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**DAAD East West
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FIELDS OF CONFLICT – A DISCOURSE ON SOCIO-ECOLOGICAL FOREST RESTORATION IN TIMES OF WAR AND MULTIPLE CRISES

**Assessment of biodiversity as a basis for developing approaches to effective management of
forest ecosystems in times of war and multiple crises**

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CHAPTER 1

BIODIVERSITY OF PLANT GROUPS NPP "SYNOHORA"

1.1. General characteristics of NPP "Synohora"

Synohora National Nature Park, with an area of 10,866 hectares, is located in the central and highest part of the Gorgany mountain range of the Ukrainian Carpathians. The territory of the Park is the only solid massif of the upper reaches of the Bystrytsia Solotvynska river basin. It is located within the altitudes from 660 to 1837 m above sea level. Within the NPP "Synohora" there are the highest peaks of Gorgany: Syvulya Velyka (1837 m), Syvulya Mala (1808 m), Igrovets (1804 m), Vysoka (1803 m). The territory of the Park is poorly explored.

On the territory of NPP "Synohora" the highlands of the Ukrainian Carpathians are represented by three vegetation belts: high-mountain fir and mountain pine forests; subalpine meadows with the participation of green alder and alpine wastelands.

According to the 2023 forest management data, 28 forest types have been identified in the park. The total area of the highlands in the park is 3224 hectares, that is, almost a third of the entire territory. Two types of forest dominate in the highlands of the park: humid cedar-silver fir subregion – 745.8 hectares (23%); wet net fir subregion – 686.7 hectares (21%).

1.2. Determination of biodiversity of forest biomes in NPP "Synohora"

The main goal of this study stage is to demonstrate the possible options for assessing the biodiversity of a forest ecosystem group and its biome, the composition of which is practically constant. The studies are based on data obtained from the Chronicle of Nature of the Synohora National Park (2023). According to the research results in 2023 on the territory of the Synohora NPP, the most common natural habitat of the park is the Carpathian fir-beech-spruce forests and the Carpathian fir-spruce forests. Data on the composition of biomes formed by the main tree species and their level of encounters were also used. The data were processed according to the indicators provided by forestries: Syvulske, Mezhyritske, and Duplianske, which operate on the territory of the Synohora NPP (Fig. 1.1., Table 1.1).

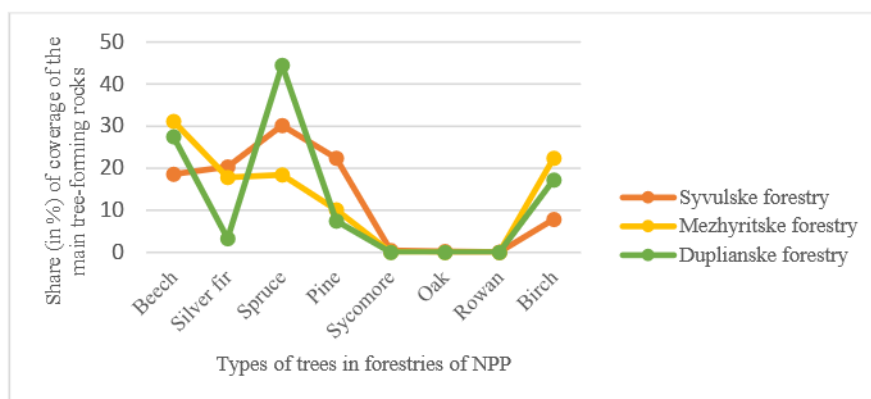


Figure 1.1. – Synohora NPP forest biomes

Formula (1.1) was used for calculations.

$$H' = - \sum_i p(i) \cdot \log p(i), \quad (1.1)$$

where p is the probability of each species of the plant grouping of the biome, and i is the index of this species.

It is considered that at the time of sampling 102, the Shannon index does not exceed the value of 3.5, provided that the entropy is zero, that is, the area is fully surveyed.

Calculations were carried out for species of forest groups (biomes) of the Park's forestries. The total index of each forestry enterprise was determined as the sum of the biome indices specific to a given territory. Thus, the average value of the Shannon index was determined for each forestry enterprise.

Table 1.1 – Share of coverage of the main tree-forming rocks in the territory
NPP "Synohora" in forestry

	Syvulske forestry, %	Mezhyritske forestry, %	Duplyanske forestry, %
Beech	18.5442	31.1465	27.4677
Silver fir	20.3473	17.8197	3.2444
Spruce	30.1561	18.3968	44.4463
Pine	22.3385	10.1484	7.4236
Sycamore	0.4686	0.0978	0.0249
Oak	0.2265	0.0054	0.0000
Rowan	0.0538	0.0000	0.0000
Birch	7.8599	22.3728	17.2224
<i>Shannon index</i>	<i>2.27</i>	<i>2.25</i>	<i>1.91</i>

When assessing biodiversity, the Shannon index shows the average minimum taxonomic code of the forestry units that are part of the Park. It is advisable to use the obtained data for mapping the Park territory.

It has been established that the complexity and internal diversity of forest systems of the Synohora NPP forestry farms differ to some extent. It has been established that according to the indicator, N' forests of Duplyanske forestry are marked by the greatest stress, which can be associated with both negative anthropogenic and natural effects. Also, biodiversity and species richness indicators demonstrate the predominance of tree-edificators in the forest area of Duplyanske forestry, which displace other species and form a forest monosystem. This situation will also lead to changes in the biodiversity of this forest area. Species will look for more comfortable places to live due to changing conditions that worsen their life stages, such as hibernation, getting out of hibernation, hunting, breeding, mating season, moving to breeding and hunting sites, etc. Thus, there will be a disruption of ecosystem links and a new ecosystem will begin to form.

Therefore, the Duplyanske forestry of the Park needs carefully thought-out management decisions. Before making appropriate decisions, additional monitoring should be carried out to accurately assess the "forest-animal" system.

