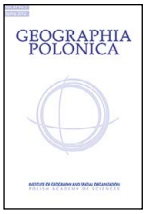

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CHANGES IN THE PHYSIOGNOMY OF THE ARCHAEOLOGICAL LANDSCAPE – LEARNING FROM THE PAST TO BUILD THE FUTURE (WITH PREHISTORICAL BURIAL SITES IN POLAND AS AN EXAMPLE)

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Abstract

The aims of this research were to identify the key processes that have occurred in the past that have caused changes in the physiognomy of archaeological landscape and to indicate possible future processes, along with their landscape implications. The study was based on cartographic and literature studies, and field visits. It covered an analysis of the land cover, the history of archaeological research, the establishment of forms of legal protection and tourist infrastructure development. The past changes are visualised for each site in the form of a block graph. Possible future scenarios with landscape implications are presented on a tree diagram.

Key words

archaeological landscape • life-history of the archaeological landscape • landscape physiognomy • processes of landscape change • landscape scenarios

Introduction

The landscape of archaeological sites is a subject of research which integrates interdisciplinary methods, including archaeological, geographical and architectural approaches. Depending on the discipline, the concept of "archaeological landscape" can vary. The archaeological sciences concentrate on the relationship that exists between humankind, fauna, flora and landscape (Mosler, 2006), using differentiated methods, such as landscape biography (Darvill, 2006) and phenomenology (Tilley, 1994). The geographical and architectural approaches relate to past and present landscapes' structure and visual effects (Jerpåsen, 2009; Gillings, 2009). This last insight is becoming increasingly present as our understanding of the significance of the whole landscape increases, with the cultural

material considered as its integral component (Mosler, 2006). In this physiognomic term, the archaeological landscape is considered to be a landscape in which archaeological forms such as tombs, barrows and cromlechs are the dominant element (Kobyliński, 1999) and are visible on the surface and form a specific landscape type (as a subtype of cultural landscape) (Żemła-Siesicka, 2022).

The study of archaeological landscapes focuses on the history of landscape, the policy of preserving archaeological sites and landscapes, and their use for science and tourism (Vijulje et al., 2014). The study of an archaeological landscape's history concentrates mainly on the times of its construction and the primary use of its archaeological forms. The history of change from the long-term point of view is raised less often, e.g., Holtorf's life-history of megaliths (1998) or the Model of Archaeological Landscape Analysis (Żemła-Siesicka, 2022). For the purposes of planning and protection, a focus on the present condition of the landscape is required. Such an approach is reflected in historic landscape characterisation (HLC) in Great Britain, which aims to improve the quality of the landscape by identifying, describing, interpreting and mapping the main historical influences that have shaped and defined the contemporary landscape (Young, 2015).

Understanding the past evolution (the history) of landscapes and their present condition is crucial for these areas' future development and protection. Analysing the landscape transformation of the last few centuries allows us to identify the key processes that caused changes in landscape physiognomy. Tracing the past and present processes of the transformation enables the determination of possible future changes. As Antrop (2005: 31) noted, "lessons from the past help to build the future landscapes". Forecasting landscape change is vital for developing cultural landscapes. This topic has recently been raised in landscape research by scientists from various disciplines. This was shown at the last IALE congress (2022), whose main motto was "Making the future, learning from the past". The possibilities of studying the history of landscape in the context of projected changes were also raised by Chmielewski et al. (2014). Attempts to predict future landscape transformation are often based on a presentation of alternative scenarios, especially for landscape planning. They refer "to the different possible stories, or alternative assumptions that underlie landscape change" (Iverson Nassauer & Corry, 2004: 344). The past, the present and the future in the archaeological context are often used in the literature (e.g., Willems et al., 1997; Berg, 2010; Campana, 2018), but by concentrating on the archaeological methods of the research, these studies do not touch the issue of landscape change.

The study presented in this article focuses on a specific group of archaeological sites related to the burials of a megalithic (in terms of the construction, not the culture) nature. As the name indicates: megas – great, and lithos – stone, the structures are made of stone or stone and earth (Krzak, 1994). The monuments considered in the study are dated from the Prehistoric Period.

There are a lot of archaeological cemeteries in Poland that are spectacular to lesser or greater degrees and are in various conditions, depending on when they were discovered and the method of research carried out on them (invasive or non-invasive). Some were explored a long time ago (such as Wietrzychowice, where the first archaeological interest came at the end of the 19th century, Papiernik & Płaza, 2017), but there are also sites which were discovered recently (as in Dąbrowa Górnicza in 2021, where the study is just beginning, Rozmus, 2022). There are also sites experiencing an increasing amount of human influence through tourist development. The places that are most well-known and best prepared for tourists are located in northern Poland (Pomeranian voivodeship). But some of the places that remain "undiscovered" by the public are deteriorating, and the characteristic elements of the past landscape's composition are being obliterated.

The aim of this research was to trace and to compare the physiognomic change in selected archaeological landscapes and to identify the key processes that caused this change in the distant and recent past. On this basis, possible future processes have been indicated, along with their physiognomic landscape implications. "Landscape", according to the definition presented in the European Landscape Convention, is an area perceived by people, whose character is the result of the action and interaction of natural and/or human factors (Council of Europe, 2000). In this approach, the physiognomic structure of natural and cultural elements is of great importance. The physiognomy of the landscape is understood here as the "landscape appearance", related to the structure and arrangement of material elements. As such, the research is related to the factors that play an essential role in the physiognomic aspects of the archaeological landscape:

- land cover – it is one of the features of the physiognomy of the landscape (Regulation of the Council of Ministers regarding the preparation of landscape audit, 2019); whether the site is located in closed (forest) or open (glades, arable fields), landscape is crucial for the structure and appearance of the archaeological landscape,
- cultural elements: archaeological structures – they are the main feature of the archaeological landscape; their condition (whether they are in a state of slow deconstruction, partially or fully reconstructed, or constructed as a replica) – determines the character of the landscape change,
- contemporary human-made elements – tourist facilities – are new cultural elements that change the structure and visual effect of the landscape.

In addition, the establishment of forms of protection was indicated as an important issue for landscape conservation and planning.

The basic research questions were as follows:

- How and under what processes within the adopted factors has the physiognomy of the landscape changed?
- What processes within the adopted factors may cause changes in the future?
- What are and will be the landscape implications? How does the change influence the landscape's physiognomic character (the land cover, composition and historical values)?

To answer these questions, the research was organised into three sections: the past, the present and the future. The past was analysed on the basis of cartographic studies and literature research. The present was analysed mostly based on current maps and field visits. Each site was presented in the form of a block graph indicating changes across the time. On this basis, possible future scenarios and their landscape implications were presented on a tree diagram.

Study area

The study presented in the paper includes several archaeological burial sites in Poland, which are located in various geographical regions: Pomerania, West Pomerania, Kuyavia-Pomerania, Lower Silesia, and Wielkopolska (Fig. 1).

The choice of the study areas was motivated by the different states of preservation of the structures (several reconstructed structures in good condition, some degraded), as well as the varying forms of legal protection (not protected at all, protected by one form or two forms) and tourism development (without any tourist infrastructure and less or more equipped with tourist facilities). Only the sites with forms that were legible in the landscape were considered. 11 sites dated from the Prehistoric Period were included in the study, covering cemeteries with long barrows, dolmen, stone circles, burial mounds and other structures, such as kerbs and cairns. A table presenting the photographs taken in 2021 and the location of the archaeological forms presented on the hill shade maps and orthophotomaps is included in Appendix A.

