

Hilltop Sites with Early Medieval Military Finds in the Eastern Alpine Area

Reverse Engineering of Predictive Modelling

1 INTRODUCTION

As this volume demonstrates, hilltop settlements with early medieval military finds are a phenomena detected over a large area. A majority of the known sites is located in the Eastern Alps and these are further analysed in this text.

At a first glance all of the sites exhibit not only very similar types of finds but are also set in a very similar hilltop environment. However, on a closer inspection significant variations are observed: some locations are more remote than others, some are more prominent in the landscape, some are better positioned for subsistence agriculture, and so on.

These differences are addressed in a systematic and quantifiable manner employing a GIS toolset often termed a predictive modelling kit. The aim of this article is to provide a landscape context to the interpretation of the hilltops with Early Medieval military finds in the eastern Alpine area.¹

Predictive modelling has been at the core of GIS applications in archaeology from the beginning in the early 1990s² and is nowadays accepted as a valuable tool in archaeological research and cultural heritage management.³ It is a set of analytical tools aimed at finding correlations between archaeological site locations and the proximity of environmental variables. It is grounded on the assumption that archaeological sites are where people conducted activities and that these locations are what we want to predict. However, predictive modelling cannot be a productive archaeological pursuit without the explicit realization that statistical tests and correlations can only inform us about coincidences in the present, which must then be linked with the past through the process of explanation.⁴ Most often this method has been applied to detecting previously unknown archaeological sites in heritage management.⁵

¹ The studies on the Austrian Hilltop Settlements were funded within the FWF-Project "Eastern Alps Revisited" (P.Nr. P24045) by the Austrian Science Fund.

² Interpreting space: GIS and archaeology, ed. Kathleen M. S. Allen/Stanton W. Green/Ezra B. W. Zubrow (London 1990); Zoran Stančič/Tatjana Veljanovski, Arheološki napovedovalni modeli in GIS, in: Geografski informacijski sistemi v Sloveniji 1997–1998, ed. Marko Krevs/Drago Perko/Tomaž Podobnikar/Zoran Stančič (Ljubljana 1998); Gary R. Lock, Beyond the Map: Archaeology and Spatial Technologies (Amsterdam/Berlin/Oxford/Tokyo/Washington, D.C. 2000).

³ E.g. Hans Kamermans, The application of predictive modelling in archaeology: Problems and possibilities, in: Beyond the Artifact. Digital Interpretation of the Past. Proceedings of CAA2004, Prato 13–17 April 2004, ed. Franco Niccolucci/Sorin Hermon (Budapest 2010) 271–277; Aikaterini Balla/Gerasimos Pavlogeorgatos/Despoina Tsiafakis/George Pavlidis, Recent advances in archaeological predictive modeling for archaeological research and cultural heritage management, in: Mediterranean Archaeology and Archaeometry 14/4 (2014) 143–153; overview in Aikaterini Balla/Gerasimos Pavlogeorgatos/Despoina Tsiafakis/George Pavlidis, Efficient predictive modelling for archaeological research, in: Mediterranean Archaeology and Archaeometry 14/1 (2014) 119–129.

⁴ James I. Ebert, The state of the art in "Inductive" Predictive Modeling: Seven big mistakes (and lots of smaller ones), in: Practical Applications of GIS for Archaeologists. A Predictive Modeling Toolkit, ed. Konnie L. Westcott/Joe R. Brandon (Philadelphia 2000).

⁵ E.g. Practical Applications of GIS for Archaeologists. A Predictive Modeling Toolkit, ed. Konnie L. Westcott/Joe R. Brandon (Philadelphia 2000); Wilko K. van Zijverden/Walter N. H. Laan, Landscape reconstructions and predictive modeling in archaeological research, using a LIDAR based DEM and digital boring databases, in: Archäologie und Computer Workshop 9, ed. Wilhelm Börner (Forschungsgesellschaft Wiener Stadtarchäologie, Vienna 2004); R. E. Warren/D. L. Asch, A Predictive Model of Archaeological Site Location in the Eastern Prairie Peninsula, in: Practical Applications of GIS for

Surprisingly rarely, though, the method has been applied to research-based projects that would allow for the parameters used to be refined and field-tested.⁶ Furthermore, predictive modelling is rarely applied to the interpretation of known sites rather than to the prediction of potential site location.

We have termed this approach *reverse engineering* the predictive modelling kit. The tools – i.e. GIS algorithms – used are among the most often used ones: slope, viewshed and visibility, relative height, site-catchment.⁷ However, they are used to extract the values for known site locations thus enabling the classification of the sites.⁸

2 DATA

The adopted methodology is built from the ground up on two premises. First is that mentioned above: correlations between site locations and digital representation of the present day landscape can only inform us about coincidences in the present, which must then be linked with the past through the process of explanation. Second, the tools used must be adapted to the regional scale of this study, the size of which has rarely (if ever before) been attempted in predictive modelling in archaeology.

The latter led us to the decision that only analyses of the digital elevation model (DEM) will be used. DEM is the only data source that could presumably be acquired with sufficient *accuracy* and *precision*.⁹ For example, the proximity of water is often considered in predictive modelling and there are several data sources for surface waters available for the entire study area; however, the water springs that would be of interest as a source of drinking water are not reliably mapped, let alone available in consistent quality for the entire region. And even if the data for modern springs were to be available, it could not be uncritically applied to the 8th and 9th c. AD.

Initially 28 Slovenian sites were considered (Figure 1). Due to the encouraging results the study area has been considerably enlarged to incorporate 106 sites from Slovenia, Austria, Bavaria in Germany and the Czech Republic, 296,100 km² in total (Figure 2). The Slovenian and Austrian sites have been extracted using Zbiva¹⁰ by applying the search for the hilltop locations with 8th and 9th c. AD “militaria” finds. However, the sample is heavily biased by the results of the previous work by the authors and hence 75% of the sites are from Slovenia and the Austrian province of Carinthia. To those, 11 sites in Bavaria and 2 in the Czech Republic have been added, based on the data provided by Christian Later and Nad’a Profantova respectively.¹¹

In Austria these sites attracted scholarly attention from an early date, especially in the first half of the 20th c. They have, in particular, been investigated regarding their late Roman phases and have often been interpreted as early-Christian Roman or Germanic settlements from Late Antiquity or the Migration period.¹² Only a small number of them have been excavated and a very large number have only been surveyed by field-walks. In most cases the remains of buildings, especially walls, can still be seen as rampart-like surface features. For Carinthia, where the centre of the early Medieval Carantanian

Archaeologists. A Predictive Modeling Toolkit ed. Konnie L. Westcott/Joe R. Brandon (Philadelphia 2000) 7–36; Temps et espaces de l’homme en société, analyses et modèles spatiaux en archéologie, ed. Jean-François Berger/Frédérique Bertonecello/ François Braemer/Gourguen Davtian/Michiel Gazenbeek (Actes des 25. Recontres Internationales d’Archéologie et d’Histoire et d’Antibes, Antibes 2005).

⁶ E.g. Benjamin Štular, Analiza gospodarskega zaledja v arheologiji krajina (Site catchment analysis in landscape archaeology), in: Geografski informacijski sistemi v Sloveniji 2005–2006, ed. Drago Perko/Janez Nared/Marjan Čeh/David Hladnik/Marko Krevs/ Tomaž Podobnikar/Radoš Šumrada (Ljubljana 2006).

⁷ Cf. Practical Applications of GIS for Archaeologists.

⁸ For the use of term classification, see Leo S. Klejn, Arheološka tipologija (Ljubljana 1988) 192, 510.

⁹ Cf. Metric Survey Specifications for Cultural Heritage, ed. Paul Bryan/Bill Blake/Jon Bedford/David Andrews (Swindon 2009) 20 for accuracy and precision.

¹⁰ Andrej Pleterski/Mateja Belak, Zbiva. Cerkev v vzhodnih Alpah od 8. do 10. stoletja. Zbiva. Archäologische Datenbank für den Ostalpenbereich. Die Kirchen in den Ostalpen vom 8. bis 10. Jahrhundert, in: Zgodovinski časopis 49/1 (1995) 19–43; Pleterski, Belak, 2016, Zbiva. <http://zbiva.zrc-sazu.si>.

¹¹ We are thankful to both for providing us with the data on the site’s locations.

¹² C.f. Rudolf Egger, Frühchristliche Kirchenbauten im südlichen Noricum (Sonderschriften des österreichischen archäologischen Instituts 9, Wien 1916); Franz Jantsch, Die spätantiken und langobardischen Burgen in Kärnten, in: Mitteilungen der Anthropologischen Gesellschaft in Wien LXVIII (1938) 337–390.

principality can be located, in the early 20th c., Franz Xaver Kohla – amongst others – has collected information about all sites known to date and a compilation of them was published in 1973.¹³ This compilation has been enlarged by various selected sites from Styria, Upper and Lower Austria, the Czech Republic and, of course, Slovenia¹⁴. For this paper we chose a selection of 106 of these approximately 300 currently known sites to investigate by means of various statistical and GIS-analyses.