CHAPTER 2

TAXONOMIC STRUCTURE OF GROUPS OF AMPHIBIANS AND REPTILES OF NPP “SYNOHORA”

2.1. Assessment of the taxonomic composition of amphibians and reptiles in different types of NPP groups "Synohora"

We identified six ecosystem groups for systematization of information on the presence of amphibians and reptiles in NPP: 1. Forests; 2. Meadows; 3. Agrocenoses (pastures, hayfields); 4. Urbocenosis (inpatient recreation, economic zone); 5. Reservoirs (lakes, rates). 6. Banks of the Bystrytsia Solotvynska River and the valley of its.

On the territory of the Synohora NPP, 10 species of amphibians have been identified, which belong to 2 rows, 4 families, and 7 genera, and 7 species of reptiles, which belong to 5 families and 7 genera (Table 2.1).

Table 2.1- Taxonomic composition of amphibians and reptiles in different types of NPP groups
“Synohora”

Taxonomic composition of amphibians							
	Amphibian species	Ecosystem Group					
		Forests	Meadows	Agrocenoses (pastures, hayfields)	Urbocenosis (inpatient recreation, economic zone)	Reservoirs (lakes, rates)	Banks of the Bystrytsia River and the valley of its
1	<i>Salamandra salamandra</i> *	+	—	—	—	—	++
2	<i>Lissotriton vulgaris</i>	—	—	—	—	++	—
3	<i>Lissotriton montandoni</i> *	—	—	—	—	++	—
4	<i>Ichthyosaura alpestris</i> *	—	—	—	—	++	—
5	<i>Bombina variegata</i>	+	—	—	+	++	+
6	<i>Bombina bombina</i>	—	—	—	—	+	++
7	<i>Bufo bufo</i>	+	++	++	++	—	+
8	<i>Rana temporaria</i>	++	++	—	+	—	+
9	<i>Rana arvalis</i>	++	++	+	—	—	+
10	<i>Pelophylax esculentus</i>	+	—	—	—	+++	+
	Total species	6	3	2	3	6	7
Taxonomic composition of reptiles							
	Species of reptiles	Ecosystem Group					
		Forests	Meadows	Agrocenoses	Urbocenosis es	Reservoirs	Banks of the Bystrytsia River and the valley of its
1	<i>Anguis fragilis</i>	++	++	+	+	—	++
2	<i>Lacerta agilis</i>	+++	+++	++	++	—	++
3	<i>Zootoca vivipara</i>	+	+	—	—	—	+
4	<i>Natrix natrix</i>	++	++	+	+	—	++
5	<i>Coronella austriaca</i> *	+	—	—	+	—	—
6	<i>Zamenis longissimus</i> *	+	—	—	—	—	—
7	<i>Vipera berus</i>	++	++	+	+	—	++
	Total reptile species	7	5	4	5	—	5

Source: developed by the author

Symbols: * - species listed in the Red Book of Ukraine.

The table uses point estimates of the relative number of species: + rare species (usually registered only during individual excursions and surveys); + ordinary species (registered regularly, during each excursion and survey); + numerical species (characteristic of the grouping and registered during each survey)

A clade of Caudata are represented in the Park: *S. salamandra*, *L. vulgaris*, *L. montandoni*, *I. alpestris*. The species *S. Salamandra*. belongs to the rare fauna and is listed in the Red Book of Ukraine. The distribution of the species within the park is typical for the Ukrainian Carpathians. The species tends to moist deciduous forests, along the streams, with a vertical spread of up to 1500 m, rising to the upper boundary of the forest. *L. vulgaris*, *L. montandoni*, and *I. alpestris* were found in small reservoirs along roads, temporary small reservoirs, and swampy ditches along roads. *L. vulgaris* does not rise above 700 m above sea level, and *L. montandoni* and *I. alpestris* are more tolerant to fluctuations in altitude. The distribution of the last two species within the park has a specific nature: the number of *I. alpestris* decreases with increasing altitude, and the number of *L. montandoni* remains constant for low-flow reservoirs up to an altitude of 1600 m above sea level.

The *Anura* clade in the Park is represented by 6 species. From the *Ranidae* family, 3 species are common: *R. temporaria*, *R. arvalis*, and *P. esculentus*. These species of amphibians are inhabitants of mainly wet biotopes of river valleys, standing and low-flowing reservoirs, with isolated finds in deciduous moist beech forests. The species *B. bufo* is found alone throughout the Park, can rise to the zone of curviness, and is found in the meadows. *B. bombina* is distributed along the main channel of the Bystrytsia Solotvynska River to an altitude of 730 m above sea level. The species *B. variegata*, despite its high conservation status, is found in temporary stagnant reservoirs throughout the Park to an altitude of 1650 m above sea level.

L. agilis and *V. berus* are distributed throughout the Park from the valley of the Bystrytsia River to the stone placers of the highlands. *C. austriaca* and *Z. longissimus* are rare and tend to be mixed forests dominated by *Fagus sylvatica*. In turn, *N. natrix*, *Z. vivipara*, and *A. fragilis* are confined to wet stations and are most often observed in river valleys.

According to the dominant structure, as a result of observations by the route method, the most common reptiles of the Park are *L. agilis*, *N. natrix*, and *A. fragilis*. Less common species are *V. berus* and *Z. vivipara*. The most rare species of the Park are *C. austriaca* and *Z. longissimus*, which were recorded once during route observations.

2.2. Assessment of similarity of amphibians and reptile groups by species composition

Let's analyze the similarity of groups based on the calculation of the Serenson faunal similarity indicator (Odum, 1975). This indicator makes it possible to determine the frequency of species common to groups according to the formula:

$$S = \frac{2C}{(A+B)},$$

where *A* is the number of species in the first group; *B* is the number of species in the second group, and *C* is the number of common species for both groups. If $S > 0.5$, the species diversity of the groups is similar, if $S < 0.5$, it differs significantly. Calculations are presented in Table 2.2.

