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The Use of Camouflage Colours to Reduce the Visual Impact of Industrial Facilities on Open Landscape

Otylia Serwatko [1], Kamila Pawłowska [1,*] and Bartosz Jawecki [1]

Department of Landscape Architecture, Wrocław University of Environmental and Life Sciences, Grunwaldzka 55, 50-357 Wrocław, Poland

* Correspondence: kamila.pawlowska@upwr.edu.pl; Tel.: +48-691-211-543

Abstract: The use of camouflage colours on industrial sites reduces the visual impact on the open landscape and indirectly identifies the impact of the current condition on visual perception. The research includes the creation of original landscape panoramas and those with camouflage patterns on them in order to analyze and examine their impact on the surrounding landscape. Sector Panorama Analysis was chosen as the leading method of analysis. The knowledge of the objects selected for the study contributed to a better judgment and, thus, a more thorough interpretation of the factors affecting the environment. A survey questionnaire was used to investigate the visual impact of camouflage. Results of the present study were used to compare the average ratings obtained by particular camouflage patterns and also to draw conclusions about the improvement of the visual perception of the object after their application. The highest increase in comparison to initial panoramas was achieved by the Polish pattern WZ.93.

Keywords: visual assessment; colour camouflages; industrial landscape; panorama analysis

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1. Introduction

The landscape is a space that we should care for not only due to the visual sensations that it brings but also because it plays an important role in the proper functioning of space. The ambiguity of the definition of the term "landscape" is reflected in numerous fields where this subject is analysed. Humans are an important factor in shaping the space that surrounds us; their decisions may be beneficial or not, but each of them affects the visual perception of places and of space. The perception of landscape and the evaluation of its changes is often a subjective matter that depends on numerous factors, including both the observer and the analysed space. Changing seasons, sunlight, and the observation process in itself are proof of the complexity of the factors that determine the final assessment of the landscape. The landscape is a reflection of human responsibility and awareness with respect to shaping it and the changes that take place in it [1–3].

Industrial facilities are an inherent part of the modern world. Although many believe that they disfigure the landscape [4–6], they are necessary, mainly due to the economic opportunities that they carry. Incorrect decisions about positioning objects in space often have negative consequences that affect the appropriate perception of landscape, in particular, its unique values. The appropriate actions aimed at restoring harmony in the perceived landscape may bring tangible benefits, not only in aesthetic terms but also in the environmental aspect [7,8]. Knowledge about camouflage may be successfully used to mitigate the negative visual effects of unattractive, large cubature objects whose shape stands out in the background of open spaces.

The subject of this study is to analyse the influence of the application of military camouflage patterns on industrial facilities in order to reduce their visual impact on the surrounding landscape. The aim is to reduce the impact on the landscape and to blur the site so that it does not have features that dominate and disharmonise the landscape.

Panoramas of selected industrial objects with applied selected military camouflage patterns were analysed. Industrial facilities do not have to introduce drastic modifications to the landscape. The application of camouflage methods may contribute to maintaining the visual order and harmony of the landscape and satisfying the economic needs at the same time. In addition, the masking and blurring effect of cubic objects in the open landscape can be achieved without an increase in expenditure.

2. Literature Review

2.1. History, Types, and Patterns of Camouflage

The origins of camouflage should be sought in nature, where living organisms tried to adapt to living conditions. In the course of the evolution process, numerous predators and their prey developed traits that allowed them to remain unnoticed by their opponents. The adaptation to the conditions and circumstances resulted in the development of natural camouflage, which is usually manifested in the form of masking colours and sometimes also in the shape of the body [9]. This state has been adapted for use as a military technique. The aim of using artificial or natural camouflage applied on objects, humans, and tactic positions is to deceive, confuse, and mislead the opposing party [10,11].

Historical uniforms worn by soldiers in bright colours, such as red or orange, made a perfect target for shooters. This is why it became necessary to introduce masking colours [12]. In the mid-19th century, members of British troops stationed in India wore khaki uniforms that matched the shade of the soil in Punjab. Traditional colours were abandoned and replaced by masking shades by introducing khaki-coloured uniforms in 1902. Similar conclusions about the need to camouflage their own troops were also drawn in other countries (the USA, Tsarist Russia, Italy, Germany, and Austro-Hungary), which introduced uniforms in masking colours in the years 1902–1910. However, other countries (e.g., France) decided to introduce this type of uniform as late as during World War I.

The main breakthrough in camouflage took place during World War II. Johann G. O. Schick, a professor at Munich University, attempted to create a universal type of camouflage by analysing the influence of plants and light intensity in different seasons as well as of the colours and shapes that exist in nature on the camouflaging possibilities. According to Schick, a perfect camouflage should both blend in with the surroundings and decompose the contour of the silhouette to deceive the senses. The patterns created during the Second World War and shortly after it are often the basis for modern versions of camouflage [13].

Camouflage was created as a result of the observations of nature. It is based on the illusion effect, where the shapes of the observed objects are deformed, the shadows and edges are dispersed, and the sharp edges of spatial forms are smoothened. As a result, forms are transformed into flat images of delicate, blurred shapes, which blend in with the environment [14].

Masking may be divided into tactical, operational, and strategic [15]. Dojlitko (2015) proposed a classification that takes into account the colours and aesthetic values, distinguishing the following types of camouflaging: decorative, imitational, colour-based, natural, lighting, and masking vessels [16]. Another classification mentions mimetic, deforming, indirect, pixelated, commercial, and winter camouflage [9,17].

Mimetic (mimicking) camouflage refers to patterns whose simplest version consists in selecting a monochromatic pattern being the average of the palette of shades in the selected space. This group includes the so-called "Khaki", "ochre", and "olive". The second type of this camouflage is based on multi-coloured stains whose size and shape correspond to that of parts of the environment, e.g., leaves, branches, or stones [18].

Deforming camouflage breaks up the lines of the silhouette using a macro-pattern (irregularly shaped stains in contrasting colours). Stains whose shapes did not match the contour of the object gave the best results. Large stains work well on longer distances, where a micro-pattern would be perceived as a monochromatic spot [9,18]. However, clearly mimetic or deforming types account for a small part of a large number of camouflage patterns. A more frequently used technique is indirect camouflage, which is a combination

of a micro-pattern consisting of small spots grouped into larger stains that create the macro-pattern, which significantly improves the masking effects [9,18,19]. Pixel camouflage consists of pixels that form a specific colour arrangement creating micro- and macro-patterns. An example may be the MARPAT (United State Marine Corps) or the UCP (US Army) [16]. Winter camouflage, in most cases, consists of a wholly white pattern and is designed for units that are in open spaces covered with snow or white patterns with brown o green stains that imitate leaves or trees for wooded areas [16].

Numerous camouflage patterns were designed for the U.S. Armed Forces. These patterns include WOODLAND, Universal Camouflage Pattern (UCP), and MULTICAM. US Navy uses the woodland, desert, and dark blue versions of the AOR camouflage. The People's Liberation Army of China uses the Xingkong pattern (among others, in the woodland, desert, and tundra versions) and ChinaCam. The British Armed Forces use the Multi-Terrain Pattern, which has replaced the Disruptive Pattern Material (DPM). Finally, the Polish Armed Forces use field uniforms in the WZ.2010 "Frontiera" pattern [20,21].

2.2. The Notion of Landscape

According to the European Landscape Convention, a landscape is defined as an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors. It is an important determinant and element of the life of its inhabitants. The ubiquity of landscape shows the extent of the phenomenon, as the landscape is located both in areas that are extremely beautiful, and in plain locations, in the towns or country, in degraded zones, but also in zones of high aesthetic values. The European Landscape Convention was created for the purposes of cooperation for the proper management of various European landscapes. Apart from the Convention, other instruments that devote special attention to this issue include, among others, the Convention on the protection of wild flora and fauna and their natural habitats adopted in Bern on 19 September 1997 or the Rio Convention on Biodiversity of 5 June 1992 [22].

In Poland, the landscape was defined in the Act on spatial planning and management as an area, as perceived by humans, that contains elements of nature or products of civilisation, shaped as the result of the action of natural factors or human activity. This definition shows how many elements may create the landscape, but it also points to the fact that it consists not only of natural elements but also those transformed or created by humans [23]. Polish subject literature distinguishes, among others, open and closed, rural and urban landscapes, as well as many other categories [24,25].

2.3. Selected Methods of Landscape Assessment and Analysis

There are multiple methods of assessing the landscape and the impact of human activity:

- Visual Impact Assessment—an assessment of the visual impact on the surrounding space, consisting of three parts: description, assessment on a scale from 0–3, and analysis. The aim of this assessment is to provide objective information concerning the visual quality of landscape as well as to estimate the influence of the activities related to the use of landscape. The aim of the methods used is to support the decision-making process and management. They should be effective and constitute reasonable practices [1,26–33].
- The curve of impressions—this method was developed by Kazimierz Wejchert. The aesthetic and visual assessment presented in graphic form refers to the feelings experienced by the observer and was divided into several stages. The first step consists in dividing the analysed area into zones based on natural borders, such as roads, or into squares of the side length of approx. 1 km. The sectors defined in the previous stage become routes for the observers. On both sides of the spatio-temporal route, approx. 200–250 m apart from each other, locations are defined where observations are performed. The observers assign a score on the scales of 0–5, 0–10, or 0–100 for each location. The assessed landscape values include the degree of diversity, the level of devastation, saturation with infrastructure, and the harmonious arrangement of

all elements of landscape. The final result is a sum of all the assigned scores, and the classification of the adopted values is subjective [34,35].

- Sector Analysis of Landscape Interiors and Panoramas (SAWiPK)—a method that was developed for the purposes of the Country Renewal programme realised in the Opole Voivodeship. Its main objective was to find the individual properties that distinguish the landscape of a given village based on the conducted detailed inventories, analyses, creating a catalogue of unique elements based on photographic documentation and descriptions, quantitative calculations, and a list of conclusions and comparisons [36].
- Index of Visual Assessment of a Landscape with Quarry—the assessment of landscape with a quarry is conducted based on taxonomic aesthetic parameters and measurable indicators in the aspects of the quarry interior, close view, and distant panorama. The Index of Visual Assessment of Landscape with a Quarry (WOWKK) includes both the subjective evaluation made by the observer based on the defined criteria and measurable parameters. The WOWKK indicator is the total score from the general evaluation, which is then assigned to one of four evaluation classes: negative, neutral, positive, and very good [3,37].

