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RESEARCH ON HISTORICAL AGRICULTURAL LANDSCAPE FOR THE DESIGN AND MANAGEMENT OF A BIOSPHERE RESERVE

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Abstract

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The study area covers one of the most valuable historical agricultural landscapes in Poland – the Roztocze-Solska Forest region which is located in the south-east of the country, near the Ukraine border and which has been nominated to UNESCO Biosphere Reserve status. The analysis presented in this paper is focused on:

- the delineation of the UNESCO biosphere reserve borders,
- an indication of areas which required different protective status via the zoning system,
- the identification of landscape quality objectives as an instrument of ecological and cultural heritage management.

To this end, the following four types of landscape structure analysis were applied: (1) delimitation of the system of landscape spatial units; (2) an integrated method to evaluate the values, problems and potentials of the region; (3) elaboration of a catalogue of landscape features which decide the *genius loci* of the place and which should be permanently maintained (canon of the place); (4) elaboration of the goals in landscape conservation and design and methods for achieving desirable landscape quality (guidance and instruments).

Key words: biosphere reserve, landscape quality objectives, natural-landscape units, protected areas zoning system, landscape management

Introduction

One of the most valuable historical agricultural landscapes in Poland can be found in the Roztocze-Solska Forest region (3640 km^2), located in the south-east of the country near the Ukraine border. The Roztocze macroregion is divided into three mezoregions, with different landscape character. West Roztocze landscape of loess uplands covered with traditional, multi-stripe field mosaic, Middle Roztocze has an upland landscape on carbonate

rocks covered with diverse forest ecosystems while South (East) Roztocze has an upland landscape on silicate rocks and a landscape of periglacial plains covered with a mosaic of leafy forests, fields and villages. The Solska Forest is located on the Biłgoraj Plain macroregion, representing an alluvium landscape with dunes covered with pine forests with small complexes of peatbogs (Kondracki, 1981; Chmielewski, 2004/2005).

This area is located within the following two large European structural units: the East-European platform consolidated in pre-cambrian era and the orogenic Palaeozoic structures of western Europe. The region is also located within the European water division splitting the Vistula river system with catchment area in the Baltic Sea from the Dniestr river system with catchment area in the Black Sea. It is also one of the most important water source regions in Poland (Buraczyński, 2002). It is mostly covered with extensive, compact complexes of multi-species forest, particularly pine, fir and beech woods. The historical agricultural landscape of this region is a very important part of Polish cultural heritage. Unique in Europe are the multi-stripe and multicolour field mosaic, with lines of numerous balks covered with various weeds and numerous clusters of trees and bushes which is mainly characteristic of the West and Middle Roztocze is unique in Europe (Fig. 1). Additionally, many examples of traditional, wooden architecture have been preserved there (Fig. 2). Wooden Orthodox churches which are characteristic elements of this South Roztocze cultural heritage are evidence of its multi-ethnic past.

The unique richness of this region resulted in the creation of various forms of protected areas here composed of 1 national park, 4 landscape parks, 15 nature reserves, 16 Natura

Fig. 1. Field mosaics of West Roztocze (Photo T.J. Chmielewski).

Fig. 2. A riverside chapel in the Solska forest (Photo T.J. Chmielewski).

