Field Work Report

Of

Principles of Landscape Ecology

On

The evaluation of the landscape components in town Wągry

Group Members

Jakub Sowa, Jeremias Czekalla, Julia Mursztyn,Kamil Nowakowski, Laura Ighwre
Ali Dia, Jan Rapczyński, Kazi Jahidur Rahaman
Alireza Heidari Mehr, Luma Vanessa Forti, Paul Schumann

Students, MSc in Forest Information Technology
Warsaw university of life Sciences
&
Eberswalde University for Sustainable Development

Submitted to

Dr. Taida Tarabuła and
Dr. Marek Sławski
Warsaw university of life Sciences, Warsaw, Poland

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Introduction

In ecological management it is crucial to combine ecological harmony and intrinsic beauty of natural landscapes with urbanisation. In order to understand the state of the harmony in nature, our project explores the region of Wągry and its surroundings in the Łodzkie Voivodeship of Poland. In this context, the study explores the interactions between the geology, hydrology, and land use of the landscape as well as the anthropogenic factors that have shaped the region. We want to comprehend the current landscape structure and find areas for improvement by assessing the ecological and aesthetic values of these elements.

To understand the interaction, we first identified natural and anthropogenic components in the landscape which was done through a field work under the guidance of Dr. Marek Sławski. The components were scored based on their functions and impact. After the field work all these individual components were synthesised based their corresponding score with which we could identify some ecologically valuable natural and anthropogenic components from the landscape. Based on the field observations we also tried to identify the factors which impact the ecological values of the components. At end we tried to come up with some recommendations to improve the quality of the landscape. One of these recommendations was to suggest a tourist path for visitors, which should divert the negative impacts of the tourism to a particular direction while rest of the landscape can be a better habitat for the living species in the forest. Along with that, we identified some locations where some changes can be introduced to improve the ecological connections between the components.

Materials and Methods

Geographical Location of Study Area

The study area is located in the Central Poland, Łodzkie voivodeship, Brzeziny county, sub counties of Brzeziny and Rogów, just next to the small town of Brzeziny (ca. 12 000 human population). The area is known for its picturesque landscapes, rural charm, and agricultural activities. The nearest big city is Łodź (more than 600 000 residents), around 15 km from the study. The only nature conservation form present in the area is Morga and Mrożyca Natural Park (Obszar Chronionego Krajobrazu), next to Landscape-Nature Park of Morga (Zespół Przyrodniczo-Krajobrazowy). Nearby flows the river of Rawka, protected as a Nature Reserve (Rezerwat Przyrody), a few kilometers to north-east and south-west there are other Nature Reserves, and the closest Landscape Park (Park Krajobrazowy) is Wzniesienia Łódzkie, surrounding the town of Brzeziny from north-west together with the closest Natura2000 area – Buczyna Janinowska. The nearest National Park (Park Narodowy) is Kampinos, located around 70 km north-east from the study.

Figure 1. Localization of study area with Łódź city and Brzeziny County. Source: Google Maps

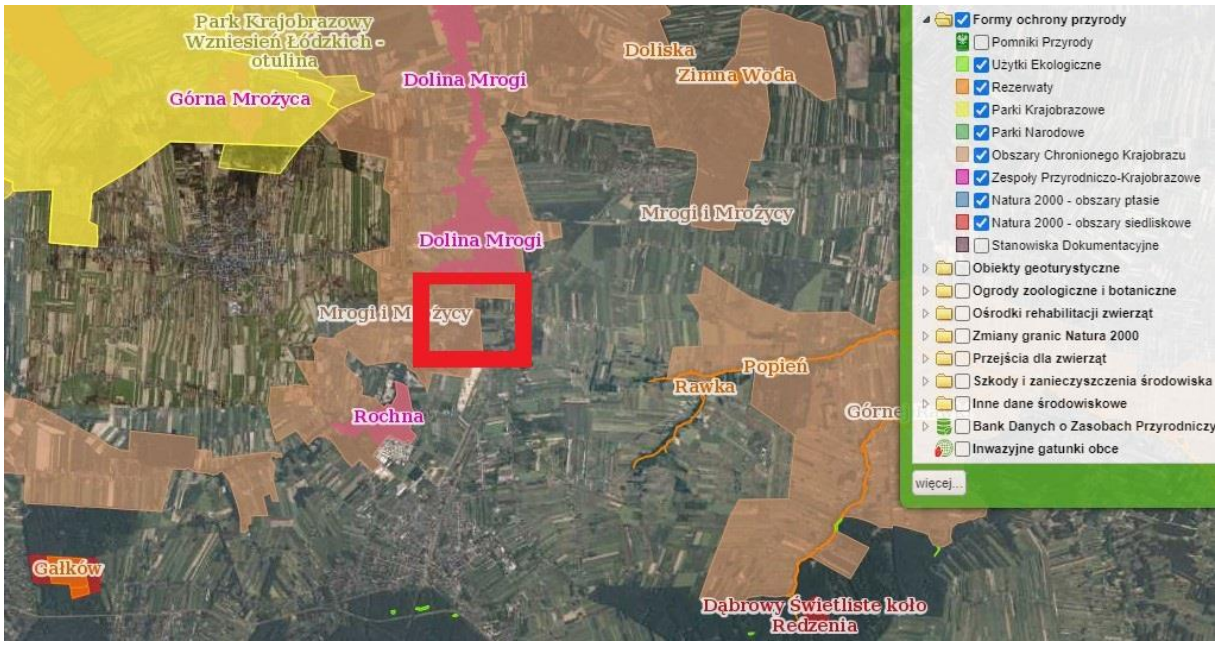

Figure 2. Localization of the study area among protection zones. Source: Geo-service of the General Directorate of Nature Conservation

Geology

The geology of Wągry and its surrounding area in the Łódź Voivodeship of Poland is characterized by a combination of sedimentary rocks and glacial deposits. The area is primarily composed of sedimentary rocks, which are formed from the accumulation of sediments over millions of years. These rocks often consist of layers or strata that provide valuable information about the geological history of the region. Common sedimentary rock types in the area may include sandstone, limestone, and shale.

The region also bears the imprint of glaciation, as much of Poland was covered by ice during the last Ice Age. Glacial deposits, such as glacial till, moraines, and outwash plains, can be found in the vicinity

of Wągry. The interplay of geological processes has shaped the landforms in the area. The presence of glacial deposits has led to the formation of drumlins. Additionally, glacial erosion and meltwater activity may have created valleys, ridges, and other distinctive features in the local landscape.