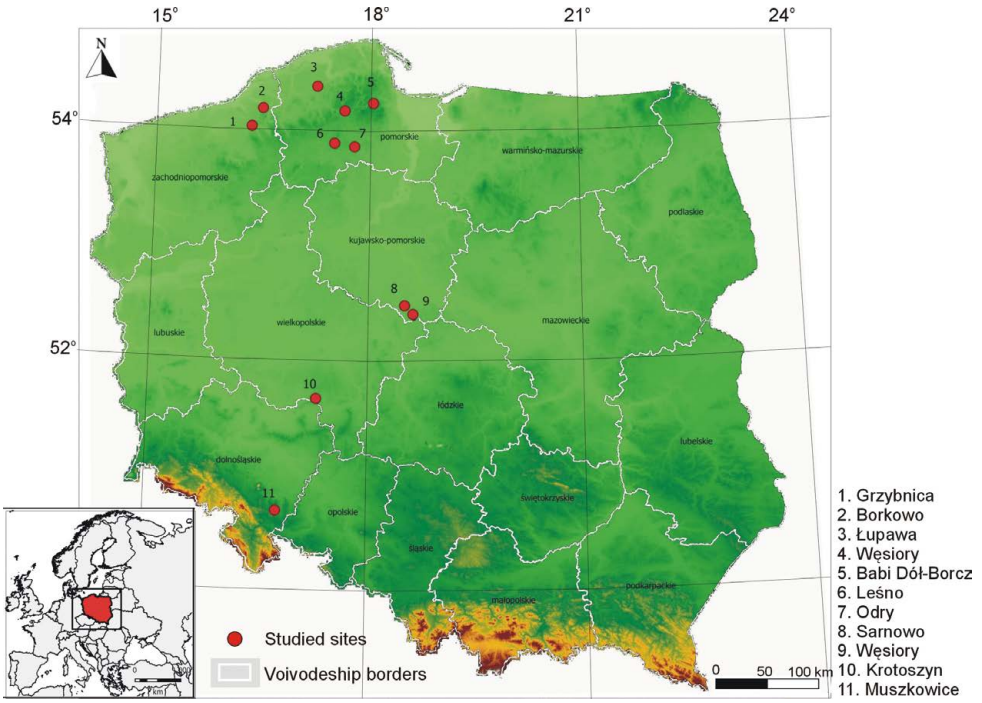


Figure 1. The location of the study areas on the map of Poland

Materials and methods

Materials

Data collection included various materials. An important part of the analyses was cartographic materials. Contemporary topographic maps from 2021 (Database of Topographic Objects, 10K) and historical topographic maps from the end of the 19th and the first half of the 20th century were analysed (Tab. 1). The varying locations of the sites meant that different historical materials were available for each, so it was impossible to use maps from the same year. As topographic maps do not provide sufficient detail of land cover information, orthophotomaps from the last 20 years (1997-2021) were analysed.

The analysis of the landscape of the archaeological sites required the exact location of each structure to be marked on the maps, but also in the field (in the cases where the constructions had already been destroyed or overgrown). For this purpose, LIDAR data were used. In most cases, Digital Terrain Models (hill shade visualisation) delivered detailed information (long barrows, mounds), but in some cases the structures have not undergone changes in land form (stone circles, cairns), so they are not always visible on maps but are better observed in the field. These structures were identified during field visits, which were supported by Global Positioning System (GPS), as well as maps and schemes of the sites available in the scientific literature and on websites.

The second group of materials used in the study was the literature. Scientific materials and thematic guidebooks were used to date the structures and to follow past archaeological research. In the case of recent archaeological studies, online articles and websites were also consulted. Information from the municipalities and "fan" community websites were useful for finding out about the development of the tourist infrastructure.

Table 1. Cartographic materials

No	Area	Material
1	Grzybnica	1897, 1:25,000, Agronomishe Bohrungen, Blatt Klannin, Topogr. Aufnahme 1889, Herausgegeben, 1897 1935, 1:25,000, Topographic map, Zirchow, prepared by the Army Map Service, copied in 1952 from Germany, 1:25,000, Reichsamt für Landesaufnahme, 1935
2	Borkowo	1897, 1:25,000, Agronomishe Bohrungen, Blatt Zirchow, Topogr. Aufnahme 1889, Herausgegeben, 1897 1935, 1:25,000, Topographic map, Zirchow, prepared by the Army Map Service, copied in 1952 from Germany, 1:25,000, Reichsamt für Landesaufnahme, 1935
3	Łupawa	1877, 1:25,000, Topographische carte, Blatt Lupow, Preuss Landes-Aufnahme 1875, Herausgegeben, 1877 1912, 1:25,000, Topographic map, Lupow, prepared by the Army Map Service, copied in 1952 from Germany, 1:25,000, Reichsamt für Landesaufnahme, 1912
4	Węsiory	1902, 1:25,000, Topographische carte, Blatt Stendsitz, Preuss Landes-Aufnahme, 1875, Herausgegeben, 1877, Einzele Nachträge 1902 1937, 1:25,000, Topographic map, Skorzewo, Wojskowy Instytut Geograficzny
5	Babi Dół-Borcz	1911, 1:25,000, Topographische carte, Blatt Kelpin, Preuss Landes-Aufnahme, 1875, Herausgegeben, 1877, Einzele Nachträge, 1911 1936, 1:25,000, Topographische carte, Kelpsee
6	Leśno	1874, 1:25,000, Topographische carte, Leśno 1936, 1:25,000, Topographische carte, Leisten
7	Odry	1874, 1:25,000, Topographische Karte, Wielle, Reichsamt für Landesaufnahme 1874, 1:25,000, Topographische Karte, Malachin 1933, 1:25,000, Topographic map, Karsin, Wojskowy Instytut Geograficzny 1933, 1:25,000, Topographic map, Czarna Woda, Wojskowy Instytut Geograficzny
8	Sarnowo	1831, 1:126,000, Topographic map of the Kingdom of Poland, Col. II, Sec. III 1944, 1:25,000, Deutche Heereskarte, Mühlental
9	Wietrzychowice	1831, 1:126,000, Topographic map of the Kingdom of Poland, Col. II, Sec. III 1944, 1:25,000, Deutche Heereskarte, Moosburg
10	Krotoszyn	1887, 1:25,000, Topographische carte, Blatt Krotoschin, Preuss Landes-Aufnahme, 1886, Herausgegeben, 1887 1940, 1:25,000, Topographische carte, Krotoschin
11	Muszkowice	1884, Topographische carte, Blatt Tepliwoda, Preuss Landes-Aufnahme, 1883, Herausgegeben, 1884 1956, 1:25,000, Topographic map, Stolec

The last type of data collected covers information related to the location, present condition and presence of tourist facilities, which was obtained during field visits (in 2021).

Methods

The research was organized into three sections: the past, the present and the future (Fig. 2).

The past landscape was analysed using historical topographic maps (two historical maps for each site, dating from the 19th/20th century). This part of the research was aimed at investigating changes in the land cover. The historical maps were digitalized, and the maps of land cover types were prepared in GIS software (Mapinfo Pro 19). The literature research allowed us to verify if and when excavations or reconstructions of monuments were carried out and if and when forms of protection were established.

The present landscape was described using current topographic maps, followed by

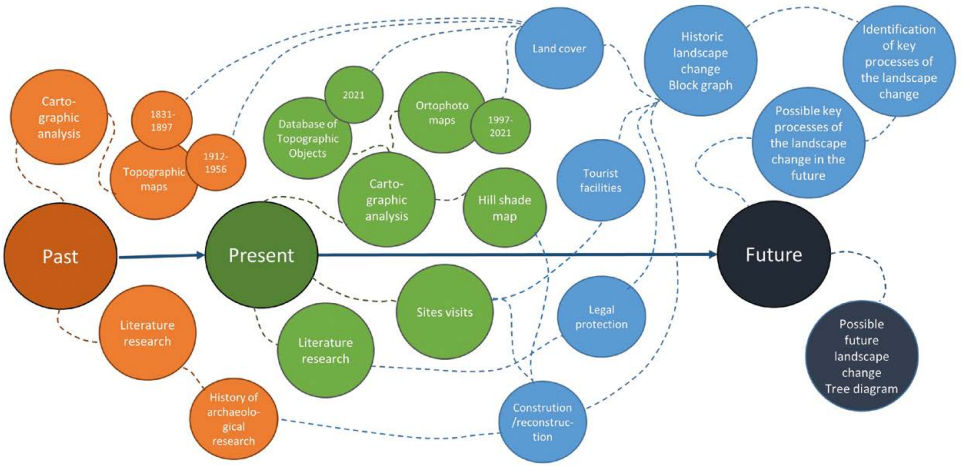


Figure 2. The algorithm of the research

field visits in 2021, during which the present condition of the landscape was verified. The latest changes were investigated more thoroughly by analysing orthophotomaps from the last 20 years. These maps offer a more comprehensive insight into the landscape. This part of the research was conducted to verify if there were any changes in the land cover that were not legible on the topographic maps.

Five groups of factors relevant for landscape physiognomy were described: land cover, tourist facilities, forms of legal protection, whether or not archaeological research has been carried out and if the structures were reconstructed.

In order to track and compare the changes across time of the archaeological landscapes studied, in the next step, on the basis of the literature, cartographic research, and field visits, a block graph was prepared for each site using coded colors in the corresponding time frame. Each block is composed of five columns representing the factors adopted. The length of the blocks represents the occurrence of the factor in time, and the colors in the columns code the information about the factor. The left columns are related to archaeological structures. The first column shows the state (construction, slow deconstruction, reconstruction, partial reconstruction or lack of reconstruction) of the archaeological forms (barrows, burial mounds, stone circles, stone kerbs). The second column presents the type of archaeological research (excavation or non-invasive research). The next column presents the type of land cover occurring at a given time (arable fields, forests, glades, settlements). The dates of the changes are estimated, as the cartographic materials do not cover all periods of time. The next column indicates the approximate date of the introduction of tourist facilities (categorized in four groups: single element, a few elements, numerous elements, overdevelopment), and the last one shows the date of the establishment of the form of protection (monument, culture park, nature reserve, UNESCO). The method for constructing the block graph including the color coding for the groups of the factors is illustrated in a form of an ideological scheme in Figure 3.

