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## **STATUS AND ROLE OF NATURAL ECOSYSTEMS IN NORTH REGION OF THE REPUBLIC OF MOLDOVA**

### **SUMMARY**

Regional development in Moldova is a necessity assumed by Law no. 438-XVI from 28.12.2006. The regional development model provides the division of the country territory into 6 regions and is based on the country's sustainable economic development. In this regard, the natural areas protected by the state have a special role. Due to their special protection status they ensure the conservation of natural resources in the region.

The work is focused on some aspects of the ecological status of state protected natural areas in the Northern Region. The results were obtained on the basis of a comprehensive study conducted during field expeditions and laboratory research over several years. There are highlighted valuable items specific for protection category, the ecological state of biotic and abiotic components and the human impact on protected natural areas in the region.

As a result of the research it was found that the specific elements for the categories of investigated areas are in satisfactory condition and the transboundary sources are the main sources with negative impact on these studied areas. The investigated natural ecosystems, especially those located in the forestry sector, provide favourable conditions for a rich diversity of plant and animal species, among them rare species protected at the national and international level. Interconnection between biotic and abiotic components of protected areas and surrounding habitats, especially agrocoenoses ensure ecological balance in the region.

**Keywords:** *state protected natural areas, valuable items, human impact*

### **INTRODUCTION**

Sustainable regional development is a priority determined by the alarming state of the environment which, over the last time, threatens the survival of humanity. In this context, the key issue of sustainable development is the reconciliation between two human aspirations: the need to continue economic and social development, and environmental protection and improvement as the only way for the welfare of both the present generation and those to come. This

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concept is placed at the base of Regional Development in Moldova, which is a necessity assumed by Law no. 438-XVI from 28.12.2006. The Model of Regional Development provides the division of the territory into 6 regions and is based on the sustainable development of the country's economy.

At the the basis of the transition to a sustainable development model is the research, that can be achieved in such pilot areas as protected areas. The natural areas have a special status of protection. They ensure the conservation of natural resources and contribute to maintaining the ecological balance in the region.

Those referred above come to argue on the research timeliness and need regarding the ecological status assessment of State Protected Natural Areas (SPNA) in the North Region of Economic Development (NRED) of Moldova. The study is motivated also by the very small share of protected areas (4.65% of the country) and their uneven spread in the country.

### **MATERIALS AND METHODS**

The study includes field researches to assess the status of specific components of the categories of protected areas, the natural ecosystems in the main phonological development phases of efemeroide vegetation, annual and perennial and of animal life (Doniță I., Doniță N., 1975; Begu A. *et al.*, 2005; Munteanu A. *et al.*, 2004), to record rare species and collect samples of plants and animals to determine the systematic affiliation (Negru A., 2007; ГейдеманТ. С., 1975).

The abundance and coverage degree of the substrate by rare species were determined according to Braun-Blanquet (Braun-Blanquet J., 1964). The category of threat to rare species was determined by the classifier IUCN and the protection status at the national, regional and international levels according to the List of Rare Plants from Spontaneous Flora of RM (R), 2012, Red Book of Moldova (MRB), 2015, Romania (RRB), 2005, Ukraine (URB), 2009, European Red List (ERL), 2011, the Annexes of Conventions from Bern (CBern), 1979, Bonn (CBonn), 1979, Washington (CWash.), 1979 and Rio de Janeiro, 1992.

Air quality assessment was carried out on the basis of emissions from local and transboundary pollution sources (Evidentele statistice, 2014). The emissions of pollutants SO<sub>2</sub>, NO<sub>x</sub> from stationary sources were established on the basis of the statistical data and yearbooks of the State Ecological Inspectorate and the Department of Statistics and Sociology, while the emissions of the mobile sources were calculated using the methodology EMEP Corinair (Transboundary Acidifying Air Pollution in Europe..., 1998). The Roentgen fluorescent spectrometry method was used to determine the heavy metal concentration (Методикавыполнения..., 2002).