This paper focuses on the Early Medieval usage of the sites and some of those mentioned above have shown finds or features from this period, especially military equipment. Some others, that are not proven by archeological evidence are, however, mentioned in medieval charters and can be identified with certain material remains, still visible today.¹⁵ Of course, not all of the 106 selected sites have delivered evidence for Early Medieval usage. In such cases they have been chosen because they show similar structures to sites with Early Medieval dating, for example regarding surface features from high-resolution digital elevation models.

The Slovenian sites have been analysed using the high quality 25 m DEM.¹⁶ As a first step, the analyses were run on selected well-known sites and the results have been compared with field experience and other data, e.g. viewsheds have been compared to photographs. Then the analyses were replicated using 50 m and 100 m DEMs. Based on the comparison of the results, it was determined that the analyses can be run on 50 m DEM without losing important information, whereas the 100 m DEM was not suitable. DEM50 produced by median aggregation of the said 25 m DEM has therefore been used to analyse the Slovenian sites.

In 2014 the study area was considerably enlarged. An important factor in that decision was a digital elevation model over Europe from the GMES RDA project (EU-DEM) that became available in late 2013. EU-DEM is a hybrid product based on SRTM and ASTER GDEM data fused by a weighted averaging approach and it has been generated as a contiguous dataset **with stated** geographic accuracy of 25 m.¹⁷

Since this dataset has been published without a formal validation we decided against aggregation and ran the analyses on the 25 m DEM at the expense of computing time. For example, the calculation of the necessary viewsheds on a desktop computer running ArcGIS took more than 197 hours to process and it produced an excess of 200 GB of data.

Unfortunately, EU-DEM visual assessment and the error statistics validation that became available subsequently concluded that the horizontal spacing of EU-DEM is over-estimated and in fact bears more similarity to the SRTM DSM.¹⁸ In other words, although the *precision* of the EU-DEM is 25 m, the *accuracy* is about 90 m.¹⁹

¹³ Franz X. Kohla, *Kärntner Burgenkunde* (Aus Forschung und Kunst 17, Klagenfurt 1973).

¹⁴ C.f. Slavko Ciglenečki, *Höhenbefestigungen aus der Zeit vom 3. bis 6. Jahrhundert im Ostalpenraum* (Ljubljana 1987).

¹⁵ On the discussion of the Medieval dating: Stefan Eichert, *Zur frühmittelalterlichen Besiedlung des Ostalpenraums am Beispiel Kärntens*, in: *Untergang und Neuanfang-Tagungsbeiträge der Arbeitsgemeinschaft Spätantike und Frühmittelalter*, ed. Orsolya Heinrich-Tamaska (Studien zu Spätantike und Frühmittelalter 3, Hamburg 2011) 107–124; Stefan Eichert, *Frühmittelalterliche Strukturen im Ostalpenraum. Studien zu Geschichte und Archäologie Karantaniens* (Aus Forschung und Kunst 39, Klagenfurt am Wörthersee 2012); Paul Gleirscher, *Keltisch, frühmittelalterlich oder türkenzeitlich? Zur Datierung einfach strukturierter Wehranlagen im Südostalpenraum*, in: *Beiträge zur Mittelalterarchäologie in Österreich* 26 (Wien 2010) 7–32.

¹⁶ Tomaž Podobnikar, *Kronologija izdelave digitalnega modela reliefa Slovenije*, in: *Geodetski vestnik* 47/1–2 (2003) 47–54.

¹⁷ Andrew Bashfield/Andreas Keim, *Continent-wide DEM creation for the European Union* (International Society for Photogrammetry and Remote Sensing, Proceedings, Sydney 2011); EU-DEM Metadata. <http://www.eea.europa.eu/data-and-maps/data/eu-dem#tab-metadata> (accessed 1.7.2016).

¹⁸ Edina Józsa/Szabolcs Á. Fábián/Mónika Kovács, *An evaluation of EU-DEM in comparison with ASTER GDEM, SRTM and contour-based DEMs over the Eastern Mecsek Mountains*, in: *Hungarian Geographical Bulletin* 63/4 (2014) 401–423.

¹⁹ For SRTM DSM cf. Konstantinos G. Nikolakopoulos/E K. Kamaratakis/Nektarios Chrysoulakis, *SRTM vs ASTER elevation products. Comparison for two regions in Crete, Greece*, in: *International Journal of Remote Sensing* 27/21 (2006) 4819–4838; Djamel Athmania/Hammadi Achour, *External validation of the ASTER GDEM2, GMTED2010 and CGIAR-CSI-SRTM v4.1 free access digital elevation models (DEMs) in Tunisia and Algeria*, in: *Remote Sensing* 6/5 (2014) 4600–4620.

Bearing in mind the above-mentioned initial tests on Slovenian DEM, this leads to the conclusion that the results of analysis based on EU-DEM are severely limited. Hence all analyses have been executed twice:

- on a high-quality DEM50 for the small area (Slovenia) and
- on a low-accuracy EU-DEM for the large area.

3 TOOLS

With the term tools we are addressing the GIS algorithms developed for this particular analysis. Reflecting Ebert's²⁰ considerations, our starting point is the research question embedded in archaeological interpretation. Given the focus of this analysis – hilltop sites with Early Medieval military finds – the underlying questions are:

- Could these locations have been used as settlements in the Early Medieval period?
- If yes, what kind of settlements?

To address these questions five criteria have been formulated that, on the one hand, sufficiently describe the type of the potential activities on each hilltop and, on the other hand, are observable in the available data on a regional scale:

1. defensibility,
2. living conditions,
3. remoteness and
4. control of local resources,
5. presence in the landscape.

Below both the archaeological reasoning and the GIS algorithm for each of the above criteria are presented. The results are discussed separately for the smaller area with accurate DEM (Slovenia) and the large area with poor accuracy EU-DEM.

3.1 DEFENSIBILITY

By defensibility the natural affordance of each location to be defended against possible attackers has been evaluated. Obviously, the defensibility of every location depends on many factors such as types of weapons, available military logistics, size of the battle force etc.²¹ Without dwelling on the details, the only criterion pertaining to the natural affordance relevant to Early Medieval warfare that can be extracted using GIS analyses at this scale is minimum drop from each hilltop. The bigger the height drop, the higher the slope that needs to be scaled by potential attackers before the defenders can be engaged in combat. Obviously, the steepness is also a very important factor that can be easily calculated in the GIS environment. However, in order to get meaningful results high-resolution DEM's – e.g. lidar derived – are needed.

The only proxy that can be calculated on such a coarse scale is the height of each hilltop, i.e. the vertical distance in metres between the peak (summit) and the highest surrounding area. Within common concepts, the peak is defined as being any point on a surface that is elevated by a certain difference in height with respect to its surroundings.²²

Algorithm: This proxy was calculated using LandSerf v2.3 software. Peak classification has been iterated five times with values for minimum drop surrounding the peak 10, 20, 30, 40 and 50 m respectively. The results have been added together so that in the resulting raster peak values 1 to 5 reflected

²⁰ Ebert, State of the art.

²¹ Cf. Takashi Sakaguchi/Jesse Morin/Ryan Dickie, Defensibility of large prehistoric sites in the Mid-Fraser region on the Canadian Plateau, in: *Journal of Archaeological Science* 37/6 (2010) 1171–1185.

²² Tomaž Podobnikar, Detecting mountain peaks and delineating their shapes using Digital Elevation Models, Remote Sensing and Geographic Information Systems using autometric methodological procedures, in: *Remote Sensing* 4 (2012) 784–809, at 785–788.

value 1 for peaks with 10 m or smaller minimum drop, 2 for peaks with 10 to 20 m drop up to value 5 for peaks with 40 m or more. Height brackets have been chosen arbitrarily.

However, more than half of the sites – described by archaeologists as “strategic” hilltop locations – were attributed value 0. The majority of those are either ridge or saddle locations. Since ridge and saddle locations afford some potential defensibility they were attributed the value 2.

Results. Among the Slovenian sites 50% were ridge or saddle locations, 3% were located on the slope. 11% of the sites had peak value 1, 3% value 2, 3% value 4 and 29% value 5. Two thirds of the Slovenian sites are therefore located on sites with poor (values 1, 2) and the remaining third on locations with very good (values 4, 5) natural defensibility affordance, thus creating two distinct groups (Figure 3).

The comparison of the results for the Slovenian sites calculated on DEM50 and EU-DEM revealed that 23 were an exact match, 1 was an approximate match and 2 were a mismatch (value difference 1 and 2 respectively). 2 sites were a complete mismatch exhibiting value 0 instead of 5. With 71% of exact matches and only 7% of complete mismatches we consider the defensibility analyses executed on EU-DEM to be acceptable.