The past section allows us to identify the processes that caused the changes in the landscape physiognomy for each site. On this basis, possible future changes can be predicted. The possibilities of successive changes are presented in a tree diagram. The diagram is based on a decision tree model. This is a decision-support tool that uses a tree-like graph or model of decisions

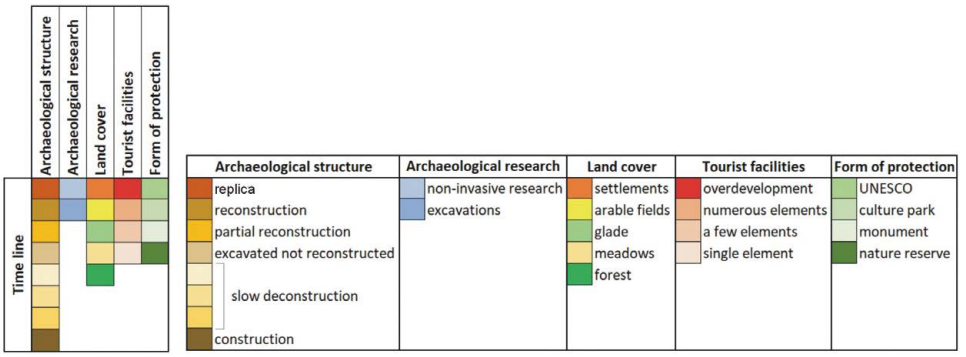


Figure 3. Ideological scheme of the block graph

and their possible consequences (Hassan et al., 2011). In the decision tree, the value of a variable is determined, and the next action is chosen accordingly (Moret, 1982). Decision trees have a fixed order: the root corresponds to all possible decisions, each internal node corresponds to a certain decision we can make, and the leaves correspond to the goals (Bujak, 2008). Decision trees are used in many fields, such as biology, computer science and information theory (Moret, 1982).

In the present study, the diagram represents the processes in archaeological landscapes that occurred in the past or may occur in the future. The root, common for all the sites, is the construction of the archaeological structure and, after a slow deconstruction caused by time (and eventually human activities), the discovery of the site. The decision nodes are further factors that subsequently influenced the landscape, such as excavations or tourist developments, but also natural processes, such as erosion or natural disasters. The possible processes within each factor were considered (e.g. for the tourist infrastructure factor, the possibilities could be a lack of tourist facilities, location of a few tourist facilities, sustainable tourism development or tourism overdevelopment). In the diagram in this research, the "leaves" are the consequences for the landscape physiognomy (landscape implications), understood as the change related to the land cover (e.g. deforestation caused by the natural disasters), in the composition (e.g. the restoration of the original cultural composition in result of the reconstruction of the archaeological forms) or loss of the historical values. Figure 4 shows the ideological scheme presenting the location of the roots, nodes and leaves.

Each site, or groups of sites, is currently located at a different stage in the process of landscape transformation, so the location of each one on the tree diagram varies. The location of the sites is indicated in the tree diagram, which enables us to follow the possible future scenarios and predict possible landscape consequences for each of them.

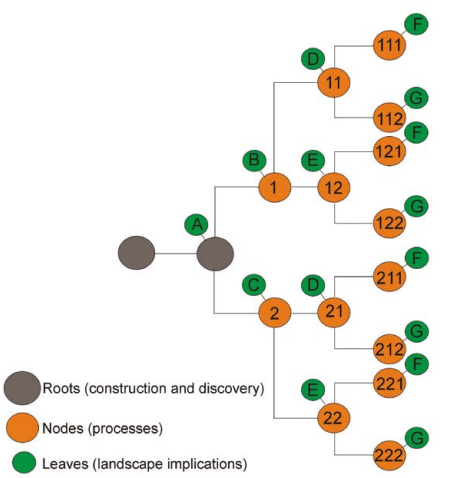


Figure 4. Ideological scheme of tree diagram used in the research

Results

The past and the present

History of the archaeological sites – construction and archaeological research

The first step in the research was a literature review, which was carried out in order to follow the life history of the structures. The sites were constructed in three periods, but some of them were used by several cultures. The oldest cemeteries, the long barrows constructed around 3500 BC in the Neolithic period (Funnel Beaker Culture), are in Wietrzychowice, Sarnowo, Muszkowice and Łupawa. Another structure dating from the Neolithic is the only passage-grave construction (dolmen) discovered in Poland, which is found in Borkowo. The burial mounds in Krotoszyn were constructed in the Bronze Age. Other sites studied were Odry, Węsiory, Babi Dół-Borcz and Grzybnica, dating from the Iron Age, and including cemeteries with stone circles, burial mounds and kerbs. The site in Leśno is a multicultural cemetery.

The history of archaeological research is varied. The sites in Wietrzychowice, Odry and Leśno have a long history of archaeological research, with the first scientific research conducted in the 19th century and the main excavations and reconstructions at the beginning of the 20th century (Wietrzychowice) or in the second half of the 20th century (Odry and Leśno). The research in Krotoszyn has continued with interruptions for more than 100 years, both invasive and non-invasive and only partial reconstruction was performed. In Borkowo, the discovery, excavation and reconstruction of the dolmen took place at the beginning of the 20th century. Sarnowo, despite being located close to Wietrzychowice, was not discovered until 1946 and the barrows were excavated and reconstructed a few years later. In Węsiory, the main excavation and reconstructions took place in the late 1950s and early 1960s. Łupawa, Babi Dół-Borcz and Grzybnica were studied, excavated and partially reconstructed in the 1970s. The site in Muszkowice has the shortest history of research. It was discovered at the end of 20th century and studied in the 21st century. The details of the origin of the sites and of the archaeological research are given in Table 2.

Forms of legal protection

Most of the sites analysed are protected as monuments under Polish law. All of them were established in the last century. The oldest monuments, which date from 1968, are Wietrzychowice, Sarnowo and Odry, with Babi Dół-Borcz dating from 1969. In the 1970s,

Table 2. Description of the history of the archaeological sites – construction and archaeological research

No	Site name	Form of the structure Period and time of construction	Archaeological research: invasive/ non-invasive	Dates of archaeological research	Literature source
1	Grzybnica	Stone circles, burial mounds, cairns, kerbs Iron Age Wielbark Culture 1st-2nd century AD	Invasive	excavations and partial reconstructions: 1974	Walenta, 2007;
2	Borkowo	Dolmen (passage-grave), long barrows, Neolithic 3500 BC Burial mounds: Lusatian Culture Bronze Age	Invasive	discovery: 1927; surface survey, the first excavations and reconstruction of the dolmen: 1934; excavation and reconstruction of the second barrow: 1939; surface survey: 1963	Żurkiewicz, 2021; Wierzbicki, 2005

No	Site name	Form of the structure Period and time of construction	Archaeological research: invasive/ non-invasive	Dates of archaeological research	Literature source
3	Łupawa	Long barrows: Funnel Beaker Culture, Neolithic 3500 BC Burial mounds: Lusatian Culture Bronze Age	Invasive	excavations and partial reconstructions: 1970-78	Jankowska, 1975; Sukniewicz, 2017
4	Węsiory	Stone circles, burial mounds, cairns Iron Age Wielbark Culture used 50-300 AD	Invasive	excavation: 1955-63; supplementary research: 1997-99	Walenta, 2007; Cieśliński, 2013; Kalka & Elwart, 2020
5	Babi Dół-Borcz	Stone circles, burial mounds Iron Age Wielbark Culture used 80-310 AD	Invasive	research conducted with interruptions: 1978-2015; partial reconstructions: 2015	Walenta, 2007; Cieśliński, 2013; Kalka & Elwart, 2020
6	Leśno	Burial mounds, cairns, chest graves Lusatian Culture Bronze Age, Wielbark and Pomeranian Culture Iron Age, used 50-220 AD	Invasive	first discovery: second half of the 19th century; complex research and reconstructions: 1975	Breske et al., 2006; Walenta, 2007; Cieśliński, 2013; Kalka & Elwart, 2020
7	Odry	Stone circles, burial mounds Wielbark Culture Iron Age used 70-220 AD	Invasive	first scientific research: 1874; excavations: 1926 and 1962	Walenta, 2007, Kalka & Elwart, 2020; Cieśliński, 2013;
8	Sarnowo	Long barrows Funnel Beaker Culture Neolithic 3500 BC	Invasive	discovery: 1946; excavations and reconstructions: 1950-51	Papiernik & Płaza, 2019
9	Wietrzychowice	Long barrows Funnel Beaker Culture Neolithic 3500 BC	Invasive	First interests: 1873; first scientific research: 1934; reconstruction of one barrow: 1935; reconstructions of barrows 2-6: 1967-69	Papiernik & Płaza, 2019
10	Krotoszyn	Burial mounds Tumulus Culture, Bronze Age 2000-1400 BC	Invasive Non-invasive	surface survey: 1916; excavations: 1923, 1965 and 2008-2011. non-invasive research – 2008 partial reconstruction: 2015	Stróżyk, 2019 Pospieszny, 2013
11	Muszkowi-ce	Long barrows Funnel Beaker Culture Neolithic 3500 BC	Invasive Non-invasive	discovery: 1995; excavations of one barrow: 2001-2006; non-invasive research: 2010-2012	Przybył, 2014

