Archaeological Research at Păuleni Ciuc, Harghita County

Cuvinte cheie: Păuleni Ciuc, Transilvania, Aşezare, fortificaţii, georeferenţiere
Key words: *Păuleni Ciuc, Transylvania, Settlement, Fortifications, georeferenced data*

Rezumat

Acest raport prezintă implementarea Sistemul de georeferenţiere (GIS) în activitatea arheologică de la Păuleni Ciuc, judeţul Harghita pe parcursul campaniei din anul 2010. Sistemul de georeferenţiere este unul care cuprinde o serie de unelte folosite la crearea, depozitarea şi reprezentarea unor date spaţiale. Echipa de cercetare a implementat sistemul GIS la două niveluri. În prima fază am construit o bază de date pentru sit pentru reprezentarea diferitelor contexte arheologice (complexe, artefacte, mostre) descoperite sau preluate pe parcursul cercetării de teren. Baza de date a fost construită în primul rând din planurile şi fotografiile săpăturii, georeferenţiate la caroiajul sitului. În al doilea rând, am coordonat măsurători topografice pe o suprafaţă de 0,65 km^2 din jurul sitului cu o unitate GPS Garmin. Raportul prezintă folosirea iniţială a acestor date la crearea unui model tridimensional pe care dorim să îl realizăm pe viitor pentru analiza vizibilităţii aşezării de la Păuleni-Ciuc, Ciomortan, "Dâmbul Cetăţii", jud. Harghita.

During the 2010 research excavation at Păuleni Ciuc, the Muzeul Naţional al Carpaţilor Răsăriteni and ArchaeoTek teams began collecting spatial data in order to implement Geographic Information Systems (GIS) research at the site. The following article details the preliminary results of the GIS research, as well as the archaeological data and research procedures necessary to produce this data.

The archaeological site of Păuleni Ciuc is located in the foothills above the village of Şoimeni in Harghita County, approximately eight kilometers northeast of the city Miercurea Ciuc (Figure 1). The site is located in a small saddle between two peaks, at a point recessed from the Ciuc Depression[1]. Due to the interesting location of the settlement within the Ciuc Mountains, constructing a landscape model of the site became a high priority during the 2010 field season. The archaeological site was occupied during the Eneolithic (Cucuteni-Ariuşd culture), the transition period (Coţofeni culture) and Middle Bronze Age (Costişa-Ciomortan and Wietenberg cultures)[2].

The site was first identified by Al. Ferenczi, and explored in the 1950s and 1960s by Z. Székely. Following this initial research, studies at the site remained dormant for some time, until archaeological research resumed in 1999 under the direction of V. Kavruk. In 2010 the author joined the excavations with the Archaeotek team, with the stated objectives of developing a GIS procedure to facilitate further archaeological research.

A geographic information system is a potent suite of tools used for the construction, curation, and analysis of spatial data. Although GIS is frequently associated with computer mapping, applications extend further than this to incorporate the logics of representing complex real-world phenomena in a digital environment. Therefore, for archaeologists a GIS is best envisioned as a toolkit for examining questions of space. Two distinct GIS applications used in the research at Păuleni Ciuc are presented in this report: the construction of a geographic database (geodatabase) for intra-site research, and the creation of topographic data for landscape research.

Geographic Information Systems in Archaeological Research

Before reporting the work done at Păuleni Ciuc, a few words must be said about the state of GIS in particular, of computational / digital methods in general, and their role in the field of archaeology. While the inclusion of digital methods can prove beneficial to any science, practitioners must be careful to avoid an overreliance on any new technology or method[3]. Indeed, following a perhaps over-eager effort to include GIS models in archaeological research, many scholars became skeptical of viewing the software as more than a useful tool[4], while others advocated a critical evaluation of the applied methods[5].

Aldenderfer[6] noted three uses for GIS in archaeology: to more efficiently complete

tasks we could already do; to attempt analyses which were previously too complex; and to use emerging digital technologies to challenge and revolutionize our way of thinking. Contention within archaeological circles has been in response to that final claim. While some archaeologists have effectively used digital environments to develop new methods of examining archaeological data[7], other GIS practitioners have criticized the "push-button" nature of poorly designed models[8]; and others still remain skeptical of approaching archaeological research in the heavily quantitative and empirical terms demanded by a digital system[9].

