

Article

Is It Always Advisable to Promote Geodiversity and Geoheritage in a Traditional Recreational Area? A Case Study from Brno Reservoir and Its Surroundings (Czechia)

Lucie Kubalíková ^{1,*} , Marie Balková ¹ , Aleš Bajer ¹ and Karel Kirchner ² 

¹ Department of Geology and Soil Science, Faculty of Forestry and Wood Technology, Mendel University in Brno, Zemědělská 3, 613 00 Brno, Czech Republic; marie.balkova@mendelu.cz (M.B.); ales.bajer@mendelu.cz (A.B.)

² Department of Environmental Geography, Institute of Geonics of the Czech Academy of Sciences, Drobného 28, 602 00 Brno, Czech Republic; karel.kirchner@ugn.cas.cz

* Correspondence: lucie.kubalikova@ugn.cas.cz

Abstract: Geodiversity and geoheritage represent an important resource for geotourism and subsequent economic development both in remote natural areas and in traditional, frequently visited recreational areas. Identification, assessment, and suitable management of particular geosites may contribute to the development of sustainable forms of tourism and attract more people to the topics of geodiversity and geoheritage. However, if there is only one aim represented by geotourism development, there can be a danger of overexploitation of geoheritage, especially if the sites are promoted less adequately and not provided suitable protection. This paper is focused on the assessment of particular sites, in terms of their Earth science interest, regarding their geotourist and geoeducational potential; it is also focused on an assessment of possible risks and threats which may be related to the higher promotion and more intensive use of these sites. Based on this, proposals for sustainable management, both for geotourism and geoeducational development and nature conservation, are presented and discussed.

Keywords: geodiversity; geoheritage; recreation; nature conservation; risk assessment; geotourism



Citation: Kubalíková, L.; Balková, M.; Bajer, A.; Kirchner, K. Is It Always Advisable to Promote Geodiversity and Geoheritage in a Traditional Recreational Area? A Case Study from Brno Reservoir and Its Surroundings (Czechia). *Sustainability* **2024**, *16*, 9551. <https://doi.org/10.3390/su16219551>

Academic Editor: Nemanja Tomić

Received: 30 August 2024

Revised: 25 October 2024

Accepted: 30 October 2024

Published: 2 November 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Over the past decades, an increase in geotourist and geoeducational activities has occurred worldwide, both as a result of the mainstreaming of geodiversity and geoheritage research [1–6], and thanks to the development of international (e.g., the Global Geopark Network, the International Association for the Conservation of Geological Heritage, the International Union of Geological Sciences), national (e.g., national networks of geoparks, geosite databases of national geological surveys), and regional or local initiatives and projects. Indeed, although geodiversity and geoheritage have always offered a wide spectrum of services and benefits to society [7–11], including tourist and educational uses, the rapid growth of related activities in the last years has been fast and remarkable.

Thanks to modern technologies and approaches to mapping geodiversity and geoheritage, thanks to changing attitudes to nature conservation, and thanks to the growing interest in the interpretation of natural heritage, geodiversity and geoheritage, even in remote areas, are now well-known and explored; they are very often used for tourist activities and may contribute to the economic development of specific regions [12,13]. However, it is not just remote, wild, and undiscovered areas that are a subject of interest for Earth scientists and geodiversity research. Numerous studies have focused on geodiversity and geoheritage in urban areas [14–18], in highly populated suburban areas [19], or in highly visited nature spaces, e.g., national parks or nature reserves. Studies primarily focused on the protection of living nature are being explored from the geodiversity or geoheritage point of view [20].

The potential of geodiversity or geoheritage for geotourist and geoeducational activities has been widely recognized and accepted [6,12,21–26]. Numerous methods for assessing this type of potential have been developed and used (e.g., Brilha [25], Reynard et al. [26], the recent overview provided by Mucivuna et al. [27]). Geodiversity and geoheritage also play an important role in reaching the Sustainable Development Goals [28–30] and are crucial in providing geosystem services [10,11,31–35]. Because geodiversity and geoheritage are intensively used [36–38], they are endangered by numerous threats [35,39–41]. These threats have been identified and evaluated in several studies using various methods [40,42,43].

One of the identified threats to geodiversity and geoheritage is represented by tourism and recreational use [35,39,44]. Even though developing geotourism may contribute to the better acceptance of the importance of geodiversity and helps to recognize the geoheritage value of specific sites and areas [12,22], intensive tourist and recreational use of sites may lead to deterioration or damage to particular Earth science phenomena, including fragmentation of site integrity, footpath erosion, or loss of soil organic matter [23,24,35,45,46]. The negative impacts of geotourism and recreation on geodiversity and geoheritage have somehow been overlooked until now [34,44], and finding a balance between sustainable use (including geotourist and recreational activities) and geoconservation may be quite challenging [24,34,47].

In this paper, we present an area where geodiversity plays a crucial role both for living nature and historical or cultural aspects. Currently, this landscape is intensively used for various types of recreation and leisure (trekking, hiking, cycling, fishing, bathing, as well as cruising or spending time in cottages, traditional tramp communities, or camping). Particular sites with Earth science interest are identified and mapped regarding their geoheritage values.

The main objective of the research is the assessment of geotourist and geoeducational potential of sites with Earth science interest which represent a basis for activities related to sustainable and rational use [11,23,26], along with the assessment of possible risks and threats, which may also be related to the higher promotion and more intensive use of these sites. Based on the assessment, particular proposals for sustainable management for geotourism, geoeducational development, and nature conservation are outlined. The advantages and disadvantages of developing new approaches to the geo-interpretation of particular sites and connecting them to traditional recreational activities (hiking, cruising) are discussed.

Related to these issues, several questions arise as follows:

1. Is there any relationship between the geotourist/geoeducational potential and the degree of possible risks and threats? It is supposed that the higher the geotourist and geoeducational potential, the higher the intensity of threats?
2. Is it always desirable to promote geoheritage in intensively used areas although it may reach a considerable number of visitors?
3. Is it possible to propose such management that would benefit both from the geotourist/geoeducational potential of the sites and respect the scientific values and geoconservation principles?

These questions are discussed and the possible future direction of the research on sustainable use of the sites with Earth science interest is outlined.

2. Materials and Methods

2.1. Methods

The first step of the methodological procedure is represented by the identification and mapping of the sites that should be included in geotourist and geoeducational activities. This comprises a detailed review of the literature and fieldwork and represents a basis for further assessment [25]. The possible threats on the sites and generally in the study area are identified and described as well. This step is based on the classification of threats to geodiversity and geoheritage provided by Crofts et al. [39] and detailed fieldwork.

The second step is represented by an assessment of the geotourist and geoeducational potential of the sites. Based on local conditions and methodological relevance, a slightly modified geosites/geomorphosites approach was used [25,26,47–49]. A proper assessment is based on scientific (SV), added (AV), educational (EV), tourist (TV), and conservation values (CV) using particular criteria, as explained in Table 1. A value ranging from 0 to 1 is attributed to every criterion and there are no weights. Partial values are counted as a simple average of particular criteria. For this study, the values are divided into two groups: main values (scientific and added values) and use values (educational, tourist and conservation values). This division reflects an approach presented by Reynard et al. [26], who define so-called “intrinsic value” of the site as a simple sum of scientific and added values (here, it was decided to use the term “main value” as the term “intrinsic” may refer to the inner value of the site regardless on human perception [8]) and “use and management characteristics” as a sum of tourist, educational and conservation values (the term “use values” is used here). This approach has been applied in several case studies, e.g., Boukhchim et al. [50]. The “main value” of a particular site is then counted as a simple average of scientific and added values, and “use value” is counted as a simple average of educational, tourist, and conservation values. The total value is the average of all the partial values. At this point, it is necessary to emphasize that this methodological approach does not represent an equivalent to GAM models, e.g., [51], but it serves as a basis for a simple analysis (or comparison) of mutual relationships between main and use values of particular sites. Table 1 provides a detailed description of the criteria for assessing the sites.

Table 1. Set of criteria used for the assessment of geoeducational and geotourist potential of specific sites (based especially on [25,26,47–49]). In addition to the criteria commonly used in geoheritage studies, a special criterion “visibility from the boat” has been added thanks to the character of traditional recreational activities in the study area (cruising, boat trips). For each criterion, a brief explication is inserted.

Values	Criteria	Description	Scoring
Scientific value (SV)	Integrity and current status of the site	Related to the present conservation status of the geosite or geodiversity site, its fragility, taking into account active processes.	0—bad conditions, site damaged; 0.25—bad conditions, with a possibility to recover; 0.5—average; 0.75—good; 1—excellent conditions
	Rarity (uniqueness)	A number of similar sites in the study area.	0—the phenomenon on site is not rare; 0.5—several similar sites; 1—the unique site in the study area
	Inner diversity of the Earth-science features (phenomena)	Diversity of the geodiversity features: a number of different elements with scientific interest.	0—just one phenomenon; 0.25—two different phenomena; 0.5—3 phenomena; 0.75—4 phenomena; 1—5 and more phenomena at a site
	Scientific knowledge	The existence of published scientific studies about the site (papers, dissertations).	0—site is practically unknown for the geo-scientific community; 0.5—locally known: papers in national journals; 1—scientific papers about the site in international journals
	Paleogeographical value	Importance of the site for understanding the Earth’s history and past environmental conditions.	0—no or very limited importance for research, the site is important, e.g., only for geological mapping; 0.5—partial importance for research; 1—site has palaeogeographical value, or it can be considered a key locality

Table 1. Cont.

Values	Criteria	Description	Scoring
Added value (AV)	Ecological aspect	The relevance from the ecological or biological point of view (e.g., species/ecosystems)	0—geodiversity has no important relation to the ecological aspects, no occurrence of ecological aspects on the site; 0.5—occurrence of protected species or other ecological phenomena; 1—geodiversity supports the occurrence of protected species or specific ecosystems
	Aesthetic aspect	Refers to contrasts, colours, vertical development, space structuration and overall panoramic value.	0—not interesting (hidden); 0.25—partly interesting (e.g., interesting colours or structure of geodiversity features); 0.5—interesting (colour contrasts, interesting structure); 0.75—aesthetically valuable (interesting setting in surrounding landscape, colour contrasts); 1—a very high aesthetic value (big contrasts, impressive setting in the surrounding landscape)
	Cultural aspects	A number of different cultural aspects (e.g., historical, archaeological, architectonic, artistic).	0—no cultural aspect; 0.25—1 cultural aspect; 0.5—2 different cultural aspects; 0.75—3 different cultural aspects; 1—4 and more different cultural aspects
Educational value (EV)	Representativeness	Site exemplarity. Refers to the fact that the site shows a typical process or landform.	0—site is not representative; difficult to see the phenomena; 0.5—site partially representative with the help of interpretative materials; 1—typical occurrence of phenomena, high representativeness
	Didactic and interpretative potential	The capacity of a site to illustrate Earth science elements or processes for people with no geological background	0—practically not possible to understand and recognize the phenomena; 0.25—possible to understand, but with explanations from professionals; suitable for students or informed public; 0.5—possible to understand with explication from professional guide; 0.75—possible to understand just with leaflet or information panel; 1—easy to understand and recognize the phenomena
	Existing interpretative materials	Presence of educational facilities, e.g., educational trails or information panels, the existence of leaflets or specialized maps related to the site.	0—no materials; 0.25—geodiversity aspects mentioned, but primary, the promotion materials focus on different aspects (e.g., cultural); 0.5—existing materials about the geodiversity aspects on the web; 0.75—leaflets, supporting material “ex situ”; 1—geodiversity of the site is well promoted “in situ” (informative panels, educational path)

Table 1. Cont.

Values	Criteria	Description	Scoring
Tourist value (TV)	Visibility in field	Refers to the visibility on site and from its close surroundings.	0—no or very limited (with special equipment); 0.25—limited; 0.5—observable from one viewpoint and well visible; 0.75—geodiversity features are observable from two different viewpoints and well visible; 1—very good visibility, 3 and more viewpoints
	Visibility from the boat	The possibility of seeing the site from a boat. Related especially to the sites that cannot be easily accessed.	0—not visible; 0.5—limited visibility; 1—good visibility from boat
	Accessibility	Possibility of how to reach the site both by public and individual transport.	0—more than 1 km both from a parking place and a stop of public transport; 0.25—less than 1 km from the parking place, but more than 1 km from the stop of public transport; 0.5—the stop of public transport and/or parking place in the distance 0.5 and 1 km; 0.75—the stop of public transport and/or parking place less than 0.5 km; 1—the stop of public transport and/or parking place no more than 200 m from the geosite
	Safety	Limits of the use related to the safety issues. The easier the access to the site (no need for permissions), the higher relevance for geotourist and geoeducational activities.	0—ongoing danger phenomena (rockfall, landslides) that may endanger visitors, access at own risk; 0.25—existing, but limited danger phenomena that can endanger visitors; 0.5—hypothetical danger phenomena, but if the safety rules are respected, the site is quite safe for the visitors; 0.75—site quite safe; 1—site safe for everyone, the movement on the site cannot be dangerous

The third step comprises an assessment of particular threats and risks that may affect the area. This is performed for each site by using the risk assessment matrix [52,53], where every identified threat is assessed in terms of probability and impact, and the values are multiplied [43,53]. Concerning the proper rating of the degree of impact and probability, a 5-step scale is used. The rating of levels are as follows: 1—very low impact, 2—low impact, 3—medium impact, 4—high impact, 5—very high impact. Similarly, the ratings of probability are defined as follows: 1—rare (extremely unlikely to occur, less than once every 20 years), 2—unlikely (unlikely to occur, but possible; could be incurred in 5–20 year timeframe), 3—possible (likely to occur sometime, could be incurred in 5-year timeframe), 4—probable (could be incurred over a 1–2 year timeframe, will occur several times), 5—highly probable (more than every year, likely to occur frequently). The risk assessment matrix represents a simple tool to assess the existing and potential risks directly on site and, thus, it enables us to rank the threats and risks according to their importance (or urgency). The degree of risk is divided into four groups: minor, moderate, major, and severe (Figure 1). The particular scores of risk assessment (reaching the values from 1 to 25) are then converted to relative values.

