM. 2004. Pojavlenije shakala (Canis aureus L., 1758) u beregov Crimea. Vest. Zool. 38 (3): 80 [in Russian]

Walkh B.S. 1911. Materials for ornithology of Ekaterinoslav Province. The list of birds found in the province from 1892 to 1910. / Ornithological Bulletin. – Issue 3-4. – P.240-271. [in Russian]

Walter G. 1982. General geobotany. – M.:Mir. – 264 p. [in Russian]

Wenger, E.L., Zinke, A. & Gutzweiler, K.A. 1990: Present situation of the European floodplain forests. Forest Ecology and Management 33/ 34: 5–12.

Wildi, O. 1989: Analysis of the disintegrating group and gradient structure in Swiss riparian forests. Vegetatio 83: 179–186.

Yena A.V. 2012. Natural flora of the Crimea: monograph. – Simferopol : N.Oreanda. – 232 p. [in Russian]

Yunakov N.N. 2003. Weevils of Entiminae subfamily (Coleoptera, Curculionidae) in Ukraine / Thesis for PHD degree in Biology. – St. Petersburg. – 24 p. [in Russian]

Zakharov V.M. et al. 2000. Health of environment: methods of assessment. – Moscow: Center of ecological politics of Russia. – 68 p. [in Russian]

Zaydiner Yu.I. 1997. Catches of fish and non-fish objects by fishery organizations of the Azov –Black Sea Basin (1990-1995): Statistical collection of articles / Yu. I. Zaydiner, L. V. Popov. – Rostov-on-Don: Publ. House "Molot". – 100 p. [in Russian]

Zhdanova N.P., Zakharov V.M. 2001. Changes in development stability of two species of the lizard of Lacerta genus (L. agilis and L. strigata) depending on temperature of incubation // Issues of herpetology. Proceedings of the 1st session of herpetological society named after A.M.Nikolsky 4-7 December 2000, Pushchino-on-Oka. – Pushchino-Moscow. – P.98-99. [in Russian]

Zhmud M.E. 2000. Waders in the winter period in Ukrainian part of the Danube Delta and in neighbouring areas // Branta: Transactions of the Azov-Black Sea Ornithological Station. – Issue. 3. – P.27-38. [in Russian]

Zhmud M.Y. 1998. Wintering waders of the Ukrainian part of the Danube Delta // H.Hötker, E.Lebedeva, P.S.Tomkovich, J.Gromadska, N.S.Davidson, J.Evans, D.A.Strond & R.B.West (eds). Migration and international conservation of waders. Research and conservation on north Asian, African and European flyways. International Wader Studies 10. – P.375-377.

Zorić K, Simonović P, Đikanović V, Tomović J, Atanacković A, Vasiljević B, Marković V, Nikolić V, Simić V, Cakić P, Paunović M. 2013. Checklist of non-indigenous fish species of the Danube River. Aquatic Invasions 8 (in press)

Annex 1. Revised list of indicator species and communities (AZBOS)

Insects

Species, community	Indicator properties	Quantitative characteristics
Hyles hippophaes Esp. (Sphingidae, Lepidoptera)	Marker species of temperature increase in a cold period of the year and of decrease in soil freezing depth in winter	Presence or absence of species (yes/no), and also multiple increase of imagoes number in summer period. Increase of size of species habitat
Locusta migratoria L. (Acrididae, Orthoptera)	Reliable estimating indicator of significant and steady increase of air temperature and decrease of humidity (draught) in late spring/summer period.	Threshold number of locusta migratoria is 400-500 ind./1 km of a route count, this is also the threshold of economical injuriousness. Further growth of number gives birth to a gregarious form

Fish

Species, community	Indicator properties	Quantitative characteristics
Neogobius melanostomus	Estimating indicator of growth in productivity of bottom communities and improvement of species breeding conditions	Standard Fulton's fattening index is used
		Population size structure: average length of specimens is used
Community of freshwater fish species in the ichthyocoenoses structure	Estimating indicator of freshening of the Azov Sea	Increase of percentage of community in composition of all ichthyocoenoses
Carassius gibelio	Estimating indicator of freshening of the Azov Sea	Increase of occurrence frequency in catches with different catching tools
Lepomis gibbosus	Indicator invasion species of anthropogenic and climate changes	Extension of the species range