2.4. Visual Impact of Large-Capacity Investments on Open Landscape

The complexity of the problem of constructing large-capacity industrial facilities lies in the conflict between two extreme views. The first one concerns critical opinions about the created objects and their negative influence on landscape values. The second one is presented by supporters of the investment who argue for the need to develop and create new workplaces at the expense of the scenic beauty of the landscape. Places that are at risk of devastation include, among others, spaces that are attractive in terms of landscape values but do not bring profits from tourism, situated far away from big cities with rich labour markets [38]. Introducing large-capacity objects to the landscape has an important influence on its perception. However, not all investments interfere with the harmony of the surroundings. This is proven by certain industrial architecture investments, mainly in Western Europe, which are in perfect harmony with their environment. However, this requires a longer design process, increased financial expenditures, and precise formulation of landscape protection requirements by local government authorities. Unfortunately, in Poland, such care for the unique properties of landscapes, especially in so-called Special Economic Zones (SEZ), is rare. Poorly developed regions establish SEZs in order to create workplaces at low costs without taking into consideration the consequences for the environment [4,39–41].

Regardless of whether the newly developed facility is a small warehouse or a vast industrial area, the influence of manufacturing plants on the everyday landscape of local inhabitants is often negative. The results may refer to several interconnected scales and aspects, from environmental problems to issues related to aesthetic perception and social aspects. The location, visual aspects, terrain quality, function, and technological aspects, are comprehensive issues that are important for designing a sustainable industrial facility. For example, the colours, materials, and natural properties of the open space in a manufacturing plant may influence multiple aspects, such as the microclimate and attractiveness of the place and the well-being of employees. The current global challenges require eliminating, mitigating, or at least compensating for the environmental, social, and visual disruption of the landscape by the factory [6,42–45].

3. Scope Methodology and Objective of the Study

The scope of the research works involved creating landscape panoramas that included industrial facilities and their surroundings. Then, a simulation of masking with military camouflage patterns was performed on the selected objects. The resulting panoramas, with and without camouflage simulations, were then subjected to surveys of the assessment of the perception of the analysed objects in open landscape. Additionally, for the current state and the panorama with a simulation of military camouflage that received the best score

in the survey, analysis and visual assessment were performed with the use of the Sector Analysis of Panoramas (SAP) method. Finally, the results of the conducted analyses were juxtaposed and compared.

The materials that were used for tests and analyses were the photographic documentation of open landscape panoramas made on 23 August and 20 September 2020. Due to the restrictions caused by the SARS-CoV pandemic, the photos were taken in the summer (when the lockdown was cancelled). Then, selected military camouflage patterns were applied to the form of the industrial facility.

Six camouflage patterns used on field uniforms: mimetic (imitating), deforming, and indirect, were tested. The criteria of pattern selection were as follows: the DPM, AOR2, and WOODLAND patterns were selected because they had been designed for the moderate climate zone and wooded areas, MULTICAM as a widely used and universal pattern, UCP, which is also a universal pattern due to its masking properties in more urbanised areas, and, finally, the WZ.93 "Pantera", which was designed especially for the Polish conditions. A more detailed description of the selected patterns of military camouflage is presented in the table below (Table 1). In the temperate zone, due to a warm climate, snowy winters have not been observed in recent years. The period with snow cover lasts from a few to several days. The use of overlapping universal colours will be more economical to use for most of the year. Winter camouflages are therefore not considered.

Table 1. Camouflage patterns selected for analysis.

Name and Origin of the Pattern	Photo	Name and Origin of the Pattern	Photo
DPM (Disruptive Pattern Material) Country of origin: Great Britain Year of introduction: 1942	 source: [46]	AOR2 Country of origin: The United States Year of introduction: 2009	 source: [47]
MULTICAM Country of origin: The United States Year of introduction: 2010	 source: [48]	UCP (Universal Camouflage Pattern) Country of origin: The United States Year of introduction: 2004	 source: [49]
WOODLAND Country of origin: The United States Year of introduction: 1981	 source: [50]	WZ.93 "Pantera" Country of origin: Poland Year of introduction: 1993	 source: [51]

The questionnaire was prepared based on the study by Krok (2015). The survey was conducted on 102 participants of various ages and educational backgrounds. The survey was sent by private messages and published on social media, in groups of students, tourists, AirSoft Guns (ASG) fans, and among professional soldiers, employees of industrial companies, and landscape architects. The questionnaire contained photos of selected objects taken from various distances: for object 1 the panorama was taken at a distance of approx. 500 m, object 2 was presented from a distance of approx. 1000 m an object 3 from approx. 1500 m. It also contained photos with camouflage patterns applied to the analysed

buildings. Each panorama was taken from a different distance due to the presence of roads and publicly accessible areas and due to the different perceptions of the objects. The influence of the analysed industrial facilities and objects covered by camouflage patterns on the landscape was assessed on a scale from 1 to 5. Score 1 meant that the object did not blend in well with its surroundings, while score 5 meant that it blended in perfectly. For the integration between the object and its environment, 1 meant a lack of integration, while 5 meant that the integration was good. Apart from the photos, the respondents were asked additional questions concerning the selection of the dominant, integration with the surroundings, the camouflage that masked the analysed object in the best way, the effectiveness of masking on this building, and summarising questions on their attitude towards large surface and capacity objects, their thoughts on the idea to use camouflage to mask industrial or service facilities and their opinion on whether the used method would improve the visual perception. Data from the survey were then analysed. The results of the analyses are presented in diagrams and tables and discussed below.

Moreover, to determine the visual impact of industrial facilities with or without camouflage on the landscape, the SAP method was used [36,52]. Its aim is to capture the essence of perception with a strong emphasis on the visual aspect of the analysed open landscape.

SAP consists of two parts. The first one focuses on the correct proportions of the pictures taken. The frames used to create the matrix should intersect. An important element of constructing the matrix is applying a grid of squares on the side equal to 1/12 of the height of the image. To improve the accuracy, the selected angle should be compared with the map of the given location, and the visibility of the take should be determined based on the location where the photos were taken. After that, elements that constitute the selected interior are marked graphically. When the matrix is prepared, the next step is the research that involves: the analysis of the objects creating the interior in terms of their type and function; analysis of sectors in the context of their technical condition, landscape, and cultural values and form; and finally, the conclusions and suggestions that result from the analyses. Then, the share of the specific fraction components on the surface of the analysed interior is calculated. This part of the analysis focuses mainly on the proportions, while the second part puts an emphasis on the interactions between the elements and their influence on their surroundings. The results of the analyses are then assigned to three categories: poor, neutral, and good. This step is followed by the classification of the walls that build the interior into Subjective, objective, specific, and non-specific, and the division into sectors. All variables are entered into the matrix, and another assessment is made based on such criteria as order, chaos, walls, dominants, landscape value, openings, etc. These properties are presented in the form of lines of different colours, thicknesses, and the assigned numerical value: very good—3, good—2, sufficient—1, and insufficient—0. In panoramas, the elements are assigned in detail, i.e., a specific type of development (e.g., residential) is assigned, and the greenery is assigned to a specific function, e.g., background. Two lines are used: one is red and refers to the outline of buildings, and the other is a dotted green line that refers to the greenery accompanying the buildings, which allows us to determine whether the whole panorama is harmonious and consistent. The letters used in the study refer, respectively, to the functions of the objects, followed by the letter marking whether the element belongs to the landscape. The overall result of the analysis is presented in the form of a diagram of the sums of values, which define, e.g., the zones to be preserved or places that need improvement. The final form of the analysis consists of the following elements: the photo without the analysis at the top, part 1 of the analysis below it, analysis 2 with diagrams even lower, and fragments of the maps presenting the analyses are next to the elements mentioned above. Two methods were chosen: a structured interview method and an expert method to analyse the impact of the site on the landscape. The two were juxtaposed to compare the results of the experts and the results of the public, unrelated to the subject matter, to check whether the expert method has a positive reception among the people and whether its results coincide with the surveys.

The main aim of the study was to determine the influence of military camouflage on the perception of industrial facilities in the landscape.

4. Characteristics of The Selected Objects

4.1. Object 1

The object is situated in Poland, Lower Silesian Voivodeship, in the Oleśnica Poviat, in the Wądoły region of the town of Oleśnica (Figures 1 and 2). The facility produces elements of low-noise drainage components, gravity roof drainage systems, etc. The whole complex has a surface area of 5.3 ha. The Local Spatial Development Plan [53] classifies the area where the facility is located as an area for manufacturing, storage, and warehousing facilities [54].

Figure 1. The location of the object in Europe, Poland, the Lower Silesian Voivodeship, the Oleśnica Poviat, and the town of Oleśnica (author: Kamila Pawlowska).

Figure 2. View of Objects 1, 2, and 3. Location on the background of the Municipality of Olesnica, with the observer's viewpoints from which the photographs for the analyses were taken marked (orthophotomap, ID M-33-35-B-d-3-1, downloaded from the Geoportal of Infrastructure and Spatial Information, published by the Head Office of Geodesy and Cartography, source: [55], author: KP).

4.2. Object 2

The object is situated in Poland, Lower Silesian Voivodeship, in the Oleśnica Poviat, in the town of Oleśnica (Figures 2 and 3). This is a company from the agricultural sector that produces, among others, seeds, plant protection agents, etc. The facility in Oleśnica includes offices with departments that are responsible for chemical agents, cereals, consulting and development, logistics and administration, financial services, and a farm. The whole complex has a surface area of a little over 2 ha. This area is not covered by a Local Spatial Development Plan.

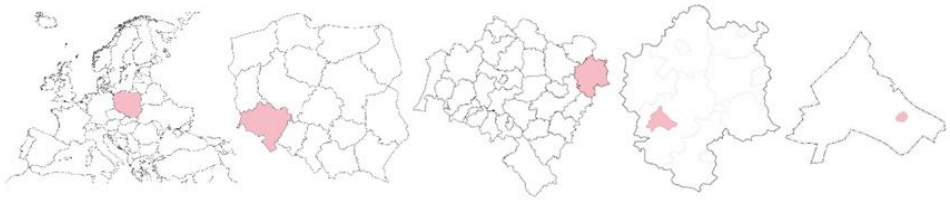

Figure 3. The location of the object in Europe, Poland, the Lower Silesian Voivodeship, the Oleśnica Poviat, and the town of Oleśnica (author: KP).