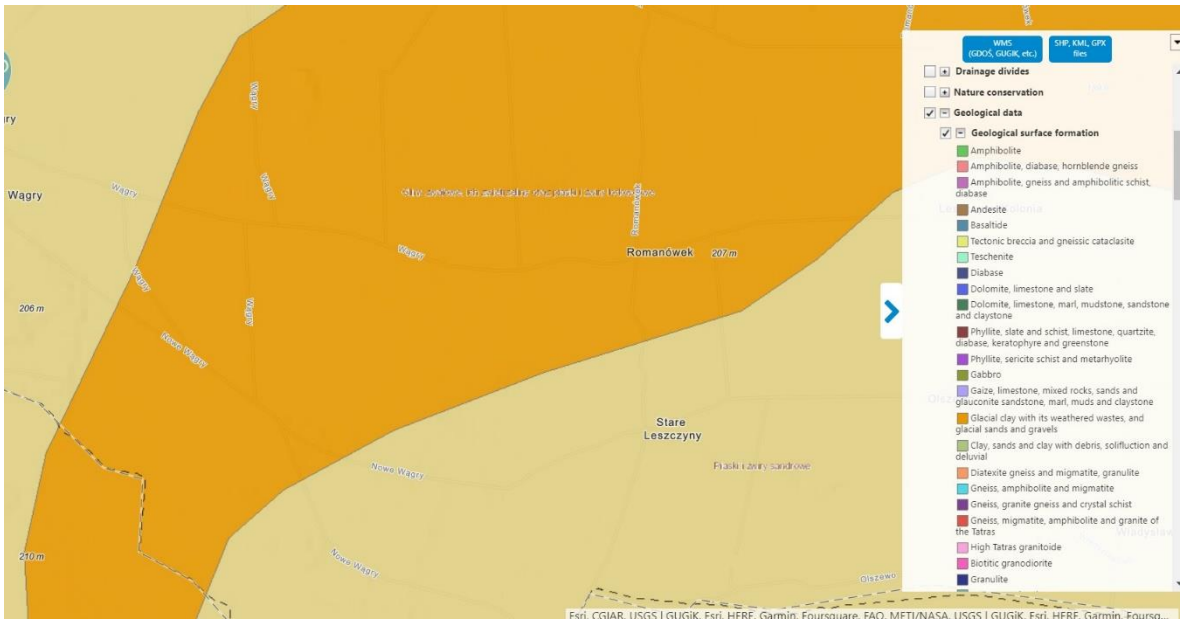

Figure 3: Geological Map of Wągry Area, Source: Forest Data Bank, Poland

Hydrology

The area has a temperate climate, with moderate rainfall throughout the year. The local topography and geological features, including the presence of rivers, streams, and aquifers, play a significant role in the hydrological characteristics of the area.

Land Use

Land use of the study area is a mosaic of small forests, arable fields, and villages. The geology is also differential with a small river valley in the middle and a lowland landscape with some highland features. Hydrology can be described together with ecological corridors, as the Morga river represents well preserved river with thin but natural riparian forest, than can be connection route for many animals. However, in the south there is a weir, which makes it all the way upstream of the river inaccessible, so the water ecosystem in our study area is both corridors, but also a barrier e.g., for fish.

In the case of the international ecological network ECONET, the study area does not include any natural corridors, however it is quite close to one national corridor.

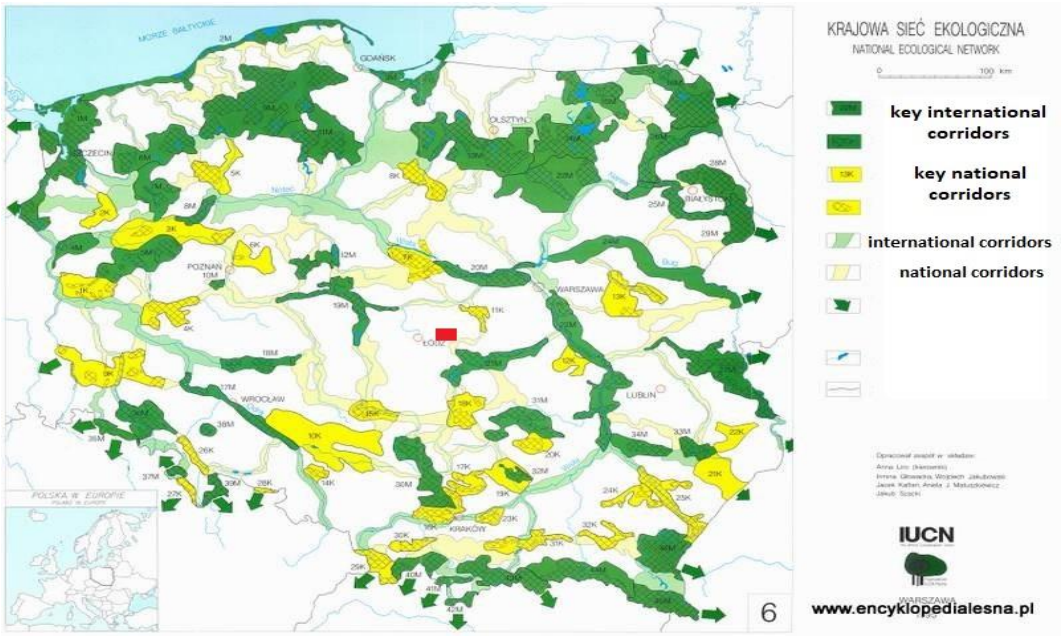

Figure 4. ECONET ecological net in Poland with our study area.

Field Work

On May 22nd, the master's programme "Forest Information Technology" assembled in Wagry for field measurements as part of the Principles of Landscape Ecology module. The day began with Mr. Marek Sławski welcoming us at the train station and organizing the course into two groups. He provided an informative introduction to the excursion and distributed necessary documents to aid us in completing the task.

Following the introduction, our group further divided into three subgroups. Each subgroup then dispersed into their respective vehicles and made their way to the designated area to commence the observations. To facilitate our work, each group received maps of the study area in both A3 and A4 formats. Our primary objective was to document the most significant landscape components and assign them numerical identifiers directly on the maps. Furthermore, we recorded detailed descriptions of these landscape components in two separate tables to ensure a comprehensive documentation process:

- Table 1: Natural and semi-natural components of the landscape
- Table 2: Anthropogenic components of the landscape

In Table 1, we utilized symbols to describe various aspects of landscape components, such as their form and position. To distinguish between different components, we applied a scale ranging from 0 to 5 in most cases. This scale allowed us to evaluate the effectiveness of each landscape component in fulfilling ecological functions. A score of 5 represented the highest level of performance, while 0 indicated the lowest. If a specific category was not relevant to a particular component, we left it blank and marked it with a dash. It's important to note that the column "Management intensity" in Table 1 required special consideration. As this category relates to human influence on the landscape, we employed a negative scale ranging from -5 to 0. This allowed us to assess the degree of human impact, with -5 indicating a high level of intensity and 0 representing no discernible influence. The exact breakdown of the individual categories and their meaning can be found in the appendix.

