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Archaeological landscape – the past and the present. A case study of the megalithic landscape of Wietrzychowice, Poland

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Abstract

Archaeological landscapes are crucial to understanding the evolution, form and meaning of cultural landscape. This paper presents a complex analysis of the archaeological landscape and its temporal and spatial changes, with particular reference to the last 200 years, using the example of a megalithic landscape with barrows in Wietrzychowice (Poland). The aim of the research was to determine the changes in the structure and function of the landscape and to identify the processes that caused these changes. A complex Model of Archaeological Landscape Analysis (MALA) was proposed which presents the current archaeological landscape and its historical changes both graphically and descriptively. The literature was studied and cartographic research was conducted, and this was supplemented by field visits. The results allowed us to distinguish 6 stages of the life-history of the analysed landscape. The megalithic landscape of Wietrzychowice represents a genetically heterogeneous, homotonous in terms of land cover, reversed (chronologically younger landscape replaced by a chronologically older landscape) stratigraphic type. The most persistent landscape type is the forest. The main processes occurring there were erosion, deforestation, afforestation, barrow construction, excavation and reconstruction. The functions changed from ecological to touristic. The visual role of the barrows as the dominant features of the landscape has varied. This method can be used in landscape protection and planning and in landscape education.

Keywords:
archaeological landscape, megaliths, megalithic landscape, landscape changes, cultural landscape, physiognomy of landscape, Wietrzychowice

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1 Introduction

Landscape is a complex concept which has various interpretations. It can relate to the dynamic relationship between ecosystems (heterogeneous land area composed of a cluster of interacting ecosystems, Forman and Gordon 1986), the physiognomic structure of natural and cultural elements (an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors, Council of Europe, 2000) or focus on the processes of humans and nature through time and across space (Denham 2017). As a type of landscape, the cultural landscape has developed based on the natural landscape, and its structure depends significantly on the functions that man has designated for each particular area (Żemła-Siesicka and U. Myga-Piątek 2021a). The cultural landscape is a subject of study in various disciplines, including landscape archaeology, geography and landscape architecture, which implies different approaches to research. One of its sub-types is the archaeological landscape. This can be defined as a landscape in which archaeological sites (which have its own landscape form, such as tombs, barrows, cromlechs) are the dominant element (Kobyliński 1999). It refers to current landscapes which have been historically transformed but with a certain contemporary form, function and physiognomy. Such understanding of this term tends to be used in the geographical or architectural sciences, in contrast to the concept of landscape archaeology, which refers to the significance of landscape for past cultures and concentrates on the study of artefacts, features and sites within the broader spatial realms (physical and meaningful) of past human experience (Yang and Han 2020). Cultural landscapes, covering also archaeological sites, are crucial to understanding the evolution of generations and the form and meaning of landscapes, as well as to track the interaction between man and nature (Żemła-Siesicka and U. Myga-Piątek 2021a).

Combining the concept of archaeological landscape (understood as a current landscape with a long history) and landscape archaeology (in a landscape biography approach) allows us to analyse the changes in a landscape throughout history, not only the distant, but also the recent. Understanding past landscapes and their history and describing the patterns and causes of evolution and change are all important activities in landscape planning and protection (Marcucci 2000). This approach to the historic landscape (including archaeological ones) – taking into account the contemporary need for protection and planning – is reflected in the historical landscape characterisation (HLC) introduced in Great Britain (Aldred and Fairclough 2003; Turner 2018). The purpose of the HLC is to identify the historic influences that have shaped and defined the present day landscape. It delineates landscape types with a relatively homogeneous character of historic land cover or land-use and current historical structures (Majchrowska 2015). The archaeological context was highlighted in Lowland Cornwall project, which analyses the relationship between HLC and pre-medieval archaeology (Young 2015). Another method of assessing past changes is the analysis of landscape persistence. The temporal continuity of the given landscape type enables the identification of “old” and “new” landscapes (Darvill 2006). The temporal changes of historic landscape are often described by the landscape biography used in archaeology (Kobyliński 1999; Roymans et al. 2009;) but can also be presented using a graphical method of landscape stratigraphy (Myga-Piątek 2018; Żemła-Siesicka and U. Myga-Piątek 2021b;) or by cartographic analysis (Affek 2016; Sobala 2018; Godziek and Szypuła 2020; Forte et al. 2006). Most landscape history studies cover only the physical elements of the landscape, but there are also some attempts to integrate tangible and intangible components to trace changes through time and space (Yang and Han 2020). Marcucci (2000) claims that landscape history exposes the evolutionary structure of a specific landscape through its ecological and cultural periods and keystone processes. It covers a specific place, describes a holistic system and includes the processes that shape the landscape over time. The efforts to plan and protect archaeological landscapes force us to consider what a place used to look like in the past. The visual aspects of landscape history include visualisation and restoration of historical cultural landscapes (Forte et al. 2006; Kolbovsky and Medovikova 2017) or an assessment of the visibility range of archaeological structures (Sjögren 2010; Gillings 2009).

A specific type of archaeological landscape is the megalithic landscape. This is a landscape with a specific physiognomy characterized by its own landform, i.e., the presence of more or less visible stone or stone-earth megalithic structures, unique non-material features and specific genius loci related to its historical and current functions (Żemła-Siesicka 2019). Research on megalithic constructions and their relationship with the landscape mostly focuses on pre or protohistory, meaning on the time of their construction and use, which provides information on the peoples and the landscape of the time. There are some examples where the time of research has been extended to early history or even modern times, as Holtorf's publication (1998), which presents a life-history of megaliths, divided into birth, childhood, youth and adulthood or biographies of prehistoric monuments presented by Diaz-Guardamino et al. (2015), which follow their history from prehistoric and Roman periods up to Modern periods. But there is a gap in the research covering complex landscape changes in the last centuries.

This paper presents a complex analysis of the contemporary archaeological landscape and its temporal and spatial changes, with particular reference to the last 200 years, using the example of a megalithic landscape in Wietrzychowice (Poland). The aim of the research is to determine the changes in the structure and function of the landscape and to identify the processes that influenced those changes. To complete this purpose, a complex Model of Archaeological Landscape Analysis (MALA) is proposed which presents the current archaeological landscape and its historical changes both graphically and descriptively. MALA allows us to trace changes in the following areas:

- Changes in the structure of landscape types (land cover),
- Changes in landscape structure (natural and cultural elements),
- Changes in the physiognomy of the landscape,
- Evolution of landscape functions,
- Identification of the key processes that cause changes,
- Determination of the stages (periods) of the evolution of archaeological landscape.

For these purposes, a megalithic landscape with barrows was chosen as an example of an archaeological landscape distinguished by its own, well visible landform. The literature was studied and cartographic research was conducted, and this was supplemented by field visits.

The complex concept of landscape, its multivalence, the variety of scales of study and the different approaches to research depending on the discipline require an initial adoption of the main assumptions of the research with regards to the concept of megalithic landscape:

- Landscape is a dynamic system in which all elements, both natural and cultural, and with them the physiognomy and the function of landscape, are constantly changing.
- The megalithic landscape is a subtype of archaeological landscape.
- The megalithic landscape is an area with a specific physiognomy characterized by its own landscape form of stone or stone-earth megalithic monuments (Żemła-Siesicka 2019).
- The term megalithic landscape can only apply to areas where there are several structures with visible landforms. In the case of a single structure, it is more appropriate to consider megaliths as objects placed in the landscape.
- The megalithic landscape can be considered a sub-landscape or meso-landscape, (Chmielewski et al. 2018), and so research is conducted on an architectural scale but using architectural and geographical methods.

Methods from diverse discipline are used, but the landscape architecture approach is predominant.

2 Material and methods

2.1 Study area

Megalithic forms are present in several locations in Poland, and more and more of them are being discovered thanks to new methods of research, such as non-destructive prospection – light detection and ranging (LIDAR) (i.e., Przybył 2014; Guyot et al. 2018; Cerrillo-Cuenca and Bueno-Ramírez 2019).