Among the 106 sites, 9% are located on a slope, 3% on peaks 10 m high or less, 8% on peaks between 10 and 20 m high, 49% are positioned either on a ridge or on a saddle, 4% on peaks between 20 and 30 m, 3% on peaks between 30 and 40 m high and 24% on peaks more than 40 m high. Similarly to the above, 69% of sites are therefore located on sites with poor natural defensibility affordance, 4% have medium and 26% are located on sites with very good natural defensibility affordance. Therefore, two distinct classes can be determined, sites with poor defensibility affordance and sites with medium or very good defensibility affordance (Figure 4)

3.2 LIVING CONDITIONS

Detecting the agricultural potential – for the purposes of this article termed *field* – suitable for the 8th and 9th c. AD technology and climate conditions can only be achieved on a case-to-case basis.²³ In addition, the possibility of other types of self-sufficient agriculture should be considered.²⁴

Therefore, a far more robust proxy for calculating the agricultural potential was needed, such as slope.²⁵ In an Alpine environment, however, most intensive agricultural activities take place on alluvial soils in valley bottoms and other flat formations surrounded by higher ground. Soils on hillslopes are generally shallower than in valleys and are dominated by erosion and transportation regimes, whereas valley bottoms are generally depositional environments where material accumulates over time.²⁶

We therefore consider the valley bottom area within a 3 km radius – a rough approximation of a sedentary site catchment area²⁷ – to be the proxy for each site’s agricultural potential. The term *field* is therefore used throughout this article as denoting this area

Algorithm: The multiresolution index of valley bottom flatness was calculated using System for Automated Geoscientific Analyses GIS software (hereafter SAGA) v2.1. The morphometric analysis multiresolution index of valley bottom flatness utilizes the flatness and lowness characteristics of valley bottoms that are combined by multiplication and are interpreted as membership functions of fuzzy sets.

²³ E.g. Štular, Analiza gospodarskega.

²⁴ E.g. Tina Milavec, Poznorimske pasne garniture z jezdecima iz jugovzhodnih Alp in Panonije = Late Roman belt sets with riders from the southeastern Alps and Pannonia, in: Prilozi instituta za arheologiju u Zagrebu 28 (2011) 133–146.

²⁵ E.g. Robert E. Warren/David L. Asch, Practical applications of GIS for archaeologists. A predictive modeling toolkit, in: 2000, Practical Applications of GIS for Archaeologists. A Predictive Modeling Toolkit, ed. Konnie L. Westcott/Joe R. Brandon (Philadelphia 2000) 7–36, at 13–18.

²⁶ John C. Gallant/Trevor I. Dowling, A multiresolution index of valley bottom flatness for mapping depositional areas, in: Water resources research 39/12 (2003) 4–1; 4–13.

²⁷ Mike R. Jarman/Claudio Vita-Finzi/Eric Higgs, Site catchment analysis in archaeology, in: Man, Settlement, and Urbanism, ed. Peter J. Ucko/Ruth Tringham/G. Dimbleby (London 1972) 61–66; Alan Zarky, The Early Mesoamerican village (1976) 117–130; Donna C. Roper, The method and theory of site catchment analysis: a review, in: Advances in Archaeological Method and Theory 2, ed. Michael B. Schiffer (New York 1979) 119–140; Štular, Analiza gospodarskega; Oula Seitsonen, Prehistoric land-use in the Loita-Mara Region, Southwest Kenya: A preliminary GIS site catchment analysis, in: NYAME AKUMA 71 (2009) 46–53; Isaac I. T. Ullah, A GIS method for assessing the zone of human-environmental impact around archaeological sites: a test case from the Late Neolithic of Wadi Ziqlāb, Jordan, in: Journal of Archaeological Science 38/3 (2011) 623–632.

Values greater than 0.5 are considered as valley bottom areas. For this module, the default settings have been used since these are already optimized for a 25 m DEM.²⁸ The result is reclassified into a binary raster where values of 0.5 and higher are considered to be valley bottoms (value 1) and the rest are not (value 0). Clusters with an area of less than 2 ha are deleted in order to limit the negative influence of the EU-DEM poor quality, especially spikes. As a last step, the result is expressed as the *field* percentage of the total 5 km radius area.

The results can be classified in 5 classes using Jenks natural breaks implemented in ArcGIS Desktop 10.2. Natural breaks classes are based on natural groupings inherent in the data, whereby the class breaks are identified that best group similar values and that maximize the differences between classes. The features are therefore divided into classes whose boundaries are set where there are relatively big differences in the data values.²⁹

Results: The Slovenian sites have from less than 1% to 84% – i.e. 4 to 2379 hectares – of *fields* within the 3 km radius. The average value is 21% and the median value 15%. 18% of the sites fit the very small *field* category, 36% small, 25% average, 14% large and 7% very large (Figure 5; Figure 6).

To compare the results for Slovenian sites calculated on DEM50 and EU-DEM first some statistical observations have been made. A discrepancy of $\pm 3\%$ would result in a misclassification for 3 % of the sites whereas $\pm 5\%$ misclassifies 50 %, $\pm 7\%$ misclassifies 80% and $\pm 12\%$ misclassifies 97 % of sites. This means that a tolerable discrepancy is $\pm 3\%$ whereas $\pm 5\%$ would already misclassify half of the sites.

The comparison of the results for Slovenian sites calculated on DEM50 and EU-DEM reveals that the EU-DEM results on average estimate the size for 15%. Only 18% had a discrepancy of no more than $\pm 3\%$ and only 25% had a discrepancy of no more than $\pm 5\%$. In other words, had *field* category for Slovenian sites been calculated based on EU-DEM, only 5 sites would be classified correctly and 23 would be misclassified. Therefore the *field* category based on EU-DEM data has only been used to detect the outliers, i.e. sites that differ greatly from the majority. In other words, from the categories calculated with natural breaks on the DEM50 data we only kept the very small (6%) and very large category (54%) and the rest have been merged and are considered to be of average size.

Among the 106 sites analysed based on EU-DEM data 7% have a very small, 77% an average, and 16% have a very large *field* (Figure 7).

The regional scale of the analysis has been an all-important factor in calculating the *accessibility* of the *field* as well. The standard approach such as the site catchment's time budget³⁰ or path modelling³¹ were not applicable, especially given the problems identified with modelling travel on the steep slopes.³²

A more robust method was therefore needed. Since we are interested in the travel between the hilltop and the valley floor, calculating the height-difference-dependent time budget is a valid approximation for the accessibility of the *field*. Experienced hikers report that a fit person walking on maintained paths on average ascends 300 m of height difference per hour.

Algorithm: Vertical distance to channel network was used to calculate the height of the hilltop location above the valley. This module – implemented in SAGA v2.1 – calculates the vertical distance to

²⁸ Gallant/Dowling, multiresolution index.

²⁹ Mike De Smith/Mike F. Goodchild/Paul Longley, *Geospatial Analysis: A Comprehensive Guide to Principles, Techniques and Software Tools*. (5th online edition: <http://www.spatialanalysisonline.com> 2015) chapter 4.2.12.

³⁰ E.g. Štular, *Analiza gospodarskega*.

³¹ Benjamin Štular, *Mreža poti = Path Network*, in: *Poznoantična utrjena naselbina Tonovcov grad pri Kobaridu. Naselbinski ostanki in interpretacija = Late Antique fortified settlement Tonovcov grad near Kobarid. Settlement remains and interpretation*, ed. Slavko Ciglenečki/Zvezda Modrijan/Tina Milavec (Ljubljana 2011) 53–64, see cited bibliography; Dimitrij Mlekuž, *Modeliranje gibanja in dostopnosti*, in: *Geografski informacijski sistemi v Sloveniji 2011–2012*, ed. Rok Ciglič/Drago Perko/Matija Zorn (Ljubljana 2012) 153–160; Philip Verhagen, *On the road to nowhere? Least cost paths, accessibility and the predictive modelling perspective*, in: *CAA2010: Fusion of Cultures. Proceedings of the 38th Annual Conference on Computer Applications and Quantitative Methods in Archaeology*, Granada, Spain, April 2010, ed. Francisco Contreras/M. Farjas, Fco J. Melero (Oxford 2013) 383–390; Heather Richards-Rissetto/Kristin Landau, *Movement as a means of social (re)production: using GIS to measure social integration across urban landscapes*, in: *Journal of Archaeological Science* 41 (2014) 365–375; Peter Bikoulis, *Hypothesis Testing and Validation in Archaeological Networks*, in: *CAA2015. Keep The Revolution Going. Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods in Archaeology*, ed. Stephano Campana/Robert Scopigno/Gabriella Carpentiero/ Marianna Cirillo (Oxford 2016) 543–554.

³² Štular, *Analiza gospodarskega* 201, slika 2.

a channel network base level. The algorithm interpolates a channel network base level elevation and then subtracts it from the original elevations.³³ The value of each site's location on the resulting digital surface model (DSM) therefore equals the height in meters above the valley. This divided by 300 produces the results in hours needed to ascend from the valley to the hilltop.

For DEM50 the hydrological map has been used as a channel network input, whereas for EU-DEM the channel network has been interpolated from DEM.