4.3. Object 3

The object is situated in Poland, Lower Silesian Voivodeship, in the Oleśnica Poviat, in the town of Oleśnica (Figures 2 and 4). This is an automotive industry manufacturing floor building, erected in 2016 and developed in 2019. The whole complex has a surface area of more than 11 ha. In the Local Spatial Development Plan [56], the area of the facility is designated for manufacturing and service activities.

Figure 4. The location of the object in Europe, Poland, the Lower Silesian Voivodeship, the Oleśnica Poviat, and the town of Oleśnica (author: KP).

5. Results

5.1. Results of the Survey Analysis of the Visual Assessment of Selected Industrial Facilities in Open Landscape

5.1.1. Object 1

For object 1, the main dominant mentioned by respondents were the high-voltage pylons (54%) (Figure 5A). The integration (Figure 5B) was evaluated as sufficient by 40%, followed by "poor" (33%), while the score of 5 was given by only 3% of respondents, being the last.

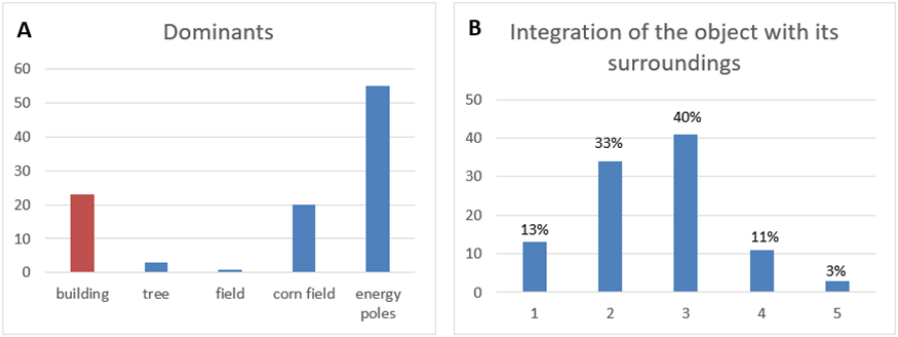

Figure 5. Dominants and the integration of Object 1, highlighted in red (author: O. Serwatko 2021, modified by: KP).

The results of the assessment of the panorama without camouflage showed that 39% of the respondents stated that the degree of blending in with the surroundings was medium, 32% were of the opinion that it was low, and 18% answered that it did not blend in with the landscape at all. The object with the DPM pattern (Figure 6B) was assessed as well integrated with the environment by 39% of the respondents, while 30% considered this camouflage to be very well fitted. Extreme scores (very poor and poor) were chosen by 5% of the respondents each. The DPM camouflage pattern received an average score of 3.85 points (Figure 6H, Table 2), which was 1.41 points higher than the average score without camouflage. As for the object with the AOR2 camouflage pattern (Figure 6C), 47% of the respondents stated that it blended in well with the surrounding landscape, while as many as 23% of the participants gave a sufficient score. The third most frequent answer was the very good score (19%). The AOR2 camouflage pattern received an average score of 3.70 points (Figure 6H, Table 2), which was 1.26 points higher than the average score without camouflage. The object with the MULTICAM pattern (Figure 6D) received 40% of sufficient scores and 28% of good scores. Scores 2 and 5 were chosen by similar numbers of respondents, 14% and 13%, respectively. The MULTICAM camouflage pattern received an average score of 3.30 points (Figure 6H, Table 2), which was 0.86 points higher than the average score without camouflage. As far as the object with the UCP pattern (Figure 6F) was concerned, 21% of the respondents answered that it blended in well with the surroundings, 34% assessed it as sufficiently integrated, while 28% decided that it blended in poorly. Extreme scores 1 and 5 were chosen by 9% of the respondents each. The UCP camouflage received an average score of 2.93 points (Figure 6H, Table 2), which was 0.49 points higher than the average result without camouflage. After the application of the WOODLAND pattern on the object (Figure 6G), scores of 3 and 4 points were granted by 34% of respondents each, while 14% stated that the camouflage was very well integrated (5 points). The WOODLAND camouflage received an average score of 3.36 points (Figure 6H, Table 2), which was 0.92 points higher than the average result without camouflage. The best results were obtained for the object with the WZ.93 pattern (Figure 6H). In total, 41% of the respondents gave 4 points, while the 5-point score was granted by 31% of the survey participants. Very poor and poor scores were chosen by 6% and 5% of the respondents, respectively. The WZ.93 camouflage pattern received an average score of 3.87 points (Figure 6H, Table 2), which was 1.43 points higher than the average score without camouflage.

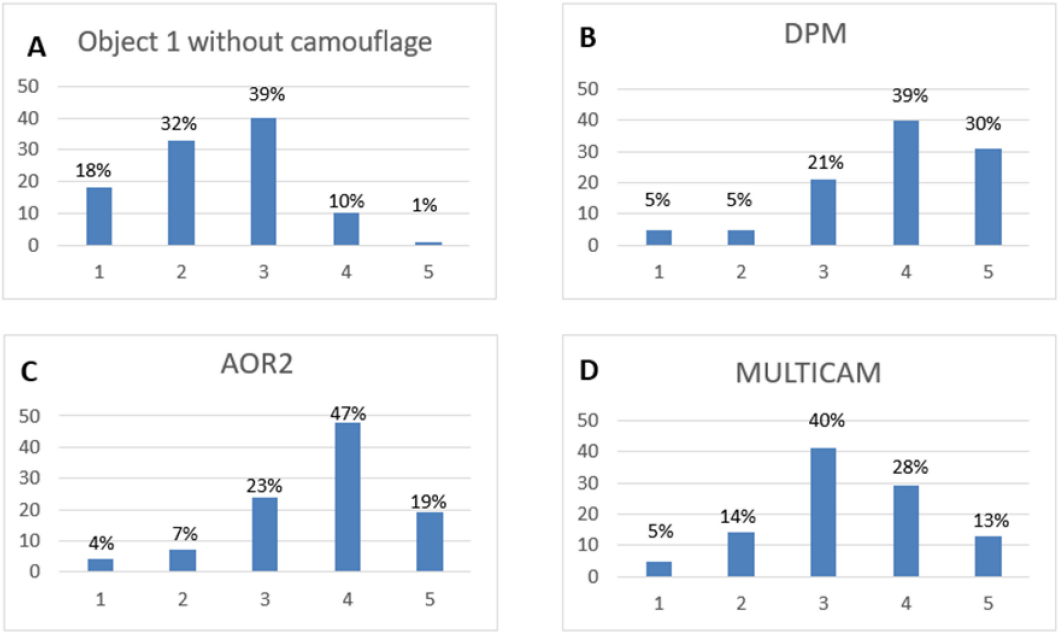

Figure 6. *Cont.*

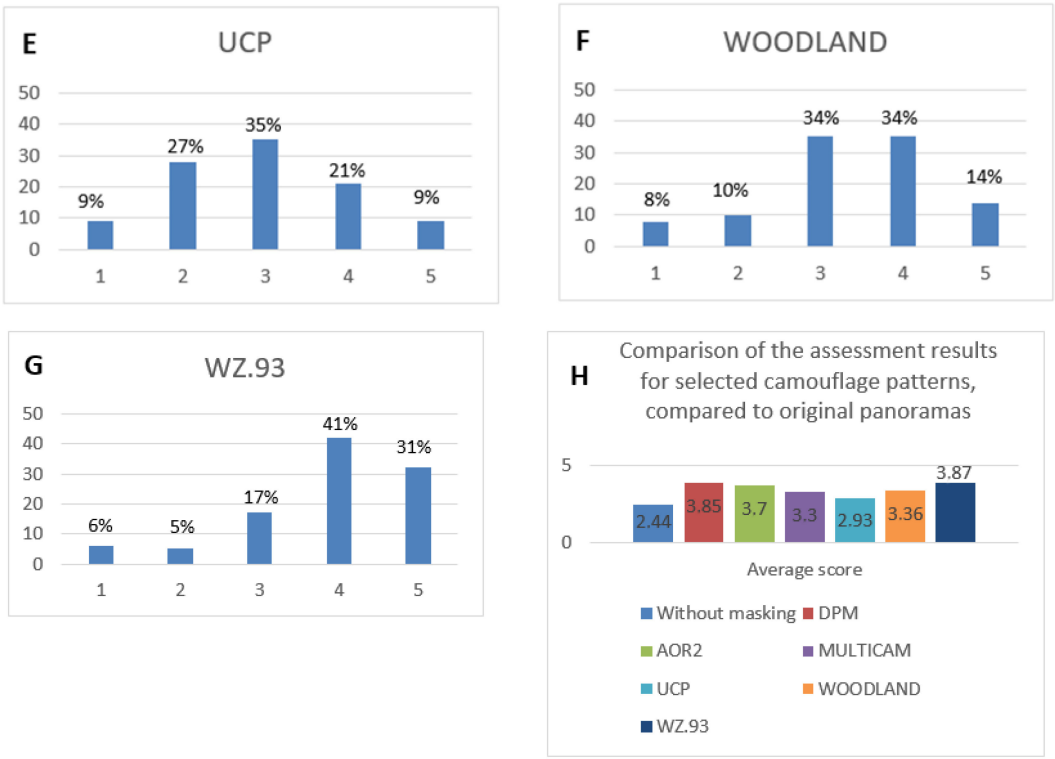

Figure 6. Quantitative and percentage presentation of the assessment results for object 1, panorama without masking and with camouflage patterns (author: OS 2021, modified by: KP).

The presentation of the average scores of individual masking patterns (Figure 6H) shows that the best score was obtained by the object with the WZ.93 pattern (3.87 points), and the object with the DPM pattern received a score that was only 0.02 points lower. The lowest score was awarded to the UCP pattern 2.93 points. The average result of the assessment of all objects covered with camouflage was 3.54 points, which was 1.1 points higher than the average score without camouflage, where the lowest average result differed from the highest one by 0.94 points. The scores awarded to the panoramas of Object 1 with camouflage patterns were higher than for the panorama without applied effects. The efficiency of the applied patterns (Figure 7) was assessed as very good (41 persons) and good (38 respondents), which confirms the need to apply this type of solution in industrial areas.

