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Assessment of the Selected Regulating Ecosystem Services Using Ecosystem Services Matrix in Two Model Areas: Special Nature Reserve Obedska Bara (Serbia) and Protected Landscape Area Dunajske Luhy (Slovakia)

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Abstract: In this paper we are analyzing the potential of land cover features to provide three regulating ecosystem services (ESs), ES Local climate regulation, ES Water quality regulation and ES Biodiversity promotion, in two case study areas: Special nature reserve (SNR) Obedska bara (Serbia) and Protected landscape area (PLA) Dunajske luhy (Slovakia). Regulating ESs are not only important for proper functioning of ecosystems, but they are also crucial for the existence of human society. To assess the potential of land cover features to provide regulating ESs, we used biophysical methods. The maps of land cover potential to provide regulating ES are the result of the analyses. The results indicate that forests are the most important ecosystems that provide ES Local climate regulation and ES Water quality regulation. For ES Biodiversity promotion, the most important ecosystems were natural and seminatural meadows, wetlands, natural and seminatural rivers and water bodies as well as forests. Overall SNR Obedska bara has higher potential to provide all three regulating ESs than PLA Dunajske luhy. These findings point to the importance of natural areas in ensuring the provision of regulating ESs. Properly selected landscape management is the key for maintaining or improving the potential of land cover features to provide regulating ESs. The research can help local authorities in decision making and in creating conservation strategies for selected protected areas.

Keywords: local climate regulation; water quality regulation; biodiversity promotion; land cover; land use

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1. Introduction

The efforts to ecologically and sustainably use natural resources, to conserve world's biodiversity, to mitigate or eliminate negative impacts on nature, and to prevent and limit actions that damage, threaten or destroy living conditions and life forms are increasing nowadays [1]. The concept of ESs provides new, anthropogenic justification for conservation of species and habitats. It is based on our dependence on goods and services that ecosystems provide us [2]. Although the origin of the ESs concept can be dated to the 1980s of the 20th century, the real development of this concept began in the late 1990s of the 20th century with authors such as Constanza et al. [3], Daily [4] and de Groot [5]. In the first decade of the new millennium, global research was dedicated to biodiversity and natural capital [6], which led to large-scale projects, such as the Millennium Ecosystem Assessment [7] project that defined ESs such as benefits that people obtain from ecosystems. Other important projects worth mentioning are TEEB (The Economics of Biodiversity and Ecosystem Services), MAES (Mapping and Assessment of Ecosystems and their Services), ESP (Ecosystem Services Partnership) and others. The concept of ESs is increasing in popularity [8] and the number of studies concerning ESs in Slovakia has grown in the last decade.

The studies are focused, e.g., on legislation concerning ESs [9] or more often on assessment and mapping of selected ESs in protected areas [10–16] or smaller case study areas [17–19]. Besides studies on the local or regional scale, national assessment of ESs was conducted in Slovakia [6,20,21], which is a good basis for comparing the results. In Serbia, there are just several studies focused on ESs on a local or regional scale, mainly in protected areas [16,22–24], but no complex study at a national level. Serbia, as a candidate country for accession to the EU, must meet certain conditions for the accession and one of the conditions is to map biodiversity in the country. Therefore, one of the aims of this research is to bring tools for assessment of biodiversity and the ESs related to it.

There are several categorizations of ESs [3,7,25,26] and for purpose of the research we have chosen the one according to CICES [26], which divides ESs into three categories: provisioning, regulating and maintenance and cultural ESs. These benefits are in form of tangible products, such as provisioning services of wood, food, and fresh-water production, or intangible products, such as habitat for biodiversity conservation, erosion control, air quality, recreation, and aesthetics [27].

We are focusing on regulating ESs which are the benefits obtained from the regulation of ecosystem processes [7]. Regulating ESs are crucial for human well-being as they mitigate extreme events, such as climate change, landscape degradation and others [28]. The provision of ESs depends on biophysical conditions and changes over space and time [29]. Different ecosystems have different functions. It is based on their structures and processes.

The individual ecosystem capacities to provide services are linked to natural conditions such as land cover, climate, soil conditions as well as to human impacts such as land use, pollution, etc. Consequently, these services are generated from different ecosystems, such as grasslands, forestlands, farmlands, and wetlands, at varying levels and extents, so the ecosystem's capacity to provide certain ESs can vary significantly [29–31]. Ecosystems, such as forests, natural water bodies and watercourses, wetlands, pastures and natural meadows have the potential to provide ESs. The higher the biodiversity is, the higher the potential to provide a wide range of ESs [32]. In the past, biodiversity assessment was focused more on assessing individual species and biotopes [33], while nowadays we look at the biodiversity assessment more holistically via the concept of ESs [34]. ES Biodiversity promotion is important for ensuring the provision of another two selected ESs—ES Local climate regulation and ES Water quality regulation.

Changes in land cover can locally affect temperature, precipitation, droughts or wind, and ES Local climate regulation regulates weather conditions and provides shelter from heat or UV radiation [7,35]. ES Water quality regulation contributes to maintaining water quality through proper timing and seasonal distribution of water supply, water purification by capturing nitrates, phosphorus, sediments, and others, regulating pathogens, organic pollutants, dissolved organic carbon, acidity balancing, water temperature, dilution of contaminants, infiltration of pollutants into the soil, and others [35–37]. ES Biodiversity promotion ensures the good functioning of ecosystems, which also have an impact on provision of other important services, such as ES Local climate regulation, ES Water quality regulation, ES Pollination, ES Erosion regulation, etc., [6,32].

We selected these three ESs based on their importance in our case study areas. Water quality regulation, local climate regulation as well as biodiversity promotion are necessary in areas such as PLA Dunajske luhy and SNR Obedska bara, which are surrounded by intensively agriculturally-used landscape. Conservation of the natural areas in such landscape is matter of utmost importance for people living in a close proximity to these areas.

To make better informed decisions, policy, conservation strategies or landscape planning, it is necessary to know how land cover elements contribute to the provision of ESs in a certain area, in this case in two protected areas (SNR Obedska bara and PLA Dunajske luhy).

Consequently, we used biophysical methods to find out which land cover features are the most important in terms of ensuring provision of the three selected regulating ES (ES Local climate regulation, ES Water quality regulation and ES Biodiversity promotion). Specific mapping methods, which are often used, are part of biophysical methods. One of these mapping methods is ESs Matrix method [38,39], based on analyses in the Geographic Information System (GIS). This method can be used not only for mapping supply of ESs, but for demand and flow as well [38,39].

2. Materials and Methods

2.1. Study Area

The case study area SNR Obedska bara is located in five municipalities in Northern Serbia in Vojvodina, more specifically in Southeastern Sriem on the left bank of the Sava River in an altitude 71–82 m above sea level (Figure 1). The total area of the case study area SNR Obedska bara is 29,431 ha and the area of the SNR Obedska bara is 9820 ha [40]. The most important landscape feature is the Sava River that creates many meanders in its lower reach, one of which is the area of SNR Obedska bara [41]. The wide floodplain with dense vegetation creates a good plant filter for the Sava River.

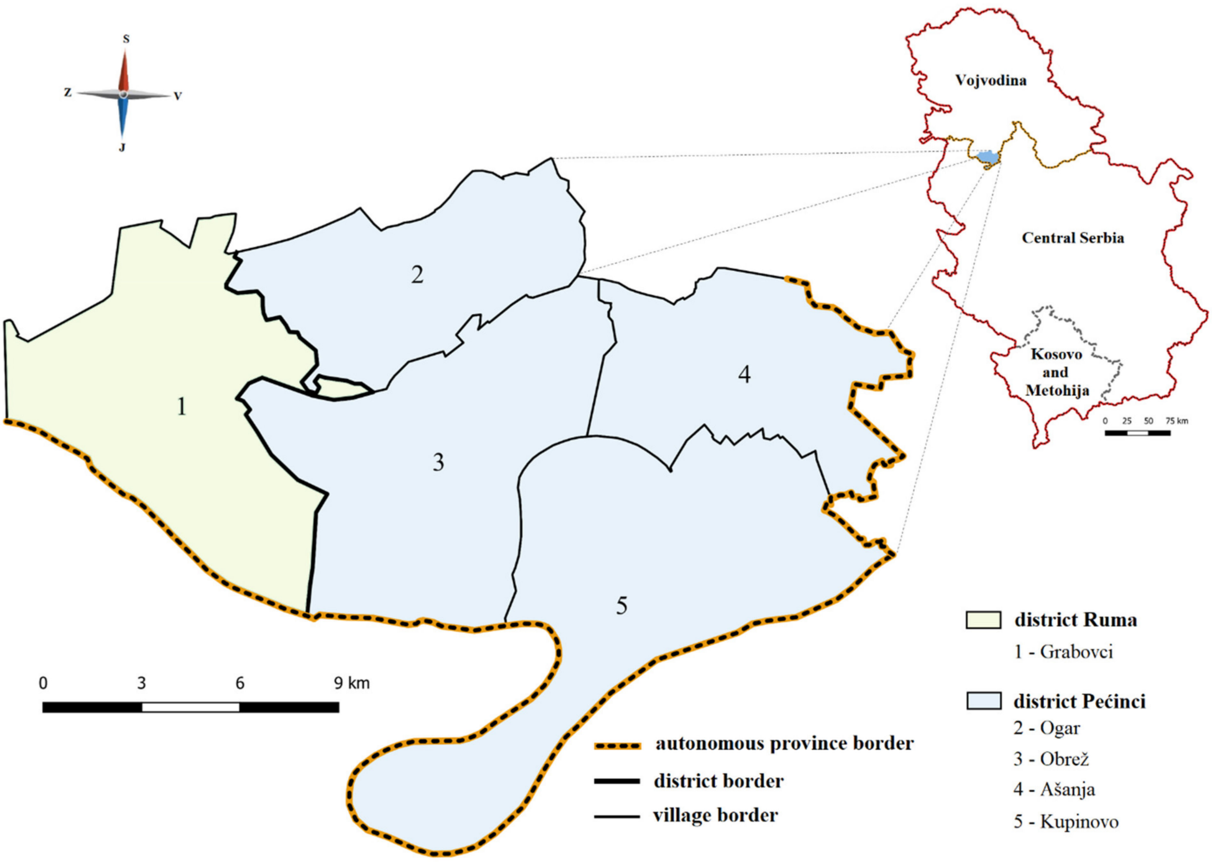

Figure 1. Case study area SNR Obedska bara.

