Chapter

Methods of Landscape Valorization and Possibilities of Its Application in Hunting Area Categorisation

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Abstract

As a result of environmental changes, assessment indexes for the agricultural landscape have been changing dramatically. Being at the interface of human activity and the natural environment, hunting is particularly sensitive to environmental changes, such as increasing deforestation or large-scale farming. The classical categorisation of hunting grounds takes into account the area, forest cover, number of forest complexes, fertility of forest habitats, lack of continuity of areas potentially favourable to wild animals. Landscape assessment methods used in architecture often better reflect the actual breeding and hunting value of a given area, especially in relation to fields and forests. The forest-field mosaic, large spatial fragmentation as well as interweaving of natural environment elements with buildings do not have to be the factors that limit the numbers of small game. Identification of the constituents of architectural-landscape interiors: content and significance assessment, determination of the functional role or assessment based on the general environmental values being represented take into account factors important for the existence of game, in particular small game.

Keywords: landscape valorization, assessment indexes for the agricultural landscape, hunting, categorisation of hunting grounds, deforestation, large-scale farming

1. Introduction

> *"When you reap the harvest of your land,*
> *you shall not be so thorough that you reap*
> *the field to its very edge,*
> *nor shall you glean the stray ears of grain.*
> *Likewise, you shall not pick your vineyard bare,*
> *nor gather up the grapes that have fallen.*
> *These things you shall leave for the poor and the alien"*
>
> *(Lev. 19: 9, 10)*

Dominant over other species, man has subdued the earth's resources. His expansive economy and, as we know today, often wasteful exploitation of natural resources has been proceeding with varying intensity for several thousand years, practically since the transition from the hunter-gatherer economy to agriculture. Problems of destruction of the natural environment have long been noticed. In Poland, common yew was the first tree legally protected by King Władysław II Jagiełło's decree issued in 1423, which stated: "If a man enters the forest and cuts any trees that are of great value, such as common yew or the like, he may be captured by the lord or squire (…)". The oldest Polish legal regulation regarding the protection of animals was a species protection act issued in the 11th century by King Bolesław the Brave, which prohibited beaver hunting. An office of lord of beavers (*dominus castorum*) was specially created, with beaver guardians (*venatores castorum*) subject to him. They took care of beaver lodges on behalf of the king [1]. Therefore, the protection of natural habitats or similar ones is not characteristic of our times only although it must be admitted that only now, in the era of instant and global information, is it gaining proper significance.

Hunting, which has always operated at the interface between human activity and the natural environment, is particularly sensitive to changes increasingly occurring in the latter: deforestation or the development of large-scale farms.

In Poland, habitat protection is probably most fully implemented in forest areas. This is probably due to the fact that the vast majority of our forests (almost 9.1 million ha in total) are managed by the State Forests National Forest Holding, which manages almost 84% of the country's forest area. Within one entity, it is easier to have a consistent legal framework and uniformity of activities. In accordance with the Forest Act [2], Art. 7.1., the leading goals of forest management are defined by foresters as the conducting of "permanently sustainable forest management (…) taking into account in particular the following objectives: forest conservation, forest protection including the preservation of natural diversity, (…) landscape values (…)". Apparently, the protection should most often apply to wooded areas, but in practice the agricultural landscape brings with it more problems, especially on sites that have not yet been significantly transformed.

Classical landscape valorization methods applied in architecture could be useful in the practice of evaluation of field hunting grounds. "Architecture is the art and the ability to shape and organize space in real forms aimed at satisfying the material and spiritual needs of man" [3]. What functions in space are natural environment systems (ecosystems) and cultural environment ones (human life systems), and landscape is their expression [4]. "As an external expression of the environment constituting a system in space, the landscape will therefore be the most widely understood object of architecture" [4]. The landscape constantly changes under the influence of natural (biotic and abiotic) and anthropogenic factors. There is a vast range of landscape measure systems and many ways of classifying these measures, essentially covering the features of landscape elements: surface area and proportions of classes on the map, number of classes, landscape diversity, shape variation, central zones, isolation, boundary and contrast, landscape fragmentation and analysis of connectivity between landscape elements [5]. Some of these features are already being applied, while others could potentially be used in assessing the quality of habitats in terms of chase game living there.

