Luka Škerjanec:

Prehistoric landscapes and medieval reuse: remote sensing and spatial modelling of prehistoric burial mounds in eastern Herzegovina [Prazgodovinske krajine in njihova srednjeveška apropriacija: daljinsko zaznavanje in prostorsko modeliranje prazgodovinskih grobnih gomil v vzhodni Hercegovini]

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Definition of the research problem

Prehistoric burial mounds (locally known as gomile, or humke) are among the most numerous and archaeologically significant archaeological structures in Hercegovina, ranging in size from a few meters to up to 30 m in diameter, with both circular and irregular base shapes, they tend to occupy prominent but approachable places in the landscape, low ridge crests, hill spurs above valley floors, and terraces that command long views along river corridors and ancient routeways. In limestone karst zones, tumuli are often stone-built cairn mounds set on rocky knolls, while in the more soil rich karst fields they tend to be built from earth. Together with hillforts (gradine) they represent the defining features of the prehistoric landscape of this region. Chronologically, tumuli in this area span multiple prehistoric periods. The earliest sites date to the late Eneolothic and Early Broze age periods (3rd MBCE), while the peak of tumular funerary tradition is associated with the Glasinac-Mati Culture (c. 1600-300 BCE). Despite their prevalence, tumuli in Hercegovina remain under-explored archaeologically, with much knowledge today derived largely from surface observations and older, oft-unsystematic documentation. Notably we are still lacking studies with a focus on a detailed spatial and distribution analysis of these burial mounds. Another area lacking research is also the extend of later reuse and the state of preservation of these monuments. Remarkably these tumuli were also reused for burial rites in later periods. Most significantly in the late medieval period (12th-15th CE) in connection with the stećci tombstone phenomenon. This trend of prehistoric burial mound reuse or “appropriation” may even have taken place all the way into the early modern period and may have significantly impacted the preservation of the original tumuli.

While attested across the entire stećci distribution area, the practice is especially common in modern Herzegovina (the medieval territories of Zachlumia and Travunia), where cemeteries are most frequently located on prehistoric mounds. This presents an interesting angle to the dynamic history of the region. While the medieval reuse of prehistoric mounds is recognized as a pan-European phenomenon, it is nevertheless

extraordinary that such practice appears in the western Balkans much later - about 200-400 years later according to the current research - than the rest of comparable examples. This burial phenomenon is not entirely limited to prehistoric mounds, but is also directly compatible to burials within ruins of roman buildings; most commonly late antique basilicas. “Old” churches and “old” mounds were likely chosen out of a desire to reconnect with the past. An ancient church could still count as “consecrated ground”, so being buried there might fit Christian custom. A prehistoric mound was never blessed and predates Christianity, so using it for burial may reflect different motives, such as claiming ancient ancestry, local prestige, or continuity with older traditions, rather than standard Christian rites.

Research questions and hypotheses

The main research questions are:

- Is it possible to use remote sensing data to reliably detect prehistoric burial mounds and hillforts to reconstruct the prehistoric funerary landscape?
- Is later burial reuse limited to prehistoric burial mounds or do we see it reflected in other features visible in the landscape?
- Why did medieval and later funerary practices incorporate “old” places into their funerary landscape?
- What is the chronological depth of this reuse and why has it persisted so long in comparison to the rest of Europe?
- Can we use remote sensing techniques to classify different types of burial mound damage and reuse?

As part of my doctoral thesis, I want to test the following hypotheses:

- The prehistoric landscape represents the foundation for the later formation of the medieval landscape.
- The reuse of prehistoric burial mounds represents a broader phenomenon of funerary practice, which is not necessarily limited to the period of construction of stećci tombstones.

Methodology

The methodology will focus on the spatial and quantitative analysis of prehistoric burial mounds across the historic region of eastern Herzegovina. We will use a multiscale research approach. The main research region will be the area from the vicinity of Mostar in the west to the Morine Plateau in the north the Bileća Basin in the east and Popovo polje in the south (c. 3800 km^2). Using Airborne Laser Scanning (ALS/lidar) data, we will implement automatic detection of burial mounds with a custom trained convolutional neural network (e.g., a HRNet style semantic segmentation). Preprocessing will include the derivation of terrain products such as slope, curvature