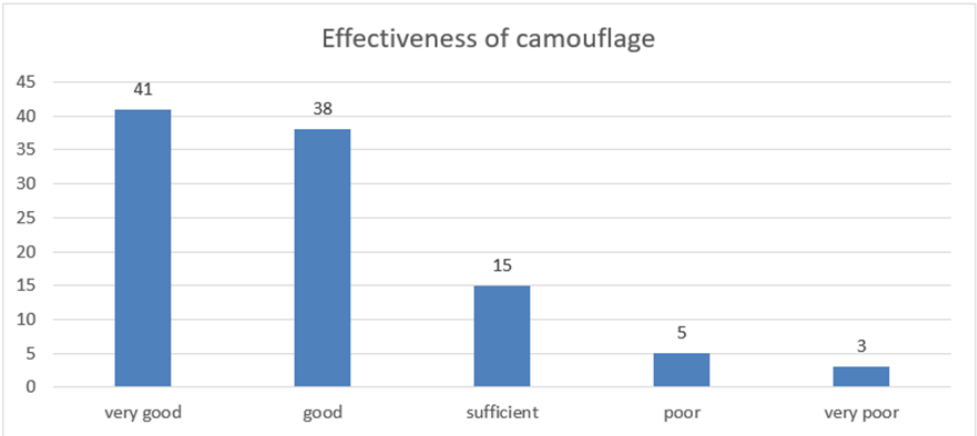

Figure 7. Masking effectiveness (author: OS 2021, modified by: KP).

Table 2. Presentation of the average results for the analysed objects with and without camouflage.

	OBJECT 1 (500 m)					OBJECT 2 (1000 m)					OBJECT 3 (1500 m)				
	Average Score	Difference from Average Score without Camouflage	Standard deviation	Minimum Value	Maximum Value	Average Score	Difference from Average Score without Camouflage	Standard Deviation	Minimum Value	Maximum Value	Average Score	Difference from Average Score without Camouflage	Standard Deviation	Minimum Value	Maximum Value
Without camouflage	2.44	0	0.92	1	5	2	0	1.03	1	4	3.76	0	1.11	1	5
DPM	3.85	1.41	1.06	1	5	3.37	1.37	0.96	1	5	4.16	0.4	0.93	1	5
AOR2	3.7	1.26	0.98	1	5	3	1	0.87	1	5	4.08	0.32	0.91	1	5
MULTICAM	3.3	0.86	1.02	1	5	1.92	−0.08	0.87	1	4	3.44	−0.34	1.14	1	5
UCP	2.93	0.49	1.09	1	5	1.75	−0.25	0.85	1	4	2.71	−1.05	1.25	1	5
WOODLAND	3.36	0.92	1.08	1	5	2.49	0.49	0.89	1	4	3.51	−0.25	1.02	1	5
WZ93	3.87	1.43	1.09	1	5	3.7	1.7	0.95	1	5	4.07	0.31	0.95	1	5

5.1.2. Object 2

As far as object 2 was concerned, 70% of the respondents considered the analysed building (cereal grain silos) as the dominant, while 14% chose the trees (Figure 8A). Object 2 became more integrated with the environment than well-blended in. A higher number of respondents (35%) gave it a "2" score than a score "1" (31%), which means a complete lack of integration (Figure 8B).

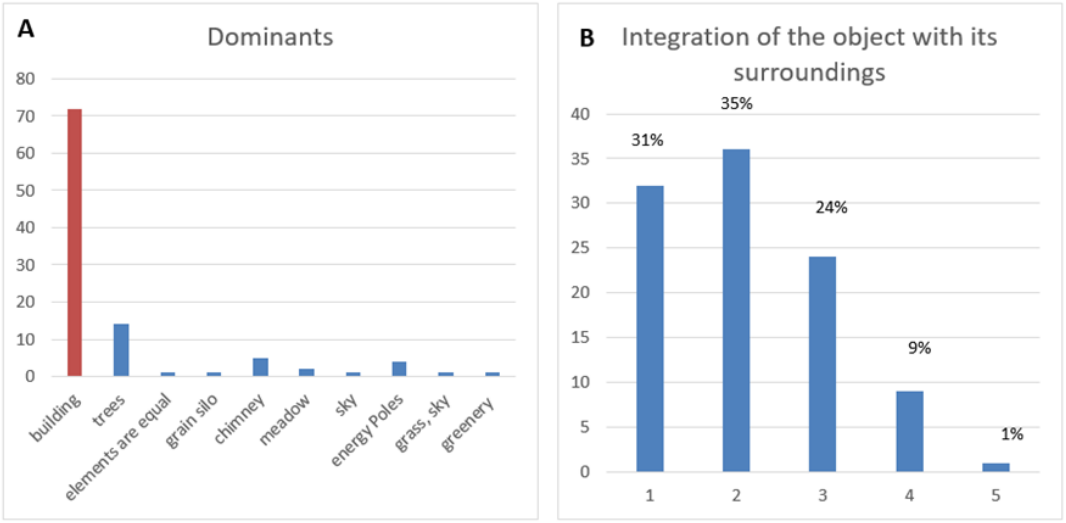

Figure 8. Dominants and the integration of Object 2, highlighted in red (author: OS 2021, modified by: KP).

For the panorama without camouflage (Figure 9A), 43% of the respondents who assessed it decided that the silo building without camouflage was not integrated with the landscape, and 26% stated that its integration with the surroundings was medium. It is worth noting, however, that in the opinion of 1% of the participants, the object was very well integrated with the landscape.

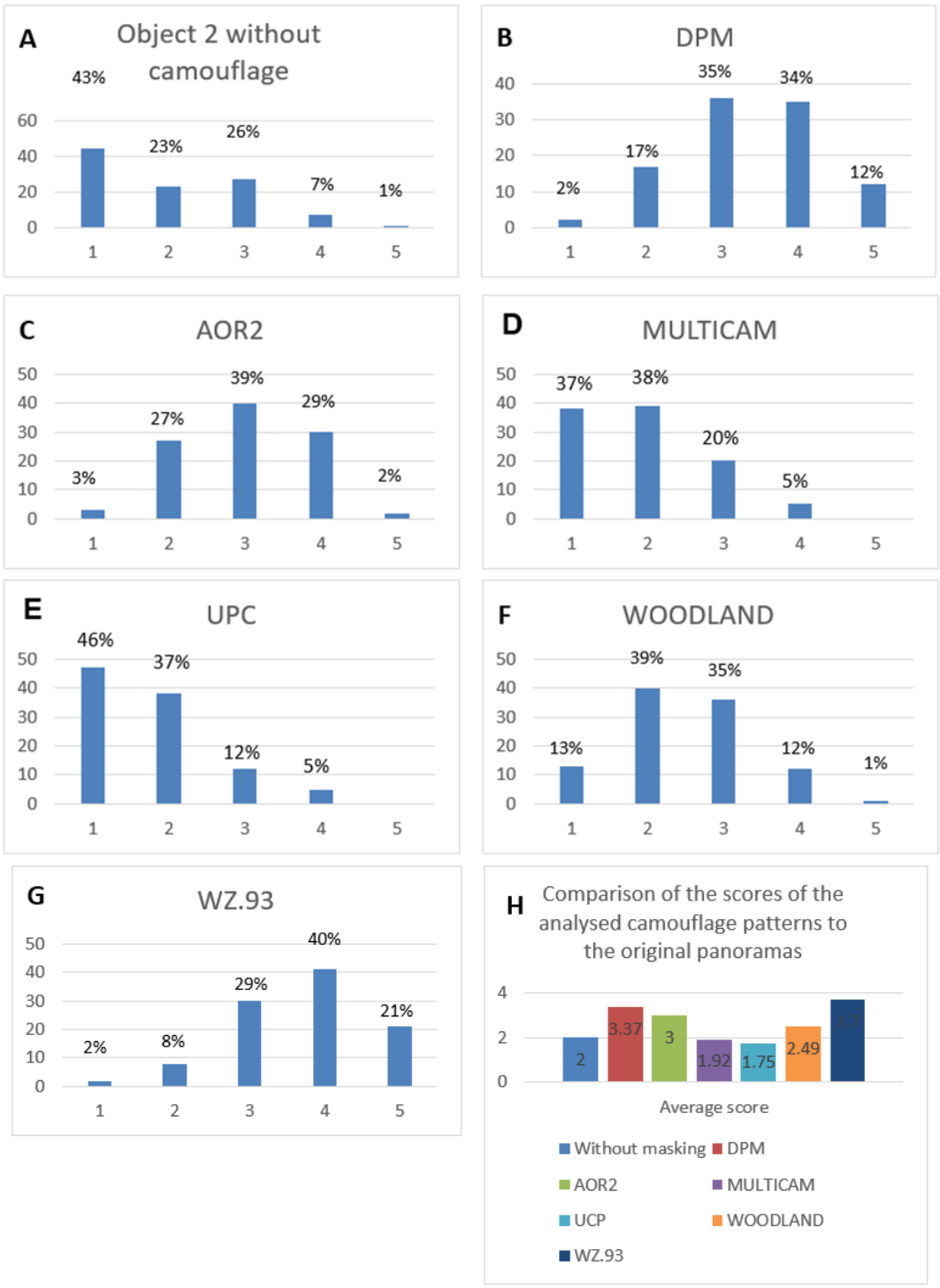

Figure 9. Quantitative and percentage presentation of the assessment results for object 2, panorama without masking and with camouflage patterns (author: OS 2021, modified by: KP).

