

# Structural and functional analysis of the network of protected areas of the Vinnytsia region as the basis of a regional ecological network

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Planning an ecological network requires special attention to the functionality of the created elements. Thus, in the case of the Vinnytsia Regional Ecological Network (REN), protection and restoration of typical landscape complexes are needed. The structure of the ecological network is branched, but heterogeneous; it is potentially capable of expansion and optimization. As the development of the REN of the Vinnytsia region is based on objects and territories of the Nature Reserve Fund (NRF), the structural and functional optimization of the eco-network requires optimization of the structure of the NRF. The purpose of the research is to study the spatial structure of the ecological network for the functional completeness and the effectiveness of ensuring the conservation of biodiversity. This paper analyses the structure and functions of the Vinnytsia REN, demonstrates dynamics of the formation of the NRF network and the distribution of protected objects among administrative regions, and proposes ways for its optimization. The results showed the necessity of a revision of the current structure and creation of new zoological and landscape reserves in order to improve the functional efficiency of the network. The results suggest paying more attention to providing multifunctionality to eco-network elements, as well as avoiding the creation of island objects.

**Keywords:** ecological network, biodiversity, nature reserve fund, level of reservation

## INTRODUCTION

Due to its advantageous geographical location, high soil fertility, and protection from sharp fluctuations in weather conditions, Ukraine is char-

acterized by a high rate of biological diversity. In addition, its territory abounds in a rich variety of landscapes and natural habitats of species (Popovich, 2007). However, over the years of economic and technological pressure on these territories, a decrease in the quantity and quality of natural landscapes has been observed (Kucher et al.,

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2018). Degradation and destruction of the natural habitats of populations, as well as hunting and direct extermination of species cause irretrievable losses of a significant part of biodiversity of Ukraine, while another part is currently facing the threat of extinction (Miller, 1994; Mudrak et al., 2018).

A trend towards a decrease in biodiversity is observed, both at the national and regional levels. The specificity of this phenomenon for the Vinnytsia region is the hyperfunction of agricultural activity, which leads to the degradation of the composition and structure of soils and, consequently, ecosystems. The biodiversity of typical meadow and steppe ecosystems, pastures located in the valleys of water bodies outside the coastal protective bands, is threatened because of forest planting without appropriate justification (DAIDENR, 2018).

The structure of ecological network of the Vinnytsia region is based on protected areas and objects. The structural and functional analysis of the reserve network of Eastern Podillia consists in the analysis of the geographical position and functionality of its facilities and is aimed at the formation and optimization of a functional, representative ecological network capable of preserving the typical biodiversity of the region (Andrienko, 1998; Secretariat of the Convention on Biological Diversity, 2001; Mudrak, 2015).

Based on this, the aim of the research is to study the spatial structure of the ecological network for functional completeness and the effectiveness of ensuring the conservation of biodiversity. The object of the study is the network structure of protected areas of the Vinnytsia region, as the basis of a regional ecological network. The subject of the research is territories and objects of the nature reserve fund of Vinnytsia region.

## MATERIALS AND METHODS

Materials: structural elements of the framework of a regional ecological network (key territories, or natural nuclei; ecological corridors, buffer zones, and renaturalization zones). The data from the register of the Na-

ture Reserve Fund (NRF) of the Vinnytsia region, data from the Vinnytsia regional department of agro-industrial development of ecology and natural resources, and guidelines for the development of Regional Ecological Network (REN) schemes were used for the research (Popovich, 2007).

Research methods: structural and functional analysis of the network of the protected areas of the Vinnytsia region was carried out with the help of the data collected from a literature review, landscape-ecological and general field studies (Ovchinnikova, 2018). The dynamics of the formation of the NRF network and the distribution of protected objects by administrative regions were studied with the help of statistical and comparative analysis of data. The data were collected by the Department of Agro-Industrial Development, Ecology and Natural Resources in the Vinnytsia region (DAIDENR) and NRF (Register of Objects of the Nature Reserve Fund). The influence of the structure and distribution of the NRF territories on the formation and viable ways of optimizing the REN of the Vinnytsia region were studied using analytical, descriptive, and retrospective methods of analysis.

## RESULTS AND DISCUSSION

The data collected by the Department of Agro-Industrial Development, Ecology and Natural Resources in Vinnytsia region shows that the modern NRF of Eastern Podillia (the last update of 3 March 2019) included 439 (virtually 425) objects and territories of protection. Their total area covers 66730.48 hectares, which is 2.52% of the total area of the Vinnytsia region (Table 1) (Ovchinnikova, 2019).

