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Visual Analysis of the Cultural Landscape in Terms of Vegetation for the Purposes of Revitalization of Rural Areas

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Abstract: The article presents a visual analysis of the landscape, based on the modified SBE method and the possibility of using this type of research for the purposes of revitalization of rural areas. The scope of the research covered the Puchaczów commune in which, due to environmental conditions, mining related to hard coal extraction has developed. The aim of the study was to test the hypothesis that the existence of diverse hight structure of the plant cover increases the attractiveness of the landscape. The research method consisted in using the SBE analysis for 13 landscape units, presented as actual illustrations and modified pictures (as computer visualizations) by adding trees and shrubs. Then, using the one-way analysis of variance (ANOVA) and Tukey post hoc test, it was examined whether there is a significant difference for the average visual value evaluation between original and modified sketches.

Keywords: Scenic Beauty Estimation, rural landscape, group of trees and shrubs

1. Introduction

The concept of sustainable development facilitates the development of rural areas and their revitalization (Kożuch 2010). It consists in integrating activities at the economic and social level, maintaining the balance of the natural environment and the sustainability of the natural processes, in order to meet the needs of current and future generations (Environmental Protection Act of 27 April 2001). In the context of the Common Agricultural Policy implemented by the European Union countries, sustainable development of rural areas is based on multifunctionality, gradual disagrarisation for the benefit of the intensification of the other economic branches, e.g. tourism (Rizov 2005), which in turn influences the transformation of the landscape. The implementation of the principles of sustainable development in rural areas is a problematic and complicated process, in which local politics is of great importance. In Poland, the tasks of municipalities include environmental protection and preservation of spatial

order, carried out by developing a study of the conditions and directions of spatial development, local spatial development plans and the related determination of development conditions (Guzal-Dec 2015). The spatial policy of the communes, built that way, influences their comprehensive modernization using the social and economic potential (Feltynowski 2009). The polyfunctional development of rural areas is inextricably linked with the conscious shaping of the living conditions of the population, but also with revitalization understood as the process of reconstruction of degraded areas, integrated at the social, spatial and economic level (The Revitalization Act of 9 October 2015). The tools supporting the designing and spatial planning process are analyzes of the landscape quality, including visual analyzes.

In studies of landscape, it is noted that its perception is influenced by the components that build it, but also by the memories of inhabitants of specific areas and cultural conditions (Sonnenfeld 1967, Herzog et al. 2000). As Bernat noted, through perception we establish a relationship with the landscape that affects our health not only in the mental, but also physical, spiritual and social context (Bernat 2019). People perceive an unattractive landscape as inferior, and it reduces the quality and comfort of life. One of the elements influencing the aesthetics of the landscape is the vegetation and its appropriate shape. Considering the above, the article hypothesized that the existence of vegetation with a varied height structure increases the attractiveness of the landscape. In order to prove the research hypothesis, a visual analysis of the landscape was performed, based on the modified SBE method, with particular emphasis on plant cover. The innovation of the proposed method consists in comparing the drawings showing the actual appearance of the landscape with the drawings presenting the same areas, where visualizations of vegetation clusters have been added. In further stages of the work, it allowed to examine only a feature related to the type of vegetation (medium and high greenery – shrubs and trees) and its impact on the visual assessment of the landscape. Statistical analysis of the results made it possible to unambiguously answer the question whether the existence of vegetation with a diversified composition structure influences the assessment of the attractiveness of the landscape. The results of the research will facilitate activities related to the conscious shaping of the structure of vegetation at the local level in the context of revitalization of rural areas. The territorial scope of the research covered the rural commune of Puchaczów located in the Lubelskie Voivodeship, where due to natural conditions, in addition to the traditional agricultural function, mining was developed in the second half of the 20th century. These factors have a huge impact on the contemporary shaping of the landscape of the commune and its environmental conditions.