Table 2.2 – The degree of similarity of groups of amphibians and reptiles in terms of Serenson's similarity

Ecosystem Group	Forests	Meadows	Agrocenoses	Urbocenoses	Reservoirs	Banks of the Bystrytsia River and the valley of its
Forest	X	0.83	0.73	0.83	0.00	0.83
Meadows	0.67	X	0.89	0.80	0.00	1.00
Agrocenoses	0.50	0.80	X	0.89	0.00	0.89
Urbocenoses	0.67	0.67	0.40	X	0.00	0.80
Reservoirs	0.33	0.00	0.00	0.22	X	0.00
Banks of the Bystrytsia River and the valley of its	0.92	0.60	0.44	0.60	0.46	X

Source: developed by the author

Notations:

	- degree of amphibian groups similarity;
	- degree of reptile group similarity.

Analyzing the degree of similarity for amphibian groups, it was concluded that among the studied biocenoses, the most similar in the species composition of the batrachofauna were close in spatial terms biocenoses (moist forests and banks of the Bystrytsia Solotvynska river and its tributary valley) as undisturbed areas with moderate moisture. Groupings of reptiles are characterized by the similarity of species composition in undisturbed areas (meadows and banks of the Bystrytsia Solotvynska River and the valley of its tributaries). It should be noted that the similarity of the reptile species composition is also observed in disturbed areas (urban cenoses – agrocenoses) with undisturbed (meadows). The obtained results confirm that the Urbocenosis of the Park includes a complex of biotopes, which may in some respects correspond to the structure of the undisturbed territories of the Park. In addition, the unimpeded migration processes within the Park play an important role, thanks to which the batracho and herpetofauna are preserved.

2.3. Comparative analysis of the taxonomic structure of groups of amphibians and reptiles in the park

To determine the Shannon index (Formula 1.1) of amphibians living in the groups of the park, their systematic affiliation was determined and this affiliation was calculated for each of the groups (Table 2.3).

It should be noted that a significant advantage of the diversity index is its complete independence from the biocenotic similarity (similarity) of the compared groups and the ability to assess the degree of diversity of each cenosis separately (Table 2.4).

Table 2.3 - Systematics of Synohora NPP amphibians

Ordo	Subordo	Familia	Genus	Species
Caudata	Salamandroidea	Salamandridae	Salamandra	<i>Salamandra salamandra</i> *
Caudata	Salamandroidea	Salamandridae	Lissotriton	<i>Lissotriton vulgaris</i>
Caudata	Salamandroidea	Salamandridae	Lissotriton	<i>Lissotriton montandoni</i> *
Caudata	Salamandroidea	Salamandridae	Mesotriton	<i>Ichthyosaura alpestris</i> *
Anura	Opisthocoela	Bombinatoridae	Bombina	<i>Bombina variegata</i>
Anura	Opisthocoela	Bombinatoridae	Bombina	<i>Bombina bombina</i>
Anura	Procoela	Bufo	Bufo	<i>Bufo bufo</i>
Anura	Diplasiocoela	Ranidae	Rana	<i>Rana temporaria</i>
Anura	Diplasiocoela	Ranidae	Rana	<i>Rana arvalis</i>
Anura	Diplasiocoela	Ranidae	Rana	<i>Pelophylax esculentus</i>

Thus, 10 species of amphibians belonging to 2 clades, 4 families, and 6 genera have been identified on the territory of the Sinogora National Nature Park.

Table 2.4 – Assessment of the taxonomic richness and diversity of Synohora NPP amphibious groups

Ecosystem Group	Number of taxa by rank					Sum of taxa	(H')
	Species	Genus	Familia	Subordo	Ordo		
Forest	6	4	4	4	2	20	1.55
Meadows	3	2	2	2	1	10	1.55
Agrocenoses	2	2	2	2	1	9	1.56
Urbocenoses	3	3	3	3	1	13	1.56
Reservoirs	6	4	3	3	2	18	1.54
Banks of the Bystrytsia Solotvynska River and the valley of its	7	4	4	4	2	21	1.56

The highest indicator of the biological diversity of amphibian groups was noted in the following ecosystem groups – the banks of the Bystrytsia River and its tributaries, agrocenoses, and urban cenoses. It has been established that forests are characterized by the highest indicator of the species richness of amphibians – 20 species in the composition.

The obtained data indicate that the main binding of amphibians to these ecosystem groups is the possibility of existence in familiar and favorable conditions. The forest, the banks of the Bystrytsia River and its tributaries, agrocenoses, and urban cenoses have a wide range of conditions necessary for amphibians – food, places for reproduction, the possibility of the usual course of life stages by the physiological characteristics of amphibians.

The obtained results indicate the possibility of free (without obstacles) movement of amphibians in the park and with a low level of tourist activity.

To determine the Shannon index (Formula 1.1) **of reptiles** (Table 2.6) living in the groups of the park, their systematic affiliation was determined and this affiliation was calculated for each of the groups (Table 2.5).

Table 2.5 - Systematics of NPP “Synohora” reptiles

Ordo	Subordo	Familia	Genus	Species
Squamata	Lacertilia	Anguidae	Anguis	Anguis fragilis
Squamata	Lacertilia	Lacertidae	Lacerta	Lacerta agilis
Squamata	Lacertilia	Lacertidae	Zootoca	Zootoca vivipara
Squamata	Serpentes	Colubridae	Natrix	Natrix natrix
Squamata	Serpentes	Colubridae	Coronella	Coronella austriaca*
Squamata	Serpentes	Colubridae	Zamenis	Zamenis longissimus *
Squamata	Serpentes	Viperidae	Vipera	Vipera berus

Thus, 7 species of reptiles have been identified on the territory of the Park, which is part of 4 families and 7 genera.