### **RESULTS AND DISCUSSION**

The object of research is the SPNA in the Northern Region of the Republic of Moldova, which are divided into three physico-geographic regions: The Region of Plateaus and Forest Steppe Plains of North Moldova, The Region

of Steppe Plains and Hills of North Moldova, and The Region of Codrii Plateau. The physical and geographical conditions, including type of substrate, favour various economic activities based on natural resource exploration that ultimately determine the ecological state of the environment.

### Human impact

Human impact comes from local and transboundary pollution sources. Analyzing the results on air pollution in the region, we find that about 25 and, respectively, 40% of the overall pollution in the country rests with  $\text{NO}_x$  and  $\text{SO}_2$  pollution. The data in tab. 1 state that  $\text{SO}_2$  and  $\text{NO}_x$  air pollution in the region comes from transboundary sources and the local impact is predominantly from mobile sources. During the 1990s the major stationary sources were presented in the towns of Balti and Floresti. However, actually, the largest share in pollution is owned by the mobile sources. The local impact of air pollution with  $\text{NO}_x$  is higher than the transboundary one, while that with  $\text{SO}_2$  is, practically, at the same level for each settlement. For the current period, the precipitations with  $\text{SO}_2$  in rural areas of Moldova are in the range from 0.780 to 0.825  $\text{mg}/\text{m}^3$  and with  $\text{NO}_x$  are from 0.619 to 0.885  $\text{mg}/\text{m}^3$ , which is approximately 30 times less than the critical limit (CL) value for forest ecosystems (tab. 1).

Table1. The content of  $\text{NO}_x$  and  $\text{SO}_2$  in the emissions from local and transboundary sources

Settlements	Stationary Sources, t				Mobile Sources, t		Local Sources, $\text{mg}/\text{m}^2$		Transboundary Sources, $\text{mg}/\text{m}^2$	
	1990		2013		2013		2013		2013	
	$\text{SO}_2$	$\text{NO}_x$	$\text{SO}_2$	$\text{NO}_x$	$\text{SO}_2$	$\text{NO}_x$	$\text{SO}_2$	$\text{NO}_x$	$\text{SO}_2$	$\text{NO}_x$
Edinet	3215	132	61	41.3	21	869	331	854	424	291
Falesti	3460	69	60	37.3	20	98	280	234	431	288
Floresti	7460	300	27	5.8	71	288	365	573	386	316
Balti	10406	722	35	54	285	901	6954	48142	424	281
The range for other North Districts	950-3000	88-360	8-108	8-48	16-72	539	234-573	294-402	386-501	277-316
The range for RM in precipitations, $\text{mg}/\text{m}^2$									385-518	267-326
The range for RM in atmospheric air, for $\text{SO}_2$ 0.780-0.825 $\mu\text{g}/\text{m}^3$ , for $\text{NO}_x$ – 0.619 – 0.885 $\mu\text{g}/\text{m}^3$										
CL forest vegetation/lichens for $\text{SO}_2$ $\mu\text{g}/\text{m}^3$ 20/10, for $\text{NO}_x$ 30/30 $\mu\text{g}/\text{m}^3$										

Calculation of the impact from the local sources, according to Ecolog Programme and EMEP (Monitoring and Evaluation European Programme) data, indicates a pollution of 0,005 $\text{mg}/\text{m}^3$  (or 0.1CMA, RM standard) with  $\text{SO}_2$  and

NO<sub>x</sub> in the rural settlements with an insignificant influence to forests ecosystems.

### **The content of heavy metals in soil**

Among noxious pollutants, depending of toxicity and degree of impairment of the ecosystem components, a particular role is played by the heavy metals that are released into the atmosphere with exhaust gases, emissions from industrial enterprises, chemicals used in agriculture etc. In this context it was determined the content of heavy metals in soil samples (0-20 cm) from objects of study.