In the case study area SNR Obedska bara, there are diverse ecosystems, such as forests, wetlands, meadows, and water ecosystems. Alluvial forests in SNR Obedska bara have the character of primeval forests. There are not many territories with such diverse habitats in Europe.

The case study area PLA Dunajske luhy is located in Southeastern Slovakia on the territory of twenty-eight municipalities (Figure 2) in an altitude 113–127.4 m above sea level. The total area of the case study area PLA Dunajske luhy is 53,014 ha and the area of PLA Dunajske luhy is 12,284 ha [42].

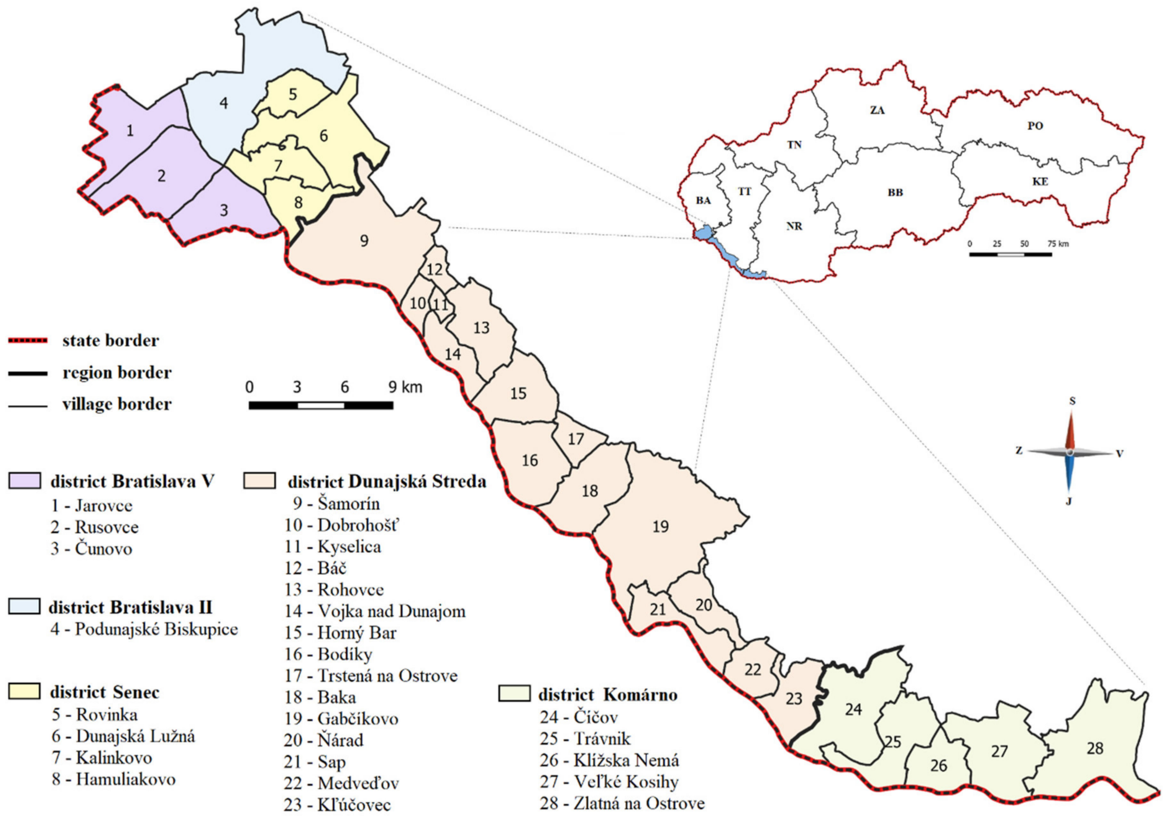

Figure 2. Case study area PLA Dunajske luhy.

The Danube River with a dense network of river channels, dead river channels and marshes is the dominant feature of the area [43]. As well as in the case study area of SNR Obedska bara, in PLA Dunajske luhy there is a wide range of valuable ecosystems, such as forests, meadows, wetlands and water ecosystems [44]. Most of the PLA Dunajske luhy is covered with alluvial forests resembling rainforests, which are protected due to their rare occurrence in Europe [45]. The Danube River is an important migratory corridor, which provides a suitable place for nesting and hibernation of waterfowl. Both case study areas belong are listed as Ramsar sites.

The case study areas were selected based on their similarities. Both case study areas are in agriculturally intensively used landscape. The large rivers such as the Danube River and Sava River are crossing these areas and creating specific ecosystems, which represent green island in an agricultural landscape.

2.2. Current Landscape Structure

One of the main inputs to the assessment of selected regulation ESs was the layer of the current land cover. A separate layer of the current landscape structure was created in QGIS for each case study area. To create a polygon layer of current land cover of the case study areas in QGIS, it was necessary to search for the most current version of online satellite images. The ones already available in the program were four or more years old. Subsequently we had to set up new images in the QGIS via "XYZ" Tile Server provider.

"ESRI satellite maps" from 2019 in a scale of 1:2500 were used as a base layer. Google Satellite 2018, Mapy.cz (accessed on 5 December 2021) 2018, OpenStreetMap, SKY Map and ZBGIS were used as control layers for the case study area PLA Dunajske luhy.

For the case study area SNR Obedska bara, a basic cadastral map from 2018 in analog form in a scale of 1:2500 from the Geodetic and cartographic institute of Serbia, which was georeferenced in QGIS, was used.

The current land cover layer for case study area PLA Dunajske luhy was digitalized in EPSG: 5514—S-JTSK (Greenwich)/Krovak East–North coordinate system and for creating the current land cover layer for the case study area SNR Obedska bara was used EPSG: 4075—SREF98 coordinate system. We classified the land cover features according to Petrovič et al. [46] and created a current land cover polygon layer in which each land cover feature was numerically coded according to methodology of Petrovič et al. [46].

According to available map data, we identified individual elements of land cover in the form of polygons. We have assigned a corresponding numeric code to each polygon, according to the above-mentioned methodology.

Not all land cover features were easy to determine by only using maps and aerial photographs in QGIS and 169 "grey areas" (polygons without a numerical code) have emerged. Consequently, the field survey was an integral part of the assessment. In both case study areas, a field survey was conducted. Polygons that we were not able to identify based on the available maps were selected, and we transferred theirs GPS coordinates into a GPS devise. Afterward, each locality was visited during the field survey, and we were focused on verifying land cover features. We wrote down what type of land cover element is in the given locality. When the field survey was completed, we assigned the numeric code to the "grey areas" in the attributes table, based on field survey data. This way the land cover layer was completed.

After creating layers of the current land cover of the case study areas, we have prepared a detailed list of all land cover elements that occurred in the case study areas and their area in hectares and percentages, which was used afterward in land cover analyses.

2.3. Matrix of ES

The potential of land cover features to provide selected ESs in case study areas was evaluated using ESs matrix according to Burkhard et al. [38,39]. On the left side of the table are land cover features and on the right side of the table are ESs. The ESs matrix was adapted for the purpose of this research, so instead of using CORINE land cover classification of land cover features, we used classification of land cover features according to Petrovič et al. [46]. The values describing the potential of a certain land cover feature to provide selected ESs are the results of an expert valuation of 23 stakeholders (mayors, scientists, foresters, farmers, environmentalists).

We used expert-based estimation to score the potential of land cover features to provide ESs. The ranking was therefore based on stakeholder's knowledge of how high the potential of land cover features is to provide ESs in study areas. Each stakeholder received a spreadsheet where on the left site in the column were land cover features and in the row were selected ecosystem services. The stakeholders scored the potential of 116 land cover features to provide each ES on scale from 0 (no potential) to 5 (the highest potential). The land cover features were determined based on the creation of a detailed map of the current landscape structure in the model areas.

A wide variety of stakeholders with varying opinions on the potential of land cover features to provide ESs was helpful because of different points of views that added a wide range of perspectives. Afterward, we counted an average value of each land cover feature for each ES based on the expert valuation to unify the values in Table 1.