Amphibians, reptiles

Species, community	Indicator properties	Quantitative characteristics
Podarcis taurica	Estimating indicator of increase of air temperature and dryness	Increase of percentage of sparsely-spotted and spotless individuals, reduction of body length and relative tail length
Lacerta agilis	Estimating indicator of deviation of egg incubation temperature from optimal (increase or decrease)	Increasing development stability index (DSI). Optimal development conditions in the experiment range 25-27^{0}C (DSI 0.11-0.21)
Lacerta viridis	Ecological indicator, marker species of availability of suitable habitats and mildness of winters	Presence/absence of species. Changes in conditions of egg development can lead to increase of percentage of asymmetric individuals
Natrix natrix	Estimating indicator of increase of incubation temperature	Above 30^{0}C leads to increase of males number in population. Increase of percentage of stripped coloration pattern is possible (form "*persa*")
Natrix tessellata	Ecological indicator, marker species of warming of winter-spring period	Presence/absence in suitable biotopes, increase of the range, increase of percentage of melanists in southern parts of the range
Elaphe sauromates	Estimating indicator of increase of incubation temperature	Above 26^{0}C leads to increase of males percentage in population.
Emys orbicularis	Estimating indicator of increase of incubation temperature	Increase of percentage of individuals with anomalies in development of carapace
Pelophylax ridibundus	Estimating indicator of increase of air temperature and dryness. Climate aridization may lead to reduction of species number.	Increase of temperature above 18-20^{0}C in stagnant or weak-flowing bodies in the period of frogspawn development leads to reduction of the species number

Birds

Indicator species of phenological trends in bird migration

Indicator species	Indicator properties	Quantitative characteristics
Anser albifrons	Indicator of early spring warming in Eastern Europe and Western Siberia	Early arrival and departure in spring to breeding grounds and late arrival in autumn to the Azov-Black Sea Region
Philomachus pugnax	Migratory condition of females (degree of fattening) has a positive trend connected with climate trends on breeding grounds	Changes in growth rate of body mass/day, shift of the last registration of transit flocks in spring to earlier dates
Vanellus vanellus	Indicator of suitability of breeding biotopes in spring	Deviation from the mean arrival date to earlier dates

Wintering bird community – markers of warming of winter temperature within the outer delta of Kiliya Branch of the Danube (ODKBD)

Species, community	Indicator properties	Quantitative characteristics
Pelecanus crispus	Species sensitively reacts to climate warming and absence of ice cover	In warm winters the species started occurring regularly, up to 20 individuals
Phalacrocorax pygmeus	Species reacts to climate warming, absence of ice cover	Almost regularly winters in the Danube Delta. In mild winters it is a usual wintering species, and the number amounts to several hundreds individuals
Nycticorax nycticorax	Species reacts to climate warming, absence of ice cover	In mild winters the species started occurring regularly, up to several dozens of individuals
Egretta garzetta	Wintering of the species in the Danube Delta is expected in the near future.	In warm winters species started occurring sporadically

Species, community	Indicator properties	Quantitative characteristics
Anas crecca	Species reacts to climate warming and absence of ice cover	In mild winters the species started occurring regularly, up to several hundreds of individuals
Anas strepera	Species reacts to climate warming, absence of ice cover	In mild winters the species started occurring regularly, up to several dozens of individuals
Anas penelope	Species reacts to climate warming, absence of ice cover	In mild winters the species started occurring regularly, up to several dozens of individuals
Anas acuta	Species reacts to climate warming, absence of ice cover	In mild winters the species started occurring regularly, up to several dozens of individuals
Anas querquedula	Wintering of the species in the Danube Delta is possible in the near future. It depends on water temperature and absence of ice cover.	In mild winters the species started occurring sporadically
Anas clypeata	Species reacts to climate warming, absence of ice cover	In mild winters the species started occurring regularly, up to 10 individuals
Aythya nyroca	Wintering of the species in the Danube Delta is expected in the near future.	In mild winters the species started occurring sporadically
Larus ichthyaetus	Species reacts to climate warming, absence of ice cover	In mild winters the species started occurring regularly, up to several dozens of individuals
Larus minutus	Wintering of the species in the Danube Delta is expected in the near future.	In mild winters the species started occurring sporadically
Chlidonias hybrida	Species reacts to climate warming, absence of ice cover	In mild winters the species started occurring regularly, up to several hundreds of individuals

