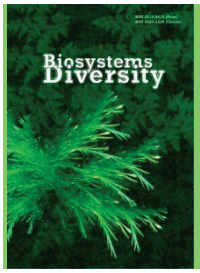

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How much space is needed for biodiversity conservation?

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The EU's 2030 Biodiversity Strategy and the Kunming-Montreal Global Biodiversity Framework call for 30% coverage of land and sea protected areas and strict protection for 10% of land area to prevent and reverse biodiversity loss. Ukraine has declared its aspiration to integrate into the European Union and must back up its statements with action and do everything to achieve such ambitious conservation goals. Like many European countries, Ukraine faces great challenges on this route. The significant level of anthropogenic transformation of the territories makes it very difficult to find new areas to expand the boundaries of the nature reserve fund. The practical steps to create nature reserves are significantly limited by legal mechanisms that guarantee land users' ownership of the relevant land plots. An important task in nature conservation is to develop indicators that can clearly and easily demonstrate the importance of areas for conservation. Such tools are necessary to convince policy makers and land users of the need to protect the relevant areas. The indicators of importance for biodiversity conservation should be scale-independent, as both large areas and small areas are important for conservation. In this article, we consider the case of a project to expand the boundaries of the Dnipro-Orylskiy Nature Reserve by adding five areas directly adjacent to it. The number of species included in the various Red Data Lists was chosen as an indicator of the conservation value of the territory. The species-area relationship was used to assess the role of scale. The number of species on the Red Lists was considered instead of the classical relationship that considers the total number of species in a community. The normalised deviation from the regression relationship was considered as an indicator of the conservation value of the respective area, which is statistically independent of the area of the site. The different Red Lists are compiled according to different criteria, so the indicator of conservation value for each Red List focuses on the relevant conservation aspect. The results of the conservation value assessment can be presented graphically, which clearly demonstrates the role of the respective areas in the maintenance of biological diversity. The proposed algorithm for assessing conservation value can be applied to a wide range of environmental protection tasks. In terms of further research, it is important to assess the role of ecosystem function assessment in the design of protected areas.

Keywords: nature reserve fund; extension of boundaries; landscape integrity; biodiversity; sozology; conservation status; rare species; nature conservation.

Introduction

Systematic conservation planning has a strong theoretical basis that allows for optimizing trade-offs between biodiversity conservation and other socioeconomic goals (Kendall et al., 2015). The main objective of nature reserve functioning is to conserve biological diversity both at the ecosystem level and at the level of individual communities and species (Franklin, 1993). A sufficiently large territory is needed to achieve this goal (European Commission, 2022). In small areas, all ecosystem components are practically impossible to preserve, including highly mobile and area-demanding species such as large mammals (Pillay et al., 2011), large birds (Alerstam & Hogstedt, 1982), migratory fish (Boerder et al., 2019), etc. The problem of the area of nature conservation objects has long been discussed by experts in the field of nature protection (Maxwell et al., 2020), and the prevailing opinion at the moment is that the protected areas should be as large as possible to contain sustainable populations of absolutely all species of living creatures living in these ecosystems (Hupke, 2023).

The movement to increase protected areas started in earnest at the 1982 World Parks Congress in Bali, where all countries were encouraged to aim to protect 10% of their territory. A decade later, protected areas received renewed support at the landmark Rio Summit, or United Nations Conference on Environment and Development in 1992 (Naughton-Treves et al., 2005). Around the world, there is a trend towards a significant increase in the area of protected areas. Unfortunately, Ukraine is among the countries with less optimistic dynamics of area growth (Zimmerer et al., 2004). The Strategic Plan for Biodiversity 2011–2020 was adopted at the tenth meeting of the Conference of the Parties to the Convention on Biological Diversity in 2010 ("SCBD 2010") to ensure the effective implementation of biodiversity actions by all parties and stakeholders, and to provide a flexible framework for setting national and regional biodiversity-related targets. It is also considered to be a comprehensive and flexible framework that is consistent with the objectives of all biodiversity-related conventions (Coates, 2016). Target 11 of this strategic plan was to achieve the objective that by 2020, at least 17% of terrestrial ecosystems and inland waters and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, would be conserved through effective and equitable management, ecologically representative and well-connected protected area systems and other effective area-based conservation measures, and integrated into wider landscapes and seascapes (Rees et al., 2018). This goal was almost achieved (UNEP-WCMC and IUCN, 2021).The EU's 2030 Biodiversity Strategy and the Kunming-Montreal Global Biodiversity Framework call for 30% coverage of land and sea protected areas and strict protection for 10% of land area to halt and reverse biodiversity loss (commonly abbreviated to '30 by 30') (Spiliopoulou et al., 2023). For European countries whose landscapes have been deeply shaped by thousands of years of land use and human impact, the target of 10% of land under strict protection is an ambitious one. The 10% target for protected areas has been chosen on

the basis of global and European objectives to conserve the world's heritage for future generations and to ensure a high level of protection for wildlife and endangered species (Dinerstein et al., 2017). A strictly protected area is a fully and legally protected space devoted to the conservation or restoration of the integrity of biodiversity-rich natural areas with their basic ecological structure and supporting natural ecological processes, according to the European Commission's working document (EC 2022). Within these areas, the natural processes are essentially undisturbed by anthropogenic pressures and threats to the overall ecological structure and functioning of the area. They may be inside or outside the strictly protected area. These categories are effective only if they remain largely undisturbed, with limited and well-controlled activities that do not disturb natural processes. Management activities may be permitted to maintain or enhance natural processes and the restoration or conservation of the habitats and species for which the area has been designated (Leberger et al., 2020).

In the mid-1980s, British ecologist Norman Myers proposed a conservation strategy of "biodiversity hotspots" (Myers, 1993). This strategy focuses on the regions with exceptionally high concentrations of endemic species and significant habitat loss. The "hotspot" approach should be complemented by a "coldspot" approach to protect and conserve areas with lower species richness but which provide important ecological services such as water capture or carbon sequestration, or have scenic beauty (Kareiva & Marvier, 2003). Conservationists are convinced of the need to protect larger areas of land for many reasons. The majority of protected areas are not large enough to support an adequate number of populations of rare or widespread species, or to maintain ecosystem-level processes that support biodiversity, such as natural fire regimes (Newmark, 1996). The majority of protected areas in the world are less than 10,000 hectares in size, accounting for approximately 80% of the world's IUCN protected areas in categories I–VI (Naughton-Treves et al., 2005). The protected areas of small size are important locally and can support global biodiversity conservation by improving matrix habitats, connectivity, and conservation of local ecosystems (Baldwin & Fouch, 2018). But only protected areas larger than 10,000 hectares are suggested to have the potential to delay long-term species loss (Cantú-Salazar & Gaston, 2010). Implementing the concept of wilderness in densely populated European countries with few remaining primary habitats is a challenging task. The fragmentation, compactness and size of natural forested areas can be criteria for the establishment of protected areas (Brackhane et al., 2019). Strictly protected areas support a greater diversity of mammals than similar areas with less strict management, with particularly strong impacts on larger and endangered species. Expanding the area under strict protection will help conserve iconic species (Ferreira et al., 2020).

The species-area relationship (SPAR) (Arrhenius, 1921) was a central concept in conservation science that originated in the 1970s and early 1980s (Matthews et al., 2019). The evident coherence of SPAR for natural areas suggests that it could be used to predict the number of species that would be conserved within the isolated boundaries of a nature reserve. The SPAR concept proves that larger reserves are better because they support more species (Diamond, 1975). Because SPAR does not require detailed knowledge of the needs of individual species, it is used to estimate the local species richness and predict the impact of habitat loss and fragmentation on biodiversity (Neigel, 2003). Species, including threatened and endangered species, require a wide range of areas and are more likely to be lost in small protected areas. Small reserves are also less successful at including rare species (Gaston, 1994). The theory and the evidence for the conservation benefits of large protected areas over small ones is clear for a number of organisms. However, in certain situations, small protected areas can also make a considerable and practical contribution to conservation success (Kendal et al., 2017). By the end of the 1980s, the equilibrium theory was no longer seen as the paradigm for reserve creation (Murphy, 1989). The new direction in reserve creation was to manage individual populations to prevent extinction and loss of genetic diversity. The SLOSS (single large or multiple small) discussion led to the development of a three-step process for assessing minimum reserve sizes. The first step requires the identification of target or keystone species whose extinction would significantly reduce the value or species diversity of the reserve. The second step is to determine the minimum number of individuals in the population required to guarantee a high probability of survival of the key species. Based on known densities, the required area to maintain the minimum population size can be determined (Soulé & Simberloff, 1986). This 'small population paradigm' led to a new appreciation of autecological research, as opposed to theoretical predictions of changes in community composition. It has also been argued that SPAR is not relevant to the problem of reserve creation, because in the future there will be no large areas available for conservation and the only practical course of action will be intensive management and administration of small reserves (Simberloff, 1988).

The aim of our study was to examine the territories adjacent to the Dnipro-Orylskiy Nature Reserve (Dnipropetrovsk oblast) and identify their landscape and ecological value in order to expand the boundaries and improve the efficiency of the main functions of protecting the biological and landscape diversity of the Dnipro River basin. To achieve this aim, the following objectives were formulated: to survey the territories and water areas adjacent to the boundaries of the Dnipro-Orylskyi Nature Reserve; to identify the presence of landscape and ecologically valuable areas and habitats near the existing nature reserve; to justify the need to expand the existing boundaries of the the Dnipro-Orylskiy Nature Reserve.

Material and methods

The Dnipro-Orylskiy Nature Reserve was created by the Decree of the Council of Ministers of the Ukrainian SSR of 15.09.1990 No. 262 on the basis of the general zoological and ornithological reserves "Taromskyi Ledge" and "Obukhivski Plavni" on the territory and waters of the floodplain systems of the upper part of the Dnipro Reservoir between the Dnipro River and the new channel of the Oryl River. At that time, the reserve included the lands of the Dnipropetrovs'k Forestry Enterprise (888 hectares), Kirovskyi State Farm (72.2 hectares), water fund lands (203 hectares), and Dniprodzerzhynsk Forestry Enterprise (2603 hectares). The current area of the Dnipro-Orylskiy Nature Reserve is 3759.4 hectares, with more than 30% of its area covered by water (Yakovenko et al., 2023). The reserve is located in the Dnipro district of Dnipropetrovsk oblast (region). This nature reserve was created to preserve the unique landscape of the middle Dnipro valley and the Oryl River with a complex of characteristic flora and fauna. The reserve represents the landscape and biodiversity of the Dnipro valley and its floodplain and tributary, the Oryl River (Stefanskyi, 2023).