Similarly, Table 2 followed a comparable structure but focused on assessing the influence of landscape components on their surroundings. Here, we utilized a negative scale ranging from -5 to 0 to evaluate this influence. The lower the score, the greater the negative impact of the component on its surroundings. Additionally, in Table 2, we also evaluated the aesthetic aspects of the landscape components. The assessment in this table incorporated other key indicators, starting from A1 and progressing onwards.

During our fieldwork, we adopted a systematic approach, exploring the landscape either by car or on foot. To ensure efficient data collection, one person was assigned to document observations in Table 1, while another person took responsibility for recording information in Table 2. However, it's important to note that all impressions and findings were discussed and agreed upon by the entire group.

To capture the aesthetic value of the landscape, we made regular stops approximately every 200 to 250 meters. At each designated location, we collectively recorded our impressions of the landscape's aesthetic qualities in Table 3. We focused on a specific direction of gaze and evaluated both the left and right sides individually using a scale of -5 to 5.

Evaluation of the landscape

After completing the field measurements, our primary focus was to consolidate all the gathered data. To accomplish this, we utilized Excel and created three tables to compile and organize the collected information. The entries in the tables were marked with their respective group affiliations to ensure accurate attribution.

The subsequent step involved aggregating the data from Tables 1 and 2. We summed up the values for each row and identified the most harmful (minimum) and most valuable (maximum) landscape component. These extreme values were rounded up, and subsequently, we divided the range into five distinct classes. In addition to the steps, we also incorporated satellite images into our analysis for cross-referencing and verifying our recorded landscape components. By comparing the observed landscape components with the information obtained from satellite images, we aimed to identify any potential gross errors or overlooked area elements.

Tools

In the final step of our analysis, we employed ArcMap, a geographic information system (GIS) developed by ESRI, to transfer the collected data onto a map. Using ArcMap, we utilized a base map as a reference and transferred the individual landscape components onto the map. Each component was assigned to its respective class based on the previously determined categories.

Results and Observations

The members of the survey team divided them into 3 smaller groups to visit the whole study area. As per the methodology of the study, the groups noted their observations from the field in 3 different tables for Natural components (including semi natural components), Anthropogenic Components, and also the aesthetic values for some points of touristic attractions.

Ecological Value of the Natural Components

As of the table for the Natural components, the natural components were comprised of mainly meadows, forests, and waterbodies. Besides that, we observed a minor amount of Riparian vegetation

as well near to the bank of the rivers. Most of the forests were managed mixed coniferous forests with dominance of *Pinus Sylvestris*. However, in some spots we noticed *Quercus robur* and *Betula pendula* some other broadleaf species in the edge of the stands, which could be a shadow to the ecotones in the edge of the forest.

Figure 5: Different vegetations in the area

In the figure 5, we can see the diversity in the vegetations in the area, broadleaf trees can give shadow to the animals who comes outside the forest for grazing, while the grass and other shrubs can be shelter for smaller animals like rabbits and different insects.

The structure and shapes of the components were linear, stripe or patch. Besides that, another interesting point that was noticed is, the locations of the components, several components were found where the position was either on the valley or slopes. This is significant to understand the nature of soil erosion in the landscape. Overall, the groups scored all of the landscape components individually, at the end the averages of these scores were also calculated so that, it could be compared with the aesthetic values. The overall table of the scores is presented in below table 1.

Table 1: Description of the Natural Components

No	Type	Structure/shape	Position	Size	Age	Species richness/composition	Origin	Height/depth	Layers	Connectivity	Ecotone	Management intensity	Health status (disturbance)	Functions								Notice (eg. conservation/ protection status, rare species, threats, surroundings)	Syn
														W/S/N	Erosion	Eutrophication	Climate	Shelters	Food source	Corridor	Aesthetics		
1	Meadow	O	-	4	-	3	-	-	1	3	-	-2	3	0	3	3	2	2	3	3	3	by village	
2	Forest	O	-	2	2	3	-	-	5	1	-	0	3	3	4	2	5	4	3	1	3		82
3	Forest	O	U	2	2	3	-	-	3	2	-	-2	4	4	4	3	4	4	3	3	2		82
4	Forest	O	^	3	3	2	-	-	5	2	-	-2	3	4	4	3	4	4	3	4	2		132
5	Forest	O	^	4	3	3	-	-	5	2	-	0	2	2	4	2	5	4	2	3	2		172
6	Pond	**o**	-	1	-	3	-	-	-	1	-	0	2	0	0	2	3	3	3	1	3		22
7	Lake	**o**	-	1	-	2	-	-	-	2	-	0	3	0	0	2	3	3	3	1	2		22
8	Forest	O	-	3	3	4	-	-	5	2	-	-1	3	4	4	3	5	3	2	4	3		141
9	Forest	O	-	3	4	5	-	-	5	4	-	-1	3	4	5	2	5	3	2	2	3		147
10	Forest	O	-	4	3	2	-	-	3	3	-	-2	2	3	4	2	4	3	2	3	2		152
11	Forest	O	-	4	3	4	-	-	3	3	-	-1	3	3	4	2	4	2	2	3	4		172
12	Forest	O	-	2	3	3	-	-	3	2	-	-2	2	3	4	2	4	3	2	3	4		76
13	Forest	O	-	2	3	3	-	-	3	2	-	-2	2	3	4	2	4	3	2	3	4		76
14	Forest	O	-	3	3	2	-	-	3	2	-	-2	2	2	3	2	4	3	2	3	4		108
15	Forest	O	-	3	3	2	-	-	4	3	-	-2	2	3	3	2	4	2	3	4	2		114
16	Forest	O	-	3	3	2	-	-	4	2	-	-3	2	3	4	2	3	3	2	3	3		108
17	Forest	O	/	5	3	2	0	4	3	2	-	0	4	2	2	-	2	5	3	3	4		220
18	Ecotone	//	/	5	3	2	0	4	3	2	-	0	4	5	2	-	-	2	3	3	3		205
19	Forest	O	/	4	3	2	0	4	1	3	-	-5	4	2	2	-	1	1	1	1	2		104
20	Succession	//	-	2	1	3	1	1	1	0	-	0	4	0	1	-	1	2	2	1	2		44
21	Woodlot	O	-	3	2	4	1	2	1	0	-	0	2	1	2	-	2	3	2	1	2		84
22	Shrubs	O	-	1	2	3	1	2	1	-	-	0	4	0	0	-	-	3	2	2	3		24
23	Meadow	//	-	2	1	2	0	1	1	-	-	0	4	0	0	-	-	2	2	-	2		34
24	Shrubs	O	-	1	2	3	1	2	1	1	-	0	4	0	0	-	-	3	2	2	3		25
25	Woodlot	O	-	2	2	4	1	2	2	1	-	0	4	2	1	-	1	3	2	2	3		64
26	Forest	O	/	3	2	3	0	2	1	2	-	-2	4	2	1	-	2	3	3	2	3		93
27	Hedgerow	//	-	1	1	1	0	1	1	-	-	-5	4	1	-	-	-	1	1	-	2		9
28	Meadow	O	-	3	1	1	0	1	1	3	-	-3	4	0	1	-	-	1	1	2	3		57
29	Shrubs	//	-	2	1	2	1	1	1	2	-	0	3	0	1	-	-	2	2	2	0		40
30	Meadow	O	-	3	2	3	0	2	1	2	-	-4	4	0	1	-	-	1	1	2	3		63
31	Shrubs	//	-	1	3	3	1	3	2	2	-	0	2	2	1	-	-	3	2	2	4		31
32	Forest	O	U	4	4	4	1	4	3	5	-	0	4	4	4	5	5	5	5	5	5		268
33	Forest	O	^	3	3	4	1	3	2	4	-	0	4	3	2	-	2	4	4	4	5		144
34	Forest	O	U	2	4	4	1	4	3	4	-	0	4	3	2	5	3	5	4	4	5		114
35	Forest	O	/	2	4	1	0	4	4	4	-	-3	4	1	1	1	1	3	2	2	2		66
36	River	/	U	2	-	-	1	1	-	2	-	0	4	-	-	-	4	3	4	5	4		60
37	Riparian Vegetation	//	U	3	-	-	-	4	4	4	-	-1	-	1	3	4	3	3	3	5	4		120
38	Forest	O	-	3	4	1	0	4	4	4	-	-3	4	2	1	1	1	3	2	3	3		111
39	Forest	O	-	3	4	1	4	4	4	4	-	-4	4	2	1	1	1	3	2	3	2		117
40	Forest	O	-	1	3	1	3	3	1	1	-	-3	4	3	1	1	1	1	1	1	2		25
41	Forest	O	-	2	3	1	3	3	1	1	-	-3	4	3	1	1	1	1	1	1	2		52
42	Pond	O	U	1	-	-	-	2	2	2	-	-3	4	-	-	-	4	3	4	3	3		25
43	Meadow	O	-	1	-	-	1	1	1	1	-	-4	2	0	0	1	1	1	1	1	1		9