Table 1. Example of calculation of average values of potentials of individual elements of land cover for each ES.

ES Local Climate Regulation					
Serial Number	**Land Cover Features**	**Evaluation of Stakeholders (23 Ratings)**	**Evaluation of Stakeholders (Average)**	**Interval for Averaged Values**	**Potential Intervals**
3.	Coniferous forest	5, 5, 5, 4, 5, 5, 5, 5, 4, 5, 5, 5, 5, 5, 5, 5, 4, 5, 5, 5, 5, 5, 5	4.87	4.51–5.00	9
20.	Large capacity greenhouses	0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0	0.22	0.00–0.50	0

For a higher informative value of the maps and to eliminate error of the results, the values of land cover features were divided into 10 more detailed intervals, displayed in Table 2. The values from ESs Matrix were assigned in QGIS to the land cover features in the current land cover layers. Subsequently, we created maps displaying potential of land cover features to provide regulating ESs for every case study area and every regulating ES. Land cover features with the values of potential in the same interval were grouped and their area in hectares and % was counted.

Table 2. Potential assessment intervals.

Evaluation of Experts	Interval for Averaged Values	Potential Intervals
0	0.00–0.50	0
1	0.51–1.00	1
	1.01–1.50	2
2	1.51–2.00	3
	2.01–2.50	4
3	2.51–3.00	5
	3.01–3.50	6
4	3.51–4.00	7
	4.01–4.50	8
5	4.51–5.00	9

3. Results

3.1. ES Questionnaire Survey

We asked 23 stakeholders to rate the potential of land cover features to provide three selected ES (Local climate regulation, Water quality regulation and Biodiversity promotion). The results of the questionnaire survey are displayed in Table 3. The stakeholders consider forests, park vegetation, other urban greenery, vegetation protection of technical objects and waterworks to have the highest potential to provide ES Local climate regulation. Other land cover features with potential to provide this ES are extensive small-scale orchards, mosaics of agricultural crops with predominance of grasslands, fruit tree and fruit bushes plantations, artificial water tanks—ponds and tanks for fishes. The results from Burkhard et al. [29,39], show that forests and peatbogs are land cover feature with the highest potential to provide this ES, which is in line with our research that shows that the highest values assigned by stakeholder belong to forests. The lowest values were assigned to man-made objects and areas with deficit of greenery. Similar results are shown in the study from Burkhard et al. [29,39].

For ES Water quality regulation, the stakeholders identified land cover features such as forests, unregulated watercourses, and natural standing waters as features with the highest potential to provide this ES. In the study of Burkhard et al. [29,39], ES Water purification, which is similar to ES Water quality regulation, is assessed. Results of this study coincide with results from Burkhard et al. [29,39] who consider forests, natural grasslands, peatbogs, and watercourses as the land cover features with the highest potential to provide this regulating ES. Similarly, to ES Local climate regulation, the lowest values were assigned to man-made objects and areas with deficit of greenery.

Table 3. Values of potentials of individual elements of land cover for each ES.

Serial Number	Land Cover Features	Potential Intervals		
		ES Local Climate Regulation	ES Water Quality Regulation	ES Biodiversity Promotion
1.	Deciduous forests (continuous)	9	9	7
2.	Deciduous forests (with gaps)	9	9	7
3.	Coniferous forests (continuous)	9	8	6
4.	Mixed forests (continuous)	9	9	9
5.	Mixed forests (with gaps)	9	9	9
6.	Batch plant (young)	2	5	4
7.	Batch plant (growing)	2	5	4
8.	Small deciduous forests	5	3	8
9.	Alley	3	3	8
10.	Bank vegetation with trees	3	3	8
11.	Meadows (intensive)	1	1	3
12.	Meadows (extensive without trees and shrubs)	1	1	3
13.	Meadows (extensive with trees and shrubs)	1	1	3
14.	Pastures (intensive without trees and shrubs)	1	1	3
15.	Pastures (extensive without trees and shrubs)	1	1	3
16.	Pastures (intensive with trees and shrubs)	1	1	3
17.	Semi-natural ana natural meadows—cane and sedge stand	3	5	9
18.	Large block fields	3	0	1
19.	Small fields	3	1	3
20.	Large capacity greenhouses	0	0	1
21.	Small capacity greenhouses	0	0	1
22.	Gardens (productive)	5	3	5
23.	Gardens (productive and ornamental)	5	3	5
24.	Gardening colony (without objects)	3	1	5
25.	Gardening colony (with objects)	3	1	5
26.	Fruit tree plantations	6	1	5
27.	Fruit bushes plantations	6	1	5
28.	Extensive small-scale orchards	6	1	5
29.	Technical woods, energy wood plantations	5	3	3
30.	Intensive vineyards	3	0	3
31.	Mosaics of agricultural crops without significant predominance of one of the cultures	3	3	5
32.	Mosaics of agricultural crops with predominance of arable soil	3	1	4
33.	Mosaics of agricultural crops with predominance of grasslands	6	4	5
34.	Mosaics of agricultural crops with predominance of perennial crops	4	2	6

Table 3. *Cont.*

Serial Number	Land Cover Features	Potential Intervals		
		ES Local Climate Regulation	ES Water Quality Regulation	ES Biodiversity Promotion
35.	Gravel and sand deposits—banks od natural watercourses	1	5	4
36.	Mining of mineral resources—sand pits and clay pits	0	0	0
37.	Unregulated watercourses	4	8	9
38.	Regulated watercourses	4	5	5
39.	Drainage channels	2	4	6
40.	Natural standing waters—lakes	4	6	9
41.	Natural standing waters—dead river channels	4	6	9
42.	Natural standing waters—peatbogs	4	6	9
43.	Natural standing waters—other wetlands	4	6	9
44.	Natural standing waters—forest wetlands	4	6	9
45.	Semi-natural and natural standing waters—flooded excavated areas	4	6	8
46.	Artificial water tanks—ponds and tanks for fish farming	6	6	6
47.	Continuous individual housing constructions	0	0	1
48.	Incoherent individual housing constructions	0	0	1
49.	Dispersed individual housing constructions	0	0	1
50.	Hamlets	0	0	1
51.	Outbuildings	0	0	1
52.	Multi-story apartment buildings	0	0	0
53.	Castles and manors	0	0	1
54.	Churches and chapels	0	0	1
55.	Monasteries	0	0	0
56.	Castle ruins	0	0	1
57.	Open air museums and archaeological sites	0	0	1
58.	Cemeteries and urn groves	0	0	0
59.	School buildings	0	0	0
60.	Research centers	0	0	0
61.	Office buildings	0	0	0
62.	Hospitals and clinics	0	0	0
63.	Shopping malls	0	0	0
64.	Hotels and guesthouses	0	0	0
65.	Amphitheaters	0	0	0
66.	Park vegetation—lawns in parks	7	4	6
67.	Park vegetation—trees in parks	7	4	6
68.	Other urban greenery—lawns	8	4	4
69.	Other urban greenery—trees and shrubs	8	4	4
70.	Cemetery vegetation—without trees and shrubs	4	2	4

Table 3. *Cont.*

Serial Number	Land Cover Features	Potential Intervals		
		ES Local Climate Regulation	ES Water Quality Regulation	ES Biodiversity Promotion
71.	Cemetery vegetation—with trees and shrubs	4	2	4
72.	Ruderal vegetation—without trees and shrubs	4	2	6
73.	Ruderal vegetation—with trees and shrubs	4	2	6
74.	Vegetation protection of roads without trees and shrubs	8	4	4
75.	Vegetation protection of roads with trees and shrubs	8	4	4
76.	Vegetation protection of waterworks	8	4	4
77.	Vegetation on the premises of industrial and agricultural enterprises	1	1	2
78.	Sport halls and gyms	2	2	1
79.	Sport stadiums	2	2	1
80.	Sport facilities	2	2	2
81.	Sport areas (with grass)	2	2	2
82.	Artificial sport areas	2	2	2
83.	Recreation facilities	4	2	2
84.	Hotel and spa complexes	4	2	2
85.	Cottage colonies	4	2	2
86.	Swimming pools	4	2	2
87.	Beaches	4	1	1
88.	Industrial and technical buildings	0	0	0
89.	Office buildings of industrial enterprises	0	0	0
90.	Production halls and warehouses	0	0	0
91.	Power plants	0	0	0
92.	Buildings of transformer station	0	0	0
93.	Industrial and technical areas	0	0	0
94.	Open storage and parking areas of industrial areas	0	0	0
95.	Fields of electric transformer pylons	0	0	0
96.	Wastewater treatment plants	0	0	0
97.	Agricultural objects	0	0	2
98.	Office buildings of agricultural enterprises	0	0	2
99.	Animal production facilities	0	0	2
100.	Grainers	0	0	2
101.	Hydro globes	0	0	2
102.	Agricultural areas	0	0	2
103.	Open storage and parking areas of agricultural areas	0	0	2
104.	Field manures	0	0	2
105.	Solid waste landfills	0	0	1

Table 3. *Cont.*

Serial Number	Land Cover Features	Potential Intervals		
		ES Local Climate Regulation	ES Water Quality Regulation	ES Biodiversity Promotion
106.	Liquid waste landfills	0	0	1
107.	Heaps	0	0	1
108.	Building grounds	0	0	0
109.	Fast highway	0	0	0
110.	Arterial roads	0	0	0
111.	Other metaled roads	0	0	0
112.	Parking lots	0	0	0
113.	Fuel station	0	0	0
114.	Multi-track railway	0	0	0
115.	Single-track railway	0	0	0
116.	Railway stations	0	0	0

Land cover features with the highest potential to provide ES Biodiversity promotion are forests, bank vegetation, semi-natural and natural meadows, natural standing waters, and mosaics of agricultural crops with predominance of perennial crops. The land cover features are partially similar to land cover features recognized as features with the highest potential to provide ES in Burkhard et al. [29] study. Their study recognizes several others land cover features such as green urban areas, agriculture and natural vegetation, agroforestry areas and transitional woodland shrubs. As well as by ES Local climate regulation and ES Water quality regulation, the lowest values were assigned to man-made objects and areas with deficit of greenery.

