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Exploring historical maps for insights into ecosystem extent and condition: a case study landscape in Poland

Abstract

The aim of this paper is to analyze how historical maps could be used in the context of SEEA EA and what information could be derived from historical maps to facilitate mapping and assessment of ecosystem extent and condition in according to the SEEA EA guidelines. The source materials were maps documenting the landscape in 1883, 1936, 1977 and 2011 of the case study area of Ślęża Landscape Park in Poland, Central Europe. The landscape level characteristics of naturalness and diversity were used to understand the condition. The Ślęża Landscape Park's ecosystem extent results show trends of increase in forest cover of about 700 ha driven by afforestation and decrease in the agricultural share of land. In 1883, the biggest forested areas were not connected to each other, but on the other hand, forest areas were more compact, as diversity of boundaries was lowered inside forests. The least natural areas were scarce and so human pressure and impacts were lower. Humans have significantly influenced this landscape by expanding mineral extraction activities and built-up areas. We discuss the challenges of local scale SEEA EA applications and present lessons learned from this process.

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1 Introduction

The System of Environmental Economic Accounting Ecosystem Accounting (SEEA EA) is a statistical framework for organizing environmental and economic information. The SEEA EA provides guidelines for preparing natural capital accounts, in particular ecosystem extent, ecosystem condition, ecosystem service biophysical and monetary accounts, and monetary ecosystem asset accounts (United Nations et al., 2021). Hein et al. (2020) report progress in natural capital accounting efforts globally while new applications (Farrell et al., 2021; Bruzón et al., 2022), methodological considerations (Maes et al., 2018; La Notte & Rhodes, 2020; La Notte 2022) and methodological reviews (Rendon et al., 2019; Maes et al., 2020) of ecosystem accounting are emerging. Solid foundations were also laid while the global consultations on improving the SEEA experimental EA (Hein et al., 2015; Obst et al., 2016) were held.

The ecosystem extent and condition accounts underpin the ecosystem service accounts, both biophysical and monetary. Therefore, the stage of preparing the extent and condition is important and needs methodological framework in order to be consistent with the rest of the system of accounts. While the ecosystem extent is a straightforward process of mapping the ecosystem accounting units of specific ecosystem types, the ecosystem condition assessment requires more consideration. It is defined as "the quality of an ecosystem measured in terms of its abiotic and biotic characteristics" (United Nations et al., 2021, p. 27). The understanding of ecosystem condition in relation to ecosystem integrity (Roche and Campagne, 2017) and ecological status (Grizzetti et al., 2019) is well established. SEEA EA recommends to follow the conceptual framework (Keith et al., 2020b) and an ecosystem condition typology (Czúcz et al., 2021a). The Ecosystem Condition Typology includes three main groups of ecosystem characteristics, i.e., abiotic, biotic and landscape level. In an abiotic group, physical and chemical state characteristics are considered, while in a biotic group these are compositional, structure and functional states. The landscape level characteristics includes different metrics describing the ecosystem mosaic (Czúcz et al., 2021a). The ecosystem variables need to be assessed against a certain reference condition. The SEEA EA (United Nations et al., 2021) guidebook includes several approaches to setting the reference condition and reference levels for ecosystem condition variables: i.e. reference site, modelled reference condition, statistical approaches based on ambient data distributions, historical observations, contemporary data, prescribed levels of ecosystem condition variables, expert opinion, and combination of any of mentioned approaches.

A historical observation approach to setting the reference condition requires historical data. It is relatively difficult to find reliable and repeatable sources of historical biophysical data on biodiversity. Therefore, many authors make statistically proved assumptions that landscape structure is related to biodiversity and landscape functions (Moser et al., 2002; Rega et al., 2018). Data about the ecosystem condition (e.g., species richness, dry matter productivity) could be linked to the land use and land cover (Moser et al., 2002). Historical land use and land cover maps are a source documenting landscape change in the long term (Schirpke et al., 2021). There are many approaches to historical landscape analysis (Haase et al., 2007), e.g., using modern techniques such as GIS (Timár et al., 2008; Tortora et al., 2015; Statuto et al., 2017), landscape metrics or deterministic models (Žuvela-Aloise et al., 2014). Moser et al., (2002) reports that landscape indicator with biggest predictive power for plant species richness is several shape characterizing points that reflects landscape shape complexity. In the study of (Renetzeder et al., 2010), this landscape indicator was highly correlated with the degree of naturalness. The structural diversity and naturalness seem to inform most about the historical condition of the landscape.

There is still limited number of published case studies and applications of ecosystem accounting in the scientific literature (e.g., Vačkářů & Grammatikopoulou, 2019; Capriolo et al., 2020; Sylla et al., 2021), however, practical applications at the national and sub-national levels from all over the world are available in press releases or project reports (NBS China, 2021). Published accounts report a compilation of different types of accounts. In scientific literature, ecosystem condition assessments for the purpose of accounting are relatively scarce (Maes et al., 2020).

Therefore, pilot ecosystem accounts that would test and improve best practice and methodological guidelines are recommended. Our research questions concern:

1. How historical maps could be used in the context of SEEA EA?
2. What information could be derived from historical maps to facilitate mapping and assessment of ecosystem extent and condition?

2 Materials and methods

The ecosystem accounting area could include administrative areas (e.g., Remme et al., 2014; Warnell et al.; 2020) or catchment area (Farrell et al.; 2021). The ecosystem asset is defined by (United Nations et al., 2021) “contiguous spaces of a specific ecosystem type characterized by a distinct set of biotic and abiotic components and their interactions”. The IUCN Global Ecosystem Typology (Keith et al., 2020a) could be used as reference classification of ecosystem types, however, there are country or case study specific approaches which result from individual ecosystem characteristics, geographic location and/or protection interests. Spanish ecosystem type classification is inspired by the national land cover datasets, whereas European Union ecosystem accounts build upon Corine Land Cover (Büttner, 2014).