Highly probable	5 Moderate	10 Major	15 Major	20 Severe	25 Severe
Probable	4 Moderate	8 Moderate	12 Major	16 Major	20 Severe
Possible	3 Minor	6 Moderate	9 Moderate	12 Major	15 Major
Unlikely	2 Minor	4 Moderate	6 Moderate	8 Moderate	10 Major
Rare	1 Minor	2 Minor	3 Minor	4 Moderate	5 Moderate
	Very low	Low	Medium	High	Very high

Figure 1. Risk assessment matrix (based on Leveson [52]) as a tool for assessing the intensity of particular threats. The scoring is as follows: 1 to 3: minor risk (a need to plan and implement the management measures and prevent the increase of the risk, monitoring the risk); 4 to 9: moderate risk (a need to implement management measures and prevent the increase of risk, monitoring the risk); 10 to 16: major risk (a need for action and implementation of management measures); 20 to 25: severe risk (an urgent need for action and implementation of management measures).

The fourth step represents a preliminary analysis of mutual relationships between an assessment of the geotourist and geoeducational potential and the risk assessment results. This is performed by comparing relative values (main values vs. risk; use values vs. risk; simple tourist value vs. risk; total value vs. risk). The results of this simple analysis may show the intensity of relationships. However, the authors are aware that this approach has its limits (e.g., simplification) and needs to be more properly developed in the future (e.g., in relation to multicriteria analysis or advanced statistical methods). Within this research, it is mainly used as a supporting method, the main emphasis is on the geotourist and geoeducational potential and evaluation of threats.

The last step is to propose, analyse and discuss such management measures including particular geoeducational and geotourist uses that are both attractive and beneficial for visitors and reflect the needs of nature conservation.

2.2. Study Area

The study area—the Brno reservoir and its close surroundings—is situated on the north-western part of the City of Brno, in the South Moravian Region, Czechia (Figure 2). The artificial lake and its surroundings represent a traditional recreational area for a city of almost four hundred thousand inhabitants, and it is a popular tourist destination for people visiting the city as well. Thanks to its natural values (both related to geodiversity and biodiversity), a considerable part of the area is protected in the category of a Natural Park (Podkomorské lesy, declared in 1989); some smaller areas are declared as Nature Monuments (NM), Nature Reserves (NR) and Important Landscape Elements (ILE) according to Act n. 114/1992 Coll. on Nature and Landscape Conservation [54].

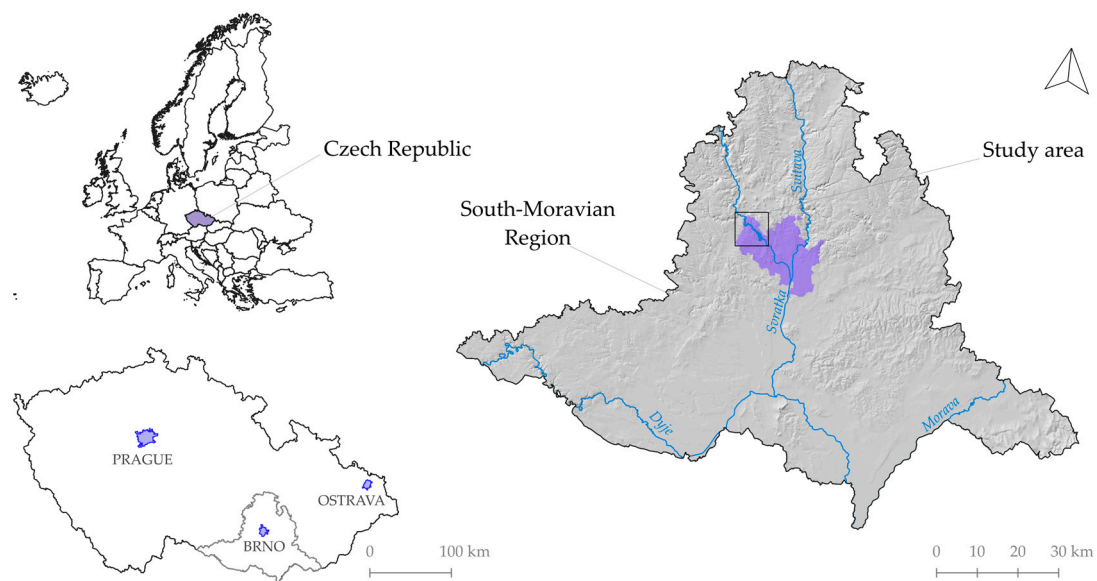


Figure 2. Situation map: position of the Czech Republic within Europe and position of the study area within the South Moravian region, data source: [55,56].

2.2.1. Geology and Geomorphology

On a relatively small area, it is possible to trace geological evolution from the Precambrian age up to the present. The high lithological diversity influences high geomorpho-diversity and soil diversity. Generally, the area is situated on the contact of the western margin of the older Brno massif and the younger Boskovice furrow (Figure 3). The Brno massif is a Cadomian magmatic body, but it was affected by the Variscan orogeny as well. It is composed of various types of granites, granodiorites, diorites (approximately 600 Ma old) with younger aplites, rhyolites, and quartz veins [57]. The western part of this magmatic body is tectonically limited by the Boskovice furrow, an elongated depression that was created during the Variscan orogeny. During the Permian and Carboniferous periods, it was filled with fluvial and lacustrine sediments (arkoses, sandstones, claystones, conglomerates). Between the Boskovice furrow and the Brno massif, a tectonic slice of Devonian limestone is inserted. Sporadic Neogene marine sediments can be found in the study area as well [58]. The youngest sediments are represented by deluvial and fluvial sediments (sands, gravels, clays, silts) and loess and loams.

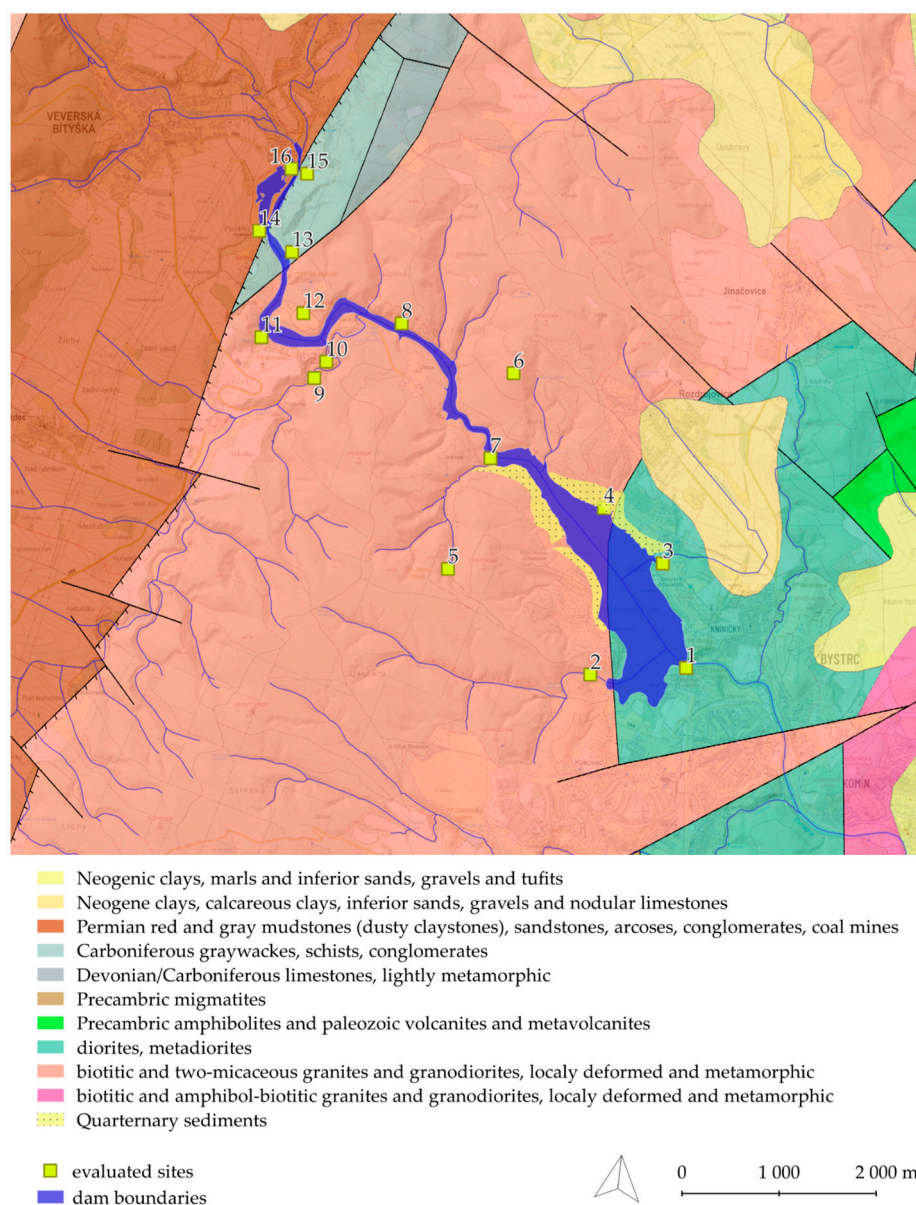


Figure 3. The geological sketch of the study area including the sites with Earth science interest (here and further in the text, tables and graphics, every evaluated site is marked with an abbreviation “S”): S1—Skalky u přehrady, S2—Rakovce, S3—Sokolské koupaliště, S4—Osada, S5—Jelení žlíbek, S6—Trnůvka, S7—Rokle, S8—Kůlny, S9—Veverka Valley, S10—Veveří, S11—Krnovec, S12—Junácká louka, S13—Na skalách, S14—Mečkov, S15—Břenčák, S16—Wetlands. Data source: [56,59].

Geomorphologically, the Svratka River creates an incised, breakthrough valley with several levels of terraces. The bottom of the valley is narrow; only in the area of the extinct Kníničky village, it is several tens of meters wide, it floods regularly and is used for agriculture and pasture. Other important landforms are represented by valleys of tributaries of the Svratka River that are structurally controlled as they often follow the fissures and faults. The most important tributary is the Veverka River, which creates incised meanders before entering the Svratka River. Another tributary, Rozdrojovice stream, enters the Svratka River in a small bay near Sokolské koupaliště where granodiorite outcrops can be seen. Other specific landforms are represented by debris accumulations, formed by disintegration of the rocks of the Brno massif, which significantly influence the vegetation (occurrence of debris forests). Anthropogenic landforms are also present, the

most remarkable is the reservoir (dam) itself, and then several settlement, agriculture, and communication landforms related to the recreational and tourist use of the area [60,61].

The geological and geomorphological settings have influenced the pedogenetic processes. Cambisols predominate on crystalline rocks, with gleyic cambisols in the valleys. On aeolian and slope sediments, illimeric soils predominate, especially haplic Luvisols, and possibly Albeluvisols [62].

2.2.2. Biota and Vegetation

The vegetation in the study area consists mainly of Hercynian oak–hornbeam forests, especially on the southern exposures with the occurrence of thermophilic oak forests and, at higher elevations, with remnants of oak beech forests [63]. The most valuable forest areas are covered by debris forests, which also represent the cores of three nature reserves in the area of interest [64]. The majority of the study area belongs to the Podkomorské lesy Nature Park and is also part of the European Natura 2000 network of specially protected sites as a part of the Podkomorské lesy supraregional biocentre.

The forests are accompanied by a mosaic of meadows, rock outcrops, and intensively used cottage colonies with gardens. The vegetation is highly conditioned by lithological, morphological, and hydrological diversity (e.g., calciphilic species on Devonian limestones, xerophytic flora on Permian conglomerates, debris forests on debris and blocky accumulations, wetland species), and is also influenced by human activity and anthropogenic influence (invasive and non-native species in gardens).

The whole complex of the Podkomorské lesy forest is only slightly affected by the conversion to coniferous monocultures (Norway Spruce and Scots Pine). Almost all spruce monocultures are now dead and are being converted back to mixed or broad-leaved forests. Within several nature monuments and nature reserves, numerous protected species occur [65].

2.2.3. Cultural and Historical Aspects of the Area

The valley of the Svratka River, which forms the axis of the territory, connects two old residential areas: the depression of the Boskovice furrow in the NW with the Brno area in the SE. Based on archaeological research, the Svratka Valley had a periodic communication function already in the Neolithic, which has been confirmed by findings of Moravian painted ceramics [66]. The occurrence of deposits of quality rocks (especially amphibole diorite) used for the production of polished stone also contributed to the attractiveness of the area. The material is currently processed at boat stops at Rokle and Veverí Castle [67].

The first continuous settlements appeared in the 11th and 12th centuries. They were related to the early colonization of higher altitudes and connected with the development of Brno City. Already in the second half of the 11th century, Veverí Castle was founded on a rocky ridge above the Svratka River. At the beginning of the 13th century, a small settlement, with a church in the forecourt of today's Veverí castle, is mentioned. Soon, Veverí Castle became the administrative centre of the area, and the entire territory was connected to the agricultural landscape of the Boskovice furrow and the nearby town of Veverská Bítýška (first written mention in 1376).

Veverí Castle has great architectural and cultural–historical value; today, it is protected in the category of Cultural Monument [68]. In the forecourt of the castle, there is the Romanesque Church of the Assumption of the Virgin Mary, from the beginning of the 13th century. Not far from the church, but already in the agricultural landscape, there is the Cholera cemetery where the victims of the cholera epidemic in Veverská Bítýška town from 1831–32 were buried.