Overall, we see that the most natural and semi-natural areas, mainly forests, natural standing waters and watercourses and natural meadows had the highest potential to provide all three selected regulating ES. The highly human-modified land cover types, such as urban fabric, industrial or commercial areas, mineral extraction, and dump sites or intensively used agricultural areas have very low or no relevant potential to support ecological integrity or to provide regulating ecosystem services [29].

3.2. ES Local Climate Regulation

Table 4 displays the potential of case study areas to provide ES Local climate regulation. Each land cover feature had assigned value from the evaluation matrix. We obtained the values in the Table 4 by calculating the areas of individual land cover features that have the same value in the evaluation matrix. The values are divided into ten classes ranging from none to the highest potential of land cover features to provide the ES Local climate regulation. This also applies on Tables 5 and 6.

The land cover features with the highest potential to provide ES Local climate regulation in the case study area SNR Obedska bara are deciduous forests, that cover 42.41% (12,502.79 ha) of the area. The case study area Obedska bara has the majority of its area (42.41%) in the category with the highest potential to provide ES Local climate regulation unlike the case study area PLA Dunajske luhy, which has the most of its territory (55.28%) in the category with low potential to provide this ES (Table 4, Figure 3). The most important land cover features with highest value to provide selected ES are deciduous forests, coniferous forest, and mixed forests. The potential of case study areas to provide ES Local climate regulation is displayed in Figure 4. where land cover features are divides into ten classes based on how high their potential is to provide ES Local climate regulation.

Table 4. The potential of case study areas to provide ES Local climate regulation.

Potential Intervals		Area of the Special Nature Reserve Obedska Bara (ha)	Area in %	Area of the Protected Landscape Area Dunajske Luhy (ha)	Area in %
none	0.00–0.50	354.83	1.20	1996.94	3.77
Very low	0.51–1.00	471.98	1.60	1227.05	2.32
slightly low	1.01–1.50	1722.93	5.84	640.21	1.21
low	1.51–2.00	10,937.19	37.10	29,256.33	55.28
slightly moderate	2.01–2.50	2653.48	9.00	7430.34	14.04
medium	2.51–3.00	562.06	1.91	3859.73	7.29
slightly high	3.01–3.50	170.75	0.58	237.77	0.45
high	3.51–4.00	2.73	0.01	61.77	0.12
Very high	4.01–4.50	99.34	0.34	1468.55	2.77
highest	4.51–5.00	12,502.79	42.41	6749.78	12.75
TOTAL		29,478.08	100	52,928.47	100

Table 5. The potential of case study areas to provide ES Water quality regulation.

Potential Intervals		Area of the Special Nature Reserve Obedska Bara (ha)	Area in %	Area of the Protected Landscape Area Dunajske Luhy (ha)	Area in %
none	0.00–0.50	7477.84	25.37	30,474.27	57.58
verylow	0.51–1.00	4434.71	15.04	1847.66	3.49
slightly low	1.01–1.50	787.17	2.67	1050.88	1.99
low	1.51–2.00	563.77	1.91	4137.88	7.82
slightly moderrate	2.01–2.50	260.93	0.89	1953.50	3.69
medium	2.51–3.00	1578.97	5.36	4684.58	8.85
slightly high	3.01–3.50	948.43	3.22	927.39	1.75
high	3.51–4.00	0.00	0.00	0.00	0.00
veryhigh	4.01–4.50	923.47	3.13	1111.27	2.10
thehighest	4.51–5.00	12,502.79	42.41	6741.04	12.74
TOTAL		29,478.08	100	52,928.47	100

Table 6. The potential of case study areas to provide ES Biodiversity promotion.

Potential Intervals		Area of the Special Nature Reserve Obedska Bara (ha)	Area in %	Area of the Protected Landscape Area Dunajske Luhy (ha)	Area in %
none	0.00–0.50	272.90	0.93	1400.95	2.65
very low	0.51–1.00	7194.05	24.40	28,766.53	54.35
slightly low	1.01–1.50	50.73	0.17	741.51	1.40
low	1.51–2.00	4177.32	14.17	1524.57	2.88
slightly moderrate	2.01–2.50	1725.51	5.85	1548.87	2.93
medium	2.51–3.00	730.70	2.48	7267.30	13.73
slightly high	3.01–3.50	942.43	3.20	1235.78	2.33
high	3.51–4.00	12,502.79	42.41	6706.08	12.67

Table 6. *Cont.*

Potential Intervals		Area of the Special Nature Reserve Obedska Bara (ha)	Area in %	Area of the Protected Landscape Area Dunajske Luhy (ha)	Area in %
very high	4.01–4.50	11.81	0.04	1807.34	3.41
the highest	4.51–5.00	1869.84	6.34	1929.54	3.65
TOTAL		29,478.08	100	52,928.47	100

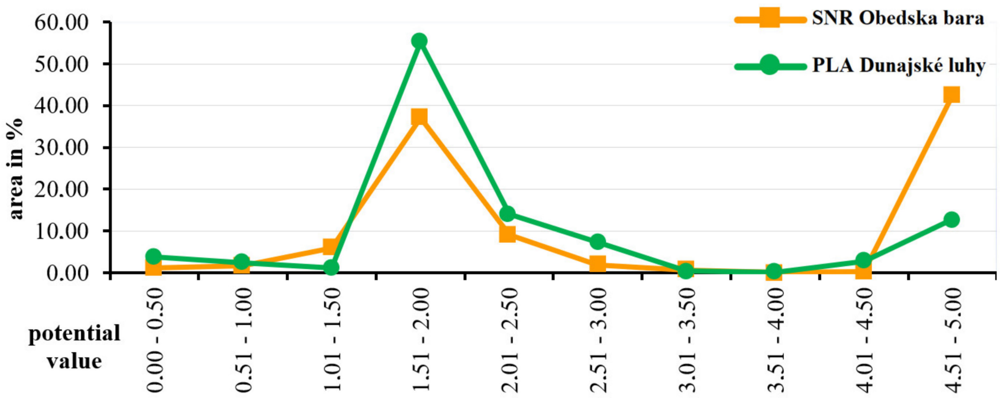

Figure 3. Comparison of the potential of case study areas to provide ES Local climate regulation.

3.3. ES Water Quality Regulation

Table 5 displays the potential of case study areas to provide ES Water quality regulation. The values are divided into ten classes ranging from none to the highest potential of land cover features to provide the ES Water quality regulation.

The results of this research show that the highest potential to provide ES Water quality regulation in the case study area SNR Obedska bara have deciduous forests that cover 42.41% (12,502.79 ha) of the area. Deciduous and coniferous forests, which cover 12.74% (6749.78 ha) of the case study area PLA Dunajske luhy, have the highest potential to provide this ES (Table 5). The results are the same as in the case of ES Local climate regulation.

More than half (57.58%) of the case study area PLA Dunajske luhy has no potential to provide ES Water quality regulation in contrast to case study area SNR Obedska bara where the largest part of the area (42.41%) has the highest potential to provide this ES (Figures 5 and 6). In Figure 6 are land cover features divided into ten classes based on how high their potential is to provide ES Water quality regulation.

3.4. ES Biodiversity Promotion

Natural and semi-natural meadows, natural watercourses, natural and semi-natural water bodies, and wetlands that cover 6.34% (1869.84 ha) of the mode area SNR Obedska bara have the highest potential to provide ES Biodiversity promotion. The highest values of potential to provide ES Biodiversity promotion in the case study area PLA Dunajske luhy have mixed forests, natural watercourses and water bodies and wetlands that cover 3.65% (1929.54 ha) of the area. The results are displayed in Table 6.

The case study area of SNR Obedska bara has the largest area (42.41%) with high potential, while in the case study area of the PLA Dunajske luhy has the most of its area (54.35%) in the category with very low potential to provide ES Biodiversity promotion (Figures 7 and 8).