In light of these concerns, it is important to note that among geographers a distinction is made between a GIS as a toolkit and the larger theory which is necessary to link spatial data and representation systems, called Geographic Information Science (GISci). Prior to the 1990s, GIS was seen as a digital butler, simply expediting complex calculations[10]. In response, geographers developed an agenda for improving GI Systems, resulting in GI Science. Mark[11] surveyed the research agenda proposed in the 1990s, noting that GISci bears more than a passing resemblance to Information Science. Based on this similarity, GISci is defined a field which seeks to understand the creation, storage, and use of geographic information by investigating ontology and representation, cognition, and the relation between computers and academic and social institutions[12]. Therefore, in a broad sense, geographic information science is not limited to the software necessary to produce digital maps; it is the larger science of information and its representation which, by definition, informs the use of digital spatial data.

Although this summary is brief and incomplete, it should demonstrate that, as a field of study, GIS is expansive and varied, and its role in archaeological research is similarly diverse. GIS can refer to, on the one hand, the use of software to produce digital maps, the management of archaeological geodatabases, and a suite of geostatistical applications, or to a theoretical inclination to use digital systems to radically reorient archaeological research.

Applying GIS to the archaeological Research at Păuleni Ciuc

While there is much epistemic debate about the role of GIS in archaeological research, the geodatabase structure has proven very effective in recording and modeling archaeological data. The growth of archaeological GIS in the United States is due in part to government mandates which required databases to be used in the management of cultural heritage material[13] and in many regions large archaeological databases have become the norm[14]. Concepts borrowed from GISci research, in particular ontology and database design, have proven useful to constructing field recording protocols[15] or archaeological databases[16]. At the level of archaeological field research, GIS provides a number of tools which archaeologists may deploy to significant effect.

Thus, while the complexity of GIS in archaeology must be acknowledged at a theoretical level, there is also a pragmatic argument for applying digital systems to archaeological field research. By focusing on data production this paper highlights the technical benefits of using GIS, particularly geodatabases, in archaeological research.

GIS can be applied at multiple scales of archaeological research: to represent entities in archaeological excavation; to build models of the local landscape around an archaeological site; and to represent multiple sites and their inventories at a regional level. The first two methods are examined here[17].

Intra-Site Applications: Mapping trench features

At the intra-site, or *'trench'* scale, the flexibility of the geodatabase approach can be used to generate detailed and varied maps. Unlike traditional or computer-aided drafting, the basic data components within a GIS are vector and raster datasets, rather than maps. Therefore, the construction of a map begins with the construction of a database. Within it, each distinct type of phenomena is represented by a feature class, containing attribute data and possessing relations to other feature classes. In order to represent the spatial character of the data, these feature classes may be represented by point (0d), line (1d),

or polygon (2d) geometry. The feature classes may also be joined to additional attributes (fields) just as in other database software, such as Zeus[18]. The software used in this report is ESRI's ArcINFO and ArcMap.

Before the geodatabase can be constructed, the feature classes must be identified. Since every distinct geographic feature must be represented by a separate feature class, the overall structure can be quite large. The geodatabase schema for the excavation at Păuleni Ciuc contains 16 features classes within three datasets (Figure 2). This schema is designed to support the production of maps for the excavation, and may need to be modified for some forms of analysis. For example, a density or spatial correlation analysis of artifacts would require each artifact to be represented by a single zero dimensional point, rather than by a two dimensional shape. In these instances the database may be expanded by importing new or modifying preexisting feature classes.

Three forms of data were used to populate the geodatabase: unit plans, photographs, and global positioning system (GPS) coordinates of the Păuleni Ciuc grid system. The unit plans provide the majority of the data used to construct the maps. Once scanned, the unit plans or photographs may be imported into ArcMap and digitized. First, the plans and photographs must be georeferenced, or rotated and scaled to correspond to their actual geographic footprint (Figure 3). Using a Garmin GPSmap 60Csx, four posts on the site grid were measured. The Garmin unit has an accuracy of approximately three meters when used for instant measurements[19]. However, the GPS may be set to continuously measure location, increasing the accuracy to the sub-meter level. Each grid post was measured using this method for six hours on a clear day, leading to an accuracy of approximately 30cm for the grid posts. Once these four measurements were entered into ArcMap, it was possible to calculate the remaining grid.