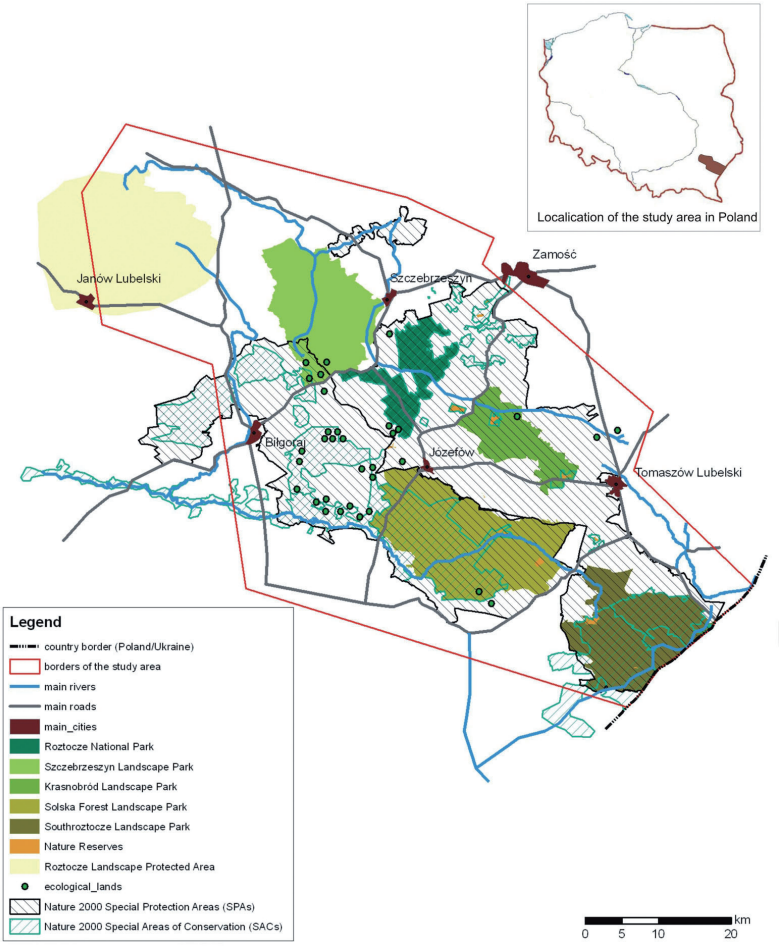


Fig. 3. The Roztocze-Solska forest region with a background of a protected area system.

2000 Special Areas of Conservation, 3 Natura 2000 Special Protection Areas, 1 landscape protected area and more than 30 ecological lands[1] (Fig. 3).

Due to the great variety of the Roztocze-Solska Forest region values, its area is nominated to become a UNESCO Biosphere Reserve (BR) called the Roztocze-Solska Forest Biosphere Reserve. Work on this issue was initiated in 2004 by T.J. Chmielewski (Chmielewski, 2004/2005).

Methods

The conducted research consisted of four main steps:
1. Delimitation of the system of natural-landscape units.
2. Integrated method of evaluation of values, problems and potentials of the region.
3. Delineation of exterior borders of the area nominated for UNESCO status as a biosphere reserve and an indication of areas which need different protected status (zoning system).
4. Identification of landscape quality objectives.

Delimitation of the system of spatial units

Delimitation of homogeneous spatial units has been widely applied in different fields of science over a long period of time. The following have generally been used; (1) *Geocomplexes*, in comprehensive physical geography (Richling, 1976), *(2) Landscape complexes of plants* or *plant micro-landscape* in phytosociology (Schmitchüssen, 1968), (3) *Functional-spatial units* which reflect demographic and economy characteristics in spatial development (Roberts, 1970) and (4) *Architectonical-landscape interiors and unit*s reflecting the physiognomic features of the area in landscape architecture, (Bogdanowski, 1976). Landscape units should be homogeneous in terms of elevation, slope range, geology, soil types, vegetation cover and land use (Geneletti, Duren, 2008). For valuable historical agricultural landscapes, such as the Roztocze and Solska-Forest region, landscape units should also reflect characteristic cultural heritage.

Therefore, the method of multi-criterion delineation of elementary spatial units was applied herein (Chmielewski, Solon, 1996; Chmielewski, 2001). This method allowed integration of information concerning biotic and abiotic environmental elements, spatial patches' composition, cultural heritage sources and landscape physiognomy. The system of units was defined using spatial overlapping of different kinds of landscape borders: (1) main tectonic structures; (2) main geomorphologic structures; (3) water divisions; (4) soil types; (5) main complexes of phytocoenosis; (6) built-up areas; (7) landscape interiors and view openings (Sowińska, Chmielewski, 2008). A series of digital maps was used for this purpose: tectonic, geological, geomorphologic, water division, soil types and topographical. Overlapping borders of some of the above forms define spatial units called natural-landscape units. The unit boundaries were checked and revised by visual interpretation of high-resolution orthophoto map with a pixel cell size of 0.25 m and all analysis was performed by ArcGis 9.3 software.

Integrated method of evaluation of values, problems and potentials

An integrated method of evaluation of the values, problems and potentials in reference to each spatial unit was applied in this study (Chmielewski, 2001). The main objective of this step was to elaborate the methodological framework for the zoning process, i.e. to indicate:

[1] Ecological land – a small size protected area similar to a nature reserve but with lower nature conservation status

- the most valuable areas requiring strict protection,
- the areas requiring active conservation action, enrichment of biodiversity and promotion of cultural heritage,
- the areas assigned to different forms of activities, including food production, settlement development and tourism.

This approach supports decision-making processes in biosphere reserve management.

The applied criteria of evaluation included the characterization of those natural, cultural and landscape components which reflect coherence, harmony, visual balance, diversity, continuity over time and the ecological and cultural quality of each unit. The intensity of each feature was estimated at a 5 scale level. The results of partial evaluation are presented on a series of maps, and then a collective map detailing the most and less valuable natural-landscape units was created in a 5 scale level (Table 1).