Table 2.6 – Assessment of the taxonomic richness and diversity of the Synohora NPP reptile groups

Grouping	Number of taxa by rank					Sum of taxa	(H)
	Species	Genus	Familia	Subordo	Ordo		
Forest	7	2	4	2	1	16	1.42
Meadows	5	2	4	2	1	14	1.46
Agrocenoses	4	2	4	2	1	13	1.47
Urbocenoses	5	2	4	2	1	14	1.48
Reservoirs	-	-	-	-	-	-	-
Banks of the Bystrytsia Solotvynska River and the valley of its	5	2	4	2	1	14	1.48

It has been established that the highest Shannon index is characteristic of groups of reptiles of urbocenosis and the banks of the Bystrytsia River. The data obtained are not random, since the banks of Bystrytsia are quite diverse and comfortable for reptiles. The shores have well-lit and rocky slopes that warm up well. Such conditions attract reptiles. Synohora NPP urbocenoses are represented by alternating forest areas with meadow areas, on which stationary recreation facilities are located. These areas are also characterized by proximity to people's homes. Thus, different lighting conditions, alternation of forest and meadow areas of the park, and proximity to human habitation contribute to the migration processes of reptiles to hunt synanthropic species (mouse-like rodents), amphibians, and insects that appear in large numbers on plowed homestead plots during agricultural work.

It should be noted that the least taxonomic diversity according to the Shannon Index is observed in the forest ecosystem group of the park. At the same time, the forest group itself is the largest (16 reptiles) in terms of species richness. The forests of NPP “Synohora” are characterized by dense plantations, which leads to moisture and reduced lighting under the canopy of trees. Such conditions allow reptiles to easily hunt for prey, breed, and hide in heaps of firewood for the winter. This feature should be paid attention to by the park management during the formation of the forest management plan of the Park.

CHAPTER 3

TAXONOMIC STRUCTURE OF THE GROUPING OF AMPHIBIANS AND REPTILIAS IN THE SPREEWALD BIOSPHERE RESERVE

3.1. Biotopes in the Spreewald biosphere reserve

The modern distribution of biotopes of the Spreewald biosphere reserve (BR) is characterized by grassy areas of various types and purposes. They occupy about 40% of the area. About 40% are occupied by forest biotopes, 5.3% by deciduous shrubs, single field trees and groups of trees. The territory of BR is characterized by a large proportion of water biotopes - flowing and stagnant water bodies, reed thickets, swamps. The rivers typical of the Spreewald have a length of 200 km. Other biotopes, such as cultivated areas and fields, landscapes modified by man (buildings, transport junctions) are represented in small proportions.

Therefore, we identified six ecosystem groups for systematization of information on the presence of amphibians and reptiles in BR: 1. Forests; 2. Wet meadows; 3. Dry meadows (fields, cultivated areas); 4. Open areas (in settlements), special biotopes, built-up areas; 5. Small water bodies (lakes, ponds, stagnant water bodies, swamps); 6. River banks and valleys of their tributaries.

3.2. Assessment of the taxonomic composition of amphibians and reptiles in different types of communities of the Spreewald biosphere reserve

13 species of amphibians and 5 species of reptiles were found on the territory of the Spreewald biosphere reserve (Tabl. 3.1).

Table 3.1 - Taxonomic composition of amphibians and reptiles in different types of communities of the Spreewald biosphere reserve

Taxonomic composition of amphibians							
	Species of amphibians	Ecosystem Group					
		Forest s	Wet meadow s	Dry meadows (fields, cultivated areas)	Open areas (in settlements), special biotopes, built-up areas	Small water bodies (lakes, ponds, stagnant water bodies, swamps)	River banks and valleys of their tributaries
1	<i>Lissotriton vulgaris</i>	—	—	—	—	+++	—
2	<i>Triturus cristatus</i> ¹	+ ^s	—	—	+ ^s	++	+
3	<i>Hyla arborea</i> ¹	+	++	—	+	—	+
4	<i>Bombina bombina</i> ¹	+ ^s	+	—	—	+	+
5	<i>Bufo viridis</i> ¹	—	+	++	—	—	—
6	<i>Bufo bufo</i> ⁺⁺⁺	+	++	+++	+	—	—
7	<i>Epidalea calamita</i>	—	+	—	+	++	—
8	<i>Pelobates fuscus</i> ¹	—	—	+	—	—	—
9	<i>Rana temporaria</i>	+	+	—	+	+	+
10	<i>Rana arvalis</i> ¹	++	++	—	—	+	+
11	<i>Pelophylax esculentus</i> ⁺⁺⁺	+ ^s	—	—	—	+++	++
12	<i>Rana lessonae</i>	—	—	—	—	++	+
13	<i>Rana dalmatina</i>	+	+	+	+	+	—
	A total of species	8	8	4	6	9	7
Taxonomic composition of reptiles							
	Species of reptiles	Ecosystem Group					
		Forest s	Wet meadow s	Dry meadows (fields, cultivated areas)	Open areas (in settlements), special biotopes, built-up areas	Small water bodies (lakes, ponds, stagnant water bodies, swamps)	River banks and valleys of their tributaries
1	<i>Anguis fragilis</i>	+	+	+	+	—	++
2	<i>Lacerta agilis</i> ¹	+	++	+++	++	—	+

3	Zootoca vivipara ¹	+	+	–	–	–	+
4	Natrix natrix*	+	+	+	+	+	+
5	Coronella austriaca*	+	–	–	+	–	–
	A total of reptile species	5	4	3	4	1	4

Source: developed by the author based on data Jahresbericht_Textteil_SW_23

Notations:

* – the species under threat of extinction

+++ – the most widespread species

+³ – the species was noted during the wintering season

¹ – the species is protected by the Federal Law on Nature Protection and the European Habitat Directive (Fauna-Flora-Habitat Directive, Appendix II and IV)

The table uses point estimates of the relative number of species: + – the species is rare (it is usually registered only during individual excursions and surveys); ++ – ordinary species (registered regularly, during each excursion and registration); +++ – numerical species (characteristic for the group and registered during each accounting)

Ordo *Caudata* is represented on the territory of the Park by 2 species. *T. cristatus* is protected by the Federal Nature Conservation Act and the European Habitat Directive (Fauna-Flora-Habitat Directive, Annex II and IV). The species was found in forests during wintering, in small reservoirs along roads, temporary small reservoirs, waterlogged ditches along roads. *L. vulgaris* is common within the reserve.