This grid measurement in turn provided the framework for referencing unit plans. As long as two grid posts are recorded in each plan, the plan can be digitally moved, rotated, and enlarged until the two grid posts correspond to the actual coordinates within the GIS. The process is more complicated for photographs. Since photographs, unlike

plans, are often taken from a slightly oblique rather perpendicular angle extra transformations are required to flatten the image. In these cases, the photo is *'stretched'* using second or third order polynomial transformations to fit the input coordinates, a process which results in some distortion and error[20]. Therefore, plans are the preferred base data for digitization.

Once georeferenced, any point on the plan or photograph now corresponds to a real world location, and the relevant features may be traced through guided or automated methods in ArcMap. For less complicated data it is possible to automate the process using the ArcScan extension. However, in the author's experience this can often lead to errors with more complex data, such as the stone layer depicted in Figure 4. In these instances, the data should be digitized manually to ensure its quality.

As stated before, the basic unit of ArcGIS is not the map but the vector and raster data. The process listed here produces shapefiles (the file type containing coordinate and feature data) linked in the conceptual scheme shown in Figure 2. Each shapefile exists independently in the geodatabase, making it possible to combine them in any sequence in a map (Figure 5). This geodatabase structure allows maps to be generated *'on the fly'* to meet the user's needs. The selected data may be further finessed by querying the attribute tables within the feature classes (e.g. *"select all stones with an area > 100cm2"* or *"select all artifacts overlapping complex 17"*), allowing maps to be quickly generated to meet the requirements of analysis or publication.

Landscape Applications: Building a 3D surface model

Intra-site applications primarily make use of the flexibility of the geodatabase and ArcMap platform, but do not require additional alteration of the data. They differ from landscape scale (defined here as the site plus its immediate surroundings) methods which use functions within ArcMap to create new data. The second application explores how these functions – interpolation techniques and triangular irregular network (TIN) creation – can be used to develop a three dimensional model of the landscape using coordinate data collected from Păuleni Ciuc during the 2010 season.

The same Garmin GPS unit was used to collect topographic data, using two survey methods: a continuous measurement of points every ten meters, and a 60-90 second measurement of points along prominent topographic features. Since spatial interpolators and triangular irregular networks were used to create the elevation and three dimensional models, a regular survey grid was not necessary. A non-gridded survey approach, in which the density of measurements corresponds to the degree of variation in topography, will produce results that better reflect the landscape (Fletcher and Spicer 1988). However, while higher resolution surveying will produce better results, the noise resulting from the GPS error will also become more apparent, necessitating longer recording times.

While the GPS data can be displayed directly in the GIS as a three dimensional point cloud or wireframe, the data may be interpolated to create a continuous surface. Interpolation is used to convert the discrete measurements from the GPS survey into a continuous field of data by estimating values at unknown locations based on nearby measured values[21]. Since elevation values are interpolated, the created raster set is a digital elevation model (DEM). Interpolation methods are classified based on a number of attributes: whether the operations are local or global, constrained or unconstrained, and exact or approximate[22]. Local operations draw only on nearby known values to estimate the unknown value, while global operations use all known values. Therefore, a global operation is more likely to produce a smooth surface but is susceptible to aberrations caused by unusually high values, while unusually high values will create only localized steps or peaks in a local operation. An interpolator is constrained if the estimated value cannot be higher or lower than the known values used to calculate it, unconstrained if the estimated value can exceed the range of known values. Finally, an interpolator is exact if the resulting surface passes through all known values, and approximate if the resulting surface does not pass through all known points.

Numerous methods of spatial interpolation were developed to emphasize different combinations of these parameters. Two methods for the topography model are examined here:

inverse distance weighting (IDW) and natural neighbor (NN). IDW is a local, exact, and unconstrained interpolator which heavily weights the closest values when calculating an unknown value. IDW is also a trend model: it is based on the assumption that the pattern of the analyzed data fits a mathematical trend. Trend models are similar to regression analysis in three dimensions and most effective when the underlying patterns are relatively simple[23]. Since IDW is a localized model, it can result in surfaces with a great degree of noise unless a larger number of known values are included in each calculation. However, the hilly topography around Păuleni Ciuc cannot be described by a simple model, and so increasing the number of inputs results in a model with less fit. The surfaces created by the IDW interpolator for Păuleni Ciuc created a series of false peaks and steps in areas where the elevation changed suddenly, such as on the southern slope of the site (Figure 6).

