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Landscape–Ecological Problems Resulting from Spatial Conflicts of Interest in the Poľana Biosphere Reserve

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Abstract: This paper is focused on presenting a methodological procedure for assessing landscape–ecological problems resulting from conflicts of interest and its application in the Poľana Biosphere Reserve. The approach is grounded in the concept of the landscape as a geosystem. It examines natural and socio-economic phenomena, classifying them as either threatened or threatening. By intersecting these phenomena, spatial delineation of the conflicts of interest has been achieved. Within the Poľana Biosphere Reserve, three groups of problems resulting from spatial conflicts of interest were identified: threats to biodiversity and ecological stability; threats to natural resources; and threats to the environment of human society. A total of 121 specific threats were identified in the area. This approach is applicable to other biosphere reserves for identifying areas with conflicts of interest as the identification of spatial conflicts is crucial for the effective and targeted design of measures aimed at their mitigation or elimination, aligning with the overarching objective of biosphere reserves—sustainable development. An indispensable condition is to bridge the sectoral approach in landscape management and ensure effective communication and cooperation between individual stakeholder groups in the territory.

Keywords: environmental problems; Poľana Biosphere Reserve; man and biosphere programme; integrated landscape management; conflicts of interest; sustainable development

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Academic Editor: Alexandru-Ionuţ Petrişor

Received: 12 December 2024
Revised: 27 January 2025
Accepted: 12 February 2025
Published: 14 February 2025

Citation: Izakovičová, Z.; Melicher, J.; Špulerová, J.; Dobrovodská, M.; Piscová, V. Landscape–Ecological Problems Resulting from Spatial Conflicts of Interest in the Poľana Biosphere Reserve. *Land* **2025**, *14*, 402. https://doi.org/10.3390/land14020402

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1. Introduction

Human activities significantly interfere with natural landscapes, altering their structure, appropriating natural ecosystems, and replacing them with artificial structures poorly integrated into the environment. These activities excessively deplete natural resources, clear forests, destroy wetlands, meadows, and other valuable habitats, regulate watercourses, remove riparian vegetation and other plant communities, reintroduce unused substances and energy into ecosystems, and gradually transform natural landscapes into intensively managed, heavily modified, and degraded areas dominated by artificial structures, thereby increasing the degree of anthropization [1–3]. Inappropriate human interventions and their accompanying effects, such as emissions, noise, radiation, and light pollution, adversely affect the quality of individual environmental components. These components represent the fundamental ecological factors vital not only for plant and animal species and their communities but also for human living conditions.

Human impacts on landscapes are particularly harmful because they are often uncontrollable, interconnected, and rarely isolated. Intervention in one component frequently triggers chain reactions, disrupting and influencing other components of the landscape.

This interference also disturbs natural phenomena and processes, often activating natural risks and hazards [4,5]. A notable example of such inappropriate interventions is inadequate river regulation, which, beyond directly affecting watercourses and their biota, disrupts the hydrological conditions of surrounding environments, endangers riparian vegetation, leads to the loss of wetland ecosystems, and disturbs the overall water cycle, ultimately resulting in floods.

Most of these problems arise from improper landscape management but they can often be mitigated or even eliminated through target measures. This can be achieved by adopting suitable land use and conservation practices, protecting the landscape and its individual components, and efficiently utilizing natural resources and the potential of the area. The application of appropriate landscape management is crucial [6–9]. Biosphere reserves (BRs) exemplify such effective management practices, serving as model territories for sustainable coexistence between humans and nature.

BRs are integral to UNESCO's intergovernmental scientific program "Man and the Biosphere" (MaB), established in 1971. This program integrates knowledge from natural and social sciences, providing a foundation for the rational and sustainable use of biosphere resources while simultaneously protecting natural ecosystems and human-altered landscapes [10]. Most BRs encompass both natural-like areas and regions affected by human activities. This duality enables the study of conflicts between human activities and the natural environment while supporting biodiversity enhancement in disturbed areas. These territories are illustrative examples of cultural and natural landscapes where humans and their activities play a key role.

One of the primary objectives of the MaB program for 2015–2025 is the conservation of biodiversity, the restoration and enhancement of ecosystem services, the promotion of sustainable natural resource use, and the development of sustainable, healthy societies and thriving human activities in harmony with nature. These goals are not always met, and the development of human activities is not always in line with these goals.

The impacts of human activities on the landscape manifest in several ways [10]:

- Construction of new technical structures: This results in the creation of artificial ecosystems at the expense of natural and semi-natural ecosystems. Their influence is evident in the direct destruction of natural ecosystems and their replacement with artificial ones. Additionally, these structures act as barriers to the migration of biota;
- Large-scale exploitation and transformation of natural ecosystems: This includes extensive forestry and agriculture. The effects on the landscape involve the transformation of natural ecosystems into semi-natural ones, alongside the disruption and endangerment of the ecological conditions of individual ecosystems;
- Designation of functional zones for the protection of specific ecosystem types or components: These components often serve as natural resources, including all forms of protected areas, water source protection zones, and special-purpose forests. These zones determine the use of specific ecosystem services, primarily non-productive services, as restrictions often limit or prohibit the utilization of certain services, particularly productive ones. Examples include bans on using forest ecosystems for biomass production in protected areas or restrictions on agricultural ecosystems for food production in water source protection zones;
- Production of foreign substances that act as stress factors for ecosystems—mostly, these are accompanying phenomena of the implementation of production sectors: These stress factors negatively impact the landscape by directly disrupting ecosystems and altering ecological conditions. Ecosystems that are thus threatened and disrupted have a reduced capacity to provide the ecosystem services for which they initially had

high potential. Many of these activities have contradictory effects, creating numerous environmental and ecological problems in the landscape.

The aim of our study is to support these objectives by developing a methodological approach for the assessment of landscape–ecological problems resulting from conflicts of interest and its application in the Pol'ana Biosphere Reserve.

Landscape conflicts have been the subject of scientific research for quite some time [11–15]. Landscape conflicts are understood to be conflicts that arise from different interpretations, evaluations, and demands on the landscape; from the relationships between individuals and social interpretations and evaluations; between individual interpretations, evaluations, and demands on physical spaces; and relationships that are carried out between individuals [11].

Most of these studies focus on assessing conflicts between individuals, groups, sectors, etc., but do not address the impacts of these conflicts on the country and its components; rather, social aspects are assessed. The present paper focuses on a comprehensive assessment of impacts on the landscape and its components resulting from land use conflicts. It also focuses on assessing indirect/secondary problems that are not entirely a consequence of direct sectoral conflicts, e.g., the problem of biodiversity threats due to environmental contamination is not a direct conflict between sectors but is an indirect consequence of industrial development near the protected area.

The methodological approach is based on an environmental assessment of conflicts of interest in land use. Land use occurs through the development of various sectors, whether productive or non-productive. Each sector imposes specific demands on the landscape and requires access to particular resources. Each seeks to identify the most suitable locations for its purposes, often disregarding the fact that these areas may also be optimal for use by other sectors. For instance, many protected water management areas are characterized by high-quality soils, making it impossible to view such locations solely from an agricultural perspective or, conversely, only from a water management standpoint. An integrated approach is essential—one that considers all aspects of the given locations, including abiotic, biotic, and socio-economic characteristics [7,16]. A lack of alignment between interests leads to landscape–ecological and environmental problems. Integrated approaches are generally well-accepted; however, in practical landscape management, they are rarely implemented due to their complexity. Such approaches require not only comprehensive knowledge of all landscape-forming components but also an understanding of the interactions and relationships between these components.

2. Materials and Methods

2.1. Methodological Steps

The evaluation methodology was based on a spatial landscape–ecological assessment of the problems resulting from conflicts of interest in land use (see Figure 1). The methodology consists of the following basic steps [17,18]:

1. Analyses—the aim was to obtain the most accurate and objective information about the characteristics of the landscape and its components, as well as their spatial expression. For the pre-processing of GIS data, we reviewed and obtained all relevant spatial data from internal and external sources, and we requested data from the relevant institutions shown in Table 1. If the data were not in vector shapefiles, we transferred them from the raster to polygons or we georeferenced the base maps to vector shapefiles. We also checked and fixed the geometries and settings for all layers of the coordinate system EPSG: 5514. Lastly, we clipped the layers by the boundaries of Pol'ana BR;
2. Interpretations—the objective of this step was to classify analytical indicators based on their impact on the landscape and the individual landscape-forming components

(threatened and threatening). The classification was conducted through expert assessment. Threatening phenomena were classified based on the intensity of their impact, while the threatened components were determined by legislative norms that define categories of protected areas and the extent of restrictions on specific socio-economic activities. Based on this step, in the GIS program, the landscape phenomena were classified into two layer groups, outlined below:

a. Threatened phenomena—phenomena indicating interests in nature and landscape protection, natural resources, and the environment. These include the following:

- Nature conservation interests—these refer to protected areas of various levels aimed at protecting the landscape, its components, and elements, through limitation of the development of certain human activities. With higher levels of nature protection, there is an increased limitation on socio-economic activities. The unsuitable location of these activities in protected areas leads to conflicts between nature conservation and other productive and non-productive sectors. Nature conservation interests are outlined below:
  - Pol'ana Special Protection Area (SPA)—designated for the conservation of bird habitats;
  - Sites of community importance (SCIs)—designated for the protection of species and habitats of community importance;
  - Small-scale protected areas—designated for the purposes of protecting endangered species and habitats, ensuring natural processes, and protecting natural monuments. Include nature reserves, national nature reserves, natural monuments, national natural monuments, and protected sites;
  - Most important habitats—identified as the most valuable and threatened areas of forest and non-forest habitats;
  - Elements of the TNES—maintaining the stability and biodiversity of the landscape (ecological networks) with designated biocenters and biocorridors;
  - Zones of the Pol'ana BR—the BR consists of three zones: the core area, buffer area, and transition area. The core area is designated for nature protection and limitation of socio-economic activities; the buffer area balances socio-economic activities and nature conservation, e.g., close-to-nature forestry; and the transition area is where socio-economic activities are poorly limited or unlimited by nature protection;
- Natural resource protection interests—activities aimed at the protection of specific natural resources, such as the following:
  - Soil resources protection—protection of the most fertile soils from non-agricultural activities;
  - Water resources protection—ensured through protective zones aimed at preserving the qualitative and quantitative characteristics of water resources. In these zones, special management regimes are required to protect water yield and quality;
- Environment of human society interests—provided through the protection of health, housing, recreation resources, and aesthetic values of human society. In such areas, human activities with negative environmental impacts are restricted or entirely excluded. These interests consist of the following:

- Recreational areas—with a purpose of recreation and well-being of citizens as well as visitors. Recreational areas consist of 5-meter buffers around tourist points of interest such as springs, shelters, huts, parking lots, viewpoints, observation towers, and tourist and hunting cabins, as well as 2-meter buffers along tourist trails, cycling paths, and educational trails, derived from a tourist map;
- Traditional agricultural landscapes—historical structures of agricultural landscapes consist of mosaics of dispersed (scattered) settlements, small-scale arable lands, and grasslands perceived as the aesthetic value of the landscape, as identified by Špulerová, et al. [19];
- Residential areas—derived from current landscape structure and OpenStreetMap, aimed at safeguarding the immediate living environment;
- Cultural–historical monuments—consist of registered national cultural monuments by The Monuments Board of the Slovak Republic;

b. Threatening phenomena—negative phenomena, whether natural or anthropogenic (stress factors), are considered threatening phenomena that endanger the landscape and its components. These include the most relevant and data-available phenomena for the Poľana BR:

