The risk of disappearance of amphibians and reptiles in the Lower Prut Area in the context of climate change

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ABSTRACT: Amphibians and reptiles are among the most endangered organisms worldwide - respectively about 35% and 20% (IUCN, 2022). Their vulnerability is related to the insufficiency of ecologically optimal habitats (climatic, physico-chemical, biocenotic) for development and reproduction. The 9 species of amphibians and 7 reptiles from in the Lower Prut Area, present important ecological links in the ecosystems specific to the given area, and 5 and 3 species, respectively, are included in the Red Book of the Republic of Moldova (2015). Thus, *Pelobates fuscus* is Critically Endangered (CR), and pollution, and especially the drying up of lakes, would lead to the extinction of the species. The vulnerable species (VU) of *Triturus cristatus* and *Lissotriton vulgaris* will be quite affected, both by desiccation and by the lack of oxygen during the summer period. The species *Bombina bombina, Hyla orientalis, Pelophylax ridibundus,Pelophylax lessonae* and *Bufo viridis* have a wider ecological valence, which makes them less threatened by climate change, but remain linked to waters for reproduction. Reptiles prefer shady, moist, swampy, aquatic habitats, etc., but they also need sufficiently sunny places. The 3 endangered species (EN), such as *Emys orbicularis*, although it is omnivorous, is very rarely encountered (RR); the species of *Podarcis taurica, Coluber caspius, Lacerta agilis, Lacerta viridis* have a wider ecological valence and show a weak vulnerability to climate change, and the dependence on food resources of the *Natrix natrix* and *Natrix tessellate* makes them more vulnerable to the drying up of water bodies. In order to reduce the negative effects of climate change on vulnerable amphibians and reptiles, scientifically substantiated interventions are needed to rebuild habitats, to form ecological corridors connecting certain fragmented isoecohabitats, to expand the areas occupied by threatened species in various sectors, both with optimal conditions, as well as at the limit of extremes.

KEY WORDS**:** amphibians, reptiles, Lower Prut, climate change.

1. Introduction

The organic world of the Earth counts about 2 million species, represented by bacteria (*Mychota/Bacteria*), protists (*Protista*), fungi (*Mycetalia/Fungi*), plants (*Plantae*) and animals

(*Animalia*). The distribution of these organisms within the limits of the Biosphere was and is conditioned by the geological history of the planet, the evolution of organisms and their ability to adapt to certain living conditions (Begu et al., 2012).

The climate changes of different geological periods were fatal for some organisms, but others survived, adapting to the new conditions or found refuge in restricted sectors, with specific living conditions, such as aquatic, marshy, terrestrial, etc.

Biodiversity assessment threatened with extinction. In the second half of the century XX, the global community began to be more and more aware that the loss of biodiversity must be stopped. In 2002, the Johannesburg World Summit on Sustainable Development reaffirmed the commitment of the parties to the Convention on Biological Diversity (CBD) (Rio de Janeiro, 1992) to undertake common and well-targeted actions to reduce the rate of loss of biodiversity (Vie et al., 2009). A key tool for achieving this goal is provided by the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN). The latest IUCN Red Lists from 2000-2017 provide objective information on the nature and type of threats to an unprecedented number of species. Thus, among the 91522 species evaluated, 25821 species (28.2%) are threatened: vulnerable - VU, endangered - EN and critically endangered - CR. This assessment presents an analysis at the level of geographic distribution, ecological and geopolitical perspectives, examines the nature and impact of threats and outlines current and potential conservation measures.

In this study, the distribution of threatened species in the Lower Prut Biosphere Reserve is represented in the following three geographical units: habitats, ecological systems, biomes.

Habitats. Forests are the most important habitats for amphibians - 5708 species. The largest number of endangered species of amphibians is recorded here. For amphibians, wet habitats are particularly important, especially for those species, which are in the larval stage. Recently, the tendency of amphibians to use artificial habitats was mentioned.

Ecological systems (ecosystems). The simplest assessment of the distribution of threatened species is to divide the surface of the planet into three ecological systems: terrestrial, freshwater and marine. On Earth 1.388 species are listed as threatened for freshwater ecosystems. In our study we will analyze aquatic, marsh, meadow and forest ecosystems.