Figure 5. Land cover of the archaeological sites

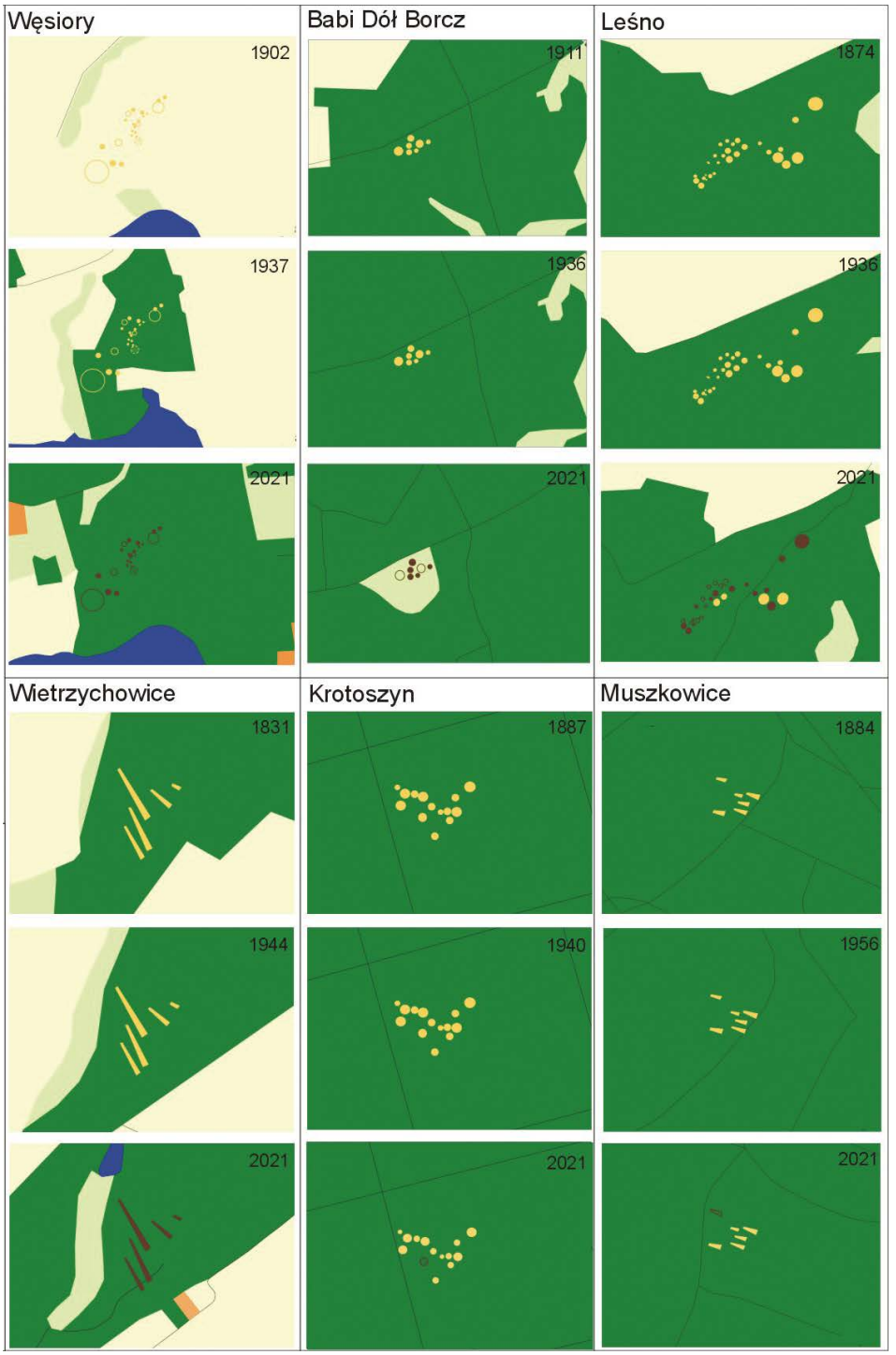


Figure 5. (continuation)

three monuments were established: Węsiory (1972), Łupawa (1974) and Leśno (1978) (Register of Archaeological Monuments, 2022). The sites in Wietrzychowice and Sarnowo are also protected by a relatively new form of landscape protection: culture park (Resolution of the Municipal and City Council in Izbica Kujawska, 2006; Resolutions of Municipal City Council in Lubraniec, 2010). The site in Odry is the only one protected as a nature reserve (Order of the Minister for Forestry and Timber Industry, 1958). Two sites, Borkowo and Krotoszyn, are not protected at all.

Land cover

Based on the topographic maps from the three periods for all the archaeological sites studied, the land cover was analysed (Fig. 5). For most of the places, the changes were not significant. In Leśno, Wietrzychowice, Krotoszyn and Muszkowice, no changes were observed, with forest covering the sites from the 19th to the 21st century, although in Leśno and Wietrzychowice, the area close by has changed slightly. The sites in Odry, Grzybnica and Babi Dół Borcz are also located in the forest, but the 2021 map shows that some of the archaeological forms are located in glades. In Sarnowo, in the 19th century, the long barrows located in the south of the area were situated in arable fields, but in the subsequent years under study, they were covered by forest. A similar situation was observed in Borkowo, where part of the site was taken up by arable fields in 1936.The most significant changes have taken place in Łupawa and Węsiory. In Łupawa, arable fields with patches of forest (one of the patches covered some of the barrows) dominated in the 19th and the 20th century. In 2021, forest covered the entire area, but the archaeological forms were situated close to the border with the arable fields. In Węsiory, arable fields dominated in 1875 but decreased through the subsequent decades, and in 2021, the whole site was also covered in forest.

As the topographic maps do not show detailed information about the land cover, orthophotomaps from the last 20 years were studied. For most of the places, there are no differences between the land cover shown on the topographic maps and that shown on the orthophotomaps. A different situation was observed in Leśno and Babi Dół Borcz (Fig. 6). In Leśno, although the land use for the area is still forest, in reality, the place is deforested due to the passage of a tornado in 2017. The forest was destroyed in this entire area, and now the place is growing back. In the case of Babi Dół Borcz, analysis of the orthophotomaps allowed us to observe the deforestation and reforestation processes related to the archaeological excavations. A similar process probably took place at other sites where excavations were performed (e.g., the archive photos show the deforestation of part of the area during the archaeological research in Sarnowo).

Tourist infrastructure

Tourist infrastructure has a significant impact on the contemporary physiognomy of the landscape. The oldest elements of infrastructure were placed in Wietrzychowice in 1935. Although funeral sites constructed thousands of years ago should be a tourist attraction, not all of them are adapted for tourism (Fig. 7). The least accessible is the site in Muszkowice, which is located away from public footpaths. The barrows in Borkowo are situated near the tourist trail, but despite the fact that it is the only dolmen in Poland, the place is not equipped with any elements of tourist infrastructure (although, according to the photos available on the Internet – e.g., at http://darlot.pl/megality_w_borkowie.html, an educational board was present at the beginning of the 21st century). The site in Łupawa is also poorly equipped (one educational board and a small tourist shelter were installed recently). Some adaptations to tourism have been implemented in Babi Dół Borcz and Krotoszyn, along with the recent reconstruction of the sites. The rest of the sites – Grzybnica, Leśno, Odry, Węsiory (these four sites are the best known among tourists, and there is a lot of tourist information about them on the Internet and tourist