Results: Statistically calculated natural breaks for the DEM50 data are as follows: 14.4, 31.2, 47.6, and 75.6 minutes, i.e. approximately $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and $1\frac{1}{4}$ of an hour. On the other hand, sample site catchment studies in archaeology (see above) allow for different breaks based on anthropological and archaeological observations:

- 7 minutes (site catchments preferred in densely populated areas)³⁴
- 15 minutes (half of anthropologically defined site catchment area)³⁵
- 30 minutes (anthropologically defined site catchment area)³⁶
- 1 hour (approximation of a 4.5 km radius for pastoral societies)³⁷
- 2 hours (approximation of a 9 km observed maximum daily grazing herding radius)³⁸

Based on excellent correlation between the 15 and 30 minute breaks and to some extent all but the 7 minute bracket – clearly not applicable to this site type – the decision has been made to use the statistically calculated natural breaks rounded up to a quarter of an hour: up to 15, 30, 45, 75, and more than 75 minutes for accessibility values 5, 4, 3, 2, and 1 respectively. Therefore, 21% of sites have excellent accessibility, 32 % good, 21 % average, 21% poor and 3 % are inaccessible (Figure 8; Figure 9).

In comparison, EU-DEM results on average underestimate the ascent time by 16 minutes, which is one full class. 29% of sites differ ± 5 minutes or less, 25% are 5 to 15 minutes lower, 29% are 15 to 30 minutes lower and the remaining 18% are more than 30 minutes lower. The prevailing underestimation of time can most likely be explained by the reduced accuracy of the data since the peaks, i.e. hilltops, tend to be lower than the actual values on low, coarser DEM's. However, the big range of dispersion of the differences – 64 minutes – means that this mistake cannot be corrected.

Therefore, accessibility results based on EU-DEM can also only be used to detect the outliers: sites with excellent accessibility of less than 15 minutes and inaccessible sites that take more than $1\frac{1}{4}$ hours to access. Among the 106 sites, 24% have excellent accessibility, 66% have average accessibility and 9% are inaccessible (Figure 10).

The *field* and accessibility modelled above are just an aid to modelling the archaeological criterion of our interest, the *living conditions*. Living conditions as used in this article describes the potential for a permanent self-sufficient agricultural settlement. This premise is built upon the assumption that in the 8th and 9th-c. AD Eastern Alpine area there were no military forts that would be externally supplied with provisions by some sort of centrally governed logistics network. Such forts were a common feature during the Roman period and probably also existed in Late Antiquity³⁹ but only reappeared in the post-medieval period. Therefore, had the sites in question had permanent military staff, the supporting infrastructure for self-sufficient supply with provisions should have been in place, i.e. conditions for

³³ Cf. Michael Bock/Bernd Cyffka/Florian Haas/Barbara Stammel, Remediation of the Danube floodplain between Neuburg and Ingolstadt (Bavaria/Germany) – GIS supported modelling of ecological flooding, in: SAGA – Analysis and Modelling Applications, ed. Jürgen Böhner/Keith R. McCloy/Josef Strobl (Göttingen 2006) 1–12; Michael Bock/Rüdiger Köthe, Predicting the Depth of hydrologic Soil Characteristics influenced by ground water, in: SAGA – Seconds Out, ed. Jürgen Böhner/Thomas Blaschke/Luca Montanarella (Hamburg 2008) 13–22.

³⁴ Cf. Štular, Analiza gospodarskega 207.

³⁵ Cf. David L. Rossmann, The village and its catchment area, in: The Early Mesoamerican village, ed. Kent V Flannery (New York/San Francisco/London 1976); Zarky, village.

³⁶ Rossmann, village; Zarky, village; Isaac I.T. Ullah, GIS 623–632.

³⁷ Cf. Ullah GIS method.

³⁸ Peter B. Coppolillo, The landscape ecology of pastoral herding: Spatial analysis of land use and livestock production in East Africa, in: Human Ecology 28/4 (2000) 527–560.

³⁹ E.g. Slavko Ciglenečki, Posočje v poznoantičnem času = The posočje area during Late Antiquity, in: Poznoantična naselbina Tonovcov grad pri Kobaridu. Naselbinski ostanki in interpretacija, ed. Slavko Ciglenečki/Zvezda Modričan/Tina Milavec (Ljubljana 2011) 33–52.

agriculture. In this vein, living conditions are therefore determined by a combination of the potential *field* size and its *accessibility* modelled above.

Algorithm: Both the potential and its accessibility are deemed of equal importance and therefore the average value has been used. However, if either *field* or *accessibility* had value 1 the living conditions value is 1. For example, even if a site is easily accessible, if there are no potential *fields* the living conditions do not exist.

Results. Among the Slovenian sites 18% do not have suitable living conditions as defined above, 11% have poor, 35% average, 25% good and 11% have excellent living conditions (Fig. 11).

As mentioned, the poor accuracy of the EU-DEM only allows for detecting the outliers in our data. Among the 106 sites, 14% do not have suitable living conditions as defined above, 72% have good or very good, and 14% have excellent living conditions (Fig. 12).

Results for both datasets display normal distribution with approximately 2/3 of the sites with average living conditions and the rest equally distributed among the no suitable living conditions and excellent living conditions categories.

3.3 REMOTENESS

Distances from probable routes of travel or inaccessibility due to barriers are to be considered with regard to the function of an archaeological site.⁴⁰ We have termed this characteristic remoteness to distinguish it from both accessibility and control. Although the three characteristics – remoteness, accessibility and control – are somewhat overlapping, it is the subtle differences we are interested in. The concept is perhaps easiest to demonstrate using the example of a medieval castle. Smlednik castle,⁴¹ for example, had an extremely large viewshed, thus exerting firm landscape presence. This was largely due to its position on a rock promontory 155 m above the valley, making it accessible in just over a half an hour. This makes sense since daily access to the fields was not a primary concern when the location for the castle was sought out. However, the castle was not remotely located since it was positioned 685 m from the fields of the closest village. The location therefore makes perfect sense for a feudal castle that obtains the majority of its provisions from the surrounding villages (or at the very least by the work of the villagers) but needs to exert strong symbolic presence in the landscape and at the same time strong factual control over its dominion in the nearby villages. This location would not be suitable for a self-sufficient settlement, though. And indeed, a self-sufficient settlement in the form of a prehistoric hilltop settlement is located on the neighbouring hilltop.⁴² Among the sites in this analysis, perhaps the difference between the Gradec at Velika Strmca (No. 6) – remote but accessible – and Home above Sora (No. 14) – non-remote but inaccessible – best demonstrates the difference between remoteness and presence in the landscape.

Algorithm: Remoteness is calculated as a Euclidian distance, i.e. as a crow flies, from the *field* category. This function is robust enough to be reliably replicated in most GIS software packages.

Results: The 28 Slovenian sites are, on average, 0.7 km away from the nearest *field*. Statistically calculated natural breaks for the DEM50 data are 0.25, 0.6, 0.83 and 1.3 km. 18% of the sites are not remote, 36% are slightly remote, 25% are averagely remote, 14 % are remote and 7% are very remote. Only 1/5 of the sites are therefore remote or very remote by being almost 1 km or more distant from the nearest *field* (Fig. 13; Fig. 14).

The distances calculated on EU-DEM are on average 0.45 km shorter than those calculated on DEM50. The range of differences is between – 0.32 and 0.92 km, a whopping 1.24 km that compares to the range of four classes.

Such poor accuracy in the EU-DEM-derived data would only allow for singling out the very remote outliers that are more than 1 km remote from the *field*. However, only 4% of sites fall into this category and all are located in Slovenia (Nos. 1, 7, 22, 27). Since more reliable information is derived for these from DEM50, the EU-DEM derived remoteness data is not suitable for further analysis.

⁴⁰ Sakaguchi/Morin/Dickie, *Defensibility* 1172.

⁴¹ Benjamin Štular, *The castle in the landscape*, in: Smlednik Castle, ed. Benjamin Štular (Ljubljana 2015) 107–116.

⁴² Petra Vojaković, *Smlednik in prehistoric times*, in: Smlednik Castle, ed. Benjamin Štular (Ljubljana 2015) 15–24.

3.4 CONTROL OF LOCAL RESOURCES

Visibility analyses were among the first to be gainfully employed in GIS studies of human behaviour⁴³ and archaeologists have been at the forefront of this development.⁴⁴ The most influential work in archaeology was done early on, most notably by Wheatley and Gillings⁴⁵ and Marcos Llobera.⁴⁶ The theoretical foundation of the methods developed is Gibson's⁴⁷ ecological approach to visual perception⁴⁸ and the pioneering work on the visual and spatial structure of landscapes by the Japanese landscape planner Tadahiko Higuchi.⁴⁹ The tool remains among the most often used in archaeology.⁵⁰

Working in archaeology it is very important to distinguish between someone or something being visible on the one hand and the unobstructed view of the said someone or something on the other hand. An unobstructed view, for example, between two people standing 20 km apart does not mean that they can see each other with their naked eyes; however, an unobstructed view of a 20 km-remote mountain on a clear day does make that mountain visible. Any result is also subject to the limitations of the DEM, such as altitude errors and the absence of vegetation data.