The creation of the reserve at that time was the result of a tense public struggle, in which a significant role was played by the principled position of some local residents, including fisheries inspectors and gamekeepers, the active and purposeful activities of the Dnipro branch of the Ukrainian Society for Nature Protection under the leadership of O. G. Lyndya, and the strong support of biologists from Dnipro State University, headed by V. L. Bulakhov with the participation of S. M. Tarasenko, A. A. Gubkin, and V. V. Tarasov. At the suggestion of the scientists, the Dnipro-Orel Nature Reserve was to include valuable forest areas on the left bank of the Oryl River (with unique isolated boreal flora in birch and aspen groves and sphagnum bogs), as well as the Mykolaiv Sandy Steppe. But this has not happened to this day, and the islands of boreal vegetation on the left bank of the Oryl River near the village of Obukhivka have been almost completely destroyed over the past 30 years as a result of construction, forest fires, and deforestation. The Dnipro-Orylskiy Nature Reserve is a part of the Emerald Network of Ukraine (Dniprovske reservoir UA 0000093 and Dnipro-Orylskiy Nature Reserve UA 000004), and is a nature conservation research institution of national importance. In addition, the unique landscape and ecological complexes of the reserve led to the granting of the International Conservation Status as a wetland in 2004 to a part of the reserve's territory (2560 hectares, which is almost 70% of its total area) under the Ramsar Convention.

Comprehensive scientific research was carried out during 2018–2023 in the territories and water areas adjacent to the boundaries of the Dnipro-Orylskiy Nature Reserve (Fig. 1). A set of field and laboratory research methods was used in the following areas: botanical, zoological, landscape, geological, and cartographic. Material sampling was carried out according to standard modern research methods. When studying the vegetation of water bodies, the generally accepted methods of describing the species

and community composition of vegetation and hydrobotanical mapping were used. After preliminary familiarization with 1:10,000 scale cartographic materials and materials, vegetation studies were conducted to identify and describe the main phytocoenoses, their composition, and distribution on the territory.

Floristic studies were conducted according to the method of collecting herbarium material. Vascular plant species lists were recorded for each 3×3 m sampling point, along with a visual assessment of species coverage using a Braun-Blanquet scale (Westhoff & Van Der Maarel, 1978). The projective cover of plant species was measured at soil level, understory (up to 2 m in height), and canopy (above 2 m in height) (Zhukov et al., 2023). All species were identified to species level at all sites (Gritsan et al., 2019; Kunakh et al., 2023). Plant taxonomy is based on Euro+Med Plantbase (http://ww2.bgbm.org/EuroPlusMed) (Yorkina et al., 2022).

Entomological data was collected and processed according to standard methods (Brygadyrenko, 2015; Putchkov et al., 2019; Ferro & Summerlin, 2019). The entomofauna was surveyed during the day using an entomological net, entomological mowing, collection of insects from tree trunks, manual litter analysis, etc. (Tutova et al., 2022). Insects were collected in a number of habitat types, such as: thickets of large sedges mainly without stagnant water (D5.2), continental salt marshes (D6.1), open non-Mediterranean dry acidic and neutral grass communities, including continental grass communities on dunes (E1.9), low and medium altitude hay meadows (E2. 2), wet or humid eutrophic and mesotrophic meadows (E3.4), wet or humid tall grass and fern fringes and meadows (E5.4), continental inland saline steppes (E6.2), riverine willow forests (G1. 11), mixed oak-elm-ash forests of large rivers (G1.22), oak-ash-hornbeam forests on eutrophic and mesotrophic soils (G1.A1), Sarmatian steppe forests with *Pinus sylvestris* (G3.4232).

Terrestrial vertebrates were recorded using methods adapted for research in conservation areas (Villegas-Patraca et al., 2022). Batrachofauna studies were conducted according to a standard methodology, taking into account the landscape features of the region (annual and long-term dynamics of the hydrological regime, the amount and nature of precipitation, etc). Species identification was performed according to the Handbook of Amphibians of Ukraine (Pisanets, 2007). Herpetofauna surveys were carried out according to standard methods. Commonly used methods of transect and point counts were used. Bird surveys in the studied areas were conducted in forested areas using route surveys without limiting the survey area. Waterfowl surveys were carried out taking into account their biology and ecology. Bird data were collected using the line-transect method without restricting the width of a transect (Järvinen et al., 1975). The density of bird populations was calculated using the Distance package (Miller et al., 2019). Birds were recorded visually and by voice. Flying birds were excluded, except when feeding airborne over the transects. We used 12-X binoculars to identify birds. Each transect was located within a homogeneous habitat. Bird counts were conducted from 6:00 a.m. to 10:00 a.m., during peak bird activity, and only in good weather (no heavy wind or rain). At least two surveys were conducted during the nesting period, which usually lasts from 20 April to 20 June. The speed of the bird observer along the transect was 2 to 4 km/h. We apply Stegman's (1938) bird taxonomy (Stegman, 1938). Bird encounters were recorded on special cards, scaled to 1:200,000 maps, and then transferred to the ArcMap 10.2 software.

Fig. 1. Map of the location of the Dnipro-Orylskiy Nature Reserve (Dnipropetrovsk region, Ukraine)

Ichthyological surveys were carried out by a technique to investigate the quantitative and qualitative composition of fish assemblages (Arsan et al., 2006). Fish collection was performed in different coastal biotopes (Bondarev et al., 2022). Smooth bottom coverage allowed the use of seine nets (Žiliukas et al., 2012). The main benefits of using seine nets are low selectivity and ease of operation during fishing (Pierce et al., 1990; Paradis et al., 2008; Kratochvíl et al., 2010). In the coastal zone, fishing was conducted using a 15 m long and 2 m high beach seine with a bag (mesh size 3 mm). One end of the seine was held on the shore. The other end was fully extended perpendicular to the shore. The seine was closed on shore. Each haul covered an area of approximately 50–300 m^2. The depth of the hauls did not exceed 1.7 m. Samples included both adult and juvenile fish. A fish was considered to be a juvenile from the time it became scaled, morphologically resembled an adult and was sexually immature (Treasurer, 1978). The age of the fish was determined on the basis of the work of Chugunova (1952). During the accounting of species richness and abundance of small mammals, the guidelines of Zagorodniuk et al. (2002) were used. Relative abundance, species affiliation and ecological features of large mammals were determined during route surveys aimed at detecting traces of their presence: tracking activity, burrows, eaten sprouts of young trees, bark, visual contacts. Chiroptera were recorded using the same methods as birds (during their flights). Counts were made along the routes. In addition, while on the territory, the places of concentration of these animals (tree hollows, abandoned birdhouses, etc.) were identified by ear.

The conservation categories of plants and animals were identified according to the Red Data Book of Ukraine (2021), the Red List of Plants of Dnipro Region (Baranovsky & Tarasov, 2010), and the Red List of Animals of Dnipro Region (Pakhomov, 2011).

Results

Configuration of the plots planned for the expansion of the Reserve's territory. The land boundary of the reserve is parallel to the Dnipro River shoreline (upper reaches of the Dnipro Reservoir) near Mykolaivka village, Dnipro district. From the floodplain lake Velyka Khatka, it turns steeply to the north and coincides with the contours of the artificial forest plantations. The northernmost point of the territory forms the top of a triangle, from which the boundary continues eastwards, crosses to the left bank of the new Oril riverbed and runs along it to its confluence with the Dnipro. The water boundary of the Reserve runs along the Dnipro Reservoir from the mouth of the Oril to the Taromsky ledge, including Kamyanysty (block 45), Kryachyny (block 44) and partially Korchuvyny (block 61) islands. Further, the boundary of the reserve runs along the Dnipro coastline to the Mykolaiv ledge. A 50-metre protection zone is established along the boundary of the reserve along the Dnipro Reservoir, and the total area of its protection zone is 3125 hectares (Fig. 2).

A survey of the territory adjacent to the Dnipro-Orylskiy Nature Reserve revealed the presence of valuable areas in terms of landscape and ecology. In general, the territory planned for expansion of the reserve boundaries is represented by the left-bank floodplain and the Dnipro floodplain terrace with predominantly forest, shrub and, partially, meadow lands, as well as islands on the Dnipro River. It consists of five plots: 4 of them border the Reserve to the north and west, and one plot consisting of two islands to the south. The total area of the territory proposed for expansion is 618.9 hectares. The expansion will increase the total area of the reserve by 16.5%. The territory planned for expansion is represented by a wide range of typologically heterogeneous landscapes (water, island and coastal areas, areas with forest, meadow floodplain systems, as well as pine and mixed plantations of the floodplain terrace). According to the geobotanical zoning of Ukraine, this territory is located within the Eurasian steppe region, steppe subregion, Samara left-bank district of mixed-grass steppes, gully forests and saline meadows. The biodiversity survey of the areas planned for expansion of the Dnipro-Orylskiy Nature Reserve showed the presence of plant and animal species of different classes that require protection in the study area.

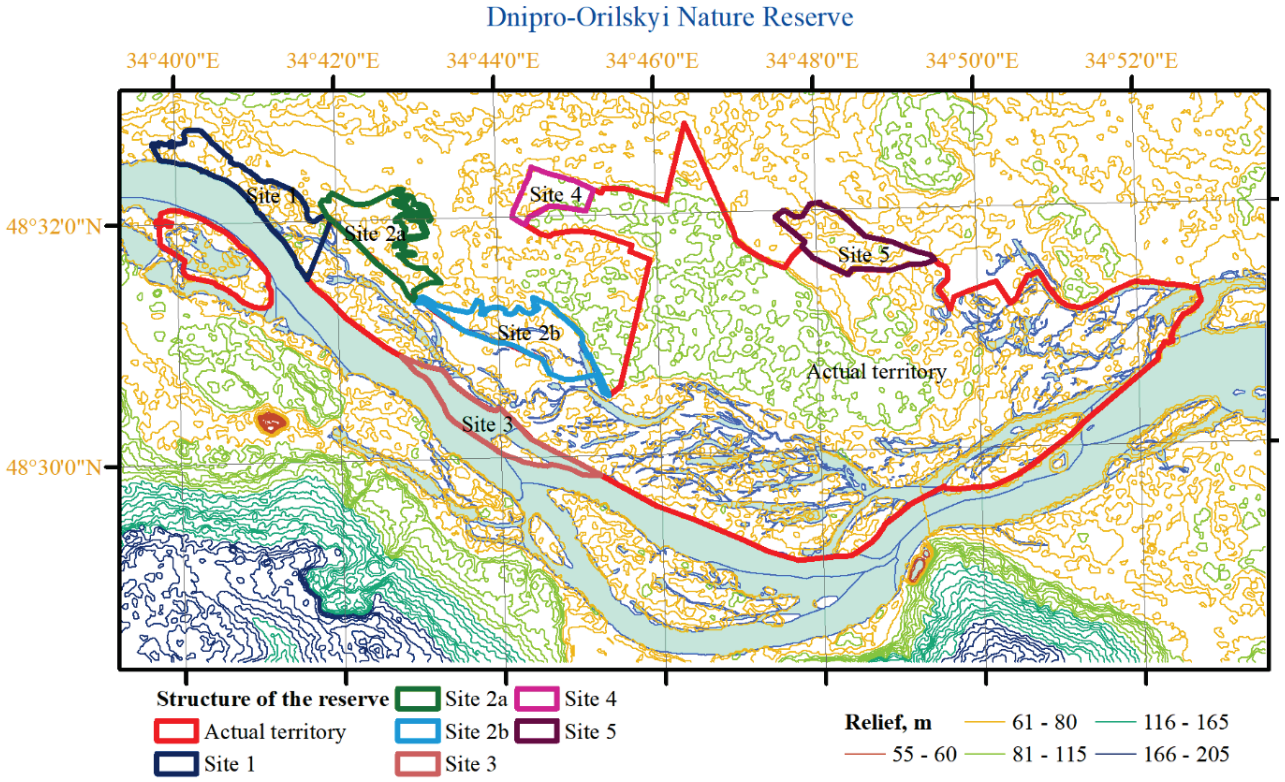

Fig. 2. Structure of the protected area of the Dnipro-Orylskiy Nature Reserve: current area and proposed sites for expansion