Ordo *Anura* on the territory of the reserve is represented by 11 species. *Ranidae* is represented: *R. temporaria*, *R. arvalis*, *P. esculentus*, *R. dalmatina*, *R. lessonae*. These species are noted in wet biotopes of river valleys, stagnant and low-flow water bodies. Single finds were also noted in deciduous moist forests. *B. bufo* spread throughout the territory of the reserve, in contrast to *B. viridis* and *E. calamita*, which occur singly. *B. bombina* widespread in the territory of the reserve along the main riverbed. *H. arborea*, *B. viridis* and *R. arvalis* are protected by the Federal Law on Nature Protection and the European Habitat Directive (Fauna-Flora-Habitat Directive, Appendix II and IV).

Among reptiles, as a result of observations by the route method, it was established that the most common species is *L. agilis*. This species together with *Z. vivipara* are protected by the Federal Law on Nature Protection and the European Habitat Directive (Fauna-Flora-Habitat Directive, Appendix II and IV).

N. natrix, *Z. vivipara* and *A. fragilis* are confined to wet stations and are observed in river valleys. *C. austriaca* and *N. natrix* are under threat of extinction.

To determine the Shannon index for groups of amphibians (Table 3.3), their systematic affiliation was determined and calculations were made for of each ecosystem group of Spreewald biosphere reserve (Table 3.2).

Table 3.2 - Systematics of amphibians Spreewald biosphere reserve

Ordo	Subordo	Familia	Genus	Species
Caudata	Salamandroidea	Salamandridae	Lissotriton	Lissotriton vulgaris
Caudata	Salamandroidea	Salamandridae	Lissotriton	Triturus cristatus
Anura	Procoela	Hylidae	Hyla	Hyla arborea ¹
Anura	Opisthocoela	Bombinatoridae	Bombina	Bombina bombina
Anura	Procoela	Bufonidae	Bufo	Bufo viridis ¹
Anura	Procoela	Bufonidae	Bufo	Bufo bufo
Anura	Procoela	Bufonidae	Bufo	Epidalea calamita
Anura	Anomocoela	Pelobatidae	Pelobates	Pelobates fuscus ¹
Anura	Diplasiocoela	Ranidae	Rana	Rana temporaria
Anura	Diplasiocoela	Ranidae	Rana	Rana arvalis
Anura	Diplasiocoela	Ranidae	Rana	Pelophylax esculentus
Anura	Diplasiocoela	Ranidae	Rana	Rana lessonae
Anura	Diplasiocoela	Ranidae	Rana	Rana dalmatina

Thus, 13 species of amphibians belonging to 2 rows, 6 families and 6 genres were found on the territory of the Spreewald biosphere reserve.

Table 3.3 – Assessment of the taxonomic richness and diversity of amphibian communities of the Spreewald biosphere reserve

Ecosystem Group	Number by ranks					Sum of taxa	(H')
	Species	Genus	Families	Subordo	Ordo		
Forest	8	5	5	4	2	24	1,35
Wet meadows	8	4	4	3	1	20	1,45
Dry meadows (fields, cultivated areas)	4	3	3	3	1	14	1,54
Open areas (in settlements)	6	4	4	3	2	19	1,55
Small water bodies (lakes, ponds, stagnant water bodies)	9	4	4	4	2	23	1,49
River banks and valleys of their tributaries	7	4	4	4	2	21	1,56

According to the calculation of the Shannon index for all ecosystem groups of the Spreewald biosphere reserve, it was established that the banks of rivers and the valleys of their tributaries, which are in sufficient quantity on the territory of the reserve, are characterized by the highest rate of taxonomic diversity of amphibian communities. The highest indicator of species richness of amphibians is observed in the ecosystem group of small water bodies. This tendency is due to the fact that the favorite places of stay of most species of amphibians are reservoirs of various types - from low-flow and stagnant rivers to rivers with a moderate current. This corresponds to the fact that amphibians spend most of their life and all its active phases in and near water bodies - the mating season, reproduction, hunting. High rates of taxonomic diversity of amphibians ($H'=1.55$ and $H'=1.54$) are also characteristic of open areas and areas of fields and cultivated areas. According to our observations, such results prove that the Spreewald biosphere reserve has created conditions for the free and safe movement of amphibians over long distances. Such movements of amphibians allow them to change, if necessary, the ecosystem groups of the reserve for better access to food, which in certain periods (spring) becomes quite available near settlements and in the area of human activity. In addition, amphibians move freely between breeding and wintering sites. This is evidenced by the findings of amphibian species in forests during route observations.