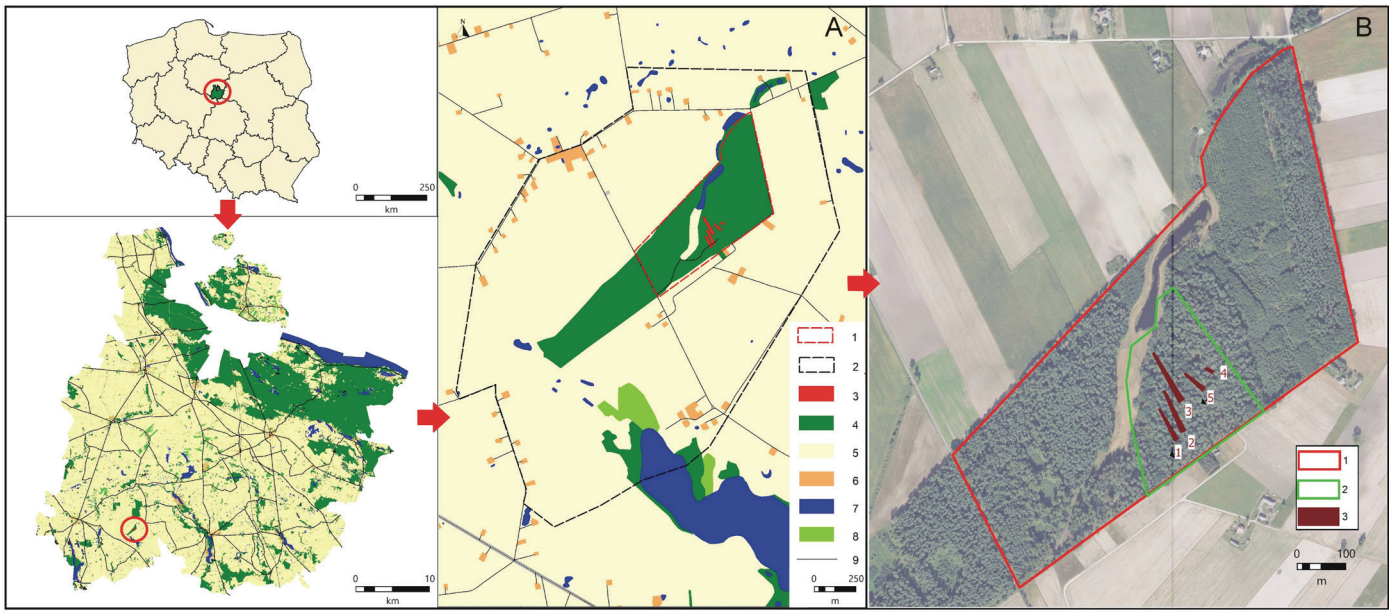

Figure 1. Location of the study area in Poland (top left), in Włocławski district (bottom left), the study area with a cultural park buffer zone (A). 1 – borders of study area (II zone of the Wietrzychowice Culture Park), 2 – borders of buffer zone (III zone of culture park), 3 – barrows, 4 – forests, 5 – arable fields, 6 – built up area, 7 – water bodies, 8 – shrub area, 9 – roads and paths. (Maps based on Database of Topographic Objects, 10K, 2020). Location of the barrows next to the study area (B). 1 – borders of the study area, 2 – conservation zone, 3 – barrows.

One of the most popular and well-described megalithic sites (cemetery) in Poland is an archaeological reserve in Wietrzychowice (Kuyavia, central Poland). The area is located in the forest near a small pond to the south of Wietrzychowice village (municipality of Izbica Kujawska, Kujawsko-Pomorskie voivodship) (Figure 1A) and includes five long barrows dating back over 5000 years.

The excavations and scientific publications of the site go back to 1873, with mentions in the literature even as far back as 1843 (Papiernik et al. 2020). Currently, the site is protected as a monument, archaeological reserve and culture park. The Wietrzychowice Culture Parc, as a protection area, includes two sites: in Wietrzychowice and in Gaj Stolarski. The site in Wietrzychowice consists of three zones: I – of conservation protection (covering the barrows and their close vicinity, 6.34ha), II – the landscape protection zone, and III – the buffer zone (covering mostly arable fields supplemented by built-up areas, 398ha) of the Culture Parc (Gerc et al. 2012). As an area of natural, cultural and scenic value, the landscape protection zone (II) of the Wietrzychowice Culture Park (37.65ha) was chosen for this study. This area is crucial for the preservation of scenic and cognitive values (Gerc et al. 2012).

The five long barrows (Figure 1B), called Kuyavian barrows or Polish pyramids, located in zone I were constructed in the Funeral Beaker period (Neolithic, 3500 BC). They are unchambered tombs of trapezoid-triangular form, constructed of earth mounds and outlined with boulders. The elongated barrows are faced around their higher and wider parts with larger boulders to the southeast, and narrow low "tails" directed towards the northwest.

Currently, after their reconstruction in the 20th century, the barrows are from 30m to 115m long, 6.5 to 10m wide and approximately 1.5 to 2.5m high (Gerc et al. 2012). As the place has a long history and a visible landform, as well as being well-promoted, it became a tourist attraction equipped with parking lots, recreational places and educational boards. (Figure 2).

2.2 Data collection

The data concerning changes to megalithic landscapes was collected on the basis of research done on specialist literature. Archaeological articles, monographs and book guides provided information mostly about barrows, their functions and archaeological excavations, but also about natural compo-

Figure 2. Current landscape elements of the area. Left: barrows 1-5 (from top to bottom), right: examples of tourist facilities (author's own collection, 2021).

nents of the studied landscape. The second source of the data was cartographic materials. Topographic maps from different periods: 1831 (Topographic map of the Kingdom of Poland, scale 1:126,000), 1944 (Deuche Heereskarte, scale 1:25,000), 1965 (scale 1:25,000) and 2020 (Database of Topographic Objects, 10K), were analysed. The limited availability of historical data has resulted in some differences in the scale and accuracy of the information (the 2020 topographic map is more detailed than historical maps, and a map from 1831 is on a different scale to the maps from 1944 and 1965).

To analyse the natural layer of 2020, an orthophotographic map was analysed, as well as data concerning forests (forest data bank, stand description, presented in online maps of State Forests) and Digital Terrain Models (hillshade visualisation). The location of the barrows was identified by using data from airborne laser scanning in the form of maps obtained by shading (Sky View Factor), which were also verified in the field (2021) and complemented by a literature review (including historical photos presented by Papiernik and Płaza (2017).

The construction of the model and its particular elements required the use of diverse software, both Geographic Information System (GIS) (for land cover analysis) and graphic (model construction, visualisation of data).

2.3 Methodological approach

The methods combine some elements of archaeological (literature review), geographic (cartographic analyses, keystone processes identification) and mostly landscape architectural (approach to landscape analysis, visualisations) methods. In July 2021, a field visit was also carried out.

The Model of Archaeological Landscape Analysis (MALA) proposed in the article is a complex method of study covering the historical changes and the present state of the area. To construct the model, several methods of landscape assessment were used. The framework for the model is the concept of Biography-Structure-Image (BSI) (Raszeja 2015), complemented by a landscape stratigraphic model (Myga-Piątek 2012; Myga-Piątek, 2018; Żemła-Siesicka and Myga-Piątek 2021a; Żemła-Siesicka and Myga-Piątek 2021b) and elements of landscape architecture methods, covering three landscape elements (layers): natural, cultural and physiognomic (visual) (Żarska 2003). According to BSI, a particular landscape is a unique spatial structure in which historical processes, geographical relationships and cultural symbols and meanings are encoded, forming a distinctive view. In this concept, there are three components of landscape identity: the biography (as a process of landscape formation under the influence of trends and phenomena of different nature and scope), the structure (the effects of historical processes determined by the nature of individual elements, their distribution and mutual relations) and the physiognomy (which results from spatial and compositional parameters) (Raszeja 2015). MALA presents the results of the landscape biography (based on the analysis of specialist literature), structural analysis (historical and contemporary topographic maps of 1831, 1932, 1965, 2020) and the resulting visualisations of the landscape.

The model includes two parts: a graphical diagram and the description (interpretation) of its elements (the conception of the diagram is presented in Figure 3). The model covers several issues:

A. Evolution of landscape types:
    1. Landscape type structure: landscape types analysed for several periods, presented on historical and contemporary maps.
    2. Landscape stratigraphy: spatial interpretation of landscape type structure over time.
    3. Stages: identified stages of the evolution of the landscape in relation to keystone processes.
B. Landscape functions: evolution of landscape functions over the time.
C. Landscape structure: analysis of landscape structure change: natural (vegetation, water bodies, relief) and cultural.
D. Landscape physiognomy: change of the physiognomy (spatial units delineated by natural and cultural elements, openness of the landscape, dominants).
E. Visualisation of the landscape
    1. Landscape model: visualisation of the landscape in the landscape model.
    2. Graphic visualisation of particular landscape elements.

