MORAVIAN GEOGRAPHICAL REPORTS

Institute of Geonics, The Czech Academy of Sciences

journal homepage: http://www.geonika.cz/mgr.html

doi: 10.1515/mgr-2016-0017

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Planning a greenway based on an evaluation of visual landscape attractiveness

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Abstract

The potential for using a standardized landscape evaluation method for planning a greenway in a young glacial area in northern Poland is evaluated in this paper. In the evaluation of visual landscape attractiveness (VLA), we took into account not only its natural but also its cultural components. The cultural components were divided into two groups, i.e. increasing and decreasing VLA scores. The sources of data needed for the evaluation included a Vector Smart Map level 2 (VMap L2), aerial photographs and a field survey. The newly-designated greenway links two landscape parks (which play the role of greenspaces) and runs along numerous lakes, forests, rivers, and objects of cultural heritage. The greenway is composed of existing local roads, allowing a more optimal utilisation of natural and cultural resources of the landscape, primarily those located between the selected greenspaces. Using this application, the idea of sustainable development can be implemented, and the overlapping protected areas will not be subject to devitalisation. The VLA method can facilitate multiple greenway designations in other areas.

Keywords: *landscape quality, visual landscape attractiveness, greenway, GIS, Poland*

Article history: *Received 15 December 2015; Accepted 1 August 2016; Published 30 September 2016*

1. Introduction

Landscape quality assessment is a complicated procedure involving many senses and quantification of all aspects of the landscape, not only natural and cultural (including infrastructure) but also perceptual, e.g. landscapes as national heritage (Visual Resource Management Program, 1980; Rogge et al., 2007; Mouflis et al., 2008; Tempesta, 2010; Sevenant and Antrop, 2010; Conrad et al., 2011; Pettit et al., 2011; Svobodova et al., 2012; Best Management Practices…, 2013; Skokanová, 2013; Špulerová et al., 2013; Tempesta et al., 2014; Van der Wal et al., 2014). Here we focus on one component of landscape evaluation – visual landscape attractiveness. It is regarded as the most important factor of the multisensory landscape (Bell, 2004). Humans evaluate landscape primarily on the basis of visual inspection, and most frequently visual evaluation determines our perception of the surroundings.

The European Landscape Convention (Council of Europe, 2000), draws attention to the need to assess landscapes, taking into account the particular values assigned to them and to define landscape quality objectives for the landscapes. One of the possible methods of landscape assessment is the evaluation of visual landscape attractiveness (Degórski et al., 2014).

The concept of greenways, sometimes referred to as trails for the 21st century (Flink et al., 2001), is poorly known among geographers in Central and Eastern Europe. The greenway concept is compared with the European vision of ecological corridors (Fabos and Ryan, 2004). Greenways, however, are supposed to serve people who need contact with nature and culture (President's Commission, 1987), while the major role of ecological corridors is to create favourable conditions for genetic exchange of fauna and flora between core areas (Perzanowska et al., 2005).

The origin of greenway planning goes back to the beginning of the landscape architecture profession in the USA (Fábos, 2004). One of its tasks was to designate greenways that link enclaves of attractive landscape, i.e. greenspaces (Fig. 1) – where people can get in touch with their cultural heritage – and urban open spaces (Zube, 1995). The idea to create greenways had evolved from a system of parkways, which connect urban and rural areas. The

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precursor of this concept is supposedly due to Frederick Law Olmsted, who designed the famous Boston Park System (Little, 1990). In the second half of the 20th century, the greenway concept has been transformed into an approach based on sustainable development and the stimulation of physical activity (European Greenway Association, 2014). Despite the passing years, however, the roles of greenway and greenspace remain the same – they should for example limit the defragmentation of green areas and create attractive transportation routes to link them. According to the European Greenways Association, greenways should be transportation routes and meet standardized criteria for their planning (e.g. Greenway Polska Society, 2015). Within cities, corridors between parks are designed (Fábos, 2004; Tan, 2006; Teng et al., 2011), while on the national or regional scale, greenways are found between national parks and landscape parks.

In the literature on this subject, several types of greenways can be distinguished, referring to their function (Viles, Rosier, 2001; Fábos, 2004):

- ecologically significant natural corridors between natural systems;
- recreational greenways (often along watercourses); and
- greenways that provide historical heritage and cultural values.

The procedures for greenway planning can be divided into several steps (modified from Fábos, 2004):

- Step 1: Research and map all existing trails, roads, protected areas and other objects of importance for ecological/nature protection, recreational and historic/cultural values;
- Step 2: Research and map all current planning proposals relevant to the three categories above (ecological/nature protection, recreational and historic/cultural values);
- Step 3: Make connections for each category of greenways at each level;
- Step 4: Determine the dominant function of the planned greenway and create single-purpose plans for nature protection, recreation, historical/cultural resources; and
- Step 5: Create a greenway plan, which integrates all existing, current and proposed plans of trails, etc., and provide statistics of the new greenway.

2. Aim of the study

The fast development of the road network and infrastructure in recent years in Poland, inspired us to attempt to design a greenway between two landscape parks: Brodnica Landscape Park (Brodnicki Park Krajobrazowy), and Górzno-Lidzbark Landscape Park (Górznieńsko-Lidzbarski Park Krajobrazowy) in Northern Poland. We aimed to plan the greenway so that it would be characterised by a high landscape value and connected with the rich tradition and history of the region (Zube, 1995). We assumed that although greenways are intended for use by non-motorised tourists, in practice exceptions to this rule are possible. Also, according to the European Greenways Association, it is permissible to share the greenway with light motor traffic. The benefits of such a solution are confirmed by the results of research on the use of existing roads in the creation of greenways in New Zealand (Viles and Rosier, 2001). In our study, we also used the current road network in planning the greenway, assuming that its basic function related to local motor traffic will be maintained.