On the basis of the graduation scale of the level of heavy metals concentration in soils in Moldova (Кирилюк В., 2006) it was found that the content of heavy metals in the top layer of soil from the protected areas located in forests was within five of six levels, being *very low*, *low*, *medium*, *increased* and *high*, excluding the *very high level*. Only in two protected areas - LRs Cosauti and Holosnita– it was recorded that the cobalt content has exceeded the alert threshold (Kloke A., 1980). However, the registered concentrations of heavy metals do not reach values exceeding the threshold for intervention, the more of the pollution one, which do not show danger of toxicity to plants and soil organisms, but does not exclude the possibility of their transmission through the food chain to the higher levels and their accumulation in the animal bodies.

### **State of representative elements**

The research objects are the protected areas placed in the NRED of the Republic of Moldova. Due to the function of SPNA is to preserve and protect the representative and rare components along with environmental factors within their boundaries, we will refer to some aspects of the state of valuable biotic and abiotic elements specific for protection categories.

From the point of view of diversity of protection categories, the fund of SPNA in the NRED are presented by various categories of protected areas such as scientific reserves, nature reserves, landscape reserves, resource reserves, multifunctional management areas, natural monuments, landscape architectural monuments and wetlands of international importance. Their surface constitutes 3.2% of the surface of NRED or about 20% of the surface of the country's protected areas.

The famous geological and paleontological elements of the natural heritage of the northern sector of the country are protected in the geological and paleontological natural monuments (GPNM) which, alternating with agricultural ecosystems, create unrepeatable and quite attractive landscapes (Begu A. et al., 2012). Our research has focused on highlighting the value of these landforms as habitats for certain rare rocky and epiphytic plant species and rare animal species like reptiles, birds of prey and rodent mammals. Thus, true reservoirs of flora and fauna, important due to the value of registered species, are recorded: GPNMs Defile Duruito area, Defile Varatic, Stinca Mare (Great Rock), Gorge Butesti, and Tectonic Fault Line near the Village of Naslavcea.

In all these reserves are present the rocky ferns from the genus *Asplenium*. On the rocks of GPNM Defile Duruitoarea and Gorge Butesti was recorded abundantly the endangered species *Sempervivum ruthenicum*, in GPNM Varatic and Defile Duruito area - the vulnerable species *Schivereckia Podolite* which has international status of protection being protected by the European Red List and Berne Convention. In the GPNMs Gorge Butesti and Stinca Mare is met solitarily the species of lichens *Peltigera polydactyla* endangered in the Republic of Moldova and in GPNMT ectonic Fault Line near the Village of Naslavceais protected the endangered species *Pulsatilla grandis*.

On top of limestone cliffs from the most GPNMs are nesting species of raptors such as: *Falco tinnunculus*, *Buteo lagopus* and *Accipiter gentilis* while on forested areas we meet *Dendro coposmedius*, *Turdus philomelos*, *Parus major*, *Carduelis spinus*, *Corvus corax* and others. Among the fauna species are reported the vulnerable species *Oryctes nasicornis* and *Papilio machaon* as well as abundant species common for the Republic of Moldova, but protected by the Bern Convention, such as: *Lacerta viridis*, *L. muralis*, *Helix pomatia*.

Exploitation of deposits of limestone and gypsum and burning tyres at lime illegal obtaining in GPNMs Defile Fetesti and Trinca, and Mine Criva lead to intense environmental pollution and, respectively, to a considerable decrease of species diversity, including there are ones.

The most favorable conditions for the preservation of biotic and abiotic components of the environment are provided by protected areas located in the forest fund. Thus, the botanical natural monuments (BNMs) comprise precious sectors with forest vegetation and trees. They aim to conserve the unique or typical habitats of endemic and relicts plant species, their communities, as well as some rare or endangered species of plants and secular trees.

The evaluation of the four BNM from NRED allows us to state their importance in conserving the forestry sectors with *Quercus robur* in Caracuseni, *Quercus pubescens* in Calinestii Mici, *Quercus pertaea* in Rudi-Gavan and the artificial spruce stand of *Piceaabies* with a high productivity in Lipnic. In the mentioned sectors are protected copies of secular trees and rare grassy plant species with national, regional and international protection status (Fig. 1). Among the valuable species we mention the endangered species of lichens *Cetrelia cetraroides* and the bird species *Dryocopus martius* and *Picus viridis* in the BNMs noticed in BNM Caracuseni and Lipnic, respectively.