Floodplain ecosystems (Site #1). Site #1 has a total area of 163 hectares. The site is located exclusively in the floodplain landscape of the Dnipro River (left bank) and partially in its channel (50 m zone from the water's edge), south of Mykolayivka village of Obukhiv settlement territorial community of Dniprodistrict of Dnipropetrovsk region. The northeastern boundary of the site runs almost along the winding bank that separates the floodplain from the first Desna terrace (arena) and is accentuated by arched fragments of the large relict Somivka coastal pond. This old waterhole is punctuated by a chain of lakes and runs almost along the border of the floodplain and the Dnipro's I and II overflank terraces. The south-western boundary of the site is the Dnipro riverbed and shoretline. The floodplain area of the site includes a developed multi-age oxbow-lake network,

in particular, an arcuate long bay (up to 1500 m long with a predominant width of 40–60 m). This bay is part of the second relict oxbow, which is younger in geomorphology than the Somivka. The latter formed the lakes Ostup and Zasukha outside the site.

Site #1 includes characteristic shoreline, meadow, wetland and forest ecosystems. In the water area of the Dnipro shoreline zone and inland water bodies, communities of higher aquatic vegetation are formed with submerged species, such as hornwort (*Ceratophyllum demersum* L.), curly pondweed (*Potamogeton crispus* L.), claspingleaf pondweed (*Potamogeton perfoliatus* L.), and spiny water nymph (*Najas marina* L.). The floating aquatic vegetation consists of such species as common frogbit (*Hydrocharis morsus-ranae* L.), common duckweed (*Lemna minor* L.), water fern (*Salvinia natans* (L.) All.), yellow pond lily (*Nuphar lutea* (L.) Smith), water pineapple (*Stratiotes aloides* L.), floating water chestnut (*Trapa borysthenica* V. Vassil.). Shoreline vegetation is represented by thickets of common reed (*Phragmites australis* L.). The forest communities are formed mainly by black poplar *Populus nigra* L., white poplar *Populus alba* L. and fragmented stands of brittle willow (*Salix acutifolia* Willd.). There are also small areas of floodplain elm oaks dominated by English oak *Quercus robur* L. and European white elm *Ulmus laevis* Pall. The shrub layer is formed by black elder *Sambucus nigra* L., hedge maple *Acer campestre* L., box elder *Acer negundo* L., European spindletree *Euonymus europaea* L. and a large number of false indigo-bushes *Amorpha fruticosa* L. The herb layer is represented by such species as catchweed bedstraw *Galium aparine* L, European dewberry *Rubus caesius* L., stinging nettle *Urtica dioica* L., cow parsley *Anthriscus sylvestris* (L.) Hoffm and chervil *Anthriscus cerefolium* (L.) Hoffm. Bog communities are formed by sharp slender tufted-sedge *Carex acuta* L. and reeds. Small patches of wasteland meadows with psammophytic vegetation are dominated by Becker's fescue *Festuca beckeri* (Hack.) Trautv. and Volga fescue *Festuca valesiaca* Gaud. Among the found and identified flora species in the relevant area of the Reserve's potential expansion, there are regionally rare species included in the Red List of Plants of Dnipropetrovsk Region: lily-of-the-valley *Convallaria majalis* L., alpine squill *Scilla bifolia* L.

The territory is characterised by a unique azonal community of insects of nemoral fauna. The vast majority of species (about 55%) are dendrophages, while 45% are predators, herbivores, saprophages and coprophages combined. In addition to the diversity of the entomofauna (about 1,500 species), the presence of rare and endangered insect species within the proposed expansion area is of particular value for the conservation of the gene pool. The presence of 10 endangered species was confirmed, including 8 species listed in the Red Data Book of Ukraine, four species protected by the Bern Convention (Appendix II and III), three species included in the European Red List, and two species protected by the Red List of the International Union for Conservation of Nature (Fig. 3).

The territory of site #1 also includes the coastal open water area of the Dnipro riverbed (50 m wide) and adjacent floodplain reservoirs and channels. It should be noted that the upper reaches of the Dnipro Reservoir above the city of Dnipro, especially on its left bank, are of key importance for the reproduction of the native (original) fish fauna. Therefore, the entire preserved floodplain system of the Dnipro left bank is a natural spawning ground and feeding ground for young fish. A significant part of the water area is part of the reserve, but some valuable areas require a protection regime. It is worth noting that one of the largest wintering pits (aquatic bioresources wintering areas) is located near the study area, in the Dnipro riverbed, which further increases its value. Of the 40 species of fish that live here, a significant number have a conservation status at the regional (Red List of Dnipro Region – 7 species), national (Red Data Book of Ukraine – 4 species) and international levels (Bern Convention, Appendices II, III – 11 species) (Fig. 3). Taking into account the nature of stay of most species at the critical stages of their life cycle (spawning migration and spawning, winter migration, fattening of young of the first year of life), the value of this site cannot be overestimated.

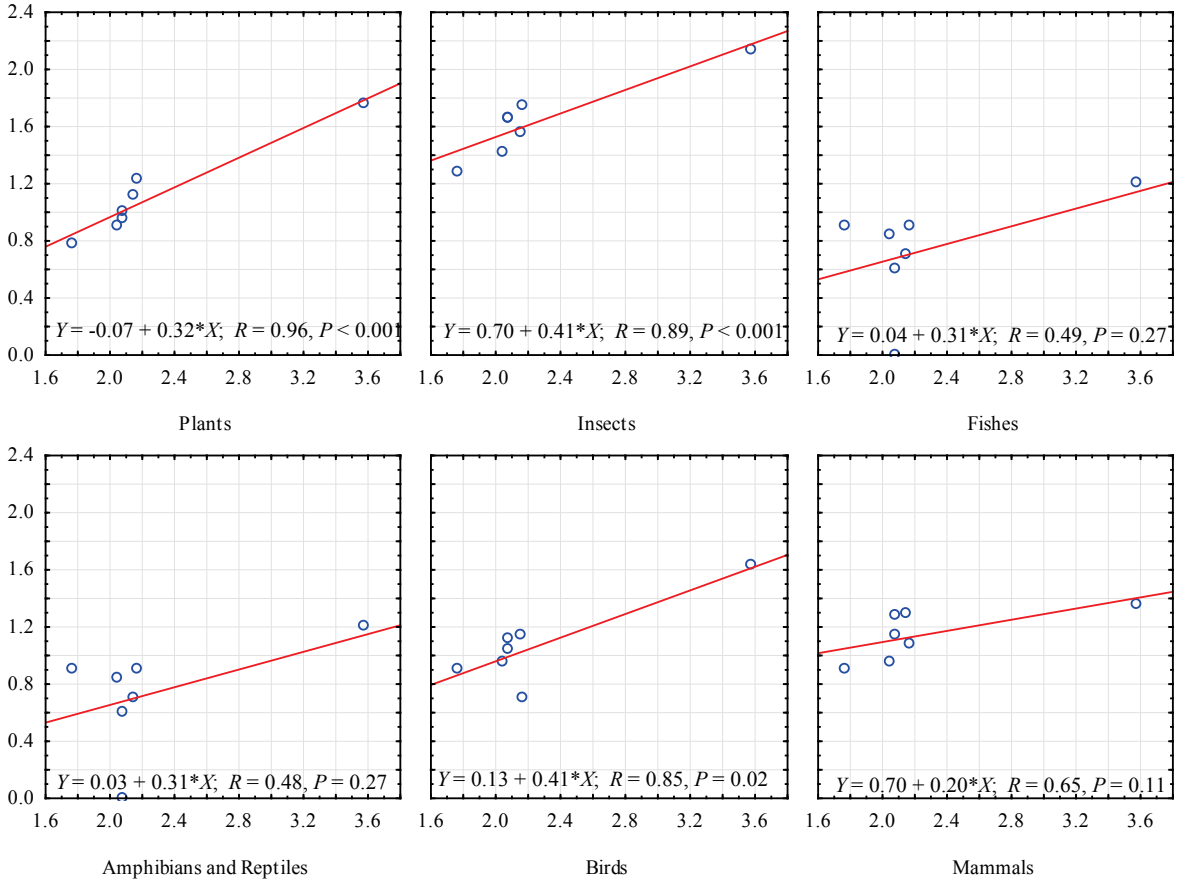

Fig. 3. Dependence of the number of species from the Red List of Dnipro region on the area of the reserve and the areas planned to be included in the reserve ($Radj^2 = 0.69$, $F = 9.1$, $P < 0.001$): the abscissa is the logarithm of the area of the site (ha), the ordinate is the logarithm of the number of species; the area is a totally statistically significant predictor of the number of species for all groups of living organisms ($F = 29.3$, $P < 0.001$)

The investigation of the batrachofauna and herpetofauna complex shows the presence of at least 6 species of amphibians and 3 species of reptiles, of which 3 species are regionally rare, 8 species are listed in Appendices II and III of the Bern Convention, 3 species are protected by the Ramsar Convention, one species is included in the European Red List, and one species is included in the list of the International Union for Conservation of Nature.

At least 66 species of birds are found in the study area, representing five ecological complexes: forest, wetland, forest edge, synanthropic, and campophilous. The summer bird fauna is the richest in terms of the status of residence in the study area, the second in terms of species diversity is the migrant group, and the third is wintering species. The high indicators of the first two groups indicate a rather high value of the study area as a breeding ground for bird populations and a resting place for birds during migrations. One species of avifauna is listed in the Red Data Book of Ukraine (great grey shrike *Lanius excubitor* L.), 60.6% are listed in Appendix II of the Bern Convention, 33.3% are listed in Appendix III of the Bern Convention.

The presence of 32 species of mammals belonging to 6 orders and 12 families was recorded in the site #1. This level of diversity is quite significant: the species composition of this area quantitatively makes up 23.9% of the total species composition of mammals in Ukraine. The 6 mammalian orders present account for 75% of the total number of mammalian orders present in our country. The typical fauna of the study area is represented by species of the forest ecological complex of mammals (44%) with a smaller participation of species of the eutrophic (19%), wetland (16%), synanthropic (13%) and steppe (9%) complexes. Among the mammal species found in the study area, there are species that require protection and are included in the protection categories of different levels, namely the Red Data Book of Ukraine (5 species), the Red List of Dnipropetrovsk Oblast (11 species), the Appendices of the Bern Convention (15 species) (Appendices II and III), the Bonn Convention (4 species) and the Washington Convention (1 species) (Fig. 4).