5 species of reptiles belonging to 3 families and 5 genera were found on the territory of Spreewald BR (Table 3.4). Based on the obtained data, an assessment of the taxonomic diversity of groups and species richness of reptiles was carried out (Table 3.5)

Table 3.4 - Classification of reptiles Spreewald biosphere reserve

Ordo	Subordo	Familia	Genus	Species
Squamata	Lacertilia	Anguidae	Anguis	Anguis fragilis
Squamata	Lacertilia	Lacertidae	Lacerta	Lacerta agilis
Squamata	Lacertilia	Lacertidae	Zootoca	Zootoca vivipara
Squamata	Serpentes	Colubridae	Natrix	Natrix natrix
Squamata	Serpentes	Colubridae	Coronella	Coronella austriaca*

Table 3.5 – Assessment of the taxonomic richness and diversity of reptile communities of the Spreewald biosphere reserve

Ecosystem Group	Number by ranks					Sum of taxa	(H)
	Species	Genus	Families	Subordo	Ordo		
Forest	5	5	3	2	1	16	1,48
Wet meadows	4	4	3	2	1	14	1,52
Dry meadows (fields, cultivated areas)	3	3	3	2	1	12	1,55
Open areas (in settlements), special biotopes, built-up areas	4	4	3	2	1	14	1,52
Small water bodies (lakes, ponds, stagnant water bodies, swamps)	1	1	1	1	1	5	1,60
River banks and valleys of their tributaries	4	4	3	2	1	14	1,52

It was established that the highest rate of the biodiversity of reptile communities is observed for communities of dry meadows (fields, cultivated areas). The data obtained is not random. Dry meadows with a predominance of cultivated areas are attractive and comfortable for

reptiles to live in. They are lighted and open areas of land, but at the same time onion grasses give reptiles the opportunity to hide and move freely. It should be noted that recently reptiles prefer to get closer to human habitations. Such dynamics of movement and changes in the behavior of reptiles are associated with the availability and large supply of food in cultivated areas. Accessibility and minimal energy expenditure during hunting attract reptiles to places that are the border between natural and anthropogenic conenoses. The forest turned out to be the richest ecosystem group in terms of species composition of reptiles. A forest for reptiles performs several functions at the same time. The forest is an arena for mating, reproduction, hunting, hibernation and hiding of reptiles from enemies. It should be noted that the result ($H'=1.6$) for the ecosystem group of small bodies of water, which includes lakes, ponds, stagnant bodies of water, swamps, was the highest compared to all analyzed groups. These data are related to the fact that as a result of route surveys in this type of reservoirs, only one species of reptile, *N. natrix*, was noted, which swims well and uses reservoirs to hunt amphibians.

So, according to the results of the calculation of the taxonomic diversity of amphibians and reptiles of the Spreewald biosphere reserve ecosystem groups, it was established that all ecosystem groups do not have significant jumps in the taxonomic diversity index. This indicates that amphibians and reptiles can freely move around the territory and without obstacles reach the necessary places for settlement, where they can experience all stages of their lives, freely interbreed and give fertile offspring. We will analyze the similarity of groups based on the calculation of Serenson's faunal similarity index (Table 3.6).

Table 3.6 – The degree of similarity of groups of amphibians and reptiles according to the Serenson similarity index

Ecosystem Group	Forests	Wet meadows	Dry meadows	Open areas (in settlements)	Small water	River banks and valleys
Forests	X	0,890	0,750	0,890	0,333	0,890
Wet meadows	0,625	X	0,857	0,750	0,40	1,0
Dry meadows (fields, cultivated areas)	0,333	0,500	X	0,857	0,50	0,857
Open areas (in settlements), special biotopes, built-up areas	0,714	0,714	0,400	X	0,40	0,750
Small water bodies (lakes, ponds, stagnant water bodies, swamps)	0,706	0,588	0,154	0,400	X	0,40
River banks and valleys of their tributaries	0,800	0,533	0,0	0,462	0,750	X

Source: developed by the author

Notations:

	- degree of similarity of amphibian groups;
	- degree of similarity of groups of reptiles.

Analyzing the degree of similarity of amphibian groups, they came to the conclusion that among the studied biocenoses, the most similar in species composition of batrachofauna were the biocenoses that are close in space (wet forests and river banks and valleys of their tributaries) as undisturbed areas with moderate moisture. Groups of reptiles are characterized by the similarity of the species composition in undisturbed areas (wet meadows and river banks and valleys of their tributaries). It should be noted that the similarity of the species composition of reptiles is also observed in undisturbed areas (forest - wet meadows; forest - river banks and valleys of their tributaries). The obtained results confirm that groups of reptiles and amphibians tend to pass all stages of their life in the undisturbed territories of the Spreewald biosphere reserve. Therefore, the similarity of groups of amphibians and reptiles is related to the similarity of the conditions necessary for the life and recovery of species, as well as to the smoothness of migration processes within the Spreewald biosphere reserve, thanks to which the transition of representatives of batrachians and herpetofauna to places of wintering, reproduction, etc. is facilitated.

CHAPTER 4

MONITORING, SYSTEMATISATION OF DATA AND ASSESSMENT OF THE EFFICIENCY OF BIODIVERSITY MANAGEMENT OF FOREST ECOSYSTEMS

Based on the obtained data, it was established the need to consider forest ecosystems in the "forest-animal" system. The obtained data will make it possible to implement effective management solutions for both forestry and biosphere reserves (BR) and other objects of the NRF. The methodology of long-term monitoring (Fig. 4.1) is proposed as a basis for the analysis and formation of goals, objectives and tasks of the biosphere reserve management program in the part "Preservation and restoration of the Forest-Animal system".