2. The use of visual assessment of the cultural landscape for the purposes of revitalization of the rural areas – the state of research

In Poland, the revitalization of degraded areas is legally regulated by the Revitalization Act (Journal of Laws of 2015, item 1777) and the Spatial Planning and Development Act (Journal of Laws of 2003, No. 80, item 717). The commune's own tasks include designating the areas requiring revitalization works, where there are unfavorable social phenomena and negative factors located at the economic, environmental or spatial-functional level. A low level of forestation should be considered a negative factor that affects the deterioration of the quality of the natural environment, but also affects the spatial structure of the commune. Identifying degraded areas in terms of nature or landscape requires an appropriate diagnosis, adjusted to the local conditions (the Revitalization Act of 9 October 2015, Journal of Laws of 2015, item 1777).

The research on the valorization of landscape resources is considered to be one of the most complex in terms of methodology (Kistowski 2007). The visual assessment of the landscape very often serves utilitarian purposes (Richling, Solon 2011). Most often, such studies are used to determine the tourism potential or to designate areas, which are attractive for recreation (Rylke, Gąsowska 2009), less often areas of natural value and in the process of real estate valuation (Bajerowski et al. 2007). As Jakiel (2015) emphasizes, visual landscape analyzes are very rarely used in the process of spatial planning, and thus in the rural revitalization activities. However, they have the potential that can be used to designate degraded areas with the accumulation of negative spatial-functional and environmental features, and consequently to undertake corrective activities.

There are numerous studies in the field of ecology and landscape architecture and geography related to the subject of research in the field of the visual landscape assessment. The Professor's Bogdanowski JARK-WAK (1994), Wejchert's Impression Curve Method (Wejchert 1984), the Bajerowski's Method of Value Matrix (1996) can be classified as the most popular methods in Poland. Among the foreign methods which are commonly used in Poland, the assessment of the beauty of scenery SBE – Scenic Beauty Estimation (Daniel, Boster 1976) should be mentioned.

The JARK-WAK method is based on the determination of homogeneous areas in terms of shape, cover and historical origin. Depending on the planning scale, architectural and landscape units or architectural and landscape interiors are distinguished, which are then divided into three categories: natural, cultural and natural-cultural landscapes. The next stage is valorization, consisting in assigning appropriate grades to the landscapes: the historic landscape receives a grade from I to III, modern IV, and mixed – grades V-VI. The last

step is to indicate the directions of activities and the scope of protection of individual units (Wrochna 2012).

The Wejchert's Impression Curve Method is based on the graphical representation of the emotional experience related to the perception of a place along a specific time-space sequence. Assessments are made at intervals according to the criteria related to the degree of diversity, the degree of devastation, infrastructure saturation and the harmony of the composition. The criteria are assessed on a point scale. The results for the criteria are summed up and presented in the form of a graph - an impression curve (Szopińska et al. 2016). This study presents the observer's feelings when staying in a given place (Gąsowska 2008). Based on this method, it can be concluded which parts of the landscape have higher or lower visual values (Szopińska et al. 2016).

It should be emphasized that the above-mentioned methods are not based on statistical data which can significantly be used to verify the relationship between landscape components and the assessment of its visual values.

The Bajerowski's Method of Value Matrix is based on a mathematical and statistical analysis of information contained in generally available maps. In these studies it was assumed that the aesthetic value of a landscape results from the configuration of spatial features. These features are often analyzed only with the help of cartographic materials. The studied area is divided into basic assessment fields and assigned a numerical measure that determines the visual value of the landscape (Litwin et al. 2009). Due to the nature of the research, this method ignores significant intangible landscape factors (Antolak 2017).

The Scenic Beauty Estimation is a method based on the evaluation of space by a group of recipients who are presented with photos showing various types of landscape. This study was developed by the United States Department of Forestry (Tveit et al. 2018). The respondents evaluate the photos on a 10-point scale, in which the lowest values are assigned to the least attractive areas. Then the arithmetic mean score for each photo is calculated and in the next step the result is normalized by the standard deviation formula (Gąsowska 2008).