2. Materials

The analyzes presented in the article were carried out for the hunting model functioning in Poland. The classification of hunting districts used in Poland includes forest hunting areas (where forest land accounts for at least 40% of the cadastral area) and open field hunting areas (where forest land accounts for less than 40% of the cadastral area) (the Act of 13th October 1995: The Hunting Law) [6]. The latter are the overwhelming majority. For example, in the Małopolska Voivodeship there are about 256 hunting districts (as of 2016) with a total area of 1,473,659 ha, where as much as 66% of the usable area is agricultural land. The problems of habitat protection and proper management of such hunting areas should therefore be one of the main objectives of game management. In view of the constant striving to make field areas "productive", what is gaining particular significance are shrubs, small ponds, permanent and periodic wetlands, natural wildlife shelters in fields, roadside tree groups and small meadows, so important for the agricultural landscape. These elements have hydrological as well as protective and feeding values for birds or small game.

Assessment of game habitats could, in a broader perspective, be carried out in two directions: based on methods of valorization of natural environment factors and on assessment of landscape preservation.

3. Methods of landscape valorization

The valorization based on the general natural environment values according to [7] is based on a point system, which assesses, among others: (1) the area occupied by: forests (1 point for every 100 ha), meadows and peat bogs (1 point for every 150 ha), (2) the landscape value: terrain variety: 1–10 points, area of water reservoirs: 1–10 points, river network density: 1–10 points, tree cover density: 1–10 points. Another method of assessment of natural environment values is the method of valorization of ecological usable land in the agricultural landscape, developed by Ilnicki [8]. It is based on the ecological assessment of landscape elements such as ponds and watercourses (surface area, shape, water quality, hydrogeographic conditions, neighbouring vegetation), tree cover density (the occupied part of the water reservoir perimeter, average tree size) and the type of land adjacent to a watercourse. This method can be used to determine the suitability of an area for agrotourism and hunting as well as the effectiveness of the direction of forest and water reclamation and management of degraded areas.

Landscape can be identified based on its selected features, which also leads to its valorization, i.e. assessment and comparison of the values of landscape elements. There are various methods of landscape identification leading to the determination of homogeneous fragments, or units, and their specific landscape. One of the best known methods, developed by Bogdanowski [9], leads to the designation of architectural landscape units and interiors (pl.: JARK-WAK). An architectural-landscape unit is "an area of uniform or very similar shape expressed in units of shape and units of cover, e.g. flat terrain (unit of shape) covered with a chessboard pattern of units filled with gardens (unit of cover)," and consists of architectural and landscape interiors [10]. Valorization consists in the valuation of architectural-landscape unit elements, their division into those of great landscape importance (or lack thereof), "protective" ones, or those subject to degradation. Another method, an impression curve proposed by Wejchert [11], is based on subjective assessment of landscape and urban values on a scale from 1 to 10. Area valorization in terms of ecological values, developed by Chmielewski [12], takes into account, among others, the size of ecosystems and the stability of their functions, biodiversity or scarcity of species occurrence. Another assessment was proposed by Kistowski [13] based on the state of preservation, variety and expressiveness of a given unit, concerning its visual and aesthetic value. Criteria developed by Myga-Piątek and Solon [14] for the purpose of valorization of the cultural landscape in the process of spatial planning include, among others, historicity and uniqueness as well as aesthetic, emotional and functional values. Raszeja [15] uses integrated assessment of the landscape structure, based on landscape indicators proposed by various authors, where the criteria are e.g. complexity, coherence, development level or visual scale [16]. A landscape can also be understood as a mosaic of homogeneous areas (patches), which in the Polish scientific literature have been called "spreads" (pl. *płaty*) by Richling and Solon [17].

For at least a decade, landscape research directions have been described that apply the so-called landscape indexes (metrics) or are based on the concept of ecosystem services. Landscape metrics, calculated on the basis of algorithms implemented in GIS (Geographic Information Systems) software, are based on spatial information in the form of vectorized topographic maps, thematic maps or other criteria in the field of land use and land cover (LULC) mapping. They express, in an objectified manner, various features of the landscape, above all its composition and spatial configuration, as well as allow, based on multi-temporal geodata series, for determination of the dynamics of changes (e.g. the appearance of new patches in the landscape by its fragmentation or total disappearance of its elements) occurring in the analysed landscape [18].