Ecological Value of the Anthropogenic Components

The similar table was generated for the anthropogenic components of the landscape. The overall summary of the components is presented in table 2 below. From the table we can see, the major anthropogenic components which were observed in the area were Agricultural fields, Bare lands, Buildings (includes residential and commercial places), Electric lines, Fence, Small plantations, Roads, and sand mine (partially located in the study area).

Table 2: Description of the Anthropogenic components of the landscape

No	Type	Structure/shape	Position	Size	Impact – potential conflicts							Notice	Synt
					Land	Soil	Water	Air	Noise/odour	Wildlife	Aesthetics		
1	Buildings	.	-	1	-1	-1	-1	-1	0	0	3		-1
2	Arable Field	o	/	5	-4	-4	-2	0	-2	-2	3		-55
3	Sand Mine	o	U	1	-5	-5	-5	0	0	-2	0		-17
4	Buildings	.	-	1	-1	-1	-1	-1	0	0	0		-4
5	Buildings	□	/	4	-3	-1	-1	0	0	0	3		-8
6	Plantation	□	-	5	-3	-5	-4	0	0	-1	0		-65
7	Buildings	.	-	2	-1	-1	-1	0	0	-1	0		-8
8	Buildings	.	-	3	-1	-1	-1	0	0	-1	4		0
9	Buildings	.	-	4	-2	-2	-1	0	0	-2	2		-20
10	Buildings	o	/	4	-3	-3	-1	0	0	-2	3		-24
11	Buildings	o	/	4	-3	-3	-1	0	0	-1	3		-20
12	Electric Line	I	/	4	-1	0	0	0	0	-1	0		-8
13	Bare Soil	□	/	2	-3	-4	-4	-2	0	-3	0		-32
14	Buildings	o	-	4	-3	-2	-2	0	0	-1	2		-24
15	Fence	/	-	1	0	0	0	0	-	-2	0		-2
16	Electric Line	/	-	1	-1	0	0	0	0	-1	0		-2
17	Buildings	□	-	4	-3	-3	-1	0	0	-1	4		-16
18	Buildings	□	/	4	-3	-2	-1	0	0	-1	3		-16
19	Road	/	-	4	-4	-3	0	-4	-4	-3	1		-68
20	Buildings	o	-	3	-4	-3	0	-3	-2	-2	2		-36
21	Arable Field	o	-	5	-5	-5	-4	-2	-1	-2	3		-80
22	Arable Field	o	U	5	-5	-5	-4	-2	-1	-2	3		-80
23	Arable Field	o	/	4	-5	-4	-4	-2	-1	-2	2		-64
24	Arable Field	o	-	3	-3	-3	-2	-1	-1	-2	1		-33
25	Electric Line	/	-	5	-1	-1	-1	-1	-1	-3	1		-35
26	Arable Field	o	-	3	-2	-4	-3	-2	-1	-2	2		-36
27	Road	/	-	2	-3	-4	0	-2	-3	-3	1		-28
28	Buildings	o	-	3	-2	-3	0	-2	-3	-1	1		-30
29	Arable Field	o	-	4	-3	-3	-4	-2	-1	-2	3		-48
30	Arable Field	o	-	3	-3	-2	-2	-3	-2	-3	3		-36
31	Buildings	o	-	2	-3	-2	-2	-3	-2	-3	3		-24
32	Buildings	o	-	2	-3	-3	-2	-3	-2	-2	3		-24
33	Arable Field	o	-	4	-3	-4	-2	-1	-1	-3	2		-48
34	Arable Field	o	-	3	-2	-3	-2	-1	-1	-3	2		-30
35	Arable Field	o	/	3	-5	-3	-3	-1	0	-2	3		-33
36	Arable Field	o	-	4	-5	-3	-3	-1	0	-2	3		-44
37	Buildings	o	-	3	-3	-2	-3	-1	0	-3	2		-30
38	Arable Field	o	-	4	-5	-3	-3	-1	0	-2	2		-48
39	Arable Field	o	-	1	-5	-3	-3	-1	0	-1	1		-12

Although the survey team could not enter sand mine, but it is understandable that, the sound of heavy machineries at the mine impacts the wildlife around the area. At the same time, the ponds also hold the diverse aquatic ecosystem in the landscape.

Figure 6: Anthropogenic Components in the Study Area

Figure 6 above shows some examples of important anthropogenic components in the study area. The interesting point about the first picture above is, the bridge could be an ecological corridor between the patches in the both sides of the lake. However, due to the presense of the restaurent beside the lake it's doing the opposite by hampering the route of movement for the habitats. In the right picture in the bottom, we see the slope of the land in an agricultural land. The soil is more sandy as well as having a slope makes the land prone to erosion. At the same time, the fertilizers from this field can also effect the waterbodies in the valley. Therefore, we can say that, the anthropogenic componets of this landscape are has diverse interaction with the whole landscape.