Biomes. Evaluating the distribution of threatened species on a finer scale is possible through biomes. Biomes represent global-scale variations in the structure, dynamics and complexity of terrestrial communities, which are conditioned by key global patterns such as temperature and precipitation. As a result of a classification in the interest of standardization, Olson et al. (2001) identified 14 types of biomes worldwide. In our study we will operate with the deciduous forest biome type.

The primary task that must be solved by the international organizations, empowered with the rights and capacities of nature conservation, is to carry out a complex (ecosystemic) study, in order to evaluate the current state of organisms threatened with extinction. The results of such a study will create premises for the scientific argumentation of the sustainable implementation of integrated ecological monitoring, the reconstruction of degraded habitats, the creation of new National Parks, Nature Reserves, etc., including protected areas for habitats and species where water is an important factor.

The aim of the research is to analyze the vulnerability of valuable species in the RBPJ to climate change and to predict scenarios for reducing the negative impact on them.

Objectives:

- compilation of the register of valuable species threatened with extinction;
- assessment of the degree of vulnerability of species according to IUCN criteria and other national and international documents;
- highlighting valuable habitats for threatened species.

2. Study area

Within the Lower Prut Area are included: the Lower Prut Biosphere Reserve (LPBR), the Scientific Reserve "Prutul de Jos" (SRLP), the Ramsar Zone the Lower Prut Lakes (RZLPL), which are part of the Emerald Network and the sector that Lake Manta with the adjacent territories (Figure 1). Ramsar zone No. 1029 "Lakes of the Lower Prut" was the first Ramsar zone designated in Moldova on 20.06.2000. The zone is located in the southwestern part of the Republic of Moldova, between the city Cahul and Giurgiulesti village in the lower part of the Prut river meadow, which serves as the western border of the area and at the same time represents the state border between the Republic of Moldova and Romania.

Figure 1 RBPJ zoning and general image of the studied area.

3. Methods

In the study, the classic research methods were used: ***direct in the field*** - by traversing transects on land, marshy areas and aquariums (by boat) with direct counting of specimens on test surfaces from the itinerary locations established on the occasion of the first field trips.

In addition to the numerical estimation of the amphibians and reptiles, the description of the ecological conditions, the state of the biotopes, data on the hydro-climatic regime were also fixed; ***indirect methods*** were applied: after some signs or indicators species; under the ***laboratory conditions***, the collected material was analyzed and based on a ***mathematical analysis*** of the recorded results, conclusions and recommendations were elaborated.

4. Results and discussion

Based on the official information, obtained from statistical reports, scientific publications, official documents, etc., it was found that the total surface of the protected area (originally the "Lower

Prut" Scientific Reserve) underwent partial changes, from 1691 ha, in the year of its foundation in 1991, up to 1755 ha, in 2013 (Figure 2) and 14771 ha, in 2015, with the foundation of the creation of the LPBR. That area was subjected to more pronounced fluctuations regarding the surface covered by water, which increases suddenly, from 446 ha in 1991, to 1255 ha in 1993, with a return from 1994 to 2001 to 650-628 ha, and from 2011, up to approx. 800 ha, with a decrease in 2016 to approx. 650 ha. Some variables of the surface of Lake Beleu can be explained by the fact that: in 1990 the lake was completely dry, and in 1991 there were long floods, which, on the one hand, increased the surface, but, on the other hand, the water level, demonstrated by the depth of 3-4m almost over the entire lake area. The feedback of these long floods was manifested by the expansion, in particular, of the areas of pasture and forests, but also the increase of the number of species of birds and plants, and to a lesser extent, of mammals and fish. So, we can assume that the maintenance of a water area of approx. 700-900 ha, ensures an ecological optimum from a hydrological and biocenotic point of view for species vulnerable to the ecological factor humidity.

The scientific information on biodiversity reflects in more detail the representatives of many systematic groups of flora and fauna in Lower Prut SR and, unfortunately, less is known about the biological diversity of forests, lakes (including Manta), steppe sectors, etc. from the perimeter of LPBR.