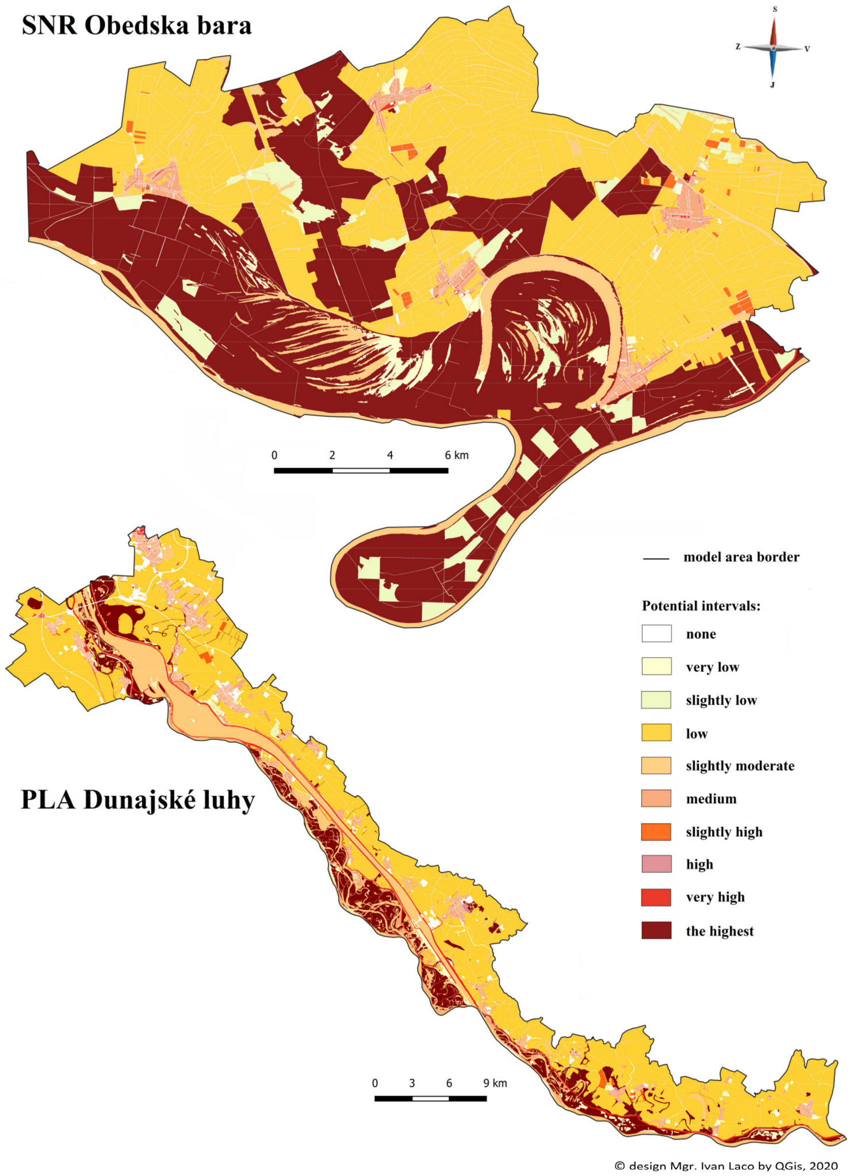

Figure 4. The potential of land cover features in case study areas to provide ES Local climate regulation.

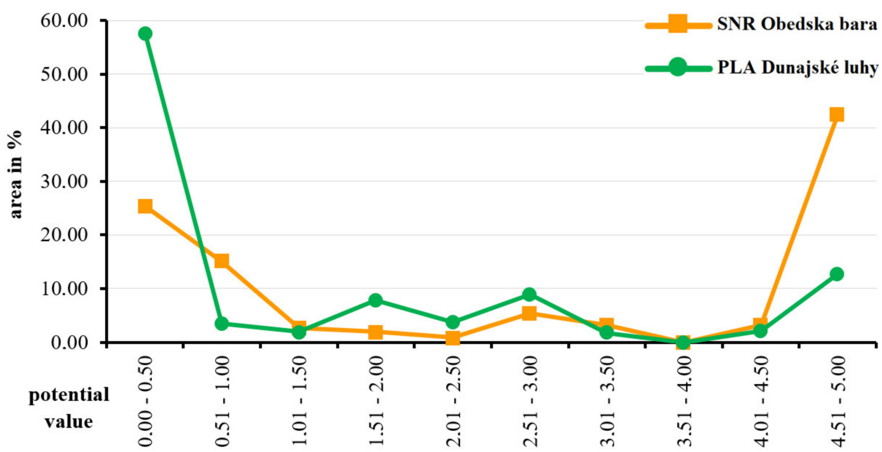

Figure 5. Comparison of the potential of case study areas to provide ES Water quality regulation.

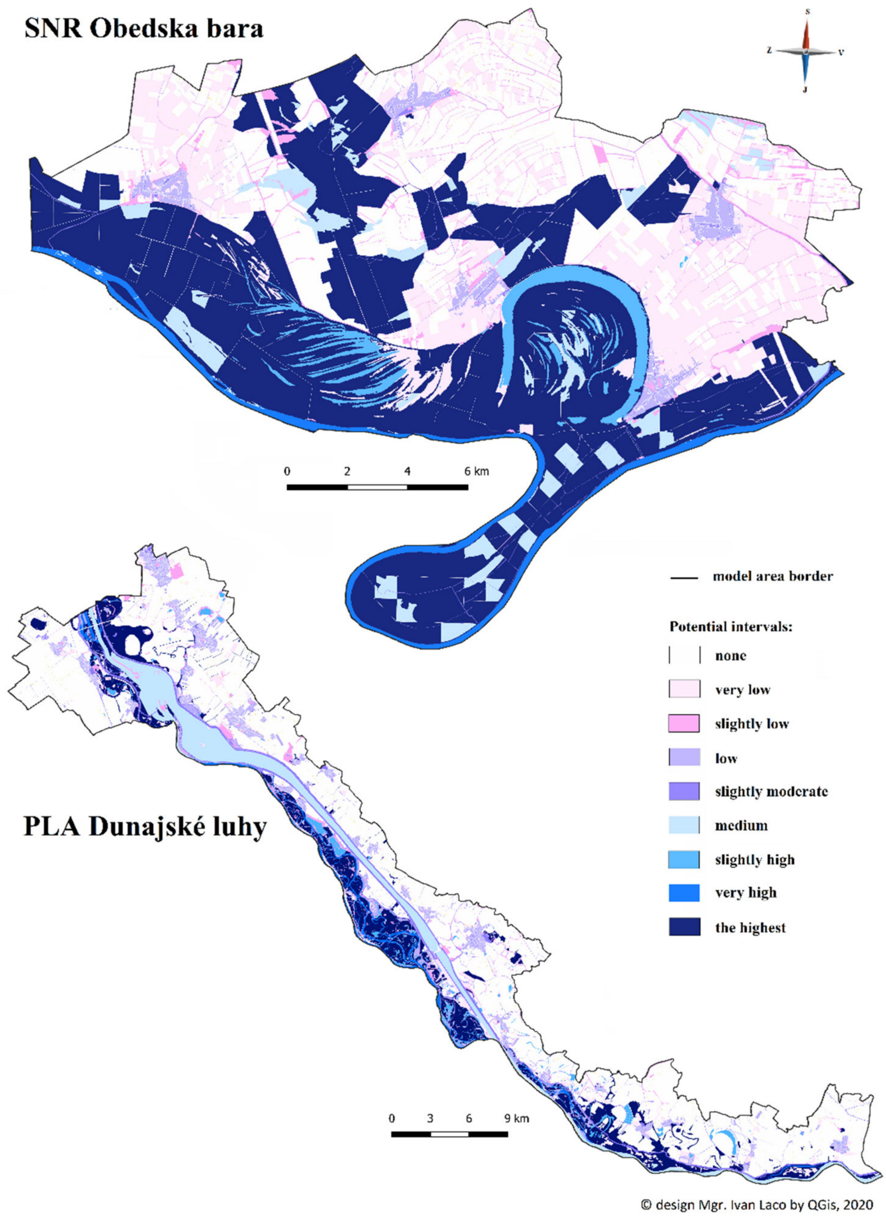

Figure 6. The potential of land cover features in case study areas to provide ES Water quality regulation.

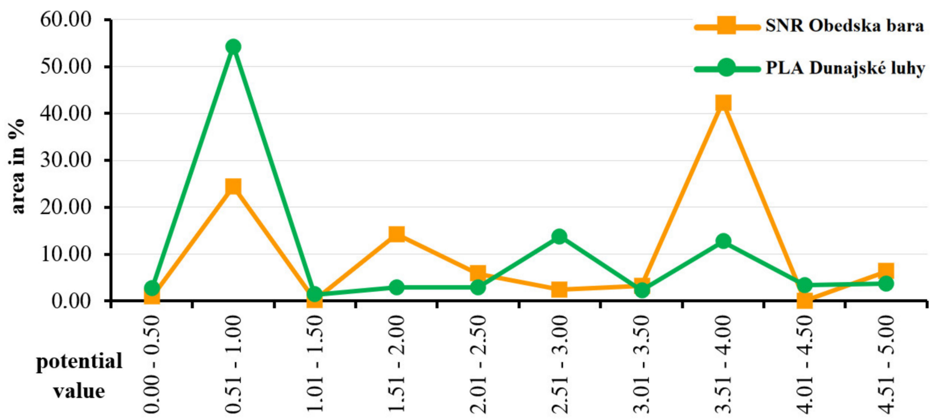

Figure 7. Comparison of the potential of case study areas to provide ES Biodiversity promotion.