After the application of the DPM camouflage pattern onto the object, the share of answers "3" (sufficient) and "4" (good) increased, respectively, to 35% and 34% of the respondents. Thus, one may claim that the analysed masking patterns have a sufficient and good influence on the perception of objects in the landscape. The DPM camouflage pattern received an average score of 3.37 points (Figure 9H, Table 2), which was 1.37 points higher than the average score without camouflage. The AOR2 camouflage pattern (Figure 9C) was assessed as sufficiently masking (39% of respondents) and good (29% of the respondents) for the integration of the object with its surroundings. The AOR2 camouflage pattern received an average score of 3 points (Figure 9H, Table 2), which was 1 point higher than the average score without camouflage. The MULTICAM camouflage pattern (Figure 9D) was assessed as poor (2) and very poor (1), respectively, by 38% and 37% of the respondents. None of the respondents stated that this pattern was very good (5) in helping the object blend in with the landscape. This proves that the analysed object had poor masking properties in open landscape. The MULTICAM camouflage pattern received an average score of 1.92 points (Figure 9H, Table 2), which was 0.08 points lower than the average score without camouflage. The UCP camouflage pattern (Figure 9F) was assessed very negatively as a way to mask the given object in the landscape. In total, 5% of the respondents considered it as good (4), although none chose the answer "very good" (5). On the other hand, 46% considered the UCP pattern as very poor in masking the object in open landscape, while 37% assessed it as poor. The UCP camouflage pattern received an average score of 1.75 points (Figure 9H, Table 2), which was 0.25 points lower than the average score without camouflage. The application of the WOODLAND pattern (Figure 9G) onto the analysed object resulted in a poor score granted by 39% of respondents, with a large representation of the 3 "medium" answer (35%). Similar numbers of respondents considered that the object blended in with the surrounding landscape well (12%) and very poorly (13%). The WOODLAND camouflage pattern received an average score of 2.49 points (Figure 9H, Table 2), which was 0.49 points higher than the average score without camouflage. Finally, the WZ.93 pattern (Figure 9H) was considered as good for integrating the analysed object with the landscape by 40% of the respondents, the medium score (3) was assigned by 29% of the participants, while 21% considered that it was very good for masking the object in the analysed landscape. The WZ.93 camouflage pattern received an average score of 3.70 points (Figure 9H, Table 2), which was 1.70 points higher than the average score without camouflage.

The comparison of the average scores of selected camouflage patterns revealed that the best results were achieved by masking with the WZ.93 pattern: 3.7 points, which was significantly higher (by 1.37 points) than the score awarded to the object without camouflage in the landscape. What is interesting are the low scores of the popular camouflage patterns UCP and MULTICAM, whose average scores did not even reach 2 points. The highest and the lowest score differed by 1,95 points, and the average result for all analysed patterns was 2.68 points, which was 0.68 points higher than the average result of the assessment of the panorama with the analysed object but without camouflage. One may notice that, in this case, lighter masking patterns were seen by the respondents as much worse than darker versions.

The use of camouflage patterns as an effective method of reducing the influence of the analysed object on the landscape was assessed as good and very good (by 45 and 38 respondents, respectively), while only 5 assessed it as poor (Figure 10). For object 3, very good results of the visual perception of the analysed object were obtained for the WZ.93 masking pattern.

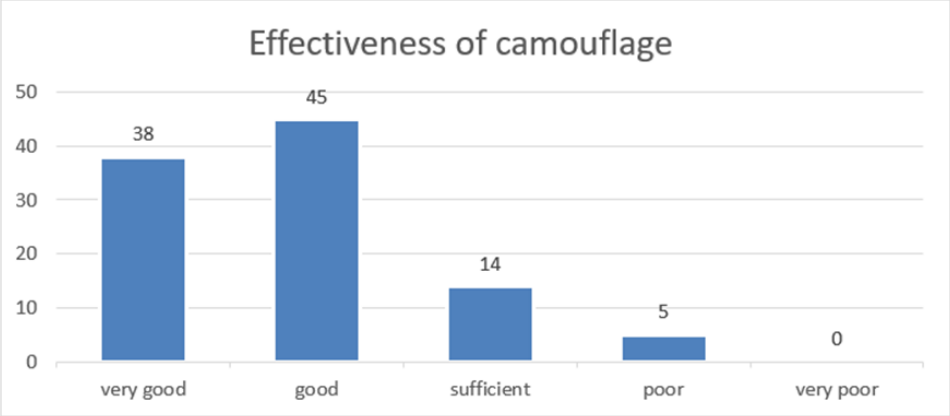

Figure 10. Masking effectiveness (author: OS 2021, modified by: KP).

5.1.3. Object 3

The respondents stated that the dominant in the presented panorama of object 3 were energy pylons (43%), followed by trees (36%) (Figure 11A). The integration of the object with its surroundings was assessed as good (48%) and medium (19%) (Figure 11B). The results for the panorama of object 3 without camouflage patterns are presented in Figure 11A. The most frequent scores are good (41%) and very good (27%). This may result mainly from a distance (the object appears very small in the panorama) but also from the fact that the lush greenery in the image attracts more attention than the distant buildings.

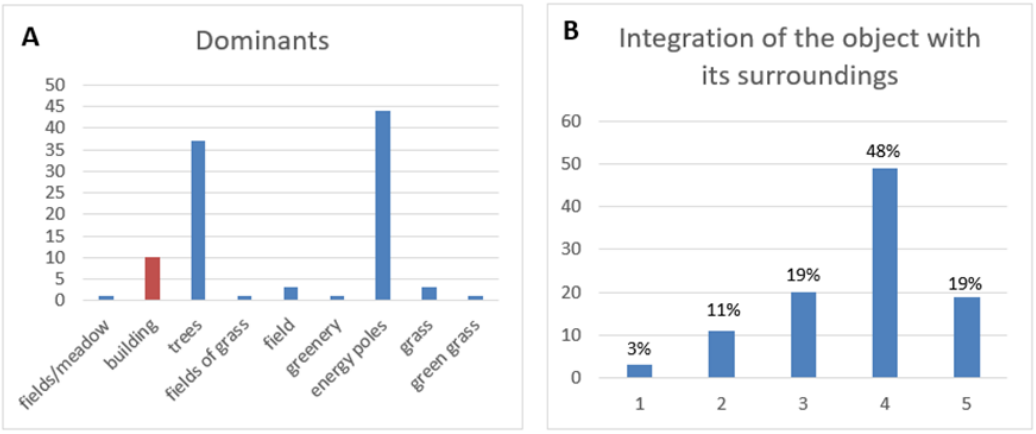

Figure 11. Dominants and the integration of Object 3, highlighted in red (author: OS 2021, modified by: KP).

The applied DPM pattern was assessed positively (Figure 12B): as very good (42%) and good (39%). This demonstrates that the pattern has adequate masking properties and is well suited to the environment. The DPM camouflage pattern received an average score of 4.16 points (Figure 12H, Table 2), which was 0.40 points higher than the average score without camouflage. For the AOR2 camouflage pattern (Figure 12C), 45% of the respondent stated that it was well integrated, 36% that it blended in very well, and only 3% answered that it did not blend in at all. The AOR2 camouflage pattern received an average score of 4.08 points (Figure 12H, Table 2), which was 0.32 points higher than the average score without camouflage. As for the MULTICAM pattern (Figure 12D), no obvious dominance of very good and good scores was noted, as opposed to the two previous patterns. The scores from sufficient to very good were distributed rather evenly: 29% sufficient scores, 25% good scores, and 23% very good ones, with a relatively high percentage of "2" answers (19%). The MULTICAM camouflage pattern received an average score of 3.44 points (Figure 12H, Table 2), which was 0.34 points lower than the average score without camouflage. The

results obtained for the UCP pattern (Figure 12F) were significantly different from those of the other applied camouflage patterns. The assessment trend was decreasing, as 29% of the respondents classified it as sufficient, and this result was followed by 24% poor scores and 21% very poor ones. The UCP camouflage pattern received an average score of 2.71 points (Figure 12, Table 2), which was 1.05 points lower than the average score without camouflage. The WOODLAND pattern (Figure 12G) received mainly good scores (36%), however, with a significant share of sufficient scores (32%). In total, 17% of the respondents considered that it blended in very well with the surroundings. The WOODLAND camouflage pattern received an average score of 3.51 points (Figure 12H, Table 2), which was 0.25 points lower than the average score without camouflage. Finally, the WZ.93 pattern (Figure 12H) received good scores from 46% of the respondents, while 35% answered that it masked the object very well. On the other hand, 4% and 2% of the respondents stated, respectively, that the WZ.93 pattern did not blend in at all or was poorly integrated. The WZ.93 camouflage pattern received an average score of 4.07 points (Figure 12H, Table 2), which was 0.31 points higher than the average score without camouflage. The average result of the assessment of the objects with camouflage was 3.71 points, and the highest score differed from the lowest one by 1.45 points. In comparison to the object without camouflage, the average result of the objects with camouflage was lower by 0.05 points. However, the average score of the object with three types of camouflage (DPM, AOR2, and WZ.93) was higher than the average score for the object without camouflage. The worst results were obtained by the UCP pattern—2.71, while the best results were achieved by the DPM pattern—4.16 points (Figure 12H, Table 2). The masking effectiveness of object 3 (Figure 13) was assessed as very good by 57 persons and as good by 32 people. The negative scores 1 and 2 were a scarce minority, with 3 and 1 votes, respectively.