Comminity of wintering waders

Species, community	Indicator properties	Quantitative characteristics
Numenius arquata	Marker species of the climate warming in winter period, increase of average monthly air temperatures of December and January* above +1^{0}C.	In case of negative average daily air temperatures during 10 days and longer, with the average temperature during a decade lower than (-5)°C (for limans) and (-10)°C (for deltas and seashore) the species leaves the region
Calidris alpina	Marker species of the climate warming in winter period, increase of average monthly air temperatures of December and January* above +1^{0}C. Indicator of a long-term trend of winter warming	Winters in case of average monthly temperatures of December and January above +1°C. If January temperature exceeds +2°C the species dominates among waders. In case of negative average daily air temperatures from 10 days and longer, with average temperature during decade lower than (-5)°C the species leaves the region.
Pluvialis squatarola	Marker of essential climate warming in winter period	Winters in case of average monthly temperature of December +2°C…+4°C and average monthly temperature in January 0°C. With gradual increase of average monthly temperatures of December there is increase in frequency of winter species registrations for the 10-year period.
Gallinago gallinago	Indicator of increase of average monthly air temperatures of December and January	Winters in case of increase of average monthly temperature of December within 0… +4°C (and precipitation amount in August-November 170…210 mm). With increase of average monthly temperature of January up to +1^{0}C…+4°C the species, as a rule, stays in the region but the number is low

Tringa totanus	Marker species of positive average monthly air temperatures of December and January	Presence/absence of the species in case of average monthly temperature of December and January. With gradual increase of average monthly temperatures of December there is increase in the size of wintering areas in the region
Recurvirostra avosetta	Marker species of a long-term trend of warming of winter temperatures	With positive average monthly temperature of December from 0^0C to +4°C the wintering of the species becomes relatively regular. With gradual increase of average monthly temperatures of December there is increase in the size of wintering areas in the region and a shift in winter distribution areas of the species to the north-east is observed.
Vanellus vanellus	Marker species of a long-term trend of warming of winter temperatures	With general warming of a winter period there is a shift in winter distribution of the species in the region to the north-east
Calidris alba	Marker species of a long-term trend of warming of winter temperatures (in December or in December/January)	There is increase in size of wintering areas in the region and a shift of winter distribution of the species to the north-east. In deltas of large river the number of wintering birds can depend from January temperature

Notes: * hereinafter December and January is viewed conjointly as the same winter period, not calendar year.

Mammals of the Dniester Delta

Species, community	Indicator properties	Quantitative characteristics
Mustella lutreola	Indicator of water content and mosaic of *plavni* biotopes	Growth of occurrence frequency per 10 km of count routes

List of indicator vegetation communities

Species, community	Indicator properties	Quantitative characteristics
Festuca valesiaca+Stipa capillata	TPC is increasing with increase of humidity and air temperature and vise versa	Total projective cover (TPC– in %)
	Can diagnose a distribution pattern of precipitation and temperature. Growth of precipitation amount and temperature in spring and the first half of summer leads to increase in PC of *Festuca valesiaca* and vise versa. Growth of precipitation amount and temperature in the second half of summer leads to increase in PC of *Stipa capillata* and vise versa	Projective cover (PC – in %) of edificator species
	Phytomass is increasing with increase of humidity and air temperature and vise versa	Phytomass, g
Festuca valesiaca	Increase of humidity and air temperature in spring and first half of summer leads to increase in TPC and vise versa	TPC, %
	Growth of humidity and air temperature in spring and first half of summer leads to increase in phytomass and vise versa	Phytomass, g
Festuca valesiaca+Stipa lessengiana	Increase of humidity and air temperature in spring and first half of summer leads to increase in TPC and vise versa	TPC, %
	Increase of humidity and air temperature in spring and first half of summer leads to increase in phytomass and vise versa	Phytomass, g
Stipa ucrainica	Increase of humidity and air temperature in spring and first half of summer leads to increase in TPC and vise versa	TPC, %
	Increase of humidity and air temperature in spring and first half of summer leads to increase in phytomass and vise versa	Phytomass, g