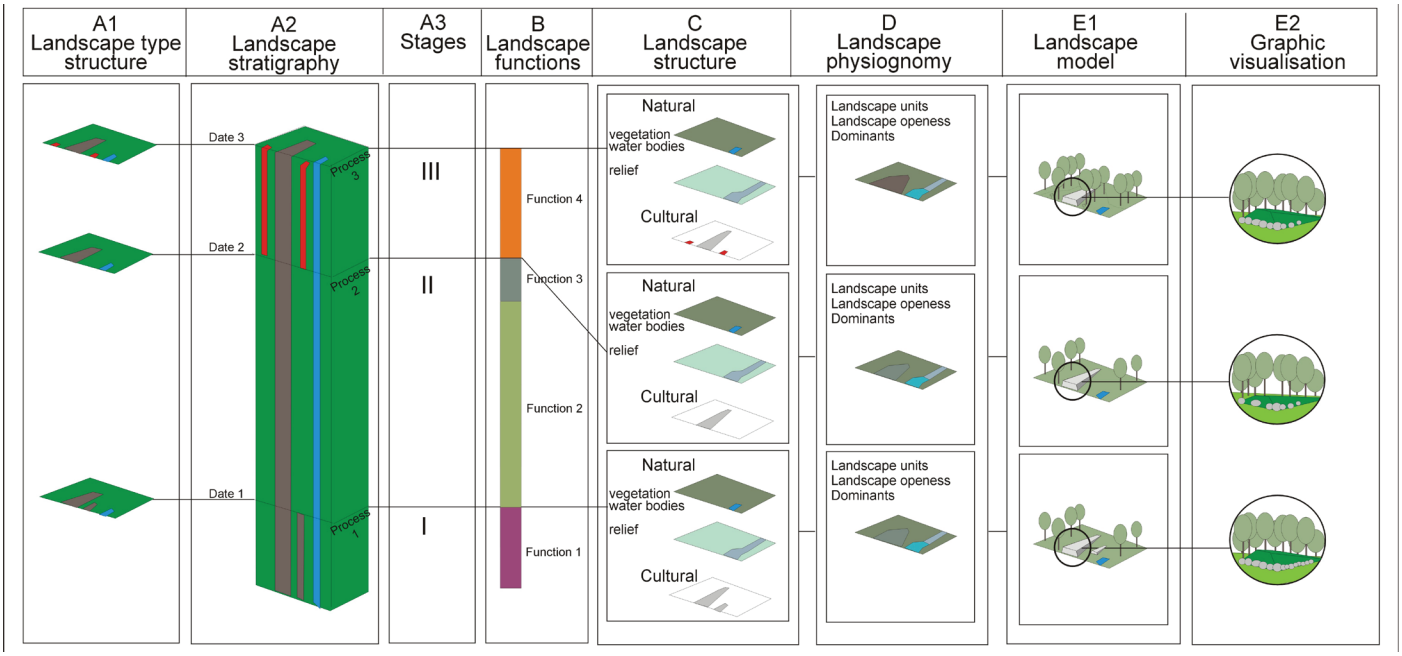

Figure 3. Schematic diagram of the Model of Archaeological Landscape Analysis (MALA).

A. Evolution of landscape types: Landscape type structure, stratigraphy and stages

Landscape is a complex term which can be studied using different approaches. According to one of them, landscape is treated as a combination of different types of land cover (Chmielewski 2012). This concept of research is popular in geography and is often used to assess landscape changes or the persistence of particular landscape types (i.e., Lieskovský and Bürgi 2017; Sobala 2018; Affek 2016). This approach allows us to describe changes based on the cartographic data available. In the presented research, the land cover was determined using topographic maps from the last 200 years: For this purpose, maps from the years 1831 (scale 1:126 000), 1928 (scale 1:25 000), 1965 (scale 1:25 000), and 2020 (TBD digital map, land cover layers at level 2) were analysed using digital layers and vectorising data from raster maps (1831, 1944 and 1965). Forests, arable fields, swamps, meadows and water bodies were identified, and the percentage share was determined. A quantitative analysis of the share of different landscape types using cartographic methods was performed using GIS software (Mapinfo Pro17), and statistical methods (calculation of the percentage). Due to a lack of precise data, only approximate landscape types were identified for the prehistorical period.

The obtained maps of landscape types were used to create a landscape stratigraphy model. Landscape stratigraphy is a method of interpretation of the specific arrangement of landscape layers (historical landscape structures) (Myga-Piątek 2018). Each level can be chronologically assigned. The model presents the surface of the land of different landscape types typical of different historical periods. The number of layers and their age indicate the so-called "time depth" of the landscape and carry information about the persistence of a given landscape type. The model is illustrated in a cuboid form constructed of subsequent time layers. In stratigraphic landscape typology, several types and sub-types of landscape can be distinguished, depending on the genetic origin (homogeneous and heterogeneous) and the uniformity of land cover and land development (homotonous and heterotonous): type 1 – Continuous homogenous and homotonous landscapes, type 2 – Heterogeneous homotonous landscapes, type 3 – Heterogeneous and heterotonous landscapes (Myga-Piątek 2018) (Table 1).

The stratigraphic model was constructed by overlapping obtained maps of landscape types using SketchUp software. Each map was imposed on a prepared block of an appropriate height, depending on the duration of the studied period. On the sides of the profile (block), landscape type changes were delineated.

Table 1. Stratigraphic landscape typology (based on Myga-Piątek 2012; Myga-Piątek 2018).

Type	Subtype	Description
Type 1 – Continuous homogenous and homotonous landscapes		landscapes formed over the „bare root" of a landscape; one (and the same) traditional mode of use, not changed over the ages (e.g. agricultural landscapes developed centuries ago on a natural land cover, not changed by the revolution, only modelled by evolution)
Type 2 – Heterogeneous homotonous landscapes	Simple sub-type (T2/A)	consistent, mostly complete and chronological landscape layer arrangement; reflection of evolutionary change related to the increasing needs and technological development of humanity (e.g. natural landscapes - agricultural - urban - industrial landscapes)
	Incomplete sub-type (T2/B)	this profile with gaps; lack of evolutionary link as a result of natural processes (e.g. re-naturalisation of habitats caused by extreme natural events) or anthropogenic processes (e.g. legal and administrative causes.); revolutionary type of transformation; new structural elements replacing destroyed structural elements of the previous landscapes (landscape erosion)
	Reversed sub-type (T2/C)	chronologically younger landscape developed on a natural land cover, replaced (covered) by a chronologically older landscape (e.g. revitalised modern post-exploitation landscapes – forest)
Type 3 – Heterogeneous and heterotonous landscapes	Mixed sub-type T3/A	transitional type between heterogeneous homotonous landscapes (T2) and heterogeneous heterotonous, vertical landscapes (T3/B); incomplete transformations (functional, structural, physiognomic); evolutionary type of transformation (gradual remodelling related to the cultural evolution of communities); presence of „landscape faults" (a sudden event associated with the impact of a strong factor); possible presence of landscape intrusions, reflecting past land use, currently „covered" by a completely different or a relatively similar type of cultural landscape
	Vertical sub-type T3/B	coexisting of cultural (or natural) landscape types, representing various styles of use, functions, origins and chronology; a mosaic of numerous functions (e.g. modern urban-industrial areas which at the same time fulfil tourist and recreation functions and contain a large percentage of post-exploitation areas)

Complemented by the cartographic and literature analysis of the natural and cultural elements, the stratigraphy allowed us to determine the stages of megalithic landscape evolution in relation to keystone processes. Keystone processes are formative processes which influence the trajectory of landscape change. Five general categories of these processes can be distinguished: geomorphological, climate change, colonization patterns and growth of organisms, local disturbances of individual ecosystems, and cultural processes (Marcucci 2000). The origin of the process can be natural and human (anthropogenic).

B. Landscape functions

The functions of the landscape have been raised by many authors (e.g., Willemen et al. 2008; De Groot and Hein 2007; Costanza and Farber 2002). Andreychouk (2015) groups them into several types: spatial, ecological, nature protection, material supply, energy supply, communication, educational, recreational, sacred and aesthetic. In the case of the megalithic landscape, the range of functions is limited to a few: among others, spatial (settlement), sacred (burial mounds) and educational (cognitive, exploratory, related to excavations and tourism development) or aesthetic functions (perception of beauty).

C. Landscape structure

Landscape is a unique combination of elements and features: natural, cultural, aesthetic and perceptual (Tudor 2014). In the landscape structure analysis, the cultural and natural characteristics were taken into account as tangible and possible to identify on maps.

In the natural layout, vegetation, water bodies and relief were analysed for each period. It was assumed that the relief has not significantly changed, so the Digital Terrain Model (DTM) – hillshade visualisation (available on national GIS portal) – was adapted to all analysed periods. A comparison of topographic maps from the analysed periods showed similar relief, especially the position of the valley, therefore the contemporary DTM was considered to be the most accurate and was used for all periods. There is no cartographic data concerning the relief for the time of construction of the barrows, but the spatial arrangement of the surface sediments confirms the position of the valley (Břízová and Roman 2015; Makohonienko et al. 2021). Given the absence of significant anthropogenic influence in the study area, it can be assumed that the landform did not change significantly over the centuries. The analysis of the relief enabled more precise identification of the land cover for the 1831 map, which was prepared on a less detailed scale than the other maps analysed.

Considering the course of the valley, the boundaries of meadows, forests and arable fields have been corrected.

The land cover of vegetation and water bodies was based on topographic maps (structure), literature and historical photos (if available) (type of forest). For the current (actual) landscape, the type of forest was presented in more detail as the orthophotomap and forest data (stand description) were available.

The cultural layer in Wietrzychowice covers megaliths and tourist facilities. Location data were obtained from contemporary maps (DTM) and field visits. Data on the origin and transformation of these elements were collected on the basis of the literature.

D. Landscape physiognomy

The physical layout (the character, number, spatial arrangement) of natural and cultural features define the visual effects of their coexistence, called the physiognomy of the landscape (Dunning et al. 1992). This addresses the aesthetic features of natural and cultural components. One of the methods of the analysis of the physiognomic structure is an identification of spatial units delineated by natural and cultural elements (Chmielewski 2012). In the presented model, spatial units were identified by combining relief and land cover units. The resulting physiognomic units were marked on maps and described. Next, the open landscape was delineated.

The physiognomic analysis can also include elements of visual composition, such as landscape dominants (landmarks). A "landscape dominant element" is similar to a "landmark" (geographic objects that structure human mental representations of a space, (Richter and Winter 2014) but has a more tangible dimension. A dominant can be defined as an object with a significant visual impact on the landscape distinguished by its height, dimensions, colour, material and texture (Ozimek 2019). The indication of visual values is essential for the design and protection of the landscape. The dominance of the barrows during individual periods was indicated on the maps.