- Natural stress factors:
  - Unstable and potentially unstable regions—regions of unstable and potentially unstable areas, representing the susceptibility of Slovak territory to slope deformations, outlined by Šimeková et al. [20];
  - Landslides—identified potential landslide surfaces by the Geological Institute of Dionýz Štúr;
  - Seismic hazard—seismic hazard of the area was expressed in values of macroseismic intensity derived from the Landscape Atlas of the Slovak Republic [21];
  - Soil contamination—includes only non-contaminated soils in which the geogenically caused concentration of some elements reaches A-limit values [22]. This is represented by the presence of excessive concentrations of risk elements, including nutrients, if their levels in the soil exceed acceptable thresholds (e.g., Zn, Cu, and others);
  - Radon risk—this includes moderate radon risk, based on the results of field measurements and laboratory determinations by the Geological Institute of Dionýz Štúr collected in the geophysical database since the early 1990s;
  - Strong and extreme real water erosion—real (actual) erosion—represents a real threat to soil due to water erosion processes, considering the actual vegetation cover and land management practices [23]: $A = R \times K \times L\,S \times C \times P$. An interactive model for determining erosion intensity utilizes the overlay of digital layers representing individual erosion factors, where A—average annual soil loss in tons per hectare; R—rainfall erosivity factor, defined as the product of rainfall energy and the maximum 30-minute intensity; K—soil erodibility factor, influenced by basic soil properties such as texture, structure, organic matter content, and permeability; LS—topographic factor expressing the effect of the slope length (L) and slope steepness (S) on soil transport, with L representing the ratio of soil loss from a given slope length to the loss from a standard 22.13 m slope and S representing the ratio of soil loss from a given

slope gradient to the loss from a standard 9% slope; C—vegetation cover factor, expressing the impact of vegetation and applied agricultural practices on erosion intensity; P—erosion control practices factor, representing the ratio of soil loss under contour farming to that under conventional tillage. Based on the calculated results, soil erodibility is categorized according to the average annual soil loss: 1—none to slight (0–4 t/ha/year), 2—moderate (4–10 t/ha/year), 3—strong (10–30 t/ha/year), 4—extreme (>30 t/ha/year) [24];

- Flood risk—Slovak Water Management Enterprise developed a flood risk map [25] in areas where the preliminary flood risk assessment has identified the presence of potentially significant flood risk and areas where the occurrence of significant flood risk is likely. We used data for the flood zone Q50, which refer to a flood with a recurrence probability of once in fifty years;
- Invasive alien plant species—the buffer was derived from the point shapefile, where the points represent the center of the polygon for each record. The attribute table data contain the area size of occurrence for each record. The buffer distance was calculated by the formula: $Radius = \sqrt{\frac{Area}{\pi}}$. The resulting buffers were incorporated into threatening phenomena. It was obtained from the Complex Information and Monitoring System (KIMS) operated by the State Nature Conservancy of the Slovak Republic [26];

- Anthropogenic stress factors:
  - Intensive forestry management—represented by the commercial forest category, derived from units of forest spatial division—forest management units—for which the prescribed timber harvest volume in cubic meters is determined according to the Forest Management Plan;
  - Agricultural land-use abandonment—by comparing the land parcel identification system (LPIS) of agricultural land use in 2004 and 2024 and by excluding currently managed agricultural areas, we obtained an overview of the abandoned land. These plots were separated from the areas currently registered as forest land;
  - Environmental burdens—primarily in areas with long-term operational activities, such as industrial sites, railway depots, hazardous waste landfills, pesticide, fuel, and other substance storage facilities, as well as locations focused on ore extraction and processing. These areas include probable and confirmed environmental burdens recorded on the Environmental Portal of the Ministry of the Environment of the Slovak Republic, with a 300-meter buffer;
  - Waste dumps— data on waste dump locations were obtained from the Geological Institute of Dionýz Štúr, and a 10-meter buffer area was created around them;
  - Power lines—based on OpenStreetMap data, the power lines network in the Poľana BR was created with a buffer of 2 m;
  - Impervious surfaces and linear features—consist of buildings and paved roads, obtained from OpenStreetMap and current landscape structure (ESPRIT), which act as migration barriers;
  - Recreational areas—with the purpose of a possible negative impact of tourism and recreation on biota with a buffer of 2 m from lin-

ear recreational elements (tourist trails, bike paths, and educational trails), and a buffer of 20 m from spatial recreational elements (parking lots, viewpoints, and cabins);

- Protective zones of industrial and manufacturing facilities—a buffer area of 100 m around existing objects of industrial and manufacturing facilities disturbing the human environment by noise and local emissions. Obtained from OpenStreetMap and the current landscape structure (ESPRIT);
- Protective hygienic zones of the agricultural enterprises—a buffer area of 100 m around the objects of agricultural enterprises affecting the human environment by noise, emissions, dustiness, and odor. Obtained from OpenStreetMap and the current landscape structure (ESPRIT). Protective hygienic zones are determined based on the expected negative impact of a given anthropogenic object on the landscape and its components. The size of the zone is based on legislative regulations and technical standards. A summary specification of all hygienic zones is provided in the manual for processing local territorial networks of ecological stability, which serves as basis for the needs of creating a basis for regulating the design of green infrastructure construction [27];

3. Syntheses—this involved the creation of spatial units where threatened and threatening phenomena intersect, using the intersection script QGIS Python console to create multiple intersections. These are homogeneous areas that differ from each other based on the combination of occurrences of specific threatened and threatening phenomena;
4. Evaluations—this involved the reassessment of conflict zones, where issues arising from the interactions between threatened and threatening phenomena were identified. We checked the intersection results and the presence or absence of spatial conflicts of interest. The resulting conflicts of interest were evaluated by the authors' expert evaluation as relevant conflicts of interest or non-relevant. Relevant conflicts of interest were categorized into three groups based on the object and intensity of the individual stress factors. Naturally, multiple types of threats may occur within the same area, such as biodiversity threats combined with issues related to the endangerment of natural resources and the environment of human society. Based on this, it was possible to identify areas with the highest accumulation of problems as well as areas with no significant issues. The evaluation resulted in identifying conflicts arising from these encounters, divided into three main groups, as outlined below:

- Problems of endangering biodiversity and ecological stability—caused by the influence of stress factors on landscape elements with high eco-stabilizing effects (forests, water areas, meadows, pastures, or public greenery). The outcome is low ecological stability and threats to biodiversity;
- Problems of endangering natural resources—result from spatial conflicts between stress factors and natural resources and their protection zones, if designated. The outcome is a decline in the quality and quantity of natural resources;
- Problems of endangering the environment of human society—arise from the impact of stress factors on humans and their environment (recreational or residential areas), leading to an increase in civilization-related illnesses.

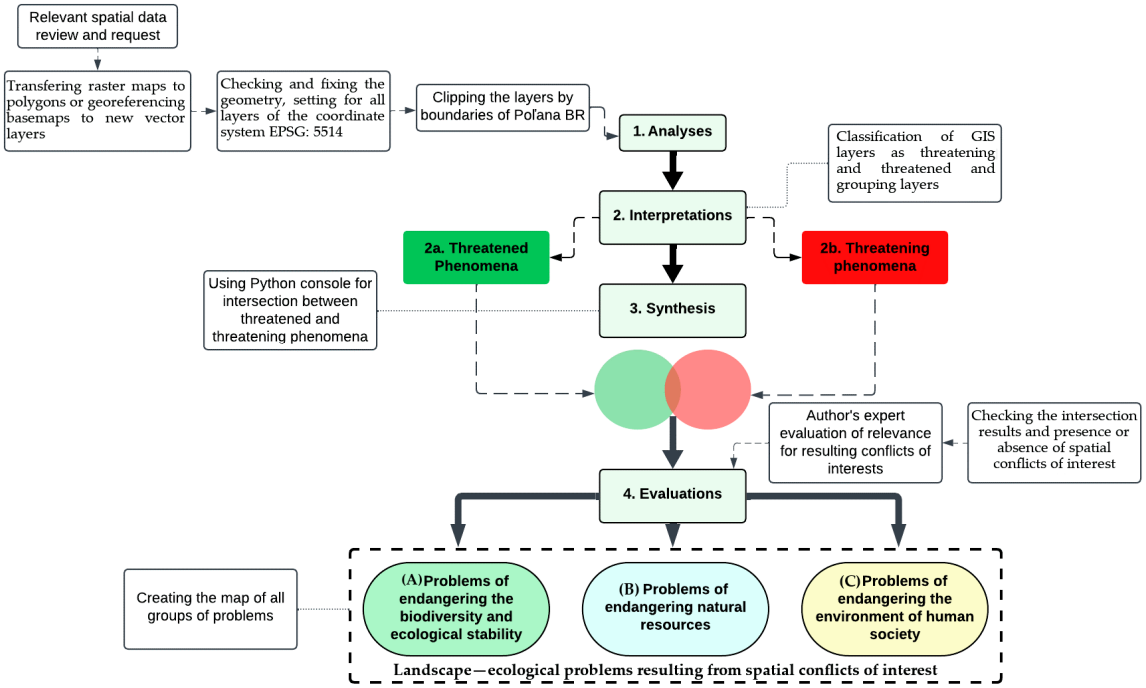


Figure 1. The methodological steps for spatial landscape–ecological evaluation of conflicts resulting from competing interests.

Table 1. Data sources of map layers used for identification of conflicts of interest.