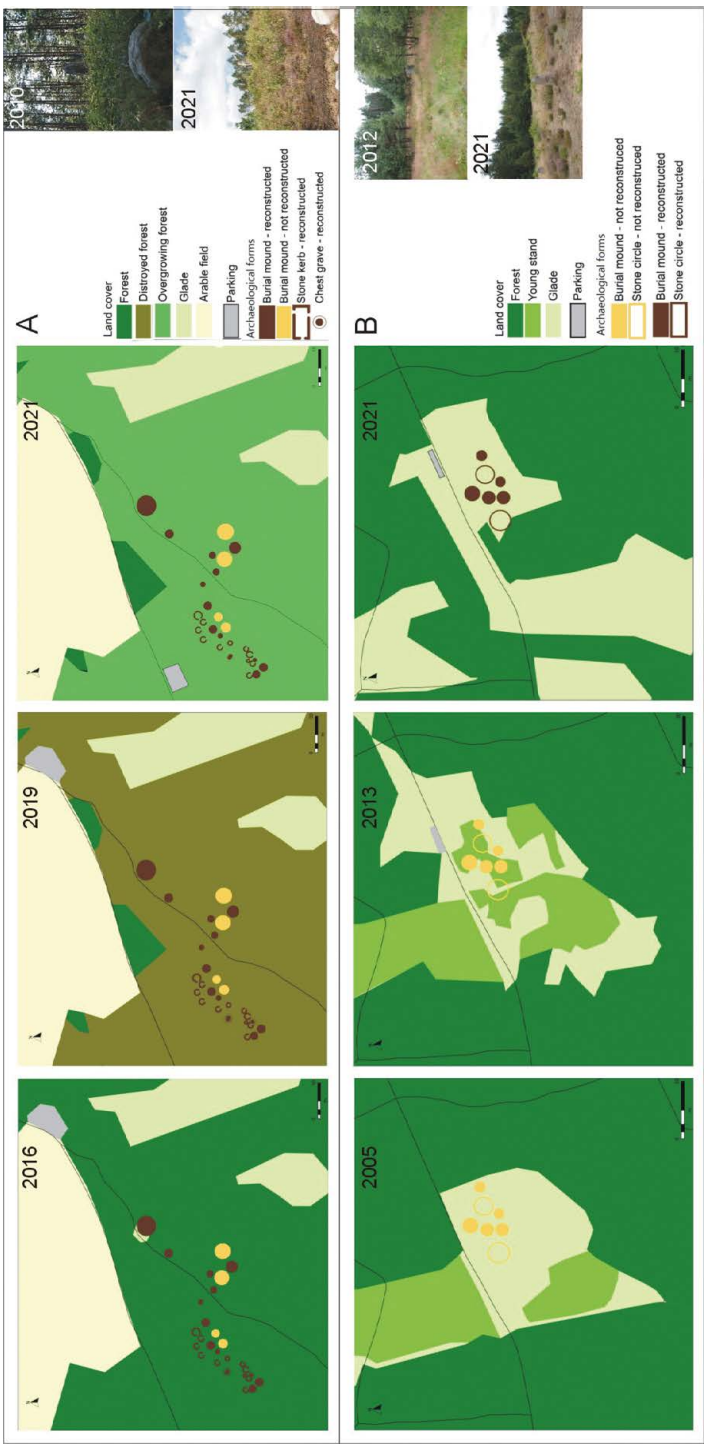


Figure 6. The land cover changes in Lesno (A) and Babi Dół Borcz (B) based on the orthophotomaps and photographs of the places before and after the change (tornado in Lesno and excavations in Babi Dół Borcz)

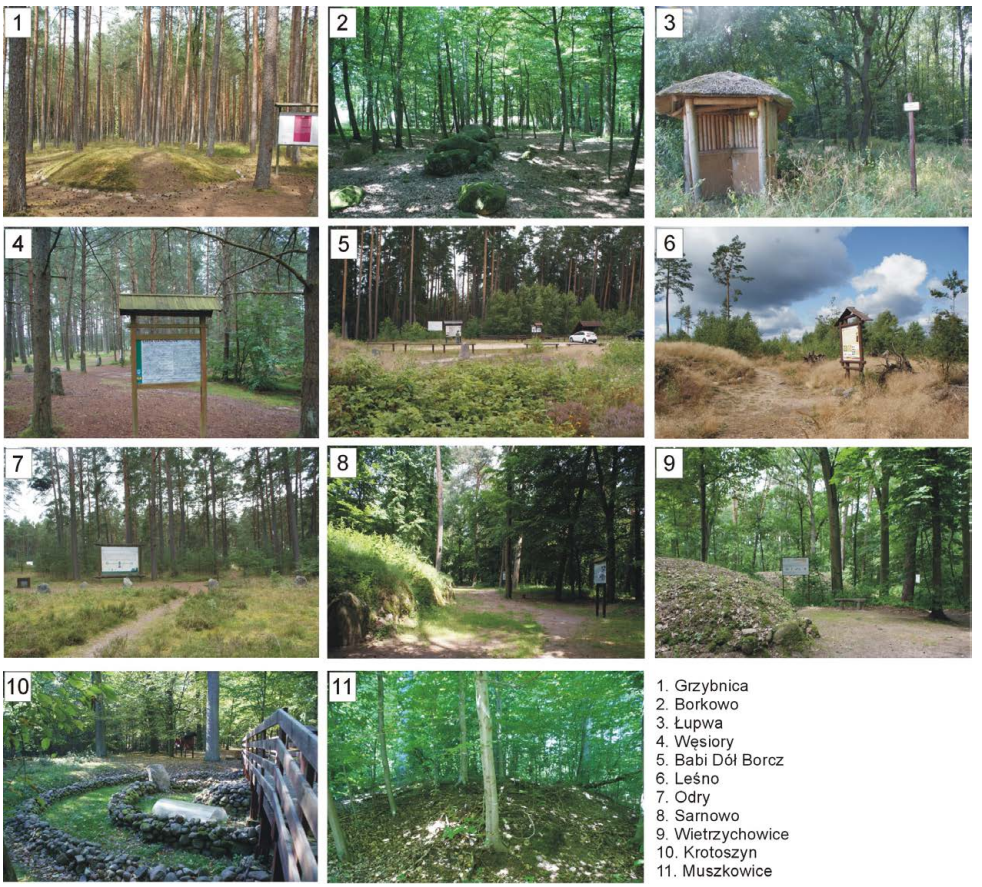


Figure 7. The site's tourist facilities (examples) *Photographs taken by the author*

infrastructure has been developed in these places for a few decades), Wietrzychowice and Sarnowo – are well equipped with tourist infrastructure, including facilities like educational boards, tourist shelters (rest points), paths and small parking lots.

Comparison of the landscape changes in the archaeological landscapes – Block graphs

The analyses of the archaeological works, legal protection and land cover with tourist development are presented in the form of block graphs (Fig. 8).

These analyses allowed us to identify the key processes within adopted factors that caused the landscape changes and to compare the changes of the studied sites.

The most significant are the changes in land cover. In the study cases, there are several directions of change (for the three periods investigated on topographic maps): arable fields-forest-forest (three cases), forest-arable fields-forest (one case), forest-forest-glades (three cases). Based on the orthophotomap, there is one case of a different change: forest-forest-destroyed forest. In the rest of the cases, there was no change (forest-forest-forest). The observed processes of land cover change are reforestation (which can be related to natural succession or to planned actions) and deforestation (caused by excavation works or sudden natural events, like a tornado).

The archaeological research conducted at the sites was an important process impacting the landscape. The lack of any archaeological research or non-invasive research (led mostly in Muszkowice and partially in Krotoszyn) caused slow natural deconstruction (erosion) of the forms but allowed the original form to be saved (or the rest of it). Excavations, on the other hand, caused significant landscape changes (in the archaeological form and land cover – deforestation), but in most cases led to the reconstruction of the form (eight cases) or partial reconstruction (two cases).

Another important process of landscape change is the introduction of tourist facilities. In nine cases, there are tourist utilities present. The introduction of one or two elements does not change the visual aspects of the landscape considerably (three cases). The location of several elements necessary for tourist accessibility, such as educational boards, small car parks, tourist shelters or benches, can be considered as sustainable (in landscape terms) development (six cases). The introduction of too many elements which are not necessary for tourists can lead to overdevelopment and a significant decrease in the value of the landscape.