Ecosystem condition is directly related to the provision of ecosystem services (Grizzetti et al., 2019) and therefore, it is crucial it is assessed. The ecosystem condition can be determined by different indicators or rather composite indicators. In order to facilitate the process of indicators selection the 12 key criteria were suggested by (Czúcz et al., 2021b). These criteria relate to the following aspects: conceptual, practical, ensemble. The SEEA Experimental EA Technical Recommendations (United Nations, 2019) also provided valuable considerations for selecting indicators: the degree to which the indicator reflects the condition and is able to track changes in condition, the link to the potential ecosystem services supply, data availability, and how difficult the interpretation of the indicators for the policy makers and general public would be. Having said this, the condition indicators need to be logically structured and linked to the rest of ecosystem accounting framework and the SEEA Ecosystem Typology (ECT) (Czúcz et al., 2021a) is useful. We searched for historical materials that could provide information on ecosystem characteristics. However, the reliable and repeatable data sources provided by the state agencies for environmental protection have been available since 2004.

2.1 Case study area

The case study area is called Ślęża Landscape Park and represents a Landscape Park together with its’ buffer zone. It is located about 40 km from Wrocław which is the fourth biggest city in Poland with about 673,7 thousand inhabitants at the end of 2023 (CSO, 2024). The area of the Ślęża Landscape Park intersects the borders of the Wroclaw Metropolitan Area and Functional Urban Area. To be precise, half of the Park’s area (two out of six municipalities) lies within them. Together with its buffer zone, The Landscape Park covers a total area of 15807 ha. It was established in 1988 (Krajewski, 2012). Landscape Park protection regime is Category V according to IUCN’s classification of protected areas (Dudley, 2008), however, there are also three nature reserves (IUCN Category Ib) (established between 1954-1958) and Natura 2000 Special Areas of Conservation designated under the Habitats Directive. Ślęża Landscape Park represents a place of specific cultural and ecological as well as scenic values that results from interactions of people with nature. The main headline point of the park constitutes a Ślęża mountain (717 m a.s.l.) that stands out in the surrounding flatlands (Figure 1). The Ślęża mountain is covered with forests, which represent 33% of the case study area. Agricultural land, including arable and grazing land, is dominant in the buffer zone and covers 59% of the total study area. Built-up areas occupy 7%, and 1% is other areas.

2.2 Data sources and timeline

In the case of the Ślęża Landscape Park, data accounts for the extent and condition exists in fragmented forms, from different time slots, and is owned by several institutions. As stated in (Czúcz et al., 2021b), the aim of the condition accounts is to provide coherent environmental information from existing data sources. Our background assumption in preparing the extent and condition study was to