In the deep valley of the Veverka River (SW of Veverí Castle), there is a former small hunting lodge from the 18th century. In the 19th century, this building was used as a castle laundry and staff dormitory. Currently, the Stará Prádelna restaurant is established here, representing a frequent destination for tourists.

The nearby village of Kníničky (now flooded, see later) also probably dates back to Medieval period. According to the local name “Na Vinohrádku” (“on the small vineyard”) and the Kníničky seal and heraldic symbol (ploughshare and two grapes), it can be presumed that a winery was also operated here.

Another cultural monument is represented by Way of the Cross from 1856 which is built on the steep rocky western slope of the Boskovická brázda Furrow near the Chudčice village. The way ends at the pilgrimage site—U Tří Křížů (Three Crosses) which was built in 1902. Originally, there was a pilgrimage chapel here, but it was demolished during the reforms of Emperor Joseph II in 1784. Another small sacral monument, the Water Chapel (also from 1856), is situated above the spring of water. This architectural ensemble of the small sacral monuments is placed in a wooded landscape and represents a valuable natural–cultural–historical complex.

2.2.4. Recreation, Reservoir Construction and Current Use of the Area

The recreational use of the study area dates back to the turn of the 19th and 20th centuries when the Brno reservoir did not exist yet. The Svratka Valley was visited by “tramps” (usually people from towns that went to nature in their leisure time). The first tramp settlement was built in Rokle in 1924 and soon, other settlements appeared. The Rokle settlement was considered a base for tramps from Brno; during the 1920s, more than 300 tramps visited the site regularly. Later, with the construction of the Brno reservoir in 1930s, the tramp settlements were flooded [66].

The idea of building a dam on the Svratka appeared as early as the beginning of the 20th century, but it was realized between 1935 and 1940 during the German occupation. The water reservoir was created by flooding the segment of the valley between the municipalities of Brno and Veverská Bítýška, and covers an area with a length of approximately 10 km. The original purpose of the reservoir was to ensure water supply for the developing Brno city; however, it was ultimately not realized. Today, recreation and partially anti-flood regulation are the most important functions. During construction, the village of Kníničky (530 inhabitants) was flooded in 1937. Generally, the residents perceived the construction of the reservoir and the forced eviction without negative emotions, because their losses were adequately compensated [61]. A new village was constructed and in 1957 it was annexed to Brno. During the Nazi occupation, the Wien–Wrocław highway project was planned. The surroundings of the Brno reservoir have been marked by these efforts: the highway pillars, communication cuttings, and embankments are still visible in the terrain. The highway has never been finished [69].

Soon after WWII, the recreation purpose of the study area was “rediscovered” and revived. The area has become a favourite place for people living in Brno and its close surroundings. Recreational cottages, summer homes, hotels, and other accommodation facilities were built on the shores of the artificial lake and in surrounding forests. The popularity of the area has been increased by introducing regular shipping in 1946. Today, there is a regular boat transport from April to October and, according to the Brno Municipal Transport Company, in 2023, over 300,000 people enjoyed the cruise on the reservoir [70].

Other uses of the study area are represented by bathing, surfing, fishing, hiking, and cycling. Generally, the area is well equipped with marked tourist paths, cycle trails, and other tourist infrastructure (accommodation, catering, shelters, information panels), and it is easily accessible by public transport (trams, buses, boats). Regarding the geotourist and geoeducational activities, at protected sites, there are some informative panels, but generally, they are focused only on the living nature. It is possible to take a “geo-cruise” which combines a boat trip and guided tour focused on geodiversity of the surrounding area.

2.2.5. Nature Conservation and Threats to Geodiversity

The area is important from a nature conservation point of view. One Nature Park (Podkomorské lesy), three Nature Reserves (Jelení žlíbek, Břenčák, Krnovec), four Nature Monuments (Na skalách, Skalky u přehrady, Junácká louka, Kůlny), and nine Important

Landscape Elements (Abrazní sruby, Křížová, Obora, Pod Trnůvkou, Strž k Rozdrojovicím, Lada u Sokolského koupaliště, Čihadlo, U dálnice, Trnková) are situated in the area of interest and close surroundings [71]. Several sites are included in the database of the Czech Geological Survey (Rokle, Sokolské koupaliště, Rakovec, Trnůvka) and, although they are not protected in any category of nature conservation, they are regularly monitored or being proposed for legal protection [72].

Crofts et al. [73] describe the main threats to geoheritage in the protected areas; however, in the study area, only some of them are relevant. Based on fieldwork and the literature and map review, five main threats can be identified: (1) urbanisation and construction; (2) changes in land use; (3) recreation and tourism; (4) emphasizing the living nature; and (5) collecting fossils and rocks. Urbanisation and construction (URB) represent one of the important threats as the study area is situated close to the expanding city of Brno. Some areas around the Brno reservoir have already been converted from recreational areas to building plots [71], which may influence the integrity and intensity of the use of particular sites and contribute to their degradation. Changes in land use (LAND) are related to agriculture use, forest management, and expansion of recreational areas including the change of natural environments to gardens; so, along with urbanisation, it may also contribute to the deterioration of both sites with Earth science interest and geodiversity of the wider area. As the study area is situated within the outskirts of a large city, and its natural environment is used by numerous visitors (both local and foreign), tourism and recreation (TOUR) with related aspects, such as vandalism, littering, pollution, and breaking rules applicable in protected areas, also represent an important threat. Emphasizing the protection and management of living nature (LIV) at the expense of geodiversity can also lead to the degradation of particular sites with Earth science interest. Some sites are protected as Nature Monuments, Nature Reserves or Important Landscape Elements; but often, in their care plans, the biota has more attention than geodiversity or, in some cases, the geodiversity is not a subject of protection [65]. Collecting fossils and rocks (COLL) can also be considered a significant threat as several sites are interesting from the mineralogical and paleontological point of view (e.g., S6 Trnůvka or S13 Na skalách). In this study, we do not consider climatic change (a threat identified by [40] or [73]) as the responsible assessment of the impact and probability of this threat requires more thorough research.

2.2.6. Sites with Earth Science Interest

In total, 16 sites with Earth science interest have been identified and described in the study area. The position of specific sites is displayed in Figure 3, particular examples are presented in Figure 4.

- S1 Skalky u přehrady

On this site, the Svratka River breaks through a narrow rocky ridge, forming the northernmost spur of the Kohoutovice Highlands and creates a gorge with rocky slopes over 40 m high. The bedrock is formed of rocks from the Brno massif and consists of hornblende and biotite–hornblende diorites and metadiorites which are overlain by fluvial terrace deposits from the Svratka River. The exceptional diversity of rocks and landforms including the presence of foothill debris contributes to the high diversity of ecosystems and biota of the site. Both slopes represent a typical example of a river phenomenon in the incised Svratka valley, which manifests itself in a contrast of predominantly mesophilic biota on cooler right-bank slopes with northern exposure and xerothermic rock steppe communities on the steeper left-bank slopes exposed to the south. The site is protected because of the presence of protected species (*Pulsatilla grandis*, *Cyclamen purpurascens*) and ecosystems (subpannonian steppe grasslands, acidophilic thermophilic oak woods). The abiotic phenomena are not included in the subject of conservation [65,72,74].

- S2 Rakovec

On this outcrop, dissected by parallel fractures and fissures, a contact of two different rocks of the Brno massif can be observed. The first one is represented by coarse-grained

granodiorite with microdiorite enclosures. The granodiorite contains amphibole, which forms black columns up to 2 cm long. The second rock is represented by banded siliceous gneisses, which are interesting from a mineralogical point of view (bands of coarser quartz, porphyroblasts of altered cordierite, and oval grains of small garnet are present). The site is situated on private land and is not legally protected; however, it is recorded in the database of the CGS [72].

- S3 Sokolské koupaliště

An inclined diorite plateau covered with gravel which belongs to the Tuřany terrace (end of Early Pleistocene). This gravel consists both of partly rounded and sharp-edged pebbles of gneiss, quartz, granodiorites, and sandstones. Their size is up to 7 cm, rarely up to 15 cm. They are often slightly weathered. Within the gravel layer, lenses of coarse sand occur. The gravel layers are overlaid by loess. Across the small bay of the Brno reservoir, rocky outcrops reaching up to 3 m in height can be observed. They are formed of diorites from the Brno massif containing alternating bands enriched with amphibole or plagioclase. Locally, the diorite is penetrated by distinct veins of granodiorites, basalts, and pegmatites reaching a thickness of several cm to several dm. There are abundant nests of black tourmaline in pegmatites and quartz chlorite veins, so the site is also important from a mineralogical point of view. The site is not legally protected; however, it is recorded in the database of the CGS [72].

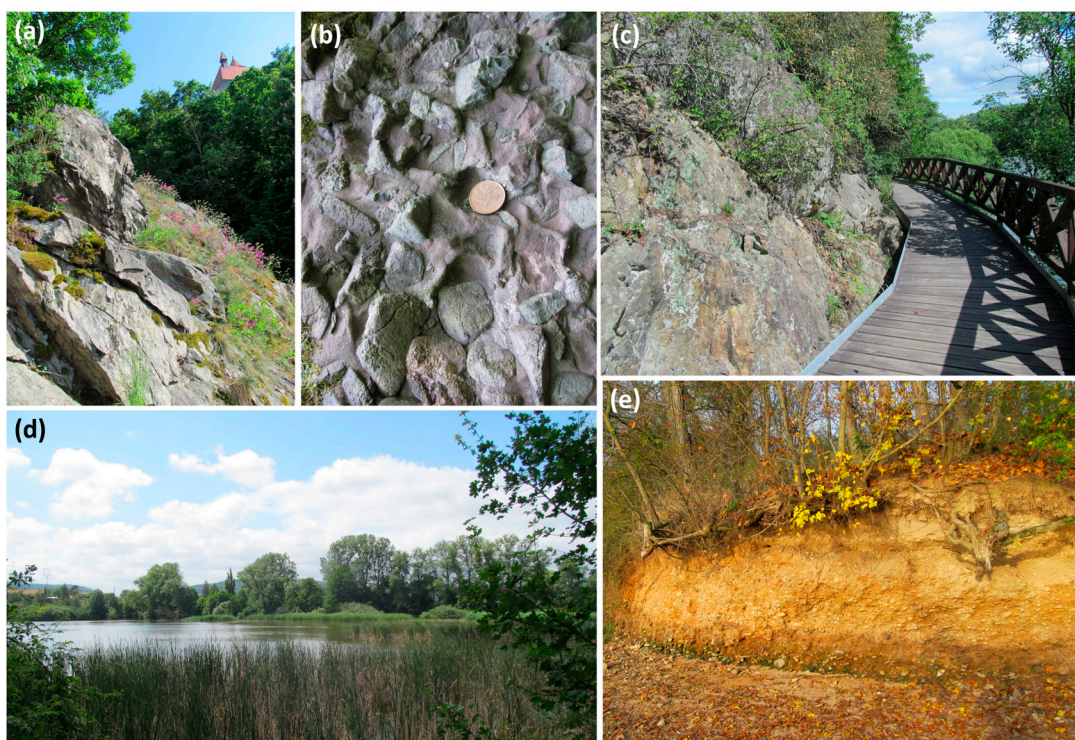


Figure 4. Selected sites with Earth science interest: (a) Veveří—outcrop of granodiorites, with a specific vegetation and high cultural relevance (Veverí castle); (b) a detail of conglomerates of Rokytná beds at the Břenčák Nature Reserve; (c) Kůlny Nature Monument with granodiorite outcrops—highly frequented tourist path; (d) Wetlands near Veverská Bítýška are situated just on the border of the Boskovice furrow; (e) Osada Abrasion Cliffs with sequences of sands and gravels. Photo: the authors.

- S4 Osada abrasion cliffs

On the left bank of the Brno reservoir near the Osada site, a 4 m high profile in Quaternary sediments exposed by the erosive action of the reservoir waters (abrasion, oscillation of the water level, and waves caused by shipping) emerges along the several tens of meters long bank. The underlying diorites and granodiorites from the Brno massif

are overlain by river gravels (usually Bíteš orthogneiss, metamorphic rocks of Svratka crystalline, moldanubic crystalline rocks) probably of the Middle Pleistocene age in a visible thickness of 1–2 m, covered by alluvial clays with noticeable layering. These are overlain by dusty sediments with lenticular positions formed by sandy to gravelly detritus originating mostly from granitoid rocks. The entire complex is covered by the youngest (Upper Pleistocene) loess. The abrasion cliffs represent a very good example of a dynamic geomorphological process in the littoral environment. The cliffs also have an ecological value as they serve as a nesting site for various bird species (sand martin, kingfisher). On the outcropping diorites situated on a narrow beach, colonies of blue mussel (*Mytilus edulis*) can be found. The site is protected in the category of Important Landscape Element and is recorded in the database of the CGS [71,72].

- S5 Jelení žlíbek

The site represents a typical landform of the area of the southern part of the Podkomořské lesy Natural Park (and also a wider area with granodiorite bedrock)—a deeply incised valley (or gully). The bedrock is formed of biotitic granodiorite overlaid with deluvial and partly eolic sediments. The lithological and morphological characteristics influence soils and vegetation—thanks to the rugged topography and, thus, limited accessibility, natural forests have been preserved here, which are important from a botanical and entomological point of view (occurrence of endangered species, e.g., *Lucanus cervus*, *Lilium martagon*, and several species of orchids). The high biodiversity is also conditioned by the intersection of three different biogeographic areas (Carpathian, Hercynian, and Pannonian). The site is protected in the category of Nature Reserve; the subjects of protection are endangered species and ecosystems of natural original oak–beech forests, but abiotic features are not a subject of protection [65,74].