The research on the visual quality of rural landscapes, based on the analysis of the beauty of the scenery combined with a statistical study, was carried out by Arriaza et al. (Arriaza et al. 2004). In the work, the authors presented the methodology of direct and indirect landscape evaluation techniques on the example of two Mediterranean rural areas. The direct method was based on the assessment of the beauty of the landscape by studying the preferences of the observers. The indirect technique involves assigning the contributions of individual landscape elements to its overall aesthetics through regression analysis. According to the results, the factors that play a key role in determining the visual quality of rural areas are the degree of naturalness of nature and the presence of historic or typical buildings, traditional for the region. Another factor deter-

mining the aesthetic value of a landscape is the presence of water and color contrast. In the above-mentioned studies, the degree of nature's naturalness is understood as the degree of trans-formation of the landscape, including the flora. This proves that vegetation, as one of the components of space to a large extent related to anthropogenic factors, which is particularly visible in rural areas, affects the attractiveness of the region. However, it should be noted that the research results did not show that the variable related to the type of vegetation (low vegetation, shrubs, trees) is statistically significant, which means that there is no reason to reject the null hypothesis that there is no correlation between the type of vegetation and visual assessment of the landscape (Arriaza et al. 2004).

3. The importance of tree stands in the revitalization of rural areas

Revitalization of rural areas is related to the protection of the envi-ronment, which can manifest itself through strengthening and improving the functioning of the existing natural systems, as well as through creating new systems in the form of, for example, trees. The importance of trees in the process of shaping the agricultural production space was known in Poland as early as the 1820s and is associated with the person of General Dezydery Chłapowski. In his estate in Turwia, General Chłapowski created a regular network of banded trees, the purpose of which was, among others the wind protection (Kujawa et al. 2019). Activities related to the reconstruction of the landscape, based on the conditions of the natural environment, resulted in the creation of a space with high aesthetic values and high production value of crops (Raszeja 2010).

Mid-field afforestation increase the yield of crops, except for the strip of land in their immediate vicinity (Koreleski 2006). They counteract the decline in the level of biodiversity caused by the intensification of agriculture (Orzechowski, Trzcianowska 2016). The mid-field tree afforestation ia a refuge environment for numerous species of flora and fauna, including pollinating insects (Ryszkowski 1998). Their presence in rural areas provides a rich food base throughout the growing season and creates suitable places for nesting. In addition to biocenotic functions, tree cover plays the role of ecological structures: patches, nodes, corridors and islands (Bożętka 2017). In addition, they regulate the microclimate, inhibit wind speed, reduce water evaporation from the soil, and affect temperature, which is particularly important in times of current climate changes.

Apart from the mid-field afforestation which is so important for the rural landscape, it is necessary to emphasize the importance of roadside and water-bearing trees, which together with forest complexes and smaller groups of vegetation form the green systems of the rural communes. Properly shaped tree systems constitute an extremely important buffer zone between industrial, agricultural and residential areas. They create a biogeochemical barrier to pollution.

They also distinguish features, elements recognizable in a monotonous agricultural landscape and definitely improve the visual value of the landscape.

4. Research methodology

The subject of the study is the analysis of the landscape of the Puchaczów commune in terms of the influence of medium and high greenery (clusters of shrubs and trees) on the assessment of visual values. Puchaczów is a rural commune in which, due to the presence of hard coal deposits, the mining industry has developed. The largest enterprise operating in the region is the Bogdanka Coal Mine, located in the central part of the commune. Industrial areas, roads with intensive traffic and compact buildings are classified as ecological barriers, i.e. structures that hinder the movement of matter, energy and information in the natural environment. Large forest complexes in the towns of Ciechanki, Ostrówek, Zawadów, Wesołówka, Puchaczów and Nadrybie have the form of ecological patches. The ecological corridors located within the studied area include meadows and pastures of a stripy nature, accompanying the Mogielnica and Świnka valleys (Fig. 1). A properly carried out revitalization process, related to the increase in the number of trees in the commune, may in the future improve the functioning of ecological structures, while inhibiting the development of negative factors. This will significantly improve the quality of life of the commune inhabitants.