The basis of the NRF is the objects of protection of biotopes, species, and landscapes: one national nature park (NNP) (20203.4 ha) – 35.53% of the total area of the NRF; four – regional landscape parks (RLP) (18468.38 ha) – 32.48%; 157 reserves (wildlife sanctuary) (25,204.18 ha) – 44.32%; 194 natural monuments (1,071.32 ha) – 1.88%; 29 protected areas (951.4 ha) – 1.67%; one

arboretum (10 ha) – 0.018%; 39 park-monuments of landscape-gardening art (PMLG) (821.8 ha) – 1.45%. Biosphere reserves (BR) and nature reserves (NR) are not registered.

Among the nature reserves that are part of the NRF of the region, the area is dominated by botanical ones (with a total area of 13,190.05 ha); general ecological and landscape reserves have close values (4722 ha and 4583 ha, respectively), and hydrological and forest reserves (1442.06 ha) occupy a much smaller area and 368.7 ha, respectively) (Mudrak et al., 2015; Ovchinnikova, 2019).

Over the past 40 years, the reserve indicator has been increased from 0.17% to 2.52% (Table 1)

The indicator of the level of conservation of the region does not reflect the real state of the ecological network. Due to the state cadastre of territories and objects of the NRF of Ukraine (2017), a significant proportion of this indicator is achieved due to individual protected areas (Table 2).

The data collected by the Department of Agro-Industrial Development, Ecology and Natural Resources in Vinnytsia region show that of the total number of territories and objects of the NRF of the region, 80.24% (341 objects) with an area of up to 50 hectares have the island character and do not fully ensure the conservation of biodiversity (Table 3) (Ovchinnikova, 2019).

Table 1. The dynamics of the NRF of Eastern Podillia

Year	Number of territories and objects	Area, ha	Share of the total area of the region, %
1978	135	4714.0	0.17
1986	320	8907.0	0.35
1989	320	9193.2	0.40
1993	311	18600.0	0.70
1996	325	18820.79	0.70
2000	339	20624.69	0.78
2003	336	23763.54	0.89
2005	338	23841.3	0.89
2006	342	24001.92	0.9
2007	342	24001.92	0.9
2008	343	27353.26	1.021
2009	344	27401.82	1.034
2010	376	51200.37	1.95
2011	391	51794.37	1.96
2012	400	54634.0	2.06
2013	404	54880.5	2.07
2017	432	65748.17	2.49
2018	420	66317.3	2.51
2019	439	66730.48	2.52

Table 2. Distribution of protected objects by administrative regions of Eastern Podillia (as of 3 May 2019)

Number of NRF objects, units	>10	10–19	20–29	30–39	40–49	50–59
Number of administrative units, units	6	15	3	4	–	–
The share of administrative-territorial units in the total number of objects of the NRF, %	1.42	3.53	0.71	0.95	–	–

Table 3. Functional and spatial analysis of the NRF of Eastern Podillia by area (as of 3 May 2019)

Area, ha	NNP	RLP	Wildlife sanctuary	NM	PA	PMLGA	Arbor-etum	Total
<1	–	–	–	108	–	–	–	108
1–5	–	–	14	65	4	8	–	91
5.1–10	–	–	9	7	8	6	1	31
10.1–25	–	–	37	5	7	15	–	64
25.1–50	–	–	30	3	7	7	–	47
50.1–100	–	–	23	4	2	3	–	32
100.1–250	–	–	24	2	1	–	–	27
250.1–500	–	–	8	–	–	–	–	8
500.1–1000	–	–	6	–	–	–	–	6
1000.1–2500	–	–	4	–	–	–	–	4
2500.1–5000	–	2	2	–	–	–	–	4
5000.1–10000	–	2	–	–	–	–	–	2
10000.1–25000	1	–	–	–	–	–	–	1
Total	1	4	157	194	29	39	1	425

NNP – national nature parks, RLP – regional landscape park, NM – natural monuments, PA – protected areas, PMLGA – park-monuments of landscape-gardening art.

Among 27 administrative districts, the level of conservation of the territory (the share of the NRF of the total area of the district) is:

a) critical – up to 1% (12 districts, 44.4% of the total);

b) very poor – from 1.01% to 2% (seven districts, 25.9% of the total);

c) bad – from 2.01% to 3% (three districts, 11.1% of the total);

d) very low – from 3.01% to 4% (two districts, 7.4% of the total);

e) low – from 4.01% to 5% (one district, 3.7% of the total);

f) satisfactory – from 5.01% to 8% (one district 3.7% of the total);

g) good – over 8.01% (one district, 3.7% of the total).

Distribution by the number of protected sites (DAIDENDR, 2019; Ovchinnikova, 2019):

a) up to ten protected sites (eight districts, 29.6% of the total);

b) 10–15 protected sites (12 districts, 44.4% of the total);

c) 16–20 protected sites (one district, 3.7% of the total);

d) 21–25 protected sites (one district, 3.7% of the total);

e) 26–30 protected sites (two districts, 7.4% of the total);

f) 31–35 protected sites (two districts, 7.4% of the total);

g) 35 and more protected sites (one district, 3.7% of the total).