E. Visualisation of the landscape: landscape model and graphic visualisation

This part of the research includes two kinds of visualisation. The first one is a visualisation of the landscape at particular stages in the form of a 3D landscape model (axonometry) which presents the whole area and is constructed on the basis of the physiognomy of the landscape.

The second type of visualisation is a graphic drawing presenting the vertical aspect of the landscape. It aims to show the change of the barrows' "life", from their construction, through degradation and excavation to reconstruction. The drawings were inspired by photographs of the barrows from different periods, except the one presenting the time of the construction, which was made on the basis of information and drawings that already existed in the literature (Papiernik and Płaza 2017).

3 Results

Based on the literature and cartographic analyses, the stages of landscape development were described. In addition, the changes in the structure of landscape types (land cover), cultural, natural and physiognomic features, and the landscape function development were analysed. The results are shown in the graphical model (Figure 4) and also described in detail.

In the biography of the megalithic landscape in Wietrzychowice, six stages of landscape evolution were distinguished based on the important events and changes in the main landscape functions.

Stage 1 – Formation of the natural (primary) landscape

This phase covers the period before the construction of the barrows (before 3500 BC), during which the relief, soils and vegetation were formed. In this phase, human interference is not visible in the landscape, the main function is an ecological one and the key processes forming the landscape are natural and related to the formation of the relief, soil and vegetation.

Stage 2 – Construction of megalithic barrows 3500-2500 BC

During this period, the barrows were constructed by the Funnel Beaker Culture (FBC) society. The human intervention in the landscape became visible. Stud-

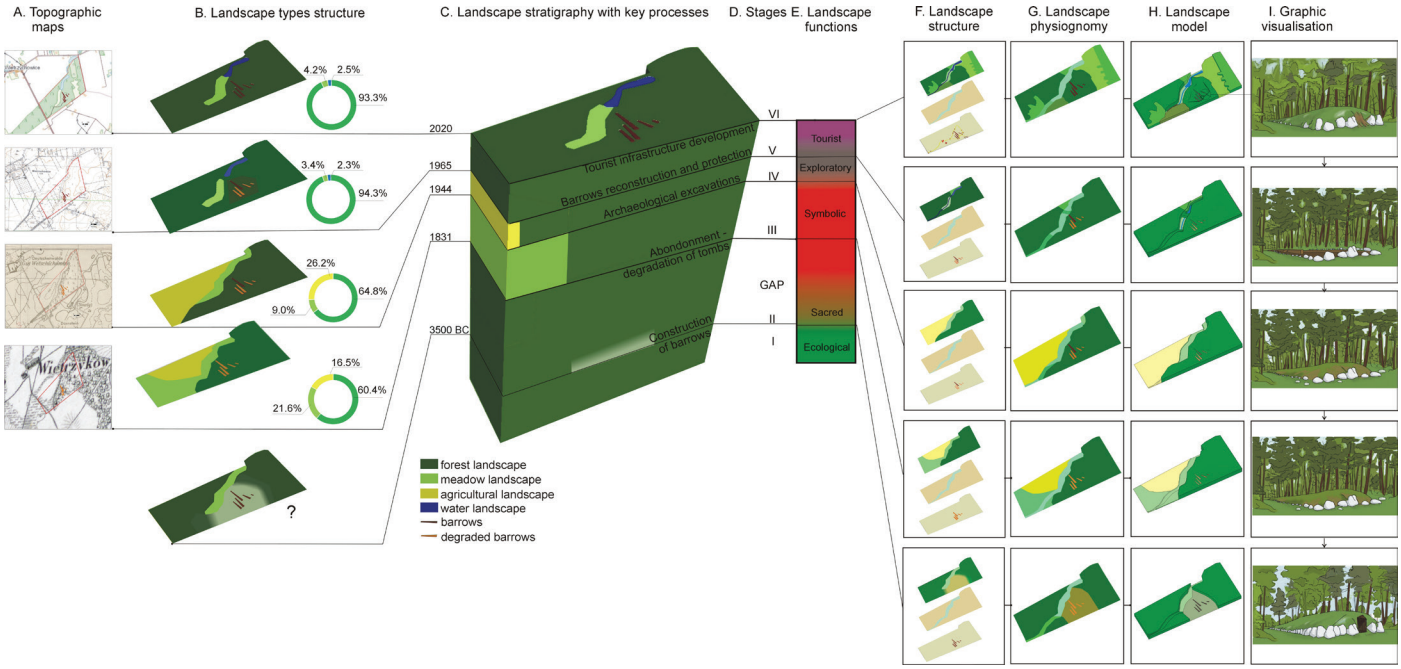

Figure 4. Graphical presentation of MALA results.

ies conducted in recent years (Makohonienko et al. 2021; Papiernik et al. 2020) show that, during the Neolithic Funnel Beaker Culture, human settlements and megalithic structures were present in the neighbourhood of the Wietrzychowice Culture Park.

The tombs were a distinctive element in the space inhabited and developed by farmers. Due to their size and location, they were spatial dominants, clearly visible from a distance.

At this time, the vegetation was dominated by trees, mainly pine, while in the valley, there was a swamp (Papiernik and Płaza 2017).

During this phase, anthropogenic processes, such as settlement and the construction of tombs and the partial deforestation that entailed, played an important role.

GAP – between the construction of the barrows and the 19th century – no literature or cartographic data is available. Maps from this period, if present, are not accurate enough to trace changes at this scale. A map from 1785 (Detailed map of Brzesko-Kujawskie and Inowrocławskie voivodeships 1785) indicates that the whole study area was covered in forest. During this period, the barrows were gradually destroyed, mainly by natural causes (erosion).

Stage 3 – discovery of the barrows – 19th century

After the abandonment of the barrows and their slow destruction, at the beginning of the 19th century, the landform of the barrows was eroded, and the boulders were reused by the locals. However, the place began to attract the interest of scientists and poets (Papiernik and Płaza 2017).

Some changes occurred in land use. According to the 1831 map, the western part of the study area was deforested and partly used as arable fields. The part with tombs was still maintained as forest, which had an influence on the preservation of the grave remains. The change in land cover influenced the landscape physiognomy.

Stage 4 – archaeological excavations – first half of the 20th century

In the first half of the 20th century, archaeologists' interest in the remains of tombs grew. In the 30s, the first excavations took place. As the excavations brought a lot of information about the Neolithic culture, the important function of the landscape was a cognitive (educational) one.

At this stage, the forest was slightly enlarged, and the arable fields expanded at the expense of the meadows. Once again, some changes in landscape composition occurred as a result of tree removal

for archaeological excavation and later as a result of the barrow reconstruction and its return to a visible landform.

Stage 5 – archaeological excavations with total reconstruction and protection – second half of the 20th century

In the 1960s, further excavations were conducted, and all the barrows were finally reconstructed. After the reconstruction, the protection forms were established, and the first educational boards appeared.

The process of reforestation continued and finally, the whole area, except part of the valley, became forest. Changes to the landscape composition continued as a result of the reconstruction of all the tombs and the return to the original landforms. This action caused a loss of authenticity (artificial reconstruction), but at the same time the significance of tourism increased.

Stage 6 – strengthening of the protection and tourist development – first half of the 21st century

The next period brought a further strengthening of the site protection – the establishment of a Wietrzychowice Culture Park. The role of tourism increased with the creation of educational paths and other tourist facilities.

3.2 Changes in the structure of landscape types

The structure of landscape types understood as land cover have been examined through the centuries. The share of different landscape types was calculated for 1831, 1944, 1965 and 2020 (table 2). Some differences in the cover are related to the accuracy of the topographic maps (water bodies are not indicated on the 1831 and 1944 maps). The forests covering the area in the 19th and at the beginning of the 20th century had a similar share. A significant increase in forests, at the expense of arable land, occurred in the second half of the 20th century. The meadows covering a significant part of the northwestern area in the first half of the 19th century were reduced to the valley in the 20th century. Arable fields were enlarged at the expense of meadows in the first half of the 20th century, before being afforested in the second half (Figure 5).