- S6 Trnůvka

A quartz dyke rising above the surrounding relief, represents a unique tectonic–mineralogical–geomorphological phenomena within the study area (and generally, the whole Moravia). Due to its dimensions (about 1 km long, splitting into two branches), a portion is exaggeratedly called the Brno Quartz Dyke (as an analogue to the Bohemian Quartz Dyke in Šumava/Böhmerwald). The formation of the Trnůvka dyke is linked to the Variscan magmatic and metamorphic processes—the fissures in older granodiorite were filled with fluids that recrystallized as quartz occasionally accompanied by grains of calcite, barite, chlorite, plagioclase, or amphibole. Later, the high geomorphological resistance of quartz contributed to the present aspect of the site—the rock outcrops reaching a height of over 5 m and with a thickness of around 2.5 m. The site is not protected legally, but it is recorded in the CGS database and proposed for conservation in the category of Important Landscape Element especially thanks to its representativeness and uniqueness [72,75].

- S7 Rokle

Rock outcrops of granodiorites and diorites from the Brno massif represent an example of specific petrographic or petrogenetic phenomena—magma mixing. The dominant rock is a coarse-grained amphibole–biotitic granodiorite. The outcrops contain numerous enclaves of diorites with different grains and in one place these rocks even predominate. They are penetrated by irregular veins of lighter and coarser granodiorites and break up into decimeter oval blocks. Beneath the diorite outcrop in the rock above the river, a slab of fine-grained, indistinctly banded amphibolite several decimeters thick is preserved in the granodiorites. Amphibolites represent a relic of the metamorphic mantle of granodiorites from the Brno massif. Similar rocks also appear among the rocks on the other bank of the Svratka River. On the plateau above the rock outcrops, there are sandy gravels from the Svratka river terrace of the Lower Pleistocene age. The site is recorded in the CGS database [72].

- S8 Kůlny

Steep and rocky slopes and outcrops on the left bank of the Svatka River are formed of tectonically strongly affected diorites, granodiorites, and granites from the Brno massif with protruding basalt and aplite veins. At the contact of granodiorite and diorite, a higher intensity of deformation can be observed in the diorites, given by the different composition of the rocks and, thus, their different competence. These rocks often pass into indistinguishable mylonites and represent an important deformation zone in the western part of the Brno massif. Among the rock outcrops, numerous scree cones and debris accumulation can be found. Thanks to the lithological and morphological diversity, a mosaic of ecosystems occurs, formed by thermophilic oak woods, debris forests, Hercynian oak–hornbeam woods, xerophilic shrubs, or vegetation of silicate rocks. Several protected insects and reptile species can be found here (*Natrix tessellate*, *Cerambyx cerdo*, *Lucanus cervus*). Both living and non-living nature are the subject of legal protection—the site is protected as a Nature Monument and is also recorded in the CGS database [65,72,74].

- S9 Veverka Valley

The Veverka River is a right tributary of the Svatka River entering the reservoir near Veverčí Castle. It starts in the flat relief of the Boskovice furrow and then enters the crystalline rocks of the Brno massif (granodiorites). Here, the Veverka River forms a breakthrough valley (also called Helenka's Valley) which is up to 50m deep with numerous rock outcrops on the slopes. One of the most remarkable landforms is represented by a rock ridge between the Veverka River and its right tributary in the upper part of the valley. Its length is almost 500 m, the top part reaches a width of up to 20 m, in the middle it turns into a sharp rock ridge falling steeply on both sides. In the valley segment, under Veverčí Castle, there are also numerous granodiorite rock formations (slope stepped ridges, rock cliffs, small outcrops). Here, the Veverka valley floor is narrow, stony, and the river flow has a torrential character. The other rock formation (over 30 m) rises directly from the valley floor opposite Veverčí Castle and its upper part is formed by pronounced ribs, which are conditioned by perpendicular tectonic fissures. An important fluvial landform is represented by an abandoned incised meander (paleomeander) near the reservoir. The meander has been tectonically conditioned. Today, it does not flow by the Veverka River, and only small ponds are situated here. Before filling the reservoir, the Veverka River created a small waterfall at the confluence with the Svatka River [76].

- S10 Veverčí

Veverčí is a spur and significant outcrop of granodiorites from the Brno massif rising above the last segment of the Veverka River before entering the Brno reservoir. It reaches a height of over 30 m and numerous mesoforms can be observed here (stepped ridges, rock cliffs, small outcrops). On the top, Veverčí Castle is situated, so the landform is significantly anthropogenically modified. The whole site is thus important both from a geoheritage and a cultural heritage point of view. Veverčí castle is a cultural monument built in the 13th Century using the suitable strategic position on the top of the promontory; in the walls of the castle, the local material can be seen, especially granodiorites from the Brno massif and conglomerates and sandstones from the Boskovice furrow. The site is a good example of how lithological and morphological diversity significantly influenced the cultural heritage and historical development of the wider area [66,76,77].

- S11 Krnovec

The site is formed by steep and rocky slopes descending to the reservoir in the place where the Svatka River created an incised meander. The slopes are dissected by two valleys with periodic watercourses that remain without water for most of the year. The bedrock consists of granodiorite in the southern part, two slices of Devonian limestones in the central part, and reddish-brown Rokytá conglomerates in the northern part. Both lithological (alternation of granodiorite, limestone, conglomerate) and morphological (steep escarpments, outcrops and debris accumulations) diversity influence the diversity of soils and ecosystems. Hercynian oak–hornbeam woods, debris forests, acidophilic oak woods,

calciphilic oak woods, valley ash–alder riparian forests, and vegetation of silicate and calcareous rocks create a landscape mosaic that is a home to a number of protected and endangered species. Both living and non-living nature are protected within this Nature Reserve [65,74].

- S12 Junácká louka

The site is a forest-free area historically used as pasture. It is formed by a slightly inclined fluvial terrace of the Svatka River surrounded by steep slopes built of granodiorites from the Brno massif. In the northern part, Neogene clays of marine origin can be found; in the southern and central parts, Quaternary fluvial sediments are deposited on the granodiorite of Brno massif. The relics of the river terraces are located in three height positions. The area is entomologically important, but the subject of legal protection is the occurrence of endangered *Gentiana cruciata*. The site is visited quite frequently as a tourist path goes through it and it offers nice views of Veverí Castle [58,65,72,74].

- S13 Na skalách

The site is situated 1 km north of Veverí Castle and it is created by an outcrop of Vilémovice limestone which is tectonically inserted between the granodiorites from the Brno massif and Permian conglomerates from the Boskovice furrow. The outcropping limestone which is paleontologically important (occurrence of diversified dendroid rugose corals sp. *Disphyllum*, *Thamnophyllum*, and *Peneckiella*) is of Devonian (Frasnian) age and it forms rock cliffs (steps approx. 5 m high) in the left-bank valley slope of the Svatka River. Outside the area of the NM, on the shoreline, a small cave is situated, it is 2.3 m high, 1.3 wide and approximately 3 m long. Other typical karst features are represented by karren and small caverns formed along the fissures. Thanks to the specific lithology and morphology, some calciphilic and thermophilic species (*Cephalanthera damasonium*, *Cornus mas*) can be found here. Geodiversity also influences the presence of various ecosystems occurring within a relatively small area: thermophilic oak woods, Hercynian oak–hornbeam woods, debris forests, rock thermophilic vegetation, calcareous fissure vegetation. The site is protected within the category of Nature Monument and both living and non-living nature is a subject of protection; it is also recorded in the CGS database [65,72,74].

- S14 Mečkov

The rock cliffs of Mečkov are outcropping on the left bank of the reservoir reaching a height of up to 10 m. They are characterised by intensive fissuring and alternation of limestones and conglomerates. On the site, a typical bench-like separation of conglomerates is well visible creating the steep high formation. As a result of selective weathering, limestone boulders and pebbles fall out of these conglomerates. Accessibility is limited, but they can be observed from the boat. The site has a high aesthetic value thanks to its position next to the water surface. The site is discussed as a possible Important Landscape Element.

- S15 Břenčák

The site consists of steep slopes and rocky outcrops with south-west, west, and north-west exposure above the left bank of the Brno reservoir. The lower part of the outcrop is formed of reddish and brownish conglomerates which are overlain by sandstones. Both facies belong to the Rokytňá Formation of the Permian–Carboniferous age and are a part of the Boskovice furrow. Rokytňá conglomerates serve as evidence of torrential debris flows during the Permian. The site is protected in the category of Nature Reserve and both living and non-living nature is a subject of protection. Thanks to the specific lithological and morphological conditions, important ecosystems (Hercynian oak–hornbeam woods, debris forests, acidophilic thermophilic oak woods, rock thermophilic and fissure vegetation) and endangered species (*Pulsatilla grandis*, *Centaurea triumfettii*, *Staphylea pinnata*, *Clematis recta*) are present here. The site is frequently visited as the marked tourist trail goes through it. It is also included in the CGS database [65,72,74].

- S16 Wetlands near Veverská Bitýška

The terrain is rather flat, and it is formed by fluvial sediments and loess. It is situated in the place where the Svratka River enters its breakthrough valley. Here, the fault slope of the eastern edge of the Boskovice furrow ends and the depression of the Veverskobíťská basin opens. The morphodiversity enables the water of the Svratka River to inundate the flat floor and floodplain and, thus, it creates the wetlands which represent a very important biodiversity hotspot of the wider area. Numerous protected species, especially nesting birds can be observed here. Moreover, on the opposite bank of the reservoir, aesthetically valuable conglomerate outcrops are well visible. The site is very well accessible both on foot and on bicycle.

3. Results

3.1. Site Assessment—Geotourist and Geoeducational Potential

At first, the sites were assessed by using the geosites/geomorphosites approach focused both on scientific and added values and on the tourist and educational characteristics including the conservation aspects. The overall results of the assessment are presented in Table 2. Here, we insert the assessment of the main groups of values and total values (i.e., total geotourist and geoeducational potential). For a detailed site assessment, please see Supplementary Materials. For the purpose of graphical presentation, the “main” values (SV + AV) and “use” values (EV + TV + CV) were calculated. Figure 5 then presents the relationship between the main values (i.e., the characteristics of the sites) and their use values. Total value is also counted as a simple average of particular criteria and enables ranking of the sites.

Table 2. Assessment of selected sites with Earth science interest regarding their geoeducational and geotourist potential (a detailed assessment of the sites submitted as Supplementary Materials).

Site Number	Local Name	SV	AV	EV	TV	CV	SV + AV	EV + TV + CV	Total Value
S1	Skalky u přehrady	0.70	0.92	0.92	0.80	0.75	0.81	0.82	0.82
S2	Rakovec	0.45	0.08	0.25	0.30	0.38	0.27	0.31	0.29
S3	Sokolské koupaliště	0.55	0.17	0.42	0.70	0.38	0.36	0.50	0.43
S4	Osada abrasion cliffs	0.90	0.75	0.92	0.75	0.50	0.83	0.72	0.77
S5	Jelení žlíbek	0.55	0.67	0.92	0.40	0.75	0.61	0.69	0.65
S6	Trnůvka	0.80	0.42	0.67	0.25	0.38	0.61	0.43	0.52
S7	Rokle	0.50	0.25	0.42	0.60	0.38	0.38	0.46	0.42
S8	Kůlny	0.60	0.67	0.92	0.60	0.63	0.63	0.71	0.67
S9	Veverka Valley	0.65	0.75	0.33	0.70	0.38	0.70	0.47	0.58
S10	Veveří	0.55	0.83	0.58	0.75	0.25	0.69	0.53	0.61
S11	Krnovec	0.65	0.67	0.67	0.50	0.63	0.66	0.60	0.63
S12	Junácká louka	0.30	0.42	0.42	0.40	0.75	0.36	0.52	0.44
S13	Na skalách	0.65	0.58	0.92	0.45	0.75	0.62	0.71	0.66
S14	Mečkov	0.55	0.50	0.33	0.50	0.25	0.53	0.36	0.44
S15	Břenčák	0.85	0.83	0.75	0.65	0.63	0.84	0.68	0.76
S16	Wetlands	0.65	0.67	0.50	0.75	0.25	0.66	0.50	0.58

Based on the results, it can be stated that the highest geoeducational and geotourist potential is attributed to S1 Skalky u přehrady, S4 Osada, and S15 Břenčák. These sites lie a bit apart from the other sites that have been assessed, as indicated in Figure 5. The sites S5 Jelení žlíbek, S13 Na skalách, and S8 Kůlny have higher tourist use values and relatively high main values. The sites S11 Krnovec, S10 Veverí, S16 Wetlands, and S9 Veverka Valley have higher main values and average tourist use values. Generally, all these sites can be considered as the most important resources for geoeducational and geotourist activities.