A modified method of assessing the beauty of scenery (SBE) was used in the research on the evaluation of visual values of the landscape of the described area. The choice of the method was not accidental. In order to test the research hypothesis, it was necessary to compare the areas that differ from each other by one variable feature (there is or don't exist a differentiated height structure of vegetation). The need to use a modified SBE method was also influenced by the distribution of research units over a large area, which makes it impossible to determine a uniform time-space sequence and the use of, e.g. the Wejchert's Impression Curve Method The first stage of the work was to delimit homogeneous research units. In order to distinguish the research fields, an analysis of land cover and an analysis of the shape of the surface were used. The method used enabled the designation of 13 research units, typical for the landscape of the Puchaczów commune (Table 1), having the character of agricultural land, compact buildings, meadows and pastures and industrial areas. Due to the high degree of diversity of the flora, forest units were omitted in the study of visual landscape values and the impact of medium and high greenery (shrubs and trees) on this assessment.

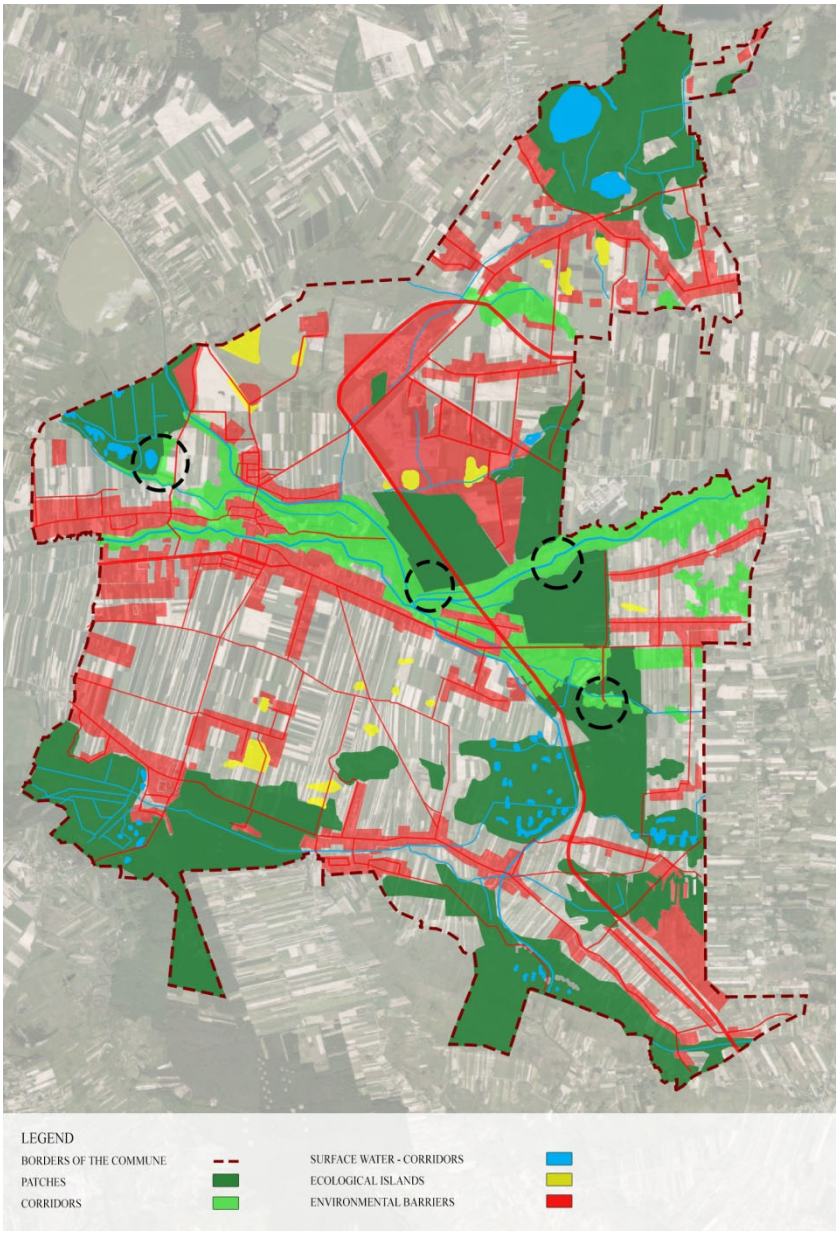

Fig. 1. An analysis of ecological structures in the Puchaczów commune (Own study based on: orthophotomap, https://puchaczow.e-mapa.net/, accessed: 08/01/2018)