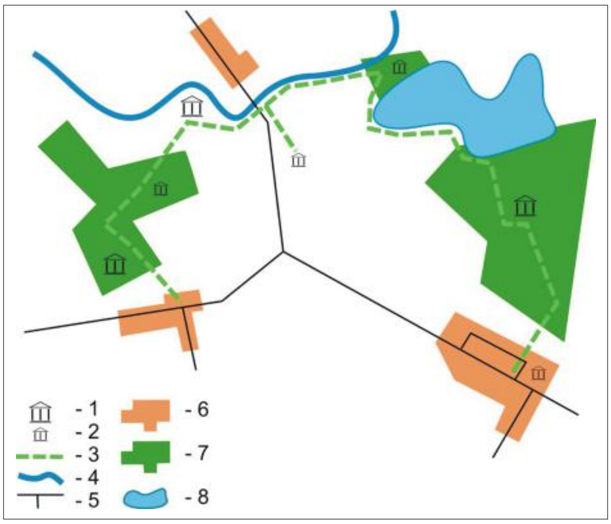

Fig. 1: The current concept of designating greenways
Legend: 1 – primary object of cultural heritage; 2 – secondary object of cultural heritage; 3 – greenway; 4 – rivers; 5 – existing main roads; 6 – built-up areas; 7 – greenspace, e.g. a landscape park; 8 – water body
Source: authors' conceptualisation

Local greenways should start in places with a well-developed road and tourism infrastructure (European Greenway Association, 2014). Brodnica and Górzno, as towns with well-developed tourism and the headquarters of landscape parks, undoubtedly have such an infrastructure. Planning of a completely new route was not considered, because of the already relatively high density of the road network in the region (1.31 km/km^2), partly to avoid further fragmentation of green areas. To designate the greenway, as reported earlier by Garré et al. (2009), we selected paved roads characterised by light traffic to allow comfortable travel and limit the cost of adapting the road to perform new functions.

3. Study area

For this study, we selected an area of 1,402.25 km^2 (Fig. 2), located at the juncture of three provinces in Northern Poland: Kujawsko-Pomorskie (in Brodnica and Rypin Counties), Warmia-Mazury (in Nowe Miasto Lubawskie, Iława, and Działdowo Counties), and Masovia (in Żuromin County).

The study area includes parts of four historical regions: Chełmno Land, Dobrzyń Land, Michałowo Land, and Lubawa Land. After the partitions of Poland (i.e. in 1795), the south-eastern part of the study area was crossed by the border between Prussia and Russia. After World War I, the whole study area was within the 2nd Republic of Poland, but the border between Poland and Germany (East Prussia) was situated north of it. Because of the changing borders between countries and the many battles that took place in the study area, it has a very rich history, but, as a result, a relatively small number of historical buildings still exist, and some of them are in poor condition.

According to the physico-geographical division of Poland (Kondracki, 2009), the study area is within the macroregion of Chełmno-Dobrzyń Lakeland (Pojezierze Chełmińsko-Dobrzyńskie), primarily in the mesoregions of Lubawa Hump (Garb Lubawski, 33.3%), Brodnica Lakeland (Pojezierze Brodnickie, 27.2%), and Drwęca Valley (Dolina Drwęcy, 17.4%), with only small parts in Górzno Plain (Równina Górznieńska, 6.9%) and Iława Lakeland

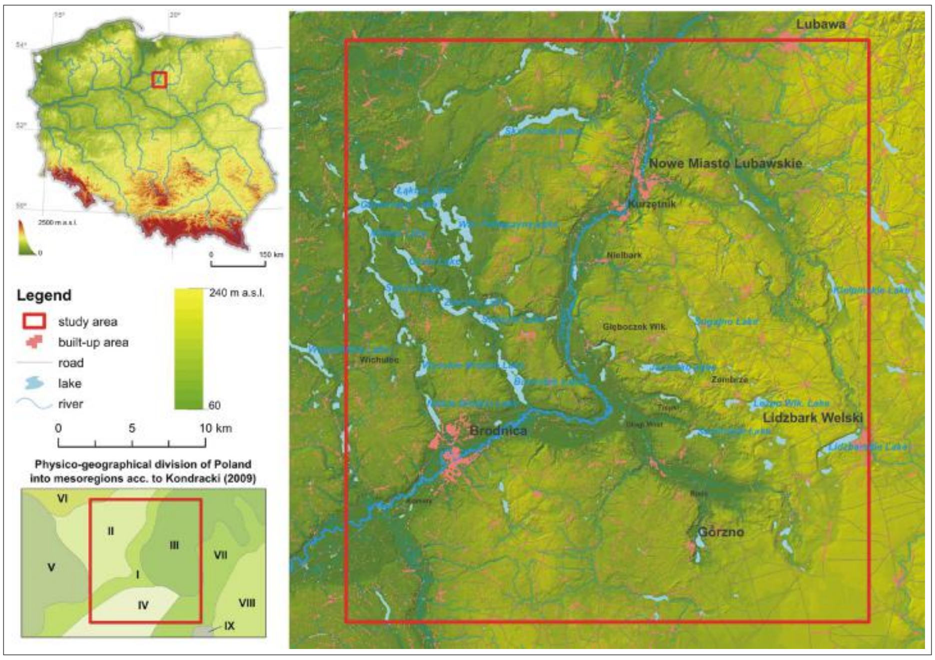

Fig. 2: Location of the study area in a hypsometric map. Legend: I – Drwęca Valley; II – Brodnica Lakeland; III – Lubawa Hump; IV – Dobrzyń Lakeland; V – Chełmno Lakeland; VI – Iława Lakeland; VII – Urszulewska Lowland; VIII – Mława Hills; IX – Raciąż Lowland. Source: authors´ elaboration

(Pojezierze Iławskie, 0.3%). The most elevated part is on the Lubawa Hump, at an altitude of 192 m (in the north-eastern part of the study area), while the lowest place is in the Drwęca Valley at an altitude of 65 m (in the south-western part of the study area).