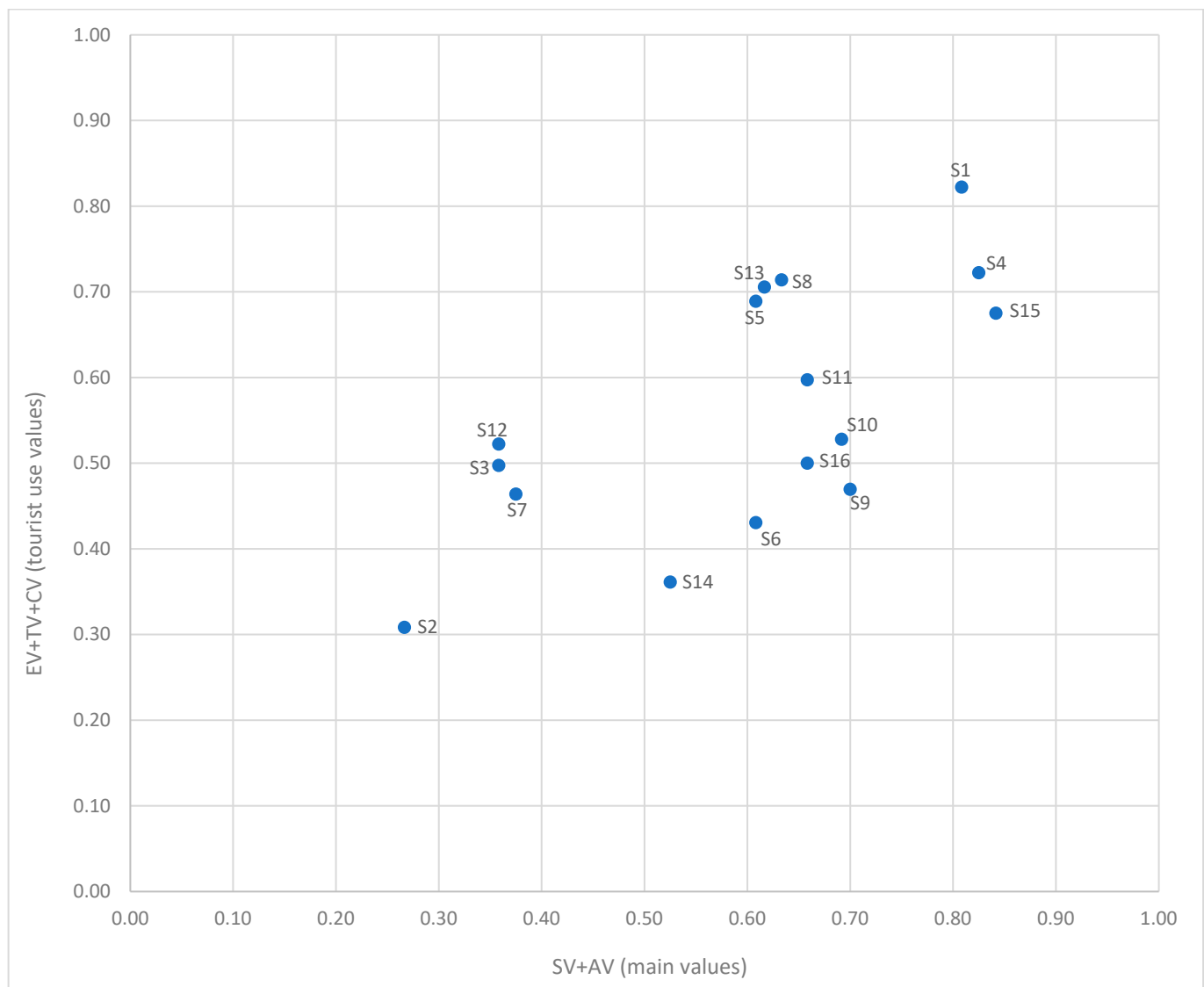


Figure 5. The relationship between main values (scientific and added values) and use values (educational, tourist and conservation values) of particular sites.

Conversely, the site S2 Rakovec has the lowest values especially due to the lower tourist and educational values and very limited added values. The sites S3 Sokolské koupaliště, S12 Junácká louka, and S7 Rokle have average tourist use values, but their main values are lower. The site S6 Trnůvka is specific—it has a relatively high main value (especially the scientific one), but its tourist use value is lower. Site S14 Mečkov is similar, however, its main values are lower than in the case of S6 Trnůvka.

Based on the site evaluation it can be said that some of the assessed sites possess a potential for geoeducational and geotourist activities, although some of them are just average. It can be presumed that in the case of developing geotourist and geoeducational activities on particular sites, this potential is going to be used by a high number of visitors and tourists thanks to the presence of regular municipal and boat transport, a dense network of hiking trails, and the position of the sites in the traditional recreational area in the outskirts of a large city.

3.2. Risk Assessment

Despite the high or average geotourist and geoeducational potential of the majority of the sites, it has to be considered that not every site is suitable for the development of these

activities, especially due to their vulnerability and occurrence of various threats. Based on fieldwork and the literature review, five main threats resulting from anthropogenic activities and uses have been identified (described in detail in Section 2.2.5) and assessed by using the risk assessment matrix. The results of the risk assessment are presented in Table 3. For a detailed risk assessment by using the risk assessment matrix, please see Supplementary Materials.

Table 3. Risk assessment for the sites with Earth science interest. Particular threats: urbanisation, construction (URB), changes in land use (LAND), tourism and recreation (TOUR), emphasizing living nature protection (LIV), and collecting fossils and rocks (COLL). A detailed assessment is given in Supplementary Materials.

Site Number	Local Name	Threats					Total Risk	%
		URB	LAND	TOUR	LIV	COLL		
S1	Skalky u přehrady	16	16	16	12	1	12.20	48.80
S2	Rakovec	15	16	12	4	2	9.80	39.20
S3	Sokolské koupaliště	12	16	16	6	2	10.40	41.60
S4	Osada abrasion cliffs	15	20	20	12	5	14.40	57.60
S5	Jelení žlíbek	5	10	12	12	1	8.00	32.00
S6	Trnůvka	8	15	20	6	12	12.20	48.80
S7	Rokle	12	12	12	6	1	8.60	34.40
S8	Kůlny	5	10	16	9	1	8.20	32.80
S9	Veverka Valley	12	12	9	9	1	8.60	34.40
S10	Veveří	8	10	16	4	1	7.80	31.20
S11	Krnovec	5	12	9	15	1	8.40	33.60
S12	Junácká louka	5	9	15	15	1	9.00	36.00
S13	Na skalách	5	10	16	12	12	11.00	44.00
S14	Mečkov	4	6	12	4	1	5.40	21.60
S15	Břenčák	5	15	16	16	1	10.60	42.40
S16	Wetlands	15	20	20	12	1	13.60	54.40
Average per threat		9.19	13.06	14.81	9.63	2.75	9.89	39.55

Based on the results given by the risk assessment matrix, it can be seen that the intensity of particular threats varies considerably. The urbanisation and construction (URB) represent major threats for the sites situated in proximity to the city of Brno and the municipality of Veverská Bítýška. The sites that lie approximately in the centre of the study area are less endangered by this threat. These sites are also very often legally protected in the higher category (Nature Monument, Nature Reserve) which guarantees a certain degree of protection. Concerning land use changes (LAND), the situation is different—it presents a more important threat to the sites regardless of their legal protection. Two sites (S4 Osada and S16 Wetlands) are particularly sensitive to these potential threats and the land use change would have a high impact on them. Tourism and recreation (TOUR) represent a most important risk that has to be taken into account when planning and managing geotourist resources. As indicated in the Introduction, the geotourist and geoeducational use of the sites can address a high number of people and may bring a significant contribution to geoconservation, but if developed spontaneously and unthinkingly, it may have a high impact on the Earth science phenomena. Emphasizing living nature in nature conservation and management (LIV) represents a moderate threat, but it can be resolved by revising care plans and indicating the abiotic phenomena as a subject of protection. Collecting rock samples and minerals (COLL) is limited only to specific sites. The overall degree of this threat is very low, so it can be considered a minor threat, but it is necessary to think individually when managing this risk.

Generally, the most endangered sites are S4 Osada and S16 Wetlands, which are very sensitive to tourist use and land use changes. A similar situation is seen with S3 Sokolské koupaliště, S1 Skalky u přehrady, and S15 Břenčák. Site S6 Trnůvka is susceptible especially

to rock collecting, as the material (quartz) from which this site is formed, is very attractive not only for amateur collectors, but for people who can bring the rocks to their gardens.

3.3. Analysis of the Relationships Between Particular Values and Risk Assessment

The results of the site evaluation and risk assessment served as a base for a simple analysis of the mutual relationships between particular values and present threats. Figure 6 sums up the main results and shows the analysis of the mutual relationships. It is necessary to say that these results are preliminary, as the number of the sites is relatively low, and the methods may have some limits.

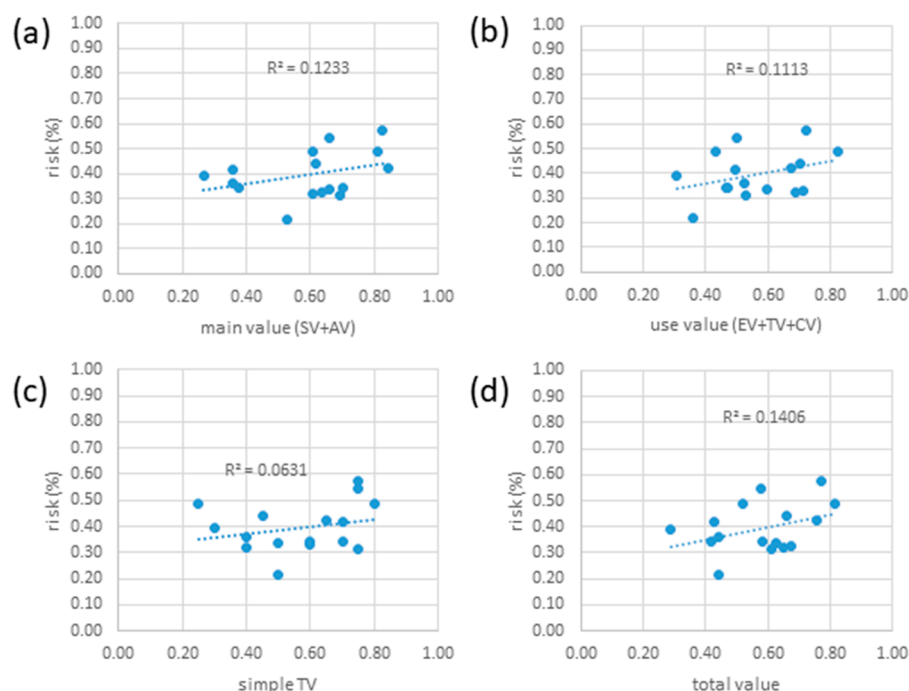


Figure 6. The preliminary analysis of the relationships between particular values and risks: (a) relation between main value and risks; (b) relation between use value and risks; (c) relation between simple tourist value and risks; (d) relation between total value and risks.

Based on the results presented in Figure 6 it can be stated that there is no important relationship between particular values (main, use, simple tourist, and total) and threats (risks) to the sites. However, the number of sites that have been included in this preliminary analysis is quite low. In the future, this methodological approach may be developed in more detail and applied to a larger research sample.

3.4. Proposals for Sustainable Management

Coming out from the assessment, the proposals for sustainable management both for geotourism/geoeducational development and nature conservation are presented. Below, particular proposals for particular sites are explained. A brief summary is presented in Table 4.

S1—Skalky u přehrady: given the fact that this site has a high geotourist and geoeducational potential and, at the same time, it reaches a relatively high-risk intensity, it should be prioritized. When revising the care plan of this Nature Monument, geodiversity should be included within the subject of protection (currently, only ecosystems and species are protected legally). Geoeducational activities on this site should be focused on linking the geodiversity, biodiversity, and eventually the historical aspects of the site. Thus, a cooperation among authorities in nature conservation, water management (who are in charge of dam), and interested public is desirable.

S2—Rakovec: the site has relatively low geoeducational and geotourist potential. Due to the fact that it is situated on private land, the possibilities of rational and sustainable development and use are limited. However, as the site is included in the database of the Czech Geological Survey, regular monitoring can be assured by this institution.

S3—Sokolské koupaliště: the geoeducational and geotourist potential of this site is average; the intensity of threats is also average. It is possible to use this site as complementary when developing geoeducational and geotourist products. Addressing local residents and owners of the nearby recreational objects and explaining their scientific value can contribute to the effective care of the site.

S4—Osada: given the fact that this site has a high geotourist and geoeducational potential and, at the same time, it reaches a relatively high-risk intensity, it should be prioritized (as well as S1). The site has only a limited legislative protection (ILE) but given the fact that it has a high scientific value, it should be declared as Nature Monument. Consequently, both living and non-living nature will be defined as subjects of protection in the care plan and thus enjoy a higher degree of protection which may decrease any possible negative impacts of land use changes and intensive tourist and recreation use. Geoeducational activities should be developed on this site as well. Addressing local residents and owners of the nearby recreational objects and explaining their scientific and added values can contribute to the effective care of the site.

S5—Jelení žlíbek: the site has above-average geoeducational and geotourist potential and it does not face any severe threats. Geodiversity is not a subject of legal protection here, although the site is protected as a Nature Monument. Thus, when revising the care plan, abiotic nature should be included within the subjects of protection (currently, only ecosystems and species are protected legally). Geoeducational and geotourist activities can benefit from linking biodiversity and geodiversity. The site should be better promoted which may contribute to a better distribution of people within the study area.

S6—Trnůvka: the overall geoeducational and geotourist potential of this site is average; however, the scientific value reaches high scores. Due to this, Trnůvka should benefit from some type of legislative protection, e.g., declaring the site an Important Landscape Element. It would be suitable to use this site for environmental education but, at the same time, it should not be “over-promoted” as the intensity of threats remain quite high for this site. As the site is included in the database of the Czech Geological Survey, regular monitoring can be assured by this institution.

S7—Rokle: the geoeducational and geotourist potential of this site is average; the intensity of threats is also average. It is possible to use this site as complementary when developing geoeducational and geotourist products. Addressing local residents and owners of the nearby recreational objects and explaining their scientific value can contribute to the effective care of the site. Moreover, the site should be better promoted which may contribute to a better distribution of people within the study area. As the site is included in the database of the CGS, regular monitoring can be assured by this institution. Legal protection is not (so far) necessary in this case.

S8—Kůlny: this site has a high geotourist and geoeducational potential and, at the same time, it reaches rather lower risk intensity, so regular monitoring (both by the CGS and nature conservation authorities) should be enough to maintain the overall good conditions. The site is suitable for some community care projects. Thanks to this, the site can be used for geotourist and geoeducational purposes and its geodiversity can be promoted together with links to living nature.