Aesthetic Value of the Components

From the above observations it is evident that, the landscape has a diverse landscape. This diversity of the landscape attracts the tourists and hikers to the area. However, not all the places of the area are equally aesthetically valuable. Although most of the places are create a positive impression, still there are places where the view of the landscape is not eye soothing. The survey groups also collected the aesthetical values of different points inside the area. The points are collected normally approximately every 200-300 meters. After collecting the values for each aesthetic criterion, we calculated the average of the values. Table 3 contains the summary of the aesthetic values for 40 points inside the location.

Table 3: Aesthetic value of the landscape

No	Visible plans	Diversity of elements	Harmony of composition	Devastation	Infrastructure	Sum		No	Visible plans	Diversity of elements	Harmony of composition	Devastation	Infrastructure	Sum		Avg
1	3	2	4		4	13		1	2	2	-2		1	3		8
2	2	2	3	0	3	10		2	3	2	4	0	3	12		11
3	3	3	4		3	13		3	3	3	2		4	12		12,5
4	3	4	3		3	13		4	2	2	3		4	11		12
5	2	2	3		1	8		5	3	2	3		2	10		9
6	4	3	3			10		6	4	3	3			10		10
7	3	2	3		3	11		7	4	2	3		3	12		11,5
8	2	3	2		5	12		8	3	3	3			9		10,5
9	1	2	2		3	8		9	4	4	4			12		10
10	3	3	3			9		10	4	4	4			12		10,5
11	2	3	3		3	11		11	4	4	4		2	14		12,5
12	3	3	4			10		12	3	3	4			10		10
13	3	4	5	1	3	16		13	3	4	5	1	3	16		16
14	4	3	3	1	2	13		14	4	3	3	1	2	13		13
15	3	3	2	1	1	10		15	3	4	3	1	1	12		11
16	4	3	2	1	2	12		16	2	3	1	1	1	8		10
17	3	2	3	1	1	10		17	3	2	4	1	2	12		11
18	4	3	5	1	2	15		18	2	3	3	1	1	10		12,5
19	2	3	2	1	2	10		19	2	3	3	1	2	11		10,5
20	4	2	3	1	3	13		20	4	3	2	1	3	13		13
21	3	3	2	1	2	11		21	3	4	2	1	2	12		11,5
22	2	4	3	1	3	13		22	2	3	3	1	3	12		12,5
23	4	4	5	1	2	16		23	3	2	4	1	1	11		13,5
24	2	3	4	1	1	11		24	4	2	3	1	3	13		12
25	4	3	1	0	0	8		25	4	0	3	4	0	11		9,5
26	4	3	1	3	0	11		26	5	3	1	3	0	12		11,5
27	3	2	1	1	0	7		27	5	2	1	1	0	9		8
28	4	4	2	2	0	12		28	4	3	2	2	0	11		11,5
29	5	4	1	4	5	19		29	5	1	2	1	0	9		14
30	5	1	3	0	0	9		30	3	3	4	4	3	17		13
31	5	2	3	1	0	11		31	4	1	3	1	4	13		12
32	3	3	2	2	0	10		32	4	1	1	4	4	14		12
33	4	0	1	3	0	8		33	3	2	3	0	0	8		8
34	4	3	3	0	0	10		34	5	3	3	0	0	11		10,5
35	3	4	3	2	4	16		35	5	3	4	2	4	18		17
36	5	2	4	1	0	12		36	4	2	3	5	5	19		15,5
37	5	2	2	3	3	15		37	3	2	4	5	5	19		17
38	5	4	4	2	0	15		38	3	4	4	1	0	12		13,5
39	5	1	2	0	4	12		39	4	3	2	1	0	10		11
40	4	1	2	4	0	11		40	2	0	0	5	5	12		11,5

Discussion

Landscape Structure

During the filed observation the survey groups has collected the data about the different components of the landscape. Besides that, the groups also made notes about the land use and land classes of the landscape which was used to produce the structural map of the location with the help of Geographic Information System (GIS) software. In the below figure, we can see the Landscape structure of the area, where we can see that, the dominant land use in the area is agriculture which is denoted as 'Field' in the map. It was also seen that; the concept of agroforestry is increasing in the area. Both agroforestry and agriculture host a large community of habitats. The crops in the agricultural fields were mostly different types of grains. The farmers might be using fertilizers and insecticides in these farms, which with the rainwater might flow to the Waterbody nearby. This creates a potential risk not only for the species in water, but also for the wildlife who drinks water from the river. Therefore, the concept of sustainable agriculture should be promoted in this region discouraging the use of pesticides.