By contrast, the Natural Neighbor interpolator is a local, constrained, and exact operation which uses Voronoi polygons to calculate a surface[24]. In a NN operation, Voronoi polygons are calculated for all known values, and then a second set of Voronoi polygons are calculated for the known and unknown values. Weights are assigned to the known values using the overlap between the first and second set of Voronoi diagrams, and the weighted known values are in turned used to calculate each unknown value. Since NN is a constrained and exact approach, it cannot approximate the extreme variation in the topography that was not recorded, such as the bottom of a stream depression or the top of a peak. However, a non-gridded survey strategy can account for these variations. Unlike IDW, NN did not produce the same artificial steps, and was chosen for this project for that reason (Figure 7). The interpolated surface represents a $0.65km^2$ area around the site at a cell resolution of 5m.

The DEM created by spatial interpolation can be projected in three dimensions. Alternatively, the DEM may be used to create a triangular irregular network, or TIN (Figure 8). A TIN is a vector model: the landscape is represented by a series of nodes (points) with elevation values and triangular faces drawn between these nodes. The faces are created by selecting a set of points according to

Delaunay triangulation, "*… in which the resulting triangles are closest to equilateral, and in which the circles whose circumferences pass through the points of the triangles contain no other points*" [25]. To better situate the survey area in the Ciuc Depression, a second TIN was generated from ASTER Global DEM satellite data with a 30m resolution to be used as a backdrop (Figure 9).

Conclusion

The two applications presented above only demonstrate how a GIS can be used to enhance and curate (in the case of the intra-site work) or create new (in the case of the landscape study) spatial data. Once these data are created, archaeologists may choose to move beyond storage and representation and into the realm of spatial statistics and analysis. As discussed earlier, the degree to which archaeologists implement spatial analysis is constrained not only by the ability of their data to meet necessary statistical assumptions, but also by their own attitude towards using empirical and quantitative methods to examine archaeological data. With this caution in mind, we examine the possibilities for using the elevation models to construct viewsheds and examine the visual affordance of the landscape near the Păuleni Ciuc site.

In the context of digital analysis, affordance is a concept which emphasizes the relation between an individual's perception and the visible environment[26]. Visual affordance can refer to prominence (how much is visible from a point, or the extent to which that point is visible), intervisibility, and to more abstract senses of openness or closeness[27]. Each of these analyses is dependent on line-of-sight or viewshed functions found within a GIS. The line-of-sight function determines whether an uninterrupted line can be traced between two points within a landscape (Figure 10), while a viewshed uses the aggregate of these lines-of-sight to measure the total visible area from a given point (Figure 11). Viewsheds, in turn, can be aggregated into a cumulative viewshed analysis (CVA) which measures the total area visible from every point on the landscape (Figure 12)[28]. These methods are not ends in themselves, but rather means to model or re-conceptualize past landscapes. For example, the CVA

created for the area between Păuleni Ciuc and the nearby Mt. Șumuleu suggests the location was not selected for a commanding view of the region.

The three visibility models presented here should be considered as tentative work, meant to provide examples of the functions rather than to guide analysis. In the two decades since viewshed analysis has entered the archaeological repertoire numerous theoretical and methodological issues[29]. Line-of-sight analysis is highly susceptible to errors in the input data: a 4m resolution, well beyond the accuracy of most available data, is ideal[30]. Furthermore, in areas such as the Ciuc Depression, visibility cannot be modeled without considering the effects of solitary trees and forests. While there have been successful efforts to estimate the location of vegetation around sites[31] and incorporate vegetation into viewshed analysis[32], these methods require the construction and testing of well-informed digital models. Therefore further work is necessary before visibility models of the Ciuc Depression become reliable enough to serve a role in archaeological interpretation. However, while the methodological issues are addressed, there is still the need for topographic surveys of archaeological sites and construction of DEMs and TINs to provide crucial high-resolution elevation data.

This has been only a preliminary report of the utility of geographic information systems in archaeological research. Even so, the benefits of incorporating geographic information systems into intrasite and landscape research should be apparent. A properly constructed site GIS provides not only a powerful framework for representing and examining spatial data, but the foundation for designing new forms of enquiry. Although this project uses ESRI's ArcGIS platform, free and open source (FOSS) programs are available. Archaeologists have used the GRASS platform in particular as an alternative to ArcGIS. For the purposes of database creation and curation, GRASS and Udig both free alternatives which offer much of the functionality present in ArcGIS[33].