S9—Veverka valley: the site has relatively high geotourist and geoeducational potential and the intensity of threats is rather lower. Geoeducational and geotourist activities can benefit from linking biodiversity, geodiversity, and cultural heritage. The site should be better promoted which may contribute to a better distribution of people within the study area. Thanks to its proximity to an intensively used S10 Veverčí, it can serve as a calm alternative or supplementary recreational area. A consideration could be given to including the site in the database of the CGS which would assure regular monitoring.

S10—Veveří: the overall geoeducational and geotourist potential of this site is relatively high and may reach even higher values if the geodiversity is promoted together with cultural heritage. The susceptibility to the risks is lower, so geoeducational and geotourist activities can be developed and the site should be promoted with an emphasis on geodiversity–culture relationships (e.g., use of building stone or landforms that influenced the location of the castle).

S11—Krnovec: this site has a high geotourist and geoeducational potential and, at the same time, it reaches rather lower risk intensity, so regular monitoring (both by the CGS and nature conservation authorities) should be enough to maintain the overall good conditions. Geoeducational and geotourist activities can benefit from linking biodiversity and geodiversity. The site should be better promoted which may contribute to a better distribution of people within the study area. However, it is necessary to keep visitors on tourist routes both for conservation and safety reasons.

S12—Junácká louka: the geoeducational and geotourist potential of the site is rather low and so is the intensity of threats. Currently, geodiversity elements are not legally protected here. They can be included in the care plan, but it is not a priority as in the case of S1 and S5. The site could contribute to a better understanding of geodiversity–biodiversity relationships; thus, environmental educational activities can be developed.

S13—Na skalách: given the fact that this site has a high geotourist and geoeducational potential and, at the same time, it reaches a relatively high-risk intensity, it should be promoted as a geotourist destination with precautions. It is necessary to carefully explain the scientific value of this site and emphasize the geodiversity–biodiversity links. Regular monitoring (both by CGS and nature conservation authorities) should be the priority within the management measures. When revising the care plan, an extension of Nature Monument can be considered (within the limestone outcrops, there is a cave which is not currently included within the NM area).

S14—Mečkov: the geoeducational and geotourist potential of this site is average, and the intensity of threats is rather low. The site can be used as complementary when developing geoeducational and geotourist activities. Addressing local residents and owners of the nearby recreational objects and explaining their scientific value can contribute to the effective care of the site. The site can be promoted which may contribute to a better distribution of visitors within the study area. Recording the site in the database of the CGS could be taken into consideration as it would assure regular monitoring.

S15—Břenčák: this site has a high geotourist and geoeducational potential and, at the same time, it reaches a high-risk intensity; thus it should be promoted as a geotourist destination with precaution with an emphasis on its scientific values and geodiversity–biodiversity relationships. This may contribute to the better understanding of the importance of this site by visitors. For monitoring of this site, cooperation among authorities in nature conservation and interested public is desirable, e.g., by developing community care projects.

S16—Wetlands: this site has relatively high geotourist and geoeducational potential; its susceptibility to risks is one of the highest. Regarding the future use of the site, geoeducation should be emphasized and geodiversity–biodiversity relationships should be explained. Recording the site in the database of the CGS could be taken into consideration as it would assure regular monitoring.

All the activities can be framed by developing a Geodiversity Action Plan, a strategic document focused on the geodiversity and geoheritage of a certain area which may also include such activities as improvement of the accessibility to some sites (with local stakeholders; introducing new official pathways where the path is already in use, which may contribute to the regulation of the visitors' movement, and keeping them on official pathways), involvement of local inhabitants (communities, stakeholders) into the care of the sites, or creating a network of geotrails, or supporting adequate and more targeted geotourist products, such as guided walks and geo-cruises (visitors see the site as they are being

educated about it, but it is not necessary to be present there, especially for S3—Sokolské koupaliště and S4—Osada).

Table 4. Management proposals for specific sites. Particular management proposals are designed based on the detailed fieldwork and assessment of threats.

Management Proposals for Particular Threats	Sites Where the Management Proposal Is Relevant
Revising care plans of Nature Monuments and Reserves and adding geodiversity phenomena as a subject of protection where relevant (URB, LAND, LIV)	S1—Skalky u přehrady S5—Jelení žlíbek S12—Junácká louka
Declaring new sites as Important Landscape Elements, eventually update the protection status (URB, LAND, TOUR)	S6—Trnůvka S14—Mečkov S16—Wetlands S4—Osada (change the status of ILE to NM because of high scientific values)
Including these sites in the territorial ecological network (URB, LAND)	All sites (depending on level—supraregional, regional, local)
Supporting materials for the promotion of geodiversity and informing visitors about the geodiversity functions and importance (TOUR, COLL, LIV)	All sites (e.g., in form of a geotourist map)
Linking geodiversity to biodiversity and cultural heritage of the area (TOUR, LIV)	S1—Skalky u přehrady (biodiversity, cultural heritage) S4—Osada (biodiversity) S5—Jelení žlíbek (biodiversity) S9—Veverka valley (cultural heritage) S10—Veverčí (cultural heritage) S11—Krnovec (biodiversity) S13—Na skalách (biodiversity) S15—Břenčák (biodiversity)
Promotion of less known and less vulnerable sites to avoid the overexploitation of more exposed sites (TOUR)	S5—Jelení žlíbek S7—Rokle S9—Veverka valley S11—Krnovec S14—Mečkov
Involvement of local inhabitants (communities, stakeholders) in the care of the sites (all the threats)	All sites

4. Discussion

Regarding the research questions indicated in the Introduction, the answers to them are quite tightly connected. Briefly, the first question: “Is there any relationship between the geotourist/geoeducational potential and degree of possible risks and threats?” can be (based on the results) answered, “no”; however, this statement is preliminary as the number of sites where this relationship has been examined is quite low. Nevertheless, if applied on a higher number of sites, the results may be more relevant. The second question: “Is it always desirable to promote geoheritage in intensively used areas although it may reach a considerable number of visitors?”—the answer is, “partly”, because despite the numerous advantages, there is a risk of overexploitation and damage to the sites. The third question: “Is it possible to propose such management that would benefit both from the geotourist/geoeducational potential of the sites and respect the scientific values and geo-conservation principles?”—the answer is, “yes”, because there exist specific proposals that may contribute to balancing the geotourist/geoeducational use and nature conservation.

The geodiversity sites in the study area possess a certain potential for development of geotourist and geoeducational purposes. Some of these can represent the “main” geotourist sites and form a backbone of geotourist offerings (*sensu* [47]), while others can be considered as complementary (e.g., thanks to higher cultural and ecological values). Generally, the development of geotourist and geoeducational activities can contribute to the awareness

of geodiversity values and it may emphasize the links between geodiversity, biodiversity, and culture [41,77]. Moreover, adding geodiversity and geoheritage content may increase the attractiveness of the traditional routes [78]. Also, linking traditional recreational and leisure activities with geotourism and geoeducation can bring some benefits and may be attractive for visitors, which is demonstrated by many projects and research papers, e.g., linking cycling and geoheritage [79], geoheritage and wine culture [80], geoheritage and horse-riding [81], diving and exploring marine geoheritage [82], boat trips and geoheritage [83] or trekking/climbing and geoheritage, e.g., international project “IGCP 714 3GEO—Geoclimbing & Geotrekking in Geoparks” [84,85].

However, at the same time, when developing these activities in densely populated or intensively visited areas, it may bring some negative consequences, e.g., overtourism and overexploitation of the sites [46] or damage to vulnerable sites [40]. In this case, it is necessary to adopt such geoconservation measures that would prevent the possible degradation of the particular sites and Earth science phenomena and integrate the geodiversity into general nature protection, or bond it more properly with biodiversity conservation [20,47,53,86–88]. As there are very tight connections between geodiversity and biodiversity [89–92] and, in the study area, the living nature is very often privileged in care plans [65], it is very important to link geodiversity and biodiversity both in geoeducational/geotourism activities and management of particular sites in all the study areas. Integrating geoconservation into the management of all categories of protected areas is beneficial not only for geoheritage, but for all of nature [93]. Particular activities related to legal protection may be represented, e.g., by management zoning and identification of core and buffer zones, site condition monitoring, or periodic plan review [94]. The possibility to manage and promote geodiversity together with its links to biodiversity is quite effective and leads to a better acceptance and understanding of abiotic nature's importance [33,92,95].

In our study area, the solution may be also in fostering the protection status of some sites. This can assure that the sites are protected from main threats in the area (urbanization and land use changes); however, it may generate misunderstanding as sometimes the declaration of the site as protected may not be accepted by local communities. Given the fact that social or community support is one of the key factors that determines the successful establishment and management of protected areas [95], the involvement of the public in such a decision is crucial. The success of conservation strategies through protected areas may be supported by the openness of authorities and by linking conservation with the needs of local communities and residents [96].

The alternative to legal protection is the bottom-up approach where local communities are involved in activities, such as defining the rules for particular sites (e.g., ethical code) and shared care of the sites, which may result in better awareness about the values of geoheritage and geodiversity. Local projects such as “Watch over a rock” [97,98] could significantly contribute to raising awareness about the sites. Another possibility of how to effectively involve local people is to include specific communities, such as climbers or hikers [85]. Generally, it is important for practical conservation to prioritize the perspectives of local inhabitants, acknowledging their unique viewpoints and contributions to the understanding and conservation of geological resources [35]. Educational activities tailored to the local communities can also contribute to a better understanding of the necessity of sustainable use of the sites. Regarding the promotion of less known and less vulnerable sites to avoid the overexploitation of more exposed sites that are very often situated along the main tourist pathways, it is possible to prepare “alternative routes” or inform visitors about other sites; however, in some cases these strategies are not very successful as people usually want to follow the traditional routes and visit the “classical” sites [45]. Thus, in this case, raising awareness about geoheritage values and the above-mentioned bottom-up approaches or involving local communities in the care of the sites seem to be more effective [80,99].

All these proposals can be roofed by creating a Geodiversity Action Plan for the specific area where all the management proposals can be developed. Burek [100], Ferrero et al. [101], Dunlop et al. [102], Kubalíková et al. [103] reflect this possibility as relevant and functioning when designed in cooperation with various stakeholders in the territory (landowners, communities, academia, authorities, etc.). Regarding the changing protection status and revising care plans, it is necessary to discuss this possibility with relevant authorities and the process may be lengthy (in Czech conditions); however, involving local communities in the care of the sites and suitable geo-interpretation may partially supply this issue, as underlined by [99,104–106].

Thus, although traditional recreational areas have a high potential regarding the number of visitors that can be affected by geotourist and geoeducational activities and it is possible to link geoheritage interpretation with classical leisure activities, it is always necessary to consider the risks and threats. Therefore, geotourist and geoeducational activities need to be designed carefully in a sustainable way and respecting geoethical aspects [107,108].

Generally, it can be stated that the proposed measures can be applied in more study areas that are intensively used for recreation and tourism. However, the detailed assessment should represent a base for these proposals. Continuous monitoring and further research can contribute to more precise results regarding the relationships between recreational use and the possibility of geotourist development in a certain study area and may contribute to a better understanding of the impacts of geotourism and recreation on geodiversity and geoheritage in a particular area.

5. Conclusions

The Brno reservoir and its surroundings represent an area that is intensively used for tourist and recreational purposes. Although geodiversity and geoheritage play an important role here and are closely connected to the biodiversity and cultural heritage of the area, they are used in a very uneven way for geotourist and geoeducational purposes. Some of the sites are more endangered than others, for example, due to better accessibility or general knowledge; other sites are practically forgotten or unknown, or their geoheritage values are hidden by their biodiversity and cultural values. Generally, the advantages of the traditional recreation areas regarding the development of geotourism and geoeducation are represented especially by a high number of potential recipients (which may contribute to better awareness about the geoheritage of the area), but due to the vulnerability and susceptibility to risks of specific sites (proximity of threats such as land use changes, urbanisation, or overtourism, and consequent damage of the sites), a set of management measures needs to be taken into account before the proper development of these activities (e.g., revising the degree of legal protection, involvement of local communities in the care of the sites, developing alternative ways for geoeducational activities). Therefore, it is necessary to consider all the risks and design the geotourist and geoeducational activities carefully and with respect to nature conservation and geoethical principles. Based on the assessment of geoeducational and geotourist potential, and based on the evaluation of threats, it can be summarized as follows:

- The geotourist and geoeducational potential of the sites in the Brno reservoir study area can be used, but it is suitable to support these activities by appropriate conservation measures (e.g., strengthening legislative protection measures) and involvement of local communities (e.g., care of the sites, participation on preparation of a Geodiversity Action Plan);
- Threats need to be considered, which will require very effective communication and networking (partially overlapping with activities in the previous point);
- Future research activities should include regular monitoring of the sites and a more detailed assessment of mutual relationships between the particular values of the sites. It is also desirable to elaborate a more in-depth analysis of the impacts of tourism and recreation on geodiversity and geoheritage, e.g., within a longer period;

- The proposed methodological approach can be applied in other traditional recreational and tourist areas to gain new knowledge about the impacts of geotourism and recreation on geodiversity and geoheritage.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su16219551/s1>, Table S1: Assessment of selected sites of Earth Sciences interest and detailed risk assessment by using the Risk Assessment Matrix.