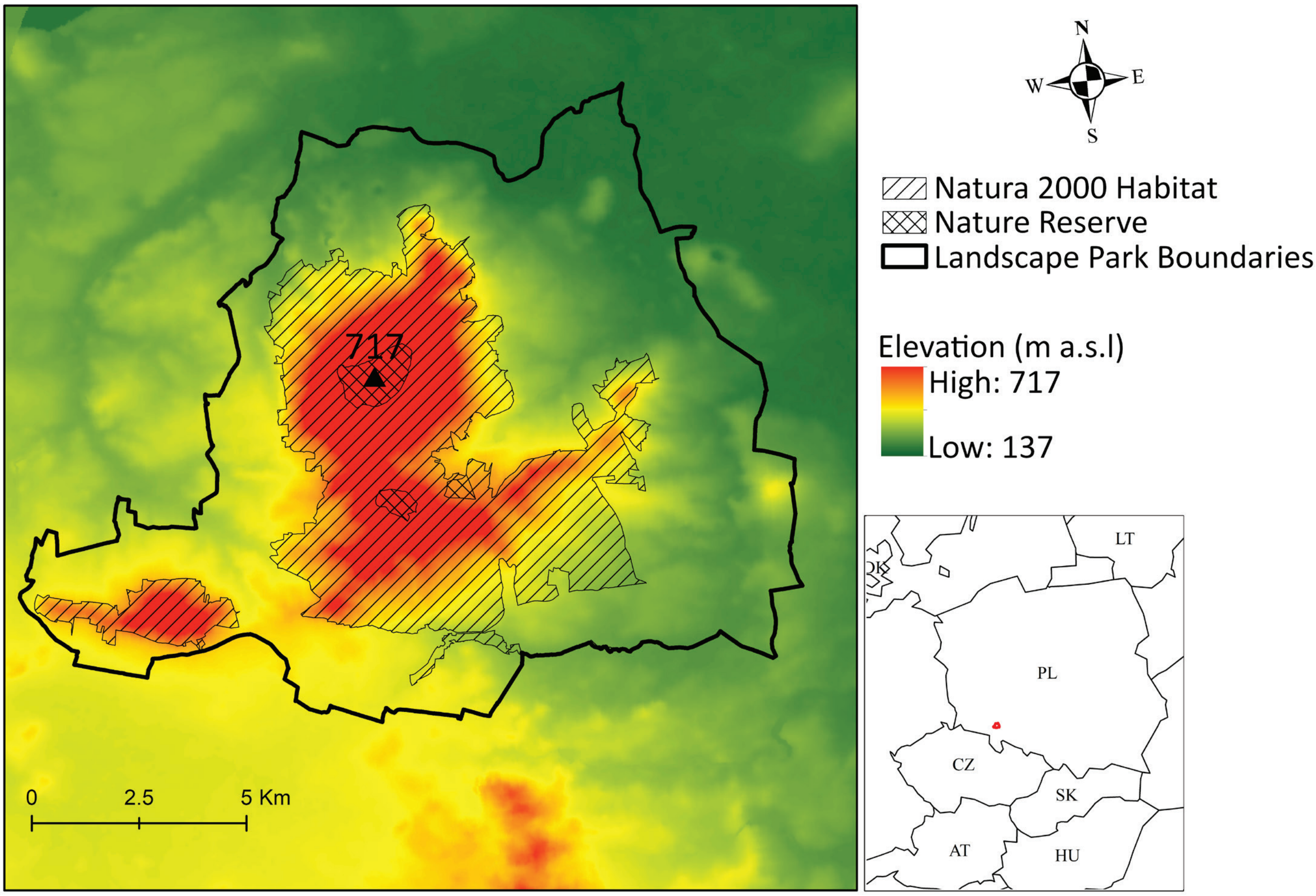

Figure 1. The Ślęża Landscape Park is located to the south of Wroclaw, Poland. The elevation shows the Ślęża massif dominating the flat landscape. Data source: Digital Elevation Model, Copernicus Land Monitoring Service - EU-DEM v1.1, 2011; Natura 2000, The General Directorate for Environmental Protection (GDOŚ), 2009 and Landscape Park map, GDOŚ, 2012.

use existing, open data sources, and also data that is available on demand for scientific explorations to test historical approach to ecosystem condition. As the case study area covers about 15807 ha, the Corine Land Cover (CLC) does not provide detailed enough information and has been available as a coherent data set since the year 2000. The text sources consisted of protection plans for nature reserves, a landscape park, and Natura 2000 sites. Protection plan includes analysis of socio-economic drivers as well as identification of existing and potential internal and external risk exposures. The plan provides fragmented information about the Park's biodiversity and recommended protective measures (Mastalska-Cetera & Krajewski, 2014). No reference to the concept of ecosystem service has been identified in the document; however, in general, stakeholders of management plans in Natura 2000 areas in Poland recognize the benefits provided by ecosystems (Maczka et al., 2016). The Landscape Park's protection plan was first published in 1990 and is updated every 20 years, i.e., in 2010 and 2030. Source materials were chosen based on similar content and the level of detailed information about land cover. The source materials were produced by (Krajewski et al., 2018) (Figure 2) in order to identify and compare landscape changes over 140-year span.

The oldest map of the case study area comes from the years 1883-1889, and it was a German topographic map. Two of the oldest sources are of German origins, since the region became part of Poland just after the World War II. The other two maps were produced by Polish institutions. We identified data sources and aligned them chronologically (Figure 3). Both oldest maps were digitized and georeferenced with relation to ground control points such as the tops of hills or preserved historical buildings. The first three maps were of raster data format, while the last