The BNM Rudi Gavan is the richest in rare species. There were recorded 14 species of plants included in the Moldova's Red Book among which the most common are *Galanthus nivalis*, *Hepatica nobilis*, *Pulsatilla grandis*, *Scopolia carniolica*, *Poa versicolor*, *Polystic humaculeatum*, and pteridofite species on rocks: *Dryopterisfilix-mas*, *Athyrium filix-femina*, *Phyllitis scolopendrium*. Here were reported rare animal species among which *Lutra lutra*, *Mustela erminea*, *Felis silvestris*, *Hyla arborea*, *Rana temporaria* are found in Moldova's Red Book.

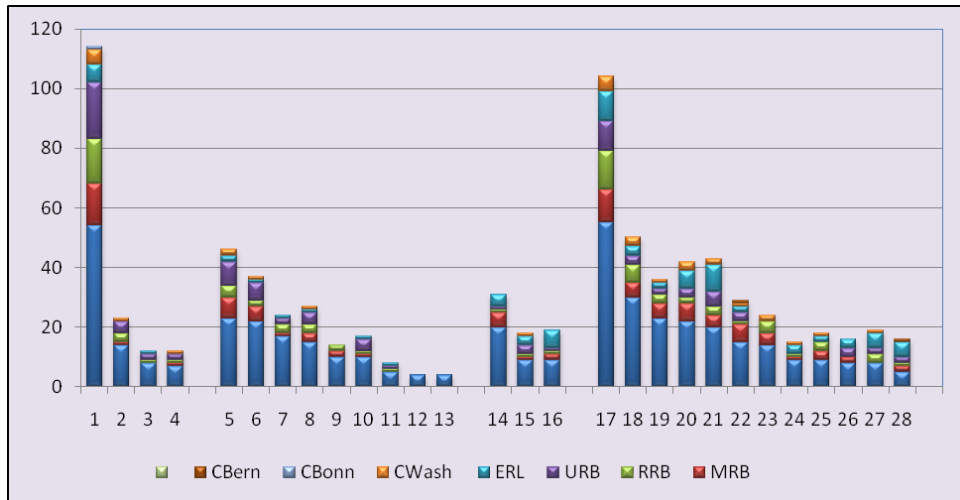


Figure 1. The numbers and the protection status of rare species of plants

The category of protected areas called Natural Reserves (NR) is the natural space, scientifically valuable for preserving or restoring one or more components for maintaining the ecological balance of nature. In the research area are located 12 NR, of which 9 belong to natural forest reserves (FNR) and 3 to natural reserves of medicinal plants (NRMP).

The specific objective of FNR is the protection of fundamental natural stands and rare species of plants and animals. In the most FNR from NRED, regarding tree species, natural stands of oak with durmast and cherry are protected. In the FNR Rososeni, the oak and birch are the basic species; in the FNR Mestecanis the species of birch (*Betula pendula*) is protected. This area shows the South-Western edge of birch growth in the Eastern Europe. On the basis of state assessment of the FNR Mestecanis were registered only a few copies of birch trees which according to their health state can be attributed to the category of healthy trees. Many copies have broken tops, affected branches and stem (about 20%) with frequent hollows. A perspective in preserving the value of this reservation is the conservation of about 80 copies of birch saplings located on the bank of the steep ravine along the border with Ukraine.

The presence of valuable species of plants and animals in the framework of a protected habitat is also beneficial to establish mutual sustainable relations and create conditions for ecological balance. From this point of view, the greatest number of rare species is recorded in FNRs Rososeni and Saptébani (23 and 22, respectively). In both of them are protected the following species listed in MRB: *Fritillaria montana*, *Dryopteris filix-mas* and *Climacium dendroides*. The critically endangered species *Gladiolus imbricatus* were signalled in the FNR Rososeni and the species *Pulsatilla grandis*, *Coronella austriaca*, *Oryctes nasicorni*, *Morimus funereus* were signalled in the FNR Saptébani.