Floodplain lakes (Site #2). Site #2 has a total area of 237 hectares. The site is located on the highest and most ancient part of the floodplain on the left bank of the Dnipro River. This part is characterised by the presence of a fragment of a chain of lakes of the shoreline old water, locally known as Somivka. Also present here are lake chains of at least two younger Dnipro oxbows. The lake relics of all the old waterways have a characteristic arched shape and emphasise the outlines of the ancient banks of the Dnipro. Together, they, along with numerous bogs, form a complex network of small water bodies that represent a unique area for the settlement of rare and endangered biota. On the territory of site #2, there are aquatic, coastal, meadow, wetland and forest ecosystems typical of the riverbed, central and near-terrace floodplain. The forest ecosystems are represented by sedge and willow-sedge forests and oak forests. Among the identified and defined species of flora in the area of the Reserve expansion, there are 2 species listed in the Red Book of Ukraine and 12 regionally rare species (Red List of Plants of Dnipropetrovsk Region). The territory of the site #2 is represented by a wide range of habitats, which leads to a large diversity of invertebrates in the area. The distribution of dendrovores and herbivores of the territory is approximately equal, and the species composition of the insect fauna according to the lowest estimates is 2000 species. Among them, the presence of 9 protected species of insects has been established, 8 of which are listed in the Red Data Book of Ukraine, three species are protected by the Bern Convention (Appendices II and III), two species are included in the European Red List, and 1 species is protected by the Red List of the International Union for Conservation of Nature (Fig. 5).

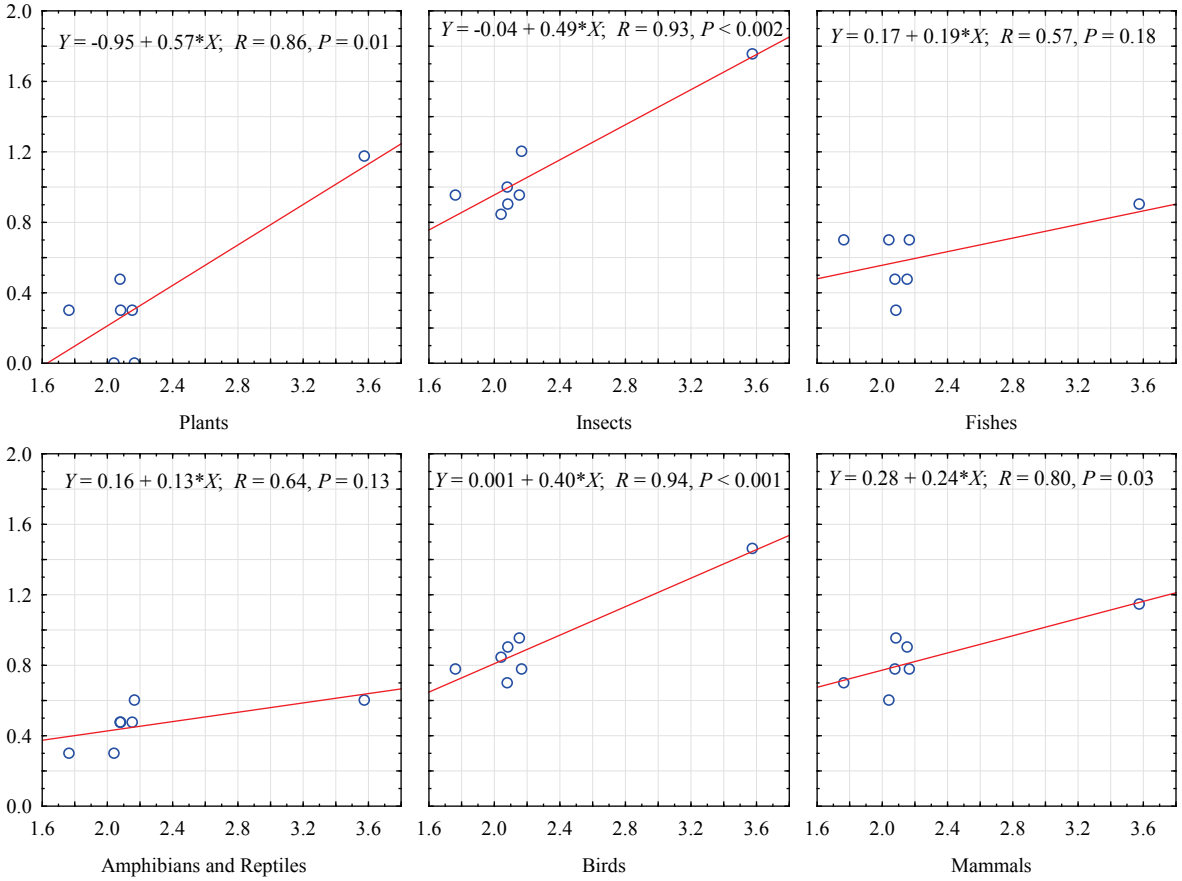

Fig. 4. Dependence of the number of species from the Red Data Book of Ukraine on the area of the reserve and the areas planned to be included in the reserve ($Radj^2 = 0.83$, $F = 18.8$, $P < 0.001$): the abscissa is the logarithm of the area of the site (ha), the ordinate is the logarithm of the number of species; the area is a totally statistically significant predictor of the number of species for all groups of living organisms ($F = 66.9$, $P < 0.001$)

The site #2 also includes floodplain water bodies (small lakes) and channels that were once connected to the Dnipro riverbed. Today, these water bodies retain their hydrological connection only partially, they are silted up and overgrown with aquatic vegetation, especially surface vegetation (reeds, etc.). However, in years with high water levels, these water bodies are partially washed out, and spawning fish of various species enter

them for natural reproduction, albeit in reduced numbers. After spawning, the breeders migrate to the Dnipro, and later, in late July and August, the young fish also migrate.

Of the 25 species of fish that live here, a significant number have a protected status at the national (Red Book of Ukraine – 1 species), regional (Red List of Dnipro Region – 3 species) and international levels (Bern Convention, Appendices II, III – 7 species). Some of these species make spawning migrations, while others stay permanently (the latter are resident).

The study of the batrachofauna and herpetofauna complex shows a rich spectrum of amphibians and reptiles in the area of site No. 2. The presence of at least 7 species of amphibians and 6 species of reptiles has been recorded, of which 7 species are regionally rare (Red List of Dnipro Oblast), all 13 species are listed in Appendices II and III of the Bern Convention, 4 species are protected by the Ramsar Convention, 3 species are listed in the European Red List, and one species is listed in the Red List of the International Union for Conservation of Nature.

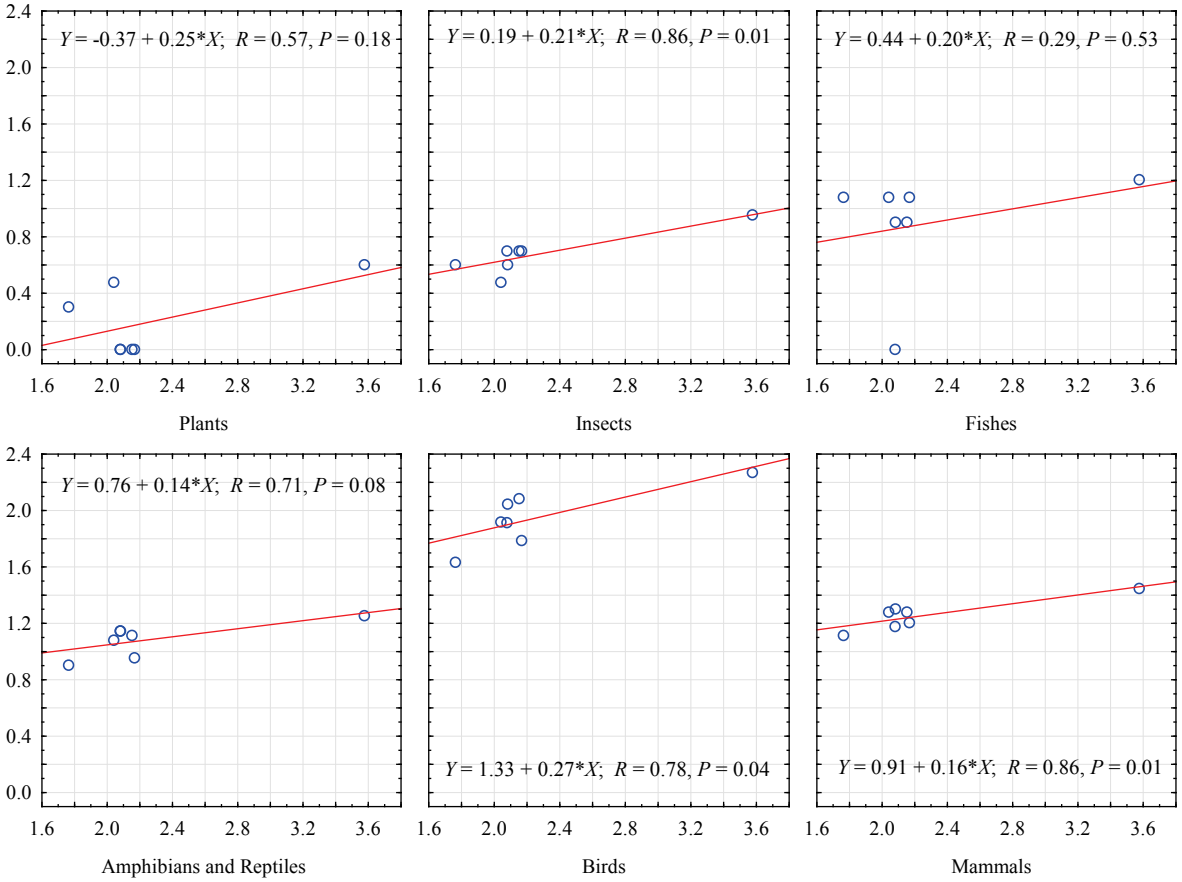

Fig. 5. Dependence of the number of species from the Berne Convention Lists on the area of the reserve and the areas planned to be included in the reserve ($Radj^2 = 0.87$, $F = 24.0$, $P < 0.001$): the abscissa is the logarithm of the area of the site (ha), the ordinate is the logarithm of the number of species; the area is a totally statistically significant predictor of the number of species for all groups of living organisms ($F = 11.6$, $P < 0.001$)

At least 115 species of birds (with different status of residence) were found in the study area, and the representatives of five ecological complexes of birds were present: wetland, forest, forest edge, campophilous, and synanthropic. The high representation of migrants and summer birds indicates that the study area is of high value as a breeding ground for bird populations and a resting place for birds during migrations. 7 species of avifauna are listed in the Red Data Book of Ukraine (osprey, Montagu's and hen harriers, white-tailed eagle, grey crane, barn owl, great grey shrike), 10.4% are listed in the Red List of Dnipro Region, 61.7% are listed in Appendix II of the Bern Convention, 33.0% are listed in Appendix III of the Bern Convention (Fig. 6).