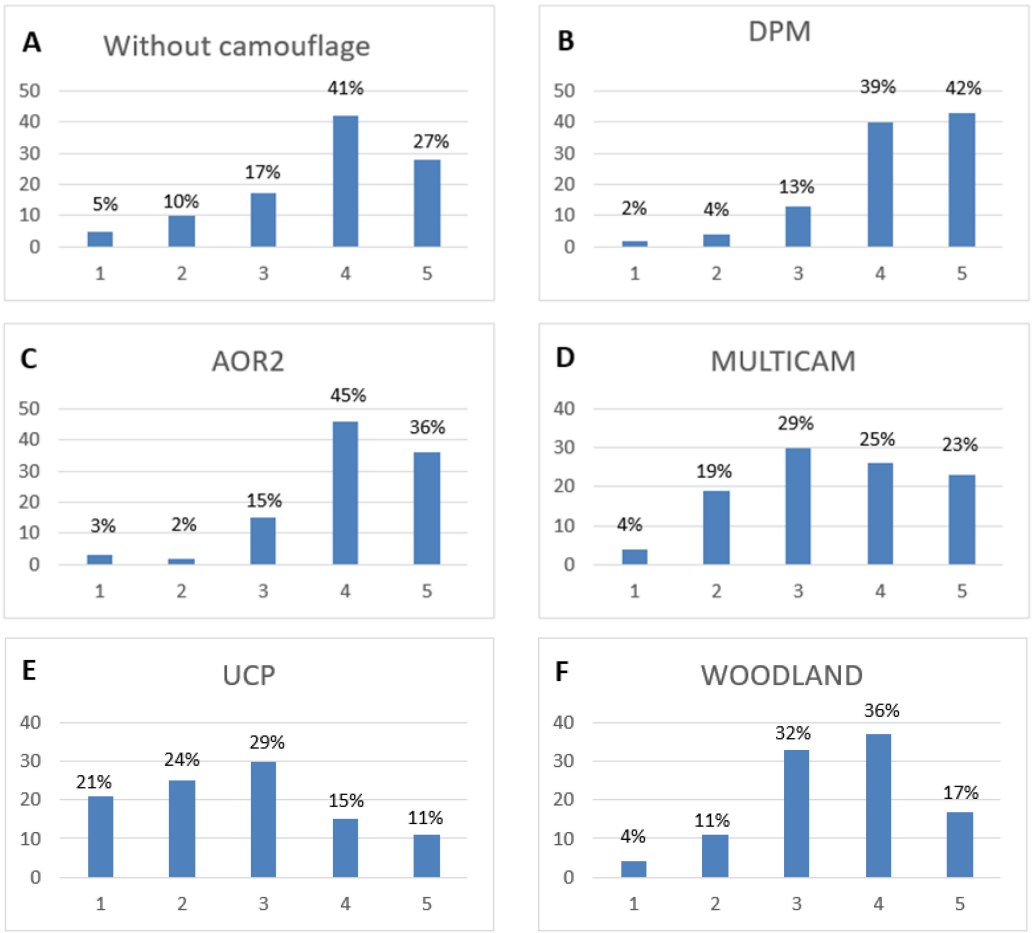

Figure 12. *Cont.*

Figure 12. Quantitative and percentage presentation of the assessment results for object 3, panorama without masking and with camouflage patterns (author: OS 2021, modified by: KP).

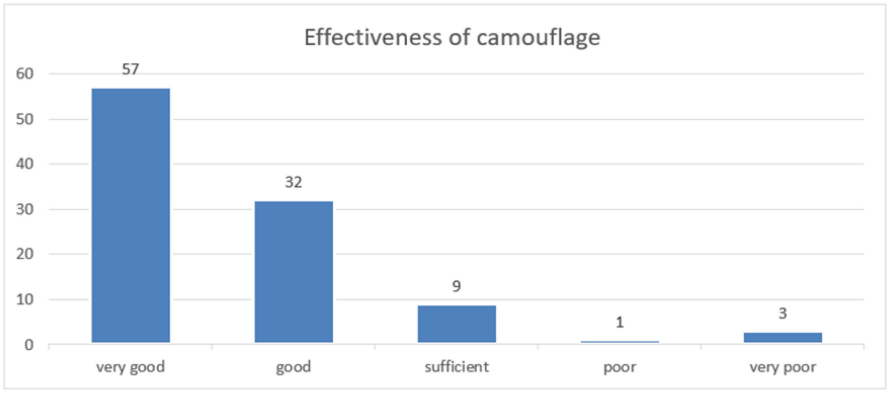

Figure 13. Masking effectiveness (author: OS 2021, modified by: KP).

5.2. Visual Analysis and Assessment of the Analysed Objects in Open Landscape

SAP was conducted for images without camouflage patterns and for the pattern that received the best score, following the analysis of the survey results.

The analysis of the panorama of object 1 (Figures 14 and 17) taken from a distance of 500 m demonstrated that the technical infrastructure surrounding the analysed object had a strong influence on the landscape. This is why the left side of the panorama received very poor scores. Individual sectors achieved: 1 point, 1 point, 3 points, and 6 points. In the two sectors on the right side, there is a noticeable influence of greenery and residential housing, which leads to a more positive perception of the landscape. This translates into better results in the sections that refer to landscape values, form, and cultural values. In the analysis of the panorama for object 2 covered with WZ.93 camouflage pattern, which received the highest average score, the sectors that contained the analysed object achieved better results in terms of form, as the building was better integrated with tall greenery. The colour of the WZ.93 pattern is very similar to the greenery in the photo. Sectors 2 and 3 received +1 point each in the category of form, in comparison to the panorama without camouflage.

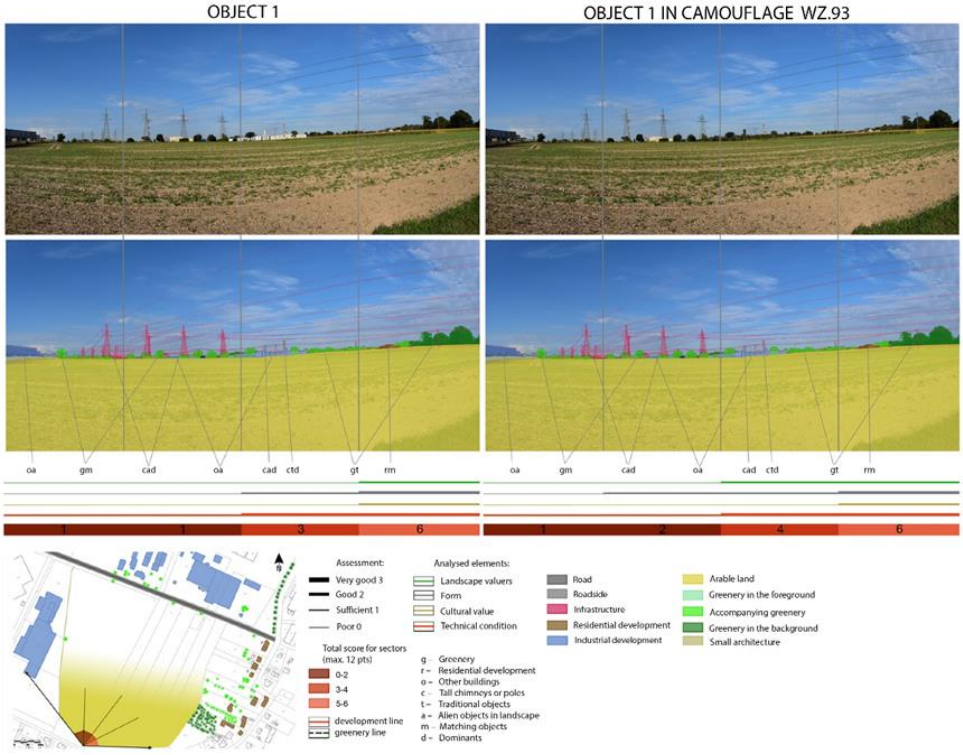

Figure 14. Analysis of the panoramas of object 1 (author: OS 2021, modified by KP, B. Jawecki).

The distant panorama of object 2 was taken from a distance of approx. 1000 m. It achieved the following results in individual sectors: 4 points, 2 points, 4 points, and 7 points. (Figures 15 and 17). The dominance of greenery is noticeable in all sectors, and this leads to a good result in the landscape value and form categories. The cultural value was assessed as low once again. The technical condition is good. The far-left sector stood out among all the analysed sectors due to the diversity of greenery. The analysis conducted for the WZ.93 camouflage pattern (which received the best average result in the survey) for object 3 showed better assessment results. Additional points were awarded for landscape values (+1 point) for sector 3 and for form (+1 point) for sectors 1 and 2. The pattern WZ.93 performed well in terms of both colour and silhouette blurring of the object.

The panorama analysis of object 3 (Figures 16 and 17) 2 was taken from a distance of approx. 1500 m. Individual sectors achieved: 8 points, 4 points, 3 points, and 10 points. Landscaping was the domain of the opposite sectors (the best evaluation scores) due to the presence of high greenery in the case of the left part of the analysed frame and the avenue along the national road on the right side. In the middle part of the photo, there is a noticeable analysed object, chimneys, and a high-voltage mast; this is why the panorama received very poor scores. In the case of sectors that were dominated by greenery, the form was satisfactory. In other cases, it was adequate for the elements involved. The cultural value was positively assessed in the side sectors. The entire evaluated panorama received good scores for technical conditions. The analysis of the panorama of object 3, with the DPM camouflage pattern (the best scores in the surveys), conducted that sectors 2 and 3, where the production hall is located, received higher scores (+1 point) in the landscape value category. Through the use of camouflage, the mass of the building blended in with the surrounding greenery. The entire panorama became more consistent.

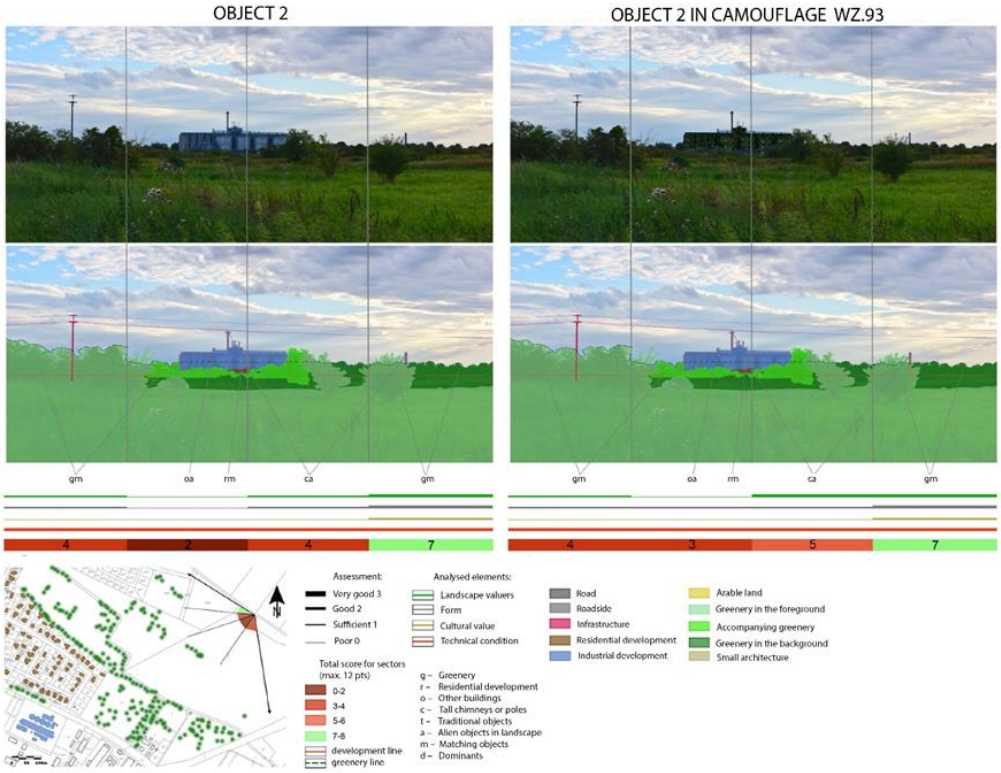

Figure 15. Analysis of the panoramas of object 2 (author: OS 2021, modified by KP, BJ).