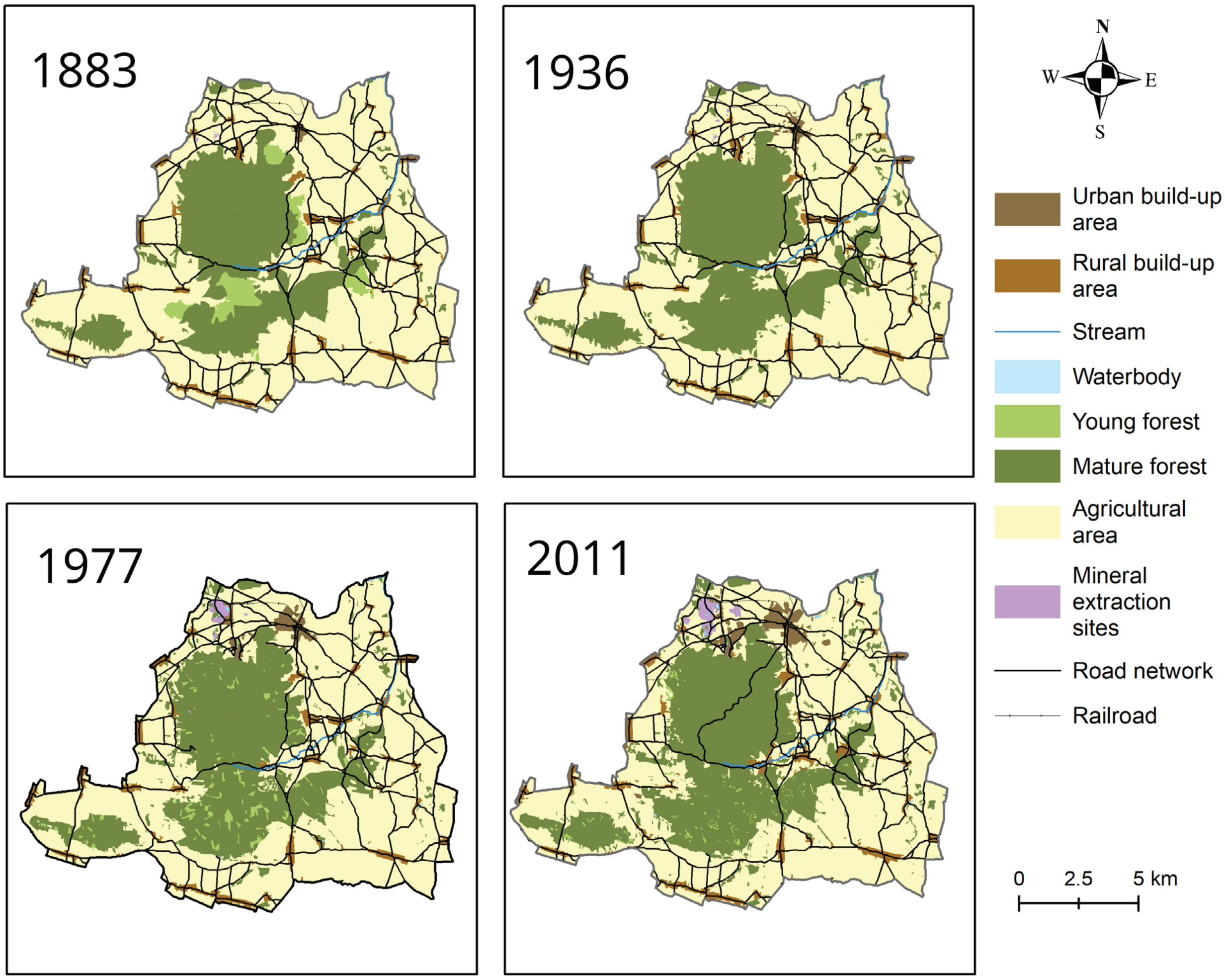

Figure 2. Historical land cover of the case study area. Data sources: Map 1883 and Map 1936-Topographische Karte - Messtischblatt for years 1883-1889 and 1936-1938; Map 1977 and Map 2011 - the Topograhic map of Poland 1977 and the Database of topographic objects 2011 from the Polish Head Office of Geodesy and Cartography.

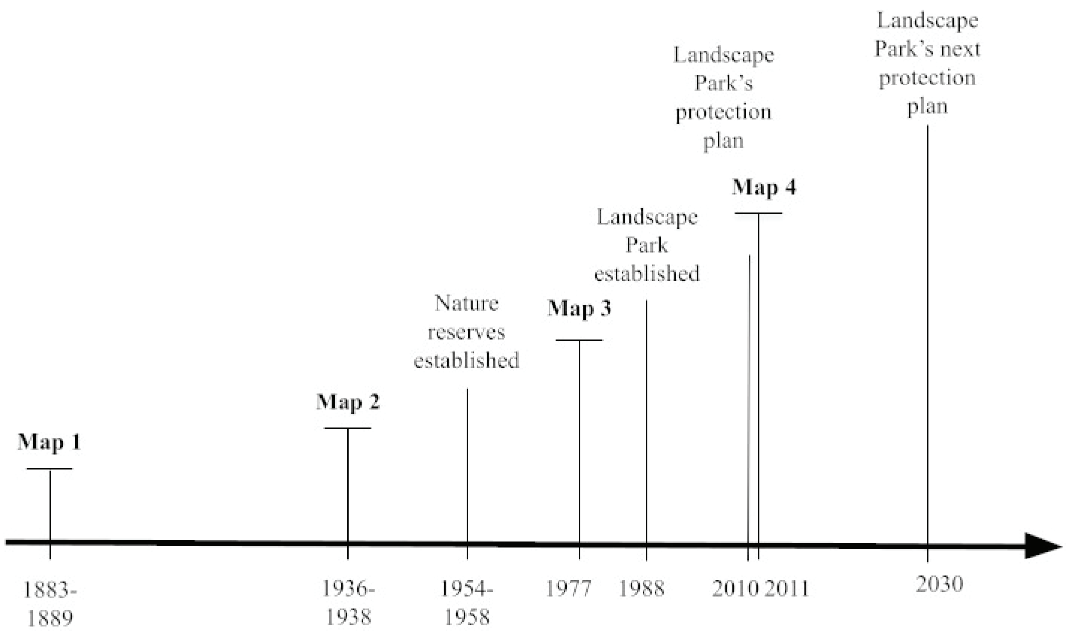

Figure 3. Timeline of data sources and Park's most important highlights.

map of 2011 was acquired in vector format. All maps were in resolution of 1:25000. A spline transformation as a rubber sheeting method was applied to calibrate the maps (Krajewski et al., 2018). All maps were calibrated by one person and validated by the team of authors to avoid bias.

2.3 Historical extent

The ecosystem extent is a starting point for compiling ecosystem accounts. At this stage, it is important to define the ecosystem accounting area, ecosystem assets, and ecosystem types. In our case, the ecosystem accounting area constitutes the protected area of the Ślęża Landscape Park together with its buffer zone, as it is shown in Figure 3. The ecosystem assets are landscape patches of a specific ecosystem type. In this case study, ecosystem types are limited to land cover types. In the source maps, the land cover types were divided into forest and non-forest areas. The forested areas included two classes based on the age of the forest cover: young and mature. Non-forest area included: water area, agricultural land, rural and urban areas, mineral extraction sites, and other areas. We created a separate class of road network, as it is a factor significantly influencing landscape metrics.

Additionally, in order to better understand the dynamics of landscape changed at the patch level, we calculated number of patches and average patch size in hectares for each time points of the analysis.

2.4 Historical condition reflected by landscape structural characteristics

The landscape level characteristics can be assessed based on historical maps. Landscape metrics are used to describe landscape structure (e.g., landscape diversity, connectivity, fragmentation) (Czúcz et al. 2021a). We analyzed different landscape metrics and decided for two indices: landscape naturalness and diversity (based on edge density) (Walz, 2015) (Table 1). The landscape naturalness and diversity indicators cover two different aspects of the landscape characteristics, i.e., one indicates the area that remained relatively natural and the other characterizes the border between them. Landscape naturalness is related to the land cover type and its perceived level of naturalness (Ojeda 2018). It is assumed that the more natural a landscape is, the more probable it is to host high biodiversity. The edge density between natural and semi natural areas is assumed to reflect the irregular borders between different habitats. Edge density is related to fragmentation (Bloomfield et al. 2020), because in some cases high edge density might be result of habitat fragmentation. To assess landscape characteristics, we use a similar approach as Hermes et al. (2018) and Solecka et al. (2022). We selected the indicator of diversity and naturalness to reflect the ecosystem condition in relation to different time periods.