Map Layer Name	Category	Authors	Source
Poľana SPA	Threatened phenomena	State Nature Conservancy of the Slovak Republic	https://maps.sopsr.sk/; accessed on 15 September 2024
SCIs	Threatened phenomena	State Nature Conservancy of the Slovak Republic	https://maps.sopsr.sk/; accessed on 15 September 2024
Small-scale protected areas (nature monuments, nature reserves, protected sites)	Threatened phenomena	State Nature Conservancy of the Slovak Republic	https://maps.sopsr.sk/; accessed on 15 September 2024
Most important habitats	Threatened phenomena	Administrative of Poľana Protected Landscape Area/BR	internal document; accessed on 20 September 2024
Areas of non-intervention	Threatened phenomena	State Nature Conservancy of the Slovak Republic	https://maps.sopsr.sk/; accessed on 15 September 2024
General of the Supra-regional Territorial System of Ecological Stability	Threatened phenomena	Slovak Environment Agency	https://data.sazp.sk/generel-nadregionalneho-uzemneho-systemu-ekologickej-stability; accessed on 20 September 2024
Regional Territorial System of Ecological Stability of district Banská Bystrica	Threatened phenomena	Slovak Environment Agency	https://download.sazp.sk/RUSES_II/; accessed on 20 September 2024
Regional Territorial System of Ecological Stability of district Brezno	Threatened phenomena	Slovak Environment Agency	https://download.sazp.sk/RUSES_II/; accessed on 20 September 2024

Table 1. *Cont.*

Map Layer Name	Category	Authors	Source
Regional Territorial System of Ecological Stability of districts Detva and Zvolen (biocenters)	Threatened phenomena	Slovak Environment Agency	https://www.sazp.sk/zivotne-prostredie/starostlivost-o-krajinu/zelena-infrastruktura/dokumenty-uses-v-sr; accessed on 20 September 2024
Regional Territorial System of Ecological Stability of districts Detva and Zvolen (biocorridors)	Threatened phenomena	Slovak Environment Agency	https://www.sazp.sk/zivotne-prostredie/starostlivost-o-krajinu/zelena-infrastruktura/dokumenty-uses-v-sr; accessed on 20 September 2024
Poľana BR and zones (core, buffer, transition areas)	Threatened phenomena	State Nature Conservancy of the Slovak Republic	https://chkopolana.sopsr.sk/wp-content/uploads/2020/05/BR-Po%C4%BEana_nomin_form_2015.jpg; accessed on 15 September 2024
Protective zones of water sources—level I, II, and III	Threatened phenomena	Water Research Institute	internal document; accessed on 24 September 2024
Protected agricultural soils	Threatened phenomena	Soil Science and Conservation Research Institute	https://portal.vupop.sk/portal/home/webmap/viewer.html?useExisting=1&layers=ed4e890964d447ba93bc7cdc5e20c412; accessed on 24 September 2024
Residential areas	Threatened phenomena	ESPRIT (Secondary Landscape Structure); OpenStreetMap	internal document; https://download.geofabrik.de/; accessed on 24 September 2024
Recreational areas	Threatened phenomena	ESPRIT (Secondary Landscape Structure); OpenStreetMap; Tourist Map of hiking.sk	internal document; https://download.geofabrik.de/; https://mapy.dennikn.sk/; accessed on 24 September 2024
Traditional agricultural landscapes	Threatened phenomena	Institute of Landscape Ecology of the Slovak Academy of Sciences	internal document; https://www.uke.sav.sk/hspk/typizacia/typizacia.htm; accessed on 24 September 2024
Cultural–historical monuments	Threatened phenomena	The Monuments Board of the Slovak Republic	https://www.pamiatky.sk/evidencie-a-registre/register-nnkp; accessed on 25 September 2024
Unstable and potentially unstable areas	Threatening phenomena	Geological Institute of Dionýz Štúr	https://www.geology.sk/geoinfoportal/mapove-sluzby-2/poskytovanie-udajov/; accessed on 24 September 2024
Landslides	Threatening phenomena	Geological Institute of Dionýz Štúr	https://app.geology.sk/geofond/zosuvy/; accessed on 11 September 2024
Seismic hazard	Threatening phenomena	Landscape Atlas of the Slovak Republic (SAŽP)	https://app.sazp.sk/atlassr/; accessed on 25 September 2024
Soil contamination	Threatening phenomena	Geological Institute of Dionýz Štúr	https://www.geology.sk/geoinfoportal/mapove-sluzby-2/poskytovanie-udajov/; accessed on 19 August 2024
Radon risk	Threatening phenomena	Geological Institute of Dionýz Štúr	https://app.geology.sk/radio/; accessed on 7 August 2024

Table 1. *Cont.*

Map Layer Name	Category	Authors	Source
Flood risk (Q50)	Threatening phenomena	Slovak Water Management Enterprise	https://www.arcgis.com/home/item.html?id=0881a807eaf14ea4bb08b02861ff7389; accessed on 8 August 2024
Intensive forestry management	Threatening phenomena	National Forest Centre	https://data.slovensko.sk/datasety/abf4c9d5-2c44-4952-b1d2-8e596cb5b72c; accessed on 8 August 2024
Strong and extreme real erosion	Threatening phenomena	Soil Science and Conservation Research Institute	http://www.podnemapy.sk/portal/verejnost/erozia/vod/vod.aspx; accessed on 8 August 2024
Invasive alien plant species	Threatening phenomena	State Nature Conservancy of the Slovak Republic	https://maps.sopsr.sk/mapy/invazne.php; accessed on 18 October 2024
Agricultural land-use abandonment	Threatening phenomena	VÚPOP, PPA (land parcels of LPIS 2004 and managed land parcels of LPIS 2024)	https://data.slovensko.sk/datasety/cc261225-7153-44a3-8ebf-05af207515c9; internal document; accessed on 12 September 2024
Waste dumps	Threatening phenomena	Geological Institute of Dionýz Štúr	https://apl.geology.sk/skladky/; accessed on 12 September 2024
Power lines (georeferenced)	Threatening phenomena	Tourist Map of hiking.sk	https://mapy.dennikn.sk/; accessed on 8 August 2024
Impervious surfaces and linear features	Threatening phenomena	ESPRIT (Secondary Landscape Structure); OpenStreetMap	internal document https://download.geofabrik.de/; accessed on 12 September 2024
Industrial and manufacturing facilities	Threatening phenomena	ESPRIT (Secondary Landscape Structure); OpenStreetMap	internal document https://download.geofabrik.de/; accessed on 12 September 2024
Protective zones of agricultural enterprises	Threatening phenomena	ESPRIT (Secondary Landscape Structure); OpenStreetMap	internal document https://download.geofabrik.de/; accessed on 12 September 2024

2.2. Data Assessment and Processing

Data from Table 1 were processed in QGIS 3.24.2-Tisler, and in Esri ArcMap 10.8.0.12790 software. Firstly, we created a database of vector shapefile layers from available sources, or raster maps were georeferenced and digitized into vector shapefiles. During the synthesis, to identify the spatial relationship between threatened phenomena and threatening phenomena, we utilized the Python Console in QGIS. The process involved importing the threatened and threatening phenomena (see Supplementary Materials: Figures S1 and S2) into QGIS and ensuring both datasets shared the same coordinate reference system (CRS), followed by verifying attribute tables and geometry validity to ensure data integrity. Using the QGIS Python Console, we imported required libraries such as qgis.core for vector layer access and qgis.analysis for geoprocessing operations. The layers were then loaded into the script and output layers were created to store the intersection results. The output layers were subsequently loaded into the QGIS interface for visual inspection and validation. Finally, in the resultant dataset we identified the presence or absence (0) of conflicts of interest, where the absence is represented as an empty layer.

We revised these conflicts and evaluated their relevance on the basis of the authors' expert evaluation. Some conflicts of interest were evaluated as non-relevant (n) due to

the characteristics and spatial abilities of the mentioned phenomena. The final conflicts of interest (A1-A67, B1-B22, and C1-C32) were categorized by type of conflicts of interest into (A) problems of endangering biodiversity and ecological stability; (B) problems of endangering natural resources; and (C) problems of endangering the environment of human society. We created a map grouping problems into presented categories by merging the geometries for each layer of a single group category. Then, we unified the BR and its zones using the Union tool and calculated the geometries for only the intersected polygons. The calculated intersection area size was used for the estimating the percentage share for each problem category for the BR and its zones.

2.3. Study Area

The Poľana BR was approved by the International Coordinating Council of the Man and the Biosphere Program, which included it in the UNESCO Biosphere Reserve network on 27 March 1990. It is part of the Poľana Protected Landscape Area (PLA) and represents one of the most well-preserved volcanic craters in Europe. The total area of the PLA covers 20,360 hectares. The Poľana BR is a distinctive and unique territory, with its northern edge housing the geographical center of Slovakia—Hrb Hill.

The Poľana BR contains the remnants of a volcanic crater (caldera) with a north–south diameter of 6 km and a circumference of 20 km. It features an intermingling of thermophilic and mountain plant and animal species. A distinctive feature of the protected area is the summit spruce forest at Zadná Poľana, located on the southernmost edge of the original range in the Western Carpathians, growing on an andesite bedrock. Zadná Poľana National Nature Reserve is the second-largest primeval forest in Slovakia.

Notable geological sites include remnants of andesite lava flows, such as the Bystrý Brook Waterfall, Jánošík's Rock, Kaľamárka, and Bátovský Boulder, many of which are designated as protected areas. Within the Poľana BR, 30 small-scale protected areas on the national list and 10 SCIs were declared [16].

The territory also holds cultural and historical significance, with unique forms of historic agricultural landscapes like the Hriňová Hills, showcasing valuable small-scale architecture such as churches, chapels, bell towers, historical cemeteries, and roadside crosses. The traditional architecture of the houses adds to the charm of the landscape.

The Poľana BR is divided into three zones (Figure 2):

- Core area: 1344.44 ha (5.6%);
- Buffer area: 6404.82 ha (26.5%);
- Transition area: 16,408.89 ha (67.9%).

The Poľana BR is a highly valuable area from a nature conservation perspective, hosting numerous important habitats as well as many protected plant and animal species. The BR overlaps with the Poľana PLA and is simultaneously designated as the Poľana SPA and the Poľana supra-regional biocenter. It consists of three primary zones: the core, buffer, and transition zones. This zonation aims to balance biodiversity protection with sustainable resource use [28].

The core zone comprises highly protected areas, with 98.7% of its territory designated as national nature reserves, such as Zadná Poľana, Ľubietovský Vepor, and Hrončecký Grúň, alongside nature reserves like Vrchslatina, Pri Bútľavke, and Kopa. These areas are predominantly under Level 5 protection, with some under Level 4. The buffer zone partially includes the Hrončecký Grúň National Nature Monument as well. The buffer zone contains reserves including Príslopy, Pod Dudášom, and Mačinová, as well as parts of Pralesy Slovenska and notable sites like the Bystrý Potok Waterfall and other natural monuments such as Spády and Havranka. Transition zones contain additional reserves, such as Kopa and Pralesy Slovenska (e.g., Bukovina and Bartkovo), and numerous natural monuments,

including Veporské Skalky, Melichova Skala, and Kalamárka. Protected areas like Meandre Kamenistého Potoka and Horná Chrapková are also found in the transition zone.