In this case study, the control that could have been exerted with the weapons and military and policing tactics employed in the 8th and 9th c. AD is of interest. The mistake often made in similar studies is to apply the 19th-c. gun-fort thinking, leading archaeologists to describe ancient hillforts as exerting "control" of river crossings and such. The historic reason for such inference is the fact that many of the early archaeologists were indeed retired 19th century military officers – e.g. General Pitt-Rivers – and the notion of what constitutes the "strategic" position of an archaeological site remained largely unquestioned.

With that in mind we built our tool based on two premises:

- the control of local resources is of interest and
- control is considered to be visual control over people and their activities (that in turn allows for the deployment of appropriate military or policing procedures).

⁴³ Peter F. Fisher, First experiments in viewshed uncertainty: the accuracy of the viewable area, in: *Photogrammetric Engineering and Remote Sensing* 57 (1991) 1321–1327; Peter F. Fisher, First experiments in viewshed uncertainty: simulating fuzzy viewshed, in: *Photogrammetric Engineering and Remote Sensing* 58 (1992) 345–352; Peter F. Fisher, Algorithm and implementation uncertainty in viewshed analysis, in: *International Journal of Geographical Information Science* 7/4 (1993) 331–347.

⁴⁴ E.g. Vince Gaffney/Zoran Stančič, *GIS Approaches to Regional Analysis: A Case Study of the Island of Hvar* (Ljubljana 1991), at 61–63; David Wheatley, Cumulative viewshed analysis: a GIS-based method for investigating intervisibility, and its archaeological application, in: *GIS and Archaeology: a European Perspective*, ed. Gary Lock/Zoran Stančič (London 1995) 171–186.

⁴⁵ David Wheatley/Mark Gillings, Vision, perception and GIS: developing enriched approaches to the study of archaeological visibility, in: *Beyond the map: archaeology and spatial technologies*, ed. Gary R. Lock (Amsterdam/Berlin, Oxford/Tokyo/Washington, D.C. 2000) 1–27.

⁴⁶ Marcos Llobera, Extending GIS-based visual analysis: the concept of visualsapes, in: *International Journal of Geographical Information Science* 17/1 (2003) 25; id. Reconstructing visual landscapes, in: *World Archaeology* 39/1 (2007) 51–69; id. Modeling visibility through vegetation, in: *International Journal of Geographical Information Science* 21/7 (2007) 799–810.

⁴⁷ James J. Gibson, *The Ecological Approach to Perception* (Hillsdale 1986).

⁴⁸ Cf. James Conolly/Mark Lake, *Geographical Information systems in Archaeology* (Cambridge 2006).

⁴⁹ Tadahiko Higuchi, *The Visual and Spatial Structure of Landscapes* (Master Thesis, Cambridge 1983).

⁵⁰ E.g. overview in Mark D. McCoy/Thegn N. Ladefoged, New developments in the use of spatial technology in archaeology, in: *Journal of Archaeological Research* 17 (2009) 263–295, at 272; Jago Cooper, Modelling mobility and exchange in pre-Columbian Cuba: GIS led approaches to identifying pathways and reconstructing journeys from the archaeological record, in: *Journal of Caribbean Archaeology* 3 (2010) 122–137; Sakaguchi/Morin/Dickie, Defensibility; Dimitrios Alexakis/Apostolos Sarris/Theodoros Astaras/Konstantinos Albanakis, Integrated GIS, remote sensing and geomorphologic approaches for the reconstruction of the landscape habitation of Thessaly during the neolithic period, in: *Journal of Archaeological Science* 38/1 (2011) 89–100; Wesley Bernardini/Alicia Barnash/Mark Kumler/Martin Wong, Quantifying visual prominence in social landscapes, in: *Journal of Archaeological Science* 40/11 (2013) 3946–3954; Mlekuž, Modeliranje; Francisco Vaz da Silva, A tomb with a view new methods for bridging the gap between land and sky in Megalithic Archaeology, in: *Advances in Archaeological Practice* 2/1 (2014) 24–37; Sylviane Déderix, More than line of sight and least cost path. An application of GIS to the study of the circular tombs of South-Central Crete, in: *Best Practices of GeoInformatic Technologies for the Mapping of Archaeolandscape*, ed. Apostolos Sarris (Oxford 2015) 137–147.

The only local resource of interest that we are able to model on the regional scale is the *field* category, i.e. the visibility of the *field*. At the same time, the *field* is the location where most subsistence-related activities would take place.

In order to model the visual control over people and their activities, the Higuchi's middle-distance of 3 km is used. The middle-distance range is that which we most commonly associate with a pictorial landscape: the outline of treetops is visible but not the details of individual trees.⁵¹ For the purposes of our analysis we interpret the middle-distance range as that enabling a local connoisseur of the landscape to distinguish between familiar and unfamiliar activities that people engage in, e.g. to distinguish between the oxen team ploughing the field from the approaching band of mounted marauders. This, in our mind, is a good approximation of the responsibilities a guard at his regular post on a day with good visibility might be tasked with.

Algorithm: Two measurements have been taken to minimize the negative effect of the coarse or low accuracy DEM for the small and large window respectively. The observer height of 4 m has been used to minimize the effect of the "shadow" produced by the raster cell. And the site locations have been manually moved to the centre of the highest local (i.e. movement of less than 100 m) cell of the DEM. A viewshed analysis for each location has been executed in ArcGIS Desktop v10.2 (a significant difference with the viewshed executed with GDAL tools has been noticed).

The binary viewshed was then multiplied with the binary *field* category and the binary 3 km radius thus resulting in a binary raster of the *field* that is visible from the respective site and is within a 3 km distance from it. The final result is expressed as a percentage of a field that is visible, i.e. value 33% means that 33% of *field* within the middle-distance range is visible.

Results. Among the 28 sites based on the DEM50, on average 46% of the *field* is visible; the range is between 0 and 86%. Statistically calculated natural breaks are at 10%, 24%, 40% and 61%. 25% of the sites have very poor, 18% poor, 14% average, 21% good and 21% excellent control of local resources (Figure 15; Figure 16). Unlike *field*, ascent time and remoteness that all exhibit the exponential growth trend, the control of local resources exhibits the logistic growth trend.

The viewsheds calculated on EU-DEM are, on average, 0.1 km² smaller with the range from 2.6 km² smaller to 1.9 km² bigger, i.e. discrepancies between – 52% and 33% of the control the range. Again, the inaccuracy of the result prohibits further use of the EU-DEM derived data for anything other than isolating the outliers.

9% of the 106 sites in the larger area have very poor, 69% average, and 22% have excellent control of the local resources (Figure 17).

3.5 LANDSCAPE PRESENCE

Landscape presence as defined in this study is a symbolic effect that a hilltop site has on the people observing it, i.e. were these sites seen and felt daily by landscape-dwellers.⁵² By definition, all of the hilltop sites have similarly high visual prominence, i.e. the hilltop sites stand out from their immediate neighbourhood. In addition to this, the calculation of visual prominence *sensu* Llobera⁵³ was beyond our scope due to the insufficient processing power and is thus considered to be equal for all of the sites.

We built the model on the assumption of a predominantly self-sufficient community: the majority of the non-urban people of the time spent most of their time engaging in agricultural activities. In this context, the effect of the site's presence on the potential travellers – a reoccurring theme in similar studies⁵⁴ – is of lesser importance. The only agricultural activity that can be reliably modelled on the regional scale is engaging in work taking place in the *field*, e.g. ploughing, crop mending, harvesting. Therefore 50 random points have been selected for each site within the *field* simulating the observers.

Potential landscape presence of a prominent site is, according to our interpretation, taking place both in Higuchi's middle- and long-distance, i.e. in the 5 km radius from the site. At the long-distance range

⁵¹ Higuchi, Structure of Landscapes 13–14; Cf. Wheatley/Gillings, GIS 16–19.

⁵² Cf. William Anderson, Fortification and landscape transformation in late antique Pessinus, in: Journal of Mediterranean Archaeology 26/1 (2013) 75–96.

⁵³ Llobera, Visual analysis.

⁵⁴ E.g. Štular 2009, 161–165; Štular, Mreža poti; Štular, Castle.

a viewer can tell that an area is wooded but little more; the contours of the treetops cannot be perceived, the overall texture is uniform and colour only functions as lighter or darker patches in an overall blur. One of the most important factors is the horizon and what is viewed acts as a vertical backdrop.⁵⁵ Our interpretation is that – since the hilltops are always on the horizon and the potential settlement or fort is also distinguished from the background by colour and shape – the presence of such a site is felt even at the long-distance range.

Algorithm: 50 random points within the *field* have been created with the “create random points” tool in ArcGIS Desktop 10.2. Intervisibility between the random points and the site has been simulated by detecting which of the random points fall within the area of the *field* within a 5 km viewshed of each site. The landscape presence is expressed as a percentage, i.e. intervisibility of the site with 25 randomly selected points (out of 50) is expressed as 50% landscape presence.

Results: Among the 28 Slovenian sites the average landscape presence is 26% with values ranging from 0 to 80%. Statistically calculated natural breaks for the DEM50 data are 6%, 12%, 28% and 53%. 25% of the sites don't have landscape presence, 18% poor, 25% good, 21% very good and 11% excellent landscape presence (Fig. 18; Fig. 19). The trend line exhibits exponential growth, however the most striking feature is that there are three very distinguishable classes: the division in 5 classes is enforced to provide compatibility with other criteria, the three classes inherent in the data are:

- 1 and 2,
- 3,
- 4 and 5.