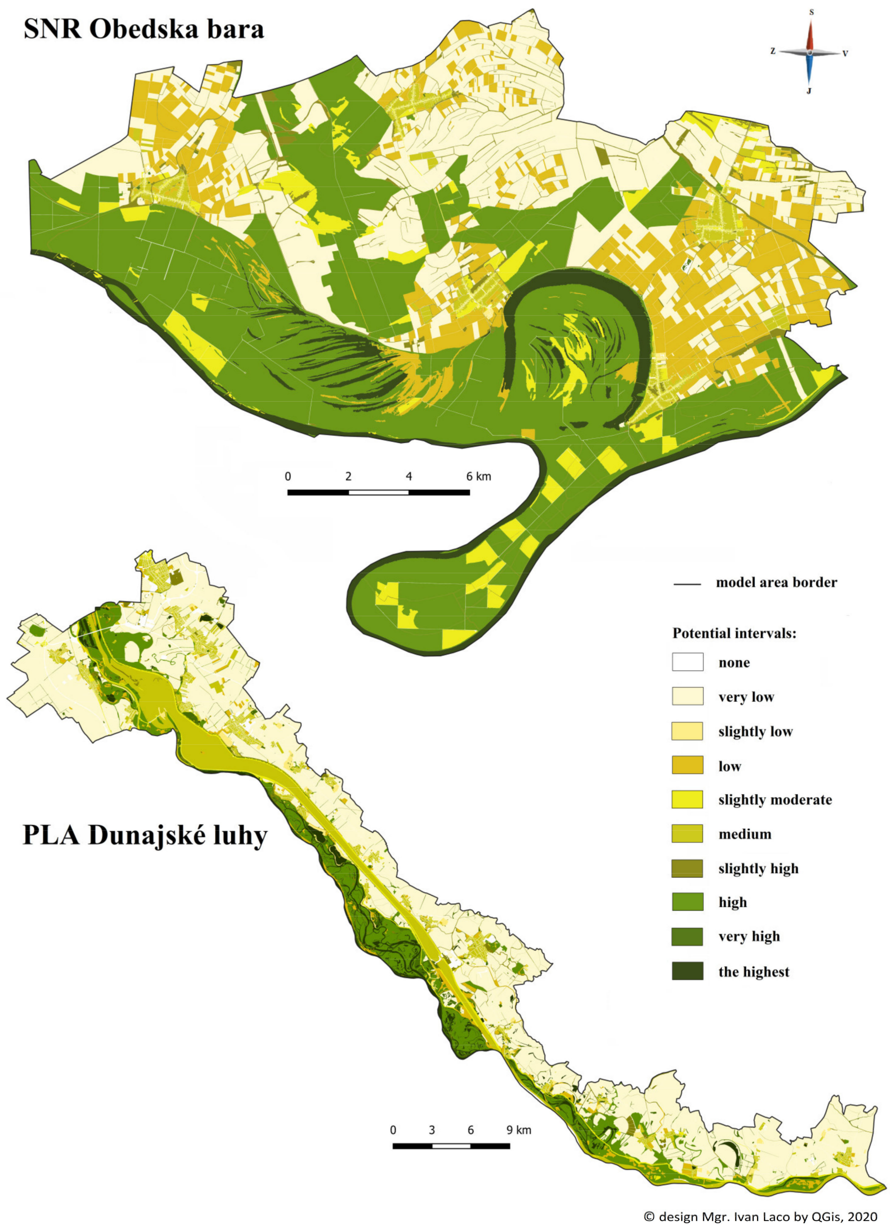

Figure 8. The potential of land cover features in case study areas to provide ES Biodiversity promotion.

To ensure the provision of ES Biodiversity promotion, the most important parameter is the quality of individual ecosystems. The naturalness of ecosystems increases the rate of biodiversity. The most important ecosystems that provide the ES Biodiversity promotion include rare ecosystems such as wetlands, peatlands, sand-bound ecosystems or alpine communities or xerothermic ecosystems. Forest ecosystems are also important, although their value differs from their degree of naturalness [6,20].

4. Discussion

Some land cover features provide certain ESs more than others. The potential to provide regulating ESs is dependent mainly on the quality of ecosystems and associated land use [21].

The study shows that all kinds of forests have the highest potential to provide ES Local climate regulation, which coincides with the data that provide national assessment of ESs in Slovakia. The national assessment of ES states that also land cover features such as meadows, pastures, water bodies, rivers, wetlands, subalpine and alpine communities have significant potential to provide ES Local climate regulation [6].

According to Grizzetti et al. [47] ES Water quality regulation is primarily linked to various aquatic ecosystems, but Smith et al. [35] argue that terrestrial ecosystems also play an important role in providing this ES. The results of the study suggest that terrestrial ecosystems have an irreplaceable role to play in the provision of ES Water quality regulation. It follows that, in addition to the presence of aquatic ecosystems, the sufficient representation and quality of ecosystems, as well as presence of well-developed riparian vegetation, is important [6]. The case study area PLA Dunajske luhy provides low potential to provide ES Water quality regulation, as most of the case study area is covered by large-scale fields.

Water regulating services, which are essential for ecosystem functioning as well as for human well-being, are found to be more preserved inside than outside protected areas [48,49]. This argument seems to be applicable in the case study areas because protected areas have the highest potential to provide this ES. But regulating services, such as water quality regulation can benefit from a non-strict protected area, due to the ability of local stakeholders to maintain traditional management of the landscape and ecosystems to ensure the provision of ES [50,51].

From the results of the research, we see that natural ecosystems have higher values of potential to provide ES Biodiversity promotion than man-made ecosystems, e.g., agro-ecosystems. However, these natural ecosystems occupy only very small parts of both case study areas.

Habitats with good conservation status can provide more biodiversity than those with unfavorable status [52] as we can see in the case study areas. The higher the degree of conservation, the higher is the degree of provision of ES Biodiversity promotion. Areas with lower or no degree of protection seem to have significantly different ability to provide this ES.

5. Conclusions

The inventory and spatial mapping of the current state of the ecosystem and its potential to provide ES has gained increasing interest over the past decade. Nation-wide inventories are now a proclaimed goal for the member states of the European Union (EU) as part of the EU Biodiversity Strategy to 2020 [28]. But there are still not many studies that focus on regulating ESs in protected areas in Slovakia and Serbia. Our main aim was to show how individual land cover features contribute to provision of selected ESs. We used several approaches to obtain data that can be used in further practice to ensure the continuous provision of ESs to people. For this purpose, we chose two case study areas in two different countries. Although these areas are located in different countries, they share some similarities that were crucial during the selection process.

The research combines various approaches based on biophysical and sociocultural methods, such as evaluation matrix, expert estimation, land cover, interviews with stakeholders and field research. By combining these methods, we can define the extent to which different land cover features can provide selected regulating ESs in the case study areas in Serbia and Slovakia. The higher the biodiversity, the higher the potential to provide a wide range of ESs [32]. Thus, by determining the value of the ESs provision, we can derive the value of biodiversity from this. This approach can be applied across a broad selection of areas, and we can use it not only for regulating ES, but for other ESs as well.

Regulating ESs are very sensitive in terms of land use and changes [53,54]. Land conversions, for example cultivation and urbanization, and more subtle land management changes, such as changes in the use intensity of cultivated lands, can have large implications on ESs provision. Changes that involve forest clearance, soil drainage, soil sealing, or fertilization, can change underlying biophysical processes and conditions, which in turn involve changes in the water cycle, climate conditions or habitat functions [55–62].

The results highlight that forest ecosystems are essential for provision of all three selected ESs. Case study areas differ in land cover features, which results in very different values in the provision of the three selected regulating ESs. In the case study area SNR Obedska bara, forest ecosystems dominate; while in the case study area PLA Dunajske luhy, large-scale fields, which have a low potential to provide selected regulating ESs, cover a large part of the area. The SNR Obedska Bara and PLA Dunajske luhy are surrounded by agricultural landscape and represent natural areas with high ecological value. They are important habitats for many species of fauna and flora, and they provide benefits to people in form of ESs.

Both case study areas have a certain degree of protection and should have the highest ecological value. The importance of nature conservation is significant for the provision of the ESs, whereas the precondition for the provision of the ESs is the state and dynamics of ecosystems, the nutrient cycle and the interconnection with other ecosystems. This can be ensured by protecting ecosystems by maintaining their favorable condition, as well as by management in protected areas. Protected areas most often also include large-scale continuous forest ecosystems, which are key in ensuring the provision of ESs [6]. Any change in land use has a very significant effect on the provision of regulating ESs [53,54], therefore proper management, especially in protected areas is essential.

The scientific research can bring valuable data not only to scientific community, but also to a wide spectrum of stakeholders. It can help decision makers, politics or conservationists to make better informed planning and management, not only in protected areas. To ensure delivering regulating ESs, it is necessary to protect natural areas as much as is possible. Cooperation with stakeholders on several levels of the research from data collection to application of results in practice can help scientists to obtain valuable data but it can also help stakeholders to make better informed decisions about landscape management and nature protection. Interviews combined with questionnaire provided a good form of stakeholder involvement in the process of evaluating ESs during this research.