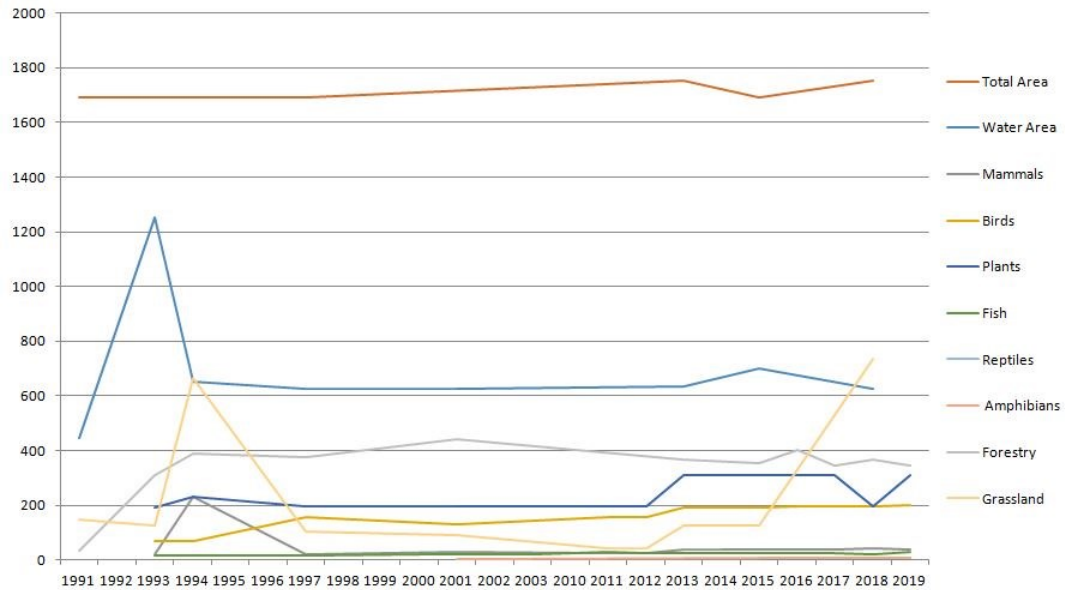

Figure 2 Modification of the area of habitats and the number of species in LPSR and LPBR.

Amphibians and reptiles are among the most endangered organisms worldwide, a fact that leads IUCN to include, as a priority, in the monitoring study all species known at the current stage. Among vertebrates, mammals and birds are fully evaluated, and amphibians – 99%. The share of threatened species is quite high in the case of amphibians – 35%, reptiles – 20% and of the number of assessed species (IUCN, 2022).

In LPBR, 9 species of amphibians were identified (Paladi et al. 2018), which constitutes 69% of the number of species in the republic (Table 1). Amphibians have favorable conditions for nutrition and reproduction in the entire territory of LPSR, but less favorable in the rest of the territory, included in LPBR. Among the 9 species – 5 are included in the Red Book of the Republic of Moldova (2015), and the crested newt species (*Triturus dobrogicus*) may inhabit the waters of Lake Beleu

and its tributaries (Postolache et al., 2012). The brown bullfrog (*Pelobates fuscus*) is Critically Endangered (CR), it inhabits forests in river meadows and areas bordering water bodies. Pollution, but especially the drying up of lakes and ponds in the LPBR, would lead to the extinction of the species, which is already very rare in the reserve.

Table 1 List of valuable and common amphibian species and their threats from the effects of climate change**.**

No.	Species	Protection category	Habitat	Abundance in LPBR/RM	Type of threat
1	Red-bellied toad (*Bombina bombina*)	VU; DHab.; CBr(III).	Meadow, forests, steppes, hills C/RM: 3-5 ind./m^2	C/RM: 3-5 ind./m^2	Lake drying, pollution
2	Astern tree frog (*Hyla orientalis*)	VU; DHab.; CBr (II).	Arboricolous; Forests, grassy thickets; Parks, orchards, meadows, swamps, deep waters	C/south of the country - of only 1219 ex./ha.	Lake drying, pollution, lack of deeper and richly vegetated ponds for spawning
3	Crested newt (*Triturus cristatus*)	VU; CBr (III).	Meadow, swamp. Standing waters with rich vegetation	C/in the south of the country - only 0.6-1.3 ex./ha. The number is reduced	Lakes drying up, pollution
4	Common newt (*Lissotriton vulgaris*)	VU; CBr (III).	Meadow, swamp. Standing waters with rich vegetation	C/ in the south of the country - only 0.6-1.3 ex./ha. The number is reduced	Lakes drying up, pollution
5	Danube crested newt (*Triturus dobrogicus*)	NT; CBr (II); DHab(II;IV);	Meadows, canals, ponds, lowland forests;	R/ small parts of southern Moldova to Odessa region	Destruction and pollution of habitats
6	Large pond frog (*Pelophylax ridibundus*)	C	Small and large rivers, lakes, streams, ponds, lakes, canals	C/	Destruction and pollution of habitats
7	Small pond frog (*Pelophylax lessonae*)	C	Water pools, streams, brooks in forests	C/	Destruction and pollution of habitats
8	Green toad (*Bufo viridis*)	C	Fields, orchards, vineyards, parks, forest curtains, etc.	C/	The drying up of lakes, pollution, vandalism by children
9	Common spadefoot (*Pelobates fuscus*)	CR; DHab.; CBr (II)	Forests in river meadows; sectors adjacent to water basins	RR/ The number of the species is reduced	Drying up of lakes, pollution