Values calculated on EU-DEM are, on average, smaller for 7% with ranges between – 56% and 42% and are thus only used to calculate the outliers.

14% of the sites don't have landscape presence, 62% have average, and 24% have excellent landscape presence (Figure 20).

4 RESULTS

The aim of the analyses described above is, as mentioned, to provide a landscape context to the interpretation of the hilltops with Early Medieval military finds in the eastern Alpine area. To this end two questions have been formulated:

- Could these locations have been used as settlements in the Early Medieval period?
- If yes, what kind of settlements?

The aim of the above analysis of the five criteria (defensibility, living conditions, remoteness, control of local resources, presence in the landscape) is therefore to aid in extracting the landscape context – i.e. archaeological meaning – of the sites. Thus, all of the criteria have been appended to each site (see Appendix).

Due to the significant data accuracy discrepancy the results for the smaller area (Slovenia) and the larger area are discussed separately.

4.1 SMALL AREA (SLOVENIA)

The subject matter of this study is hilltop sites with military finds. Therefore a very strong supposition from the start was that these are military sites (e.g. territorial defences⁵⁶) and most of the criteria address this question. The supposition is that an Early Medieval military fort exhibits:

- good defensibility (values 4 or 5),
- decent control (values 3, 4 or 5) and
- sustainable living conditions (values 3, 4 or 5).

⁵⁵ Higuchi, Structure of Landscapes 13–14; cf. Wheatley/Gillings, GIS 16–19.

⁵⁶ Cf. Johnny D. Meulemeester/Kieran O'Connor, Fortifications, in: The Archaeology of Medieval Europe, Vol. 1: The Eighth to Twelfth Centuries AD, ed. James Graham-Campbell/Magdalena Valor (Aarhus 2007) 316–341, at 319–322.

There are 6 sites (21%) that exhibit such values (Fig. 21). In an independent expert opinion (see Appendix) all of these sites have also been considered to be military or partially military, but so have 10 others that exhibit very low defensibility and/or control. This contrast is particularly useful for further discussion.

A refuge is a different type of site that could explain the presence of military finds.⁵⁷ A refuge must:

- be hidden (presence and control values 1 or 2),
- remote (values 4 or 5) and
- offer basic defensibility (values 2, 3, 4 or 5).

Since it is to be used only in exceptional circumstances, good living conditions are not needed.

There are 4 sites (14%) that exhibit typical values for a refuge (Figure 21). In an independent expert opinion (see Appendix) 2 have been defined as a refuge, one as symbolic / military and one as an unknown type.

The third possible explanation for the presence of military finds is that these are sites with special symbolic meaning. There are many, many ways to describe symbolic meaning in archaeology.⁵⁸ Perhaps the most efficient approach in this study is to consider the visual presence as has been done for medieval castles: when a castle is viewed in relation to the identities of the people who used them a whole new vantage point is uncovered; castles become backdrops against which people played out their social roles.⁵⁹ A similar approach to Early Medieval hilltop sites is warranted providing that what is known of the religious and/or symbolic Early Medieval activities is considered: although the entire inhabited landscape possesses symbolic meaning,⁶⁰ places of special meaning – *lieux de mémoire* – are very often located on the borders or otherwise remote.⁶¹ Such symbolic sites therefore exhibit:

- high landscape presence (values 4 or 5) and
- at least slight remoteness (values 2, 3, 4 or 5).

There are 7 sites (25%) that can be qualified as symbolic places. In an independent expert opinion (see Appendix) 2 have been defined as symbolic, 1 as symbolic / military and 2 as an unknown type.

Another type of potential symbolic site is a remote and hidden site, e.g. detected as a hoard in the mountains.⁶² Such sites can be understood as a component of the complex relations between those making offerings on the one hand and the numinous forces of the other world on the other.⁶³

Such sites exhibit:

- very low landscape presence (values 1 or 2),
- very low control (values 1 or 2) and
- high remoteness (values 4 or 5).

By definition, this type of symbolic sites often coincides with the refuge.

There are 5 sites (18%) that can be qualified as remote symbolic places, 4 of them are also refuge sites. In an independent expert opinion (see Appendix) 2 have been defined as a refuge, 4 as military and 1 as an unknown type.

Among the remaining sites, 4 (14%) with excellent or very good living conditions should be mentioned that are placed in such a manner as to maximize the agricultural potential. However, since these are hilltop sites with exceptional quantities of military finds they are not simple agricultural settlements.

⁵⁷ Cf. Meulemeester/O'Connor, *Fortifications* 316–318.

⁵⁸ E.g. *Symbolic and Structural Archaeology*, ed. Ian Hodder (Cambridge 1982).

⁵⁹ Matthew Johnson, *Behind the Castle Gate: From Medieval to Renaissance*. (Abingdon/New York 2002); cf. Joachim Zeune, *Burgen, Symbole der Macht. Ein neues Bild der mittelalterlichen Burg* (Regensburg 1996).

⁶⁰ E.g. Andrej Pleterski, *Kulturni genom: prostor in njegovi ideogrami mitične zgodbe* (Ljubljana 2014).

⁶¹ E.g. Benjamin Štular/Ivan M. Hrovatin, *Slovene pagan sacred landscape. Study case: the Bistrica Plain*, in: *Studia mythologica Slavica* 5 (2002) 43–68; cf. Katja Hrobat, *Ko Baba dvigne krilo. Prostor in čas v folklori Krasa* (Ljubljana 2010), at 61–107.

⁶² E.g. Andrzej Buko, *The Archaeology of Early Medieval Poland. Discoveries, Hypotheses, Interpretations* (Leiden/Boston 2008) 107–132.

⁶³ Peter Turk/Andrej Gaspari, *Gifts to the gods and ancestors*, in: *Ljubljana: kulturna dediščina reke*, ed. Peter Turk/Janka Istenič/Timotej Knific/Tomaž Nabergoj (Ljubljana 2009) 66–71, at 68.

These sites (Figure 21) therefore exhibit high potential to be a central place, i.e. *Zentralort*.⁶⁴ In an independent expert opinion (see Appendix) 3 have been defined as military or military / symbolic and 1 as an unknown type.

4.2 LARGE AREA

As mentioned, due to the data inaccuracy, the majority of sites within the large area cannot be analysed with the same rigour as the Slovenian sites within the small area. Foremost, due to the uncertainty of most of the first level results (living conditions, remoteness, control of local resources, presence in the landscape), second level results (military site, refuge, symbolic site) cannot be extrapolated. Nevertheless, some conclusions can be reached considering the outliers in the first level results.

First to be mentioned is the *defensibility* of the sites. Among the 106 sites, 9% are located on a slope, 3% on peaks 10 m high or less, 8% on peaks between 10 and 20 m high, 49% are positioned either on a ridge or on a saddle, 4% on peaks between 20 and 30 m, 3% on peaks between 30 and 40 m high and 24% on peaks more than 40 m high. Similarly to the above, 69% of sites are therefore located on locations with poor natural defensibility affordance, 4% have medium and 26% are located on locations with very good natural defensibility affordance. Therefore, 2 distinct classes can be determined, the sites with poor defensibility affordance and the sites with medium or very good defensibility affordance.

There are 13 sites (12%) that do not exhibit any natural affordance for defensibility (Figure 4: classes “Slope” and “0–10m”) and 25 sites (24%) with high natural affordance for defensibility (Figure 4: class “Upwards of 40 m”); 68 sites (64%) are average, i.e. do exhibit some natural affordance for defensibility (Figure 4: the remaining classes).

From this important archaeological inferences can be made: there are detectable differences in natural affordance for defensibility, most notably 13 sites described as hilltop do not exhibit natural affordance for defensibility. Descriptions such as “strategic position on the hilltop” are therefore insufficient for archaeological inferences regarding the natural affordance for defensibility.

The other criteria are considered in a similar vein. Regarding the *living conditions* approximately 1/6 do not have suitable living conditions, 2/3 have good or very good, and 1/6 have excellent living conditions (Figure 12). For further individual analysis the sites without suitable conditions and those with excellent conditions should be focused on in order to establish whether the living conditions of the sites influenced the composition of the finds. Should there be no noticeable differences, it would be a strong indication that these sites were not settled.

As far as *control* is concerned 1/10 of the sites have very poor control and 1/5 have excellent control (Figure 17). The former have high potential to be refuges and the latter to be military posts.

Roughly 1/9 of the sites don’t have *landscape presence* and 2/9 have excellent landscape presence (Figure 20). The latter have high potential to be type 1 symbolic sites, and the latter to be type 2 symbolic sites.