Another category of state protected areas are organized to preserve and reproduce the rare species of medicinal plants. The specific floristic elements of

NRMP in the NRED are represented by the species of medicinal plants that form a compact carpet with a luxurious development on some plots. For example, in NRMP Radoaia were attested some plots of *Convallaria majalis*, with coverage of 50-70% and *Fritillaria montana*, with coverage of 25-30%. Here were also reported other rare plant species such as *Lilium martagon* and *Veratrum nigrum* and animals such as *Meles meles*, *Capreolus capreolus* and *Lucanu scervus* with different protection status.

In the herb layer of the NRMP Rososeni were recorded the following rare species: *Dryopteris filix-mas*, *Scopolia carniolica*, *Doronicum hungaricum* and *Allium ursinum*, and in that of NRMP Cernoleuca the dominant species of medicinal plants are *Arctium lappa*, *Leonurus cardiac* and *Urtica dioica* reaching 1.0-1.5 m height. Here are also recorded some rare species of plants like *Asparagus officinalis* and *Rhamnus tinctoria* and animals like *Martes martes*, *Felis silvestris*, *Hyla arborea* and *Coronella austriaca* which enrich the value of protected area (Fig. 2).

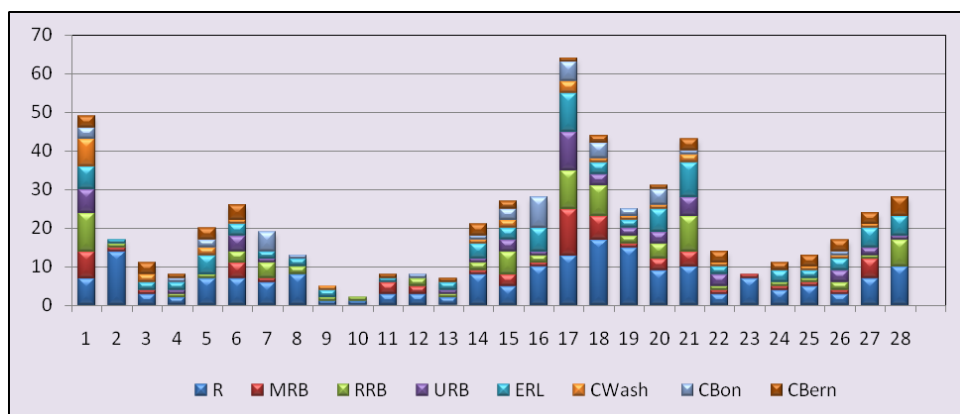


Figure 2. Number and protection status of rare species of animals

Legend to Figures 1 and 2: 1 - BNM Rudi-Gavan, 2 - BNM Lipnic, 3 – BNM Caracuseni, 4 - BNM CalinestiiMici, 5 – FNR Rososeni, 6 – FNR Saptebani, 7 – FNR Baxani, 8 – FNR Climauti, 9 - FNR Ocnita, 10 - FNR Stinca, 11 – FNR Pociumbeni, 12 – FNR Mestecanis, 13 - FNR Lucaceni, 14 – NRMP Rososeni, 15 – NRMP Cernoleuca, 16 – NRMP Radoaia, 17 - LR Rudi-Arionesti, 18 – LR Cosauti, 19 - LR La 33 de Vaduri, 20 - LR Holosnita, 21 – LR Tetcani, 22 – LR Fetesti, 23 – LR Calarasovca, 24 - LR Zabriceni, 25 - LR Izvoare-Risipeni, 26 - LR La Castel, 27 – LR Suta de Movile, 28 - LR Lopatnic.

Approximately 21% of the natural areas in the region belong to landscape reserves (LR) that according to the Law of SPNAF, 1998 presents a natural homogeneous system of forest, steppe and meadow, swamp and marsh, with scientific value, ecological, recreational, aesthetics, instructive and educational value, intended to maintain its natural qualities and carry out regulated economic activities.