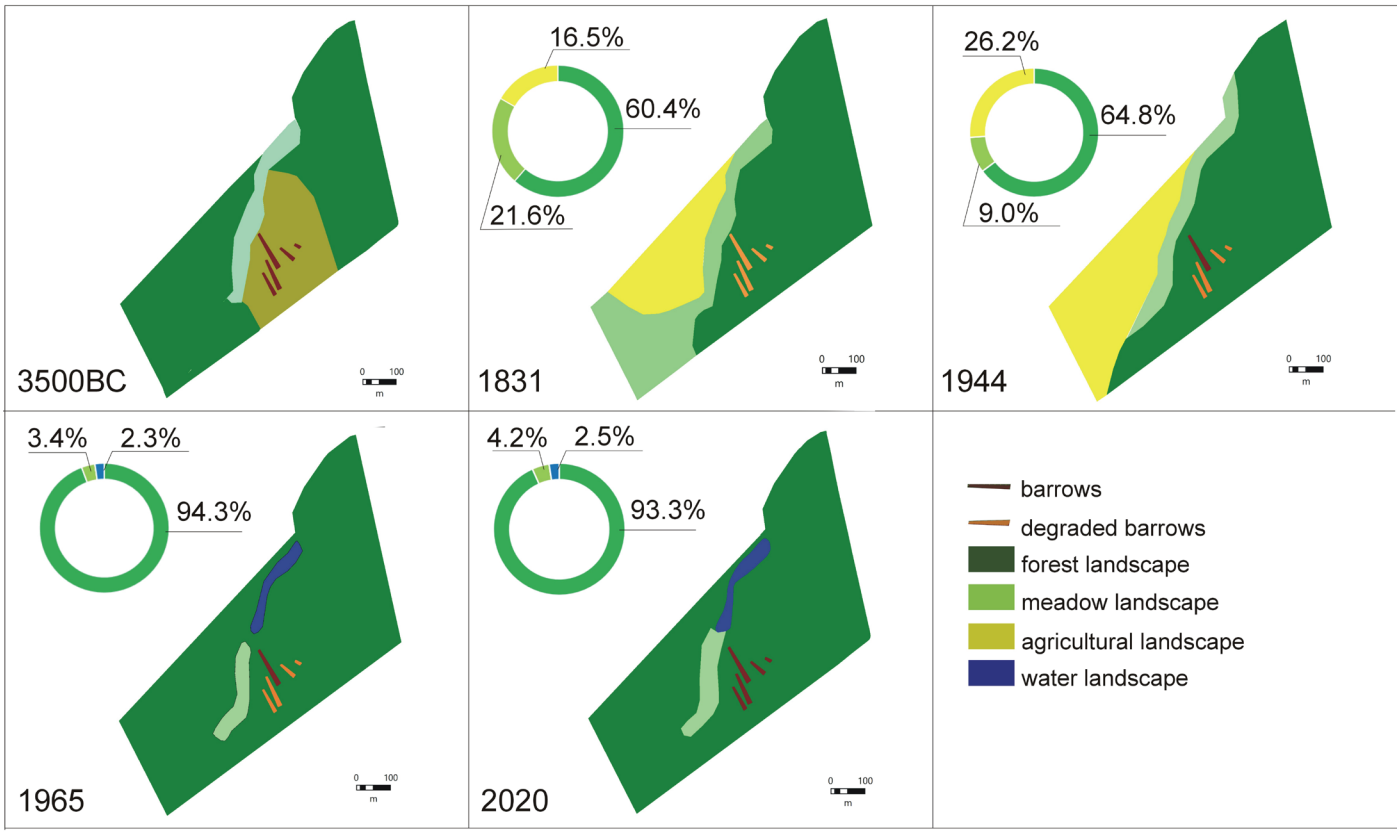

Figure 5. Landscape types in particular years.

Table 2. The percentage share of landscape types in particular years.

Year	Forest landscape	Meadow landscape	Agricultural landscape	Water landscape
1831	60.38%	21.55%	16.45%	0.00%
1944	64.80%	9.02%	26.18%	0.00%
1965	94.30%	3.40%	0.00%	2.30%
2020	93.30%	4.20%	0.00%	2.50%

3.3 Changes in the stratigraphic landscape types

According to the stratigraphic landscape typology, the presented megalithic landscape represents a heterogeneous, homotonous landscape of a reversed sub-type (T2/C). The dominant landscape type – forest – is genetically and chronologically the oldest landscape in the research area. In part of the area, this type was replaced by a genetically younger type – the agricultural (including meadows) landscape, but then forests returned to cover almost all the area. In this sub-type of the stratigraphy, changes evolve in an evolutionary, linear (undisturbed, continuous, horizontal) way. The layer arrangement only changed in the 20th century and took the reversed type.

3.4 Changes in landscape structure

Changes in natural features

Natural elements create the environment for the development of cultural elements but also influence their existence. The decision of where to locate the barrows was probably related to the natural conditions (the presence of valleys, swamps, brooks, Przybył 2014, Żemła-Siesicka 2019) and the subsequent preservation of the remains of the tombs was connected to the permanent presence of the forest. The research area is located mostly on an outwash plain with glaciofluvial sands and gravel. A small tunnel valley with humic sand, mud and peat, divides the area, running NW–SE (Makohonienko et al. 2021; Břízová and Roman 2015). The soils formed in this area are mostly rusty soils (on the plain) and organic soils in the valley. According to the maps, the natural potential vegetation (vegetation that would be expected with no human intervention, depending on habitat and climate, Wysocki and Sikorski 2014) is deciduous forest: Potentillo-albae Quercetum typicum (Matuszkiewicz et al. 1995), which occurs on rusty soils. The dominant species is oak (*Quercus petrea* and *Quercus robu*r), but pine (*Pinus sylvestris*) is also present. These are bright forests with a poorly developed shrub layer and a well-developed ground cover. The forest structure and type has changed throughout history, initially as a result of climate change and minor human impacts. At the time of the construction of the barrows, the vegetation was dominated by trees, mainly pine (habitats suitable for mixed oak and pine phytocoenosis), while in the valley, there was a swamp (Papiernik and Płaza 2017).

In the 19th and 20th centuries, as a result of increased human activities (forest cultivation), there was a change in the dominant species (Figure 6). In the first half of the 20th century, pine became the significant dominant (visible on the 1935 pictures in 31) as a result of the increased economic importance of the forest. In the second half of the 20th century, the pine forest was still dominant, but a small part near the lake was turned into deciduous forest (indicated on the 1965 map). Today, the vegetation is mostly forest, with the pine still dominant, but the phytocenosis is more mixed. The forest growing around the megaliths is mixed and includes mostly pine and oak. In the west part, there is a small coniferous forest with larch (*Larix*) as the dominant species. In the east, there is a young forest stand. On the northeast side of the valley, deciduous species (oak and poplar) are more common (Forest Data Bank). A part of the valley is covered by a meadow and there is still a small lake. The forests are considered to be protective forests (this is not a form of legal protection, but a recognition of forests as important for their ecological, soil and water protection functions).

Changes in cultural features

Cultural features are essential for the megalithic landscape. The presence of the barrows have been affected by several events: construction, abandon-

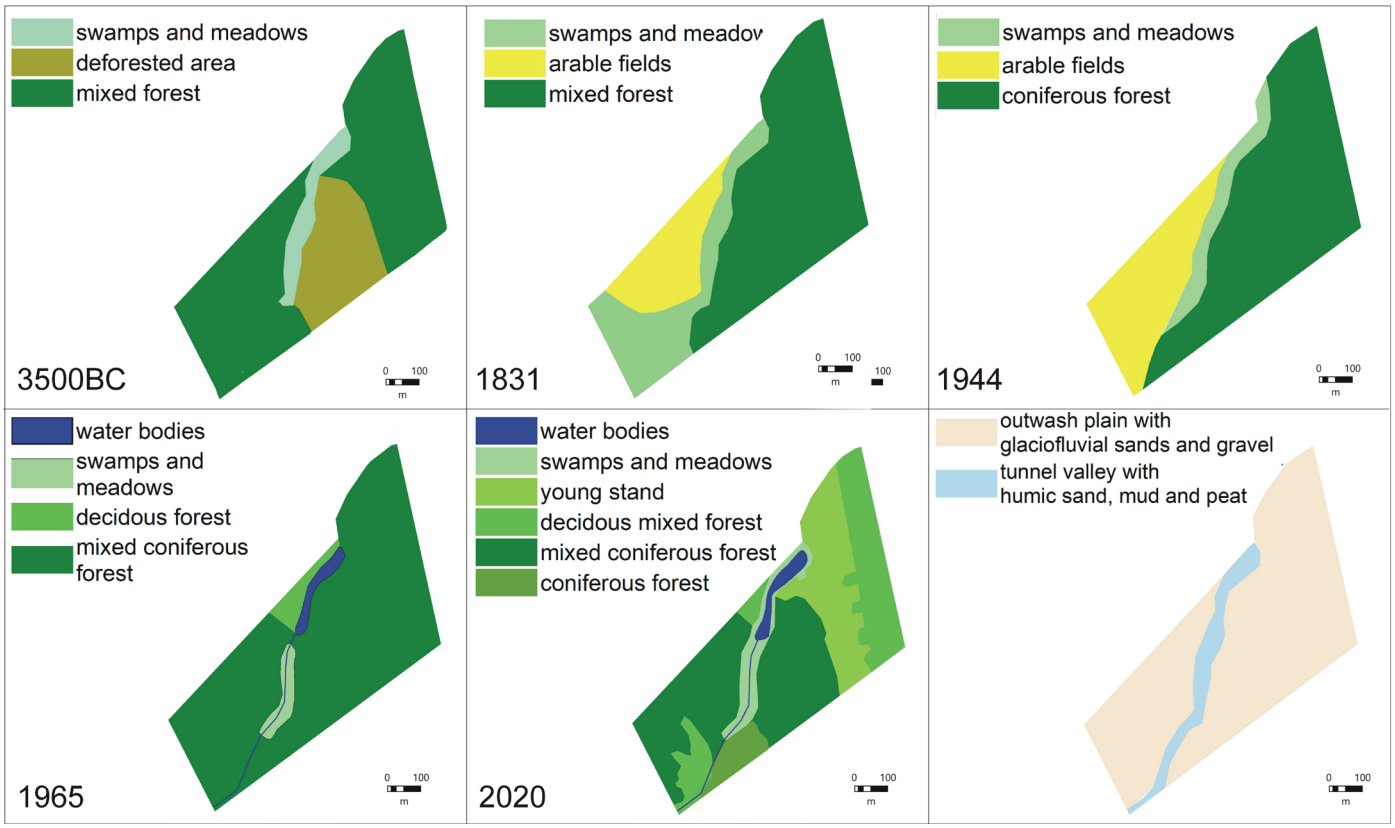

Figure 6. Natural elements (vegetation and water bodies) in particular years, and landform (right bottom).