and simple local relief model to enhance mound visibility. The CNN will produce probability maps that are post processed via thresholding, morphological filters, connected component labelling, and polygonization, with false positive reduction using size and shape metrics (e.g., diameter constraints, circularity, and elongation) and topographic context. Accuracy will be assessed through spatial cross validation, precision–recall and F1 scores, intersection over union (IoU), and uncertainty mapping, complemented by orthophoto verification and targeted GNSS field checks. We are estimating that the whole research area could contain as many as 20.000 individual burial mounds. Morphometric analysis will estimate height, basal diameter, and volume via DFM–basal surface differencing; multi azimuth radial cross sections (e.g., every 5–10°) will support an automated damage index to flag crest flattening, trench like depressions, asymmetry, and cut/fill residues, enabling classification of mounds as intact, modified, looted, or containing burials with stećci tombstones. Burial mounds will be automatically classified by the building material used (stone or earth), with the use of ALS derived surface roughness estimations and optical satellite/aerial data. This data will be supplemented with available archaeological data of the known locations of medieval cemeteries. We will also use historic and topographic maps to map the locations of possible cemeteries and churches. With this data, we will reconstruct clusters and distribution patterns using kernel density estimation, nearest neighbour statistics, Ripley's K, and density-based clustering (e.g., DBSCAN), alongside viewshed and intervisibility networks. Relationships with environmental covariates (elevation, slope, aspect, lithology, proximity to water and route corridors, and cost distance surfaces) will be modelled to explore siting preferences. Based on the results of these analyses one to three smaller geographically diverse research areas will be chosen to preform ground truthing and more detailed spatial mapping to refine and test the regional models. Possible candidates for these research areas are the Baljci plateau, Ljubomir basin and the Morine highlands.

The aim is to produce a detailed reconstruction of the prehistoric burial landscape and to quantify the extent of preservation and damage of the burial mounds across the study areas as well as providing possible explanations as to why these tumuli were so prominently reused as burial locations in later periods.

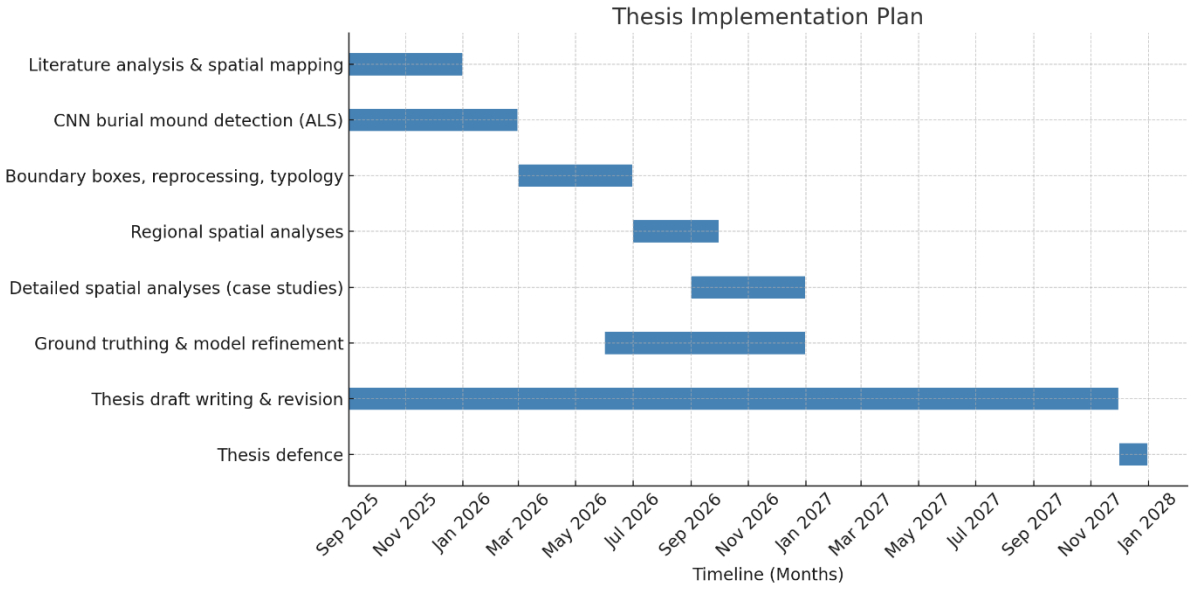
Contribution to the advancement of science

The main scientific contribution of this research lies in the development and application of an innovative, data-driven approach to understanding the spatial and temporal dynamics of prehistoric burial mounds in eastern Herzegovina. By integrating Airborne Laser Scanning (ALS, lidar), convolutional neural networks, and spatial statistical modelling, this study offers the first comprehensive, large-scale spatial and quantitative analysis of burial mounds in the region. It not only reconstructs the prehistoric funerary landscape with unprecedented resolution but also sheds light on the long-term continuity and cultural significance of these sites through their medieval

and early modern reuse. This multidisciplinary approach bridges gaps in archaeological knowledge, contributes to heritage preservation, and provides a replicable methodological framework for similar landscape-scale archaeological investigations worldwide.

Implementation plan

- Literature analysis and spatial mapping of know sites (creation of a spatial database) (September-December 2025),
- Preforming automatic burial mound detection on ALS data with CNN (September 2025-February 2026),
- Using the result of the CNN detection to extract boundary boxes of burial mounds and reprocess the ALS Point cloud for automated damage index and stećci tombstone detection, along with typological classification of burial mounds (March-June 2026),
- Performing spatial analyses and evaluating the results on a regional level (July-September 2026),
- Performing detailed spatial analyses on smaller case study areas (September-December 2026),
- Ground truthing and model refinement (June-December 2026),
- Thesis first draft writing and revision (September 2025-November 2027),
- Thesis presentation and defence (December 2027).



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