***Legend**: RM – Republic of Moldova; species included in Red Book of the Republic of Moldova (2015): VU - vulnerable, EN - endangered, CR - critically endangered, NT - not threatened; DHab.- Habitats Directive; CBr(II) – Berne Convention; Frequency of the species: C – common, R – rare, RR – very rare.*

Vulnerable newt species (VU) crested newt (*Triturus cristatus*) and common newt (*Lissotriton vulgaris*) will be quite affected, both by desiccation and by the lack of oxygen in aquatic pools rich in vegetation during the summer period. The red-bellied pond vole (*Bombina bombina*) has a wider ecological value and, in case of drying up of the basin, it can move to another basin, up to 1 km. The hydrangea (*Hyla orientalis*) is an arboreal species ubiquitous in forests, grassy thickets, parks, orchards, meadows, marshes, etc., so it is eurytopic, which makes it less threatened by climate change. However, it requires deeper ponds with rich vegetation for reproduction.

The large pond frog (*Pelophylax ridibundus*) inhabits small and large rivers, lakes, streams, puddles, ponds, canals, etc., and the small pond frog (*Pelophylax lessonae*) - water pools, streams, brooks in forests, etc., so, at like, they are eurytopic species, but remaining related to waters. The green toad (*Bufo viridis*) is one of the most present in various habitats, including urban and rural, its threat coming from the drying up of lakes, environmental pollution, vandalism by children, sometimes also by adults.

Vulnerability of reptiles to climate change. The diversity of reptiles in LPBR constitutes 7 species or 50% of the total number in the republic, and three of them are included in the Red Book of the Republic of Moldova (2015) (Table 2). Even if the preferred habitats are shaded, moist, marshy, aquatic, etc. (since many species swim and dive), being poichilotherm organisms, they need sufficiently sunny places. Unlike amphibians, reptiles reproduce on land, and their impermeable skin does not allow water to evaporate (Cozari et al., 2003). These particularities allow reptiles to have a wider ecological value, their habitats and ranges being more diverse and extensive. Thus, the reptiles' vulnerability to climate change will be reduced and they will manage to survive in greater proportion than amphibians.

All 3 species from the Red Book are assigned to the Endangered Species Category (EN): pond turtle (*Emys orbicularis*) is the only turtle species from Moldova, it inhabits smooth flowing waters, lakes, ponds, canals, it is omnivorous and it is quite resistant to lack of food or certain injuries. However, in LPBR it is very frequent found (RR), probably due to the lack of more special conditions regarding reproduction or water quality; Balkanwall lizard (*Podarcis taurica*), considered endemic to the Balkan region, is a eurytopic species, in particular, prefers dry habitats, so the climate aridification scenario will not affect it, but on the contrary, it will allow it to expand its range towards north; Caspian whipsnake (*Coluber caspius*), prefers steppe habitats and riparian slopes, is very rare in the reserve (RR), probably due to the anthropogenic factor, even if the tolerance to climate change is high.

Table 2 List of rare and common reptile species and their threats from the climate change.