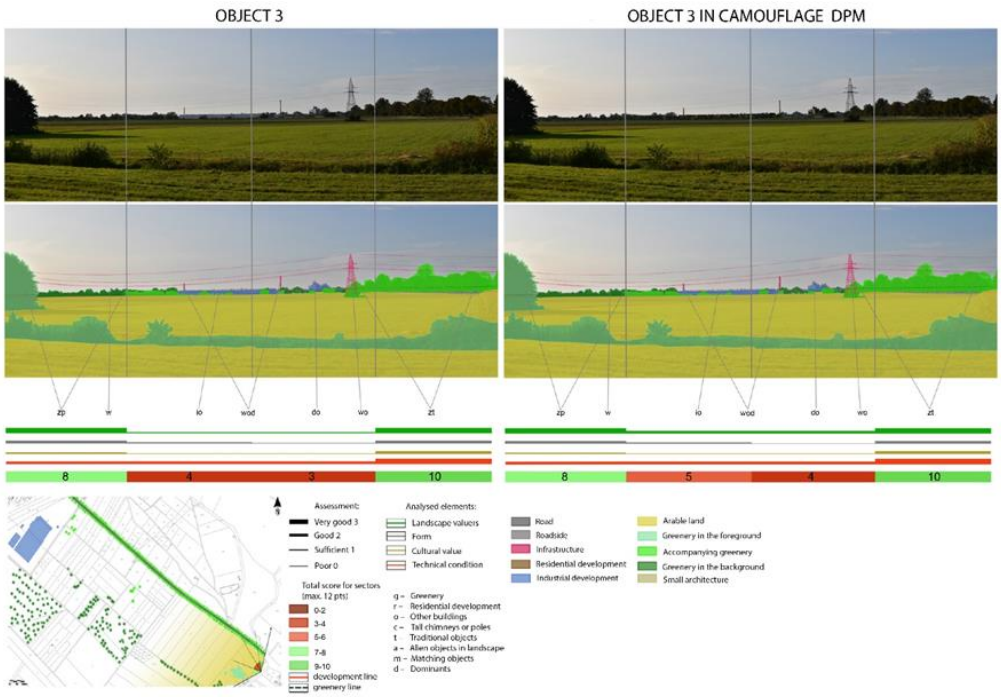

Figure 16. Analysis of the panoramas of object 3 (author: OS 2021, modified by KP, BJ).

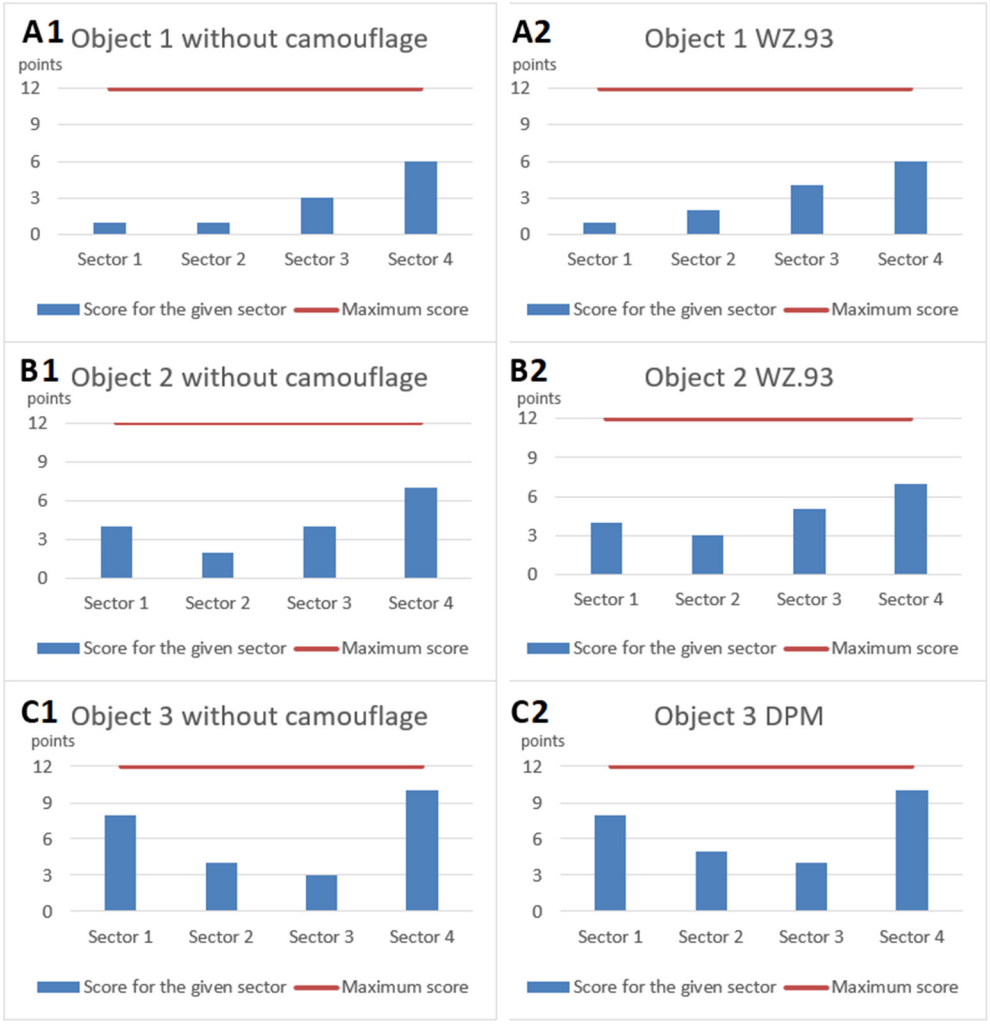

Figure 17. Presentation of the results of the Sector Panorama Analysis for individual objects (author: OS 2021, modified by: KP).

The masking pattern, selected individually for each panorama based on the highest weighted average of the results obtained by specific camouflage patterns in the survey, was then subjected to Sector Panorama Analysis for each of the objects. The objects were awarded additional points mainly for the form, as their contours started to blend in with the surroundings, and for landscape values because their colour was better matched to the environment. The whole form of the object became more integrated with the surrounding landscape.

Industrial and service facilities have a significant influence on the landscape. Most people do not devote much thought to analyse this impact. The survey demonstrated that people do not care about such facilities or do not have a clear opinion about them (Figure 18). However, promoting the appropriate methods of landscape protection and eliminating the negative impact on the landscape is an important issue. The idea of masking such objects with the use of camouflage patterns in itself was very well received among the respondents (Figure 19), which may prove that it would be justified to use such methods in practice. The respondents also stated that, in most cases, this would improve the visual appearance of the object subjected to such treatment (Figure 20). This is doubtlessly an opportunity for areas of so-called Special Economic Zones because nowadays, they are simply created without any accompanying activities aimed at reducing their visual impact on the open landscape.

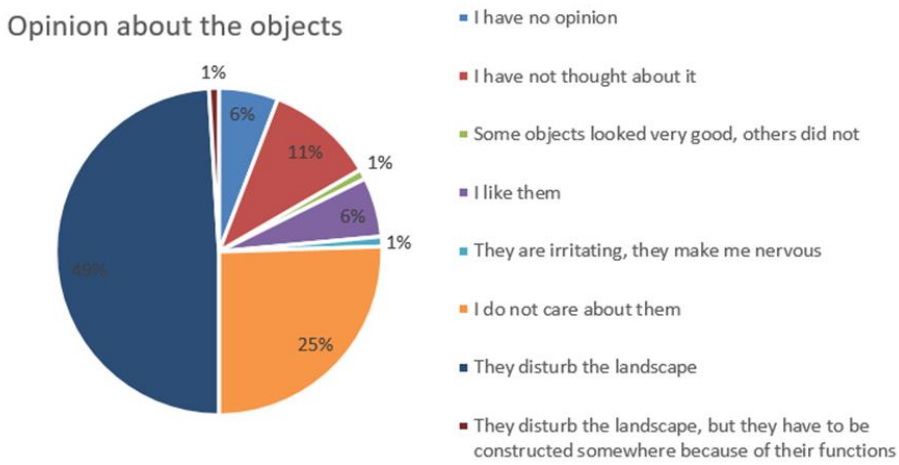

Figure 18. Presentation of the percentage of opinions about industrial and service facilities (author: OS 2021, modified by: KP).

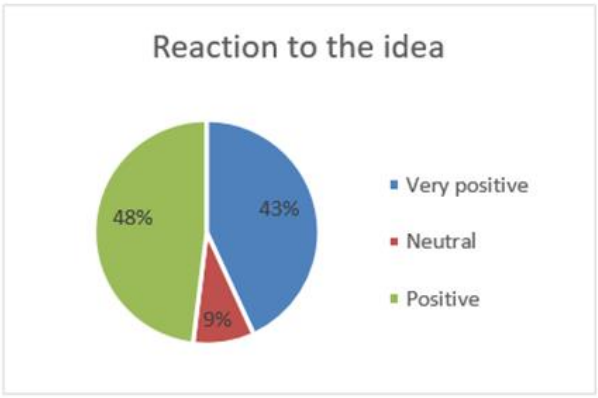

Figure 19. Presentation of the percentage of opinions about using camouflage patterns to mask industrial and service facilities (author: OS 2021, modified by: KP).