As the GIS approach only allows for the interpretations described above, we also tried to interpret selected sites the other way around. Some of them had already been investigated in detail by archeological means or described in written sources so we know about their function and usage. In the following, five examples shall be discussed. We know of military finds only from two (spurs from Karnburg and from Hemmaberg). However, Karnburg, Teurnia and St. Martin in Villach had similar functions, according to the written sources. Hemmaberg and Hochgosch also show similar attributes concerning their topographical environment. (Figure 22)

Hemmaberg

In the 6th c. a certainly very famous sanctuary was located on the Hemmaberg in south-eastern Carinthia. Next to various prehistoric phases it mainly comprised of at least 5 early-Christian churches, certain buildings for housing pilgrims, a range of infrastructure and a fortification wall. A grotto (today

⁶⁴ An overview in Edward B. Banning, *Archaeological Survey* (New York 2002), at 157–161; for the Early Medieval period, see: *Frühgeschichtliche Zentralorte in Mitteleuropa. Internationale Konferenz und Kolleg der Alexander von Humboldt-Stiftung zum 50. Jahrestag des Beginns archäologischer Ausgrabungen in Pohansko bei Břeclav, 5.–9.10.2009*, ed. Jiří Macháček/Šimon Ungerman (Břeclav/Bonn 2011).

“Rosaliengrotte”) directly underneath the hilltop’s plateau might also have played an important role for the sacred character of this place.⁶⁵ Sabine Ladstätter has analyzed the site’s material culture⁶⁶ and shown that with the advancing 6th c. a decrease of prosperity can be observed. It seems that at the end of this period the sacred buildings were in some cases no longer used for religious but rather for housing purposes. Also ceramics of the “Prague” type found there are interpreted as remains of an early Slavic population, which at that time began to dwell in the Eastern Alps. For the 7th c. no new buildings have been observed and it seems as if the “newcomers” – probably together with the remaining autochthonous people – still used the Roman hilltop settlement for habitation.⁶⁷ Around the middle or in the 2nd half of the 8th c. this place somehow seems to have been used again as the finds of two iron spurs show.⁶⁸ They were not found in defined archeological layers but in the humus directly underneath the surface. No architectural or other archeological features that can be dated to this period with certainty have been found. A rampart that has been erected using stones from late Antiquity walls might be connected to this phase but it has not yet been investigated in detail and a reliable dating is also not given.

The site of Hemmaberg was thus a very important and representative place in the Early Christian period. To place it on a hilltop might, of course, reflect the general situation when settlements were moved to better defensible terrain. Regarding the GIS-Analyses, Hemmaberg shows good defensibility. While the “field” value is average, accessibility is very poor, not to say inaccessible. This, of course, comes as a surprise and a contradiction to the site’s actual function, a place where many pilgrims are to be expected. Also, regarding the living conditions as defined in this article, the site is not suitable. Control is average and the landscape presence is excellent.

Teurnia

Teurnia/Liburnia – situated on a hill in the western part of modern-day Carinthia near Spittal an der Drau – was the late Roman capital of the province Noricum Mediterraneum. It was a bishopric and protected by a large city-wall as well as by the river Drau/Drava. As the capital city, administrative and political tasks were the most important ones here. However, at least two churches – one that of the bishop – also show the religious importance.⁶⁹ The city lacks distinct evidence for immediate further usage after the end of the late Roman period. The mention of a Church in “civitas Liburnia” – but with no clearly identified location as yet – for the time around 750 however allows speculation about Teurnia also being the centre of some elitist potentate during the Slavic era of Carantania.⁷⁰

⁶⁵ Franz Glaser, Das frühchristliche Pilgerzentrum auf dem Hemmaberg (Aus Forschung und Kunst 26, Klagenfurt 1991); ders., Eine weitere Doppelkirchenanlage auf dem Hemmaberg und die Frage ihrer Interpretation, in: Carinthia I 183 (1993) 165–186; id. Rettungsgrabung in St. Peter in Holz (Gem. Lendorf), in: Rudolfinum. Jahrbuch des Landesmuseums Kärnten 2004 (2005) 124.

⁶⁶ Sabine Ladstätter, Von Noricum Mediterraneum zur Provincia Sclaborum: Die Kontinuitätsfrage aus archäologischer Sicht, in: Slowenien und die Nachbarländer zwischen Antike und karolingischer Epoche. Die Anfänge der slowenischen Ethnogenese, ed. Rajko Bratož (Situla 39, Lubljana 2000) 219–240.

⁶⁷ Sabine Ladstätter, Die materielle Kultur der Spätantike in den Ostalpen, Eine Fallstudie am Beispiel der westlichen Doppelkirchenanlage auf dem Hemmaberg (Mitteilungen der Prähistorischen Kommission 35, Wien 2000).

⁶⁸ Erik Szameit, Zu Funden des 8. Jahrhunderts aus Kärnten, in: Acta Histriae II (1994) 89–92.

⁶⁹ On this site: Franz Glaser, Teurnia. Römerstadt und Bischofssitz. Ein Führer zu den Ausgrabungen und zum Museum in St. Peter in Holz sowie zu den Fundorten im Stadtgebiet von Teurnia (Klagenfurt 1992); ders., Teurnia – civitas Tiburnia, in: „Castellum, civitas, urbs“. Zentren und Eliten im frühmittelalterlichen Ostmitteleuropa, in: Castellum Pannonicum Pelsonense 6 (Rahden/Westfahlen 2015) 11–26; Stefan Eichert/Katharina Winckler, Von der metropolis Norici zum comitatus Lurniensis. Teurnia und sein Umfeld zwischen Spätantike und Hochmittelalter, in: Archäologie Österreichs 23/2 (2012) 35–45.

⁷⁰ Eichert/Winckler, Teurnia; Herwig Wolfram, Conversio Bagoariorum et Carantanorum. Das Weißbuch der Salzburger Kirche über die erfolgreiche Mission in Karantanien und Pannonien. Herausgegeben, übersetzt, kommentiert und um die Epistola Theotmari wie um gesammelte Schriften zum Thema ergänzt von Herwig Wolfram. Zweite, gründlich überarbeitete Auflage (Ljubljana² 2012) 66; Andrej Pleterski, Modestuskirchen und Conversio, in: Slowenien und die Nachbarländer zwischen Spätantike und karolingischer Epoche. Anfänge der slowenischen Ethnogenese, ed. Rajko Bratož (Situla 39 Ljubljana 2000) 425–476.

Finds of graves and grave goods from the 9th/10th, for example, found next to the Church of St. Peter in Holz,⁷¹ indicate the contemporary existence of the church and therefore it might have been the location of a respective surrounding settlement. The mentioning of a royal manor “curtis Liburnia” and a church may, of course, hint at these structures, but other locations for the aforementioned objects are also under discussion.⁷²

In late Antiquity and probably also in the Early Middle Ages, Teurnia – although at that time with an unclear location – was primarily an administrative and political centre.

While control is average, regarding our analyses, defensibility is not given. However, Teurnia is protected by the river Drau/Drava on one side and a wall on the other. Missing hilltop-terrain could, in this case, have been substituted by water and man-made defensive means. The accessibility is excellent. Living conditions are good, all other criteria are average.

Karnburg

The site of Karnburg has also been the focus of scholarly attention both from Carinthia and Slovenia from an early date as the prince’s stone (“Fürstenstein”) was originally located nearby. This stone and the Karnburg stronghold have become national symbols for both countries, which often caused national and ethnic interpretations by archeologists and historians.⁷³

Based on archeological evidence, one can reconstruct several phases of usage, although it has to be mentioned that only small-scale excavations have been carried out so far and that their results most probably do not represent the full spectrum of this site’s chronological, cultural and typological characteristics.⁷⁴ Based on what we know to date, a first dwelling phase can be observed in the 8th c. It is represented by the find of an iron spur and also by a ¹⁴C dating of the church’s foundation wall⁷⁵. The existence of a church at that time already points to a representative function. Also toponymical thoughts support this theory: the name of the 8th-c. Slavic principality Carantania could derive from this dominion’s main stronghold with central importance, which in this case must have been Karnburg (“Carantana”).⁷⁶

In the 9th c. the Slavic principality was incorporated into the Carolingian empire and the Slavic princes were replaced by Bavarian dukes. At least in the 2nd half of this century we know that Karnburg was a royal manor “curtis” and that even King Arnulf (emperor since 896) spent Christmas there in 888. The contemporary charters suggest that Karnburg was the main focal point of the royal power in Carantania and the crown’s most important base in the south-eastern periphery of the region. The mention of a “curtis” fits well with the archeological remains known to date.⁷⁷ For the 9th c. they do not necessarily point to a strongly fortified site but more probably to an economical and administrative centre. In the 10th c. Karnburg is mentioned as a “civitas” as well as the “sedes regalis” and an impressive fortification wall seems to have been erected sometime in that century. The Hungarian threat might be a possible reason for this modification. In the 11th c. the stronghold lost its importance and in the High and Late Middle Ages it is only mentioned as a village.

⁷¹ Franz Glaser, Neue Funde der Ostgotenzeit in Kärnten (493–536). Die Kirchen auf dem Hemmaberg und das Gräberfeld im Tal bei Globasnitz, in: Symposium zur Geschichte von Millstatt und Kärnten 2005, ed. Franz Nikolasch (Millstatt 2005) 23–55.

