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HIDDEN CULTURAL HERITAGE IN THE ABANDONED LANDSCAPE – IDENTIFICATION AND INTERPRETATION USING AIRBORNE LIDAR

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According to the European Landscape Convention that was ratified by Poland in 2004, the landscape is seen as part of European heritage that deserves protection and responsible management. Therefore, the Council of Europe obliged signatories to the Convention to identify the landscapes in their territory, their characteristics and the factors contributing to their transformation.

In reaction to the above commitment, a project entitled "Hidden cultural heritage in the abandoned landscape – identification and interpretation using airborne LiDAR" was undertaken in 2013-2016 by the Institute of Geography and Spatial Organization of the Polish Academy of Sciences. Led by Andrzej Affek, it was funded by Poland's National Science Centre (Grant No. 2012/05/N/ST10/03520) within the PRELUDIUM 5 funding scheme. The project contributed to the fulfilment of the above commitment by identifying relicts of past Carpathian landscape hidden beneath the canopy and enabled monitoring and protection of the cultural heritage recorded in the microtopography.

The main objective of the project was the reconstruction of the past Carpathian landscape by identifying the elements of the cultural heritage recorded in the topography in areas abandoned after World War II and afforested directly afterwards. It was expected that, due to the almost complete cessation of human activities in wooded areas, many earthworks created before World War II would have been preserved to the present day.

The problem of reliable representation of the terrain under dense vegetation has been dogging researchers from various fields for decades. Aerial photographs, and the Digital Terrain Models (DTM) created on the basis of them, were a good tool to identify

the elements of cultural heritage recorded in the relief only in open, treeless space. Airborne laser scanning (ALS) enables one to assign coordinates to points on the surface from which radiation is reflected (together with the characteristics of the surface) at a density of several points per square metre. Such a tool opens up new horizons for research, especially in the field of microtopography and the spatial structure of vegetation. This is the reason why ALS was chosen as the primary method for detecting elements of cultural heritage hidden under the tree canopy. Very enthusiastic reports in the world literature provided additional support for this choice.

As a result of a flight mission conducted in spring 2013, an area of 63.5 km^2 was scanned in the Wiar river valley in the Polish Eastern Carpathians. A point cloud of 1.57 billion points was obtained (Fig. 1). The mean effective ground point density was close to 12 points/m^2. Detection and interpretation of past landscape features was conducted with the help of several different data sources, such as aerial images, old

Figure 1. The Greek Catholic church (14th century) in Posada Rybotycka lying within the scanned area. The oldest existing Eastern rite church in Poland: top – a regular digital photograph, bottom – a 10 m deep profile of the obtained point cloud. Points coloured by elevation

topographic and cadastral maps, fieldwork and interviews. Materials and methods characteristic of the geographical, archaeological and social sciences complement each other, resulting in a complete picture of the feature being researched.

The analysis of LiDAR-derived DTM showed that there were numerous, well preserved earthworks created before World War II lying under the tree canopy. These largely correspond with the spatial pattern of land use presented on cadastral maps from the mid-19th century. Although 70 years have passed since they lost their original functions, earthworks such as hollow ways, agricultural terraces and field boundaries continue in the landscape in almost unchanged shape. The remnants of settlements (cellars, stone wells, foundations) are also reflected on the DTM. The initial strip pattern of land ownership dating from a period when villages were located there in the 15th century is clearly visible. Former arable land can be distinguished from permanent forest on the basis of ploughing traces. Some fields have well preserved evidence of medieval ridge and furrow patterns of ploughing with non-reversible ploughs (ridges approx. 4.5 m wide and 0.5 m high).

As a result of detailed analysis of laser data and archival cadastral maps followed by laborious, multi-faceted field verification, it was possible, for the first time, to make a complete inventory of the cultural heritage recorded in the microtopography of abandoned Ruthenian villages. The final product of the project was a map of the past Carpathian landscape preserved in the relief covering an area of 25 km^2 in the Wiar river valley (Affek 2016a). An approximate time of creation was assigned to most of the earthworks identified.

In addition, an analysis of their state of preservation was carried out in relation to the secondary land use. It turned out that pre-war microtopographic features are best preserved on farmland and settlement areas that were afforested directly after the expulsions. In contrast, almost no old man-made form of relief survived within the Wiar floodplain and on arable land that was subject to intensive use by collective farming after the war.

Contemporary ecological functions were also determined, since the modern landscape of deserted villages is dominated by nature. It was demonstrated that earthworks, which once performed a specific function for human beings, survive in the landscape over time and acquire new ecological functions after land abandonment. Stone foundations and the walls of residential buildings proved to be good hideouts for insects, birds and small mammals. Agricultural terraces, in turn, limit runoff and support water retention, whereas steep hollow ways intensify erosion and concentrate surface runoff. Flat hollow ways often serve as microhabitats for reptiles and amphibians, as they retain water and raise soil moisture. Dried ponds near former manor houses are today places where wild boars tend to feed. Old dugouts and cellars, if flooded, are unique water habitats, and if dry – they serve as a shelter for bats.

Originally on the periphery of the main research tasks, it was planned to develop a method to determine the physical characteristics of the scanned surface on the basis of the intensity of the reflection coefficient. For this purpose reference objects were located in the study area imitating the ideal white (fully reflecting radiation) and black body (fully absorbing radiation). Further detailed analysis of the problem based on the latest literature and our own research showed that the intensity value recorded by the scanner cannot be reliably converted to fixed surface characteristics (for details, see Affek 2014). The main conclusion of this part of the work is that comparing intensity values between different scanning missions is pointless.

The project has contributed to the popularisation of the use of airborne laser scanning in the study of cultural heritage at a landscape scale (Affek 2016b). The principles of good practice and methods of dealing with laser data, developed within the project (Affek 2014), can provide a good methodological basis for other researchers planning to use

this type of material. Such contributions are nowadays eagerly awaited in Poland, as there is a great amount of ALS data available with countrywide coverage generated within the IT System of the Country's Protection against extreme hazards (ISOK) and there is still little understanding on how to put this very valuable resource to efficient use.

Besides the cognitive benefits, the project will have a practical significance. The elements of cultural heritage identified are exposed to destruction as a result of the use of heavy logging machinery. The detailed inventory prepared can form the basis for entering the most valuable objects and spatial patterns onto the national register of archaeological sites of the National Heritage Institute, and therefore to protect them by law.

The study was presented at Polish and international conferences on archaeology (e.g. the 11th International Conference on Archaeological Prospection in Warsaw) and landscape science (e.g. the 9th IALE World Congress in Portland, USA), and published in leading Polish journals (Affek 2014, 2015ab, 2016a).

Editors' note:
Unless otherwise stated, the sources of tables and figures are the authors', on the basis of their own research.

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