Another approach to the delineation and classification of landscape units can be applied by using a hybrid solution based on an analysis of multi-source and multi-scale spatial data, i.e. vector layers (polygonal, points) and raster layers - using automatic object-oriented image analysis, i.e. the OBIA method (Object Based Image Analysis; [19]). This approach mainly uses satellite imagery (e.g. SENTINEL-2, ESA) or aerial digital photographs derived from both optical sensors, e.g. multispectral (MS) aerial and hyperspectral (HS) imaging, as well as microwave (radar) or so-called LiDAR data (3D point clouds). The latter data provide indispensable, valuable information about the height structure of vegetation, including e.g. occurrence of the shrub layer and saplings as well as stands of complex structure. The application of artificial neural networks for simultaneous segmentation of input images with a negligible role of the operator (who, however, must have extensive substantive knowledge) allows for repeatability and objectivity in the classification of images representing the analysed landscapes with the use of the OBIA (or GEOBIA) approach. The operator controls the segmentation process by determining the rank of the shape and the colour (brightness in individual spectral channels) of the homogeneous pixel groups sought. In addition, the operator sets the maximum size of segments generated by the algorithm, which in the next classification step are combined into appropriate class hierarchies based on e.g. standard deviation of height or NDVI and other variables.

One of the variables that can be used to segment landscape units are the so-called geomorphometric indexes (primary and secondary), generated in GIS software based on precision Digital Terrain Model (DTM). These are available for the entire area of Poland with very high accuracy reaching 10-15 cm (RMSE elevation) both in the form of developed rasters and 3D point clouds (ALS LiDAR) obtainable from the ISOK and CAPAP projects [20]. Dynamic landscape changes are mainly the result of linear investments (e.g. roads, railways) as well as processes related to socio-economic changes occurring in areas mainly used for agriculture. On the one hand, there is a sharp increase in large-scale farms; on the other, what can be observed in areas with poor soil quality is the abandonment of their use and the phenomenon of so-called secondary succession of forest communities [21]. This phenomenon is extremely interesting from the point of view of increasing (in the areas of so-called "agrarian deserts") or decreasing biodiversity (e.g. overgrowing of unused pastures, such as forest glades and mountain meadows, which leads to the disappearance of some plant species and accompanying insects and birds).

The recent decade has been characterised by a dynamic increase in the number of sources and the scope of spatial information regarding the area of Poland, and available especially in the digital form, which can be applied using GIS software [13]. In the context of valorization, the available data sources are in the analogue and raster forms. Particularly helpful are archival and current aerial orthophotomaps, high resolution satellite (HRS) images as well as the Airborne Laser Scanning (ALS) point clouds, which require processing for the purpose of inference and landscape assessment. Laser scanning (LiDAR) is a revolutionary and innovative technology in various fields of science and economy related to monitoring, management and visualisation of the natural environment [20]. Currently, the entire surface of Poland is covered with ALS point clouds, obtained in Standard I (4 points/m^2) for most of Poland or in Standard II, which includes cities (12 points/m^2). What is often applied in current landscape valorization are GIS visibility analyses [22], which allow for the simulation of a view from a selected place based on the Digital Terrain Model (DTM) or Digital Surface Model (DSM). Digital height models enable identification of the variability of field forms along with forests and trees growing there. The use of GIS visibility analyses conducted on 3D data in the assessment of landscape interiors is extremely valuable. 3D models of vegetation and land relief can also be used in the analysis of observation fields (hunting blind platforms) as well as the safety of shooting from hunting weapons (**Figures 1**–**3**).

Figure 1.
An RGB aerial orthophotomap.