The presence of 37 species of mammals belonging to 6 orders and 13 families was recorded at site 2. The species composition of this area quantitatively makes up 27.6% of the total species composition of mammals in Ukraine. The 6 mammalian orders present in the projected area for conservation account for 75% of the total number of mammalian orders present in our country. The typical fauna of the projected part of the protected area includes representatives of the forest ecological complex (46%) with a smaller participation of species of the eutrophic (16%), wetland (14%), synanthropic (8%) and steppe (16%) complexes.

Among the mammalian species found in the study area, there are species that require protection and are included in the protection categories of different levels, namely the Red Data Book of Ukraine (8 species), the Red List of Dnipro Region (18 species), the Bern Convention (Appendices II and III) (19 species), the Bonn Convention (4 species), and the Washington Convention (2 species).

Dnipro River Islands (Site #3). Site #3 has a total area of 76.5 hectares. This area, proposed for expansion of the boundaries of the nature reserve, is located on two small unnamed islands and the adjacent water area of the Dnipro River, 25 m wide from the water's edge towards the riverbed and the water area from the inner side of the islands to the boundary of the reserve on the left bank of the Dnipro River. This site is also located to the south of site 1 and from the village of Mykolaivka in the Obukhiv village territorial community of the Dnipro district of Dnipro Region. The islands are located very close to the left bank of the Dnipro River and its floodplain, and they practically border the territory of the Reserve along the water area. The islands are elongated along the Dnipro riverbed from north-east to south-west. Both islands are about 1000 m long with a maximum width of 200 m in the northern parts. The northern island is separated from the shore by a strait about 40 m wide; in the southern part of the island there are two small elongated lakes, which may be relics of an old waterway. The southernmost island is separated from the shore by a strait about 200 m wide. It has two internal lakes (the largest is up to 80 m long), as well as floodplain-type areas in its northwestern part. A wide shoal stretches between the islands for a distance of about 400 m.

The formation of island ecosystems in the middle reaches of the Dnipro is associated with intensive processes of bank formation or erosion, re-

deposition of alluvial sediments, siltation, and spit formation. Intensive processes of synthesis take place here: newly formed land areas are quickly overgrown with coastal and aquatic vegetation dominated by common reed *Ph. australis* and broadleaf cattail *T. latifolia*. The vegetation cover protects the shores from erosion. The plant communities within the islands are represented by forest communities of willows and sedges. Inland water bodies of the islands form wetland complexes formed by hygrophilous herbs. In the water area around the islands, there are communities of higher aquatic submerged vegetation. Three regionally rare species included in the Red List of Plants of Dnipropetrovsk oblast and 2 species listed in Appendix II of the Bern Convention were found. Of the plant communities, three formations are included in the Green Book of Ukraine: yellow pitcher plant (*N. luteae*), arrow-leaved arrowroot (*S. sagittifoliae*) and floating salvinia (*S. natantis*) formations. 10 habitat types are included in Resolution 4 of the Bern Convention and two in the Habitats Directive (Fig. 7).

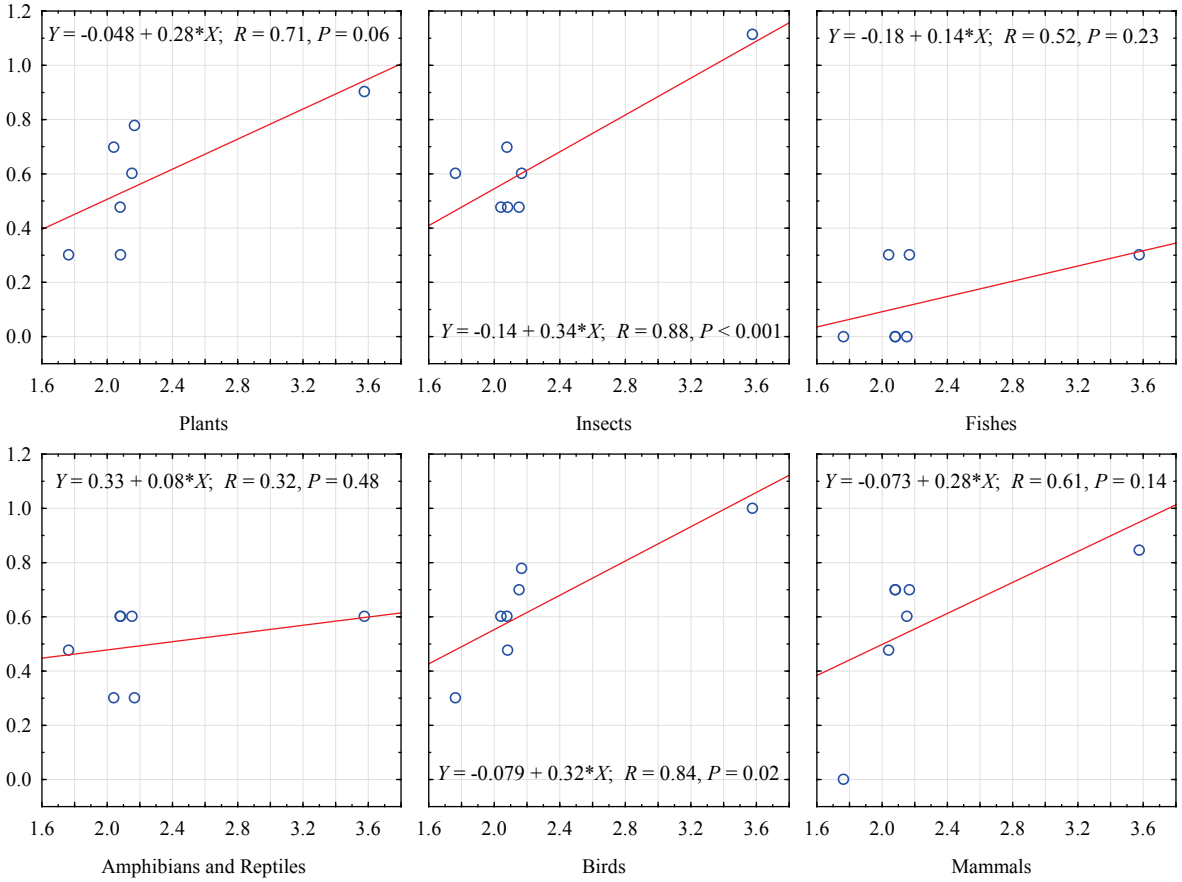

Fig. 6. Dependence of the number of species from the European Red Lists on the area of the reserve and the areas planned to be included in the reserve ($Radj^2 = 0.62$, $F = 7.1$, $P < 0.001$): the abscissa is the logarithm of the area of the site (ha), the ordinate is the logarithm of the number of species; the area is a totally statistically significant predictor of the number of species for all groups of living organisms ($F = 26.4$, $P < 0.001$)

The entomocomplex of the islands of site #3 has a somewhat reduced species composition due to its isolation from the land. It includes approximately 500–700 species of terrestrial invertebrates. The main proportion is composed of aquatic insects and insects whose development cycle is associated with water: Coleoptera, Diptera, Odonata, Hemiptera, Hemiptera, Trichoptera, Plecoptera, and Ephemeroptera. Of particular importance are the species with the conservation status, 6 of which were found. Five of them are listed in the Red Data Book of Ukraine, two species are protected by the Bern Convention (Appendices II and III), and two species are included in the European Red List.

Site #3 comprises the two small islands with an outer coastal zone of 25 m (open water area of the Dnipro riverbed) and the water area from the inner part of the islands to the boundary of the reserve, as well as shallow water between the islands and small island water bodies (lakes). This site has the main features of Site #1, but is distinguished by the presence of islands and shallow water between them. Accordingly, this site is also important for the reproduction of the native (original) fish fauna, and the young of the first generations of fish are fed here. Of the 39 species of fish that live here, a significant number have a protected status at the national (Red Book of Ukraine – 4 species), regional (Red List of Dnipropetrovs'k Region – 6 species) and international levels (Bern Convention, Appendices II, III – 11 species). Taking into account the nature of stay of most species at critical stages of the life cycle (spawning migration and spawning, winter migration, feeding of young of the first years of life), location near the islands with a reduced level of concern, the value of this site is undeniable. The study of the batrachofauna and herpetofauna complex shows the presence of at least 11 species of amphibians and 3 species of reptiles, of which 6 species are regionally rare. All amphibians are listed in Appendices II and III of the Bern Convention, 3 species are protected by the Ramsar Convention, 1 species is included in the European Red List, and 1 species is included in the Red List of the International Union for Conservation of Nature.

At least 85 species of birds are found in the area of site 3, with representatives of five ecological complexes of birds: wetland, forest, forest edge, campophilous, and synanthropic. The rich migratory and summer bird fauna indicate a rather high value of the study area as a resting place for birds during migration and a place for reproduction of bird populations. Based on the results of the analysis of species composition in the nature conservation lists of different jurisdictions, it should be noted that 5 species of the avifauna of this site are listed in the Red Data Book of Ukraine such as the black kite (*Milvus migrans* (Boddaert, 1783)), white-tailed eagle (*Haliaeetus albicilla* L.), little tern (*Sterna albifrons* Pallas, 1764), common goldeneye (*Bucephala clangula* L.), Eurasian oystercatcher (*Haematopus ostralegus* L.), 9.4% of species are listed in the Red List of Dnipropetrovsk Region, 64.7% of bird species are listed in Appendix II of the Bern Convention, 31.8% are listed in Appendix III of the Bern Convention. The presence of 17 species of mammals belonging to 5 orders and 8 families was recorded at the site #3. The species composition of this area quantitatively makes up 12.7% of the

total species composition of mammals in Ukraine. The 3 mammalian orders present in the projected area for conservation account for 62.5% of the total number of mammalian orders present in our country. The typical fauna of the projected part of the protected area is represented by representatives of the forest ecological complex (53%) with a smaller participation of species of the eutrophic (6%), wetland (29%) and steppe (12%) complexes. Among the mammal species found in the study area, there are species in need of protection and included in the protection categories of different levels, namely the Red Data Book of Ukraine (3 species), the Red List of Dnipropetrovsk Region (8 species), the Bern Convention (8 species) (Appendices II and III), the Bonn Convention (2 species) and the Washington Convention (1 species).