Land relief has been shaped chiefly by erosion and accumulation related to the ice sheet and its meltwaters during the last glaciation (Vistulian) about 17,000 to 16,000 years BP. In that period, glacial forms (flat and undulating moraine plateaus, terminal moraines), as well as fluvioglacial forms (e.g. sandurs, meltwater channels) have been shaped. They were transformed in the late Pleistocene, in periglacial conditions. Then, periglacial denudation valleys were created, and during the warmer phases the dead ice melted and the resultant kettle holes were transformed into kettle lakes. After the arrival of Neolithic settlers, who introduced agriculture and pastoralism, anthropogenic denudation was initiated as a result of forest clearance and tillage.

In the Brodnica Lakeland, near the village of Wichulec, a chain of morainic forms is visible in the land relief, extending to Zembrze and Wielkie Leźno. The moraine plateaus are slightly undulated and dissected by numerous subglacial channels (up to 50 m deep). The subglacial channels, currently used by the watercourses of Struga Brodnicka, Skarlanka, and Rypienica, are up to about 0.5 km wide. The Drwęca valley is the widest (1–3 km), running from the NE to SW. Close to it, near the village of Kurzętnik, the greatest differences in altitude (over 100 m) are observed.

In the current land relief, some landforms result from economic activity, including excavation of gravel or other construction aggregates. The largest excavation pits are located in the Drwęca Valley (near the villages of Nielbark and Długi Most) and are partly flooded. Abandoned pits are also found near the villages of Ruda, Głęboczek Wielki, and Kominy. Some of the excavation sites have been rehabilitated and designated for afforestation or development. In the study area, apart from construction aggregates, lacustrine tufa was also extracted, e.g. in Trebki and Janówko, as well as clays and peat. Moreover, currently gravel and sand are often extracted from small pits, which are not rehabilitated afterwards.

Because of the varied relief and large differences in altitude, road construction has led to the creation of many embankments, roadside ditches, excavation, trimming, and levelling. Anthropogenic landforms also include grading plains and levelled areas in housing estates, as well as remnants of small medieval settlements, which are relatively rare. Some other anthropogenic landforms result from water resource management: drainage and irrigation ditches, embankments of reservoirs, the basins of mill ponds, mill streams (leats), etc. The landscape is only to a small degree affected by anthropogenic forms resulting from agrotechnical denudation (mostly due to ploughing) and natural slope processes activated by many years of tillage. The forms related to farming activity include high borders between fields (usually grassy), soil-slope aggradation cones from arable fields, areas degraded by farming activity, aggradation covers, grading plains and levelled areas in farmlands. The land relief has been transformed by human activity in only about 4% of the study area in total, however, and the transformed sites are associated primarily with human settlements and transportation (Podgórski, 1996).

A large part of the study area is covered by landscape parks (LPs, Fig. 3): Brodnica LP (166.85 km^2) and Górzno-Lidzbark LP (227.64 km^2). Brodnica LP was created in 1985. A relatively high proportion of the park area is covered by lakes (10%) and over 60% by forests, primarily pine-dominated and mixed forests on sandy acidic soils. Alluvial forests and alder carr forests occupy only a small part of the area. Brodnica LP, along a section of 3 km, borders directly with Górzno-Lidzbark LP. Górzno-Lidzbark LP was created in 1990. The main attraction of the park is the varied terrain characterised by young glacial landforms: patches of moraine plateau, kames, drumlins, eskers, morainic hills, subglacial channels and kettle holes, and in the northern part of the Park, outwash plains. As in Brodnica LP, a large proportion of the Park is covered by forests (ca. 70%).