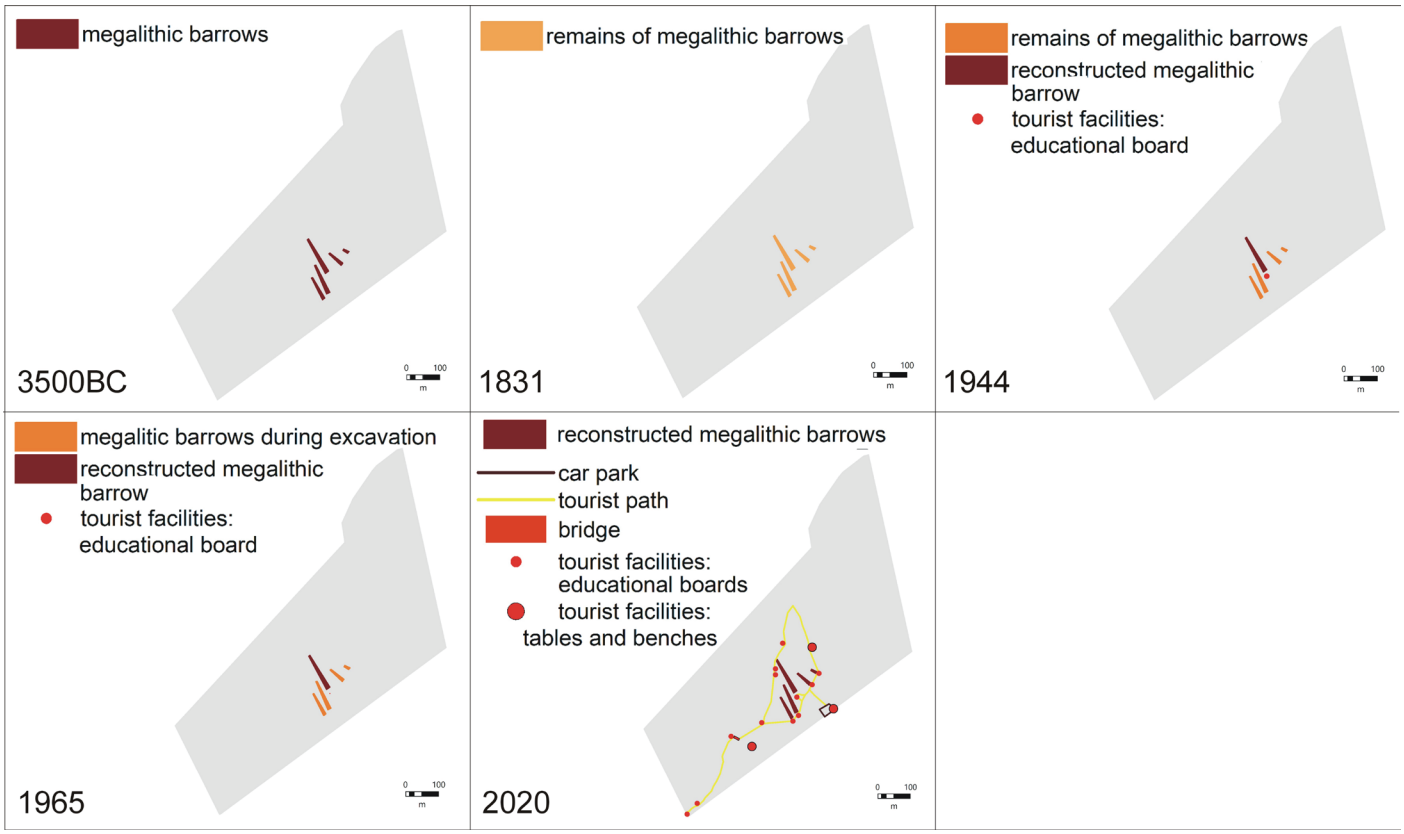

Figure 7. Cultural elements in particular years.

ment and slow reconstruction (destruction), excavations, reconstruction, protection and tourist infrastructure development (Figure 7).

The barrows were constructed in about 3500 BC. For the moment, individual dating of the barrows has not yet been carried out (Papierni and Płaza 2018). They are different sizes, from 20 to 115m long and 6.5 to 10m wide, and they have a unified NNW-SSE direction. In modern history, the barrows have undergone a slow destruction. Probably in the 19th, but also at the beginning of the 20th century, the local inhabitants contributed to the partial destruction of these structures. Some of the boulders that formed their kerbs were used to construct fences, building foundations and roads (Papiernik and Płaza 2017). In 1934, Konrad Jażdżewski started the excavations. In this phase, only barrow no. 3 was studied and reconstructed. In the 1960s, further excavations were conducted by Konrad Jażdżewski. This time, all the barrows were examined and reconstructed (table 3). In front of each tomb, an information (educational) board was installed. After the reconstruction, the protection of the site was strengthened by its entry into the register of monuments and the establishment of an archaeological-natural reserve. In 2006, the Wietrzychowice Culture Park was established. Nowadays, two forest parking lots with rest areas (benches, shelters) are located near the megaliths, and the educational (natural and cultural) path, equipped with educational boards, leads around the megaliths. Every year, an archaeological festival "Time machine" is organised in a specially designated recreation area.

3.5 Changes in landscape physiognomy

Changes in the landscape physiognomy result from transformations in the structure of natural and cultural elements. Over the centuries, the degree of openness of the landscape has changed, as well as the compositional elements and the possibilities to observe (viewpoints, scenic paths) the characteristic elements of the landscape.

During the period of the construction of the barrows, the landscape went from being exclusively closed (forest) to being partially open (deforestation caused by construction) (Figure 8). The tombs were distinctive elements in the landscape, which was inhabited and developed by farmers, as spatial dominants with a unified direction. The openness of the landscape increased, and in 1831, it covered a significant part of the area (agricultural open landscape). In recent history (from the 2nd half of the 20th century), this open landscape decreased again and remained only partially in the valley (swamps and meadows, including the lake). The composition of the landscape faded through the partial disappearance of the tombs, causing a decrease in their visual dominance. In the 20th century, the partial removal of trees for archaeological work and then subsequent reconstructions of the barrows caused them to return to visible landforms. Their original compositional role returned but wasn't so significant due to their location in the forest. Forest cultivation caused differentiation in land cover species and forest age structure. In the current (actual) landscape, the most important unit is a mixed coniferous forest on the plain with the barrows. In the present, observation of the barrows is possible from a scenic (educational) path.

3.6 Landscape functions development

Initially, the landscape had an ecological function. This aspect decreased with the appearance of humans and land use changes but was more or less present in all the life-history of the area (the forests, swamps and meadows were more or less present at all stages). With the construction of the barrows, the area became a place with multiple meanings. The most important were ritual and sacred. The principal

Table 3. Barrows basic information (based on Wietrzychowice Culture Park Protection Plan, 2012 and field visit).

Barrow	Year of reconstruction	Length [m]	Width [m]	Approximate height (m)	Stones (cairns)
1	1967	75.0	10.0	2.5	Stone kerb at the front and on the sides of the tomb
2	1968	93.0	9.0	2.5	Large stones at the front
3	1934	115.0	10.0	1.7	Large stones at the front
4	1969	30.0	6.5	1.0	Lack of kerb
5	1968	47.0	7.5	1.7	Large stones at the front