The importance of a geographic information science to archaeological research should not be understated. GISci grew from the efforts of geographers to properly situate new digital techniques in the larger methods and practices of their discipline. Although

archaeology shares many characteristics with geography, archaeological data is complex in ways that geographic data is not, namely in the importance of stratigraphy and temporal issues. An archaeological information science, which develops protocols for the recording and curation of archaeological data in perpe-tuity, may soon become a reality[34]. It is the author's hope that presenting the techniques used to incorporate GIS research into the archaeological project at Păuleni Ciuc will stimulate further discussion and exploration of archaeological data and its spatial repre-sentations.

Raymond Whitlow

Note / *Notes*

1. **Cavruc 2000**, p. 173
2. **Buzea 2006**, p. 128-9
3. **Zubrow 2006**, p. 14-5
4. **Stoddart 1997**
5. **Wheatley 2004**
6. **Aldenderfer 1992**, p. 14
7. **Kohler et alii 2008**, p. 79-83; **Lake and Woodman 2003**; **Llobera 2007a**
8. **Wheatley and Gillings 2000**, p. 2
9. **Thomas 1993**; **Wickstead 2009**
10. **Goodchild 2006**, p. 200
11. **Mark 2003**, p. 5
12. **Mark 2003**, p. 14, 8-12
13. **Kvamme 1998**, p. 127
14. **Plog and Most 2006**
15. **Katsianis et alii 2008**; **Tripcevich 2004**
16. **Tennant 2006**
17. for a discussion of the third scale see **Kvamme 1999**, p. 162-4, 169-74; **McCoy and Ladefoged 2009**, p. 270-1

18. **Tarcea and Lazarovici 1996**
19. **Wing and Eklund 2007**, p. 92
20. **Conolly and Lake 2006**, p. 86-89
21. **Hageman and Bennett 2000**, p. 115
22. **Wheatley and Gillings 2002**, p. 184
23. **Wheatley and Gillings 2002**, p. 187, 189
24. **Sibson 1981**
25. **Wheatley and Gillings 2002**, p. 149
26. **Gillings 2009**, p. 341; **Llobera 2001**, p. 1007
27. e.g. **Llobera 2006**
28. **Lake et al 1998**; **Wheatley 1995**
29. **Conolly and Lake 2006**, p. 228-233
30. **Riggs and Dean 2007**, p. 193
31. **Gearey and Chapman 2006**
32. **Dean 1997**; **Llobera 2007b**
33. **Steiniger and Hay 2009**, p. 192, Table 2
34. **Arroyo-Bishop and Zarzosa 1995**, p. 52

Bibliografie / *Bibliography*

Aldenderfer 1992
ALDENDERFER M., *The state of GIS and anthropological research*, în *Anthropological Newsletter*, no. 3:14

Arroyo-Bishop and Zarzosa 1995
ARROYO-BISHOP D., LANTADA ZARZOSA M. T., *To be or not to be: will an object-space-time GIS/AIS become a sci-entific reality or end up ian archaeological entity?* în *Archaeology and Geographical Infroamtion Systems: A European Perspective*, edited by G. LOCK AND Z. STANČIČ, Taylor and Francis, London, p. 43-53

Buzea 2006
BUZEA D., *Models of Altars and Miniature Tables Belonging to the Cucuteni-Ariușd Culture, discovered at Pauleni Ciuc-Ciomortan „Dambul Cetatii" Hargita County*. în *Acta Terrae Septemecastrensis*, nr. 5, Sibiu, 2006, p. 127-158

Conolly and Lake 2006
CONOLLY J., LAKE M., *Geographical Information Systems in Archaeology. Cambridge Manuals in Archaeology*, Cambridge University Press, Cambridge, 2006

Dean 1997
DEAN J. D., *Improving the accuracy of forest view-sheds using triangulated networks and the visual perme-ability method*, în *Canadian Journal of Forestry*, nr. 27, 1997, p. 969-977

Fletcher and Spicer 1988
FLETCHER M., SPICER D., *Clonehenge: an experiment with gridded and non-gridded survey data.* În *Computer and Quantitative Methods in Archaeology*, edited by Rahtz, S. P. Q., B.A.R. International Series, 446, Oxford, 1988 p. 309-324.