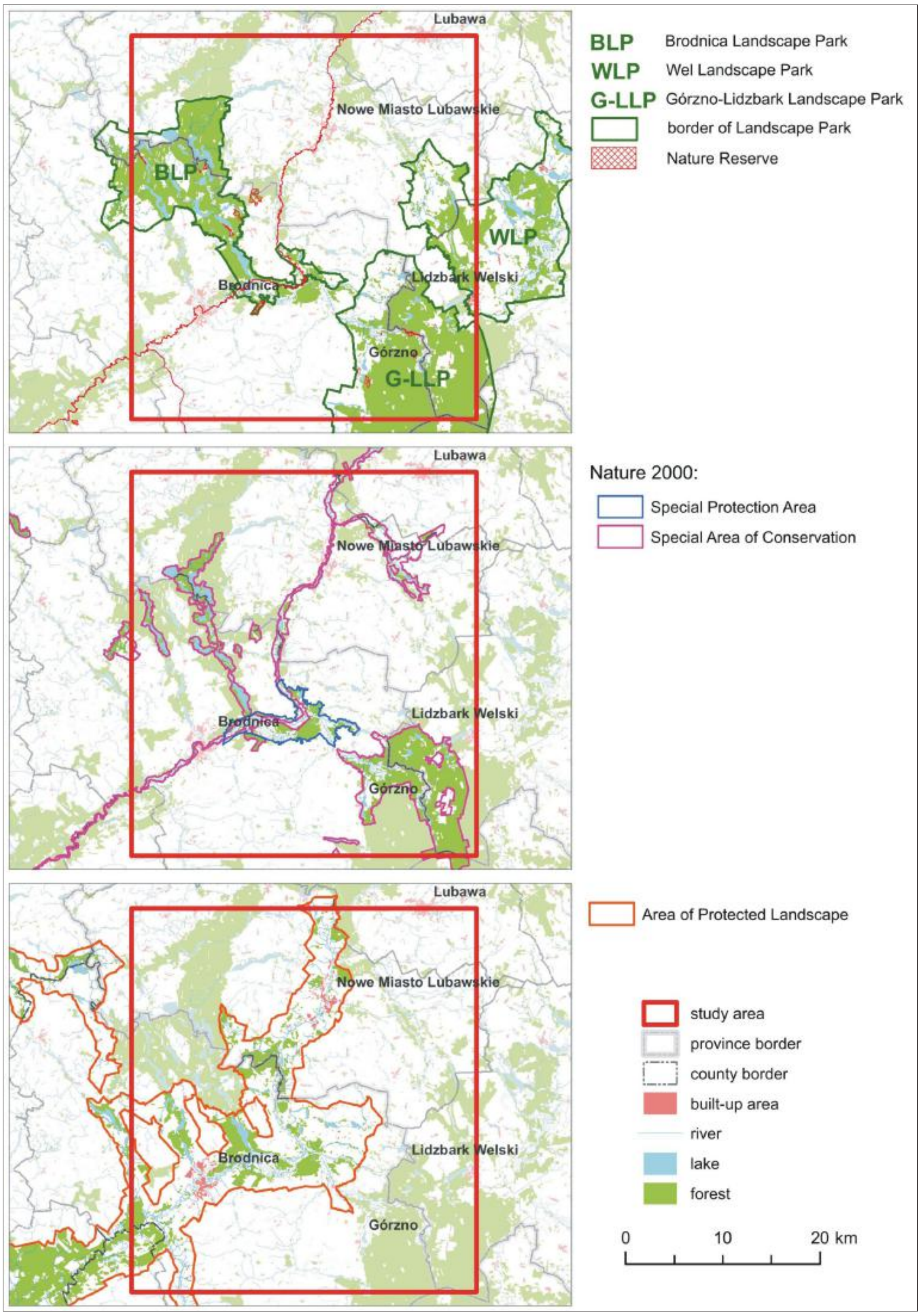

Fig. 3: Protected parts of the study area
Source: authors´ elaboration

The Drwęca Valley, crossing the central part of the study area, and adjacent parts of the direct catchment area are included in the Area of Protected Landscape of Drwęca Valley (Fig. 3). Along the river and in large parts of both LPs, a Special Area of Conservation (SAC) is located. A particularly valuable Natura 2000 site is a Special Protection Area (SPA): "Bagienna Dolina Drwęcy" (33.66 km^2), at the confluence of the Brynica and Drwęca rivers. In total, 67.7% of the study area is protected by law, mostly as landscape parks (28.5%).

4. Methods

To facilitate designation of the greenway in our study, the landscape was evaluated on the basis of visual landscape attractiveness (VLA). In the published literature on studies of visual attractiveness of landscape, some authors have emphasised that landscape attractiveness should not be treated a priori as incidental (Kostrowicki, 1992; Richling and Solon, 2011). That is why many researchers use questionnaire surveys and, on this basis, they build affective evaluations of the study areas (e.g. Cymerman et al., 1988; Pietrzak, 2006; Malinowska, 2010; Rogowski, 2012). When searching for an evaluation procedure, we referred to the one developed by Rutkowski (1978), which is consistent with the concept presented by Kostrowicki (1992), based on an analysis of about 300 evaluations from all over the world. This approach is preferred by many researchers (e.g. Warszyńska, 1970; Sołowiej, 1992; Śleszyński, 1999; Tucki, 2004; Myga-Piątek, 2007; Krukowska and Krukowski, 2009). In the case of such an evaluation, it is more difficult to defend the work against a claim of subjective evaluation than in the case of affective evaluation, but it must be remembered that the undertaken task and the very idea of VLA is supposed to identify the rules of judgments made by the participants (Armand, 1975). Moreover, it is impossible to make a completely objective evaluation, as perception in many cases depends on the psychological and physical factors of the evaluator, rather than on an independent assessment of the landscape itself (Wojciechowski, 1986). We strived to make a comprehensive and objective evaluation of the landscape using two categories: natural and cultural. For this purpose, suitable criteria needed to be developed, as described above.

The landscape evaluation was performed using a Vector Smart Map level 2 (VMap L2) on a scale of 1:50000 (using the available 2006 update package), in the EPSG 4326 system transformed to the EPSG 2180 system. We chose this map type because of the high precision and recent update of this military document, as compared to other maps (Bac-Bronowicz et al., 2007) available for the study area. Additionally, we updated the map to include objects affecting the visual attractiveness of landscape, on the basis of aerial photographs with the use of the Photogrammetry Station DEPHOS. In the analysis, we also used the database of historical buildings of the National Heritage Board of Poland.

The construction of databases, calculations, and final processing of the maps were performed with the use of the ESRI ArcGis 9.3 software. The created algorithms and the tools available in this application enabled us to obtain results relatively quickly and allowed for their elastic modelling. Raw data, after processing and addition to the evaluation database, could be freely included and excluded or transferred to a different category, or even the score could be changed. These apparently simple operations on the database enabled us to check various configurations of the developed evaluation procedure of cultural components of the landscape.

The evaluations were performed in elementary squares (artificial plots). The generated grid contained 5,609 elementary plots of 500 × 500 m, each covering a total of 0.25 km^2. The 4-fold decrease in square size, as compared with the standard 1 km¸ grid spacing, was due to the risk of excessive averaging of natural and cultural values and the resultant loss of some objective information about the study area (Chmielewski, 2012).