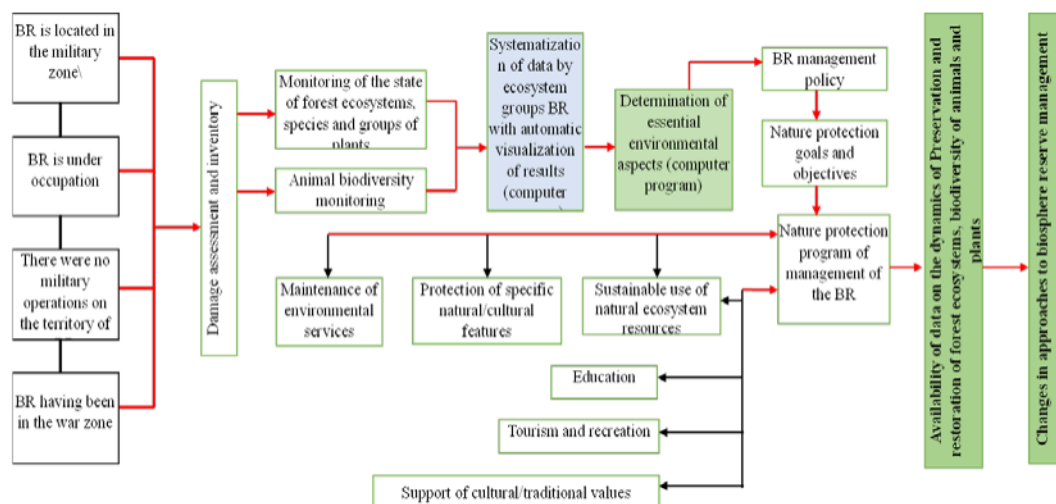


Fig. 4.1 - Methodology for long-term monitoring and systematization of data on the state of plants and animals for effective management of Biosphere Reserves (BR) for restoration of Ukraine

Data obtained as a result of monitoring are entered into the Monitoring or Forestry Program (Fig. 4.2- 4.3).

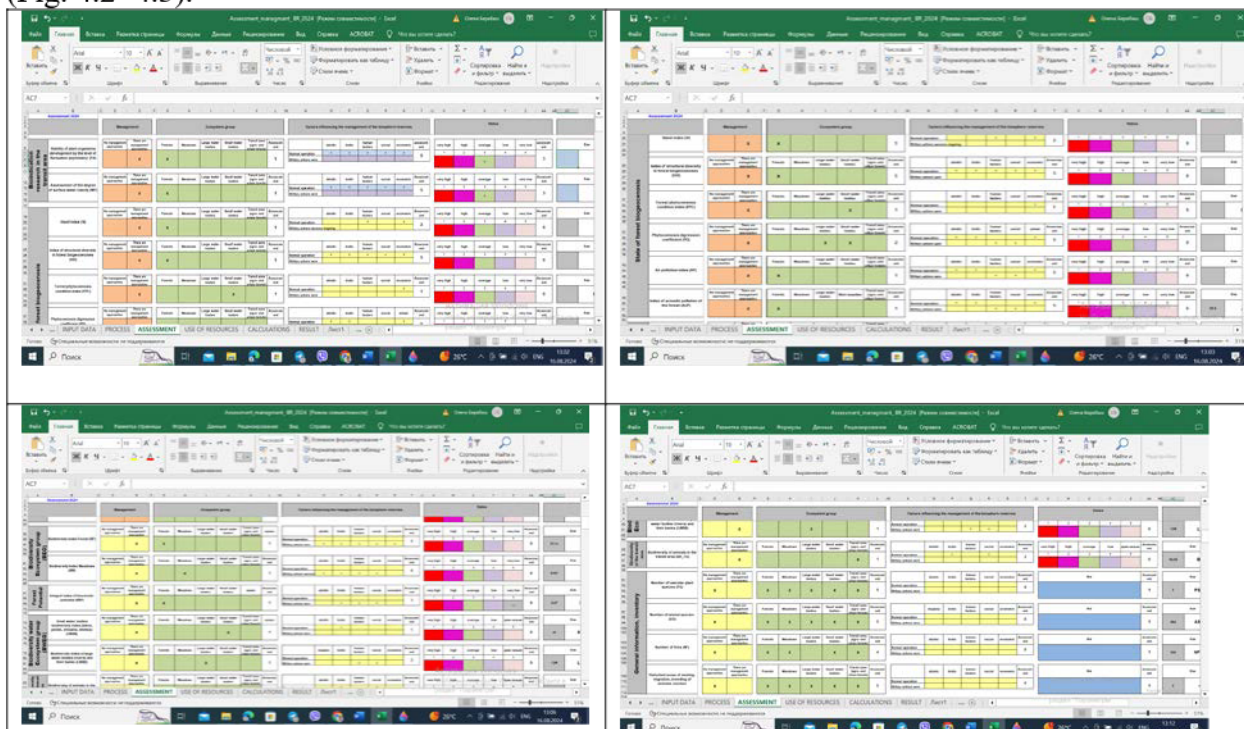


Fig. 4.2 - Fragment of the Program for monitoring and evaluating the effectiveness of management decisions in biosphere reserves (Assessment)

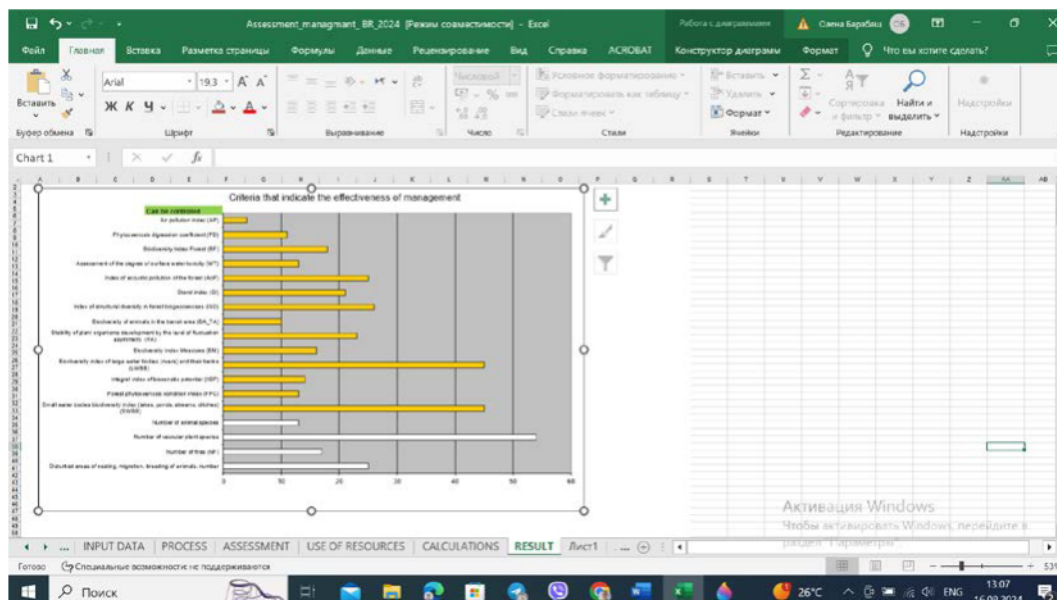


Fig. 4.3 - Fragment of the Program for monitoring and evaluating the effectiveness of management decisions in biosphere reserves (Result)