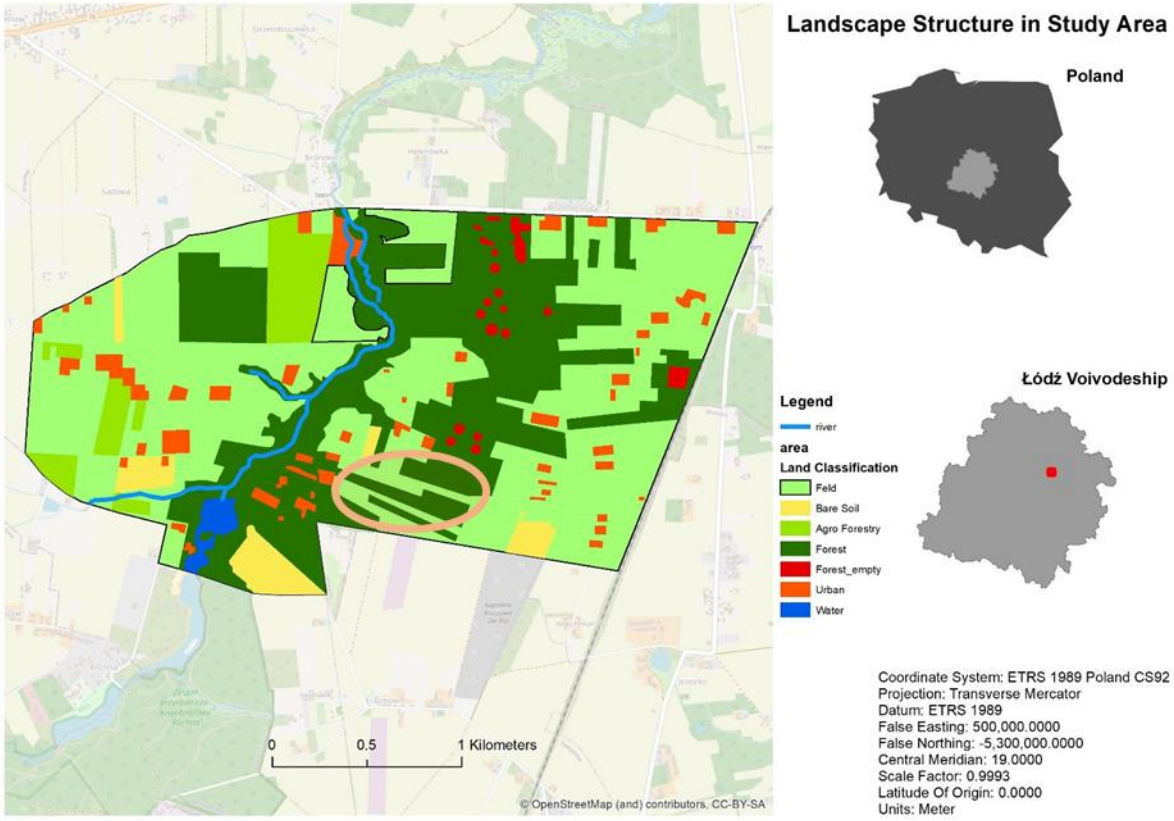

Figure 7: Structural map of the landscape

The second most dominating land use in this area is forests. Most of these forests are managed mixed forests. Since the forests are mixed, it is a positive aspect for the species diversity. Different smaller species of herbs and shrubs were also seen in the forest bed, this provides shelter for smaller insects, i.e., the survey groups spotted some of the ant hills in the forest. Along with this, the forests are hosting different species of birds as well. Nevertheless, some locations inside the forests were found (symbolised by *Forest_empty*) where the forest were cut, creating empty patches. Some urbanisations are also seen inside the forest, which is hampering the movement of the wild animals inside the forests. We can already see that, in the south-western part of the study area, near to the urban areas

the forest has started to fragment (marked in circle) in smaller pieces and there is no ecological corridor visible. As a result, the habitats in the fragment will be isolated which would create a negative impact in future and might result in the extinction of some species in that area.

Ecological Value

In the result section the synthesised values of functions and impacts were presented. Combining all the values from both anthropogenic and natural components, we classified the area in 5 classes of ecological significance. The lowest class has ecological value in the range from -100m to -20 while the ecologically best locations have values from 220 to 300. It is seen from the ecological value map that; the anthropogenic components have the lower ecological values which might be associated with the human intervention in the nature. After that, the waterbodies and some portions of the forests are in the secondary class with ecological value from 140 to 220. However, interesting fact about a large portion of the current forest are located in the class with ecological value range from 60-140. This indicates the deterioration of the forests. This was also evident during the field observations; the survey groups could locate some of the forests where small patches were cleared inside the forests.

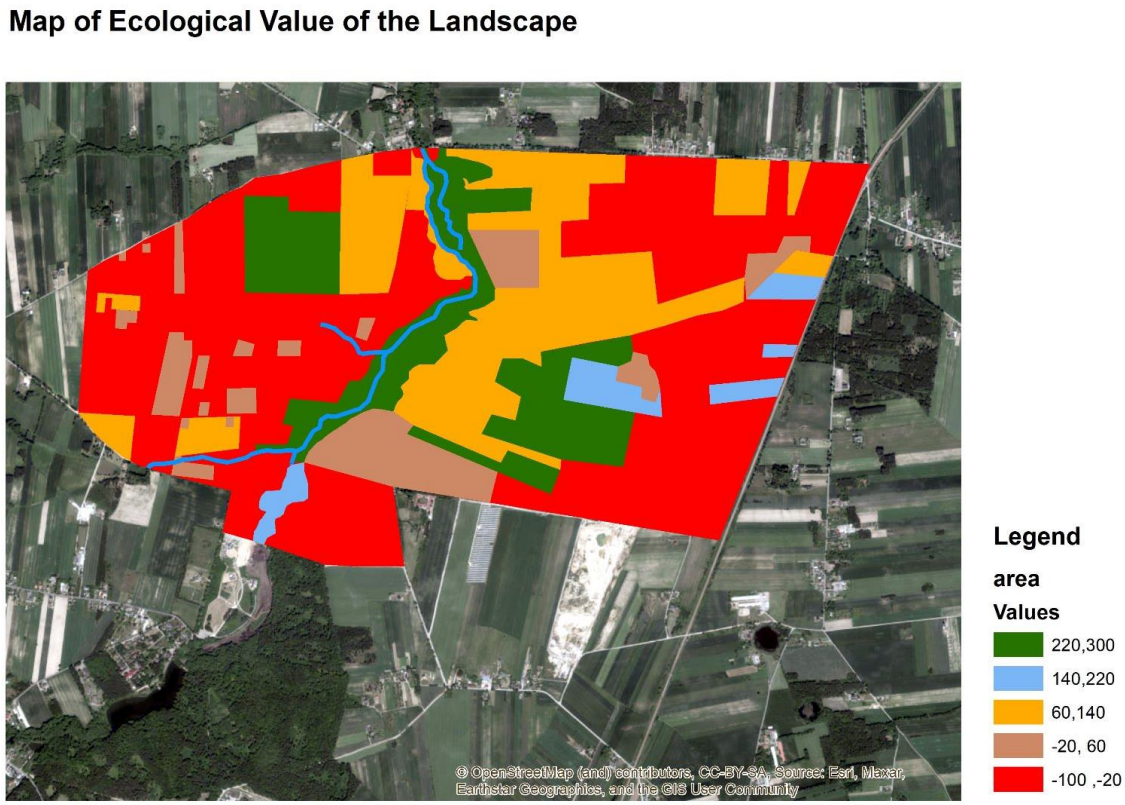

Figure 8: Ecological value map of the area

In some parts of the forest the trees were uprooted due to the storm and erosion. These places were not regenerated, as a result the dependent species may also move to some other places. The open cycle and walking track through the forest also disturbs the neighbouring habitats in the forest. Therefore, it is recommended that, the human movement should be more controlled through the forests. Nevertheless, among many functions of the forest, tourism is a significant one which cannot be completely stooped. Therefore, we tried to create a path consisting of the points with high aesthetic values based on the aesthetic scores collected during the field survey.

Aesthetical Value

Following the similar approach as the ecological values we summed up the aesthetical values as well which were collected during the field work. The figure 9 below shows the location of the points and the map of the aesthetical values of the area. We can see that the points with the lowest aesthetical values are distributed near the edges of the landscape. When we compare this map with the map of land use in figure 7, we can see that, the points with lowest aesthetical values are mainly located near to the urbanised areas, meaning the expansion of urbanisation does not only affect the exact place where urbanisation is taking place, but also surrounding places.