T a b l e 1. Criteria and system of evaluation (according to Chmielewski, 1989).

Criteria of evaluation			**Scale of evaluation (points)**		
			Partial gradation	Collective gradation	Sum of points
1.	Abiotic components values	Diversity of land relief	1–5		
		Peculiar geomorphologic forms	1–5		
		Springs	1–5	1–5	
		Natural, meandering rivers	1–5		
		Diversity of soil cover	1–5		
2.	Biotic components values	Natural water ecosystems	1–5		
		Natural peat-bog ecosystems	1–5		
		Natural forest ecosystems	1–5		
		Semi-natural meadows	1–5		
		Xerothermic laws	1–5	1–5	
		Habitats of rare plants species	1–5		
		Habitats of rare animals species	1–5		
		Protected areas and objects	1–5		
3.	Cultural heritage values	Archeological monuments	1–5		
		Architectonical monuments	1–5		
		Historical urban and rural complexes	1–5		
		Monuments of history	1–5	1–5	
		Historical parks	1–5		
		Buildings typical for regional architecture	1–5		
		Historical multi-stripe field mosaic	1–5		
4.	Landscape physiognomy values	Diversity of land relief	1–5		
		Diversity and harmony of land cover	1–5	1–5	
		Range of landscape panoramas	1–5		
		View points	1–5		
5.	Forms of degradation and threats to the landscape values	Chaotic land management (dispersed settlement)	1–5		
			1–5		
		Objects degraded the environmental quality	1–5		
			1–5	1–5	
		Disharmonious objects (industrial objects, waste disposals, derelict historical monuments, mobile phone towers)	1–5		
			1–5		
6.	Collective evaluation			Σ	1–5

Delineation of exterior borders of the area nominated for UNESCO biosphere reserve status and an indication of areas which require different protected status (zoning system)

According to the Seville Strategy, biosphere reserves should consist of 3 types of zones, ranging from strict nature conservation to the promotion of tourism and recreation.

A. Core zone(s) which are securely protected sites for conserving biological diversity, monitoring minimally disturbed ecosystems, and undertaking non-destructive research and other low-impact uses, such as education.
B. Buffer zone(s) which usually surround or adjoin the core zone(s) and used for co-operative activities compatible with sound ecological practices, including environmental education, recreation, ecotourism and applied and basic research.
C. Transition zone(s) which may contain a variety of agricultural activities, settlements and other uses (Seville Strategy, 1996).

Consequently, biosphere reserve planners face the problem of selecting the most appropriate evaluation framework to construct a zoning system. The decision for the adopted approach is strongly influenced by the type and amount of information already available, the size of the area, the legislation within which the planning exercise must fit, and the possibilities of collecting new data. Setting the zoning scheme is arguably the most relevant process in BR planning (Breymeyer, Dąbrowski, 2000; Geneletti, Duren, 2008). However, the review of scientific literature has shown that many applied methods mostly contain spatial unit set up and multi-criteria natural-cultural evaluation. Latest studies are also based on the geographical information system (GIS) which allowed database creation to further assist management processes (Lin, 2000; Boteva et al., 2004; Geneletti, 2004; Sabatini et al., 2007; Geneletti, Duren, 2008).

In the case of the Roztocze-Solska Forest region, the general criterion for delineating the borders and each zone type was its accordance with the borders of natural-landscape units. Additional criteria of the zoning process were based on the following assumptions:

- borders of all the zones should be easily detectable in the terrain and relatively permanent in time,
- core zones should contain the area of national park, and also areas of existing and planned nature reserves and the groups of the most valuable natural-landscape units,
- buffer zones should contain the areas of existing and planned areas of landscape parks and natural-landscape units with high nature and landscape values,
- transition zones should connect the other zones within a compact spatial complex.

In the process of core zone delineation, a very important criterion was the land ownership structure, and public purse grounds are especially classified within this zone.

Identification of landscape quality objectives

European scientists have been working on landscape quality objectives for almost 10 years, using different approaches and research methods (Antrop, 2006; Godienė, 2006; Naguė, Sala, 2006; Olmo et al., 2006; Rossi et al., 2006; Sala, 2006; Stalder, 2006; Sowińska, Chmielewski, 2007a, b; Sowińska, Chmielewski, 2008; Chmielewski, Sowińska, 2010). The analysis of the conducted studies, the European Landscape Convention (European Landscape Convention, 2000) and directions of the European Commission's Report (Landscape and Sustainable Development, 2006) ensured the adopted position that landscape quality objectives should consist of three main components:

1. characteristic, key features of the landscape (**canon**),
2. other expected landscape features (**aims**),
3. ways of maintaining and/or achieving those features and methods for the protection and creation of a desirable landscape state (**guidance and instruments**).