Gearey and Chapman 2006
GEAREY B. R., CHAPMAN H. P., *"Digital Gardening". An approach to simulating elements of palaeovegetation and some implications for the interpretation of prehis-toric sites and landscapes*, în *Digital Archaeology: bridg-ing method and theory*, edited by T. L. EVANS and P. DALY, Routledge, New York, 2006. p.171-190

Gillings 2009
GILLINGS M., *Visual Affordance, Landscape, and the Megaliths of Alderney*, în *Oxford Journal of Archaeology*, nr. 28(4), 2009, p. 335-356

Goodchild 2006
GOODCHILD M. F., *Geographic information science: fif-teen years later*, în *Classics from IJGIS: Twenty years of the International Journal of Geographical Information Science and Systems*, edited by. P. F. FISCHER, CRC Press, 2006, Boca Raton, p. 199-204

Hageman and Bennett 2000

HAGEMAN J. B., BENNETT D. A., *Construction of Digital Elevation models for Archaeological Applications*, în *Practical Applications of GIS for archaeologists: a predictive modeling toolkit*, edited by K. L. WESCOTT AND R. J. BRANDON, Taylor and Francis, 2000, New York, p. 113-127

Katsianis et alii 2008

KATSIANIS M., TSIPIDIS S., KOTSAKIS K., KOUSOULAKOU A., *A 3D digital workflow for archaeological intra-site research using GIS*, în *Journal of Archaeological Science*, nr. 35, p. 655-667

Cavruc 2000

CAVRUC V., *Repertoriul Arheologic al Judeţului Harghita. Seria Monografii Arheologice II,* Muzeul Carpaţilor Răsăriteni, 2000, Sfântu Gheorghe

Kohler et alii 2008

KOHLER T. A., JOHNSON C. D., VARIEN M., ORTMAN S., REYNOLDS R., KOBTI Z., COWAN J., KOLM K., SMITH S., YAP L., *Settlement Ecodynamics in the Prehispanic Central Mesa Verde Region*, în *The Model-Based Archaeology of Socionatural Systems*, edited by T. A. KOHLER AND S. E. VAN DER LEEUW, School for Advanced Research Resident Scholar Series, School for Advanced Research Press, 2008, Santa Fe. p. 61-104

Kvamme 1998

KVAMME K. L., *GIS in North American Archaeology: A summary of activity for the Caere Project,* în *Archeologia e Calcolatori*, nr. 9, 1998, p. 127-146

Kvamme 1999

KVAMME K. L., *Recent Directions and Developments in Geographical Information Systems*, în *Journal of Archaeological Research*, nr. 7(2), 1999, p. 153-201

Lake and Woodman 2003

LAKE M. W., WOODMAN P. E., *Visibility studies in archaeology: a review and case study*, în *Environment and Planning B: Planning and Design*, nr. 30, 2003, p. 689-707

Llobera 2001

LLOBERA M., *Building Past Landscape Perception with GIS: Understanding Topographic Prominence*, în *Journal of Archaeological Science*, nr. 28, 2001, p. 1005-1014

Llobera 2006

LLOBERA M., *The nature of everyday experience: examples on the study of visual space*, în *Re-Presenting GIS*, edited by D. UNWIN AND P. FISHER, Wiley & Sons, 2006, London, p. 127-134

Llobera 2007a

LLOBERA M., *Reconstructing visual landscapes*, în *World Archaeology*, nr. 39(1), 2007, p. 51-69

Llobera 2007b

LLOBERA M., *Modeling visibility through vegetation*, în *International Journal of Geographic Information Science*, nr. 21(7), 2007, p. 799-810

Mark 2003

MARK D. M., *Geographic Information Science: Defining the Field*. În *Foundations of Geographic Information Science*, edited by M. DUCKHAM, M. F. GOODCHILD AND M. F. WORBOYS, Taylor and Francis, 2003, New York. p. 3-18

McCoy and Ladefoged 2009

MCCOY M. D., LADEFOGED T. N., *New Developments in the Use of Spatial Technology in Archaeology*, în *Journal of Archaeological Research*, nr. 17, 2009, p. 263-295

Plog and Most 2006

PLOG S., MOST R., *Digital databases in archaeological research*, în *Managing archaeological data: essay in honor of Sylvia W. Gaines*, edited by J. L. HANTMAN AND R. MOST, Arizona State University Press, 2006,Tempe p. 29-37

Riggs and Dean 2007

RIGGS P. D., DEAN D. J., *An Investigation into the Causes of Errors and Inconsistencies in Predicted Viewsheds*, în *Transactions in GIS*, nr. 11(2), 2007, p. 175-196

Sibson 1981

SIBSON R., *A brief description of natural neighbor interpolation*, în *Interpreting Multivariate Data*, edited by V. BARNET, Wiley and Sons, 1981, Chichester, p. 21-36