We evaluated separately the natural and cultural components of the landscape. In the evaluation of natural components of landscape, we used criteria suggested by Rutkowski (1978). Only the evaluation criteria of surface waters were modified (adapted because of the smaller size of squares) and water quality assessment was omitted (Tab. 1). The evaluation criteria for cultural components of the landscape were created from scratch. All of the objects were divided into two groups: those with increasing VLA scores and those with decreasing scores (Tab. 2).

In the evaluation procedure, we used the traditional classification of data collected in geographic information systems. The data were classified as points, lines or polygons, which increased the possibility of objective evaluation. For example, the object "permanent fencing/wall" running across the whole length of the square was treated as a line, while permanent fencing/wall of small length was treated as a point located in the square. We decided also to introduce some "replicates" of objects, i.e. objects of the same type, depending on dimensions, could be treated as a point, line, or polygon. This resulted primarily from data (VMap L2) used in the evaluation but also from the evaluation of natural components of the landscape. Rutkowski (1978) assumed that that the length of forest edge, lake shoreline or river determines landscape attractiveness. For this reason, linear data were extracted from areal data. The approach used here allowed us to maintain the clarity of the database and the inclusion of incomplete data, e.g. about the historical location of Teutonic castles. In Brodnica, the whole castle outline is

Criterion	Description	Score
Land relief	differences in altitude ≥ 25 m	5
	differences in altitude 21–25 m	4
	differences in altitude 16–20 m	3
	differences in altitude 11–15 m	2
	differences in altitude 5–10 m	1
	differences in altitude ≤ 5 m	0
Surface waters	water body, shoreline ≥ 125 m	4
	water body, shoreline ≤ 125 m	3
	watercourse or drainage ditches	2
	wetland/peatland	1
	no surface waters	0
Forests	forest edge ≥ 625 m long	5
	forest edge 500–625 m long	4
	forest edge 375–500 m long or forest covering > 80%	3
	forest edge 250–375 m long	2
	forest edge 125–250 m long	1
	forest edge ≤ 125 m long	0

Tab. 1: Evaluation criteria for the natural components of landscape
Source: Modified by the authors from Rutkowski's (1978) criteria

Type of object		Score									No. of objects	Area of objects [km²]	Length of objects [km]
		Point object	Polygon object [% of elementary square area]				Line object [m]						
			0–25	26–50	51–75	76–100	0–62.5	62.6–125.0	125.1–187.5	187.6–250.0			
Increasing VLA	cemetery*	+ 1	+ 1	+ 2	+ 3	+ 4					25/39	0.423	
	roadside cross	+ 1									17		
	monument	+ 1									16		
	castle ruins*	+ 1	+ 1	+ 2	+ 3	+ 4					2/3	0.009	
	windmill	+ 1									1		
	historical building	+ 1									95		
	complex of historical buildings	+ 2									36		
Decreasing VLA	chimney	− 1									40		
	opencast mine	− 1	− 1	− 2	− 3	− 4					3/13	0.236	
	wind turbine	− 1									21		
	power pole	− 1									90		
	filling station/tank	− 1									78		
	distribution transformer	− 1	− 1	− 2	− 3	− 4					85/3	0.046	
	tower	− 1									5		
	radio tower	− 1									14		
	industrial plant	− 1	− 1	− 2	− 3	− 4					67/59	1.983	
	building	− 0.1									2,328		
	farm	− 0.1									6,771		
	spoil tip		− 1	− 2	− 3	− 4					7	0.222	
	warehouse or storage yard		− 1	− 2	− 3	− 4					15	0.503	
	built-up area		− 1	− 2	− 3	− 4					909	16.569	
	permanent fencing/wall						− 1	− 2	− 3	− 4	241		0.121
	power line						− 0.1	− 0.2	− 0.3	− 0.4	23		190.874
	temporary fencing						− 0.1	− 0.2	− 0.3	− 0.4	180		0.048

*Tab. 2: Evaluation criteria for visual landscape attractiveness (VLA) of the cultural components of landscape Note: *point and polygon objects*
Source: authors' original evaluation criteria

visible and in the map it can be presented as a polygon (and complete data can be obtained). Ruins of a Teutonic castle are also located in the village of Bratian (near Nowe Miasto Lubawskie). Unfortunately, in this case only small fragments of the walls are visible, so the object was treated as a point (incomplete data).

A literature search revealed two approaches to the treatment of polygons: one based on object area and the other based on border length. The opinion that borders in a landscape determine its attractiveness (Rutkowski, 1978; Śleszyński, 1999; Clay and Daniel, 2000; Krukowska and Krukowski, 2009, etc.) is reflected during the process of polygon evaluation in the calculation of the length of the evaluated object or calculation of its area relative to grid square size. During preparation of the evaluation procedure, we tested both the approaches in the course of the evaluation of wooded areas. We found no substantial differences between the results of elementary square evaluation based on object area and on border length. For this reason, we decided to apply the polygon evaluation method recommended by Rutkowski (1978) and, consequently, to make use of both approaches in the evaluation of the cultural components of the landscape.

The evaluation of hypsometric differentiation (Ar) of land relief should be based on differences in altitude, i.e. relative height. Individual squares were scored according to the applied scale (Tab. 1). The scale consists of 6 ranges of values (of 5 m each, except for the last one, which has no upper limit). During the evaluation, we took into account the maximum difference in altitude in the analysed elementary plot.

The second component of VLA evaluation, analysed in detail, were surface waters (Aw). In this category, elementary squares were scored for presence of running or standing waters (Tab. 1). Running waters include rivers and a network of drainage ditches, removing an excess of water from meadows and arable fields (2 points were added if a watercourse was present in the given elementary plot). Standing waters are primarily lakes (also oxbow lakes), so for their presence, 3 or 4 points were added, depending on the length of the shoreline in the given plot. The evaluation took into account also wetlands and peatlands (1 point was added if they were present in the plot) (Tab. 1). The coexistence of several components in one square resulted in summing up the scores, but we decided that their sum could not exceed 7. Thus for VLA scoring, the most favourable situation was coexistence of several objects in one elementary square.