The methodological framework of landscape quality objective identification instituted by the authors of this present paper has been extensively described in an previous publication (Chmielewski, Sowińska, 2010).

In the next step of the study, the typological analysis of defined natural-landscape unit diversity was carried out. The aim of this approach was to indicate the most typical micro- and mezoregion units able to represent groups of

similar units. This analysis was based on the hierarchical clustering method using the *Dendrite* computer program which was especially created for this study (Sowińska, Chmielewski, 2008).

Landscape quality objectives were defined. for those representative natural-landscape units, and these were subsequently aggregated into the following five groups:

- inanimate nature: geomorphology structure, lithology characteristics, land relief, denivelation and dominant soil types;
- animate nature: types, quality, size and state of conservation of water, peat-bog, meadow, forest and arable ecosystems;
- cultural heritage: types, quality and the state of protection of historic buildings and sites, archeological sites, and buildings of regional architecture style;
- land use structure: results of landscape metrics calculated by the Fragstats computer programme (McGarigal, Marks, 1994);
- landscape physiognomy – range of view openings, the range of landscape panoramas and the characteristics of landscape and architectonical interiors (Chmielewski, Sowińska, 2010).

The aims in landscape conservation and design and the guidance and instruments to achieve these goals in each group of landscape features were assigned according to this adopted concept of landscape quality objectives. Objectives defined in this manner are recognized as basic tools in the management process of biosphere reserve zones.

Results

Delimitation of the system of spatial units

In this study area, 623 natural-landscape units were delineated (Fig. 4). The most valuable 541 of these units were incorporated into the area of the Roztocze-Solska Forest Biosphere Reserve. The area of these selected units ranges from 10 to 3617 ha, with an average area of 520 ha and a standard deviation to 505 ha. Most of the defined natural-landscape units, at 70%, have an area less than 500 ha and only 10% have more than 1000 ha. Among the biggest units of more than 1500 ha, most are located on hilltops and are covered with compact complexes of forests in the Solska Forest region or fields in the West Roztocze mezoregion. The smallest units of less than 100 ha mostly contain built-up areas and are situated throughout the entire study area.

According to the adopted method, the units' borders were checked and revised by visual interpretation of a high-resolution orthophoto map which provides the newest source of information on land cover forms. Borders of the defined natural-landscape units were adjusted to the borders of forms which are easily recognizable on the ground. These included forest and built-up area boundaries, river courses and hard-surface roads (Fig. 5).

Integrated method of evaluation of values, problems and potentials

The effect of the integrated evaluation process was a series of maps which present:

- abiotic components values,
- biotic components values,
- cultural heritage values,