Author Contributions: Conceptualization, L.K.; methodology, L.K., M.B., A.B., and K.K.; investigation, L.K., M.B., A.B., and K.K.; resources, L.K., M.B., A.B., and K.K.; writing—original draft preparation, L.K. and K.K.; writing—review and editing, L.K. and M.B.; visualization, M.B.; supervision, L.K. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the project Dynamic Planet Earth of the Czech Academy of Sciences—Strategy AV21.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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

References

1. Gray, M. *Geodiversity: Valuing and Conserving Abiotic Nature*, 2nd ed.; Wiley-Blackwell: Chichester, UK, 2013; 512p.
2. Reynard, E.; Brilha, J. (Eds.) *Geoheritage: Assessment, Protection and Management*; Elsevier: Amsterdam, The Netherlands, 2018; 482p.
3. Chakraborty, A.; Gray, M. A call for mainstreaming geodiversity in nature conservation research and praxis. *J. Nat. Conserv.* **2020**, *56*, 125862. [[CrossRef](#)]
4. Kubalíková, L.; Coratza, P.; Pál, M.; Zwoliński, Z.; Irapta, P.N.; van Wyk de Vries, B. (Eds.) *Visages of Geodiversity and Geoheritage*; Geological Society: London, UK, 2023; 350p.
5. Gray, M. Geodiversity, geoheritage and geoconservation for society. *Int. J. Geoheritage Parks* **2019**, *7*, 226–236. [[CrossRef](#)]
6. Gray, M. Geodiversity: A significant, multi-faceted and evolving, geoscientific paradigm rather than a redundant term. *Proc. Geol. Assoc.* **2021**, *132*, 605–619. [[CrossRef](#)]
7. Gordon, J.E.; Barron, H.F. Valuing geodiversity and geoconservation: Developing a more strategic ecosystem approach. *Scott. Geogr. J.* **2012**, *128*, 278–297. [[CrossRef](#)]
8. Gray, M.; Gordon, J.E.; Brown, E.J. Geodiversity and the ecosystem approach: The contribution of geoscience in delivering integrated environmental management. *Proc. Geol. Assoc.* **2013**, *124*, 659–673. [[CrossRef](#)]
9. Gray, M.; Fox, N.; Gordon, J.E.; Brilha, J.; Chakraborty, A.; Garcia, M.G.M.; Hjort, J.; Kubalíková, L.; Seijmonsbergen, A.C.; Urban, J. Boundary of ecosystem services: A response to. *J. Environ. Manag.* **2024**, *351*, 119666. [[CrossRef](#)]
10. Frisk, E.L.; Volchko, Y.; Sandstrom, O.T.; Soderqvist, T.; Ericsson, L.O.; Mossmark, F.; Lindhe, A.; Blom, G.; Lång, L.-O.; Carlsson, C.; et al. The geosystem services concept—What is it and can it support subsurface planning? *Ecosyst. Serv.* **2022**, *58*, 101493. [[CrossRef](#)]
11. van Ree, D.; van Beukering, P.J.H.; Hofkes, M.W. Linking geodiversity and geosystem services to human well-being for the sustainable utilization of the subsurface and the urban environment. *Philos. Trans. R. Soc. A* **2024**, *382*, 20230051. [[CrossRef](#)]
12. Dowling, R.K.; Newsome, D. *Handbook of Geotourism*; Edward Elgar Publishing: Cheltenham, UK, 2018; 520p.
13. Li, B.; Németh, K.; Zakharovskiy, V.; Palmer, J.; Palmer, A.; Proctor, J. Geodiversity estimate of the Arxan–Chaihe Volcanic Field extending across two geoparks in Inner Mongolia, NE China. In *Visages of Geodiversity and Geoheritage*; Kubalíková, L., Coratza, P., Pál, M., Zwoliński, Z., Irapta, P.N., van Wyk de Vries, B., Eds.; Geological Society: London, UK, 2023; pp. 107–125.
14. Del Lama, E.A.; Bacci, D.C.; Martins, L.; Garcia, M.G.M.; Dehira, L.K. Urban Geotourism and the Old Centre of São Paulo City, Brazil. *Geoheritage* **2015**, *7*, 147–164. [[CrossRef](#)]
15. Palacio-Prieto, J.L. Geoheritage within cities: Urban geosites in Mexico City. *Geoheritage* **2015**, *7*, 365–373. [[CrossRef](#)]
16. Habibi, T.; Ponedelnik, A.A.; Yashalova, N.; Ruban, D.A. Urban geoheritage complexity: Evidence of a unique natural resource from Shiraz city in Iran. *Resour. Policy* **2018**, *59*, 85–94. [[CrossRef](#)]
17. Kubalíková, L.; Kirchner, K.; Kuda, F.; Bajer, A. Assessment of urban geotourism resources: An example of two geocultural sites in Brno, Czech Republic. *Geoheritage* **2020**, *12*, 7. [[CrossRef](#)]
18. Melelli, L.; Palombo, M.; Nazzareni, S. Ghost Mines for Geoheritage Enhancement in the Umbria Region (Central Italy). *Geosciences* **2023**, *13*, 208. [[CrossRef](#)]

19. Németh, B.; Németh, K. Spatial decision-making support for geoheritage conservation in the urban and indigenous environment of the Auckland Volcanic Field, New Zealand. In *Visages of Geodiversity and Geoheritage*; Kubalíková, L., Coratza, P., Pál, M., Zwoliński, Z., Irapta, P.N., van Wyk de Vries, B., Eds.; Geological Society: London, UK, 2023; pp. 235–256.
20. Monge-Ganuzas, M. Geoconservation in the Autonomous Region of the Basque Country (Spain). *Geoheritage* **2021**, *13*, 106. [\[CrossRef\]](#)
21. Gordon, J.E. Geoheritage, Geotourism and the Cultural Landscape: Enhancing the Visitor Experience and Promoting Geoconservation. *Geosciences* **2018**, *8*, 136–160. [\[CrossRef\]](#)
22. Ólafsdóttir, R.; Tverijonaite, E. Geotourism: A systematic literature review. *Geosciences* **2018**, *8*, 234. [\[CrossRef\]](#)
23. Štrba, L.; Kolačková, J.; Kudelas, D.; Kršák, B.; Sidor, C. Geoheritage and Geotourism Contribution to Tourism Development in Protected Areas of Slovakia—Theoretical Considerations. *Sustainability* **2020**, *12*, 2979. [\[CrossRef\]](#)
24. Migoń, P.; Pijet-Migoń, E. The role of geodiversity and geoheritage in tourism and local development. In *Visages of Geodiversity and Geoheritage*; Kubalíková, L., Coratza, P., Pál, M., Zwoliński, Z., Irapta, P.N., van Wyk de Vries, B., Eds.; Geological Society, Special Publications: London, UK, 2023; p. 530.
25. Brilha, J. Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: A Review. *Geoheritage* **2016**, *8*, 119–134. [\[CrossRef\]](#)
26. Reynard, E.; Perret, A.; Bussard, J.; Grangier, L.; Martin, S. Integrated Approach for the Inventory and Management of Geomorphological Heritage at the Regional Scale. *Geoheritage* **2016**, *8*, 43–60. [\[CrossRef\]](#)
27. Mucivuna, V.C.; Reynard, E.; Garcia, M.G.M. Geomorphosites Assessment Methods: Comparative Analysis and Typology. *Geoheritage* **2019**, *11*, 1799–1815. [\[CrossRef\]](#)
28. Stewart, I.S.; Gill, J.C. Social geology—Integrating sustainability concepts into Earth sciences. *Proc. Geol. Assoc.* **2017**, *128*, 165–172. [\[CrossRef\]](#)
29. Schrodtt, F.; Bailey, J.J.; Kissling, W.D.; Rijdsdijk, K.F.; Seijmonsbergen, A.C.; van Ree, D.; Hjort, J.; Lawley, R.S.; Williams, C.N.; Anderson, M.G.; et al. To advance sustainable stewardship, we must document not only biodiversity but geodiversity. *Proc. Natl. Acad. Sci. USA* **2019**, *116*, 16155–16158. [\[CrossRef\]](#) [\[PubMed\]](#)
30. Matthews, J.; Kubalíková, L.; Štrba, L.; Tukiainen, H. Geodiversity challenges for a sustainable future. *Nat. Geosci.* **2024**, *17*, 948. [\[CrossRef\]](#)
31. Van Ree, C.C.D.F.; van Beukering, P.J.H. Geosystem services: A concept in support of sustainable development of the subsurface. *Ecosyst. Serv.* **2016**, *20*, 30–36. [\[CrossRef\]](#)
32. García, M.G.M. Ecosystem Services Provided by Geodiversity: Preliminary Assessment and Perspectives for the Sustainable Use of Natural Resources in the Coastal Region of the State of São Paulo, Southeastern Brazil. *Geoheritage* **2019**, *11*, 1257–1266. [\[CrossRef\]](#)
33. Fox, N.; Graham, L.J.; Eigenbrod, F.; Bullock, J.M.; Parks, K.E. Incorporating geodiversity in ecosystem service decisions. *Ecosyst. People* **2020**, *16*, 151–159. [\[CrossRef\]](#)
34. Bollati, I.M.; Viani, C.; Masseroli, A.; Mortara, G.; Testa, B.; Tronti, G.; Pelfini, M.; Reynard, E. Geodiversity of proglacial areas and implications for geosystem services: A review. *Geomorphology* **2023**, *421*, 108517. [\[CrossRef\]](#)
35. Anougmar, S.; Meesters, A.; van Ree, D.; Compernelle, T. The dilemma of valuing geodiversity: Geoconservation versus geotourism. *Philos. Trans. R. Soc. A* **2024**, *382*, 20230049. [\[CrossRef\]](#)
36. Ruban, D. Quantification of geodiversity and its loss. *Proc. Geol. Assoc.* **2010**, *121*, 326–333. [\[CrossRef\]](#)
37. Volchko, Y.; Norrman, J.; Ericsson, L.O.; Nilsson, K.L.; Markstedt, A.; Öberg, M.; Mossmark, F.; Bobylev, N.; Tengborg, P. Subsurface planning: Towards a common understanding of the subsurface as a multifunctional resource. *Land Use Policy* **2020**, *90*, 104–316. [\[CrossRef\]](#)
38. Ruban, D.A.; Mikhailenko, A.V.; Yashalova, N.N. Valuable geoheritage resources: Potential versus exploitation. *Resour. Policy* **2022**, *77*, 102–665. [\[CrossRef\]](#)
39. Crofts, R.; Gordon, J.E.; Brilha, J.; Gray, M.; Gunn, J.; Larwood, J.; Santucci, V.L.; Tormey, D.; Worboys, G.L. *Guidelines for Geoconservation in Protected and Conserved Areas. Best Practice Protected Area Guidelines Series No. 31*; IUCN: Gland, Switzerland, 2020; ISBN 978-2-8317-2079-1.
40. Selmi, L.; Canesin, T.S.; Gauci, R.; Pereira, P.; Coratza, P. Degradation Risk Assessment: Understanding the Impacts of Climate Change on Geoheritage. *Sustainability* **2022**, *14*, 4262. [\[CrossRef\]](#)
41. Kubalíková, L.; Balková, M.; Zapletalová, D. Where geodiversity meets biodiversity and culture: A case study from the abandoned limestone quarries of Hády (Brno, Czech Republic). In *Visages of Geodiversity and Geoheritage*; Kubalíková, L., Coratza, P., Pál, M., Zwoliński, Z., Irapta, P.N., van Wyk de Vries, B., Eds.; Geological Society: London, UK, 2023; pp. 167–179.
42. García-Ortiz, E.; Fuertes-Gutiérrez, I.; Fernández-Martínez, E. Concepts and terminology for the risk of degradation of geological heritage sites: Fragility and natural vulnerability, a case study. *Proc. Geol. Assoc.* **2014**, *125*, 463–479. [\[CrossRef\]](#)
43. Kubalíková, L. Risk assessment on dynamic geomorphosites: A case study of selected abandoned pits in South-Moravian Region (Czech Republic). *Geomorphology* **2024**, *458*, 109249. [\[CrossRef\]](#)
44. Chakraborty, A. Geodiversity and Tourism Sustainability in the Anthropocene. *Tour. Hosp.* **2022**, *3*, 496–508. [\[CrossRef\]](#)
45. Hjort, J.; Gordon, J.E.; Gray, M.; Hunter, M.L. Why geodiversity matters in valuing nature's stage. *Conserv. Biol.* **2015**, *29*, 630–639. [\[CrossRef\]](#)