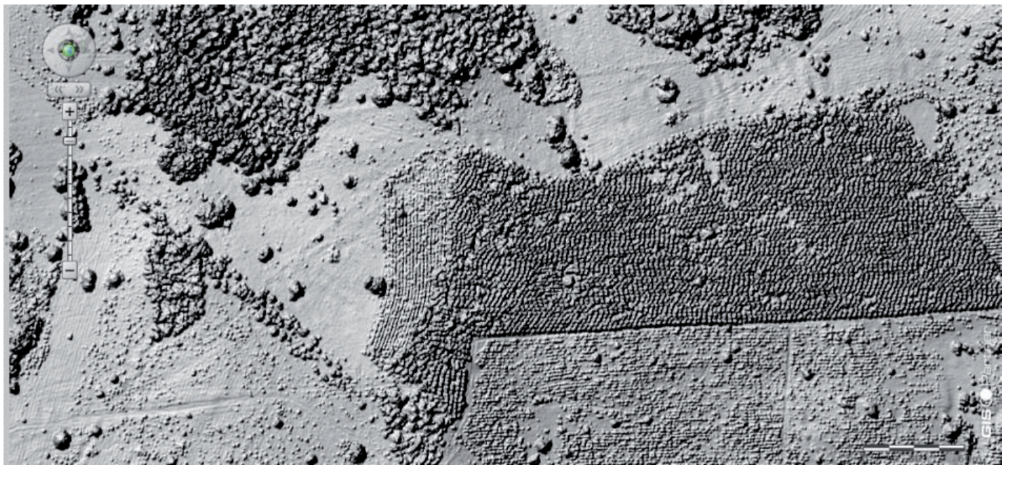

Figure 2.
A digital surface model (DSM).

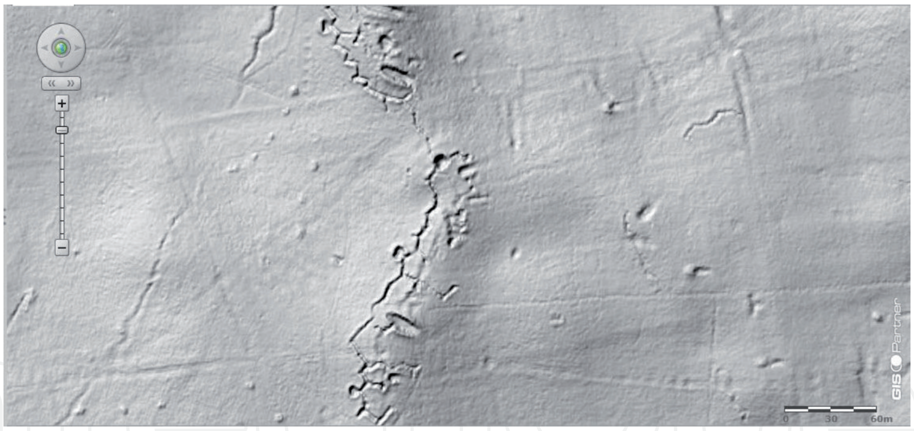

Figure 3.
A digital terrain model (DTM).

Another landscape classification method developed in recent years is based on the concept of ecosystem services (ES) or so-called landscape benefits. Its main categories [23] include:

- supply, e.g. food production, water supply, production of organic raw materials;
- regulatory services (water and air purification, decomposition and detoxification, climate regulation);
- supportive services (nutrient circulation, primary production);
- cultural benefits (spiritual, aesthetic and recreational benefits, scientific discoveries).

4. Hunting in the context of landscape valorization

According to the above classifications, the key problem in Central Europe is a decrease of areas covered by trees and resources of surface, flowing and standing water. For example, the current assessments place Poland among the countries in which the water deficit is going to get worse. It is especially bad for ponds and wetlands. Land drainage works carried out in Poland on a massive scale, especially in the 1960s, have significantly reduced the level of groundwater. The recent dry years and the lack of any work aimed at water retention (deepening overgrown ponds, repairing weirs) have aggravated the long-unfavourable tendencies. In Sweden, eco melioration solutions were introduced in design practice as early as in the years 1980–1990. Straight-line courses of drainage ditches were abandoned in favour of ones which, by meandering, slow down the outflow of water. Adaptation of straight-line ditches to their new functions consisted in creating, in each ditch crown, at 50-meter intervals, 2.5–3-meter-wide enclaves covered with rush vegetation, bushes and low trees. Similar solutions were also proposed for water outlets from drainage system collectors. Such solutions not only improve water conditions in agricultural areas but also significantly valorize the landscape. The most important functions of wetlands still visible in a given area are water retention, water supply to adjacent areas, maintenance of high quality habitats (plant and animal communities), aestheticisation of the agricultural landscape, education and recreation. Despite the currently unfavourable situation, the water retention capabilities of agricultural areas in Poland are still considerable. In an average hunting district with an area of about 4 thousand ha located in an agricultural area in southern Poland, there are about 12 wetlands with a total area of over 27,000 m^2. They retain approx. 40 thousand m^3 of water (**Figure 4**).