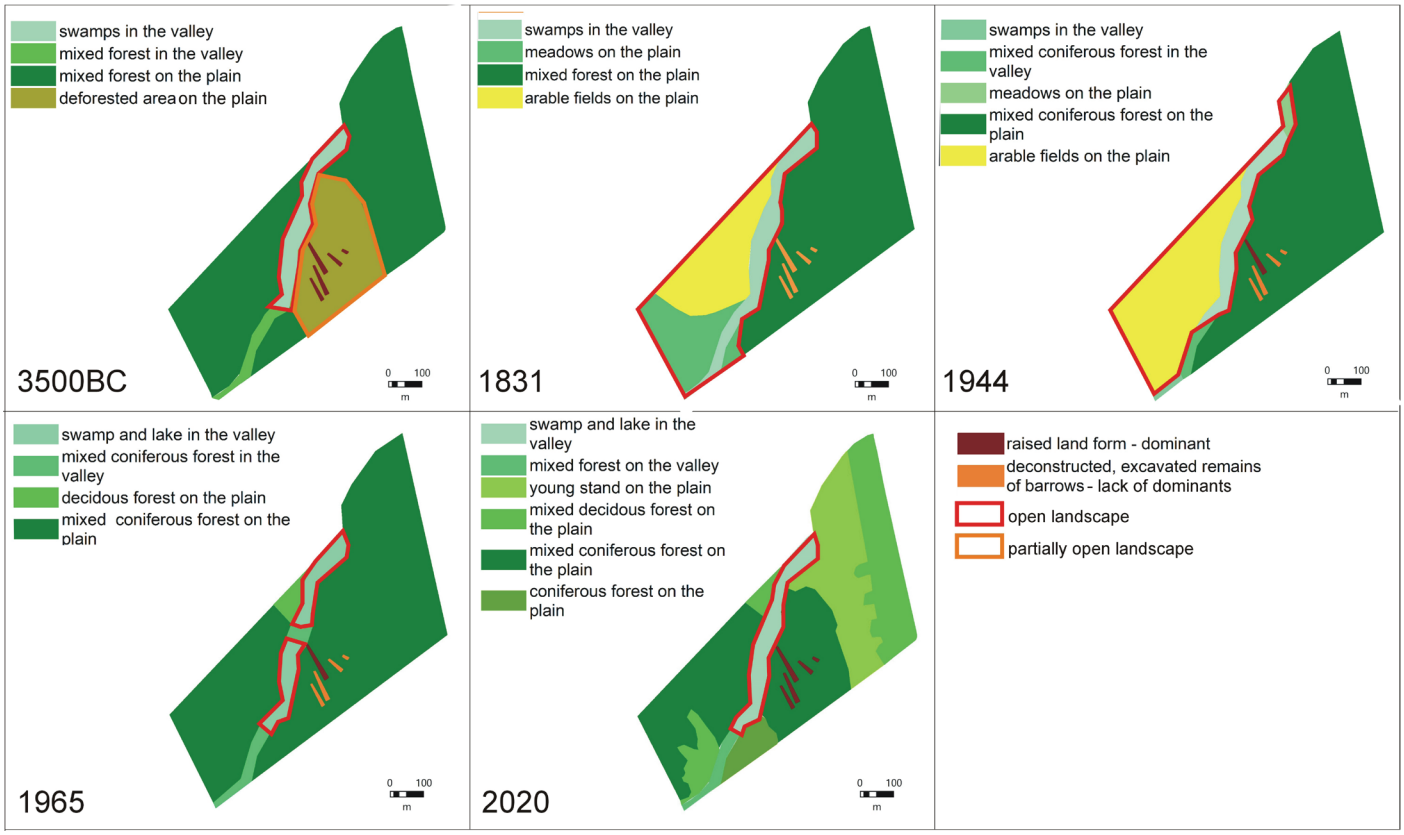

Figure 8. Landscape physiognomic units and landscape composition element (dominant) in particular years.

use of the barrows was of course related to burials and funeral ceremonies, but they also played a symbolic (as a symbol in thanatology, Rzepecki 2015) and a symbol of the ownership of the area (Przybył 2014) and a ceremonial role (cult houses, Socha 2015). Over time, the sacred significance disappeared, although the spiritual significance of the area was still present in the 19th century, which is proven by folktales, specific names given to the tombs (such as "grieves") and poets' interest (Papiernik and Płaza 2017). At that time, it was widely believed that the barrows were the graves of people from the distant past or even giants who inhabited Kuyavia in ancient times (Wierzbicki 2017).

As archaeological interest grew, cognitive functions became important. The tombs already provided much information about the life of society in the Neolithic period during the first excavations. With subsequent excavations, the data resources increased, stimulating the development of its educational function (the first information boards appeared in the 1960s). Successively, tourist interest began to develop, which was particularly enhanced after the establishment of the culture park. At present, its tourist function can be considered predominant.

3.7 Key processes related to landscape changes in Wietrzychowice

In Wietrzychowice, both natural and human influences formed the landscape. The natural processes dominated at the beginning of the life-history of the place, with the formation of the relief and soil, (geomorphological processes) and vegetation species changes before the barrows' erection (climate change). After the construction, a natural process with a significant meaning was the erosion of the barrows (geomorphological processes). Human induced processes were much more numerous. Especially important were the cultural processes related to the barrows – construction, deconstruction (stone reuse), excavations and reconstruction. Human related processes also interfered with the natural cover, i.e., deforestation and reforestation, including forest cultivation.

4 Discussion

The Wietrzychowice megaliths were discovered and studied relatively early. In addition, the excavations and non-invasive studies, especially the research "Archaeological Sources in the Region of Wietrzychowice Culture Park" (Papiernik et al. 2020) conducted in recent years, have provided lots of data on the origin of the tombs, but also on the natural conditions prevailing at the time they were built. The long history of research has also influenced the contemporary management and protection of the area. The successive establishment of different protection forms, especially of the culture park, had a significant influence on tourist infrastructure development.

The landscape analyses presented in the article are a reflection of the literature research, but especially of the cartographic research. It should be highlighted that the accuracy of the analyses of landscape changes depends on the cartographic sources available for a given period (this issue has already been raised by Marcucci, (2000), Nita and Myga-Piątek, (2012), Affek, (2012), Sobala (2012) and Kuna (2015). The historical data is more general than the recent data. The physiognomy of the landscape of the 2nd stage and of the period before the 3rd stage can only be approximated as the exact cartographical sources do not exist. Hence, the delineated stages of landscape change do not fully cover the life-history of the megaliths due to the lack of reliable area-specific information.

4.1 The megalithic landscape stages

Holtorf (1998) determines five basic stages of the life-history of megaliths: birth and childhood (4000-2700 BC) when megaliths were built and used as burial sites (this period corresponds to the second stage in the MALA); youth (2800-1600 BC, reuse of the barrows), earlier adult life (late Bronze Age, Iron Age, Slavic Period), with secondary and enclosed burials and imitations of megalithic mounds (in the model there is a gap as there are no specific data for this period); later adult life (medieval and early modern times, 1200-1750) when the megaliths were 'historized' and vandalised (stones reuse) (for this period cartographic data is too general for landscape analyses); old age (Romantic Period, Modernity and Post-Modernity) when megaliths were noticed by artists and later studied by archaeologists and finally protected (stages 3 to 6). While Holtorf presents all these stages of the life history in a descriptive and general way, the MALA presented in this article focuses on more detailed cartographic data. Hence, the MALA stages cover almost entirely the "old age" of megaliths. Considering the reconstruction process and new functions of the landscape, this "old age" of the megalithic landscape could be called a "second youth" stage.

4.2 Persistence of the megalithic landscape

The barrows are the most persistent landscape element in Wietrzychowice. They were present at all stages, but their landform has changed due to both natural and human processes. The megaliths are also the most important elements of the megalithic landscape, the change in their form resulted in changes in physiognomic structure and landscape functions. The barrows form the "core" of the landscape, which is the most important (symbolically, function determination) "intrusive" element of the megalithic landscape.

The most persistent landscape types in the study area, with considerable "time depth", are the swamps in the valley and the forest around the megaliths. The megaliths have probably been preserved thanks to the persistence of the forests around them. The analysis of landscape type change shows that the forest was present in the closest vicinity of the barrows in all studied historical periods (from the 19th century), while the neighbouring areas changed their land use. Numerous archaeological sites have been located around the study area (they are enumerated in the article of Papienik at al., 2020) which did not retain their landscape form after the area became farmland. A similar situation with megalithic tombs located in woodlands can be observed in several other sites in Poland: e.g., Sarnowo, Łupawa, Muszkowice, Borkowo (Figure 9).

4.3 Megalithic landscape threats

The analysis of landscape changes, including land cover, as well as cultural, natural and physiognomic changes and processes, helps to indicate threats