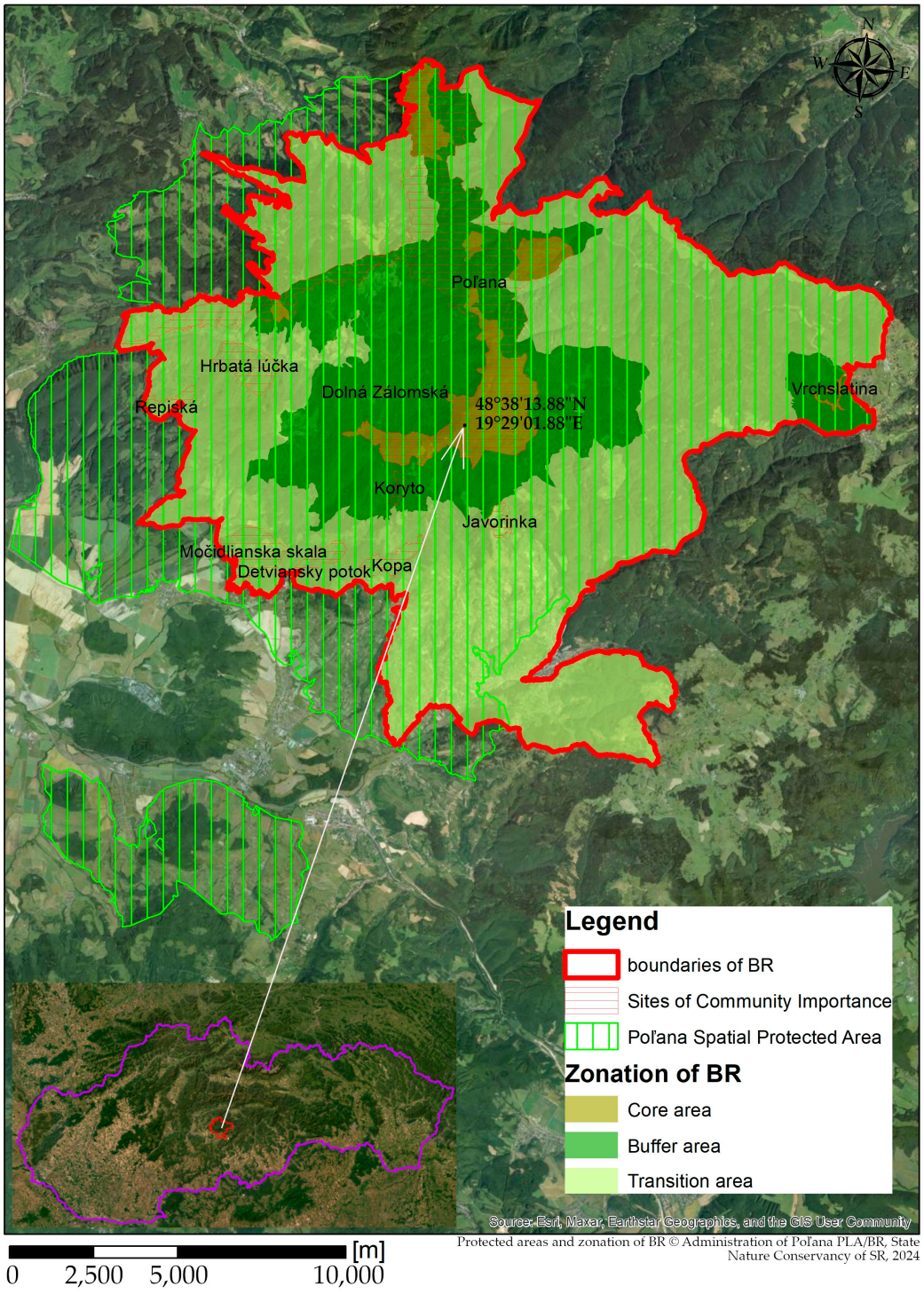


Figure 2. Map of the localization of the Poľana Biosphere Reserve within Slovak Republic, its zones and other protected areas.

Within the BR, numerous SCIs enhance its conservation value, including Poľana, Vrchslatina, Koryto, Dolná Zálomská, Detviansky Potok, Hrbatá Lúčka, Javorinka, Kopa, Močidlianska Skala, and Repiská. These SCIs frequently form the cores of regional biocenters. Additionally, the reserve's significance is amplified by its role as a hub for supra-regional biocorridors, which connect Poľana to major biocenters such as Hôľna Fatra,

Ďumbierske Nízke Tatry, and Salatiny in the north; Balocké Vrchy in the east; and Rohy, Javorie, Litava, and the Ipeľ River basin in the south.

3. Results

3.1. Threatened Phenomena

Through the integration of protected areas, SCIs, biocorridors, and the management of natural resources, the Poľana BR represents a model of sustainable conservation and biodiversity management. This balance between preservation and the responsible use of ecosystem services underscores its vital role as a landscape of ecological and environmental significance. To maintain a balance between conservation and land use, three zones of the biosphere reserve were designated. From a landscape–ecological perspective, a problem arises when the functions of individual zones (Figure 2) are threatened by stress factors.

The Poľana BR is also notable for its diverse natural resources, outlined as follows:

Forests are categorized into protective forests, covering 10.09% of the total forest area, which primarily provide ecological functions, and forests of special designation, accounting for 14.34%, which are significant for their environmental roles—ecosystem services.

Soil resources in the BR are protected through designated high-quality soil units (BPEJ), totaling 1286.17 hectares of agricultural land, mainly in the southern parts of the region such as Hriňová and Detva. These measures aim to prevent the unauthorized conversion of high-quality soils for non-agricultural purposes.

Water resources within the BR are safeguarded by hygienic protection zones (HPZs), including the Hriňová Water Reservoir; several ecologically significant watercourses like Kamenistý Potok, Hučava, Hutná, Slatina, Zolná, and Osrblianka; critical groundwater sources such as Farská Studnička (Lom and Rimavicou); and three springs at Hrochoť (Pípošová, Abčiná, and Studená).

The environmental interests of human society consist of the recreational areas, which are represented by the mountain hotels of Poľana in the center of BR, as well as tourist routes, bike paths, educational traits, and recreational points formed by parking lots, springs, shelters, huts, parking lots, viewpoints, observation towers, and tourist and hunting cabins. The areas of traditional agricultural landscapes consist of mosaics of dispersed (scattered) settlements, small-scale arable lands, and grasslands perceived as holding aesthetic value [19]. The value of this specific landscape configuration is underlined by the Ministry of the Environment, which in 2016 awarded the town of Hriňová the Slovak Landscape Award for the project: Hriňová Scattered Settlements—A Landscape of Values [29]. This award is given to organizations biennially for their contributions to the implementation of the European Landscape Convention at the national level. Residential areas primarily encompass the built-up area of the town of Hriňová as well as all of the dispersed settlements and hamlets located in the open landscape of municipalities within the Poľana BR. The Figure S1 displays the spatial extension of each threatened phenomena within the Poľana BR.

3.2. Threatening Phenomena—Stress Factors

Given the nature of the area as a BR, the Poľana territory is not significantly affected by stress factors (displayed in Figure S2). Among natural stressors, the following are notable:

- Unstable and potentially unstable regions: Regions of unstable areas comprise 728.54 ha (3.02%) of the BR, and regions of potentially unstable areas, 1676.00 ha (6.94%). They are predominantly localized in the south slopes of the Poľana volcano. These involve gravitational movements of the rock cover on slopes along shear planes;
- Landslides: Identified potential landslide surfaces are shown on 224.79 ha (0.93%) of the BR, partially copying the regions of unstable areas. The Poľana BR is categorized

as having a low susceptibility to landslides [30]. However, the potential landslides are localized mostly in the cadaster Hriňová in the south and partially southeast;

- Seismic hazard: according to the map of selected geodynamic phenomena [31], the maximum expected seismic intensity in the area is level 7 (MSK-64) in almost all areas of the BR, although the southern part of the area falls to level 6–7;
- Soil contamination: Soil contamination is influenced by natural factors such as geochemical anomalies, emissions, and agricultural activities. Potential contamination sources include illegal waste dumps and various seepages. Most of the soils in the Poľana BR are relatively clean, with only minor areas being moderately contaminated [22]. As with other volcanic mountain areas in Slovakia, Poľana shows geochemical anomalies with increased levels of Cd, Pb, and partially Zn [32]. Non-contaminated soils, in which the geogenically caused concentration of certain elements reaches A-limit values, make up two-thirds of the BR, localized in the north, covering an area of 15,861.40 ha;
- Radon risk: in terms of natural radioactivity, the Poľana BR lies within a low-to-moderate radon risk area [33];
- Flood risk: The flood risk within the flood zone Q50 [25] is identified along the Slatina River with 30.21 ha. It is caused by increased rainfall activity possibly combined with sudden snowmelt in the Slatina River, followed by the sudden failure of the Hriňová Water Reservoir;
- Strong and extreme real water erosion: The presence of all four classes of erodibility is identified in the study area [24]. The most presented (over 90% of the BR) is none-to-slight erodibility (0–4 t/ha/year). Strong erodibility (10–30 t/ha/year) reaches 2.67%, and extreme erodibility (more than 30 t/ha/year) is 1.14% of the total area of the BR;
- Invasive alien plant species: The most common invasive species include common ragweed (*Ambrosia artemisiifolia*), Canadian goldenrod (*Solidago canadensis*), knotweed (*Fallopia sp.*), Himalayan balsam (*Impatiens glandulifera*), and giant hogweed (*Heracleum mantegazzianum*) [26]. These species are most frequently found along roadsides, in built-up areas, on the outskirts of settlements, as well as near watercourses. They are also present along forest edges. Japanese knotweed (*Fallopia japonica*), black locust (*Robinia pseudoacacia*), and big-leaf lupine (*Lupinus polyphyllus*) are also notable invasive species occurring in the BR. In the Bátovský Balvan natural monument, the occurrence of Canadian goldenrod (*Solidago canadensis*) has been recorded, while in a Mačinová nature reserve, occurrences of small balsam (*Impatiens parviflora*) were recorded.

Anthropogenic stress factors include the following:

- Intensive forestry management: the commercial forest category [34], with presumed intensive forestry management, reaches 13,575.13 ha (56.19% of the BR) in the buffer and transition areas of the BR;
- Agricultural land-use abandonment: Currently, the abandonment of existing agricultural landscape areas from the year 2004 to 2024 [35] shows a loss of 1430.37 hectares (32.22%). Only a part of the abandoned agricultural landscape has been transformed into forest land—with an area of 377.33 ha—under the forest management plan. Meanwhile, the rest of the abandoned area is agriculturally unmanaged (overgrown by woody species) or without direct payments from the Common Agricultural Policy;
- Environmental burdens: The heavy machinery plants in the cadastral area of Hriňová represent remnants of engineering production with a confirmed environmental burden classified as a high-priority removal site. Additionally, the municipal waste landfill Fangová poses a potential environmental burden, representing a significant risk located near the Hriňová Water Reservoir [36];

- Waste dumps: In total, five waste dumps are registered in the BR [37]. In the past, the registered waste dumps were transported to a legal landfill, making them abandoned and removed sites. However, they still represent a potential source of contaminant release into soil or water resources;
- Power lines: the power lines network in the Poľana BR present as 16.97 km in length, which acts as a stress factor for avifauna and *Chiroptera*;
- Impervious surfaces and linear features: Consisting of buildings, gardens, and paved roads, situated mainly in the transition areas. These surfaces have negative impacts on traffic, which contributes to gaseous emissions, secondary dust, and noise pollution, as well as the risk of soil and water contamination. The Poľana BR is considered to be a low-pollution area. No major air pollutants are present within the reserve itself; however, local sources, such as heating systems in villages without a gas supply connection, contribute to air pollution during the heating season due to the combustion of solid fuels. The quality of air is also affected by long-distance pollution from areas like Žiarska Kotlina, Horná Nitra, Banská Bystrica, and Zvolen. Additionally, increasing automobile traffic contributes to gaseous emissions, secondary dust, and noise pollution [38–40]. The most affected transport corridor is secondary road 526, where traffic exceeds 7000 vehicles per day;
- Recreational areas: in the Poľana BR, the recreational areas (with the same spatial area as in threatened phenomena) have a negative impact if they are unregulated and the pressure on biota can increase;
- Protective zones of industrial and manufacturing facilities: a buffer area of 100 m around existing objects of industrial and manufacturing facilities, localized in the city Hriňová, along Slatina River;
- Protective hygienic zones of the agricultural enterprises: The protective hygienic zone is 100 m around objects of agricultural enterprises affecting the human environment. An identified agricultural enterprise is situated in Zánemecká, on the southern slope of the Poľana volcano.