In 2006, the vast majority of hunting grounds located in southern Poland still had moderate natural values (valorization class III: 6.5 site index points). Currently, the number of site index points has dropped to 4 (valorization class IV), which indicates low values of the natural environment. By limiting the range of the tree cover and removing the oldest trees, mid-field stretches of land covered by trees and such areas extending along watercourses are degraded to a large extent and fall into valorization class II. This condition is recorded within field hunting areas throughout the region. Such a clear decrease in area quality should be worrying (**Figures 5** and **6**).

If the above division of ecosystem services (landscapes) was used in the aspect of game management in larger areas, individual homogeneous areas should be assigned a specific function or even many functions. Only such a matrix would allow for hunting district valorization in terms of the selected species or a given activity profile.

Many contemporary research issues focus on modelling animal migration routes and species mobility intensity, the occurrence of natural or artificial barriers on a migration route, and the so-called landscape permeability. Identification of land cover patches or plant communities or ecosystems as components of routes (corridors) is helpful in spatial planning at various levels of detail [24], including the construction of animal crossings ("footbridges") over highways and expressways, or as a consequence of rational hunting economy. From the point of view of hunting area categorisation, guidelines for landscape valorization and formulation of recommendations and conclusions regarding landscaping and landscape protection can help in assessing the breeding and hunting value of a given area. Assessed are natural, cultural, historical and architectural, urban, rural complexes,

Figure 4.
Water enclaves with rush vegetation, bushes and low trees.

Figure 5.
Destroyed roadside trees.

Figure 6.
Intensive large-scale agriculture.

including built-up areas distinguished by their local architectural form, as well as aesthetic-visual values, in particular elements of terrain exposure, such as the exposure foreground, view axes and viewpoints. In relation to field and forest areas, cultural features are of some importance; however, the most important are the natural environment features and indicators, e.g. compositional features of plant clusters important for maintaining the diversity of field habitats:

- double or triple clusters - are a transitional form between a lonely tree and a larger cluster of trees;

- gates, frames, wings - these forms are created by trees growing at such a distance that only the edges of their crowns touch. Such a cluster forms view windows which direct the viewing axes; such forms connect landscape interiors;

- clumps - form compact clusters consisting of many trees;
- avenues - are arranger in a linear way in so-called bands forming the walls of a landscape interior; these forms are strongly geometrized and extend along the transport axes;
- lines - types of clusters formed along a line, dividing landscape interiors;
- streaks - they run freely along watercourses or terrain irregularities.

Recognition of the above components of architectural and landscape interiors creates opportunities for content and meaning assessment and for determination of their functional role [9]. Below are some selected examples of assessment:

- a mature linear form that follows natural terrain intersections is more favourable than that which cuts through uniform terrain or opposes its original shape.

Figure 7.
Natural tree group along watercourse.

Figure 8.
Cultural landscape 1.

A classic example are natural tree groups along watercourses. i.e. streaks. Such conditions are extremely favourable for game (**Figure 7**);

- a system of clumps separated by arable fields and rural buildings creates a cultural landscape that is extremely beneficial for small animals and roe deer.

Figure 9.
Cultural landscape 2.

Figure 10.
Linear tree clusters 1.

Figure 11.
Linear tree clusters 2.

Relatively small, varied acreages constitute their food base, and tree groups create ecological corridors. Large-field crops, which have become frequent in recent years, are a particular threat to such an environment. They radically change the food base to one that is beneficial for wild boars, and definitely too poor for e.g. partridges (**Figures 8** and **9**);

- landscape interiors are divided by linear tree clusters, but - assuming the diversification of crops – they determine the separation of homogeneous fragments in terms of form. This way of farming gives animals the ability to move along shelters and reduces the pressure of predators (**Figures 10** and **11**).