Naturalness

To assess landscape naturalness, we calculated land cover naturalness using adopted Hemeroby Index, a method used by Steinhardt et al. (1999), Tasser et al. (2008). The degree of hemeroby corresponds to the degree of naturalness. The most natural ecosystems are those under no human impact. The landscape in our case study had not been protected until 1988. The Ślęża mountain has served as place for religious and cultural rituals and as a nephrite and serpentinite ore. There are, however, forest areas that were attributed to an oligohemerobic degree, meaning close to natural. We used a lookup table linking land cover types to perceived naturalness scores (scale from 1 to 5) (Table 2) that was based on (Walz & Stein, 2014).

Diversity

To assess landscape diversity, we calculated the density of edges between natural and semi-natural ecosystem types (i.e., agricultural, forest, young for-

Table 1. Landscape characteristics assessed in this study: description, metrics and input data for naturalness and diversity.

Characteristic	Description	Calculation method (metrics)	Input data
Naturalness	Perceived land cover naturalness	Hemeroby Index	Land cover data from vectorized topographic map from years 1883, 1936, 1977 and 2011
Diversity	Structural diversity	Edge Density (200 m radius)	Land cover data from vectorized topographic map from years 1883, 1936, 1977 and 2011

Table 2. Assignment of land use classes to the degrees of hemeroby (based on Walz & Stein, 2014).

Ecosystem type	Degree of hemeroby	Degree of naturalness (1-5)
Mature forest	2 oligohemerobic	5
Stream	2 oligohemerobic	5
Waterbody	3 mesohemerobic	4
Young forest	3 mesohemerobic	4
Agriculture land	4 β-euhemerobic	3
Rural build-up area	6 polyhemerobic	2
Mineral extraction site	6 polyhemerobic	2
Railroad	6 polyhemerobic	2
Road	7 metahemerobic	1
Urban build-up areas	7 metahemerobic	1

est, river, water bodies) with the use of vectorized topographic map from years 1883, 1936, 1977 and 2011. The edge density indicator helps to capture the landscape patch shape complexity. Therefore, it is conveying similar information as the indicator of the number of shape characteristics point, that is correlated to the species richness of vascular plants (Moser et al., 2002). This indicator is very susceptible to show high values for elongated and narrow patches. Roads are most commonly of this shape. In order to minimize the impact of roads on the results, we excluded roads from the analysis. Although we do not include roads, we overlay the result map with the infrastructure layer for better presentation. We used the tool Line Density (in ArcGIS) within a circle having a radius of 200m (Gerstenberg et al., 2020). This means that we circle within the radius of 200m of each cell and only a portion of the line is considered when calculating the line density for each cell separately. The 200m radius has been chosen based on literature review (Hallmann et al., 2017; Smith et al., 2022; Zielonka et al., 2024) and results from initial trials of 100m and 150m radiuses. Due to the agricultural character of the landscape 200m radius best reflected landscape diversity. If no lines fall within the neighborhood at a particular cell, that cell is assigned no data. Finally, we scaled results from 1 to 5 for representation.

3 Results

3.1 Historical extent

Despite decreasing trend across four time periods, agriculture occupied biggest share of the land (Table 3). Together, forests and agriculture covered more than 90% of the total case study area. Since 1883, forest area has increased by 27% up to 2011, becoming the second largest land use type after agricultural land (see Figure 2). The most significant change was observed in mineral extraction sites, which expanded by a staggering 1823% from a mere 6.01 ha in 1883 to 109.55 ha in 2011. This increase was most notable in 1977 and 2011, showing sustained and significant growth. Urban built-up areas saw an immense increase of 986% from 32.34 ha in 1883 to 318.96 ha in 2011. The most dramatic growth was observed in 1936 (251%) and 1977 (249%), stabilizing at 158% in 2011. Rural built-up areas also expanded, albeit more modestly, growing by 9% over the period.

Figure 4 complements a quantitative summary of land use changes by depicting the number of patches and average patch areas for various land use categories over time. In general, the number of patches was increasing (Figure 4) while the average patch size was decreasing. Especially urban style settlements were spreading, most rapidly since 1977. Both the number and average size of mineral extraction sites have increased significantly, showing extensive development in this sector. Both forest and agricultural areas have become more fragmented, as evidenced by the increase in the number of patches and the decrease in average patch areas.

Table 3. The extent of land use types in 1883 (ha) and land use change (in %) in relation to year 1883.

	Mature forest	Young forest	Agricultural land	Stream	Waterbody	Urban build-up area	Rural build-up area	Roads	Railroads	Mineral extraction sites
1883 (ha)	4089.76	526.17	10263.57	23.63	13.81	32.34	670.99	196.57	3.5	6.01
1936	115%	n.d	98%	101%	111%	251%	106%	102%	120%	202%
1977	102%	n.d	95%	100%	143%	249%	90%	98%	100%	545%
2011	109%	42%	94%	100%	126%	158%	113%	102%	100%	166%
1883-2011 (%)	127%	21%	89%	101%	199%	986%	109%	102%	120%	1823%