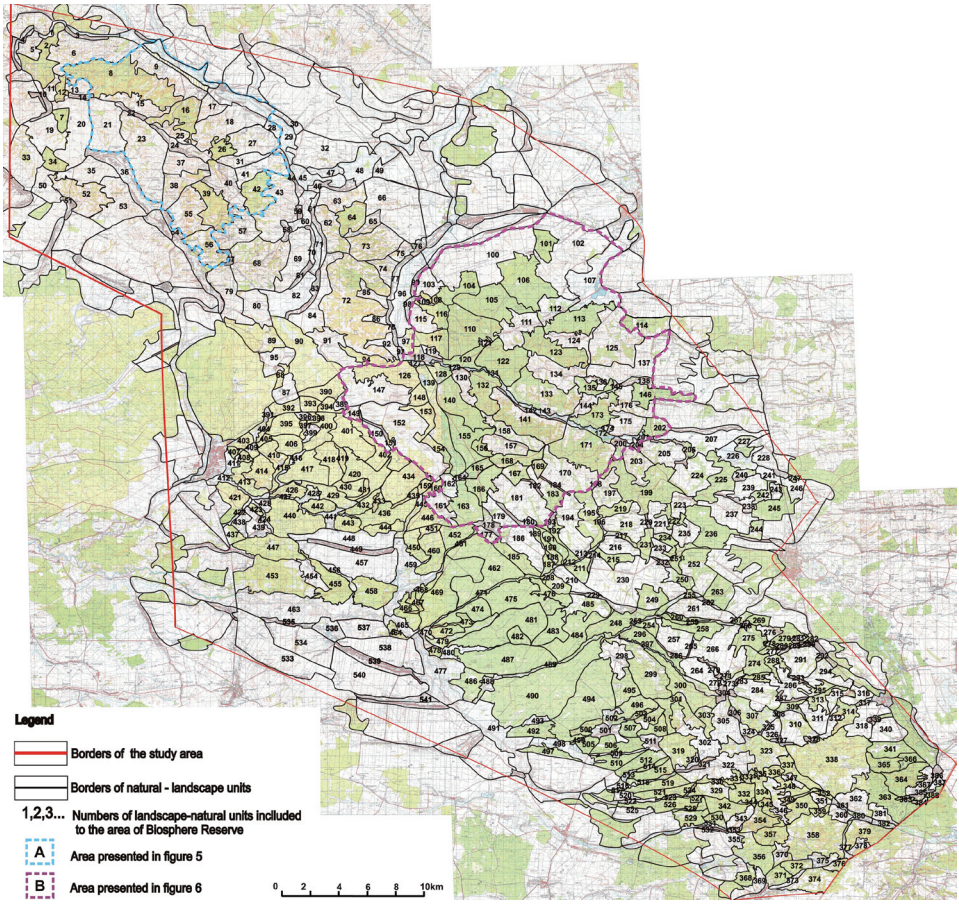


Fig. 4. The system of natural-landscape units of the Roztocze-Solska forest region.

- landscape physiognomy values,
- threats to the landscape values,
- landscape potential,
- collective evaluation of each natural-landscape unit.

Examples of some of the above maps are presented in Fig. 6.

The research revealed that the most valuable spatial complexes are created especially by forests with untransformed water and peat-bog ecosystems, units with peculiar geomorphologic forms covered with various forms of land cover and arable ecosystems located on hilltops with traditional rural settlements. Units with very low values are mostly characteristic of built-up areas with a high percentage of outspread buildings and disharmonious rural dwellings. Units which gained the highest gradation do not create a compact spatial complex, but they are dispersed within the whole study area. The results of the evaluation

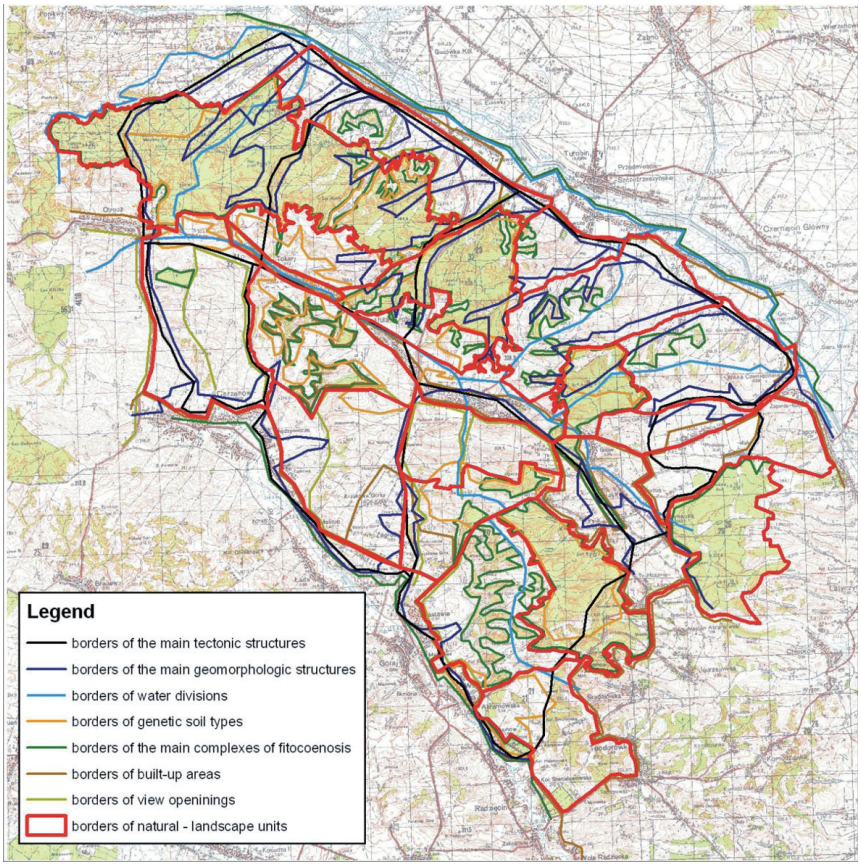


Fig. 5. The method of natural-landscape unit delineation on the background of a topographic map.

suggest that the designed Biosphere Reserve should have a multi-centre spatial structure with several core and buffer zones. The proper development of spatial connection between these is crucial for the correct functioning of nature in that region.

Delineation of exterior borders of the area nominated for the status of UNESCO biosphere reserve, and indication of areas which need different protected status (zoning system)

The total area nominated for Roztocze-Solska Forest Biosphere Reserve status is 241,322 ha. This will be one of the largest biosphere reserves in Europe, comparable with the Waddensea of Lower Saxony in Germany which has 240 000 ha and also with the East Carpathians-BR traversing Poland, Slovakia and the Ukraine with 213 211 ha (http://portal.unesco.org).