Forests are valuable components of the landscape and, for this reason, they were treated as yet another component of landscape which needs to be evaluated. We classified as forest all types of wooded habitats, i.e. both mature forests and several-year-old forest plantations. We assumed that forest is most attractive in the places where it borders with other types of land cover (e.g. with meadows, a water body or arable fields). That is why an evaluation criterion was forest edge length (0–5 points) or its percentage contribution if forest accounted for over 80% (3 points, see Tab. 1). The scale consists of 6 ranges of values (of 125 m each, except for the last one, which has no upper limit).

When developing the evaluation criteria of cultural components of the landscape, we decided that the maximum score of this evaluation should only supplement the evaluation of natural components, because natural values more strongly determine the attractiveness of an area (Malinowska, 2010). In our opinion, other evaluation criteria for cultural objects (allowing higher scores than those resulting from the evaluation of natural components) should be applied if the study area includes objects of material culture of national or international importance. We assumed that cultural objects should be scored as follows (see Tab. 2):

- for points of low significance for VLA: ± 0.1;
- for lines of low significance for VLA: from ± 0.1 to ± 0.4;
- for points of high significance for VLA: ± 1;
- for polygons and lines of high significance for VLA: from ± 1 to ± 4; and
- for complexes of historical buildings: + 2.

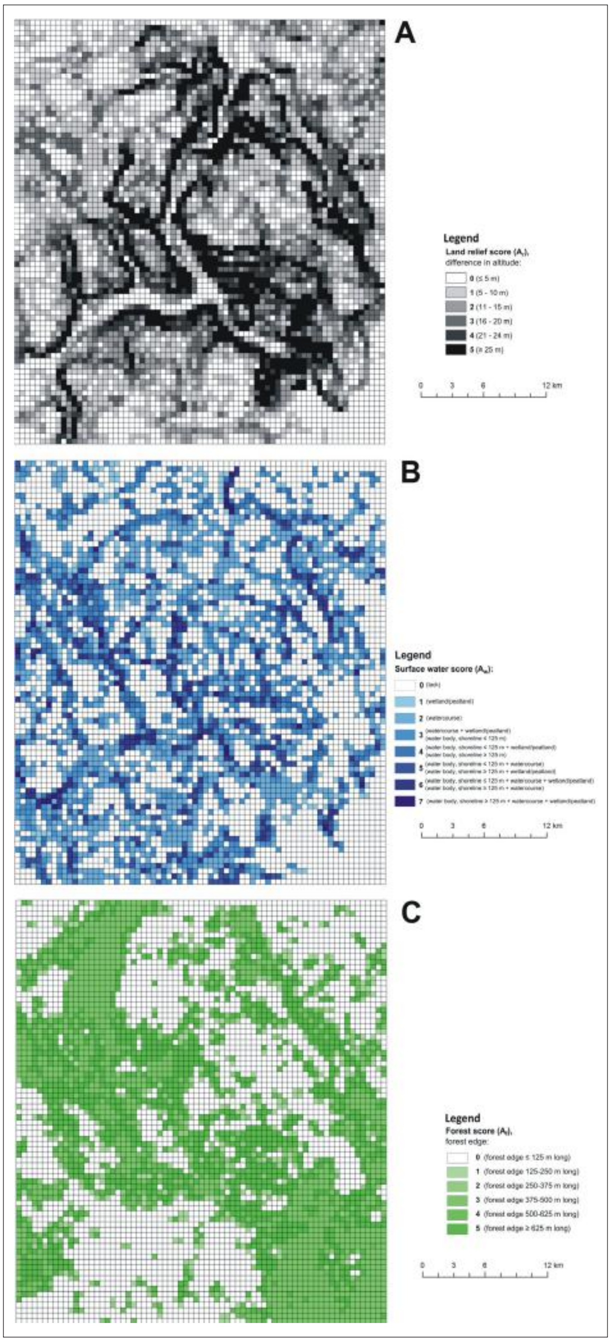

Fig. 4: Results of the evaluation of natural components of landscape (Legend: A – land relief (Ar); B – surface waters (Aw); and C – forests (Af))
Source: authors´ elaboration

The final VLA evaluation map should be constructed after taking into account the sum of the scores of natural components (AN, including land relief [Ar], forests [Af], and surface waters [Aw]) and cultural components (AC):

$$VLA = AN + AC \quad [1]$$

where $AN = Ar + Af + Aw$, and $AC = AC^{+} + AC^{-}$.

5. Results

Results of the evaluation show that land relief significantly affects the attractiveness of the landscape (Fig. 4A). Visual attractiveness of landscape and its differentiation are in the study area determined by the location within various morphological units, sometimes with a distinct geological structure. The morphogenetic character of the study area, and primarily the fact that it is composed of the proglacial valley and the valley of the Drwęca, as well as areas of moraine plateau, strongly dissected by numerous subglacial channels, resulted in large differences in attitude. The distribution of elementary squares with the highest values of Ar is closely related to the outline of the moraine plateau edges, so that in the evaluation map of land relief, the distribution of morphological units of the study area can be read easily. Consequently, the areas classified as the most attractive were the slopes of the proglacial valley and the valley of the Drwęca: edges of the plateau as well as subglacial channels. In 1,444 plots (26%) of 0.25 km^2 each, the difference in altitude exceeded 20 m (Ar score: 4–5). The edges of the terraces are too narrow to give a readable effect in the evaluation process, very much like the lumps and bumps on the well-developed, extensive flood plain. VLA scores were the lowest for moraine plateaus and extensive basins in wider parts of the Drwęca valley (for 39% of all plots, the Ar scores were in the range 0–1).