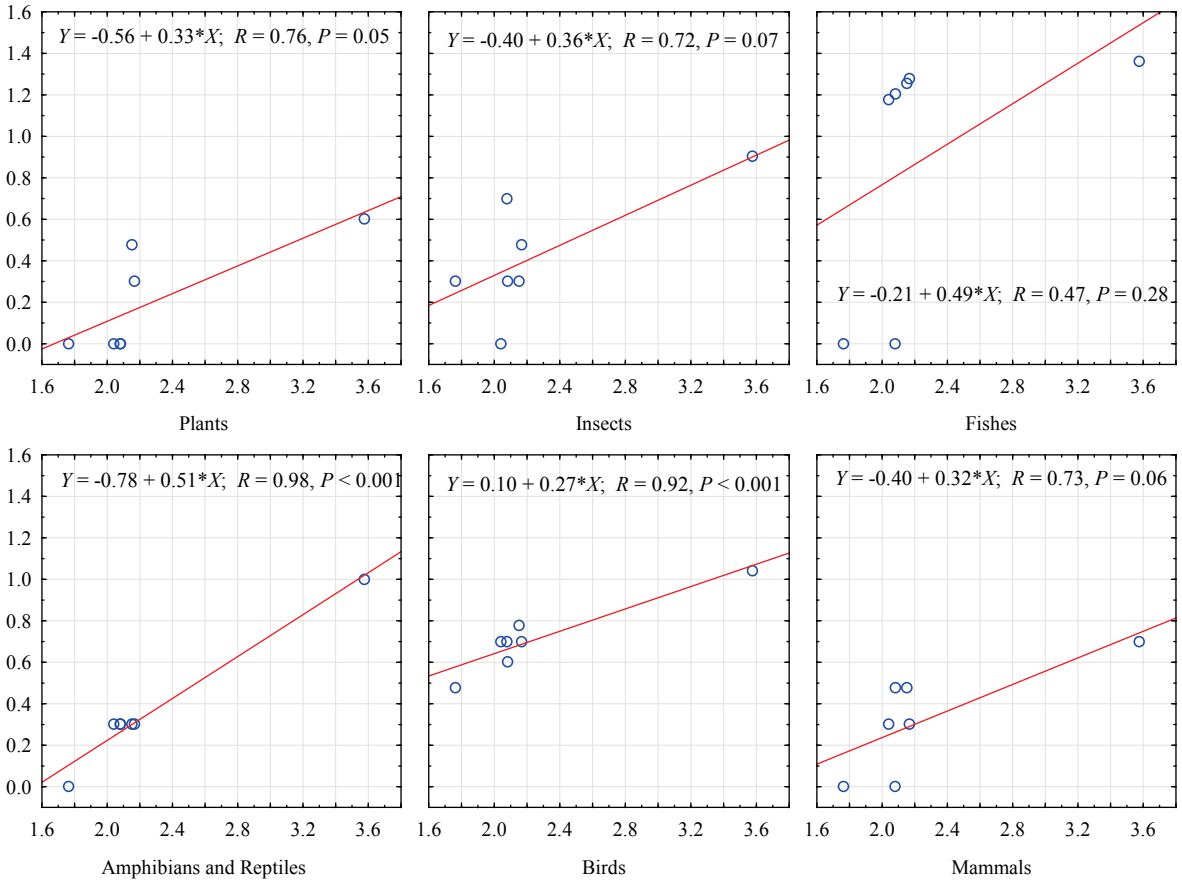

Fig. 7. Dependence of the number of species from the Red List of the International Union for Conservation of Nature on the area of the reserve and the areas planned to be included in the reserve ($Radj^2 = 0.51$, $F = 4.9$, $P < 0.001$): the abscissa is the logarithm of the area of the site (ha), the ordinate is the logarithm of the number of species; the area is a totally statistically significant predictor of the number of species for all groups of living organisms ($F = 22.6$, $P < 0.001$)

Artificial pine forest (Site #4). Site #4 has a total area of 56.4 hectares. The total area of the site is located within the I (first) floodplain terrace (Desnianska) and its hilly relief is typical for the Middle Dnipro arena and the arenas of the valleys of the Dnipro tributaries such as Vorskla and Samara, etc. Fine-grained quartz aeolian sands and sandy loams are ubiquitous in this area, forming hills ("kuchugury") up to 10 m high. The sands contain unique remains of allochthonous fossil fauna (shark teeth, sponge spicules) and minerals of Eocene glauconite facies, such as glauconite and phosphorite. The site is characterised by the typical relief of the eolian sands of Dnipro region and is an excellent natural testing ground for geological, geomorphological and biological observations. In particular, monitoring of soil-forming processes in the Dnipro-Oril fossil dunes is appropriate in terms of improving restoration measures for forests damaged by human activity in the context of current global climate change. Thus, the aeolian sands of the Desnianska terrace in area No. 4 are an important geological and paleontological site, of scientific and practical importance and promising for conservation.

The sandy and sandy loamy soils are covered with the typical herbaceous psammophilous vegetation and artificial plantations of Scots pine (*Pinus sylvestris* L.) and black locust (*Robinia pseudoacacia* L.). The psammophilous vegetation of the Dnipro arena is sandy steppes dominated by Becker's fescue (*F. beckeri*), sandy bluegrass (*K. sabuletorum*), ground fescue (*C. epigeios*), and wild rye (*S. sylvestre*). In some places, there are communities of Pallas thyme (*Th. pallasianus*) and shrubs of shelly (*S. acutifolia*). The artificial plantations of Scots pine (*P. sylvestris*) were quickly naturalised in the conditions of ecological compliance with the sandy arena of the Dnipro. The herbaceous cover includes ground fescue (*C. epigeios*), Becker's fescue (*F. beckeri*), everlasting flower (*Helichrysum arenarium* (L.) Moench), and fragrant bush (*Polygonatum odoratum* L.). In the plantations of black locust (*R. pseudoacacia*), there is a significant presence of weed species: drooping brome (*A. tectorum*), smooth brome (*B. inermis*), Canadian witch hazel (*E. canadensis*), etc. The identified flora species on this site include Savransky onion (*Allium savranicum* Besser), which is listed in the Red Book of Ukraine, and 4 species from the Red List of Plants of Dnipropetrovsk Region, 1 species is included in Appendix II of the Bern Convention.

The entomofauna of the site #4 is represented by xerothermophilic insects that exist in the vicinity of steppe cenoses and artificial forest plantations. According to rough estimates, the fauna includes about 1000 species of invertebrates. Among them, 7 species are protected. The Red Data Book of Ukraine includes 5 species, 3 species are protected by the Bern Convention (Appendices II and III), three species are included in the European Red List, and one species is listed in the Red List of the International Union for Conservation of Nature.

The investigation of the batrachofauna and herpetofauna complex shows the presence of at least 2 species of amphibians and 5 species of reptiles, of which 5 species are regionally rare, all 7 species are listed in Appendices II and III of the Bern Convention, 1 species is protected by the Ramsar Convention, 2 species are included in the European Red List.

At least 48 species of birds are found in the area of site #4, and representatives of four ecological complexes of birds are present: forest edge, forest, campophilous, and synanthropic. The high representation of summer bird fauna indicates that the study area is of high value as a breeding ground for bird populations. 3 species of bird fauna are listed in the Red Data Book of Ukraine (long-legged buzzard, Montagu's harrier, pallid harrier), 4 species are listed in the Red Data Book of Dnipropetrovsk Region, 70.8% are listed in Appendix II of the Bern Convention, 22.9% are listed in Appendix III of the Bern Convention.

The presence of 18 species of mammals belonging to 6 orders and 9 families was recorded at site #4. The species composition of this area quantitatively makes up 13.4% of the total species composition of mammals in Ukraine. The 6 mammalian orders present in the projected area for conservation account for 75% of the total number of mammalian orders present in our country. The typical fauna of the projected part of the protected area is represented by representatives of the forest ecological complex (59%) with a smaller participation of species of the eutrophic (29%) and synanthropic (18%) complexes. There are species of mammals in the study area that require protection and are included in the conservation categories of different levels, namely the Red Data Book of Ukraine (4 species), the Red List of Dnipropetrovsk region (7 species), and the Bern Convention (12 species) (Annexes II and III).

Protovch River floodplain ecosystems (Site #5). Site #5 has a total area of 86 hectares. This area is mostly located on the floodplain of the Protovch River (upper part of the first Dnipro River floodplain terrace). In the northern part, it partially covers the side of the Protovch River paleodelta. The floodplain within Site #5 is characterised by the presence of relics of the Protovcha River old water - a chain of small elongated lakes and bogs (at least seven). The geological section is typical for the northern part of the Reserve, where Eocene coal rocks (overlying Precambrian crystalline basement) and glauconite sands with a large stratigraphic discrepancy are overlain by quartz Pliocene-Quaternary fine-grained sands of the Desna terrace (to coarse-grained sands and gravel and pebble deposits). Due to the special landscape of geomorphology and hydrology, a significant floristic and biocenotic diversity with a significant share of rare and relict flora has been formed here. The site contains various types of ecosystems: water bodies, swampy lakes, marshes, floodplain saline and steppe meadows, shrub communities and forest plantations with an admixture of natural forests.

In gradually drying water bodies, wetland and coastal vegetation is represented by pleistophytes and submerged hydrophytes. Among the identified flora species on the site, 2 species are listed in the Red Data Book of Ukraine and 17 regionally rare species are included in the Red List of Plants of Dnipropetrovsk Region were found.

The close combination of artificial and natural ecosystems and their diversity leads to the simultaneous presence of insects of different ecological communities: hygrophiles, mesophiles, xerothermophiles and ubiquists on a small area of plot No. 5. In total, the fauna of the site includes 1700–2000 species. Compared to other areas, this site has the largest number of protected insects – 14 species. The Red Data Book of Ukraine includes 13 species, four species are protected by the Bern Convention, four species are included in the European Red List, and two species are protected by the IUCN Red List.

The water bodies located in site #5 are characterised by a very low level of fish fauna biodiversity due to intensive processes of siltation and overgrowth, and the lack of hydrological connection with other water bodies. In some dry years, there is almost no open water. Only species with adaptations to unfavourable oxygen and hydrochemical conditions are recorded here. Given the presence of sufficiently critical habitat conditions, the water bodies of site #5 retain their value for fish fauna as a component of the overall biodiversity. The study of the batrachofauna and herpetofauna complex shows a rich spectrum of amphibians and reptiles in the area of the Reserve No. 5 expansion. At least 7 species of amphibians and 6 species of reptiles have been recorded, of which 6 species are regionally rare, all 13 species are listed in Appendices II and III of the Bern Convention, 2 species are protected by the Ramsar Convention, 3 species are listed in the European Red List, and one species is included in the Red List of the International Union for Conservation of Nature.

At least 88 species of birds are found in the study area, and representatives of five ecological complexes of birds are present: forest, forest edge, wetland, campophilous (steppe), and synanthropic. The dominant ones are forest, forest edge, and wetland bird complexes. The summer bird fauna is the richest in the study area in terms of habitat status. The second in terms of species diversity is the group of migrants. The third is wintering species. The high indicators of the first group indicate a rather high value of the study area as a breeding ground for bird populations. The results of the analysis of the species composition in the nature protection lists of different levels of jurisdiction showed that 1 species of bird fauna of the area No. 5 of the Reserve's extension is included in the Red Book of Ukraine (great grey shrike), 3 species are included in the Red List of Dnipro Region, 67.1% are included in Appendix II of the Bern Convention, and 27.3% are included in Appendix III of the Bern Convention.