3.3. Conflicts of Interest

Based on the spatial intersection of threatened and threatening phenomena, we have identified the following three categories of environmental problems within the territory of the Poľana BR, shown in Table 2: (A) problems of endangering biodiversity and ecological stability with 67 conflicts of interest; (B) problems of endangering natural resources with 22 conflicts of interest; and (C) problems of endangering the environment of human society with 32 conflicts of interest. For the visualization of all three categories of problems, a map was created showing their localization within the BR and its zones (Figure 3); the expression of the percentage share of each problem category is presented in Table 3.

Table 2. Identified conflicts of interest.

Threatening phenomena	Conflicts of Interest	Threatened Phenomena														
		(A) Problems of Endangering Biodiversity and Ecological Stability									(B) Problems of Endangering Natural Resources		(C) Problems of Endangering the Environment of Human Society			
		SPA	SCIs	Small-Scale Protected Areas	Most Important Habitats	Areas of Non-Intervention	Elements of TNES	Core Area of BR	Buffer Area of BR	Transition Area of BR	Protective Zones of Water Sources	Protected Agricultural Soils	Residential Areas	Recreational Areas	Traditional Agricultural Landscapes	Cultural–Historical Monuments
Natural stress factors	Unstable and potentially unstable areas	n	n	n	n	n	n	n	n	A1	n	B1	C1	n	C2	n
	Landslides	n	n	n	A2	0	A3	n	0	A4	B2	B3	C3	n	C4	0
	Seismic hazard	n	n	n	n	n	n	n	n	n	n	n	C5	C6	C7	C8
	Soil contamination	A5	A6	A7	A8	A9	A10	A11	A12	A13	B4	B5	C9	n	C10	n
	Moderate radon risk	n	n	n	n	n	n	n	n	n	n	n	C11	C12	n	n
	Flood risk	n	0	0	0	0	n	0	0	A14	0	B6	C13	C14	C15	0
	Strong and extreme real water erosion	n	n	n	A15	n	n	n	n	A16	B7	B8	C16	C17	C18	C19
	Invasive alien plant species	n	0	A17	A18	0	A19	0	A20	A21	B9	B10	C20	n	C21	0
Anthropogenic stress factors	Intensive forestry management	A22	A23	A24	A25	A26	A27	A28	A29	n	B11	B12	0	n	n	n
	Agricultural land-use abandonment	A30	A31	A32	A33	0	A34	A35	A36	A37	n	B13	n	n	C22	n
	Environmental burdens	A38	0	0	A39	0	n	0	0	A40	0	B14	C23	0	C24	0
	Waste dumps	A41	0	0	0	0	A42	0	0	A43	B15	B16	C25	0	0	0
	Power lines	A44	A45	A46	A47	0	A48	0	n	n	n	B17	n	n	C26	0
	Impervious surfaces and linear features	n	A49	A50	0	A51	A52	A53	A54	n	B18	B19	n	n	C27	n
	Recreational areas	A55	A56	A57	A58	A59	A60	n	n	n	B20	B21	C28	n	C29	n
	Hygienic zones of industrial and manufacturing facilities	A61	0	0	A62	0	A63	0	A64	n	0	B22	C30	n	C31	0
	Hygienic zones of the agricultural enterprises	A65	0	0	A66	0	A67	0	0	n	0	0	0	0	C32	0

A1-67, B1-22, C1-32—conflicts of interest; 0—no intersection between threatened and threatening phenomena; n—non-relevant.

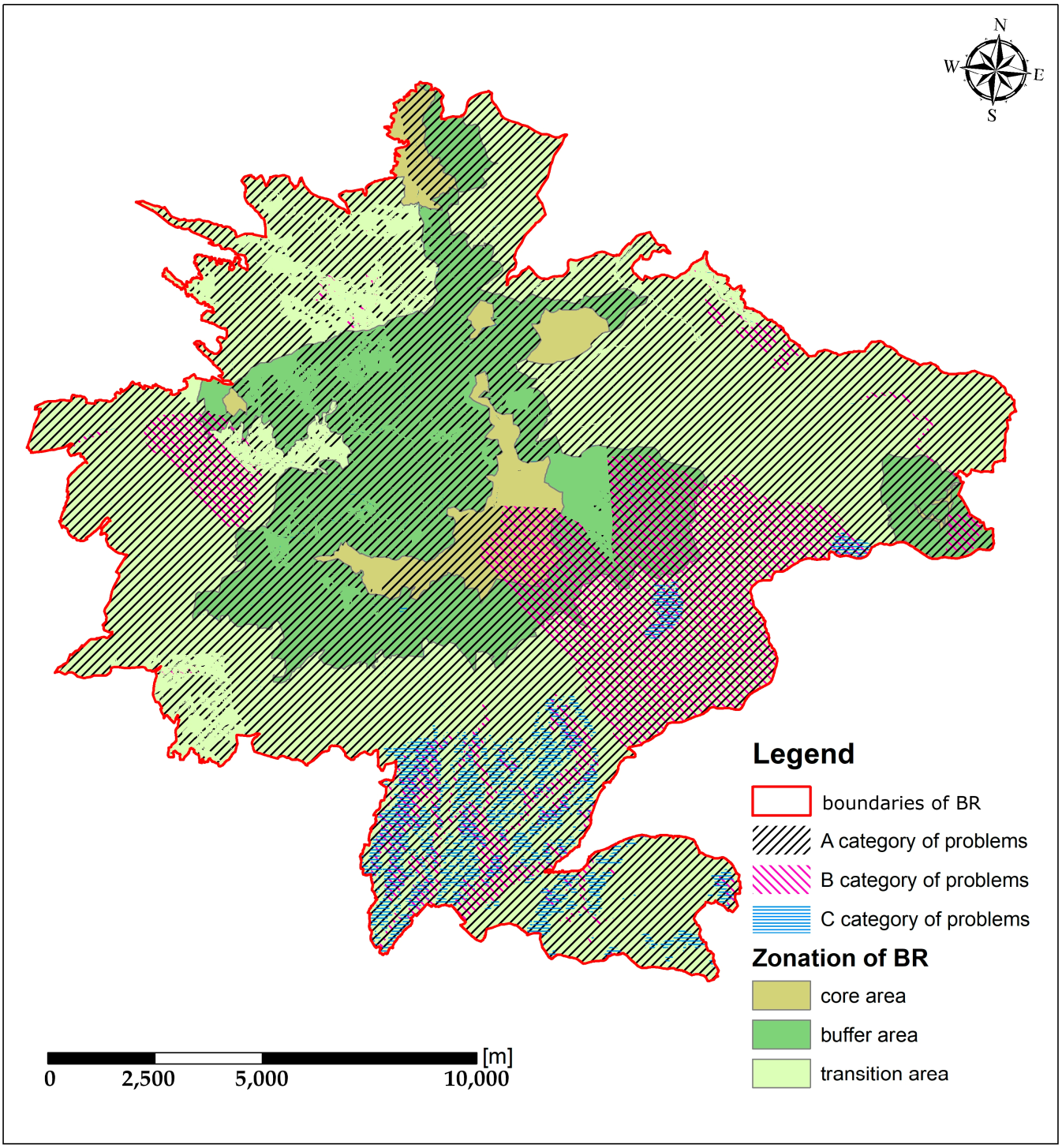


Figure 3. Map of unified problems for each category.

Table 3. Expression of percentage share between each category of problems and the BR including its zones.

Category of Problems	Core Area	Buffer Area	Transition Area	BR
A [ha]	715.32	5654.79	15,375.71	21,745.82
Percentage share [%]	53.21	88.29	93.7	90.01
B [ha]	267.47	891.1	3621	4779.57
Percentage share [%]	19.89	13.91	22.07	19.78
C [ha]	2.32	11.03	1226.77	1240.12
Percentage share [%]	0.17	0.17	7.48	5.13

The most extensive problems are problems of endangering biodiversity and ecological stability, which are present on 90.01% of the whole BR. The transition area displays 93.70% and the buffer area 88.29%. Only 46.79% of the core area is not affected by this problem category. The most extensive problems are as follows: A5—threats to Poľana SPA from soil contamination with 14,422.93 ha; A22—threats to Poľana SPA from intensive forestry management with 13,007.81 ha; and A13—threats to the transition zone of the BR from soil contamination with 12,449.05 ha.

Problems of endangering natural resources in the BR cover 19.78% of the area and are mainly present in the transition area of the BR (22.07%). The most prevalent issues are as follows: B4—threats to water sources from soil contamination with 3631.53 ha; B11—threats to water sources from intensive forestry management with 1817.94 ha; and B5—threats to protected agricultural soils from soil contamination with 1105.62 ha.

The smallest spatial area of identified problems are problems of endangering the environment of human society with only 5.13% of the whole area of the BR. The highest share for this category is in the transition area (7.48%); meanwhile, the core and buffer areas are not significant (under 1%). The most presented issues are as follows: C7—threats to traditional agricultural landscapes from the seismic hazard with 1195.24 ha; C2—threats to traditional agricultural landscapes from unstable and potentially unstable areas with 689.22 ha; and C22—threats to traditional agricultural landscapes from agricultural land-use abandonment with 221.10 ha.

3.3.1. Problems of Endangering Biodiversity and Ecological Stability

Problems of biodiversity and landscape stability threats arise from spatial conflicts between stress factors and biologically and ecologically valuable elements, such as protected areas, NATURA 2000 sites, elements of the TNES, and other eco-stabilizing features of the landscape. In the study area, the most significant conflicts of stress factors and ecologically significant areas are the following:

A1. Threats from unstable and potentially unstable areas to the transition area of the BR: this poses a risk to socio-economic activities associated with the utilization of nature by disrupting other functions characteristic of the transition zone of the biosphere reserve (BR).

A2–A4. Threats from landslides to most important habitats, elements of the TNES, and the transition area: Landslides pose a particular threat to non-forested habitats in the southern part of the BR, in the cadastral areas of Hriňová and Detva. The landslides may cause degradation of the ecostabilization functions of biocenters, and also—depending on the extent and intensity—the migration function of biocorridors. Risk for the transition area may cause problems in the utilization of nature like agriculture.

A5–A13. Threats from soil contamination to biodiversity and ecological stability: These include the transport of pollutants from surrounding air pollution sources in the districts of Zvolen and Banská Bystrica, as well as increased concentrations of foreign substances in soils. Although the soils are not officially classified as contaminated, geogenic levels of certain hazardous elements, reaching threshold values, have been recorded, particularly in the central and southern parts of the Poľana BR and around Ľubietovský Vepor in the north. Contaminated soil can alter the physical and chemical properties of the habitat, making it unsuitable for the survival of species that rely on it. Toxic substances may reduce soil fertility, disrupt nutrient cycles, or change the pH levels, adversely affecting plant growth and, subsequently, the entire ecosystem. Other problems are bioaccumulation and biomagnification, where contaminants can enter the food chain through plants or soil-dwelling organisms and endanger objects of protection in all protected areas. Contaminants may also cause long-term ecosystem degradation, leading to a decrease in the ecological stability of elements of the TNES, and endanger the functions of each zone of the BR.