The landscape elements of this type of protected areas are complemented by their rich diversity of flora and fauna. The analysis of quantitative presence of rare species in the 12 LR in the research area allows us to state that the richest and most diverse is the flora and fauna in the LRs Rudi Arionesti, Cosauti, La 33 de Vaduri, Holosnita and Fetesti. They also feature a varied relief, which creates favourable conditions for different types of vegetation. In the mentioned areas were recorded the greatest number of rare species of plants with protection status at the national, regional and European level, proved by their presence on the List of Rare Species and in MRB, RRB, URB, ERL and Annexes of Environmental Conventions.

However, the quantitative criterion does not always reflect the value of the protected object for the conservation of one or another species. For example, it is incontestable the value of LRs Lopatnic and Fetesti as favorable habitats for the species *Sempervivum ruthenicum* and *Schivereckia podolica*, LRs Izvoare-Risipeni and Holosnita for *Scopolia carniolica*, LRs Calaraseuca and La 33 de Vaduri for the most extensive areas of the species *Galanthus nivalis* and *Hepatica nobilis* and LRs Rudi-Arionesti for *Polystichum aculeatum*, *Melittis sarmatica* and *Alnus glutinosa*. The most of those reserves are favorable habitats for many species of animals such as *Felis silvestris*, *Martes martes*, *Capreolus capreolus*, *Meles meles*, *Upupa epops*, *Buteo buteo*, *Coronella austriaca*, *Lacerta viridis*, *Rana dalmatina* and *Lucanus cervus*.

The function of regulated management of natural resources goes to the multifunctional management areas (MMA), which care also of nature conservation. During the investigation period there were evaluated 10 representative sectors with meadow vegetation. The investigated areas are characterized by a biodiversity specific to meadow ecosystems with higo- and mesophyte species, aquatic and marsh systems with hygro- and hydrophilic species and steppe ecosystems with xerophyte species. Among them, the most rich in vegetation are MMA Meadow with Stoloniferous Grass, the River Raut, where were frequently encountered 35 species of herbaceous plants and MMAReedy Marshy Meadow with about 25 species. Both are dominated by grasses and cyperaceae.

An important role is played by the windbreaks nearby the city of Balti, which were created according to the planting method of nests arranged in square. *Quercus robur* is the main species and *Fraxinus lanceolata*, *Robinia pseudacacia*, *Cerasus avium*, *Acer tataricum*, *Acer pseudoplatanus*, *Acer tataricum*, *Gleditsia triacanthos*, *Armeniaca vulgaris* and others are the accompanying ones. Among shrubs prevail the species *Swida anguinea*, *Rhamnus cathartica*, *Prunus spinosa*, *Rosa canina*, *Humulus lupulus*, *Cerasus mahaleb*, *Crataegus monogyna*, *Ligustrum vulgare*, *Lonicera xylosteum* and *Sambucus nigra*. In their canopy are sheltering the birds species *Carduelis carduelis* – ERL, CBern; *Carduelis cannabina* – ERL, CBern; *Coccothraustes cocco-thraustes* – ERL, CBern; and *Passer domesticus* – ERL, CBern. Windbreaks help to maintain the ecological balance, protect from drought and



improve microclimate in field crops, i.e. it is of great importance their proper management.

## CONCLUSIONS

Along with the specific elements of protection categories, the protected areas, particularly those located in forests, provide favorable conditions for a rich diversity of plant and animal species, among them rare species protected nationally and internationally. In investigated areas 36 rare plant species and 26 rare animal species were registered.

The analysis of the system of protected areas, by establishing the compliance criteria for integration, extension and space distribution, emphasizes the fact that protected areas are spatially isolated and require the establishment of connection corridors with the national and international surrounding ecosystems, which also would contribute to the conservation of biological diversity in the region.

The interconnection between biotic and abiotic components of protected areas and surrounding habitats, agrocoenoses in particular, ensure the ecological balance in the region.

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