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Interpretation and presentation of prospection results

Exploring the past Carpathian landscape: the application of LiDAR and archival cadastral maps

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INTRODUCTION

The project uses non-invasive methods for gaining a better understanding of the past Carpathian landscape through the detection and interpretation of earthworks created before World War II.

Landscape in general is a dynamic feature that is in the process of continuous change. Most of the Carpathian landscape has been shaped by man, who has added new features often distorting or destroying older forms (palimpsest landscape, see, e.g., Mlekuž 2013) To grasp today the shape of a cultural landscape from the past one needs an area where human activity has ceased and the forms of landscape have somehow been conserved. It is what happened apparently in the Polish Eastern Carpathians, from where Ukrainians were displaced *en bloc* in the late 1940s and the abandoned land became afforested.

STUDY AREA

The research concentrated in the central part of the Wiar River basin in the Przemyskie foothills and the Sanok–Turka Mountains, close to the contemporary Polish–Ukrainian border (Fig. 1). The investigated area covered around 65 km^2 the altitude being from 290 m to 670 m a.s.l. It was inhabited since the 15th century by Ruthenian highlanders of Vallachian origin, displaced in the 1940s in the name of the communist mono-national policy (Wolski 1956). Five deserted villages are found in the area of research. More than 75% of the area is currently forested, this being twice as much as before WWII (Affek 2011a).

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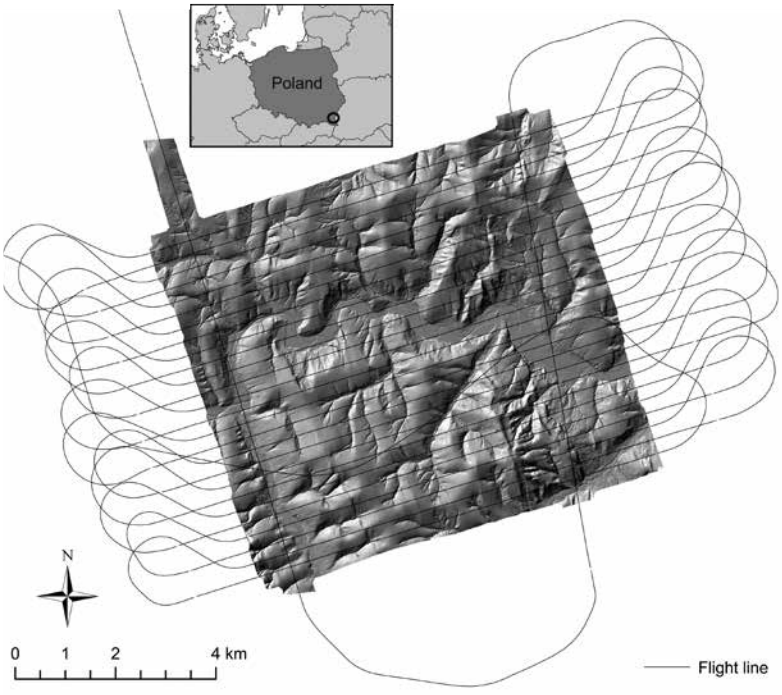

Fig. 1. Shaded LiDAR-derived DEM of the study area (part of the Wiar River basin) with marked flight lines

METHODS

An integrated approach to detection and interpretation of past landscape features was applied. Three groups of complementary research methods were used:

- remote sensing
  - airborne laser scanning (ALS): 3D point cloud, Digital Elevation Model (DEM),
  - aerial photographs taken simultaneously with laser scanning,
- analysis of current and archival cartographic and descriptive materials, such as cadastral maps from 1852, 1965 and 2008, Polish Archaeological Record (Polish acronym AZP), other topographic and thematic maps,
- field survey
  - LiDAR data verification of the detected earthworks,
  - gathering additional information regarding the time and cause of creation of earthworks (e.g., interviews with residents and Forest Office workers),
  - photographic documentation.

All the ALS parameters (data collection and processing) were selected so as to obtain the most accurate picture of the earth's surface for archaeological purposes. Airborne laser scanning

was conducted by MGGP Aero in April 2013, after the retreat of the snow and before trees started to green. The mean effective ground point density was close to 12 points/m^2.

Two main visualization techniques of LiDAR-derived DEM for the detection of features were applied: analytical hillshading with elevation differentiation (colour shading) and Sky-View Factor, a geophysical parameter that measures the portion of the sky visible from a certain point (Kokalj *et al.* 2013). These techniques proved to provide maximum benefits in hilly terrain. 3D visualization of point cloud and cross-sections served as additional sources of information.

Interpretation of the detected features was carried out by means of several parallel methods. The key issue was to extract prewar earthworks from all other microtopographic features, namely modern earthworks and forms of relief created by nature, such as former riverbeds, landslides, ravines, fallen tree pits, etc. To do this properly, all types of detected features needed to be recognized. The identification of earthworks created after forced displacement (e.g., by forestry and collective farming) was primarily based on the analysis of RGB orthophoto, LiDAR intensity data, postwar cadastres, field survey and interviews with foresters and local people. Prewar features were identified with the help of Austrian cadastral maps, other historical maps and archival sources, the documentation of the Polish Archaeological Record project, literature, field survey and, last but not least, interviews with senior local community members. Despite strenuous efforts a number of microtopographic features remained unrecognized.