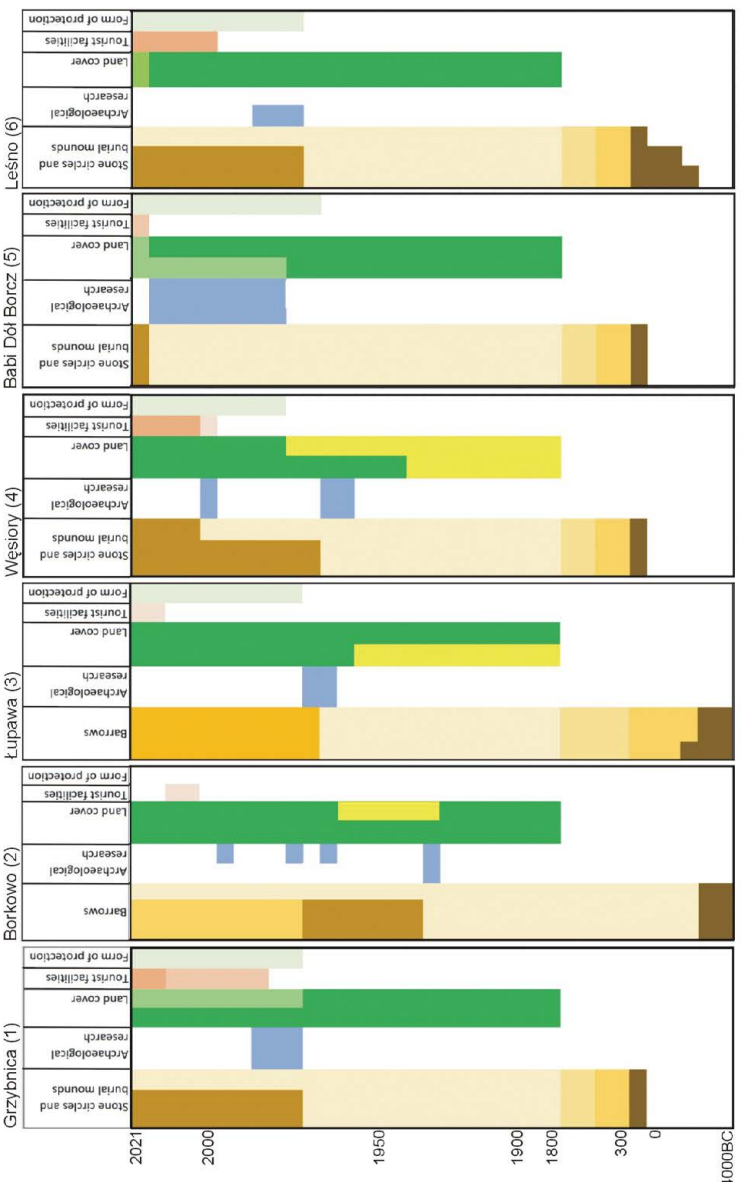
Physiognomic landscape changes are not related to the establishment of forms of legal protection. For most of the sites, forms of protection were established during (Grzybnica, Leśno, Wietrzychowice, Muszkowice) or after (Łupawa, Węsiory, Odry, Sarnowo) the archaeological research carried out at the site. In the case of Babi Dół-Borcz, legal protection was introduced before the start of the archaeological research. The unprotected sites are Krotoszyn and Borkowice, although they have been excavated and some of their forms reconstructed. On the other hand, the site in Muszkowice, protected as a monument, has not been reconstructed and equipped with tourist facilities. In the case of Wietrzychowice, the establishment of the protection form was followed by the introduction of tourist facilities, and in Sarnowo and Grzybnica the facilities were installed not long after. In other sites, the time when equipment was introduced did not coincide with the establishment of the form of protection.

The most significant changes occurred in sites where invasive research followed by the tourist infrastructure location was carried out and additionally the land cover changes (observed during the cartographic analysis) had place. This is the case with Grzybnica, Babi Dół-Borcz and Odry, where as a result of the archaeological work carried out, glades were created, the forms were reconstructed, and the tourist facilities were introduced. The changes of the physiognomy were also observed in Węsiory, Sarnowo and Wietrzychowice, as a result of the reconstructions and location of tourist facilities. Significant changes in land cover as a result of the tornado and, in addition, changes in structure as a consequence of the location of tourist facilities have been observed in Leśno. The least significant changes occurred in Muszkowice.

The future

The path of physiognomic landscape change from the past into the future, with the indication of the present location of each study area, is presented in a tree diagram (Fig. 9). Some of the processes follow a specific sequence (construction-discovery-archaeological research-type of research-process after research (e.g., reconstruction), while others may occur in parallel over time (introduction of tourist development, natural disasters, land cover changes).

Each process leads to a physiognomic landscape effect. On the tree diagram, they are presented in general groups: no implications (no change), change in land cover (deforestation, overgrowth and development of the construction), changes in landscape composition (blurring, restoration, conservation of the composition and contemporary features/traits in the composition) and changes in the intangible values of the landscape (loss of historical value).


Grzybnica (1)
Borkowo (2)
Łupawa (3)
Węsiory (4)
Babi Dół Borcz (5)
Leśno (6)
Stone circles and burial mounds
Archaeological research
Land cover
Tourist facilities
Form of protection
Barrows
2021
2000
1950
1900
1800
300
0
4000BC