Distribution of NRF objects by area (Ovchinnikova, 2019; NRF, 2019):

a) up to 1 ha – 149 protected sites (36.8% of the total);

b) 1–5 ha – 64 objects (15.8%);

c) 5.1–10 ha – 35 objects (8.6%);

d) 10.1–25 ha – 47 objects (11.6%);

e) 25.1–50 ha – 38 objects (9.4%);

f) 50.1–100.0 ha – 26 objects (6.4%);

g) 100.1–250.0 ha – 22 objects (5.4%);

j) 250.1–500.0 ha – nine objects (2.2%);

k) 500.1–1000.0 ha – five objects (1.2%);

m) 1000.1–2500.0 ha – three objects (0.7%);

m) 2500.1–5000.0 ha – four facilities (0.9%);

o) 5000.1–10000.0 ha – one object (0.24%);

p) 10000.1–25000.0 – one object (0.24% of the total).

The results of the World Watch Institute (Washington) indicate that to maintain the proper functioning of ecosystems and landscape complexes, the area of “wild”, undamaged sites within region should be at least 10–12% of the total area, and the optimal area of protected sites 20%, while the reserve indicator for Vinnytsia region is 2.5% (Ovchynikova, 2019).

There are no protected objects of multifunctional significance with a strict nature reserve regime in the territory of the Vinnytsia region. The share of protected sites of a multifunctional purpose (NNP, RLP) is insufficient to ensure the conservation of species diversity. There is a small proportion of protected sites with an area of over 500 ha (14 sites – 3.4% of the total), which would serve as a biocentre of a regional ecological network.

The structure of the regional ecological network contains a large number of small protected objects (333) with an area of up to 50 ha – 82.4% of the total. They have a localized island character and cannot fully ensure the conservation of genetic and landscape diversity.

Furthermore, there are significant imbalances in the functional structure, quantity, area of the nature reserves and territories of the administrative areas. The largest number of nature reserves and territories are localized in Vinnytsia (45), Mogilev-Podolsky (33), Teplitsky (31), Trostyanetsky (30) districts, and the smallest in Kalinovsky – 5 (0.04% of the reserve), Oratovskyy 6 (0.3%), and Lipovetsky 6 (0.02%).

## CONCLUSIONS

At the current stage of development, the ecological network of the Vinnytsia region has an insufficient level of conservation to ensure normal functioning of ecosystems and landscape complexes. The majority of the 27 administrative-territorial districts have a critical, very poor or poor, level of preservation. Most of the NRF objects are insular and therefore they are unable to perform the function of biocentres protecting unique species and habitats from anthropogenic interference.

Analysis of the spatial and functional structure of the region’s ecological network showed the need for its revision and creation of new zoological and landscape reserves in order to increase the level of conservation and improve the functional efficiency of the network (the ability to preserve genetic and landscape diversity). While forming the ecological network of Vinnytsia region, it is necessary to pay more attention to providing multifunctionality to its elements and avoiding the creation of island objects.

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## VINICOS REGIONO (UKRAINA) SAUGOMŲ TERITORIJŲ TINKLO STRUKTŪRINĖ IR FUNKCINĖ ANALIZĖ KAIP REGIONINIO EKOLOGINIO TINKLO PAGRINDAS

### *Santrauka*

Ekologinio tinklo planavimui turi būti skiriamas ypatingas dėmesys. Vinicos regioninio ekologinio tinklo (REN) atveju siekiama apsaugoti ir atkurti tipinius kraštovaizdžio kompleksus. Ekologinio tinklo struktūra yra šakota ir nevienalytė, tačiau ją galima išplėsti ir optimizuoti. Kadangi Vinicos regioninis ekologinis tinklas yra kuriamas remiantis gamtos rezervato fondo (NRF) objektais ir teritorijomis, būtinas struktūrinis ir funkcinis NRF struktūros optimizavimas. Tyrimo tikslas – ištirti ekologinio tinklo erdvinę struktūrą, jos funkcinį išbaigtumą ir veiksmingumą, užtikrinantį biologinės įvairovės išsaugojimą. Straipsnyje analizuojama Vinicos REN struktūra ir funkcijos, atskleidžiama NRF tinklo formavimosi ir saugomų objektų pasiskirstymo tarp administracinių regionų dinamika, siūlomi jo optimizavimo būdai. Analizė rodo, kad, siekiant didesnio tinklo funkcinio efektyvumo, būtina peržiūrėti dabartinę struktūrą ir sukurti naujus zoologijos ir kraštovaizdžio draustinius, daugiau dėmesio skirti ekologinio tinklo elementų daugiafunkciškumui.

**Raktažodžiai:** ekologinis tinklas, biologinė įvairovė, gamtos rezervato fondas, rezervacijos lygis