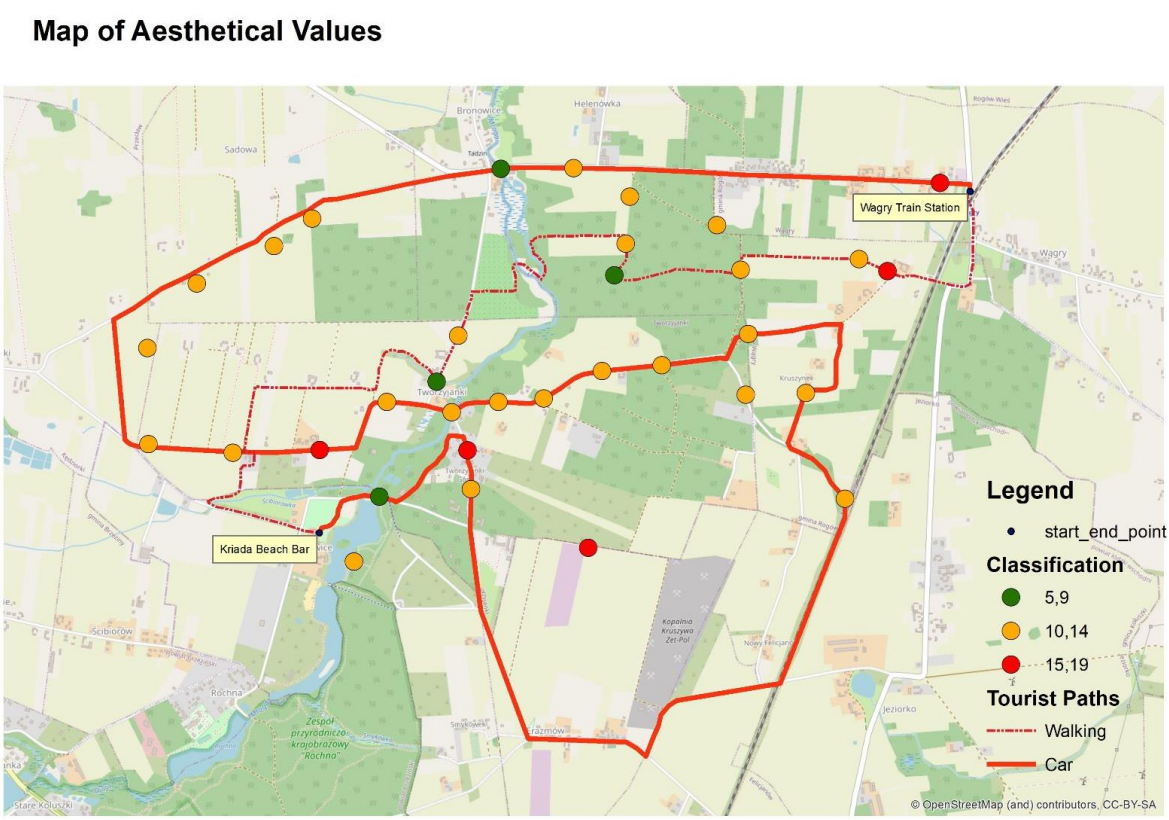

Figure 9: Ecological value map of the landscape

However, it is also true that, the infrastructure that is already built those cannot be removed instantly as these involved investments. Therefore, it could be considered that, the urbanisation inside this area be done in planned and sustainable way. We saw a lot of small and medium walking and biking tracks inside the forest which is creating more patches causing the fragmentation inside the forest. We suggest that the whole forest should be covered with one path for which the tourists can follow. By following this approach, the rest part of the forest can be left unused. The dotted line in the map is the recommended route for the tourists who visit the location on foot or by their bike. It is noticeable that, the path is going through the forest. For the tourists with vehicle, we recommend diverting the vehicle through the outer area of forests, thus we can reduce the impact of the vehicles on the habitants of the forest.

Alongside these paths, some restrictions should be introduced to ensure the least amount of disturbance. The tourists should be informed to limit the speed of their bikes, not to make excessive amount of noise, and not leave their trash inside the forest etc. There was a bridge noticed on the roads. We recommend introducing some additional bridges which should be designated only for the

movement of the wild animals. By doing so the ecological corridors can be established among the smaller patches.

Recommendations to Improve the Landscape

From the map of the ecological value of the landscape, we can draw two conclusions that are important when it comes to improving the quality of the landscape: stabilise and preserve ecologically valuable areas and change critical ones.

Among the various landscape components observed, one of the most ecologically valuable elements appears to be the river and its adjacent forest. This area serves as a buffer zone, offering multifunctionality and playing a crucial role in supporting biodiversity. It is essential to prioritize the protection of this ecosystem in order to maintain or enhance its quality. One potential step towards ensuring its long-term preservation could be the establishment of a nature reserve. By designating this area as a protected zone, we can create a framework for implementing further actions and conservation initiatives, for example:

- **Riparian buffer enhancement:** In some places the buffer zone is rather small. Planting native trees, shrubs and grasses helps stabilize the soil, filter pollutants, and provide habitat for wildlife. It will also serve as a natural barrier in the event of flooding.
- **Habitat improvement:** Assess the river for barriers that impede fish migration and implement fish passage solutions if necessary. Check the forest for invasive species.
- **Monitoring program:** Establish a long-term monitoring program to assess the effectiveness of landscape improvement initiatives. Regularly monitor water quality, vegetation composition and wildlife presence.

The presence of the river and the adjoining forest plays a crucial role as a migratory pathway from north to south in the landscape. To improve the overall quality of this area, it is essential to focus on enhancing connectivity. A recommended approach is to establish an east-west corridor that connects the vast forested region in the northwest with the nearby river. This can be achieved by creating a field-edge corridor spanning approximately 10 meters wide. Planting a combination of native grasses, shrubs, and trees within this corridor will create suitable habitats and facilitate wildlife movement. This concept can also be applied to the woodlands in the eastern part of the landscape. In figure 10 some locations are identified where the plantation can be introduced to ensure the movements of the animals like deer, wild boar, and other predatory mammals from one patch to other patch.

Figure 10: Recommended locations to introduce new forests (Numbered as 1-6)

To further enhance the ecological value of the field-edge corridor, additional wildlife-friendly features can be incorporated. Installing birdhouses and bat boxes along the corridor will provide nesting opportunities for birds and bats, promoting biodiversity and contributing to the overall health of the ecosystem.

In general, the strategic placement of trees along field edges or within the fields offers numerous benefits. Trees provide shade, which helps regulate temperatures and reduce water evaporation. They also serve as windbreaks, safeguarding crops from strong winds. Moreover, trees contribute to biodiversity by providing habitats for beneficial insects and birds. Another approach to consider, particularly for agricultural fields on sloping terrain, is contour farming. By aligning cultivation with the natural contours of the land, small ridges or furrows can be created. This technique mitigates the flow of water down the slope, allowing it to seep into the soil. Consequently, moisture retention is improved, soil erosion is prevented, and overall soil health is enhanced.

Expanding agroforestry practices is a valuable alternative for converting degraded areas. It offers the opportunity to diversify crop production by introducing a wide range of crops, including cash crops and food crops. This diversification helps mitigate risks, enhance income stability, and contribute to food security. Additionally, integrating livestock through rotational grazing within agroforestry systems presents another avenue for sustainable land use.