5. Discussion and conclusions

In recent years, dynamically progressing changes in the use of field and forest space have been visible throughout Poland. Areas intensively developed with buildings, road infrastructure, power networks, GSM poles and wind farms are growing. They all affect the landscape, changing it irreversibly and leaving their mark. These are certainly factors adversely affecting the existence of game, especially small animals. Changing the landscape from purely agricultural to one enriched with natural succession areas may contribute to an increase in the population of selected animal species, important for hunting.

A varied cultural field-forest landscape is certainly the most beneficial for maintaining the stability of small game populations. The above short presentation of methods of its valorization can be helpful in assessing the quality of hunting districts. Related to the growth of intensive farming economy, there is a visible process of gradual degradation of the environmental valorization class of a given area and a decrease in the value of landscape interiors that determine the living capabilities of game. The cultural landscape shaped over the centuries has quickly managed to reach, in many places, an environmentally and architecturally degenerated landscape.

The Polish Forest Act (1991) rightly points out the close relationship between classic pro-environmental conservation measures and the preservation of landscape values. Therefore, the link between the above activities is landscape ecology, understood as the identification and quantification of relationships occurring between the spatial structure of the landscape (e.g. the number of forest patches) and processes occurring within and between ecosystems [24]. What is particularly important is quantitative assessment of the impact of spatial heterogeneity of the landscape on such phenomena as distribution and movement of animals, which is crucial for conducting sustainable game management as well as active protection of valuable habitats.

Due to the growing human impact on the landscape, in 2000 the Council of Europe adopted the European Landscape Convention, which Poland ratified on 27th September 2004, thus recognising the landscape as an important part of people's quality of life and a key element of the well-being of society. For the needs of the landscape audit, a special typology of landscapes has been developed [14] as well as a classification based in particular on criteria such as: the nature of the factors dominant in the landscape, land relief and land cover. The inventorying of landscape values consists in an analysis and assessment of the values of individual landscapes, taking into consideration the following resources: abiotic, biotic and anthropogenic, i.e. historical, cultural and aesthetic ones [25]. The goal of landscape audits is identification of landscapes which occur within a given voivodeship (province), determination of their characteristics, conducting their valorization and distinguishing the priority landscapes, i.e. those regarded as the most valuable and requiring special protection [26]. An important task is a detailed assessment and presentation of recommendations and conclusions regarding formation and landscape protection, which can be used in many other studies, e.g. in the categorisation of areas managed by hunting clubs. Conducting a landscape audit requires the use of multi-source data, environmental information and field inspections. The detailed results of an audit are to enable its practical application in spatial planning processes at the communal level, or in local strategic-planning documents, including those related to the valorization of landscapes at a microscale. Characteristics of landscapes are prepared by determination of the following analytical features:

1. natural environmental (protected areas and species protection; valuable natural objects; forest and stand site types; boundaries with sea water; ecological corridors; linear bush and tree covers; area fragmentation; land cover; a single field; an agricultural plot; spatial structure);

2. cultural (archaeological sites, rural systems, rural and suburban building objects, objects related to former borders and relict ownership forms, objects connected with fortifications, mining, metallurgy, power industry, craft and industry, religious building complexes and places of worship, places of martyrdom and commemoration; objects of town and palace architecture; historical objects of architecture connected with transport, spa, tourism and recreation, leisure, sports, observation and navigation infrastructure; protected objects; communication objects);

3. synthetic (tradition, identity, familiarity, basic and supplementary functions of a landscape).

Visible in recent years across Europe, a decline in small game has attracted the attention of practitioners and scientists to the causes of this regression. An indication of the reasons for this phenomenon constitutes the starting point for possible corrective actions; the next task should be to assess (valorise) adverse effects. This assessment is extremely important, because by ranking threats, it sets a schedule for corrective actions. Research methods that could be used in the situation described are different than in the case of standard assessments used at the stage of categorisation of hunting districts: area, forest cover, number of forest complexes, fertility of forest habitats, lack of continuity of a given district. The factors included in it do not necessarily have to reflect the actual value of a field area. In relation to small game, the field-forest mosaic, large spatial fragmentation and interweaving of natural environment elements with buildings do not have to be the factors limiting its number. Hunters, obviously interested in maintaining such game numbers that are appropriate for the capacity of hunting areas, should be particularly sensitive to the landscape values of the area in which they hunt. Contrary to appearances, this factor creates an inseparable whole with environmental components.

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