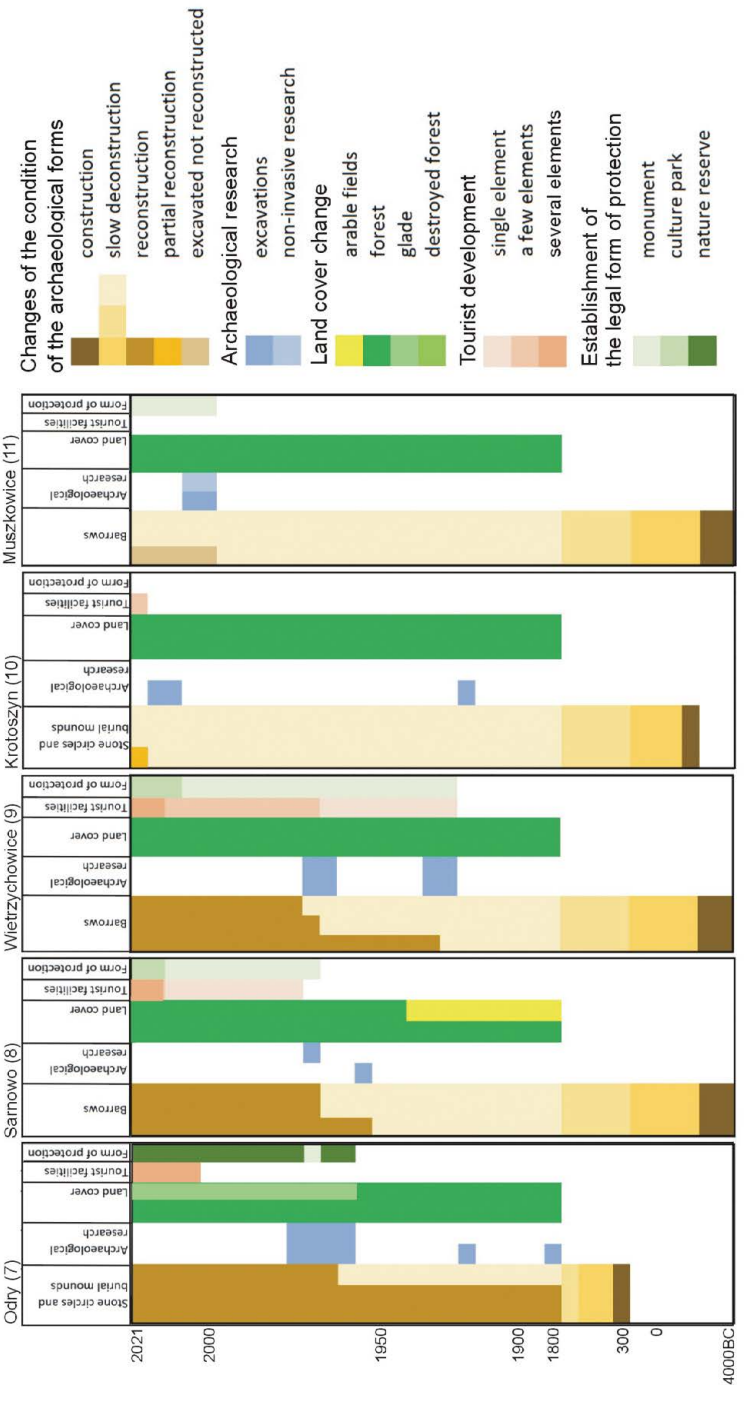


Figure 8. Block graphs presenting the changes in time of study areas

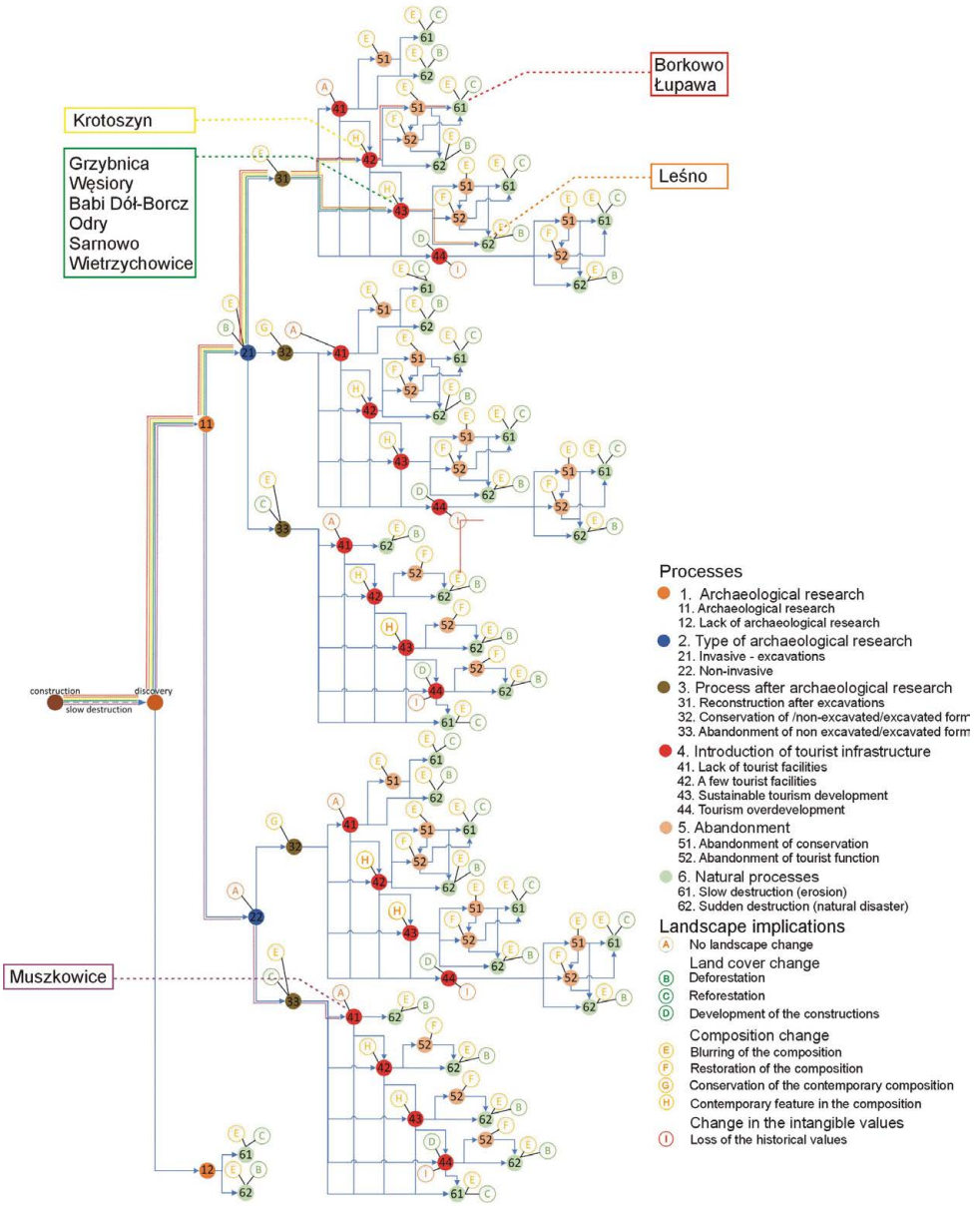


Figure 9. Tree diagram showing the path of landscape transformation

Every site has a similar beginning: the construction of the archaeological forms and the moment of archaeological discovery. From this moment, there are two possibilities: a lack of research (which is not represented in the areas studied) or the initiation of archaeological research. Further landscape changes depend on the type of research: non-invasive (only Muszkowice, although one of the graves was researched with invasive methods)

or related to excavations (invasive research). The next differences in the path are connected with the archaeological activities performed on the forms: reconstruction (or partial reconstruction) of the form (most of the sites studied), the conservation of non-excavated or excavated forms, or abandonment after research without the conservation of the forms (Muszkowice).

The next process on the diagram represents tourist development, which depends on the level of tourist facilities introduced: lack of tourist facilities (Muszkowice), single facilities (Łupawa, Krotoszyn), several tourist developments (most of the sites) or tourist overdevelopment. Tourist overdevelopment was not observed in the sites studied, but it is possible that further tourist development could lead to an excessive number of facilities and, as a result, to significant landscape changes. On the other hand, the sites could be abandoned, both in the process of conservation (like in Łupawa) and to maintain tourist infrastructure (like in Borkowo).

Independently, any site can suffer from sudden destruction (natural disasters) during its path, like in Leśno. As the areas are covered by forests and glades, further processes related to land cover change would be related to deforestation and reforestation (as in Leśno).

Most of the sites (Grzybnica, Węsiory, Babi Dół Borcz, Odry, Sarnowo, Wietrzychowice) have had a similar path of landscape changes up to today (construction-discovery-archaeological research-excavations-reconstruction-sustainable tourist development). The diagram shows the possibilities of further changes that might take place (tourist overdevelopment, abandonment of tourist function or of conservation or both, natural processes of destruction leading to deforestation). Partially, the same path can be observed for Krotoszyn, Łupawa and Borkowo (construction-discovery-archaeological research-excavations-reconstruction-a few tourist facilities). Next, the path for these sites leads in different directions, leaving Krotoszyn at this point. In the case of Łupawa and Borokowo, there has been abandonment of maintenance and slow erosion, but in Łupawa the tourist facilities are still maintained, while in Borkowo, the tourist function has also been abandoned.

Discussion

Archaeological heritage is a fragile and non-renewable cultural resource (Charter for the Protection and Management of Archaeological Heritage, 1990). The archaeological landscape changes under the influence of both natural and human-induced factors. This research presents the changes that influenced the landscape in the past and, analogically, can also occur in the future.

Possibility of future changes – discussion

Future changes in the landscape are mostly based on past events, but their occurrence is more or less probable. In the case of the type of archaeological research, the possibility of invasive research is lower than non-invasive. The increased knowledge and awareness of scientists caused some shifts in the directions and guidelines of these studies. Most of the sites studied were excavated in the last century, when the standards of the research covered the excavations and reconstruction of the forms. At the end of the 20th century, the objective of academic archaeological research placed an emphasis on shifting conservation policies from excavation to *in situ* preservation (Charter for the Protection and Management of Archaeological Heritage, 1990). This new insight has influenced the physiognomy of the landscape. Non-invasive research with no excavations allows the original form to be saved, but this related to a lack of reconstruction, so the archaeological forms are not clearly visible in the landscape. On the other hand, the excavations and reconstructions restore the original composition of the landscape (landmarks) but lead to more significant changes (deforestation) and influence the intangible values of the place (non-authenticity).

In the archaeological sites studied, there are no examples of tourist infrastructure overdevelopment, but it is possible that infrastructure will be developed in the future. Archaeotourism is still developing, so tourist pressure will probably grow (Comer & Willems, 2012). It is possible that with increasing tourist interest, facilities that are more invasive to the landscape (such as restaurants or museums, but also replicas) will be established, leading to more significant physiognomic change, thus bringing contemporary traits to the historic place, changing the landscape composition and, in effect, leading to a loss of landscape values. The beginnings of this phenomenon are visible in Krotoszyn. There are only a few tourist facilities, but a replica of a burial – a human figure, is located in the middle of a partially reconstructed grave mound, which strongly impacts the visual effect of the landscape. In many places around the world, the introduction of tourist infrastructure is limited (as in Stonehenge, where the site is fenced and the tourist facilities are located a long way from the stone circle and the road next to the site has been closed and regressed over (Paksoy, 2014) or not present at all (as in Muszkowice or at Dolmen Haga in Hagadösen, Norway). But there are also examples of a high infrastructure load on the landscape (as in Carnac in France, where the negative tourist impact related to the lack of management was minimised by the development of tourist infrastructure: a fence, parking lots and a museum were established, but near the megalithic alignments) (Hayes & Patton, 2001).

Nowadays, all the sites are located in forests, although some parts of them are deforested and now in glades as a result of excavations. As most of the places analysed are maintained in their current condition, overgrowth will not take place unless conservation is abandoned. But regrowth and reforestation can be a major factor leading to landscape change, as has been observed in Northern Norway (Barlindhaug et al., 2007). According to the forest management plans for the sites in question (the data available on the interactive map prepared by "Forests and citizens", based on the Forest Data Bank, Public information bulletin, requests for access to public information to State Forests, https://mapy.lasyiobywatele.pl/zanim-wytna-twoj-las.html), no tree felling is planned for the coming years, so deforestation is also unlikely, unless natural disasters occur. Among natural hazards, those related to the climate (hurricanes, snowstorms, desertification, thunderstorms, etc.) and biophysical hazards (fire) (Micle, 2014) are the most likely to occur. Hydrological (floods, Flood Risk Maps) and geomorphological (landslides) disasters are not really a threat due to the locations of the sites analysed.