The final picture of the evaluation of running or standing waters shows a mosaic pattern (Fig. 4B), but a high attractiveness of landscape is clearly related to the distribution of components of the hydrographic network, i.e. the Drwęca and lakes located in the subglacial channels. The Aw score was ≥ 4 points for 1,360 plots (24%). The least attractive parts of the study area (0–1 points) were the patches of the moraine plateau: 2,877 of elementary plots in total (51%).

Wooded habitats cover a large proportion of the study area. Attractive sites are located primarily in north-western and south-eastern parts of the study area (Fig. 4C), where the two landscape parks play the role of greenspaces. Special attention should be paid to the existing "chains" of forest patches, which link these two parts, and the relatively small contribution of small isolated or scattered forest patches. This is an important factor facilitating the designation of the greenway. The Af score was ≥ 3 points on 2,765 plots (49% of all plots), while 2,349 plots were devoid of forest (0 points, 42%).

The VLA evaluation map of the cultural components of landscape [AC] is a result of the evaluation of cultural objects increasing [AC^{+}] or decreasing [AC^{-}] visual attractiveness (Fig. 5). The components increasing the VLA value are usually scattered. Rarely, historical buildings are located very close to one another, but their positive effect on VLA is counterbalanced by their location in built-up areas (negative effect). AC^{+} was recorded on only 165 plots. In the study area, VLA values are more strongly affected by the components that have negative values (AC^{-}), which applies to 3,303 plots (59% of all elementary plots). On many plots (290), VLA values were so strongly reduced that they were finally negative. This indicates an overall negative human impact on the landscape. Plots of this type are located mostly in urban areas (towns and compact villages).

The analysis of spatial variation in VLA within the study area (Fig. 6), shows that the highest scores were recorded in woodlands with varied relief and water bodies or large watercourses (Fig. 7). They are found mainly in subglacial channels and the valley of the Drwęca. In contrast, the lowest VLA scores were recorded in moraine plateaus, mainly used for farming, with scattered or densely built-up areas (the latter greatly decreasing VLA; see Fig. 8).

The greenway was designed on the basis of a grid combining the road network with the results of VLA scoring (Fig. 6). The greenway uses only local asphalt roads running near visually attractive areas, taking into account the recommendations of the European Greenways Association. Next, field research was conducted to check the condition of the tourism infrastructure, available public transportation options, road surface quality and the distribution of food and beverage outlets.

6. Discussion and conclusions

The designated greenway satisfies our assumptions, i.e. it links the most naturally attractive sites protected within the landscape parks, which play the role of greenspaces. This is a recreational route both for tourists coming to Brodnica

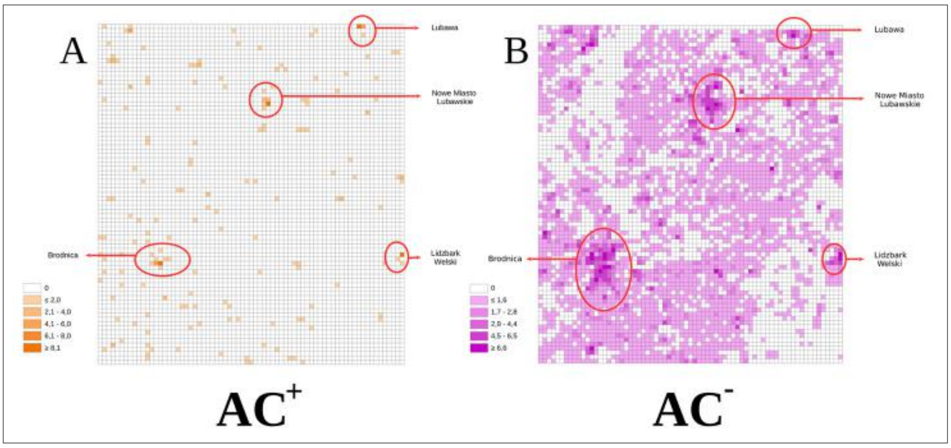

Fig. 5: Evaluation of cultural components of visual landscape attractiveness (VLA; Legend: A – objects increasing VLA (AC^{+}); B – objects decreasing VLA (AC^{-})). Source: authors´ elaboration