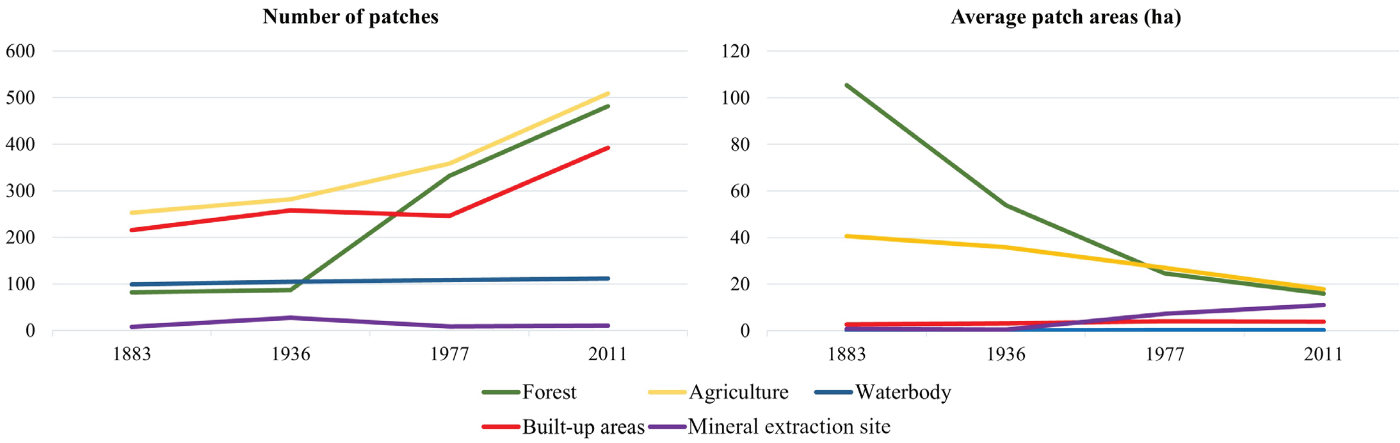

Figure 4. Number of patches and an average patch areas.

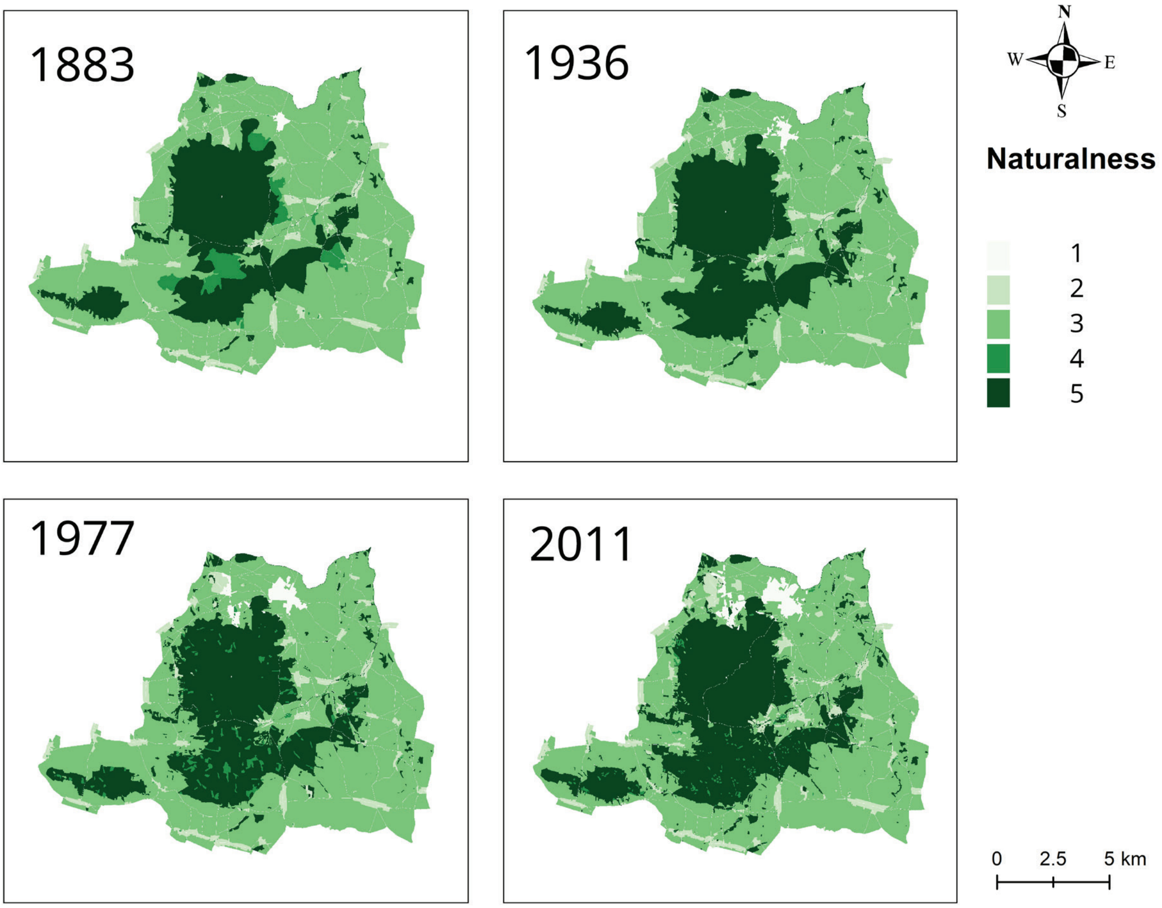

Figure 5. The spatial distribution of landscape naturalness scores within the Ślęża Landscape Park. Scale from 1 to 5 (1-least natural and 5-most natural) over 4 time periods (1883, 1936, 1977, 2011).

Table 4. Landscape naturalness and landscape diversity change in relation to year 1883.

	Landscape naturalness				Landscape diversity			
	1883 (ha)	1936 (%)	1977 (%)	2011 (%)	1883 (ha)	1936 (%)	1977 (%)	2011 (%)
1	228.93	123%	175%	222%	4884.36	106%	83%	91%
2	680.51	107%	105%	127%	5065.52	96%	107%	135%
3	10263.58	98%	94%	89%	3729.31	98%	115%	68%
4	539.99	3%	52%	25%	1706.18	100%	105%	82%
5	4113.40	114%	117%	127%	418.68	86%	62%	138%

3.2 Historical condition reflected by landscape structural characteristics

The historical landscape characteristics assessment included landscape naturalness and diversity. In terms of naturalness, forest land cover type scores the highest. They are located at the tops of hillsides of the Ślęża Massif within the Landscape Park area (Figure 5).