The results of the case study can be used as a base for ES's mapping. The map outputs can be uses to meet the challenge of the EU Biodiversity strategy, as the EU has called on Member States to map the ES and Serbia as a candidate state for EU need to fulfil this appeal.

The Ministry of Energy, Development and Environmental Protection of the Republic of Serbia within the framework of integration into the EU, has started to meet the requirements also within the framework of nature protection. This first phase is the data creation for the GIS for integration into the European ecological network. The developed map data in digital form could be used as detailed data in the creation of a Geographical Information System for SNR Obedska bara. It could also be used in creation of the map internet servers, which could serve the state administration, as the Republic of Serbia does not have official map internet servers publicly available, such as VUPOP created by National agriculture and food center or ENVIROPORTAL in Slovakia.

Future research will concern both case study areas. We want to add data obtained with the methods of the Remote Sensing Time Series. The analysis of the time series will give the study another dimension and will be used to compare long-term changes in land cover and their environmental consequences in both case study areas.

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References

1. Egoh, B.N.; Bengtsson, J.; Lindborg, R.; Bullock, J.M.; Dixon, A.P.; Rouget, M. The importance of grass lands in providing ecosystem services: Opportunities for poverty alleviation. In *Routledge Handbook of Ecosystem Services*; Routledge: New York, NY, USA, 2016; pp. 421–436. ISBN 9781138025080.
2. Balvanera, P.; Pfisterer, A.B.; Buchmann, N.; He, J.S.; Nakashizuka, T.; Raffaelli, D.; Schmid, B. Quantifying the evidence for biodiversity effects on ecosystem functioning and services. In *Ecology Letters*; Shahid, N., Ed.; Blackwell Publishing Ltd./CNRS: Hoboken, NJ, USA, 2006; Volume 9, pp. 1146–1156.
3. Constanza, R.; d'Arge, R.; De Groot, R.; Farber, S.; Grasso, M.; Hannon, B.; Limburg, K.; Naeem, S.; O'neill, R.V.; Paraelo, J.; et al. The Value of the World's Ecosystem Services and Natural Capital. Available online: https://www.nature.com/articles/387253a0 (accessed on 5 December 2021).
4. Daily, G.C. (Ed.) *Nature's Services: Societal Dependence on Natural Ecosystems*; Island Press: Washington, DC, USA, 1997; p. 412. ISBN 1559634758.
5. De Groot, R.S. *Functions of Nature: Evaluation of Nature in Environmental Planning, Management and Decision Making*; Wolters Noordhoff: Groningen, The Netherlands, 1992; p. 315. ISBN 9001355943.
6. Mederly, P.; Černecký, J. (Eds.) *A Catalogue of Ecosystem Services in Slovakia*, 1st ed.; Springer International Publishing: Cham, Switzerland, 2020; p. 259. ISBN 9783030465087.
7. Millennium Ecosystem Assessment. *Ecosystems and Humanwell-Being Multiscale Assessments*; Island Press: Washington, DC, USA, 2005; p. 155. ISBN 1597260401.
8. Fisher, B.; Turner, R.K.; Morling, P. Defining and classifying ecosystem services for decision making. In *Ecological Economics*; Elsevier: Amsterdam, The Netherlands, 2009; Volume 68, pp. 643–653.
9. Bezák, P.; Mederly, P.; Izakovičová, Z.; Moyzeová, M.; Bezáková, M. Perception of ecosystem services in constituting multi-functional landscapes in Slovakia. *Land* **2020**, *9*, 195. [CrossRef]
10. Getzner, M. Economic and cultural values related to protected areas. Part A: Valuation of ecosystemservices in Tatra (PL) and Slovensky Raj (SK) nationalparks. *Public Sect.* **2009**, *36*, 3–42. [CrossRef]
11. Považan, R. *Acta Universitatis Matthiae Belii Séria Envirnomentálne Manažérstvo*, 1st ed.; Recreationalvalues of NP Veľká Fatra (Rekreačné hodnoty NP Veľká Fatra); University Mateja Bela, Faculty Natural Sciences: Banska Bystrica, Slovakia, 2013; Volume 15, pp. 82–94.
12. Považan, R. *Ecosystem Services in Protected Territories-Muránska Planina National Park*; Ministry of the Environment of the Slovak Republic: Bratislava, Slovakia, 2014; pp. 1–40.
13. Fűziová, Ľ.; Láníková, D.; Novorolský, M. *Polish Journal of Environmental Studies*; Economic Valuation of Tatrasnational Park and Regional Environmental Policy; University of Economics, 811-818 Faculty of Business Management: Bratislava, Slovakia, 2009; Volume 18, pp. 811–818.
14. Švajda, J.; Vološčuk, I. Assessment of ecosystem services (recreational and intangiblevalues) in NP Mala Fatra. In *Environmental Indices, Areas of Ecological Interest and Ecosystem Services in the Country, Proceedings of a Scientific Seminar*; National Agricultural and Food Center, Research Institute of Soil Science and Soil Protection: Bratislava, Slovakia, 2015; pp. 49–56. ISBN 9788081630095.
15. Vološčuk, I.; Sabo, P.; Škodová, M.; Švajda, J.; Lepeška, T. *Dynamic of Landstructure and Diversity of Ecosystems in Kriváanska Fatra*; University Mateja Bela, Belianum: Banska Bystrica, Slovakia, 2016; p. 179. ISBN 9788055711966.
16. Laco, I. Evaluation of Ecosystem Services of the Selected Territory as a Basis for Country Management. Ph.D. Thesis, University of Constantine Philosopher, Nitra, Slovakia, 2020.
17. Špulerová, J.; Petrovič, F.; Mederly, P.; Mojses, M.; Izakovičová, Z. Contribution of traditional farming to ecosystem services provision: Case studies from Slovakia. *Land* **2018**, *7*, 74. [CrossRef]
18. Vrbičanová, G.; Kaisová, D.; Močko, M.; Petrovič, F.; Mederly, P. Mapping cultural ecosystem services enables betterinformed nature protection and landscape management. *Sustainability* **2020**, *12*, 2138. [CrossRef]
19. Jančovič, M. Assessment of Ecosystem Services in Selected Area of Nitra District. Ph.D. Thesis, University of Constantine Philosopher, Nitra, Slovakia, 2020.
20. Černecký, J.; Gajdoš, P.; Špulerová, J.; Halada, Ľ.; Mederly, P.; Ulrych, L.; Ďuricová, Ľ.; Andráš, P.; Rybanič, R. Ecosystems in Slovakia. In *Journal of Maps*, 2nd ed.; Informa UK Limited, Trading as Taylor & Francis Group on Behalf of Journal of Maps; Pensoft: Newport News, VA, USA, 2020; Volume 16, pp. 28–35.
21. Mederly, P.; Černecký, J.; Špulerová, J.; Izakovičová, Z.; Ďuricová, V.; Považan, R.; Švajda, J.; Močko, M.; Jančovič, M.; Gusejnov, S.; et al. National ecosystem services assessment in Slovakia—Meeting old liabilities and introducing new methods. *One Ecosyst.* **2020**, *5*, 1–31. [CrossRef]
22. Đurđić, S.; Stojković, S.; Belij, M. The importance of ecotourism in the process of improving ecosystem services in Serbia. In *Proceedings of the International Scientific Symposium New Trends in Geography, Ohrid, North Macedonia, 3–4 October 2019*, 1st ed.; Macedonian Geographical Society: Ohrid, North Macedonia, 2019; pp. 123–132.
23. Kašanin-Grubin, M.; Štrbav, S.; Antonijević, S.; Djogo Mračević, S.; Randjelović, D.; Orlić, J.; Šajnović, A. Future environmental challenges of the urban protected area Great War Island (Belgrade, Serbia) based on valuation of the pollution status and ecosystem services. *J. Environ. Manag.* **2019**, *251*, 1–12. [CrossRef]
24. Zorić, M.; Đukis, I.; Kijajić, L.; Karaklić, D.; Orlović, S. The Possibilities for Improvement of Ecosystem Services in Tara National Park. *Topola Polar* **2019**, *203*, 53–63.