A14. Threats from flood risk to the transition area of the BR: Floods affect intensively used meadows along the Slatina River and its tributaries, leading to changes in species composition. Besides the ecological threats, it represents potential socio-economic threats (agricultural losses, reduced ecosystem services, and health and property risk).

A15–A16. Threats from strong and extreme water erosion to the most important habitats and transition area: The real water erosion that reaches strong erodibility and extreme erodibility is identified as hazardous for habitats as well as for socio-economic activities bounded to agriculture. The most endangered are large-scale arable lands on higher slopes and grasslands with more than 20° of slope without ecological stabilization measurements. The impact can also accelerate large-scale deforestation and the disturbance or removal of vegetation cover in conjunction with the operation and passage of heavy machinery.

A17–A21. Threats from invasive alien plant species to biodiversity and ecological stability: One of the most commonly occurring invasive species [26] is common ragweed (*Ambrosia artemisiifolia*), Canadian goldenrod (*Solidago canadensis*), knotweed (*Fallopia* sp.), Himalayan balsam (*Impatiens glandulifera*), and giant hogweed (*Heracleum mantegazzianum*). These species are frequently found along roadsides and built-up areas, on settlement edges, and near watercourses such as the Slatinka and Hutná Rivers, as well as at the forest edges like Kozí chrbát, Javorinka, Šulkov vrch, and Hrochotský les. The most endangered protected area is the buffer zone of the natural monument Kaľamárka, threatened by Japanese knotweed (*Fallopia japonica*), black locust (*Robinia pseudoacacia*), and garden lupin (*Lupinus polyphyllus*). In the natural monument Bátovský Balvan, Canadian goldenrod (*Solidago canadensis*) has been recorded, while the natural reserve hosts small balsam (*Impatiens parviflora*) and Canadian goldenrod (*Solidago canadensis*). They significantly alter habitat characteristics, threaten native plant species, and form homogeneous monocultures. Their occurrence in elements of the TNES can cause a decrease in ecological stability and promote their spreading by biocorridors. By degrading the natural and semi-natural habitats, they lower the ecosystem functions and services of the buffer and transition areas of the BR.

A22–A29. Threats from intensive forestry management to biodiversity and ecological stability: Threats to wildlife may be due to inappropriate logging timing, with many forest stands being harvested during the nesting season. In Poľana SPA it is necessary to maintain and enhance the favorable conditions for bird species and their habitats. Intensive forest management poses a threat to the favorable conservation status of habitats and species of community importance and represents a direct risk to their continued existence. Intensive forest management poses a direct risk to objects of protection and the continued existence of protected species and habitats and negatively impacts the natural processes within. Intensive forestry management can also cause the degradation of forest habitats, decreasing the favorable conservation status and quality of the ecosystem services produced. It acts as a disturbance to peace and quiet in non-intervention areas, disrupting natural processes. Intensive logging threatens the ecological stability of biocenters and their functions. In the core area of the BR, it disrupts the function of the Poľana Biosphere Reserve on less than 4.5 ha. Intensive logging may also cause disruption of the buffer area's function.

A30–A37. Threats from agricultural land-use abandonment to biodiversity and ecological stability: The grasslands, with a wide range of important habitats, are endangered by abandonment, leading to succession that results in community degradation, which manifests in a decline in species diversity, the encroachment of woody plants, and an increased coverage by competitive grass species. The encroachment of woody plants leads to the gradual degradation of non-forested peat bogs, reducing their natural significance. The abandonment of traditional land management and insufficient management practices threaten the landscape–ecological value of these areas (e.g., the conversion of overgrown

grasslands into forests). From 2004 to 2024, the Poľana BR has lost 357.9 hectares (12.3%) of utilized permanent grasslands [35]. This trend is observed throughout the BR. A decrease in the amount of livestock, particularly sheep, has been documented in four districts within the Poľana BR (Banská Bystrica, Brezno, Detva, and Zvolen) between 2010 and 2023, with a 25% decline overall, and the Detva district, which occupies the largest part of the BR, recorded a decline of up to 37.75% [41,42]. The impact of agricultural land-use abandonment forms a problem with necessary feeding and nesting habitats for bird species as an object of conservation in the Poľana SPA. The disappearance of non-forest habitats threatens protected areas and their conservation targets, particularly if they consist of grassland and herbaceous vegetation or non-forest plant species. For these habitats, this means successional changes that can lead to the loss of the habitat. In the case of the TNES, the landscape mosaic shifts in favor of continuous overgrown areas. For the core and buffer areas, this poses a threat to the rarest non-forest ecosystems and the reduction in their areas. In the transition area, we can observe a decline in socio-economic activity, where shrub encroachment first requires removal and then restoration to its original productive state, which entails economic costs.

A38–A40. Threats from environmental burdens to biodiversity: Residues from the registered potential environmental burden of the recultivated Fangová landfill may have a potential negative impact on the conservation targets. Remnants of heavy machinery plants in the cadastral area of Hriňová represent a potential risk of degrading the ecological conditions for existing habitats. These threats also represent a potential risk for the reduction in biodiversity, primarily for production ecosystem services—on which socio-economic development depends.

A41–A43. Threats from waste dumps to biodiversity and ecological stability: This phenomenon is widespread across the study area and is primarily a consequence of tourism development and the rise in recreational housing. Scattered waste is particularly evident near hiking trails. Registered waste dumps were previously transported to legal landfills, rendering them abandoned and officially removed sites; however, these sites still pose a potential risk as sources of contaminant release into soil or water resources. Residues from removed waste dumps form a potential negative impact on the conservation targets of the Poľana SPA by entering the food chain. There is a potential risk of contamination by residues to ecosystems, lowering their ecological stability. In the transition area, they pose a risk not only to ecosystems but may also lower the human environment quality. Illegal waste dumps can also occur randomly and cause problems for threatened phenomena.

A44–A48. Threats from power lines to biodiversity and ecological stability: Wildlife, particularly birds, within designated the Poľana SPA face significant barriers due to electrical lines, with the highest concentration of such lines found in the southern part of the BR as well as in the built-up area of Hriňová and its surroundings. The management of tree overgrowth under power lines represents a potential negative impact on the SCIs and small-scale protected areas by disturbing the conservation targets. The presence of power lines contributes to the fragmentation of most important habitats and decreases the ecological stability of biocenters and the connectivity of biocorridors.

A49–A54. Threats from impervious surfaces and linear features to biodiversity and ecological stability: The intensity of road traffic continues to rise and is expected to keep increasing. High traffic volumes are found on secondary roads, such as road 526 (sections 91710 and 91711) with 7200–7600 vehicles passing daily, and road 529 (section 91701) with 1100–4600 vehicles passing daily [38–40]. These roads are located in the southern and southeastern parts of the Poľana BR. Increased noise levels are also caused by logging and timber transport. The threats relate to ever-growing pressures for new developments. These structures, besides increasing the level of anthropization in the area, also act as

barriers to the migration of biota in SCIs, small-scale protected areas, and the buffer area. In particular, for the TNES, the division of biocenters and biocorridors by anthropogenic structures—such as built-up areas and transportation corridors—represents a barrier effect. For example, biocorridors collide with transport routes, and sections of biocorridors run through built-up areas. The densest network of migration barriers is found in settlements and their surrounding dispersed settlements, where urban development and road networks dominate, as well as near major transport routes (second- and third-class roads). The signal tower in the center of Poľana—where the non-intervention and the core areas of the Poľana Biosphere Reserve are located—represents a potential risk to the biota due to disturbance of the quiet environment or unforeseen interventions associated with the maintenance of this facility.

A55–A60. Threats from recreational areas to biodiversity and ecological stability: Recreation, whether through hiking or cycling, poses an increasing risk to biodiversity and ecological stability as its intensity grows. For the Poľana SPA, this may involve disturbing the nesting of rarer bird species. In SCIs and small-scale protected areas, it could lead to the trampling of valuable habitats, the disturbance of wildlife, or undesirable encounters with bears. For valuable non-forest habitats, vegetation trampling can result in adverse changes to species composition. Cycling also damages non-forest habitats as unpaved bike trails destroy the vegetation cover. Some hiking trails are located in non-intervention areas; however, they do not pose a significant risk if tourists are well-informed about appropriate behavior in nature and if the localization of trails is designed by conservation experts. For the TNES, such infrastructure may potentially disturb wildlife or negatively affect animal migration during the tourist season. The negative effects of tourism are also due to unregulated recreation development and the change of a residential function to recreational.

A61–A64. Threats from the hygienic zones of industrial and manufacturing facilities to biodiversity and ecological stability: Industrial zones can lead to the loss or fragmentation of critical habitats for bird species, disrupting breeding, feeding, and migratory behaviors. Constant noise, vibrations, and human activity in industrial zones can disturb birds, especially during sensitive periods such as nesting and migration. Artificial lighting can disorient nocturnal and migratory birds, increasing their mortality risk. Air, water, and soil pollution from industrial activities can harm bird populations directly (e.g., through toxic exposure) or indirectly by reducing prey availability. Industrial emissions, such as pollutants and particulate matter, can degrade air and soil quality, affecting plant growth and ecosystem health. Expansion of industrial zones often encroaches on nearby habitats, altering their structure and function. Industrial areas may inadvertently introduce invasive species, which can outcompete native flora and fauna, further degrading habitats. Industrial zones can sever ecological corridors that connect habitats, disrupting wildlife movement and gene flow. Infrastructure such as roads, fences, and buildings associated with industrial zones creates physical barriers, impeding animal migration and dispersal. Industrial water usage and discharge can alter local hydrological cycles, negatively impacting wetlands, streams, and other critical nodes in ecological networks. The buffer area acts as a protective barrier for the core area, supporting conservation efforts and reducing external pressures. Industrial activities can disrupt this role by increasing noise, pollution, and human activity. Industrial activity in the buffer zone may lead to indirect impacts, such as increased logging, poaching, or encroachment in the adjacent core area.

A65–A67. Threats from the hygienic zones of the agricultural enterprises to biodiversity and ecological stability: Although the area around Poľana is primarily an agricultural landscape, only one larger agricultural enterprise has been identified. This enterprise poses potential risks to the conservation objectives of the Poľana SPA, primarily through noise

and contamination of nearby water sources where birds drink. Leachate from manure and slurry storage can release substances into the surrounding meadows, potentially leading to eutrophication, altering the natural species composition, and causing the degradation of habitats of community importance. For the TNES, this represents a stress factor as the enterprise is located within a regionally significant biocenter.

3.3.2. Problems of Endangering Natural Resources

Problems of endangering natural resources arise from the spatial conflict between stress factors and individual natural resources. In the area of interest, the most significant threats from stress factors include the following:

B1. Threats from unstable and potentially unstable areas to protected agricultural soils: unstable and potentially unstable areas can damage the highest-quality and most-fertile soils in the area of interest.