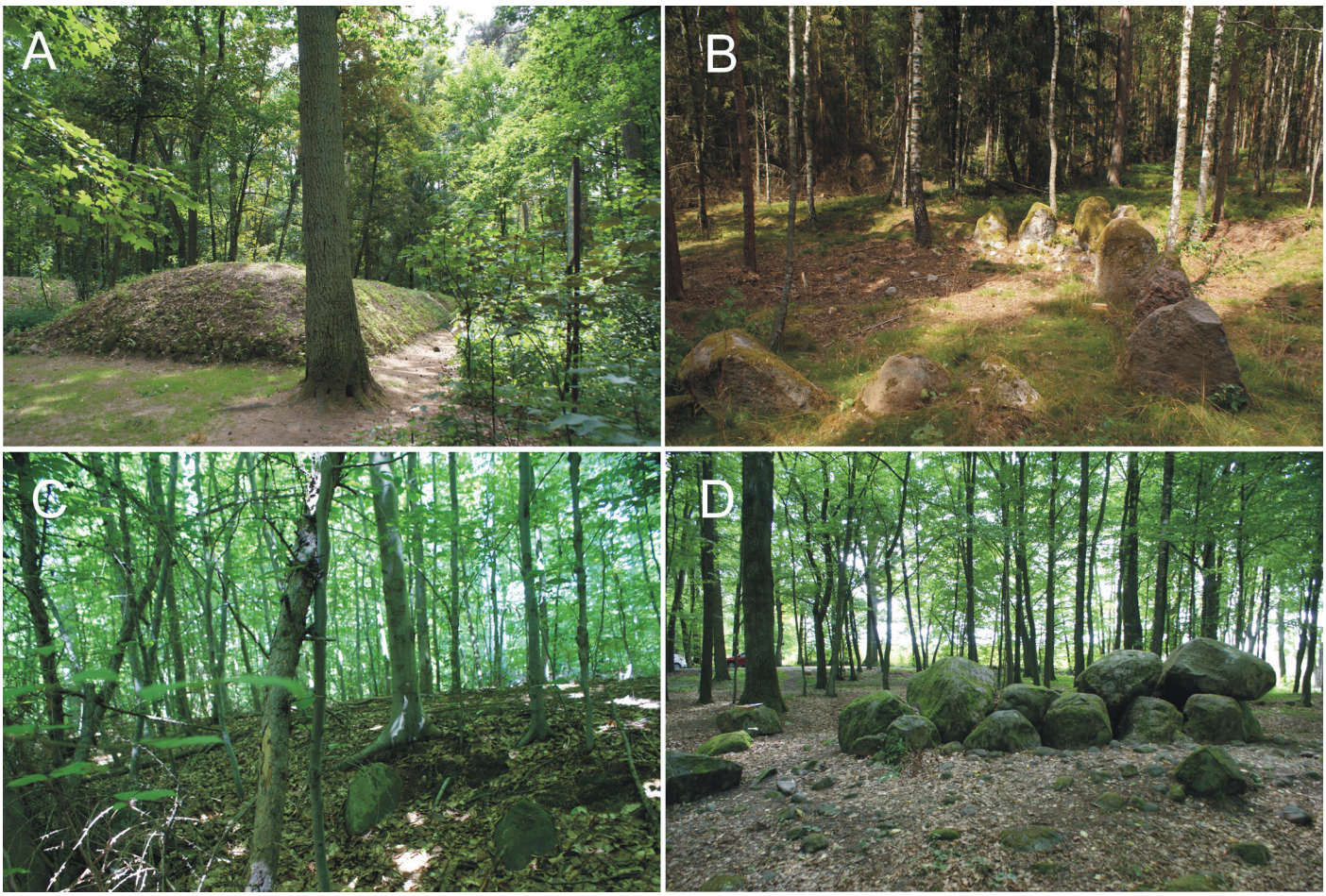

Figure 9. Examples of megalithic tombs located in the forest in Poland: A – Sarnowo, B – Łupawa, C – Muszkowice, D – Borkowo (author's own collection, 2021).

to the megalithic landscape. The factors affecting the megalithic landscapes include nature-induced (floods, treefall, animal and tree root disturbance, climate change) and human-induced ones (logging, farming, vandalism) (Widjaja 2016; Gani 2019; Berenfeld 2008). Kobyliński (1997) divides threats into external ones which are independent from the archaeological environment (resulting from the development of civilization), and internal ones which are related to poor protection and lack of social education. Micle (2014) distinguishes natural hazards: climate (such as hurricanes, snowstorms, desertification, thunderstorms, etc.), hydrological (floods, torrents), geomorphological (soil erosion, landslides, etc.), biophysical hazards (fire) and manmade destruction: such as roads, real estate developments, networks and infrastructure, and agricultural management.

The location of the Wietrzychowice archaeological site has only a few natural and anthropogenic hazards. Among the natural threats, hurricanes and fires could occur and are impossible to predict. Such a situation took place on an archaeological site in Leśno. In 2017, after a huge hurricane, the landscape changed significantly. Forests and the area's tourist facilities were destroyed (Figure 10).

Another natural hazard – geomorphological – soil erosion of the barrows has already occurred in the past and is very likely in the future. Flooding, on the other hand, is unlikely (the area is not mapped as a flood risk, Map of flood risk).

The Wietrzychowice Culture Park is located in an extensive agricultural area with small villages. At the present, urbanisation pressure is not visible, and the considerable distance to larger cities does not predispose the area to increased settlement. The commune Izbica Kujawska has one of the lowest population densities in the Kujawsko-Pomorskie voivodeship (Development plan for the kujawsko-po-

Figure 10. Archaeological landscape change caused by a natural hazard – a hurricane, Leśno, the same mound on the left – in 2010, on the right – in 2021 (author's own collection, 2021).

morskie voivodship, 2018). However, intensive farming in the buffer zone and changes to the landscape through the introduction of wind turbines can occur in the area (Gerc 2012). The most likely threats are the damage caused by vandalism and the negative influence of tourism. Tourism in particular could be a potential threat to the harmony of the megalithic landscape. The inflow of visitors depends on tourist accessibility, adequate infrastructure, catering and transport infrastructure, and cyclical accompanying events (Krzemińska et al. 2018). In the Protection plan for the Wietrzychowice Culture Park and in the strategy for Izbica Kujawska (Municipal development strategy Izbica Kujawska 2016), the development of tourism is indicated as an area for promotion. The strategy even points to the possibility of creating a theme park or a national, historical and scientific entertainment centre. This suggests that large tourist facilities (buildings) could be established in the immediate vicinity of the megaliths. On the other hand, the Protection plan notes that the area should be popularised, but tourist traffic, as a threat, should be controlled.

4.4 What's next? Possible scenarios

The scenario approach to landscape development enables research and policy to face a variety of different choices (Tress and Tress 2002). Tracing changes in the landscape in Wietrzychowice and in other places where megalithic constructions are found makes it possible to indicate general directions for possible future transformations. The most likely scenario, i.e., further development of tourism infrastructure, has already emerged from the identification of threats. Currently, the area is equipped with basic tourist facilities, such as car parks, educational boards and rest places. If the promotion of the site develops, new tourist infrastructure will probably be established, such as restaurants, tourist information centres or museums. Such development is already present in archaeological places, such as Biskupin (Poland) or Carnac (France). The overdevelopment of tourism may lead to a significant degradation of landscape values in the long run. Another possible scenario is that the current protection and conservation state would be maintained, and the landscape would not change significantly.

Other scenarios which are less likely involve the opposite, i.e., the abandonment of protection and the inflow of tourists. In this case, both the barrows and the tourist facilities would slowly deteriorate, and the landscape would return to its past state.

4.5 Possibilities of using the model in further research

The Model of Archaeological Landscape Analysis presented in the article can be applied in all archaeological sites with distinctive landscape forms where historic mapping is available. The comparison of the evolution of particular areas will indicate the stage of the development of each site. Depending on the history of the research and the archaeological methods used, the evolution can proceed in different direc-

tions. For example, the Muszkowice barrows were discovered just recently (in 1995), and non-invasive methods of research were used (Przybył 2014). The barrows are not reconstructed, but their landform is visible, though they are overgrown with trees (Figure 9). There are no tourist facilities. In the case of Łupawa (Figure 9), the landform is deconstructed and poorly visible in the landscape, but the boulders are still in lines (Sukniewicz 2017). The place is promoted and there are a few tourist facilities, but the intensity of tourist development is much lower than in Wietrzychowice. These differences indicate the varied state and direction of landscape development, conservation and management. Carrying out research and systematising knowledge on this issue could help to better understand the archaeological landscapes and to plan future protection and development of the sites, especially related to tourist infrastructure.

However, it is necessary to highlight the limitations of the MALA related to the availability of historical data, including cartographic and literature sources. The site in Wietrzychowice presented in the article has already been well studied and described by archaeologists (almost a century of archaeological research has also resulted in considerable photographic documentation), so the model could have been constructed, although landscape changes during the first stages of life-history can only be assessed approximately. Another problem is the cartographic source and the lack of maps dating back to before the 19th century, making it impossible to analyse changes in landscape types (and determine their percentage share) over earlier centuries. The differences in the accuracy of the maps used, and the architectural scale of the research which is incompatible with topographic maps, can be challenging. These limitations can make it difficult to implement the model, particularly for sites with a short history of investigation and, therefore, insufficient information on the landscape structure present at the time of the construction of archaeological forms.

The graphical part of the model visualises changes, which can be very helpful in educating the public. The archaeology focuses on the distant past, leaving aside issues of landscape change in recent times. MALA could be the element to give emphasis to the whole life-history of these places and also to present and future times.

5. Conclusions

In this paper, a method for complex archaeological landscape analysis was presented. This model helps us to better understand the archaeological landscape and enables the identification of the important moments in the life-history of megalithic landscapes. The conducted research allowed us to make the following conclusions:

- In the history of the megalithic landscape, six periods with different structures and dominant processes can be identified, covering the prehistoric period before the construction of the barrows, the stage of erection and use of tombs, historic stages of abandonment of megaliths, excavations and reconstruction, complete reconstruction and protection, and the last stage – of increased protection and tourism development.
- The stratigraphic model shows the considerable "time depth" of forest and swamp landscapes. Forest with megaliths is the most persistent landscape type of the Wietrzychowice megalithic landscape. The megalithic landscape of Wietrzychowice represents a heterogeneous, homotonous, reversed stratigraphic type.
- The megaliths are the "core" of the area change. They are the most persistent elements in the megalithic landscape, but their landform is changing due to both natural and human processes, resulting in changes in physiognomic structure and landscape functions.
- The physiognomy of the megalithic landscape has changed over time, the openness of the landscape increased in the 18th century and decreased in the last stages. The visual dominance of the barrows was significant at the 2nd stage, then decreased and increased again in the 20th century.
- Combining the concept of archaeological landscape (understood as a current landscape with a long history) and the landscape archaeology (in the landscape biography approach) allows us to analyse changes in the landscape throughout history, not only distant, but also recent.

- The model of this research can be used in other archaeological landscapes. The analysis and comparison of the stages of change could be helpful in the indication of future possible changes (possible scenarios). It could also be useful in protection and management planning.
- MALA, as a complex visualisation of the landscape and its changes, can be helpful in landscape education. On a graphical model, landscape can be better "seen" and, therefore, understood by society.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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