Table 1. Featured research units in the Puchaczów commune (Own study 2019)

Research Unit	Unit symbol	The degree of variation in the height of the plant cover	The outline number on the map
Compact settlement on flat areas	ZP	Low	1
Compact settlement on slightly undulating areas	ZL	Low	2
Compact settlement in clearly undulating areas	ZW	Low	3
Agricultural lands in flat areas	RP	Low	4
Agricultural lands in slightly undulating areas	RL	Low	5
Agricultural lands in clearly undulating areas	RW	Low	6
Industrial areas in slightly undulating areas	PL	Low	7
Industrial areas clearly undulating	PW	Low	8
Industrial areas in river valleys	PD	Low	9
Meadows and pastures in flat areas	ŁP	Medium	10
Meadows and pastures in slightly undulating areas	ŁL	Medium	11
Meadows and pastures in clearly undulating areas	ŁW	Medium	12
Meadows and pastures in river valleys	ŁD	Medium	13

Fig. 2. Map showing the locations of the drafts performed against the background of the distinguished research units in the Puchaczów commune, gray color marks the omitted forest complexes in visual analysis (Own study 2020)

For the selected units, the author indicated representative places (chosen at random), in which she made illustrations showing individual types of landscape (Fig. 2). The figures were then computer-modified by adding bushes and trees. The use of black and white traces in the study is justified by the need to standardize the way individual units are perceived by the respondents.

For SBE reaserch to be credible, standards for group diversity and number of observers must be adhered to. According to Daniel and Boster (1976), a group of just 20 people can provide reliable landscape assessment results. Bearing in mind the above statement and the limited time frame of the experiment itself, the SBE research presented in the article was attended by a group of 20 people diversified in terms of sex, age, education and place of residence. Among the respondents, 50% were men and 50% were women. 15% of the answerers are people under the age of 20, 25% in the 20-30 age group, 20% in the 30-40 age group and 25% in the 40-50 age group. 15% of participants were over 50 years old. More than half of the respondents (60%) were people with higher education, 35% with secondary education, and 5% with primary education. Among the answerers, 45% live in the city, and 55% in rural areas (in order to eliminate the subjective assessment related to the sense of belonging to a given place, they were not, however, inhabitants of the studied region). The respondents were presented with illustrations in a random order, in the form of a multimedia presentation. The people taking part in the study were unaware that the figures represented the actual and computer-modified appearance of the space. A single slide was displayed for 15 seconds. The study participants assessed the aesthetic level of the illustrations on a 10-point scale, in which 10 was assigned to areas of higher visual value, and 1 to the least aesthetic areas. As a result of the study, a total of 260 assessments were obtained, which were then standardized using the formula:

$$Zij = (Rij - Rj) / sj \quad (1)$$

where:
Zij – the standardized result for the i-th assessment of the respondent j,
Rij – the i-th j-observer's assessment,
Rj – the mean of all ratings of respondent j,
sj – the standard deviation of all observer j ratings (Daniel, Boster 1976).

5. Results

The average results of the standardized assessment for individual drafts are shown in Fig. 3. On the axis truncated with symbols, illustrations showing research units are described, where the original figures (without added plant clusters) contain a letter designation (e.g. ZP), and the drawings contain a letter-number designation (e.g. ZP2).