The proposed zoning system consists of:

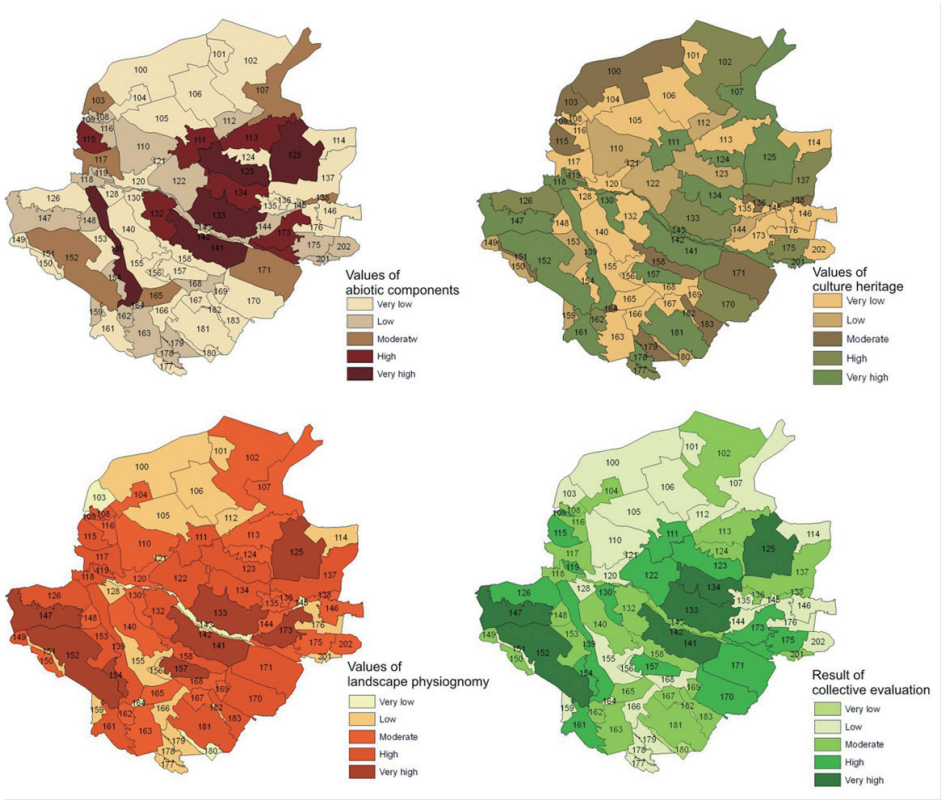


Fig. 6. Examples of evaluation maps (fragment of the study area presented in Fig. 4b).

– 7 core zones with an area of 16,211 ha (6.72%), which include the natural-landscape units with the most unique natural and landscape values which cover the area of the Roztocze National Park and are mainly under nature reserve protection;
– 6 buffer zones with an area of 106,546 ha (44.15%), which include natural-landscape units with moderate and high values which partly cover landscape park areas;
– 1 transition zone of 118,565 ha (49.13%), which surrounds and connects the other zones within a compact spatial complex (Fig. 7).

Identification of landscape quality objectives

As the result of the typological analysis of natural-landscape unit diversity, 30 units representative of the natural and cultural landscape of each micro- and mezoregion of the study area were identified (Fig. 4). *Cards* of *units' landscape* were initiated for these selected units,