The presence of 30 species of mammals belonging to 6 orders and 12 families was recorded on the territory of the site No. 5. The species composition of this area quantitatively makes up 22.4% of the total species composition of mammals in Ukraine. The 6 mammalian orders present in the projected area for conservation account for 75% of the total number of mammalian orders present in our country. The typical fauna of the projected part of the protected area includes representatives of the forest ecological complex (47%) with a smaller participation of species of the eutrophic (20%), wetland (10%), synanthropic (10%) and steppe (13%) complexes. Among the mammalian species found in the study area, there are species that require protection and are included in the protection categories of different levels, namely the Red List of Dnipro Region (13 species), the Red Data Book of Ukraine (5 species), the Bern Convention (14 species) (Appendices II and III), and the Bonn Convention (4 species).

Assessment of the conservation potential of the areas proposed for inclusion in the reserve. The number of species included in the Red Lists of different levels can be an indicator of the conservation importance of an ecosystem. The total number of species and the part of them that needs protection depends on the size of the area. As the area of the territory increases, the number of species increases. Obviously, to compare sites with different areas, they need to be normalized to a common denominator. The deviation of the observed number of species from the regression dependence of the number of species on the area can be such a comparable indicator. Such deviations can be normalized to the range of 0–5, which makes it possible to graphically compare the conservation importance of different sites with each other and with the base area to which individual sites are planned to be added (Fig. 8). The base area of the reserve corresponds to the baseline of 0.5. The predominance of the level of 0.5 in a particular site indicates a greater relative importance of such a site compared to the reserve as a whole. This indicates both the need for protection of such a site and the significant contribution of the accession to the territory to increase the conservation potential of the Reserve as a whole. The Red Lists of species of different levels were formed according to different criteria, so the multidimensional projection of the importance of the territory for protection allows us to identify the functional significance of the territory for the conservation of biological diversity.

For the protection of plant diversity, sites #1 and #3 are of the greatest importance. For the protection of plant species included in the Bern Convention, sites #3 and #4 are of the greatest importance. For the protection of plants included in the Red Data Book of Ukraine, sites #4 and #5 are of the greatest importance. Site 5 is the most important for the protection of insects. However, almost all sites proposed for inclusion in the Reserve's territory have a relative potential for conservation of insect biodiversity not less than the entire Reserve's territory on average. Sites #1, #2, and #3 are of particular importance for fish conservation. In fact, these sites are the centers of biodiversity of these animals and, most importantly, they help to preserve the existence of animal populations that are included in the Red List of the International Union for Conservation of Nature. Sites #1, #3 and #4 have a high potential for conservation of amphibian and reptile species. These areas make a special contribution to the conservation of species included in the Red List of Dnipro Region. The role of the proposed areas for the expansion of bird and mammal species is very significant. Site #1 is of the greatest importance for the conservation of species included in the European Red List.

Discussion

Most of Europe has been profoundly altered by humans, so strictly protected areas should also include territories which may recover their biodiversity importance through restoration and rewilding (Navarro & Pereira, 2012). In strictly protected areas, the conservation efforts can be aimed at protecting ecological processes and wild areas, as well as restoring degraded ecosystems and recreating areas with a high level of naturalness (Carver et al., 2021). To achieve the goals specified in the EU Biodiversity Strategy 2030, it is first of all necessary to identify a sufficient area of sites subject to strict protection, as envisaged by the EU target of 10%. Ukraine's European integration strategy should also include nature conservation goals accepted by the European Union. Ukraine is an industrially developed country with a high population density, and this is fully relevant to Dnipropetrovsk region (Getzner & Moroz, 2022). In such circumstances, the creation of a large strictly protected area becomes a very difficult task due to imperfect legislation. There are cases when a huge national nature park cannot be created due to the lack of consent of only a few land owners or tenants, as is the case with the Orilskyi National Nature Park, which was planned to be created in Dnipropetrovsk region. Voluntary consent to the creation of a nature reserve should be obtained from all landowners in the territory where the reserve is planned to be established. This is a requirement of Ukrainian law. Similar problems exist in other European countries. For example, in Germany, ownership of forests and protected areas designed to protect cultural landscapes further limits the potential for creating new reserves (Brackhane et al., 2019). Therefore, in some situations, the tactic of "frog leaps" may be more effective, when a small protected core is created and neighbouring areas begin to join it, which will gradually expand the boundaries of the protected area to the ecologically necessary size. This development tactic can be used for the Dnipro-Orylskiy Nature Reserve.

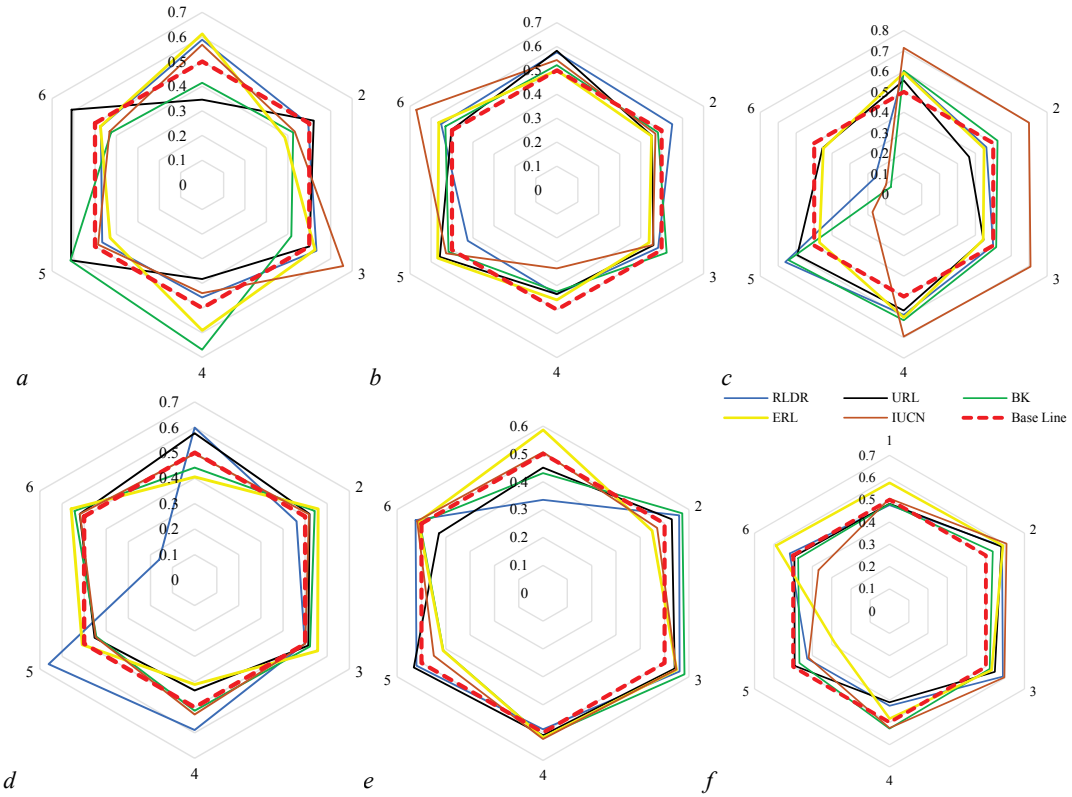

Fig. 8. Diagram of estimates of the conservation significance of the sites proposed for the expansion of the reserve: the residuals of the regression model of the number of species as a function of area, normalized to the range 0–1, are presented: the score of 0.5 (red dashed line) corresponds to the level of species numbers in the corresponding protected area on average for the reserve; scores that are closer to 1 indicate a higher conservation importance of the site according to the criteria that formed the basis for the species to be included in the relevant Red list; sites: 1 is site 1, 2 is site 2a, 3 is site 2b, 4 is site 3, 5 is site 4, 6 is site 5; groups of living organisms: a is plants, b is insects, c is fishes, d is amphibians and reptiles, e is birds, f is mammals; RLDR is Red List of Dnipro Region, URL is Red Data Book of Ukraine, BK is Bern Convention, ERL is European Red List, IUCN is the Red List of the International Union for Conservation of Nature

A specific feature of this unique conservation area is its location in the center of the densely populated Dnipro-Kamyanska industrial agglomeration on the left bank of the Dnipro River, surrounded by man-made and transformed landscapes. The reserve is home to rare species of animals and plants, and there is a typological diversity of landscapes in a small area. These are different types of habitats: river mouths, riverbeds, lakes, central floodplain lakes, swamps, temporary and permanent channels, the shoreline part of the Dnipro River, virgin sandy steppe, artificial forest plantations and natural forest areas. Long-floodplain forests with a system of water bodies (floodplain lakes) of the Taromskyi and Mykolaivskyi ledges form a unique floodplain complex in the middle reaches of the Dnipro River. The aquatic ecosystems of the Reserve have been experiencing constant negative pressure of anthropogenic origin throughout its existence, associated with hydroelectric construction and regulation of the Dnipro River flow (creation and operation of reservoirs), pollution with various pollutants and waste. There is a gradual successional transformation of the original ecological complexes against the background of constant anthropogenic impact. Therefore, the preservation of the original natural complexes near the existing protected area is extremely necessary.

According to the provisions of the Dnipro Regional Integrated Program (Strategy) for Environmental Safety and Climate Change Prevention for 2016–2025, one of the qualitative indicators of its implementation in the region is an increase in the total area of the nature reserve fund (NRF). At the same time, the expansion of the territory of the nature reserve is envisaged by the Project for the organization of the territory of the Dnipro-Orylskyi Nature Reserve and protection of its natural complexes as a strategic task, the implementation of which will contribute to a more comprehensive protection of natural areas. Given the current situation, when significant areas of the nature reserve fund of the regions bordering Dnipropetrovs'k (Kherson, Zaporizhzhia, Donetsk) have been desecrated as a result of Russia's armed aggression against Ukraine, it can be assumed that the territory of the Dnipro region will be a source of restoration of flora and fauna of the destroyed lands of the south and east of the country, which emphasizes the relevance of developing protected areas in our

region. It should be noted that today Dnipropetrovsk region is one of the regions that lags far behind the approved targets for the creation of new nature reserve areas. According to the ranking of regions published by the Ministry of Environmental Protection and Natural Resources of Ukraine, Dnipropetrovsk region ranks 25th among all regions of Ukraine in terms of the number of protected areas created (3.1% of the region's area). According to a study by the NGO Ukrainian Nature Conservation Group, which was submitted to the leadership of the Dnipro Regional State Administration in 2021, more than 3000 hectares of protected areas in the Dnipro region have been illegally plowed and another 10000 hectares have been distributed as shares by local governments, leaving only 2.5% of the region in protected status, which is the worst indicator in the country. Thus, the creation of new protected areas is an extremely important and urgent task in Dnipropetrovsk region.