25. Institute for European Environmental Policy. Available online: https://ieep.eu/publications/guidance-manual-for-teeb-country-studies-version-1--0 (accessed on 10 March 2021).
26. CICES. Available online: https://cices.eu/content/uploads/sites/8/2015/09/CICES-V4-3-_-17-01-13a.xlsx (accessed on 12 March 2021).
27. Kumar, P. (Ed.) *TEEB. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*; Earthscan: London, UK; Washington, DC, USA, 2010.
28. Stürck, J.; Schulp, C.J.E.; Verburg, P.H. Spatio-temporal dynamics of regulating ecosystem services in Europe. The role of past and future landuse change. *Appl. Geogr.* **2015**, *63*, 121–135. [CrossRef]
29. Burkhard, B.; Kroll, F.; Nedkov, S.; Műller, F. Mapping ecosystem service supply, demand and budgets. *Ecol. Indic.* **2012**, *21*, 17–29. [CrossRef]
30. Bastian, O.; Haase, D.; Grunewald, K. Ecosystem properties, potentials, and services—The EPPS conceptual framework and an urban application example. *Ecol. Indic.* **2012**, *21*, 7–16. [CrossRef]
31. Baskent, E.Z. A Framework for Characterizing and Regulating Ecosystem Services in a Management Planning Context. *Forests* **2020**, *11*, 102. [CrossRef]
32. Becerra-Jurado, G.; Philipsen, C.; Kleeschulte, S. *Mapping and Assessing Ecosystems and Their Services in Luxembourg—Assessment Results*; Le Gouvernment du Grand—Duché de Luxemburg: Luxembourg, 2015; p. 75. [CrossRef]
33. Nunes, P.; Van den Bergh, H. Economic valuation of biodiversity: Sense or nonsense? In *Ecological Economics*, 2nd ed.; Elsevier: Amsterdam, The Netherlands, 2001; Volume 39, pp. 203–222. [CrossRef]
34. DEFRA. *An Introductory Guide to Valuing Ecosystem Services*; Department for Environment, Food and Rural Affairs: London, UK, 2007; p. 65.
35. Smith, R.; Madsen A., L.; Haines-young, R.; Barton, D. WP3 Methodological Guidelines for Bayesian Belief Networks—OpenNESS Project EP7. *OpenNESS*. 2013. Available online: http://openness.hugin.com/huginprog/documentation/WP3_Method_Guidelines_BBNs_050314.pdf (accessed on 5 December 2020).
36. Dudley, N.; Stolton, S. *Running Pure: The Importance of Forest Protected Areas to Drinking Water*, 1st ed.; World Bank/WWF Alliance for Forest Conservation and Sustainable Use: Washington, DC, USA, 2013; p. 114. ISBN 2880852625.
37. Brauman, K.A.; Daily, G.C.; Duarte, T.K.; Mooney, H.A. *The Annual Review of Environment and Resources*, 1st ed.; The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services; Annual Reviews Inc.: San Mateo, CA, USA, 2007; Volume 32, pp. 67–98. ISSN 1545-2050.
38. Burkhard, B.; Kroll, F.; Műller, F.; Windhorst, W. Landscapes capacities to provide ecosystem services—A concept for land-cover based assessment. *Landsc. Online* **2009**, *15*, 1–12. [CrossRef]
39. Burkhard, B.; Kandziora, M.; Hou, Y.; Müller, E. Ecosystem service potentials, flows and demands—Concepts for spatial localisation, indication and quantification. *Landsc. Online* **2014**, *34*, 1–32. [CrossRef]
40. Puzović, S. *Contemporary Ecological Framework of Obedska Bara*; Mladi Istraživači Srbije: Beograd, Serbia, 1995; p. 399.
41. Laco, I. Current State and Landscape Use Nature Reserve Obedska Bara (Srbsko—Vojvodina). Bachelor's Thesis, University of Constantine the Philosopher in Nitra, Nitra, Slovakia, 2012.
42. Rybanič, R.; Šutiakova, T.; Benko, Š. *Important Bird Areas in Slovakia. Territories Important from the Point of View of the European Union*, 1st ed.; Society for the Protection of Birds in Slovakia: Bratislava, Slovakia, 2004; p. 220; ISBN 8096907808.
43. Plesník, P. *Definition and Appreciation of Tourism Regions*, 1st ed.; Economist: Bratislava, Slovakia, 2008; p. 87. ISBN 9788022524766.
44. Fulajtar, E.; Čurlik, J.; Barančikova, G.; Sedlakova, B.; Šurina, B. *Impact of the Gabčíkovo Waterworks on Agricultural Land*, 1st ed.; Research Institute of Soil Fertility: Bratislava, Slovakia, 1998; p. 199. ISBN 8085361280.
45. Bohuš, M.; Ružičková, J.; Lehotská, B. *The Danube, Its Ecosystems and Human Activity Bratislava*, 1st ed.; Comenius University: Bratislava, Slovakia, 2011; p. 370. ISBN 9788022331364.
46. Petrovič, F.; Bugár, G.; Hreško, J. List of landscape elements mapped in Slovakia. In *GEO-Information 5*, 1st ed.; Dubcová, A., Ed.; University of Constantine Philosopher: Nitra, Slovakia, 2009; Volume 5, pp. 112–124. ISSN 1336-7234.
47. Grizzetti, B.; Lanzanova, D.; Liquete, C.; Reynaud, A.; Cardoso, A.C. Assessing water ecosystem services for water resource management. *Environ. Sci. Policy* **2016**, *61*, 194–203. [CrossRef]
48. Quijas, S.; Jackson, L.E.; Maass, M.; Schmid, B.; Raffaelli, D.; Balvanera, P. Plant diversity and generation of ecosystem services at the land scape scale: Expert knowledge assessment. *J. Appl. Ecol.* **2012**, *49*, 929–940. [CrossRef]
49. Dos Santos, V.; Laurent, F.; Abe, C.; Messner, F. Hydrologic Response to Land Use Change in a Large Basin in Eastern Amazon. *Water* **2018**, *10*, 429. [CrossRef]
50. Castro, A.J.; Martın-Lopez, B.; Lopez, E.; Plieninger, T.; Alcaraz-Segura, D.; Vaughn, C.C.; Cabello, J. Do protected areas networks ensure the supply of ecosystem services? Spatial patterns of two nature reserve systems in semi-arid Spain. *Appl. Geogr.* **2016**, *60*, 1–9. [CrossRef]
51. Manhães, A.P.; Mazzochini, G.G.; Oliveira-Filho, A.T.; Ganade, G.; Carvalho, A.R. Spatial associations of ecosystem services and biodiversity as a base line for systematic conservation planning. *Divers. Distrib.* **2016**, *22*, 932–943. [CrossRef]
52. Maes, J.; Egoh, B.; Willemen, L.; Liquete, C.; Vihervaara, P.; Philipp, S.; Grizzeth, B.; Drakou, E.G.; La Notte, A.; Zulian, G.; et al. *Ecosystem Services*, 1st ed.; Mapping Ecosystem Services for Policy Support, and Decision Making in the European Union; Elsevier: Amsterdam, The Netherlands, 2016; Volume 1, pp. 31–39.

53. Sohl, T.L.; Sleeter, B.M.; Zhu, Z.; Sayler, K.L.; Bennett, S.; Bouchard, M.; Reker, R.; Hawbaker, T.; Wein, A.; Liu, S.; et al. A Land-Use and Land-Cover Modeling Strategy to Support a National Assessment of Carbon Stocks and Fluxes. *Appl. Geogr.* **2012**, *34*, 111–124. [CrossRef]
54. Su, S.; Xiao, R.; Jiang, Z.; Zhang, Y. Characterizing landscape pattern and ecosystem service value changes for urbanization impacts at an eco-regional scale. *Appl. Geogr.* **2012**, *34*, 295–305. [CrossRef]
55. Grimm, N.B.; Foster, D.; Groffman, P.; Grove, J.M.; Hopkinson, C.S.; Nadelhoffer, K.J.; Pataki, D.E.; Peters, D.P. The changing landscape: Ecosystem responses to urbanization and pollution across climatic and societal gradients. *Front. Ecol. Environ.* **2008**, *6*, 227–288. [CrossRef]
56. Kanowski, J.; Catterall, C.P. Carbon stocks in above-ground biomass of monoculture plantations, mixed species plantations and environmental restoration plantings in north-east Australia. *Ecol. Manag. Restor.* **2010**, *11*, 119–126. [CrossRef]
57. van Oudenhoven, A.P.E.; Petz, K.; Alkemade, R.; Hein, L.; de Groot, R.S. Framework for systematic indicator selection to assess effects of land management on ecosystem services. *Ecol. Indic.* **2012**, *21*, 110–122. [CrossRef]
58. Schulp, C.J.E.; Nabuurs, G.-J.; Verburg, P.H.; de Waal, R.W. Effect of tree species on carbon stocks in forest floor and mineral soil and implications for soil carbon inventories. *Appl. Geogr.* **2008**, *256*, 482–490. [CrossRef]
59. Snapp, S.S.; Blackie, M.J.; Gilbert, R.A.; Bezner-Kerr, R.; Kanyama-Phiri, G.Y. Biodiversity can support a greener revolution in Africa. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 20840–20845. [CrossRef] [PubMed]
60. Izakovičová, Z.; Miklos, L.; Miklosová, V.; Petrovič, F. The Integrated Approach to Landscape Management-Experience from Slovakia. *Sustainability* **2019**, *11*, 4554. [CrossRef]
61. Dobrovodská, M.; Kanka, R.; David, S.; Kollár, J.; Špulerová, J.; Štefunková, D.; Mojses, M.; Petrovič, F.; Krištín, A.; Stašiov, S.; et al. Assessment of the biocultural value of traditional agricultural landscape on a plot-by-plot level: Case studies from Slovakia. *Biodivers. Conserv.* **2019**, *28*, 2615–2645. [CrossRef]
62. Izakovičová, Z. Evaluation of the stress factors in the landscape. *Ekol. Bratisl.* **2000**, *19*, 92–103.