The program provides a quantitative assessment and visually demonstrates changes and differences in certain indicators of the "forest-animal" system from the time of the previous monitoring to the time of the current monitoring. Such information makes it possible to quickly and efficiently carry out corrective measures and apply changes in the forest management plan. The Program also takes into account the aspect of whether or not military operations were conducted on the territory of the reserve.

The developed Program needs to be refined, in particular, the development of evaluation scales. You can also increase the list of monitoring data for input in the Program. These can be data on the conduct of educational events, public hearings, etc., which will allow to expand the list and quality of management of the NRF object in its entirety, and not only in the "forest-animal" system. If research in this direction develops, the Program can be refined and a pilot project launched.

A pilot project of long-term monitoring and evaluation of the effectiveness of management actions should be conducted for at least two NRFs. They should differ not only in terms of geography, climate, etc. factors, but also whether hostilities took place on their territory.

CONCLUSIONS

Thus, as a result of the conducted research, we suggest that the management of NPP "Synohora" pay special attention to the management of ecosystem groups of the Park.

Based on the results of the study of the biodiversity of animals, in particular amphibians and reptiles of the Park, we propose to include in the management plan of the Park goals for the restoration and preservation of the buffer - natural vegetation located along the Bystrytsia River, streams and other reservoirs of the Park. We suggest setting the parameters of the width of the buffer zone on each side of the reservoir. Such a buffer zone should be $\leq$ the width of the reservoir. The formation of such a goal in the management plan of NPP "Synohora" and its implementation will ensure the continuous development of the tree canopy and the preservation of litter. All this will reduce erosion, retain precipitation, and minimize water temperature fluctuations in reservoirs. Such conditions will contribute to the increase of species richness, diversity of plant communities and animal communities of NPP "Synohora".

According to the results of the study of the forest ecosystem group of NPP "Synohora", we suggest that the management of Park include the following tasks in the forest management plan.

- Conducting short- and long-term monitoring of the forest areas of the Park.
- To obtain more accurate information, we suggest using drones.
- Formation of the base of forest plantations by forestry and the general base of the Park's forests.
- Development of analytical and informational software for the formation of a database of the state of tree species and the Park's constituent tree species.
- Planting tree seedlings and involving the public. To do this, it is advisable to develop your brand, as an example "Participant in the restoration of the Siniohora forest".
- To develop a chatbot, as an example of "Synohora - forever", for the public to receive as much and more detailed information as possible about natural resources, species of plants and animals, interesting places, excursion routes, places of rest.
- Keeping a nature calendar to identify climate changes and their impact on the state of the forest.
- Conducting educational and explanatory work for the public living near the Park about the consequences of reducing the area of forests. For this, it is necessary to find a form that would make information easy and accessible for perception by all sections of the population.
- A clear schedule of meetings to adjust the management plan of the Park.

A large number of NRF of Ukraine are currently under occupation. Forest ecosystems suffer, and so do species of animals confined to these territories. Taking into account the fact that significant, sometimes irreparable damage has been caused to the NRF objects, the proposed methodology and the Program for long-term monitoring and evaluation of the effectiveness of management decisions will allow a balanced and scientific approach to the processes of restoration and preservation of forests of Ukraine, to improve opportunities for evaluation and adjustment of already existing management decisions for restoration of forests and preservation of populations and their genetic diversity.

Thus, 5 species of reptiles belonging to the order Caudata and 3 families and 5 genres and 13 species of amphibians belonging to 2 rows, 6 families and 6 genres were found on the territory of the Spreewald BR. Taxonomic biodiversity for groups of amphibians and reptiles shows the stability and sustainable development of the ecosystem groups of the Spreewald BR, which are home to amphibians and reptiles. According to the state and structure of amphibian and reptile groups, no significant differences were registered between disturbed and undisturbed ecosystem groups located in different functional zones of the Spreewald BR. The constant free movement of amphibians and reptiles between ecosystem groups located in different functional zones of the Spreewald BR indicates the safe conditions created by the reserve's workers for the preservation and restoration of amphibian and reptile communities. Thus, the reserves are model sites for the sustainable development of territories for the preservation and restoration of diversity in the territories of nature protected areas and territories partially used by humans.

Based on the results of the research, three articles will be submitted for publication:

1. Barabash O., Khrutba O., Pokshevnytska T., Tarasiuk M. (2025). The realisation of sustainable development goals through the implementation of international environmental projects. International Scientific Conference «INTELLIGENT TRANSPORT SYSTEMS: Ecology, Safety, Quality, Comfort». 26-27 November 2024, Kyiv, Ukraine, 2025, (in progress)
2. Barabash O., Sevostianova A., Weigang G. (2025). Modeling the taxonomic richness of amphibian and reptile communities in Spreewald Biosphere Reserve ecosystem groups. *Revue Roumaine de Géographie/Romanian Journal of Geography (RjGEO)*, 2025, (in progress)

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8. Die Arbeit der Naturwacht im Biosphärenreservat Spreewald. Im Einsatz für Mensch und Natur. Im Einsatz für Mensch und Natur, 2023. 32 p.
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