The following criteria were used to justify the expansion of the boundaries of the existing reserve: 1) a geological, geomorphological and hydrological structure and heterogeneity; landscape diversity; 2) a wide variety of habitats (from aquatic and wetland and island habitats to meadows, shrubs, forests and steppes); 3) the high level of biodiversity of flora and fauna; 4) the functional role of the territories as a habitat for animals at the most important stages of their life cycle (reproduction, fattening, migration, etc.); 5) the presence of a significant number of plant and animal species with a protected status at the regional, national and international levels; 6) the formed adaptation potential of communities and individual species of flora and fauna to the conditions of existence in the anthropogenic environment; 7) the possibility of sustainable functioning of the territories in the most favourable conservation regime for landscapes and biota; 8) the preservation of habitats of many typical and rare species of the Dnipro River basin as a genetic bank.

In addition to the main conservation value, the territories proposed for conservation and inclusion in the Dnipro-Orilskyi Nature Reserve have scientific, aesthetic, cognitive, educational and educational importance. Another significant aspect is that the area is inhabited by species included in the conservation lists of different jurisdictions and has unique habitats of different types of ecosystems (water, wetland, meadow, forest, steppe, etc.). Together, they are key reserves of species and races of unique and common organisms. The areas planned for expansion of the Reserve's boundaries are also important as a functioning component of the international nature conservation system (the Emerald network). According to Art. 11 of the Law "On the Red Data Book of Ukraine", "...protection of the Red Data Book of Ukraine is ensured through the priority creation of nature reserves, other territories and objects of the nature reserve fund, as well as the ecological network in the territories where the Red Data Book of Ukraine objects are located (grow) and on the migration routes of rare and endangered species of fauna". Accordingly, the presence of species of flora and fauna included in the Red Data Book of Ukraine is already a sufficient condition for the inclusion of this territory in the reserve.

The importance of the considered areas for biodiversity protection coexists with the facts of significant anthropogenic impact on these territories, which necessitates the extension of the conservation regime to these areas. During the survey of site #1, the following signs of excessive anthropogenic pressure and degradation of natural communities were found: traces of felling, among which the felling of large trees (poplars 50–100 years old, etc.) predominates, the presence of places of spontaneous recreation, the remains of fires, litter, soil compaction and breakdown, damage to the grass cover, etc. This mode of land use threatens the integrity of the vegetation cover, the habitat of invertebrates and vertebrates, including protected species, and the sustainability of the ecosystems. In the spring, the concern factor becomes very intense, which is critical for the natural reproduction of all species, including fish in the spawning grounds located here. If urgent measures are not taken to protect the area of the site accession, gradual degradation of habitats for species reproduction, reduction of species diversity by 50% or more, and loss of 90% of protected species over the next 5–10 years (if the current rate of degradation and anthropogenic pressure is maintained) are possible. Therefore, it is extremely important to include plot No. 1 in the Dnipro-Orylskyi Nature Reserve as part of the work to protect and preserve landscape and biological diversity.

The analysis of the territory of plot #2 showed the presence of natural ecosystems with minimal anthropogenic pressure, taking into account the current stage of use of natural areas in the region. There is a rare opportunity to preserve a system of almost undisturbed habitats for invertebrates and vertebrates in the steppe zone of Ukraine. Risks of degradation include haymaking, cattle grazing, excessive pressure from fishermen and recreationists, and illegal logging. If the negative expectations come true, we can predict a decrease in species diversity, deterioration of the conservation status of valuable nature complexes in the region, and loss of habitats for protected species.

On site #3, due to the presence of a water barrier that prevents the easy exchange of species, the island fauna is vulnerable. The ecosystem balance is easily disrupted even in the event of minor anthropogenic interference, and a significant proportion of the species composition can be lost in a short time. In order to preserve the localities of rare species found on the islands, their priority protection is required. We should also take into account the value of island systems for reproduction and fattening of young native fish (shallow waters and inland lakes are first natural spawning grounds, then fattening grounds for young fish, and are partially used for fattening by mature individuals).

Due to the close proximity of the site #4 to the territories of dacha cooperatives, the ecosystem is under significant anthropogenic pressure. The main danger to the existence of rare species habitats is the threat of fires due to human negligence. In order to preserve the habitats of protected species, it is necessary to strengthen the protection of the territory, and it is optimal to grant the territory the status of a nature reserve. Landscape diversity and the presence of specific habitats with significant potential for the development of floral and faunal complexes, especially in the invertebrate group, add to the natural value of the site.

Site #5 is located to the north of the reserve and directly borders on its northern boundary. This is state-owned forestry land used by the State Enterprise "Dnipropetrovs'k Forestry". This area is located in close proximity to the laboratory building of the Dnipro-Orilskyi Nature Reserve and is divided by the road leading to it. The site contains swampy lakes, marshes and shrubby cenoses, as well as forest plantations with an admixture of natural forests.

The aesthetic value of the location of the Dnipro-Orylskyi Nature Reserve and its neighbouring areas has long been proven even before its creation. The floodplain systems of the Taromskyi and Mykolaivskyi ledges were a place of traditional green tourism for residents of large cities on the Dnipro River and surrounding villages. All these people were attracted to these places by the scenic beauty of the Dnipro and its floodplain, various lakes and streams, oaks, and willow forests of the area. The scientific value of the discussed expansion areas lies in the fact that they are the only place where the long-floodplain ecosystems of the middle reaches of the Dnipro have been preserved to date. Such ecosystems have a unique combination of vegetation and fauna, which makes them a one-of-a-kind object of scientific research. Another factor that increases the scientific value of the reserve's territory is the high mosaic of vegetation (aquatic, near-water, terrestrial). In fact, the types of ecosystems and habitats in the reserve change almost every few hundred metres along the route. All of this leads to an incredible diversity of ecosystem connections within a relatively small area. This is a unique and powerful outdoor laboratory that attracts researchers from various scientific centres in Ukraine. The latter is confirmed by a number of dissertations defended on the basis of materials collected on the territory of the reserve not only by its scientific staff, but also by researchers from various educational and academic institutions.

The educational and upbringing values of the reserve and the territories planned to be included in it are determined by the interaction of the Reserve with the local public education system. The reserve, unlike many other protected areas in Ukraine, is located very close to the large cities of Dnipro and Kamianske, as well as the settlements of Obukhivka, Mykolaivka, Karnaukhivka, Sukhachivka, and Diyivka. Therefore, the reserve can actively interact with secondary and higher education institutions of the above-mentioned settlements within a short transport distance. In the reserve, schoolchildren can gain basic knowledge of the nature of their native land and get acquainted with its beauty, which is a powerful incentive to foster a caring attitude towards nature. Students of biological and environmental specialities of higher education institutions, in addition

to gaining professional knowledge, can learn practical skills of environmental protection and scientific work in nature reserves. Thus, the territory to be included in the Dnipro-Orylskyi Nature Reserve is of nature and water protection, landscape, geological and morphological, scientific and aesthetic importance. Its protection will help preserve the ecosystem, landscape and biological diversity of Dnipro region.

The nature reserve regime fully meets the requirements for the protection of rare species of plants and animals. The status of the reserve provides for fire protection measures, no sanitary felling, ploughing, grazing, etc. The preservation of the valuable complex within its boundaries is ensured by complete isolation from anthropogenic impact of habitats and maintenance of ecological balance in all biotic systems of the reserve. Unfortunately, the habitats that are the breeding grounds for rare and protected species are not fully protected by the nature reserve and suffer from excessive anthropogenic pressure. Therefore, in order to preserve the complex of plants, invertebrates and vertebrates that are under threat of complete extinction, it is imperative that the areas presented in the petition be urgently included in the Dnipro-Orylskyi Nature Reserve, where this protection will be properly implemented.

Conclusion

The Dnipro-Orylskiy Nature Reserve is located in the floodplain of the left bank of the middle reaches of the Dnipro River (upper reaches of the Dnipro Reservoir) and consists of various types of landscapes, with a wide range of ecosystems (aquatic, wetland, meadow, forest, and steppe). The area of the reserve is 3759.4 hectares, with more than 30% of its territory occupied by water. It was found that the reserve's territory is insufficient to maintain all components of biological and landscape diversity in full. The location of the nature reserve in the centre of the densely populated Dnipro-Kamyanska industrial agglomeration, being almost completely surrounded by man-made and transformed landscapes, necessitates the implementation of additional measures to protect its landscape and biological diversity, and preserve the habitats of species with protected status. The most effective measure is to directly increase the total area of the reserve by expanding its boundaries and including the most valuable areas located near or adjacent to it. As a result of the research, the five most valuable areas in terms of landscape and ecology were identified, with a total area of 618.9 hectares, which directly border the territory/water area of the reserve. This will increase the total area of the reserve by 16.5%, which is quite a significant figure for today. Rare species of plants, invertebrates and vertebrates protected by the Bern Convention (Annexes II and III), the European Red List, and the Red List of the International Union for Conservation of Nature have been identified on each of the sites. In accordance with Article 11 of the Red Data Book of Ukraine, the presence of plant and animal species included in the Red Data Book of Ukraine on the territory of all sites is a sufficient condition for the inclusion of this territory in the reserve. Thus, all the studied sites are promising for conservation and inclusion in the reserve. In terms of representation in conservation lists, the most valuable is site #2 (biota of this area is mentioned 241 times in the lists of different jurisdictions). The second most valuable in terms of conservation value is site #5 (196 mentions), the third is the site #3 (184 mentions), the fourth is the site #5 (157 mentions), and the fifth is the site #4 (140 mentions). This indicates the order of priority of these plots. The most urgent is the conservation of site #2 and beyond. The species composition and the nature of rare and endangered species indicate a high ecological potential of the studied areas. In addition, the expansion of the boundaries of the Dnipro-Orilskiy Nature Reserve is of priority importance for the sustainable functioning of the reserve itself and the expansion of its conservation functions. Expanding the boundaries of the reserve as one of the key parts of the Dnipro eco-corridor of the National Ecological Network of Ukraine (Law of Ukraine "On Ecological Network") will help to increase its status and role in shaping and restoring the environment. The inclusion in the reserve of a part of the territories (water areas) that are already part of the international nature protection system (Emerald Network, Dniprovske Reservoir (UA 0000093), as well as its location near the Dnipro-Orylskyi Nature Reserve (UA 000004), taking into account the spatial proximity to wetlands, designated under the Ramsar Convention (Dnipro-Oryl Floodplains, this is site No. 1399, date of designation 29 July 2004), will contribute to increasing the importance of the Dnipro- Orilskiy Nature Reserve as a nature conservation institution, not only in the general ecological sense, but also in the international conservation sense. The development process of the reserve against the backdrop of the ongoing armed aggression of the Russian Federation proves the invincibility and resilience of all parts of the state, including the scientific community.

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