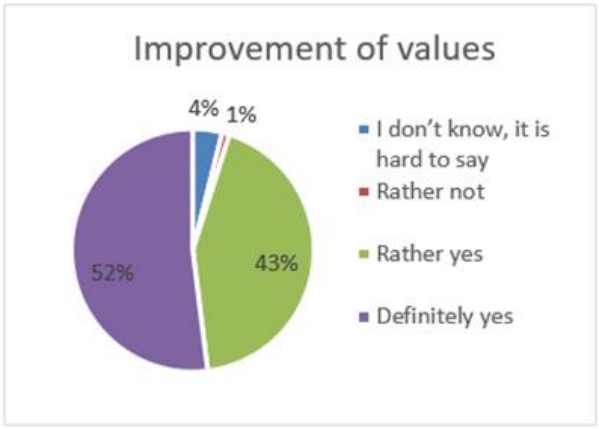

Figure 20. Presentation of the percentage of opinions about the improvement of the appearance of objects with the use of masking (author: OS 2021, modified by: KP).

The juxtaposition of the results for specific panoramas and camouflage patterns (Table 2) provides an overall view of the conducted survey. The highest average score (4.16) was noted for DPM masking on object 3. Considering all the presented panoramas, the highest scores were awarded to the WZ.93 camouflage pattern. In two cases, the results for this pattern were the bases for preparing a Sector Analysis of Panorama in camouflage,

while the third analysis was conducted for the DPM pattern. There were only five cases when the scores for camouflage patterns were lower than those for the original panorama without masking. These are mainly light-coloured patterns (MULTICAM and UCP), which attract more attention if seen from a further distance. This is contrary to the intended effect. The analysis of the other camouflage options demonstrated that the visual perception of the analysed objects improved by between 0.05 and 1.70 points.

For the panorama of object 1, the best score of 3.87 points was given to the WZ.93 pattern. It was 1.43 points higher than the score of the panorama without camouflage. The lowest result (2.93) was achieved by the UCP pattern. It was only 0.49 higher than for the panorama without camouflage. The best score for object 2 (3.7) was also noted for the WZ.93 pattern. It was 1.7 points higher than the panorama without camouflage. The lowest result was noted for the UCP pattern (1.75), which was 0.25 lower than the score without camouflage. Finally, the best result (4.16 points) noted for object 3 was noted for the DPM pattern, and it was 0.4 points higher than for the panorama without camouflage, while the lowest score (2.71) was awarded to the UCP pattern: 1.05 lower than the result for the original panorama.

In the case of the expert assessment of Object 1 without camouflage (Table 3), the average value can be assigned to categories 3–4 (Total score for sectors, Figures 14–16); adding camouflage increased the average value of the scores received, but the category did not. In the case of the respondents' assessment, Object 1 received an average score classifying it in the "poor" category, while the addition of camouflage increased the average value, and the overall score changed to "good", thus changing the category of the site two classes higher. The average value of the rating for Object 2 in the expert assessment increased after the addition of camouflage by half a point, which was enough to raise the category by one class. The results of the ratings from the surveys without and with camouflage differed by 1.7 points, which raised the class by 2 values, from "poor" to "good". With the addition of camouflage, the average rating in the expert method of Object 3 increased by only 0.25 points while raising the class by 1. Despite the increase of 0.40 points in the average rating of the respondents, the class of the object did not change.

Table 3. Comparison of the total score of the impact of the surveyed sites with and without camouflage on the open landscape (for the total score of the landscape impact categories, mean values have been rounded to whole values, and category colours according to the expert method, see Total score for sectors, Figures 16–18).

Industrial Facilities	Expert Method without Camouflage	Expert Method with Camouflage *	Surveys without Camouflage	Surveys with Camouflage *
Object 1	2.75	WZ93 Pattern 3.00	2.44 2-poor	WZ93 Pattern 3.87 4-good
Object 2	4.25	WZ93 Pattern 4.75	2 2-poor	WZ93 Pattern 3.7 4-good
Object 3	6.25	DPM Pattern 6.5	3.76 4-good	DPM Pattern 4.16 4-good

* analysis and evaluation of the panoramas with the best-rated camouflage.

6. Discussion and Conclusions

The main reason for the use of camouflage on industrial buildings was to eliminate their distinctive shape and colour, reducing the visibility of the building in the skyline. In the article of Randa Hassan Mohamed [57], the author came to a similar conclusion. He recognised that there is a complex relationship between different types of camouflage and their application in space. The different effective patterns represent the concept of colour, which as a multi-tasker: can solve many visual problems and can positively influence

people's perceptions and psychological comfort. Thus, camouflage will be considered as a way to 'hide a building' from view, not only from the function it fulfils but also from the landscape.

In Lia Marchi's publication [6], the main premise is that whether it is a small warehouse or a vast industrial area, the impact of these facilities on the landscape skyline and on residents is complex and often adverse. A range of aspects, from environmental issues to perceptual-aesthetic and social issues, can cause many problems. Location, site quality, visual aspects, and function are some of the most important aspects of a sustainable factory project. The microclimate and attractiveness of a site to the well-being of its workers can be influenced by factors such as, for example, the colours, materials, and morphological features of the open space in a production facility.

Among the problematic aspects that characterise contemporary society and the environment is one related to industrial areas and plants and their incompatibility with the urban, rural, and natural landscape. The article of Boeri, Braz de Oliveira, and Giambruno [4] points out that this is not only an environmental problem but also a social, cultural, and economic one. In order to reconcile all aspects, a new concept of 'cosmetics', mainly related to colour and blur, should be used to promote a new quality of visual perception and perception that attempts to reconcile a purely raw, industrial image with an urban, rural, natural landscape [4].

Architect Rafael Gómez-Moriana [58] believes that instances of everyday camouflage seem to occur mainly in high-tech urban zones that have undergone modernisation in recent decades. The fact that camouflage, which is intrinsically oppositional, occurs in the supposedly more civilised sphere of the city.

In another publication by Lia Marchi [45,59], the author performed analyses of the impact of factories on the landscape, in which she combined environmental aspects and social and visual disturbances. She developed a catalogue of best practices that serves as both an assessment tool and design support. The tool is based on detecting the main disturbances of an industrial facility on the landscape. Then, on this basis, the company consults the results to select appropriate practices useful for mitigating impacts. Three mitigation scenarios were re-created, one of which consisted of a 'cosmetic' intervention on the building façade. The others already required a large financial investment and a high impact on the appearance and shape of the building.

The obtained results confirm the fact that industrial facilities have a significant visual impact on the landscape. Their form and colour attract attention, which makes them stand out from their surroundings. The application of camouflage patterns on such objects was met with a positive reaction and, in most cases, improved the visual perception of the analysed facilities. The exceptions to this rule are light-coloured patterns in distant panoramas. In these cases, the assessment of the objects was lower than for objects without masking. However, a vast majority of camouflage patterns work well, improving, even if only slightly, the visual impression of the whole panorama.

Although the overall opinions of the respondents were positive, the application of military camouflage on civilian objects may still seem controversial. However, the idea of using the appropriate paint colours (the shades used in camouflage) to paint buildings (of industrial and service facilities) may effectively reduce the impact of such objects on the landscape, in particular the open landscape. Local spatial development plans and similar regulations should contain provisions that would oblige investors to paint large-surface and large-capacity industrial and/or service objects in colours that would allow them to blend in with the surrounding open landscape.

The perception of the landscape is an individual feeling of the observer, depending on the observer's judgement; hence, the expert method made by specialists differs from the landscape assessment made by ordinary non-expert observers. Hence, it seems advisable in landscape research to simultaneously use expert and survey methods based on observer assessments.

The evaluation carried out using the expert method showed that the mean score and the overall rating increased due to the camouflage (Table 3). Only in the case of

Object 1 did the overall assessment category not change significantly. In contrast, the surveys showed that the addition of camouflage to the surveyed objects resulted in a higher average point value and an increase in the overall rating (e.g., from bad to good). Site 3 remained in the same category, but the average values were highest compared to the other sites. Both in the expert assessment and in the survey assessment, the camouflage applied positively influenced the overall rating at the object located at a distance of 1000 m from the observer where the overall rating increased by 1 (expert assessment) or 2 categories (survey assessment). In contrast, the site closest to the observer (500 m) remained in the same category in the expert assessment and the survey assessment increased by 2 categories. For the site furthest away (1500 m), the situation was reversed, with the overall rating increasing by 1 category in the expert method and remaining the same in the survey method. For sites further away from the observer, the ratings were higher. The aim is to change the colour of the buildings to match the colour of the surroundings and the landscape panorama. Taking into account the colours of high, medium, and low greenery and considering the change of the plants' colours during the seasons and at different latitudes When designing the appearance of the facade of the buildings, an analysis of the existing colours and greenery in the surroundings of the project should be carried out in order to select suitable camouflage colours. For this reason, it is advisable to rely on the many years of experience and knowledge of different armies in the selection of such timbres of patterns. The effect should be to apply the colours found in the environment to the façade of industrial buildings in the open landscape.

The conducted studies and analyses verified the research hypothesis that the application of masking with the use of selected military camouflage patterns has a positive influence on the landscape, because it allows large-capacity objects to blend in with the panorama of scenic landscape.

The aim of the study was to analyse the influence of military camouflage on mitigating the visual impact of industrial or service facilities on the open landscape. The conducted research allowed the authors to formulate the following conclusions:

1. It was found that in open landscape panoramas, many of the selected camouflage patterns fulfilled their task by blurring the form of the analysed object and integrating the colours with the surrounding greenery.
2. The colour of camouflage plays an important role in its application to reduce the visual impact of industrial facilities on the landscape: if the pattern was too light, the visual perception of the analysed objects deteriorated, while colours that were adapted to the local flora improved the reception of the objects by observers.
3. An adequate selection of the camouflage pattern or, at least, the colour of the façade with appropriately selected masking colours might bring better effects in masking the visibility and improving the perception of large-capacity objects in open landscape, as the painting will mask the potential gaps and inconsistencies in the landscape, even with well-maintained insulation greenery.
4. Another important factor is the distance from which the analysed element is observed. For photos taken from a further distance, e.g., 1500 m, the object becomes less noticeable. As the distance from the analysed object increases, its visibility in the landscape, both with and without camouflage, decreases. However, the results for objects with camouflage were still better.
5. Another important aspect is the reference point to which the given camouflage is compared. Different patterns should be selected, depending on whether the reference point is the sky or trees, or even greenery in general.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. The study was fully anonymous and voluntary. The survey questions did not apply to the participants themselves.

Data Availability Statement: Not applicable.

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

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