⁷² Eichert/Winckler, Teurnia.

⁷³ Stefan Eichert, Archäologie und ethnische Identitäten – Das Fallbeispiel Kärnten, in: Beiträge zur Mittelalterarchäologie in Österreich 29/2013 (2014) 263–271; Sabine Nikolay, Der Kärntner Fürstenstein im Bild. Darstellungen eines europäischen Rechtsdenkmals. Mit Beiträgen von Heinz Dopsch und Peter Štih (Klagenfurt-Celovec/Ljubljana-Laibach 2010).

⁷⁴ Die Karnburg. Forschungen zu Kärntens Königspfalz. 2006–2010, ed. Heimo Dolenz/Christoph Baur (Klagenfurt am Wörthersee 2011). On the discussion: Eichert, Strukturen 138–151; Paul Gleirscher, Die Karnburg im Kärntner Zollfeld: vom königlichen Wirtschaftshof zur Residenz des Gewaltboten, in: Mitteilungen des Instituts für Österreichische Geschichtsforschung 119 (Wien 2011) 287–310.

⁷⁵ Dolenz/ Baur, Karnburg 93–94; 121.

⁷⁶ Peter Štih, The Middle Ages between the Eastern Alps and the Norther Adriatic. Select Papers on Slovene Historiography and Medieval History (East Central and Eastern Europe in the Middle Ages, 450–1450 11, Leiden/Boston 2010).

⁷⁷ On the charters: Eichert, Strukturen 139.

In Karnburg we have archaeological and historical evidence for an administrative, political, economic, cultural and military centre. One would therefore expect certain characteristics for its position in the landscape. On the one hand this would be a high landscape presence and good living conditions. Also the control of the surrounding landscape must have been important. The defendability on the other hand does not seem to have been the most important factor as the fortification wall was erected only very late during the site's life-span. It should, however, be mentioned, that the place itself is already well protected against the Glan river valley by steep slopes. The low/average defensibility value may also result from the DEM resolution that does not properly show the small-scale differences in the elevation.

Villach St. Martin

The church of Villach St. Martin, on the right side of the river Drau/Drava was founded at least in the 10th c. as the remains of early graveyard burials have shown.⁷⁸ Until the 1960s massive remains of a surrounding rampart (up to 5 m high) around the churchyard could still be observed.⁷⁹ They have been removed due to the construction of new buildings and roads. Thus archaeological evidence points to an important fortified site with a church inside and therefore, most probably, also with representative duties. This theory is supported by a charter from the late 10th c. that tells us about “curtis”, “castellum” and “ecclesia” in Villach.⁸⁰ There are, of course, discussions on the exact location of these structures but St. Martin seems to be the most probable solution to this question. Further excavations inside the former fortified area have shown remains of walls as well as burials. Assuming that the archeologically and historically passed on structures are identical, St. Martin would be a representative political, religious and economical centre. It was protected against possible attackers on one side by the river and on the other by a wall or rampart.

The attributes of this site are average landscape presence and control, combined with excellent living conditions, accessibility and field value. However, the defensibility is non-existent. Similar to Teurnia, here we have a case where this is compensated for by a wall/rampart and the river.

Hochgosch

On a mountain ridge above the lake Millstätter See the fortified hilltop of Hochgosch is located.⁸¹ A wall constructed of earth and wood with a dry-stone wall at its front surrounds an area of 21,000 sqm. Due to radiocarbon and dendrochronological datings we know that this wall was erected in the middle of the 9th c.⁸² At that time this landscape was part of the region Liburnia, where a royal “curtis” of the same name is also mentioned in historical sources (see above). The site of Hochgosch has been investigated by a small-scale excavation. Except for the features mentioned above, no early medieval remains have been found: neither metal finds nor pottery or anything else that would provide definitive evidence of a permanent settlement of that time. So one interpretation is that it was a refuge or hideout, a fortification used only temporarily, that could be frequented in the event of danger.

It shows very low values regarding control combined with good defensibility. Living conditions such as, for example, a proximity to nearby fields can more or less be neglected.

For building castles at that time – at least in theory – the crown had to give its permission and a stronghold like Hochgosch was most probably erected under the king's influence.⁸³ As the royal manor “curtis Liburnia” must have been located nearby, it even seems possible that Hochgosch was the connected “castellum” to this manor. In this case we would have a division between administrative, religious and economical functions that were fulfilled by a non-fortified manor with a church in the valley and military functions, held by Hochgosch on the mountain top.

⁷⁸ Eichert, Strukturen 175–178 (with further bibliography).

⁷⁹ Wilhelm Neumann, Zur Geschichte von Burg und Stadt Villach, in: Bausteine zur Geschichte Kärntens, Spätlese (Das Kärntner Landesarchiv 33, Klagenfurt 2005) 193–225, at 202.

⁸⁰ Eichert, Strukturen 175.

⁸¹ Kordula Gostenčnik, Die frühmittelalterliche Befestigungsanlage auf dem Hochgosch bei Molzbichl, Kärnten, Die Grabung 1987, in: Archaeologia Austriaca 81 (1997) 255–271; Eichert, Strukturen 96–101.

⁸² Huber 2009, 153–155.

⁸³ Eichert, Strukturen 282–283.

SUMMARY

Teurnia, Karnburg and Villach St. Martin represent settlements that were permanently used and held a central administrative meaning for the surrounding landscape. In many cases churches also indicate the religious function. In the 9th and 10th c. they were mentioned as “curtis” in contemporary charters. Usually such curtes are located in valleys or basins and not fortified. They are often the cornerstones of today’s villages. This fits well with what we know from early medieval “leges”, that tell us that the manor was not to be surrounded by a wall. At the most a wooden fence was allowed. However the cases given above are different: although they contain fortification walls they are mentioned as “curtis”. In Karnburg we can observe a development from a “curtis” in the 9th c. to a fortified “civitas” in the 10th c. There a change of meaning, legal status and terminology goes along with a change of architectural structures. From Karnburg comes an iron spur. Given Karnburg’s central character, this spur might best be explained by the presence of military forces on the site.

As explained above, Villach St. Martin is mentioned in a charter that tells us about “curtis”, “castellum” and “ecclesia”. Here all three functions seem to be united in one place. The function is the same as the one of a “regular” manor. One important difference concerns its architectural design: it is well-protected due to artificial elements like walls and ramparts in combination with natural features like steep slopes and the river. The combined mentioning of “curtis” and “castellum” for one site might probably point to such cases where manors were fortified

The three examples discussed show similar GIS-attributes. A common one is a lack of defensibility. They are actually not hilltop settlements but built in the valleys or basins on a slightly elevated terrain. However this “disadvantage” is compensated for by walls/ramparts and/or by nearby floating rivers.

Another category of sites we know by archeological and historical evidence are sites with a mainly protective function. They did not serve as civil settlements and were often used only temporarily:

In a charter from 888 King Arnulf orders his fellow Heimo to organize the construction of a “castellum” and instructs him to take care of its custody afterwards.⁸⁴ As at that time no standing armies are to be expected for the Eastern Alps it seems most probable that this did not include a permanent garrison but rather the maintenance of the buildings and walls. Such a site must have been used only as and when required. From an archeological viewpoint, the Hochgosch may be an example of such a type of site. Built in the crown’s immediate area of influence (the nearby royal “curtis Liburnia”) but in a well-hidden/hardly visible location it might have served as a separate refuge to retreat to and defend in times of danger.

Hemmaberg shows similar GIS-attributes to Hochgosch. One reason for the spurs found there could be that it had been used as a refuge in the 8th century. However, one could also think of a similar explanation as for Gradišče above Bašelj⁸⁵ and discuss intentional deposition.

5 CONCLUSION

The aim of this article is to shed additional light on the landscape context to the hilltop sites with Early Medieval military finds in the Eastern Alpine area. The most important conclusion is that the sites in question are not positioned in a uniform environment as suggested by the generic description hilltop.

The exciting results (Figs. 19 and 20) should not be mistaken for the final interpretation. Rather, the results can serve as an additional argument in interpretation of individual sites as demonstrated above. The Mali grad and Na Bleku sites have been used to demonstrate the validity of the GIS analysis since the results confirmed previously existing interpretations. Using the study case of the Gradišče above Bašelj we demonstrated the input of the GIS analysis in scholarly ambiguity regarding the site’s interpretation⁸⁶.

⁸⁴ Eichert. Strukturen 282–283.

⁸⁵ See Štular this volume.

⁸⁶ See Štular this volume.

For further individual analysis, the outlier sites should be focused on. For example, a comparison of the finds between the positive and negative outliers on the one hand and between the outliers and average sites on the other hand should establish whether any of the above criteria influenced the composition of the finds. Should there be no noticeable differences in defensibility and living conditions it would be a strong indication that these sites were not settled (for military purposes or otherwise), i.e. it is more likely that this entire phenomenon is to be viewed as hoards or similar. Should there be noticeable differences in landscape presence, this would be a strong indicator that places of special importance in the Early Medieval Eastern Alpine area were chosen according to visual properties. And vice versa.