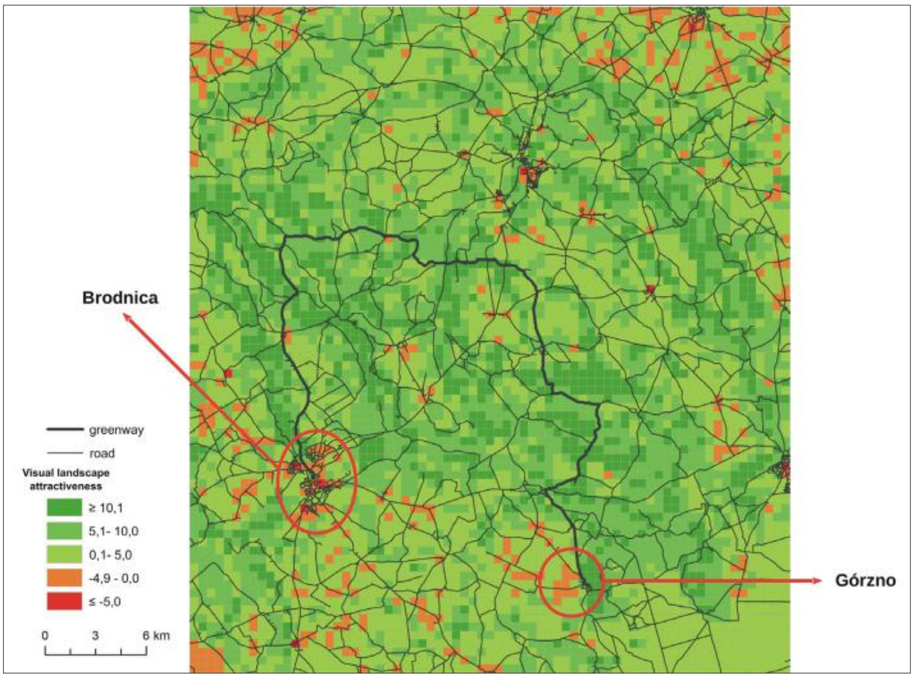

Fig. 6: Greenway designation between Brodnica and Górzno based on the current evaluation of visual landscape attractiveness (VLA) and the existing road network. Source: authors´ elaboration

Fig. 7: Example of a landscape with a high VLA value. Photo: Ł. Sarnowski

Fig. 8: Example of a landscape with a low VLA value. Photo: D. Brykała

Lakeland and for local inhabitants. It is used by cyclists, strollers, and horse riders, as two large stud farms are located near the greenway (in Głęboczek and Leźno). The varied relief and natural water bodies situated close to the greenway are parts of extensive landscape panoramas. The objects of cultural heritage, located close to the greenway, raise the attractiveness of the route. The scattered buildings of farms do not disturb the harmony of the rural landscape. Moreover, in the towns and villages on the route, visitors can see historical churches and cemeteries. Unfortunately, on the designated route there are no particularly interesting historical buildings or other objects that could be the destination for a tourist's travel.

The greenway, because of its predefined function, has the real possibility of encouraging the regional development of the study area, much greater than when a tourist trail is designed in a traditional way, where the space between selected objects (cultural or natural) is less important. The greenway is composed of existing local roads, allowing a more optimal utilization of natural and cultural resources of the landscape, primarily those located between the selected greenspaces. Because of these features, the idea of sustainable development can be implemented and the overlapping protected areas will not be subject to devitalization (Domon, 2011).

During the procedure of greenway designation, we found that it is advisable to make use of the Road Data Bank. The first edition of VMap L2 does not include complete and updated information about road conditions, which makes many analyses impossible, e.g. the least-cost path analysis or network analysis (Li et al., 2010; Tenga et al., 2011, Oh et al., 2007). It is possible to design one greenway on the basis of detailed field research, but when designating several greenways to link a larger number of greenspaces, it would be difficult to conduct extensive field research, so geographic information systems should be used.

In the procedure of greenway designation presented here, the use of the VLA evaluation proved to be very effective. The dense grid of elementary squares forced us to construct a clear and easily modified database. The database enabled us to make a graphic presentation of the introduced changes quickly, and consequently to specify the evaluation criteria more precisely. When developing the procedure, we took into account the possibilities of making the grid denser (by reducing the size of the elementary squares) or processing data concerning a larger area than in this study. The effectiveness of the algorithms was also confirmed for more complicated calculations and analyses, e.g. for the description of the range and field of view (Sarnowski, 2013; Sarnowski et al., 2013). We considered as relevant the inclusion of cultural components of landscape in the evaluation procedure, as well as the use of criteria distinguishing between categories of objects (points, polygons, and lines) and their various sizes.

One of the assumptions of this evaluation procedure was to strive for an objective assessment of the negative effect of cultural objects on VLA scores. During our research on VLA, the need for inclusion of cultural components of landscape was confirmed, but we assumed that they should not be treated exclusively as decreasing its attractiveness. Some components, particularly those regarded as objects of cultural heritage, increase the perceived value of landscape. Hence, a separate category of objects was distinguished. We observed that even single objects can significantly affect the evaluation results, but only when the evaluation is conducted in small-sized elementary squares. The results show that sites with a high AC^+ value are usually scattered and their aggregations are characteristic of only densely built-up areas with complexes of historical buildings. This approach is consistent with our assumptions that the evaluation of cultural components of the landscape should be considered as equally important as the evaluation of natural components. As a consequence, results of the evaluation of natural components of landscape should be corrected based on the evaluation of cultural components, i.e. increased or decreased. For 290 elementary squares, VLA scores were negative, i.e. a negative effect of human pressure prevailed in the perceptions of the given area. Aggregations of squares with negative VLA scores were found primarily in towns and densely built-up villages without objects of cultural heritage. We did not decide in this case to exclude them from the VLA analysis, assuming that they are an integral part of the greenway, and sometimes even of a greenspace.

It would be wrong to assume that built-up areas are always unattractive (Gobster et al., 2004). Our results confirm that densely built-up areas, despite their disputable visual landscape attractiveness, should be subject to an evaluation based on criteria formulated especially for urban areas (Wojciechowski, 1986; Cieślak, 2012).

Acknowledgements

Part of these results derives from the implementation of a research grant funded by the N. Copernicus University – Grant No. 1699-G/2013: "Role of land-cover in 3D modelling processes of viewshed in young-glacial landscape". As well, this study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution Analysis – ICLEA– of the Helmholtz Association: Grant No VH-VI-415, and was also partly supported by the research funds of the Polish Ministry of Science and Higher Education for 2015-2016, assigned for implementation of a co-financed international project (contract No. 3500/ICLEA/15/2016/0).

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Please cite this article as:

SARNOWSKI, L., PODGÓRSKI, Z., BRYKAŁA, D. (2016): Planning a greenway based on an evaluation of visual landscape attractiveness. Moravian Geographical Reports, 24(3): 55–66. Doi: 10.1515/mgr-2016-0017.