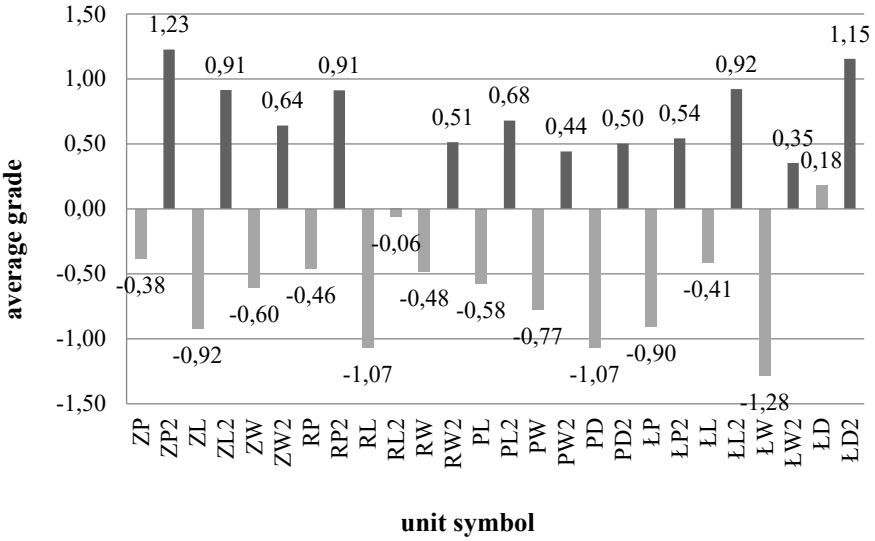

Fig. 3. Average results of standardized assessments for individual sketches (Own study 2020)

As it results from the analysis of Fig. 3, all the drafts with shrubs and trees added were assessed as more attractive compared to the original figures. The lowest scores during the SBE analysis were given to primary illustrations characterizing meadows and pastures in clearly undulating areas (ŁW), production areas in valleys (PD), agricultural lands with a slightly undulating areas (RL), compact settlements in slightly undulating areas (ZL) and meadows and pastures in a flat area (ŁP).

Fig. 4. Real illustration showing meadows and pastures in a clearly undulating area (ŁW) assessed by the respondents as the least attractive (Own study 2019)

Among the presented illustrations, the highest rated were the modified figures, showing: compact settlements on a flat area (ZP2), areas of meadows and pastures in river valleys (ŁD2) and in slightly undulating areas (ŁL2), agricultural lands in flat areas (RP2) and compact settlements in slightly undulating areas (ZL2).

Fig. 5. The highest-rated computer-modified sketch showing compact settlements in a flat area (ZP2) (Own study 2019)

In order to test the research hypothesis that increasing the diversity of the height structure of vegetation significantly influences the differentiation of the visual assessment of the landscape, a one-way analysis of variance was performed. As a result, it turned out that the compared traces differ in a statistically significant maner $p < 0.05$. Tukey's post hoc test was used to check the significance level of the differentiation of the mean scores between the original and the modified drafts for individual units. The test results are presented in tabular form (Table 2). The lowest p value equal to 0.000020 can be observed in four groups: ZP-ZP2, ZL-ZL2, PD-PD2, ŁW-ŁW2 (Fig. 6). In the RW-RW2 group (Fig. 7) the p value is the highest and amounts to 0.010457. However, in all compared groups, the p value is less than 0.05. This means that the differences in the mean visual value assessment between the original and the changed drafts are statistically significant for each research unit. Moreover, in order to show disproportions between the ratings of the primary drawings in relation to the visualization, the author presented the differences between the average ratings in the individual compared groups. It is worth noting that the greatest difference between the average assessment of the primary outline and the modified image is in the ZL-ZL2 group and amounts to 1.83. Another large difference was noted in the ŁW-ŁW2 group (1.63). The smallest difference in mean scores is in the LD-LD2 group (0.91).