Steiniger and Hay 2009

STEINIGER S., HAY G. J., *Free and Open Source Geographic Information Tools for Landscape Ecology* în *Ecological Informatics*, nr. 4(4), 2009, p. 183-195

Stoddart 1997

STODDART S., *GIS: a useful research technique, not an end in itself*, în *Archaeological Dialogues*, nr. 4(1), 1997, p. 65-70

Tarcea and Lazarovici 1996

TARCEA L., LAZAROVICI GH., *Zeus: Sistem pentru gestiunea şi prelucrarea datelor arheologice*, în *ActaMN*, nr. 33(1), 1996, p. 683-689

Tennant 2007

TENNANT E. W., *A Sample Geodatabase Structure for Managing Archaeological Data and Resources with ArcGIS*, în *Technical Briefs in Historical Archaeology*, nr. 2, p. 12-23

Thomas 1993

THOMAS J., *Politics of vision and the archaeologies of landscape*, în *Landscape Politics and Perspectives*, edited by B. BENDER, 1993, Berg, Oxford, p. 19-48

Tripcevich 2004

TRIPCEVICH N., *Flexibility by Design: How mobile GIS meets the needs of archaeology survey*, în *Cartography and Geographic Information Science* 31(3), 2004, p. 137-151

Wheatley 1995

WHEATLEY D., *Cumulative viewshed analysis: a GIS-based method for investigating intervisibility, and its archaeological applications*, în *Archaeology and Geographical Information Systems: A European Perspective*, edited by G. LOCK AND Z. STANČIČ, Taylor and Francis, 1995, London, p. 171-186.

Wheatley 2004

WHEATLEY D., *Making space for an archaeology of place*, în *Internet Archaeology*, 15, 2004, http://intarch.ac.uk/journal/issue15/wheatley_index.html

Wheatley and Gillings 2000

WHEATLEY D., GILLINGS M., *Vision, perception, and GIS: developing enriched approaches to the study of archaeological visibility*, în *Beyond the Map: Archaeology and Spatial Technologies*, edited by G. LOCK, IOS Press, 2000 Amsterdam. p.1-27

Wheatley and Gillings 2002

WHEATLEY D., GILLINGS M., *Spatial Technology and Archaeology. The Archaeological Applications of GIS*. Taylor and Francis, 2002, London

Wickstead 2009

WICKSTEAD H., *The Uber Archaeologist. Art, GIS and the male gaze revisited*, în *Journal of Social Archaeology*, nr. 9(2), 2009, p. 249-271

Wing and Eklund 2007

WING M. G., EKLUND A., *Elevation Measurement Capabilities of Consumer-Grade Global Positioning Systems (GPS) receivers*, în *Journal of Forestry*, nr. 105(2), 2007, p. 91-94