In 1883, the most natural areas constituted three group areas. In 2011, two of these areas were connected and enlarged. The total area of the most natural ecosystems has increased since 1883 (Table 4) by more than 1100ha. The two least natural areas were also characterized by the increasing trend in terms of surface area across the years. Their location is mainly in the northern parts of the studied landscape. This is where the city of Sobotka is located together with its new housing areas as well as mineral extraction areas.

The landscape diversity indicator measures patches' edges densities between agricultural, forest, young forest, river, water bodies (Figure 6). The results include the hectares of boundary areas (Table 4) of a different level of complexity, 5 being the most complex and 1 being the least. We multiplied the grill cell size (in ha) by the number of cells. We overlay the results with the road layer to indicate where roads caused the natural borderline to be more rugged. In 1883, the most diverse edges occurred at the forest-field boundary. The total area of most diverse boundaries decreased between 1883 and 1977, as the case study landscape has been more intensively managed by new residents, farmers and foresters. However, until 1997 these changes related mainly to changing forest edge management (Figure 6). The diversity results for the year 1977 and 2011 show significant changes in the inner forest patches, in the southern and central parts of the park.

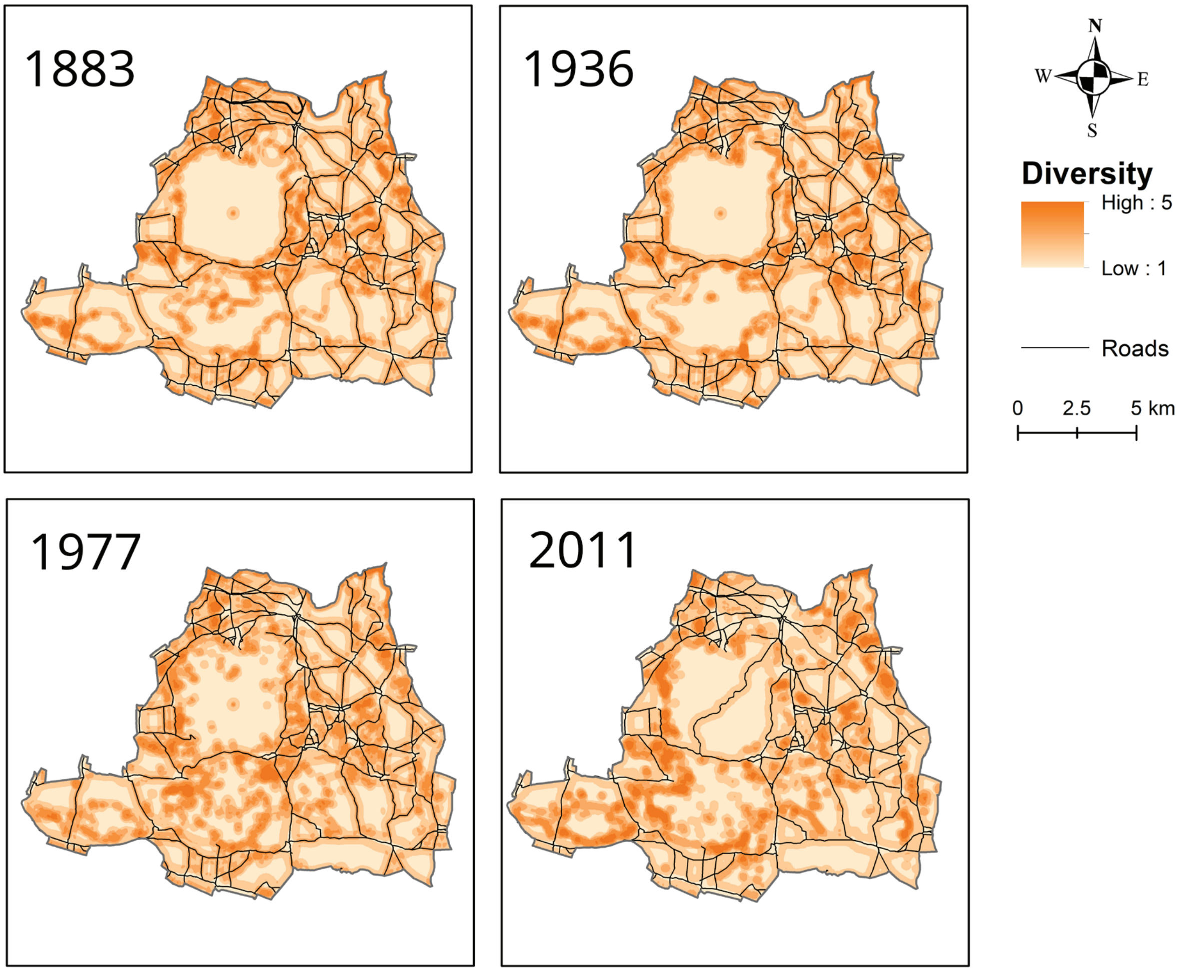

Figure 6. The spatial distribution of landscape diversity scores within the Ślęża Landscape Park. Scale from 1 to 5 (1-least diverse and 5-most diverse) over 4 time periods (1883, 1936, 1977, 2011).

The landscape diversity results are in line with the increasing number of land use patches and decreasing average size of the patches. Based on the general trends, showing decreasing hectares of patches with borders scoring 1 and 3 and increasing in patch border's diversity scoring two, we can say that the edge diversity is not significantly increasing. Although, there is a surge in the number of patches with the most diverse border type in 2011 (Table 4), it is the impact of sustainable forest management introduced in the recent years.

4 Discussion

Our motivation for this study was driven by discussions on changes in ecosystem extent and condition that could be trace back to the past. It also stems from the fact that today's ecosystem's potential to provide services is influenced by past landscape changes and changes in land management regimes (Jepsen et al., 2015). The historical maps provide valuable information about the landscape structure and cover types, which could be used to populate ecosystem extent tables, as well as ecosystem service assessments (Chen et al., 2022; Jiang et al., 2013).