Table 2. Tukey's post hoc test results for the average assessment of primary contours and modified (Own study 2020)

Sketches compared with each other	*p* value	Differences between the mean values of standardized assessments
ZP-ZP2	0.000020	1.61
ZL-ZL2	0.000020	1.83
ZW-ZW2	0.000105	1.24
RP- RP2	0.000022	1.37
RL-RL2	0.002167	1.01
RW-RW2	0.010457	0.99
PL-PL2	0.000030	1.26
PW-PW2	0.000246	1.21
PD-PD2	0.000020	1.57
ŁP-ŁP2	0.000021	1.44
ŁL-ŁL2	0.000022	1.33
ŁW-ŁW2	0.000020	1.63
ŁD-ŁD2	0.007161	0.91

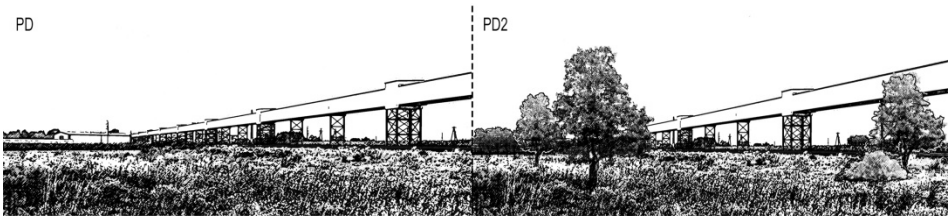

Fig. 6. Primary and modified traces of an industrial area in the valley with a *p* value of 0.000020 (Own study 2020)

Fig. 7. The compared group of the original (RW) and the modified (RW2) draft for an agricultural unit in clearly undulating areas with the highest p value of 0.010457 (Own study 2020)

6. Conclusions

The SBE analysis carried out in the Puchaczów commune showed that, regardless of the form of use and topography, the figures of landscape units on which trees were added had higher visual values. Results of one-way analysis of variance and Tukey's post hoc test showed that there is a statistically significant difference in the mean visual value of the original and modified sketches. This proves the correctness of the research hypothesis presented in the article saying that the existence of differentiation in the height structure of the flora has an impact on increasing the attractiveness of the landscape.

On the basis of the presented research, elementary activities facilitating the revitalization of the Puchaczów commune can be determined. It should be noted that the places requiring improvement of the visual quality of the landscape for the studied area are, in particular, compact settlement on flat areas, slightly undulating areas, industrial units in the river valleys and meadows and pastures in in clearly undulating areas, that is, the units with the lowest visual rating. This quality of landscape aesthetics can be increased by changing the structure of vegetation and introducing groups of trees. In densely built up areas, along the main communication routes, insulating vegetation should be introduced, which will also reduce noise. Between the industrial areas and other units, it is necessary to expand the existing greenery system with a buffer function. In addition, tree plantings should obscure the technical infrastructure related to the existence of the mine, which is unattractive for observers. The landscape of meadows and pastures can be diversified by planting groups of trees and shrubs. In addition to increasing the visual value, they will also improve the functioning of the main ecological structures, and in the future they may be-

come ecological islands of local importance, facilitating the movement of matter in the environment.

It is worth emphasizing that the introduction of new groups of tree stands should always be preceded by actual plant community research and identification of the existing habitat conditions. Only such a research process will make it possible to correctly indicate specific species recommended for planting. For example, in the process of shaping mid-field shelterbelts in dry soils, species such as: *Pyrus communis*, *Prunus spinosa*, *Malus sylvestris*. In humid and shady habitats: *Prunus padus*, *Sambucus nigra*, *Sorbus aucuparia*, *Corylus avellana.*

7. Summary

Visual analyzes of the landscape facilitate the process of identifying rural areas requiring revitalization works. They are an effective tool in identi-fying specific elements disrupting the spatial order and thus, indirectly, they can be used to indicate guidelines aimed at improving the quality of rural life.

Revitalization of rural areas, which consists in deliberately shaping the vegetation by introducing tree coverings of a form appropriately matched to the area, e.g. in the field, along communication routes, has a positive effect on the landscape structure, both at the environmental and functional-spatial level. Proper species selection is also an inseparable issue related to the increase in the number of trees. The general rule is to avoid invasive species in favor of native plants adapted to the prevailing habitat conditions.

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