Species, community	Indicator properties	Quantitative characteristics
Elytrigia intermedia (in steppe areas)	Increase of humidity and air temperature in vegetation period leads to increase in TPC and vise versa. Increase of TPC allows to diagnose meadowfication processes of steppe areas.	TPC, %
	Increase of humidity and air temperature in vegetation period leads to increase in phytomass and vise versa. Increase of phytomass allows to diagnose meadowfication processes of steppe areas.	Phytomass, g
	Increase of surface areas of communities allows to diagnose meadowfication processes of steppe areas.	Surface area, ha
Elytrigia intermedia+Stipa capillata	Increase of humidity and air temperature in vegetation period leads to increase in TPC and vise versa.	TPC, %
	Increase of perecipitation amount and temperature in vegetation period leads to increase in PC of *Elytrigia intermedia* and vise versa.	PC, % of edificator species
	Increase of humidity and air temperature in vegetation period leads to increase in phytomass and vise versa. Increase of phytomass allows to diagnose meadowfication processes of steppe areas.	Phytomass, g
	Increase of surface areas of communities allows to diagnose meadowfication processes of steppe areas.	Surface area, ha
Stipa ucrainica+Festuca valesiaca	Increase of humidity and air temperature in spring and first half of summer leads to increase in TPC and vise versa	TPC, %
	Increase of humidity and air temperature in spring and first half of summer leads to increase in phytomass and vise versa	Phytomass, g

Species, community	Indicator properties	Quantitative characteristics
Festuca valesiaca+Agropyron pectinatum	Increase of humidity and air temperature in spring and first half of summer leads to increase in TPC and vise versa	TPC, %
	Increase of humidity and air temperature in spring and first half of summer leads to increase in phytomass and vise versa	Phytomass, g
Agropyron pectinatum+Elytrigia repens	Increase of humidity and air temperature in vegetation period leads to increase in TPC and vise versa.	TPC, %
	Can diagnose a distribution pattern of precipitation and temperature over the vegetation period. Growth of precipitation amount and temperature in spring and first half of summer leads to increase in PC of *Festuca valesiaca* and *Elytrigia repens* and vise versa. Growth of precipitation amount and temperature in the second half of summer leads to increase in PC of *Elytrigia repens* and vise versa	PC , % of edificator species
	Increase of humidity and air temperature in spring and first half of summer leads to increase in phytomass and vise versa	Phytomass, g
Elytrigia repens (meadow biotopes)	Increase of humidity and air temperature in vegetation period leads to increase in TPC and vise versa.	TPC, %
	Increase of humidity and air temperature in vegetation period leads to increase in phytomass and vise versa. Increase of phytomass allows to diagnose meadowfication processes of steppe areas.	Phytomass, g
	Rate of sprouts growing in height after cutting. Increase of humidity and air temperature in the second half of summer leads to increase in growth rate of sprouts and vise versa it slows or stops.	Phytomass, g

Species, community	Indicator properties	Quantitative characteristics
Puccinellia gigantea (meadow biotopes)	Increase of humidity and air temperature in spring and first half of summer leads to increase in TPC and vise versa	TPC, %
	Increase of humidity and air temperature in spring and first half of summer leads to increase in phytomass and vise versa	Phytomass, g
Elytrigia elongata (meadow biotopes)	Increase of humidity and air temperature in vegetation period leads to increase in TPC and vise versa.	TPC, %
	Increase of humidity and air temperature in vegetation period leads to increase in phytomass and vise versa.	Phytomass, g
Phragmites australis	Increase of humidity and air temperature in vegetation period leads to increase in TPC and vise versa.	TPC, %
	Increase of humidity and air temperature in vegetation period leads to increase in phytomass and vise versa.	Phytomass, g
	Increase of humidity and air temperature in vegetation period leads to increase in height of sprouts and vise versa.	Height of sprouts, cm
	Increase of humidity and air temperature in vegetation period leads to increase in diameter of stalk and vise versa.	Diameter of stalk