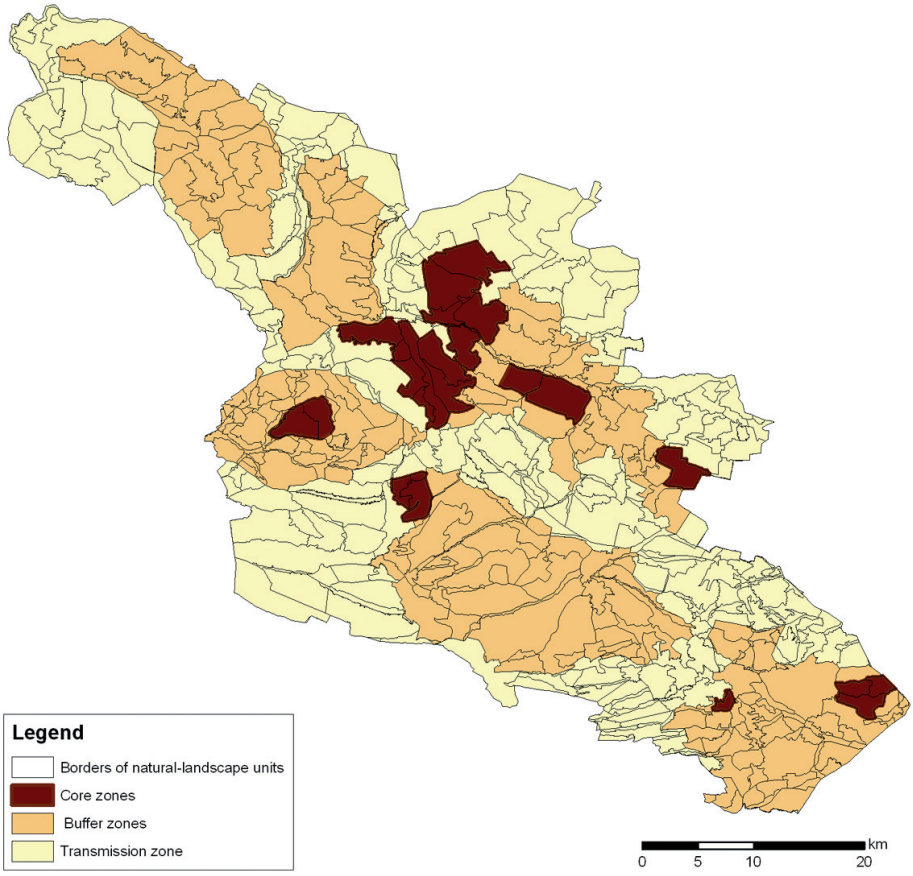


Fig. 7. The concept of the Roztocze-Solska Forest Biosphere Reserve zoning system.

where each card clearly provides descriptive and numerical data and photographs and drawings within a uniform graphical frame. This consists of the following seven main parts:

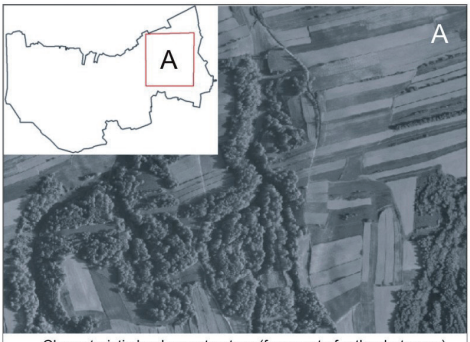
- general data,
- characteristic of lithology and land relief,
- characteristic of soil types,
- characteristic of land cover,
- synthesis of landscape features of natural and cultural heritage, landscape physiognomy and threats to landscape values (**canon** of the place),
- **aims** of landscape conservation and design,
- **guidance and instruments** for landscape management (Chmielewski, Sowińska, 2010).

Fig. 8. presents an abbreviated version of the landscape card for unit No. 63.

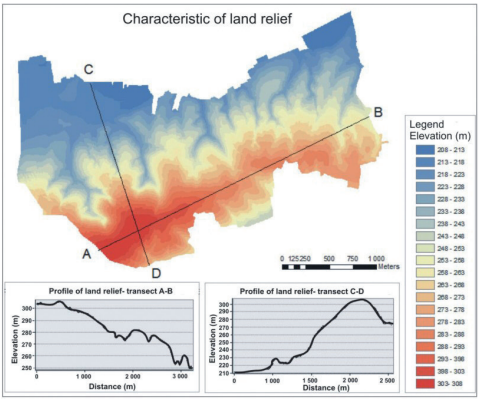
General data
Mezoregion: West Roztocza
Location: Lubelskie voivodeship, zamojski district, Sułów municipality, between villages: Mokrelipie, Przymiarki, Sąsiadka
Topographic names: Middle Forest, Podlipcze
Area: 582.21 ha
Borders of unit: N - build-up area; E - ground road; S - forest; W ground road
Typological group: L4
Shape: compact

Characteristic of lithology
Area domination of loess (80%), stripes of gaizes (8%) and sands (12%)

Characteristic of soil
Area domination of podsolic soils (98%).



Characteristic land-use structure (fragment of orthophotomap)




The loess ravine (Photo: B.Sowińska 2010)

Inanimate nature
Area of very diverse land relief with very high denivelation (109 m). In the north flat terrine located below 320 m npm. In the south loess hummocks (300 m npm), separated by branched loess ravines (length 15 km, density 0.03 km/ha).

Animate nature
Strongly brunched, small patches of hornbeam and beech forests (12 patches) with great share of multi-species bushes, possessing irregular shape which result from the route of loess ravines. Very numerous patches of multi-species, narrow and long planting trees (148 patches). Numerous, usually fruit in-field trees, situated near the patches of forests (178 items).