RESULTS

The analysis of LiDAR-derived DEM showed that under the tree canopy there were numerous, well preserved earthworks created before WWII, corresponding to a great extent with the spatial pattern of land use presented on cadastral maps from the mid-19th century (Fig. 2). Although 70 years have passed since they lost their dedicated function, earthworks such as rural roads, 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 DEM. Most of them did not match exactly the location shown on mid-19th century cadastral maps. Still, they did not change location among parcels, only within the boundaries of a given parcel. That is because wooden buildings were short-lived and were usually built again in a new spot. Specific ruderal vegetation found in the forest additionally indicates the location of former buildings.

The initial fief structure of land ownership dating from the period the village location 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) (see Sittler 2004).

Village boundaries are usually marked by embankments or ditches. Often boundary corners are marked by small mounds, while tripoints are marked by three middle-sized mounds. No burial mounds were detected in the study area. Some mounds visible on DEM turned out to be piles of decomposing branches formed as a result of forest maintenance. The existence of one medieval stronghold was confirmed (Zoll-Adamik 1958). A thorough analysis of the collected data revealed many locations of potential archaeological sites to be verified by excavation.

Fig. 2. Village Borysławka abandoned and afforested after forced displacement in the 1940s. Top: orthophoto taken simultaneously with ALS (pixel size: 10 cm); center: Sky-View Factor from ALS data (DEM resolution: 0.5 m); bottom: Austrian cadastral map from 1852, original scale: 1:2880 (source: author, Austrian cadastral map from the State Archive in Przemyśl, sygn. 56/126/0/129M)

CONCLUSIONS

Earthworks generally survive in better condition under the tree canopy than in open space. In villages with continuity of settlement, it is hard to distinguish and extract prewar landscape patterns.

Airborne laser scanning gave a unique possibility to reveal a historic Carpathian landscape in areas abandoned after WWII and afforested directly afterwards. Prewar earthworks appeared to be very well preserved under the canopy of trees planted after the war that have not been felled since then. It is also quite easy to distinguish prewar features from modern ones, which are rather sparse and of different shape.

Nevertheless, a total and immediate afforestation of the deserted villages was not a common occurrence. Fields in most of these villages were cultivated and managed by postwar collective farming at least for some time. The prewar field mosaic and settlements were wiped out by planned levelling and mechanised agriculture. Only in a few former villages (e.g., Borysławka in the study area, see Affek 2011b) the historic Carpathian landscape is clearly readable and may serve as a site of cultural heritage of great value.

Therefore, there is need to protect the prewar landscape pattern hidden today under the forest canopy. Threat comes from modern forestry and high levels of mechanization. Monstrous trucks heavily deform the existing microtopographic relief. Multiple parallel logging roads leading along the ridges and streams have often ruts deeper than 1.5 m. Also the application of new methods of forest planting involving deep ploughing results in the destruction of prewar earthworks. Nowadays, there is not much left to protect and a very urgent need of conservation emerged.

The work confirmed the usefulness of archival cadastral maps in verifying findings from ALS and field survey. The high consistency between data sources proved the good quality of the maps and the durability of earthworks.

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REFERENCES

Affek, A. 2011a. Landscape continuity versus landscape transformation: a case study in the Wiar River catchment, Polish Carpathians (1780-2000). *Problemy Ekologii Krajobrazu* 30: 147-155.

Affek, A. 2011b. Wartości krajobrazu opuszczonego przez ludność na przykładzie byłej rusińskiej wsi Borysławka. *Prace Komisji Krajobrazu Kulturowego PTG* 15: 148-160.

Kokalj, Ž., Zakšek, K., Oštir, K. 2013. Visualizations of LiDAR Derived Relief Models. In R.S. Opitz and D.C. Cowley (eds), *Interpreting Archaeological Topography: Airborne Laser Scanning, 3D Data and Ground Observation*, 100-114. Oxford.

Mlekuž, D. 2013. Messy landscapes: LiDAR and the practices of landscaping. In R.S. Opitz and D.C. Cowley (eds), *Interpreting Archaeological Topography: Airborne Laser Scanning, 3D Data and Ground Observation,* 88-99. Oxford.

Sittler, B. 2004. Revealing historical landscapes by using airborne laser scanning. A 3D model of ridge and furrow in forests near Rastatt (Germany). Proceedings of the ISPRS working group VIII/2, I*nternational Archives of Remote Sensing and Spatial Information Sciences* 36 (8/W2): 258-261.

Wolski, K. 1956. Osadnictwo dorzecza górnego Wiaru w XV wieku [The colonization of the upper Wiar river catchment in the 15th century]. *Annales Universitatis Mariae Curie Skłodowska, sectio B,* II, I: 1-45.
Zoll-Adamik, H. 1958. Wczesnośredniowieczne grodzisko w dolinie Wiaru (Polska). *Acta Archaeologica Carpathica* I: 125-128.