Among the threats to land cover change in the archaeological sites related to man-made destruction, some authors distinguish farming and real estate development pressures (Micle, 2014; Zaina, 2019). In the case of the areas analysed, this threat is not likely to occur, since they are covered by forests, surrounded by rural areas with rather low housing density and far from big cities, so with low urbanization pressure, and, in most cases, are protected.

It is also worth highlighting that in the sites studied here, there is no sign of vandalism, which often occurs at archaeological sites (Gani 2019; Vella et al., 2015), although some looting was present in the past (e.g. in Wietrzychowice, stones taken from the site were used for the construction of roads and buildings) (Papiernik & Płaza, 2017).

Advantages and limitations of the study

This study allows landscape changes to be compared between the sites analysed. It enables us to trace the physiognomic landscape changes that have occurred in the distant and recent past. It also allows the time and factors of change as well as possible future paths of transformation to be identified and visualised, and can therefore be used as a tool to assist in the conservation and management planning of these sites. It is worth

highlighting the interdisciplinary approach presented in this article, which introduces unique insights by combining archaeological, architectural and geographical conventions.

The method presented here can also be used for other types of landscape. The processes, block graphs and tree diagrams can easily be modified and applied in various areas for future landscape planning. The landscape history analysis used in the research is an important planning tool to understand landscape changes (Marcucci, 2000).

But identification of both historical and future processes can raise some problematic issues. Marcucci (2000) points out two difficulties for landscape history: lack of convention ("landscape history will have to synthesize its own conventions, keeping in mind the ultimate utility for landscape planning", p. 75) and obscure data ("the necessary data may not exist, be unavailable, or be difficult to locate", p. 75). Obscure data is a common problem related to past landscape analysis. It causes difficulties with the lack or low accuracy of some cartographic materials and various scales of maps (Stäuble et al., 2008), but also other documentary data (such as the information presented in the article concerning tourist infrastructure, archaeological research and reconstruction of sites).

Another problem relates to predicting future landscape development. The dynamics of the change are often presented in landscape models. Daniel et al. (2016) distinguished landscape vegetation models developed by ecologists and land-use/land-cover (LULC) change models developed by geographers. Another approach is the architectural one, which covers the physiognomy of the landscape, such as basic aesthetic categories of future landscapes (Nohl, 2001). This approach concentrates on the landscape planning process, presenting prognoses (Chmielewski et al., 2014) or scenarios. Shearer (2005) points out that scenarios "describe situations, actions, and consequences; [...] describe what could happen" (p. 68). This description is consistent with the one presented in the article, as the future of archaeological landscape development, depicted as a path on the decision tree, shows just possible paths, the changes that could and not necessarily will happen.

Conclusions

The algorithm of the research presented in this article, which covers the study of the past and present condition and processes that influenced the physiognomy of the landscape in order to point out the future possibilities of landscape change, helps make the right decisions in the planning process in order to "make" the future of the archaeological landscape.

The study enables several significant conclusions to be drawn. Analysis of the past and present archaeological landscape allows the process of landscape change in the last centuries to be traced. In the sites studied, the processes were both human-induced: forest introduction, archaeological processes (invasive research and the reconstruction of the forms), tourist infrastructure development, and nature-induced: natural disasters, overgrowth, erosion.

However, in these archaeological sites, there are no examples of tourist infrastructure overdevelopment, and it is possible that infrastructure will be developed in the future.

There were no significant land cover changes observed, except in a few cases of change from arable fields to forests and forest destruction caused by natural disasters. A natural disaster occurred in just one case, but caused one of the most significant changes in the archaeological landscape. All the sites studied are located in forests. According to the forest management plans, no tree felling is planned for the coming years, so the land cover will not change unless there is a natural disaster.

Possible landscape implications for future change are deforestation, reforestation, development of tourist infrastructure, blurring, conservation or restoration of the landscape composition, introduction of contemporary features to the landscape composition, and loss of historical value.

The method for analysing the past and present in order to identify possible future landscape transformations can contribute to the landscape planning process, particularly from the perspective of landscape conservation (including legal forms of protection) and tourism development. The study opens up opportunities to analyse and indicate possibilities for the future transformation of valuable cultural landscapes that are undergoing rapid or uncontrolled change, such as fortified landscapes (tourist pressure on castle surroundings) or pastoral landscapes (settlement development or reforestation).

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Unless otherwise stated, the sources of tables and figures are the author's, on the basis of their own research.

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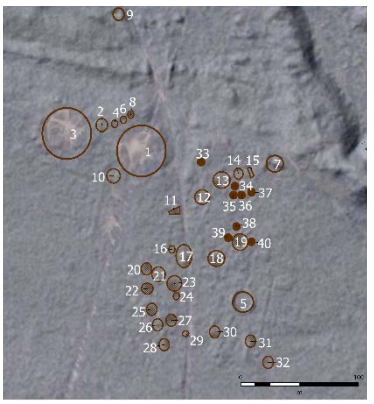
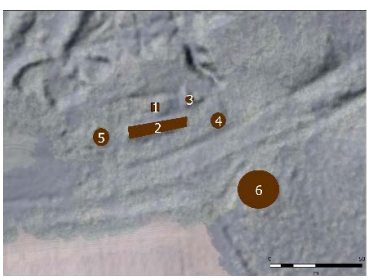
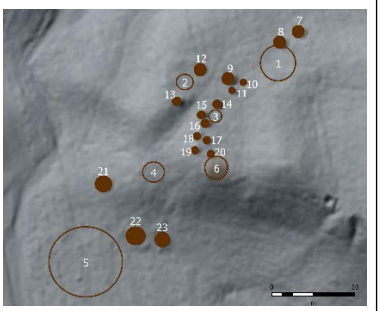
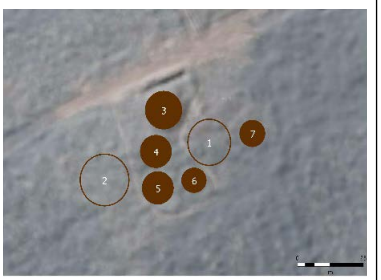
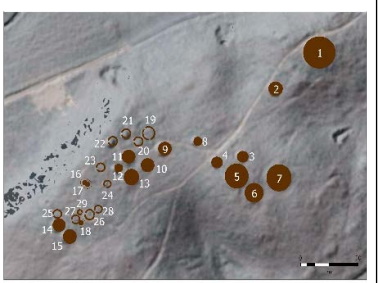
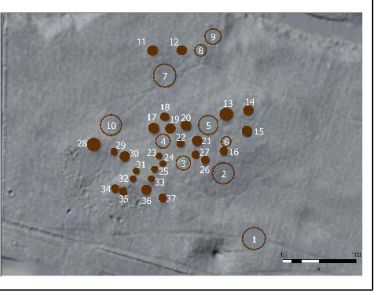
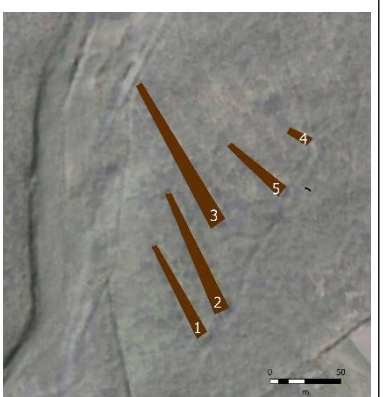
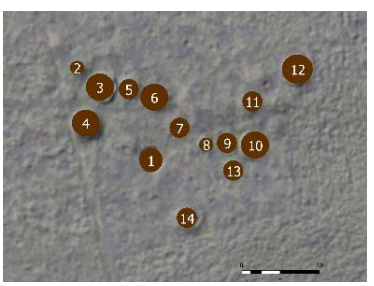
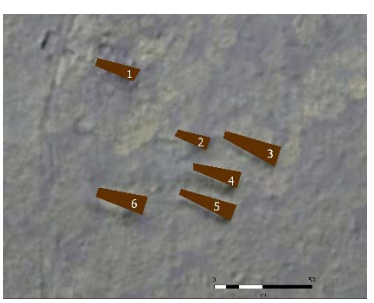
Appendix A

No	Site name	Photodocumentation	Location on the hill shade map
1	Grzybnica		
2	Borkowo		
3	Łupawa		

No	Site name	Photodocumentation	Location on the hill shade map
4	Węsiory		
5	Babi Dół-Borcz		
6	Leśno		
7	Odry		

No	Site name	Photodocumentation	Location on the hill shade map
8	Sarnowo		
9	Wietrzychowice		
10	Krotoszyn		
11	Muszkowice		

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