Culture heritage
Very narrow and long field stripes (ca. 16 m width) with narrow stripes of raspberries and aronia plantation (ca. 18 m width), separated by balks and clusters of trees. In the north archeological site from XII century the Middle Aged burg city surrounded by earthworks.

Land use structure
Very numerous, small patches of different forms of land cover (mean area 2.65 ha), with strongly irregular shape. The mosaic of three main land cover forms: multi-stripes fields (72%), leafy forests (22%) and planting trees (6%). Very dense system of ground roads (0.1 km/ha). Lack of build-up areas and hard-surface roads.

Landscape physiognomy
In the north very wide view openings on the agriculture landscape. The ridge of loess hummocks is a view point.

Fig. 8. Example of the card of unit's landscape for unit number 63 (abbreviated version).

The definition of the aims of landscape conservation and design was preceded by examination of social expectations concerning landscape quality in the Roztocze- Solska Forest region. The survey method was used to achieve this and the questionnaire was conducted among 8 social and work groups of persons who exerted an important role in landscape protection and management in the region. This comprised a total of 240 people. The results of this research are presented in separate publications (Chmielewski, 2006; Sowińska, Chmielewski, 2007a). Analysis of the questionnaire results revealed that the social expectations are mostly similar to expert opinions, with significant meaning for landscape quality being attributed to:

1. high natural values,
2. harmony between land relief and land cover,
3. high standard of environmental elements quality,
4. well preserved cultural heritage,
5. those features which distinguish the analyzed region, such as multi-stripe field mosaics and riverside chapels.

High service standards are expected in cites located near the Biosphere Reserve, while the most desirable components in its area are silence, peace and visual harmony.

The study also revealed that the aims of landscape conservation and design depend in similar proportion on the landscape character and also on the function of the area, its state of protection and the influences of anthropogenic transformation. The analysis of these aims in selected natural-landscape units showed that they could be divided into five groups:

A. units under various forms of nature and landscape protection, in which the existing form of protection should be continued and their values should be preserved against tourist pressure (20%);
B. units with high nature and landscape values which need to be protected and/or their values need to be restored (16%);
C. units with rural and urban settlement which require improvement in visual appearance and/or the protection and promotion of culture heritage (20%);
D. units in which the existing structure of land use, namely the mosaic of field and compact rural settlements, should be maintained (16%);
E. units covered by forests in which the existing structure of land use should be maintained and their ecological values should be protected (28%) This especially applies to the contained wetland areas.

Guidance and instruments for landscape management are based on the following assumptions:

1. The area of natural-landscape units should be treated equally in terms of the conservation of characteristic landscape features and their exposure and spatial management.
2. A landscape policy should be instituted for the collection of units which belong to the same typological group and which create compact spatial complexes.
3. The realization of social expectations should be harmonized with the protection of the natural and cultural heritage.

These established landscape quality objectives can become efficient instruments in the management of the Roztocze-Solska Forest Biosphere Reserve when they also incorporate:

- nature conservation plans of the national park, landscape parks, nature reserves and Natura 2000 sites,
- local spatial management plans,
- regional and local programs of environmental protection.

Discussion and conclusion

In the majority of previous cases, existing protected areas and especially territories of national parks have been nominated for biosphere reserve status. The Seville Strategy places emphasis on the poly-functional character of reserves which should be used for nature conservation, environmental education, recreation, agricultural and culture activities. Newly established reserves cover different areas with different levels of natural, cultural and landscape values with different land use forms (Final Report of the EuroMAB VI Conference, 1997; Breymeyer, Dąbrowski, 2000; Biosphere Reserve Technical Notes, 2003).

The results presented in this paper show the importance of natural-landscape unit application in the process of protected area evaluation and zoning. This approach allowed the generation of a zoning scheme which could be immediately implemented, because its spatial elements are homogeneous in terms of ecological and culture meaning and visual quality, and they are also easily detected in the terrain and relatively permanent in time. The applied methods allow biosphere reserves managers and other stakeholders to visualize and understand the processes leading to this zoning scheme in a clear and transparent way. When these things are considered, it is expected that the proposed zoning system will facilitate the management process of this highly valuable protected area.

The importance of this study lies in the stimulation of discussion concerning the implementation of landscape quality objectives involved in the process of landscape design and management. The most innovative aspect of this applied approach is the use of these objectives as mechanisms for Biosphere Reserve zone management. The three-scale level process of landscape quality objectives definition – **canon, aims and guidance** – appears the best in reference to the goal of the conducted study.

The potential of this presented approach is the possibility of its relatively easy application in the area of other biosphere reserves and also in areas of national parks and landscape parks.

Translated by the authors
English corrected by R. Marshall

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