46. Drápela, E. Geoheritage and overtourism: A case study from sandstone rock cities in the Czech Republic. In *Visages of Geodiversity and Geoheritage*; Kubalíková, L., Coratza, P., Pál, M., Zwoliński, Z., Irapta, P.N., van Wyk de Vries, B., Eds.; Geological Society: London, UK, 2023; pp. 257–275.
47. Kubalíková, L.; Drápela, E.; Kirchner, K.; Bajer, A.; Balková, M.; Kuda, F. Urban geotourism development and geoconservation: Is it possible to find a balance? *Environ. Sci. Policy* **2021**, *121*, 1–10. [CrossRef]
48. Reynard, E. The Assessment of Geomorphosites. In *Geomorphosites*; Reynard, E., Coratza, P., Regolini-Bissig, G., Eds.; Pfeil: Munchen, Germany, 2009; pp. 63–71.
49. Pereira, P.; Pereira, D.; Alves, M. The geomorphological heritage approach in protected areas: Geoconservation vs. Geotourism in Portuguese natural parks. *Mem. Descr. Carta Geol. D'Italia* **2009**, *87*, 135–144.
50. Boukhchim, N.; Fraj, T.B.; Reynard, E. Lateral and “Vertico-Lateral” Cave Dwellings in Haddej and Guermessa: Characteristic Geocultural Heritage of Southeast Tunisia. *Geoheritage* **2018**, *10*, 575–590. [CrossRef]
51. Vujičić, M.D.; Vasiljević, D.A.; Marković, S.B.; Hose, T.A.; Lukić, T.; Hadžić, O.; Janičević, S. Preliminary geosite assessment model (gam) and its application on Fruska gora mountain, potential geotourism destination of Serbia. *Acta Geogr. Slov.* **2011**, *51–52*, 361–377. [CrossRef]
52. Leveson, N. Improving the Standard Risk Matrix (White Paper). Available online: <http://sunnyday.mit.edu/Risk-Matrix.pdf> (accessed on 16 January 2024).
53. Kubalíková, L.; Balková, M. Two-level assessment of threats to geodiversity and geoheritage: A case study from Hády quarries (Brno, Czech Republic). *Environ. Impact Assess. Rev.* **2023**, *99*, 107024. [CrossRef]
54. Act No. 114/1992 Coll. on Nature Conservation and Landscape Protection. Available online: <https://www.zakonyprolidi.cz/cs/1992-114> (accessed on 16 January 2024).
55. ZABAGED®—Planimetric Components. State Administration of Land Surveying and Cadastre: Prague, Czech Republic. 2024. Available online: <https://geoportal.cuzk.cz> (accessed on 20 August 2024).
56. Digital Terrain Model of the Czech Republic of the 5th Generation; State Administration of Land Surveying and Cadastre: Prague, Czech Republic. 2013. Available online: <https://geoportal.cuzk.cz> (accessed on 20 August 2024).
57. Müller, P.; Novák, Z. *Geologie Brna a Okolí*; Český Geologický Ústav: Praha, Czech Republic, 2000; 90p.
58. Peterková, L. Reliéf a Geomorfologický Vývoj Řeky Svratky v Brněnském Prostoru v SZ Části Bobravské Vrchoviny (Relief and Geomorphological Development of the Svratka River in Brno Area in NW Part of Bobravská Vrchovina Highland). Ph.D. Thesis, Masaryk University, Brno, Czech Republic, 2011; 187p.
59. Geological Map 1:50,000, Web Map Service. Czech Geological Survey: Prague, Czech Republic. 2013. Available online: <https://mapy.geology.cz/geocr50/> (accessed on 12 July 2024).
60. Buček, A.; Kirchner, K. Krajina města Brna. In *Dějiny Brna 1. Díl*; Procházka, R., Ed.; Archiv města Brna: Brno, Czech Republic, 2011; pp. 43–81.
61. Mlejnková, H. (Ed.) *Zatopené Kulturní a Přírodní Dědictví Jižní Moravy*; Výzkumný Ústav Vodohospodářský T. G. Masaryka: Brno, Czech Republic, 2016; 264p.
62. IUSS Working Group WRB. *World Reference Base for Soil Resources. International Soil Classification System for Naming Soils and Creating Legends for Soil Maps*, 4th ed.; International Union of Soil Sciences (IUSS): Vienna, Austria, 2022.
63. Chytrý, M.; Kučera, T.; Kočí, M. (Eds.) *Katalog Biotopů České Republiky*; Agentura Ochrany Přírody a Krajiny ČR: Prague, Czech Republic, 2010; 447p.
64. Neuhauslová, Z.; Moravec, J.; Chytrý, M.; Sádlo, J.; Rybníček, K.; Kolbek, J.; Jirásek, J. *Mapa Potenciální Přirozené Vegetace České Republiky*; Botanický Ústav AV ČR: Průhonice, Czech Republic, 1997; 1p.
65. Nature Conservation Agency of the Czech Republic: General Database of Protected Areas. Available online: <https://drusop.nature.cz> (accessed on 11 January 2024).
66. Kuča, M. *Brno—Vývoj Města, Předměstí a Připojených Vesnic*; Baset: Brno, Czech Republic, 2000; 644p.
67. Kuča, M.; Kirchner, K.; Přichystal, A.; Vachůt, P. Praveká minulost skrytá pod hladinou brněnské přehrady. *Brno Minulosti Dnes* **2018**, *31*, 200–214.
68. National Monument Institute: List of Cultural Monuments. Available online: <https://www.pamatkovykatalog.cz/pravni-ochrana/hrad-veveri-147657> (accessed on 20 August 2024).
69. Dostál, I.; Havlíček, M.; Skokanová, H. The unfinished Hitler’s motorway—A heritage in the contemporary landscape. In *Proceedings of the Recreation and Nature Protection*, Křtiny, Czech Republic, 9–11 May 2023; pp. 340–345.
70. Transport Enterprise of Brno Municipality. Available online: <https://www.dpmb.cz/77-plavebni-sezona-je-opet-rekordni-lode-dpmb-prepravily-306-tisic-lidi> (accessed on 20 August 2024).
71. GIS Brno—Geographical Information System of Brno. Available online: <https://gis.brno.cz/> (accessed on 12 January 2024).
72. Czech Geological Survey: Significant Geological Localities of the Czech Republic. Available online: <http://locality.geology.cz> (accessed on 6 January 2024).
73. Crofts, R.; Tormey, D.; Gordon, J.E. Introducing New Guidelines on Geoheritage Conservation in Protected and Conserved Areas. *Geoheritage* **2021**, *13*, 33. [CrossRef]
74. Mackovčín, P.; Jatiová, M.; Demek, J.; Slavík, P. Brněnsko. In *Chráněná Území ČR, Svazek IX*; Mackovčín, P., Ed.; Agentura Ochrany Přírody a Krajiny ČR a EkoCentrum: Brno, Czech Republic, 2007; 932p.
75. Přichystal, A.; Slobodník, M. Brněnský křemenný val. *Geol. Výzkumy Moravě Slez.* **2011**, *18*, 148–152.

76. Kirchner, K. Skalní útvary v údolí Veverky. *Veronica* **1995**, *9*, 25.
77. Mrázek, I. *Kamenná Tvář Brna (Stone Face of Brno)*; Moravské Zemské Museum: Brno, Czech Republic, 1993; 238p.
78. Telbisz, T.; Čalič, J.; Kovačević-Majkić, J.; Milanović, R.; Brankov, J.; Micić, J. Karst Geoheritage of Tara National Park (Serbia) and Its Geotouristic Potential. *Geoheritage* **2021**, *13*, 88. [\[CrossRef\]](#)
79. Železné Hory National Geopark: Educational Geo-Cyclo-Trail. Available online: <https://www.geoparkzh.cz/cs/naucna-stezka-magma/> (accessed on 20 August 2024).
80. Pijet-Migoń, E.; Migoń, P. Linking Wine Culture and Geoheritage—Missing Opportunities at European UNESCO World Heritage Sites and in UNESCO Global Geoparks? A Survey of Web-Based Resources. *Geoheritage* **2021**, *13*, 71. [\[CrossRef\]](#)
81. Helgadóttir, G.; Sigurðardóttir, I. The Riding Trail as Geotourism Attraction: Evidence from Iceland. *Geosciences* **2018**, *8*, 376. [\[CrossRef\]](#)
82. Coratza, P.; Vandelli, V.; Fiorentini, L.; Paliaga, G.; Faccini, F. Bridging Terrestrial and Marine Geoheritage: Assessing Geosites in Portofino Natural Park (Italy). *Water* **2019**, *11*, 2112. [\[CrossRef\]](#)
83. Dudley Cannals Trust 2024. Boat Trips. Available online: <https://dudleycanaltrust.org.uk/boat-trips-2/> (accessed on 20 July 2024).
84. UNESCO 2024. IGCP Project 714—3GEO Geoclimbing & Geotrekking in Geoparks. Available online: <https://www.unesco.org/en/igpp/igcp-projects/714> (accessed on 20 July 2024).
85. Bollati, I.M.; Masseroli, A.; Al Kindi, M.; Cezar, L.; Chrobak-Žuffová, A.; Dongre, A.; Fassoulas, C.; Fazio, E.; Garcia-Rodríguez, M.; Knight, J.; et al. The IGCP 714 Project “3GEO—Geoclimbing & Geotrekking in Geoparks”—Selection of Geodiversity Sites Equipped for Climbing for Combining Outdoor and Multimedia Activities. *Geoheritage* **2024**, *16*, 79.
86. Comer, P.; Pressey, R.L.; Hunter, M.L., Jr.; Schloss, C.A.; Buttrick, S.C.; Heller, N.E.; Tirpak, J.M.; Faith, D.P.; Cross, M.S.; Shaffer, M.L. Incorporating geodiversity into conservation decisions. *Conserv. Biol.* **2015**, *29*, 692–701. [\[CrossRef\]](#) [\[PubMed\]](#)
87. Peña, L.; Monge-Ganuzas, M.; Onaindia, M.; De Manuel, B.F.; Mendia, M. A Holistic Approach Including Biological and Geological Criteria for Integrative Management in Protected Areas. *Environ. Manag.* **2017**, *59*, 325–337. [\[CrossRef\]](#) [\[PubMed\]](#)
88. Boothroyd, A.; McHenry, M. Old Processes, New Movements: The Inclusion of Geodiversity in Biological and Ecological Discourse. *Diversity* **2019**, *11*, 216. [\[CrossRef\]](#)
89. Alahuhta, J.; Ala-Hulkko, T.; Tukiainen, H.; Purola, L.; Akujärvi, A.; Lampinen, R.; Hjort, J. The role of geodiversity in providing ecosystem services at broad scales. *Ecol. Indic.* **2018**, *91*, 47–56. [\[CrossRef\]](#)
90. Hjort, J.; Tukiainen, H.; Salminen, H.; Kemppinen, J.; Kiilunen, P.; Snåre, H.; Alahuhta, J.; Maliniemi, T. A methodological guide to observe local-scale geodiversity for biodiversity research and management. *J. Appl. Ecol.* **2022**, *59*, 1756–1768. [\[CrossRef\]](#)
91. Tukiainen, H.; Toivanen, M.; Maliniemi, T. Geodiversity and Biodiversity. In *Visages of Geodiversity and Geoheritage*; Kubalíková, L., Coratza, P., Pál, M., Zwoliński, Z., Irapta, P.N., van Wyk de Vries, B., Eds.; Geological Society, Special Publications: London, UK, 2023; Volume 530.
92. Tukiainen, H.; Bailey, J.J. Enhancing global nature conservation by integrating geodiversity in policy and practice. *Conserv. Biol.* **2023**, *37*, e14024. [\[CrossRef\]](#)
93. Gordon, J.E.; Crofts, R.; Gray, M.; Tormey, D. Including geoconservation in the management of protected and conserved areas matters for all of nature and people. *Int. J. Geoherit. Parks* **2021**, *9*, 323–334. [\[CrossRef\]](#)
94. Gordon, J.E. Geoconservation principles and protected area management. *Int. J. Geoherit. Parks* **2019**, *7*, 199–210. [\[CrossRef\]](#)
95. Zorondo-Rodríguez, F.; Díaz, M.; Simonetti-Grez, G.; Simonetti, J.A. Why would new protected areas be accepted or rejected by the public: Lessons from an ex-ante evaluation of the new Patagonia Park Network in Chile. *Land Use Policy* **2019**, *89*, 104248. [\[CrossRef\]](#)
96. Andrade, G.S.M.; Rhodes, J.R. Protected areas and local communities: An inevitable partnership toward successful conservation strategies? *Ecol. Soc.* **2012**, *17*, 14. [\[CrossRef\]](#)
97. Díez-Herrero, A.; Gutiérrez-Pérez, I.; Vegas Salamanca, J. ‘Apadrina una roca’, una iniciativa de voluntariado popular para la conservación del patrimonio geológico. *Geo-Temas* **2012**, *13*, 388.
98. Vegas, J.; Cabrera, A.; Prieto, A.; Díez-Herrero, A.; García-Cortés, A.; Díaz-Martínez, E.; Carcavilla, L.; Salazar, A. Watch over a rock’, a Spanish programme towards geosite stewardship. In Proceedings of the 9th ProGEO Symposium, Chęciny, Poland, 25–28 June 2018; pp. 140–141.
99. Prosser, C.D. Communities, Quarries and Geoheritage—Making the Connections. *Geoheritage* **2019**, *11*, 1277–1289. [\[CrossRef\]](#)
100. Burek, C. The Role of LGAPs (Local Geodiversity Action Plans) and Welsh RIGS as Local Drivers for Geoconservation within Geotourism in Wales. *Geoheritage* **2012**, *4*, 45–63. [\[CrossRef\]](#)
101. Ferrero, E.; Giardino, M.; Lozar, F.; Giordano, E.; Belluso, E.; Perotti, L. Geodiversity action plans for the enhancement of geoheritage in the Piemonte region (north-western Italy). *Ann. Geophys.* **2012**, *55*, 3.
102. Dunlop, L.; Larwood, J.G.; Burek, C.V. Geodiversity Action Plans—A Method to Facilitate, Structure, Inform and Record Action for Geodiversity. In *Geoheritage: Assessment, Protection, and Management*; Reynard, E., Brilha, J., Eds.; Elsevier: Amsterdam, The Netherlands, 2018; pp. 53–65.
103. Kubalíková, L.; Bajer, A.; Balková, M.; Kirchner, K.; Machar, I. Geodiversity action plans as a tool for developing sustainable tourism and environmental education. *Sustainability* **2022**, *14*, 6043. [\[CrossRef\]](#)
104. Pijet-Migoń, E.; Migoń, P. Promoting and Interpreting Geoheritage at the Local Level—Bottom-up Approach in the Land of Extinct Volcanoes, Sudetes, SW Poland. *Geoheritage* **2019**, *11*, 1227–1236. [\[CrossRef\]](#)

105. Bussard, J.; Reynard, E. Heritage Value and Stakeholders' Perception of Four Geomorphological Landscapes in Southern Iceland. *Geoheritage* **2022**, *14*, 89. [[CrossRef](#)]
106. Rodrigues, J.; Costa e Silva, E.; Pereira, D.I. How Can Geoscience Communication Foster Public Engagement with Geoconservation? *Geoheritage* **2023**, *15*, 32. [[CrossRef](#)]
107. Peppoloni, S.; Di Capua, G. (Eds.) *Geoethics: The Role and Responsibility of Geoscientists*; Geological Society: London, UK, 2015; 187p.
108. Peppoloni, S.; Di Capua, G. (Eds.) *Geoethics: Manifesto for an Ethics of Responsibility Towards the Earth*; Springer: Cham, UK, 2022; 123p.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.