A final important step in improving the landscape is to involve the local population in decision-making processes and provide them with further education. By doing so, we can witness a significant positive impact that will lead to the improvement of residential areas, gardens, and other spaces. Education plays a crucial role in raising awareness about the importance of preserving and protecting the natural environment. It enables individuals to understand the significance of sustainable land use practices, such as organic farming, agroforestry, and responsible tourism. When equipped with this knowledge, people are more likely to actively participate in local initiatives aimed at improving the landscape. By involving the local population, we empower individuals to take ownership of their surroundings and contribute to a more ecologically friendly landscape.

Conclusion

In this field survey and corresponding analyses, we tried to realize the theoretical knowledge what we achieved in the lectures for the module 'Principles of Landscape Ecology' in practice. Using the theoretical knowledge, we tried to analyse the landscape. In short, the landscape was sum of a diverse smaller ecosystems like aquatic, urban, forest, and agricultural. Despite having a diverse ecosystem, we realized that, in some locations the ecological values were very poor due to the improper management of the individual landscape components, and unstructured tourist activities which consequently impact the aesthetic values of the landscape too. After studying the ecological and aesthetical components of the whole landscape, we recommended some tourist routes to reduce the negative impact of human mobilisation through the whole landscape. Parallelly, we recommended some steps to enrich the ecological values as well like enhancing riparian buffer zones, introducing new plantations and safer habitation for valuable species in the landscape. It is expected that if these recommendations are applied the ecological values of the landscape will be preserved as well as the tourist activities can be conducted.

As from the student's perspective, the field work was an interesting way to experience how the ecosystems in a landscape function interdependently on field. Besides that, we learned how to implement different theoretical concepts as well as GIS technologies to conduct a landscape analysis under the guidelines of Dr. Taida Tarabuła and Dr. Marek Sławski. We are thankful to them for their contributions to successfully finish this field work.

Appendix

Field work

Mark on the maps more important landscape components using consecutive numbers. If possible, draw boundaries of the elements.
It is suggested to separate numbering of natural or semi-natural components (1, 2, 3...) from the anthropogenic ones (1a, 2a, 3a...). Alternatively, you may use different colours or different maps for natural and anthropogenic elements. Describe each marked component using enclosed tables (for the two distinguished groups).

Natural and semi-natural components (soil surface is not altered by human interventions):
forest islands, woodlots, hedgerows, hedges, shelterbelts, old parks, orchards, streams, rivers, ditches, **ponds**, strips of riparian vegetation, meadows, grasslands, heathlands, abandoned fields with spontaneous succession, ecotones, etc.

Anthropogenic components (soil surface is altered by human interventions):
arable fields, buildings, roads, energetic lines, factories, waste disposal sites (including illegal ones), recreation sites, sand and turf exploitation sites, landfills, various sources of pollution, etc.

Note: We decided to include ponds and water ditch into natural and semi-natural components of the landscape due to their great importance in water retention and biodiversity of the study area.
On the other hand, arable fields are included into anthropogenic elements due to their prevailing adverse effects on environment.

Guidelines for making a description:
Most of the properties can be described using simple symbols and scores (see below).
Assume 1-5 scale. Sometimes you can use 0 or dash -

Natural and semi-natural components:

1. Consecutive number
2. Type of element – as listed above
3. Structure/shape – line /, spaced line ', stripe //, point •, patch O
4. Position – top of a hill ∩, plain terrain -, valley U, slope /
5. Size (width, length, area) – 1-5
6. Age (only for woody vegetation) - 1-5
7. Species richness/composition – if possible, indicate main plant species or vegetation type, otherwise give the approximate number of main species; 1-5
8. Origin: natural - 1, man-made - 0
9. Height/depth– scores 0-5 (0 for bare soil; depth - for aquatic, height – for terrestrial systems)
10. Layers (0 for bare soil; 5 for multi-layered old forests)
11. Connectivity – 0-5 (0 for isolated objects)
12. Ecotone – 0 no evident transition zone, 5 – well developed ecotone, for forests and woodlots only
13. Management intensity – ***Use negative scores!*** (-5-0) (0 for unmanaged elements, -5 for highly intensive management)
14. Health status – 0-5 (completely devastated 0, perfectly good state 5)
15. Functions. Effectiveness of each landscape element in fulfilling various ecological functions should be assessed using score system 1-5. If the function is not relevant to a particular component type, use a dash -, for example protection against wind, snow, noise for ponds:
    a. W/S/N – protection against wind, snow, noise
    b. Erosion – protection against soil erosion
    c. Eutrophication – protection against water eutrophication
    d. Climate – climatic/water retention
    e. Shelters – shelters for animals

f. Food source – source of food for animals
g. Corridor – ecological corridor
h. Aesthetics – aesthetical value

16. Notice – additional important information, e.g. proximity of objects that pose a serious threat (factories, waste disposal sites), protection/conservation (reserves, nature monuments)

In the case of protected areas (e.g. nature reserves) or areas/components of special importance (e.g. patches of vegetation unique to the region), extra scores can be ascribed (max. 10)

Anthropogenic components ***(USE NEGATIVE SCORES in the range of -5-0!!!)***

1. Consecutive number
2. Type of element – as listed above
3. Structure/shape – line /, spaced line ', stripe //, point •, patch O
4. Position – top of a hill ∩, plain terrain -, valley U, slope /
5. Size (width, length, area) 1-5
6. Impact. Possible impact on environment using negative scores. If the impact is not relevant to a particular component type, use a dash -
   a. land (elimination of topsoil)
   b. soil (physical and chemical changes, due to e.g. fertilisation, herbicides, ploughing)
   c. water (thermal or chemical pollution, eutrophication, etc.)
   d. air (dust, gases)
   e. noise/odour
   f. wildlife (adverse effects on plants and animals)
   g. aesthetics
7. Notice – additional important information

Aesthetical value of the landscape

Stop every 200-250 m and assess the visible surroundings with regard to aesthetical traits given below. Assessment should be made for the left and right side of the route, separately.

No	Criteria	Scores
I	Perspectives/visible layers: 1. plain monotonous terrain 2. distinct foreground and background, slightly diversified relief 3. much diversified multidimensional view, distinct perspective	0-5
II	Visible components of the landscape (diversity) 1. monotonous, homogenous view (e.g. arable fields) 2. monotonous view with few single diversifying elements (e.g. single trees, small patches of bushes, water bodies) 3. diversified view (mosaics of patches of different types and structure)	0-5
III	Harmony of composition 1. disharmony, distinct dominance of an element or complete disorder 2. some elements in harmony, some others not 3. majority of elements in good proportions 4. all elements in good proportions, perfect harmony	-5 to 5
IV	Level of devastation 1. no devastation 2. minimal share of devastated areas 3. greater proportion of devastated areas	-5 to 0
V	Infrastructure (buildings, energetic lines, roads, etc.) 1. no visible anthropogenic elements of the landscape 2. single elements of infrastructure having high aesthetical value 3. greater share of infrastructure of no aesthetical value	-5 to 0