B2–B3. Threats from landslides to natural resources: Landslides pose a risk in the area around the Hriňová Water Reservoir, where cumulative impacts—such as deforestation, soil contamination, and waste disposal—threaten to compromise the quality of drinking water. Landslides, particularly in the cadastral area of Hriňová and other dispersed settlements, pose a potential risk to agricultural soil resources. A small-scale active landslide has been documented in the northern part of Hriňová, near a road beneath the Hriňová Reservoir.

B4–B5. Threats from soil contamination to natural resources: Contamination from soils, particularly around the Hriňová and Hrochoť protected water source areas, poses a risk of pollutants leaching into local water resources. The area around Hriňová and remote locations in the northern part of the BR Poľana are particularly vulnerable. Overall, 85.9% of protected soil quality assessment units reach the contamination threshold values for some elements due to geogenic causes, while the remaining areas consist of relatively clean, non-contaminated soils.

B6. Threats from flood risk to protected agricultural soils: the impact of floods results in the degradation of soil quality and in the removal of fertile soil layers.

B7–B8. Threats from strong and extreme water erosion to natural resources: The real risk of water erosion may lower the quality of drinking water in Hriňová Water Reservoir. Water erosion of the highest levels may cause damage to agricultural land, mostly arable lands without anti-erosion measures. This can be reflected in the soil quality and in the loss of fertile soil layers.

B9–B10. Threats from invasive alien plant species to natural resources: The problem of invasive plant species in the protective zones of water sources lies on the one hand, in the legal obligation for land managers to remove invasive species; on the other hand, these areas have strict regulations regarding vegetation management, and the use of chemical treatments against invasive species may pose risks for the water sources. Some invasive species can alter the chemical composition of the soil. For instance, certain invasive plants may release allelopathic compounds (chemicals that inhibit the growth of other plants) into the soil, which can harm surrounding native vegetation and disrupt nutrient cycles.

B11–B12. Threats from intensive forestry management to natural resources: A potential risk may arise if increased intensity of forest management disrupts the isolating and hygienic functions of the Hriňová Reservoir, potentially accelerating erosion processes and landslides, compromising the quality of drinking water. In the case of protected soils, the problem lies in the current legislative framework, which, on the one hand, prohibits the non-agricultural use of areas with protected agricultural soils, but on the other hand, these areas are being used as forests.

B13. Threats from agricultural land-use abandonment to protected agricultural soils: the threat to their function as the most fertile parts of soil in the relevant cadastral areas of the Pol'ana BR arises from the absence of agricultural land use.

B14. Threats from environmental burdens to protected agricultural soils: a potential risk of disrupting the ecological properties of the soil, leading to a decline in its fertility.

B15–B16. Threats from waste dumps to natural resources: The creation of unregulated waste dumps presents a risk to water sources. Waste dumps have been identified in the protective zones of Hriňová Water Reservoir. The site has been remediated, although it still poses risks of contaminant leaching into groundwater. This poses a potential risk of disrupting the ecological properties of the soil, leading to a decline in its fertility.

B17. Threats from power lines to protected agricultural soils: the problem lies in the current or potential future construction of high-voltage power line towers on the most fertile soils, which not only leads to taking land but also involves strict regulations that apply to agricultural use under power lines and within the protective zones of power lines.

B18–B19. Threats from impervious surfaces and linear features to natural resources: In the southeast area of the BR is an existing road network that can negatively impact the water resources by fuel exhalation and de-icing materials. It can cause a threat to the quality of drinking water from water reservoirs. Threats to soil resources are especially evident around the town of Hriňová and in its northern rural settlements, where de-icing materials contribute to soil degradation. The protected soils with high soil fertility can be damaged by inefficient spatial development, where there are existing or planned built-up areas and transportation infrastructure.

B20–B21. Threats from recreational areas to natural resources: This represents a potential and very small risk of contamination of the water sources of the second protection degree from tourist trails and recreational infrastructure in the western part of the biosphere reserve. This threat can involve the conversion of protected agricultural soils for the purposes of recreational infrastructure.

B22. Threats from the hygienic zones of industrial and manufacturing facilities to protected agricultural soils: industrial areas represent a potential risk for soil contamination, leading to a reduction in its ecological properties and a loss of fertility.

3.3.3. Problems of Endangering the Environment of Human Society

Problems of endangering the environment of human society arise from the spatial conflict between stress factors and humans with their environment. Within this category, the most significant threats from stress factors include the following:

C1–C2. Threats from unstable and potentially unstable areas: The unstable and potentially unstable areas and landslide processes are particularly present in the rural settlements north of Hriňová and in the Snohy area. The risk of lower slope stability endangers the residential function of the environment. Slope instability can result in the loss of aesthetic value, such as traditional rural settlements with a mosaic of agricultural structures.

C3–C4. Threats from landslides: The surfaces associated with landslides occur in the rural settlements north of Hriňová and in the Snohy area. The occurrence of landslides threatens the loss of the positive visual characteristics of the traditional agricultural landscape areas.

C5–C8. Threats from the seismic hazard to the environment of human society: According to the map of selected geodynamic phenomena [31], a maximum expected seismic intensity of level 7 MSK-64 is almost present across the whole area of the BR, while the southern part of the BR reaches level 6 MSK-64. Level 6 is felt by most people both indoors and outdoors, many people run outside in panic, lose their balance, and even heavy furniture shifts, bells ring, and cracks appear in plaster. Level 7 is felt by people in motor

vehicles, cracks appear in walls, poorly constructed buildings collapse, and water bodies ripple [43]. From this perspective, the threat is localized to residential areas, recreational areas (tourist and hunting cabins), buildings and constructions of traditional agricultural landscapes (houses and barns), and cultural–historical monuments (buildings of national cultural monuments).

C9–C10. Threats from soil contamination to residential areas and traditional agricultural landscapes: soil contamination primarily represents a potential risk of harmful substances entering the food chain through vegetables, fruits, or agricultural crops, localized on fields of residential and traditional agricultural landscape areas.

C11–C12. Threats from moderate radon risk to residential and recreational areas: In the northeastern and eastern edges of the BR Poľana and smaller areas north of the Poľana Massif, a moderate radon risk is indicated. The most at-risk areas are the town of Hriňová and its rural settlements, as well as Iviny, Snohy, and Vrchslatina. Radon gas negatively impacts human health, increasing the risk of lung cancer when buildings are not properly secured against it.

C13–C15. Threats from flood risk to residential areas, recreational areas, and traditional agricultural landscapes: The most threatened areas by floods are those along the Slatina River, from the Hriňová Water Reservoir in the municipality of Hriňová. The negative impacts of floods affect human health, the environment, cultural heritage, and economic activities.

C16–C19. Threats from strong and extreme water erosion to the environment of human society: Water erosion can cause adverse environmental incidents, especially in agricultural landscapes without erosion control measures, potentially damaging buildings or roads within inhabited and recreational areas. It can also visually degrade existing structures of traditional agricultural landscapes. Last but not least, cultural and historical monuments are at risk.

C20. Threats from invasive alien plant species to residential areas: Canadian goldenrod (*Solidago canadendis*) is a notable allergen occurring in residential areas, while others, like giant hogweed (*Heracleum mantegazzianum*), can cause skin injuries. Their occurrence is recorded in or around residential areas [26], where they may cause some medical issues for citizens.

C21–C22. Threats from invasive alien plant species and land-use abandonment to traditional agricultural landscapes: These threats are caused by the decline in family farming and the lack of interest among the younger generation in farming. The preserved structures are necessary to manage to preserve the traditional agriculture landscape's character. The presence of invasive plant species in the traditional agricultural landscape of the Podpolanie region is not only a sign of abandonment of land use but also decreases the visual quality of their structures.

C23–C24. Threats from environmental burdens to residential areas and traditional agricultural landscapes: These are located near the borders of the BR Poľana in Hriňová—one confirmed burden is left over from the heavy machinery industry and one potential environmental burden is from recultivated waste dump. They may contaminate the food chain in gardens of residential areas and in traditional agricultural landscapes associated with food production.

C25. Threats from waste dumps to residential areas: Localization of the unmanaged waste dumps is notably near residential areas, which, in addition to degrading the aesthetic quality of the environment, also serve as sources of bacterial contamination. Several sites have been remediated, though they still pose risks of contaminant leaching into groundwater.

C26. Threats from power lines to traditional agricultural landscapes: power lines in such areas can have a visual impact, reducing the aesthetic value of traditional agricultural landscapes.

C27. Threats from impervious surfaces and linear features to traditional agricultural landscapes: especially along roads 526 and 529 in the southern and southeastern parts of the BR Pol'ana, which are the most heavily used by motorists in the area, from producing transport emissions.

C28–C29. Threats from recreational areas to residential areas and traditional agricultural landscapes: A potential risk may arise from the uncontrolled development of tourist infrastructure, which often overlaps with residential areas. Parking lots can emerge, as well as various parked cars along tourist routes. Additionally, a potential issue may be the conversion of residential areas into recreational, introducing elements that cause a visual impact, thus disrupting the characteristic appearance of the traditional agricultural landscape.

C30. Threats from the hygienic zones of industrial and manufacturing facilities to residential areas and traditional agricultural landscapes: Local industrial and manufacturing facilities create threats related to noise, smell, and light pollution, producing emissions from industrial operations and transportation-related emissions and pollutants. Bigger agricultural enterprises can also contribute to environmental pollution through the emission of odors. The above-mentioned threats can also decrease the aesthetical value of traditional agricultural landscapes.

C32. Threats from the hygienic zones of the agricultural enterprises to traditional agricultural landscapes: The newly constructed building is located in areas with identified historical agricultural landscape structures [19]. These areas once featured forms of traditional mosaic agricultural landscapes, dominated by small-block arable land. The agricultural building represents the loss of aesthetic value as well as having a visual impact.

4. Discussion

BRs can be considered as natural laboratories for sustainable development. According to UNESCO (2016) [44], BRs are expected to fulfill three primary functions: (1) a conservation function—protecting natural and semi-natural ecosystems, landscapes, and their resources; (2) a development function—promoting sustainable socio-economic development; and (3) a logistic function—supporting research, monitoring, environmental education, and training.

Studies have shown that land-use changes and ecosystem service co-production vary across the BRs zones, with anthropogenic contributions generally increasing from the buffer zones to the transition areas [28,45]. Natural contributions, however, tend to remain consistent or decrease from the buffer zones to the transition areas for some ecosystem services [28].

In a broader context, BRs can be viewed as "designated areas for study" where interdisciplinary approaches are assessed to understand and manage changes and interactions between social and ecological systems. These efforts aim to prevent conflicts and safeguard biodiversity [44]. Each BR should foster solutions that align biodiversity conservation, land protection, and sustainable resource use [46]. BRs should align with the vision of an "ecologizing society" and demonstrate how this could be achieved [47]. However, balancing societal development with biodiversity protection, nature resources protection, and the quality of the environment of human society remains a challenge. The management of BRs involves multiple stakeholders, requiring collaboration and compromise rather than a unilateral enforcement of interests [48]. Achieving this requires up-to-date empirical knowledge of how goals and interventions in one sector affect others [49], which calls for long-term, systematic research in these areas.