No.	Species	Protection category	Habitat	Ecological niche	Abundance in LPBR / RM	Type of threat
1	Pond turtle (*Emys orbicularis*)	EN; CBr(III); DHab. (IV); RL UICN	Smooth flowing waters, lakes, ponds, canals	It feeds on invertebrates, fish, amphibians and vegetation	R/ the relative density is up to 15 ex./ha	Drainage of ponds, damming of rivers, cementing of canals, destruction of laid nests/ Lasts long without food or injured

2	Balkan lizard (*Podarcis taurica*)	EN; CBr(II); DHab. (II,IV); IUCN-LC	Steppe, dunes, stony places, agricultural fields	It feeds on various insects and spiders	C/ In the RM, it can reach up to 300 ex./ha	Excessive grazing, pesticide pollution, celery plowing. Endemic to the Balkans
3	Sand (*Lacerta agilis*)	RLE./C	Fields, banks meadows, forest strips,	Different invertebrates	C/	Degradation and pollution of habitats
4	Green lizard (*Lacerta vir idis*)	C	Open grounds with grasses, shrubs, glades, fields	Different invertebrates	C/	It is not threatened. Degradation and pollution of habitats
5	Grass snake (*Natrix natrix*)	C	Around rivers, ponds, lakes, meadows, streams. Orchards, basements of houses, piles of garbage	It lurks on willow trunks, in dry, matted reeds where it hunts frogs	C/	The degradation and pollution of habitats, the vandalism of man who confuses him with the viper
6	Dice snake (*Natrix tessellata*)	C	Smooth waters, lakes, streams with clean stony bottoms and vegetated banks	They prefer fish and amphibians	C/	The sanitation of water bodies, the vandalism of man who confuses him with poisonous snakes
7	Caspian whipsnake (*Coluber caspius*)	EN; DHab (II;IV); CBr(II)	Riparian slopes, steppe	Rodents	RR/ in the RM until 5-7 ex./ha	Habitat degradation and pollution, human vandalism due to aggressiveness and large size (2.5m)

***Legend**: RM – Republic of Moldova; species included in: Red Book of the Republic of Moldova (2015): VU - vulnerable, EN - endangered, CR - critically endangered, LC - low risk; LR IUCN – Red List of the International Union for Conservation of Nature; RLE – Red List of Europe; DHab. - Habitats Directive; CBr(II) – Berne Convention; Frequency of the species: C – common, R – rare, RR – very rare.*

The common species (C) of the sand lizard (*Lacerta agilis*) and the green lizard (*Lacerta viridis*) inhabit areas adjacent to water bodies, with plains, meadows, forest strips, hedgerows, sunny grasslands and shrubs and show low vulnerability to climate changes. The grass snake (*Natrix natrix*) is a eurytopic species, which hunts amphibians, in particular, the marsh frog, and makes it more dependent on these resources, and the dice snake (*Natrix tessellata*) inhabits only smooth flowing waters, lakes, ponds, streams with stony and clean bottoms and banks with vegetation (so it is stenotopic) and it consume, predominantly, fish, which makes it more vulnerable to the drying up of water bodies.

5. Conclusion

1. Most of the identified species inhabit extensive sectors of the Lower Prut basin, which includes both the Lower Prut Biosphere Reserve and other categories of protected areas such as State Protected Natural Areas, the Ramsar Site or the Emerald Network.
2. For valuable species, the most important, but also vulnerable, were aquatic and marshy, meadow and forest ecosystems.
3. Ecological corridors are important elements of the national and international ecological network. For all the groups of organisms described, they can have the role of both habitat, refuge, displacement - for threatened species, and barrier - for other wild species.
4. Among animals, the most vulnerable to climate change are bird species, followed by amphibians and reptiles, then mammals, fish and invertebrates, assigned to the IUCN threat categories - Vulnerable, Endangered, Critically Endangered, Low Risk and other lists, annexes of Conventions or Directives.
5. In order to reduce the negative effects of climate change on vulnerable amphibians and reptiles, scientifically substantiated interventions are needed to reconstruct habitats, to form ecological corridors connecting certain fragmented izoecohabitats, to expand the areas occupied by threatened species in various sectors of LPBR with optimal conditions and at the limit of extremes.
6. Road, railway infrastructure or agrocenoses, localities, recreation areas, etc. they are often obstacles in the movement of terrestrial species to vital resources (water, food, reproduction, wintering, summering, etc.), disrupting their life cycle. In these cases, for threatened wildlife, it is indispensable to create ecological corridors (crossing points, bridges, ecoducts, ecotunnels) over these obstacles.
7. The richness of the specific diversity and quantity of natural biological resources in the RBPJ requires in-depth multilateral/systemic studies for all groups of organisms, including, bacteria, fungi, lichens, algae, mosses, invertebrates, etc., to ensure the functionality of the ecosystems under optimal conditions, to reduce the risk of vulnerability to climate change and to enable the rational, scientifically proven use of biological resources by the local population.

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