The ecosystem extent table highlights the changes in land use and land cover over the period from 1883 to 2011. The analysis of land use changes reveals significant trends in forest area increase, urban expansion, agricultural area decline, and increased mineral extraction activities. Although some authors report deforestation in Europe as early as before c. 1500 (Williams, 2000), we were able to track forest area increasing since 1883 and especially after formally protecting landscapes in the case study. We also analyzed the number of patches and average patch area to understand landscape structure better. The number of forest patches increases along the four time periods, however there is a significant surge between years 1936 and 1977. Between these years, the nature reserves were created. The Landscape Park was established between the next two time slices and the increase in the number of forest patches is also observed. While the number of forest patches increases, their average size decreases. This indicates that the reforestation was taking place in many small parcels, which is typical forest management practice of a clear cut of small areas, very often inside densely forest patches. This conclusion is also supported by the square shape of these parcels. One may indirectly deduce from land cover types and patches' shapes the state of the forest. The results show that the forest cover in 1883 was smaller by almost 700 ha than in 2011 and the biggest forested areas were not connected. On the other hand, the forest area was more compact, as diversity of boundaries inside the forests was reduced. The least natural areas were scarce and so human pressure and impacts were lower.

Agricultural land shows a consistent decline over the examined period. The overall decline from 1883 to 2011 is 11%, reflecting a shift away from agricultural use, due to urbanization and agricultural intensification. Historical maps of agricultural lands from similar period are used to explain current environmental problems, for instant with small mammal population (Halliez et al., 2015).

Historical maps could also provide information on landscape level characteristics, which we analyzed using two indicators: landscape naturalness and diversity (based on edge density). Landscape naturalness helps to assess the degree of hemeroby, which corresponds to the degree of naturalness. This indicator is used in the ecosystem service assessment studies, e.g., for assessing the nature-based recreation (Zulian et al., 2013; Vallecillo et al., 2019) or aesthetic quality of landscape (Hermes et al., 2018; Gottwald & Stedman, 2020). However, hemeroby offers only limited possibility to express the complexity of ecosystems and their condition. Therefore, this indicator is sufficient for case studies where data constitutes a challenge but should be supplemented with other indicators or be part of a model assessing ecosystem condition (e.g. InVEST Habitat Quality model (Terrado et al., 2016) or DPSCR conceptual framework for assessing ecosystem health (Harwell et al., 2019)). Landscape diversity pictures the complexity of edges between natural and semi-natural landscape types. The irregular shape borders offer habitats as well as shelter for biodiversity (Ma et al., 2013). More diverse edges at the agricultural-forest boundaries allow transitional vegetation and can proved habitat for pest predators (Riggi et al., 2024). However, increasing edge density inside forest area may indicate some natural or human made losses in the standing timber stocks. Natural losses usually could cause fewer regular shapes of patches than human led clear cutting.

The exploration of historical maps provides valuable insights into ecosystem extent and condition, particularly for landscape-scale applications. Firstly, it is unclear to what extent the Ślęża Landscape case study is representative of other similar landscapes, limiting the ability to generalize or extrapolate the findings. While historical maps were available for this particular case, the availability of such data across the rest of the country is uncertain. If environmental-economic accounts were to become a standard statistical procedure, they would need to rely on uniform and consistent data sources. Consequently, historical maps can only serve as supplementary material for specific landscapes and are unlikely to provide a comprehensive foundation for assessing ecosystem extent on a broader scale.

Additionally, the analysis of historical maps for the Ślęża Landscape reveals that while the forest area was significantly smaller nearly 150 years ago, it was considerably denser compared to present conditions. This suggests that using generalized assumptions about past forest cover as a reference point may lead to biases. Therefore, the findings of this study serve as an argument of why ecosystem accounts need to consider the reference condition of the present years rather than reaching far back.

Several limitations to this study need to be acknowledged. The use of historical material introduces a certain level of uncertainty to the analysis that stems from the historical cartographic practices (Kramer et al., 2011), level of knowledge and measuring equipment, as well as addressing pressing environmental issues (Beller et al., 2020). The use of historical maps often could not ensure total cover at the country level for the purpose of ecosystem accounting. Historical maps provide limited information about ecosystem condition comparing to modern cartographic representations of environmental characteristics, i.e. leaf area index (Li et al., 2024) or NDVI (Teeuwen et al., 2024).

However, historical landscape ecology is a well-established and developed field of study that environmental-economic accounting can draw from. The historical ecosystem information can feed into assessment of flow of ecosystem services or at least landscape structure's potential to provide ecosystem services to be able to understand factors for low/high ecosystem service flow and the scale of environmental degradation. SEEA EA offers standardized accounting guidelines to systematize information on ecosystem flow assessment in biophysical and monetary terms.

5 Conclusion

In this contribution, we investigated the applicability of information derived from historical maps to support mapping and assessment of ecosystem extent and condition in accordance with the SEEA EA guidelines, using the case study of the Ślęża landscape in Poland.

Based on this information source, we were able to assess the type C1 landscape level characteristics of the SEEA Ecosystem Condition Typology. We were not able to fill in information for group A: Abiotic and B: Biotic ecosystem characteristics. Consistent monitoring of environmental conditions in Poland started in 1992, but reliable and comparable data is available only since about 2000. Since then, the environmental monitoring system has used more mechanized techniques, as well as more sophisticated engineering solutions and satellite imagery. Therefore, we conclude that although historical maps offer a great opportunity to track ecosystem extent changes, they might have limited usability for condition accounts. Therefore, we did not create ecosystem extent and condition accounts in this case study. However, by analyzing past landscape changes we are better able to understand the current ecosystem service potential (Sylla, 2024) as well as the local socio-ecological system (Sylla, 2023).

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Declaration of Competing Interest

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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