Individual biosphere reserves should represent certain model areas of sustainable land use. The Bookmark Biosphere Reserve in Australia demonstrates innovative approaches to bioregional planning and resource-use diversification [50]. However, implementing dual conservation and development goals remains challenging, with few BRs fully meeting the model's criteria [51]. The "Etna River Valleys" BR in Italy exemplifies efforts to adopt sustainable development models, using tools like the Rough Sets methodology to support strategic decision-making for managing complex environmental, cultural, and economic factors [52]. Recent research has focused on developing evaluation methodologies to assess BRs' potential for establishing sustainable development models [53]. Geographic Information Systems can be valuable tools for land management, as demonstrated by the Erosion Prediction Information System (EPIS) developed for the Sierra de Manantlán Biosphere Reserve. This system models land-use change scenarios to predict and minimize soil erosion, aiding in informed decision-making for conservation strategies [54].

Human activities in the landscape can be categorized based on their impact:

Positive human activities benefit the landscape and its ecosystems, such as activities focused on conservation, designating protected areas, and various protective zones to safeguard natural resources. These zones typically ensure the protection of supporting and ecological ecosystem services.

Negative human activities stress ecosystems and their services, such as activities that diminish the quality of these services. For instance, the damage to forest ecosystems due to stress factors reduces their economic value and recreational potential.

An uncompromising, one-sided enforcement of interests leads to conflicts and, subsequently, landscape–ecological and environmental problems [55]. Issues in BRs highlight deficiencies in their management [56]. One of the main objectives of BRs is to foster cooperation among stakeholders to achieve sustainable development [48]. Coordination councils can play a significant role in managing BRs.

UNESCO BRs play a crucial role in landscape governance and management, balancing conservation and sustainable development [57]. The proposed landscape–ecological approach to assessing environmental issues and its outcomes can serve as a valuable resource for BR managers as well as involved stakeholders in formulating proposals for action plans, not only for the Poľana BR but also for other BRs with specific challenges and requirements. However, the use of the methodology in other BRs depends on the availability of suitable data for such comprehensive assessments.

The methodological approach is based on an integrated framework. The concept of integrated management is widely recognized as the most suitable framework for managing natural resources, enabling the achievement of various environmental goals—such as reducing land degradation, protecting ecosystems and biodiversity, and mitigating the effects of climate change. It is considered an innovative approach aimed at reducing the size, duration, and intensity of human impacts on the landscape [6], while also serving as a framework for achieving economic and social objectives, such as the fair and efficient use of ecosystem services [58,59]. The focus is on organizing and harmonizing human activities in the landscape while ensuring the protection of its individual components. The scientific foundation for this approach is the definition of the landscape as a geosystem. A landscape is a complex system of space, location, landform, and all other functionally interconnected material elements (both natural and human-modified) and the socio-economic phenomena arising from their interrelationships in the landscape [60]. The importance of perceiving the landscape as a holistic complex is emphasized by several authors [11,12,61]. This leads to the basic principles of integrated landscape management [4,62,63]:

There is only one space so all activities must fit within the same space (Earth, continent, region, and cadastral territory).

The space is filled with material entities from the geosphere, forming an integrated unity of space, location, and all other interconnected material components (elements) of geosystems. The space and location provide a unifying framework, the stage on which all resources—such as geological, water, soil, climate, biotic, and relief resources—interact as overlapping layers. Natural resources are used for various purposes and activities, which often compete with each other and cause conflicts.

The concept of landscape as a geoecosystem is similar to Popper's Three Worlds concept [64]. Within the landscape, it distinguishes three basic subcategories: (a) Primary structure—forms the basis for the secondary and tertiary landscape structures, and is composed of material elements (a geological base and soil-forming substrate, soil, and water), intangible elements/phenomena (relief, potential natural vegetation), and transitional material and/or intangible element/phenomena (air). The elements/phenomena of this landscape structure are more or less stable compared to the elements of secondary and tertiary landscape structures. (b) Secondary landscape structure—is made up of material elements with a specific spatial definition. It represents a combination of natural (forests, wetlands, permanent grasslands, watercourses, etc.), semi-natural (fields, vineyards, orchards, etc.), and artificial, man-made elements of the landscape structure (anthropogenic objects). (c) Tertiary structure—represents the interests, requirements, and demands of man for the land use. These are later reflected in the use of the land and, if they do not respect natural conditions, cause many landscape–ecological and environmental problems.

The key is to harmonize the use of each plot with the characteristics of all the components present in that landscape. It is not feasible to carry out land use that protects only one component at the expense of damaging or degrading another.

A significant problem is the misinterpretation of the role of BRs, which are often seen merely as another category of protected areas with associated restrictions or prohibitions. In nature conservation, attention is often focused solely on the protection of life forms, neglecting the protection of the conditions for life. The human impact on these areas, both positive and negative, is also insufficiently assessed.

It is crucial to understand that BRs are not typically protected areas in the traditional sense but model territories where the protection of natural values is supported by sustainable human land use [65]. Therefore, efforts should not only focus on protecting biota but also on safeguarding all components of the landscape and proposing land use that aligns with the protection of life conditions and forms. Balancing the interests of all groups in the territory is necessary. Failure to reconcile these interests leads to landscape–ecological and environmental problems, as seen in the Poľana BR case.

Furthermore, it is crucial to ensure that communities practicing "ecological land management" that preserve cultural traditions and natural values receive compensation and support from the state. It is increasingly recognized that biodiversity conservation must be integrated with social and economic development in modern conservation policy and practice at all levels—national, regional, and local [66].

The evaluation of the current landscape–ecological and environmental challenges arising from the utilization of the Poľana BR is relevant to propose measures to eliminate specified problems and to ensure the fulfillment of its primary objectives. These include biodiversity conservation, the efficient utilization of ecosystem services, and the promotion of sustainable natural resource use. The identified problems serve as a basis for further development of the territory development strategy and the management plan for the care of the area.

In addition, the approach used has several limitations. To optimize land use, a solid knowledge base is required, which is often lacking. Information about the properties of all landscape-forming components in the area is essential. This is a complex process as not all

areas are subject to sufficient research and monitoring [67]. The lack of data often results in the use of derived, interpreted, or outdated information, which can pose risks in designing optimized land use.

An important component in identifying threatened and threatening phenomena is public engagement. Various forms of digital citizen science applications can support this process, including tools for detecting illegal waste dumps (TrashOut), monitoring invasive or endangered species (VISITOR, Invasive Alien Species Europe, iNaturalist, PlantNet, and Flora Incognita), assessing water surface quality (EyeonWater), compiling observation databases for birds (eBird) and mammals (eMammal), measuring noise levels or identifying quiet zones (NoiseCapture and Hush Citylab), and tracking drought conditions (INTERSUCHO). Citizen science can support existing state or interested institutional registries and monitoring systems and support in providing more targeted local solutions.

Conflict assessment requires an interdisciplinary team with representation from experts in all components of the landscape (abiotic, bio-, and socio-) who know the relationships between individual landscape-forming components. At the same time, the assessment should involve key stakeholder groups to identify land-use requirements. It should be noted that eliminating conflicts requires measures in land management, which are often associated with changes in land use. These decisions are in many cases linked to power and political decisions. Conflict resolution can also be negatively affected by ownership relationships. However, from the perspective of the mission of the biosphere reserve, ecological and environmental principles over economic ones should be prioritized in decision-making [68], and such forms of use should be supported that ensure the fulfillment of the main mission of the given biosphere reserve.

Spatial assessment of conflicts is very challenging as multiple clashes and resulting conflicts occur in individual areas. Further research in this area should focus on assessing cumulative problems in a given area and quantifying problems in given areas.

5. Conclusions

This study addresses the assessment of landscape–ecological challenges arising from conflicting interests, with the Poľana BR in Slovakia serving as a case study. The research adopts an interdisciplinary framework, conceptualizing the landscape as a geosystem. GIS methods were utilized to spatially delineate the areas of conflict. Within the Poľana BR, three primary categories of challenges were identified—threats to biodiversity and ecological stability, threats to natural resources, and threats to the environment of human society—with 121 conflicts of interest identified.

Human activities in the landscape are accompanied by both positive (e.g., the designation of protected areas and protective zones for nature and natural resources) and negative (e.g., the impact of stress factors) effects on the landscape and its components. If one component of the geosystem is damaged, the other components are also affected, disrupting the overall functioning, ecological balance, and stability of the landscape, which in turn impacts its ability to meet the needs of society. For example, increased anthropization of the land has negative effects on climate change (e.g., the heat island effect, temperature rises, and disruption of water flow). If optimal measures for land use organization are applied, based on an integrated approach, the landscape as a whole—and all of its components—can be protected. For example, ensuring optimal forest management practices can protect biodiversity, landscape stability, and safeguard against natural risks and hazards.

Integrated landscape management is a logically organized, harmonized system of "planning, organizing, and controlling". The presented methodological approach can be applied to any territory. It represents a logical system of interconnected steps that need

to be implemented and adapted based on the natural and socio-economic specifics of the particular landscape.

The approach presented in this paper can be used for other biosphere reserves to identify areas with spatial conflicts of interest—as well as to build and extend the geographical dataset of problems resulting from spatial conflicts—as a critical step in the development of precise and effective measures for their mitigation or elimination. Also, biosphere reserves are envisioned as model regions for sustainable development, where approaches can be applied and tested if they achieve the main objectives. Functioning as "learning places for sustainable development", they emphasize the active involvement of local communities and stakeholders in the planning and management processes; moreover, they serve as "sites of excellence", facilitating the testing of interdisciplinary approaches to address and manage changes and interactions within social and ecological systems [44].

Today, our approach to biodiversity, natural resources, and ecological stability is primarily economic. Scientists examine environments and species for what they have to offer humans and what their loss might mean for us. This approach remains limited and dangerous given that it considers species only in relation to humans and is not part of a balanced cooperation within whole ecosystems. However, the evaluation of landscape–ecological problems resulting from conflicting interests eliminates this approach, which makes it ecologically pragmatic for the future.

For a better argument in land management, it will be necessary in the future to quantitatively evaluate the losses resulting from the existence of individual problems in a given area (the value for revitalizing damaged ecosystems, the monetary value resulting from biodiversity loss, the value needed for remediation of damaged resources, etc.).

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/land14020402/s1, Figure S1: Map of threatened phenomena; Figure S2: Map of threatening phenomena.

Author Contributions: Conceptualization, Z.I. and J.M.; methodology, Z.I.; software, J.M.; validation, Z.I. and J.M.; investigation, Z.I. and J.M.; resources, J.M.; data curation, J.M.; writing—original draft preparation, Z.I. and J.M.; writing—review and editing, J.M., V.P., J.Š. and M.D.; supervision; J.Š. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Slovak Research and Development Agency, grant number APVV-20-0108: Implementation of Agenda 2030 through Biosphere Reserves.

Data Availability Statement: The data presented in this study are not available in a publicly accessible repository due to technical issues; however, they are available upon request.

Acknowledgments: This research was supported by Project APVV-20-0108, Implementation of Agenda 2030 through Biosphere Reserves. We thank the Pol'ana Biosphere Reserve Administration for the data and cooperation.

Conflicts of Interest: The authors declare no conflicts of interest.

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