Zubrow 2006

ZUBROW E. B. W., *Digital Archaeology. A historical context*, în *Digital Archaeology: bridging method and theory*, edited by T. L. EVANS AND P. DALY, Routledge, 2006, New York, p. 10-23
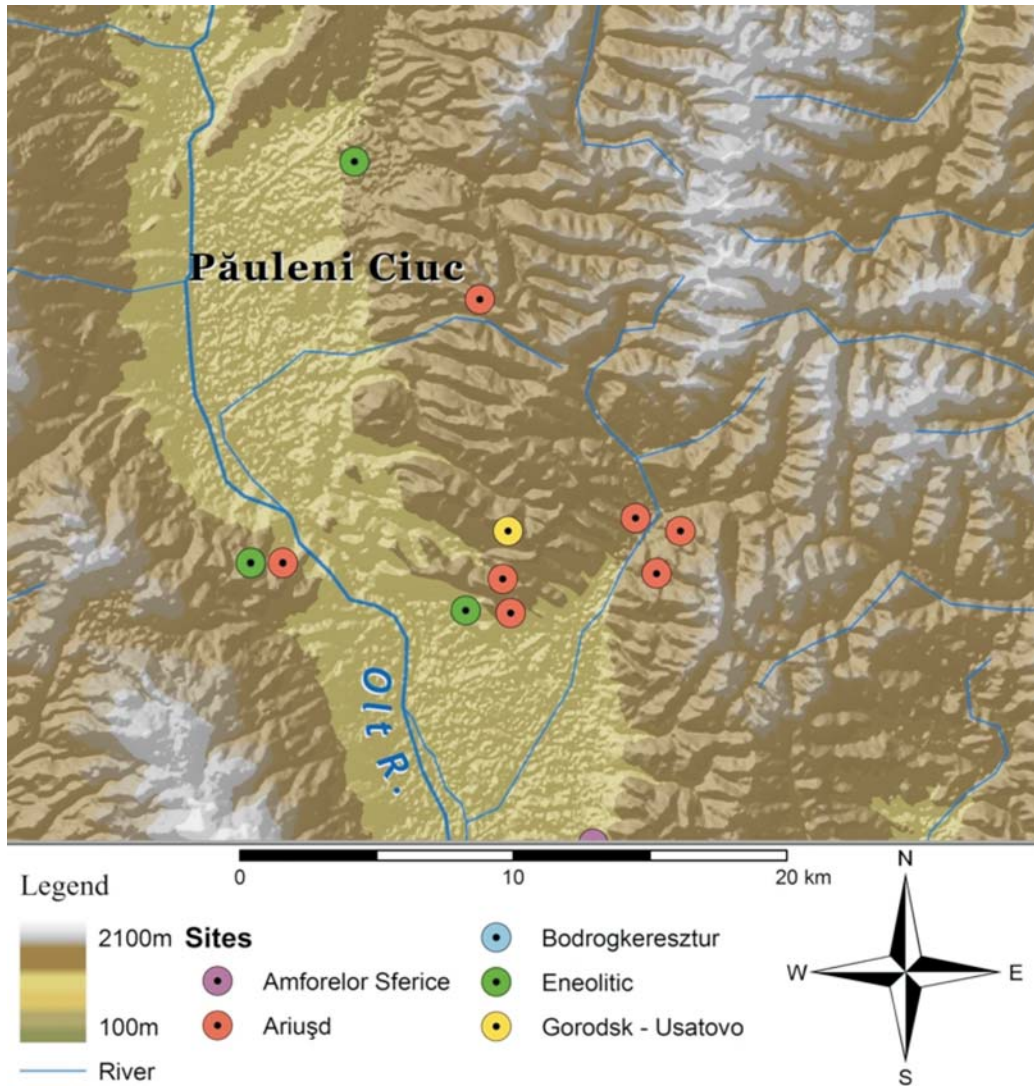
Figure 1 / *Figura 1*
Map of the Păuleni Ciuc site within the Ciuc Depression
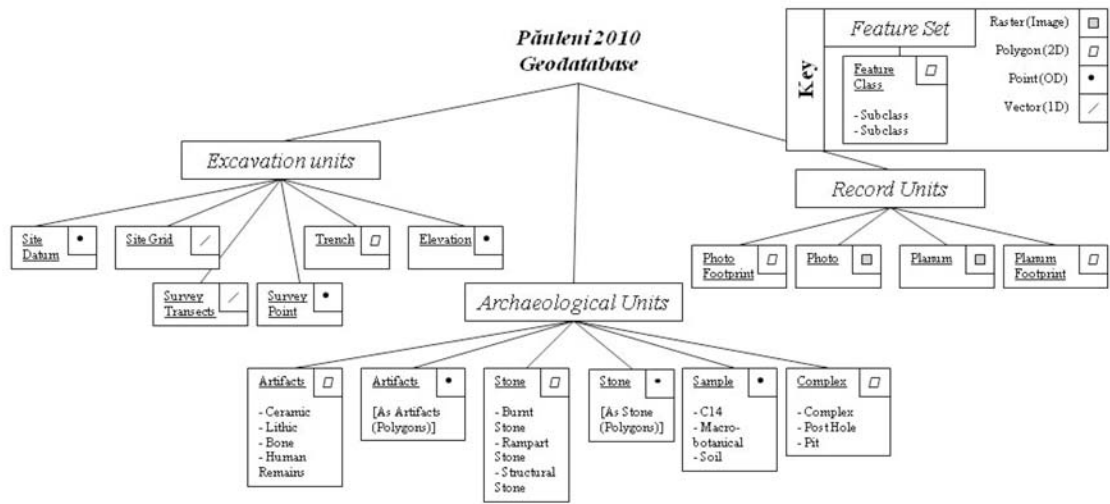*Harta sitului de la Păuleni Ciuc în interiorul Depresiunii Ciucului*

Figure 2 / *Figura 2*
Geodatabase Schema for Păuleni Ciuc
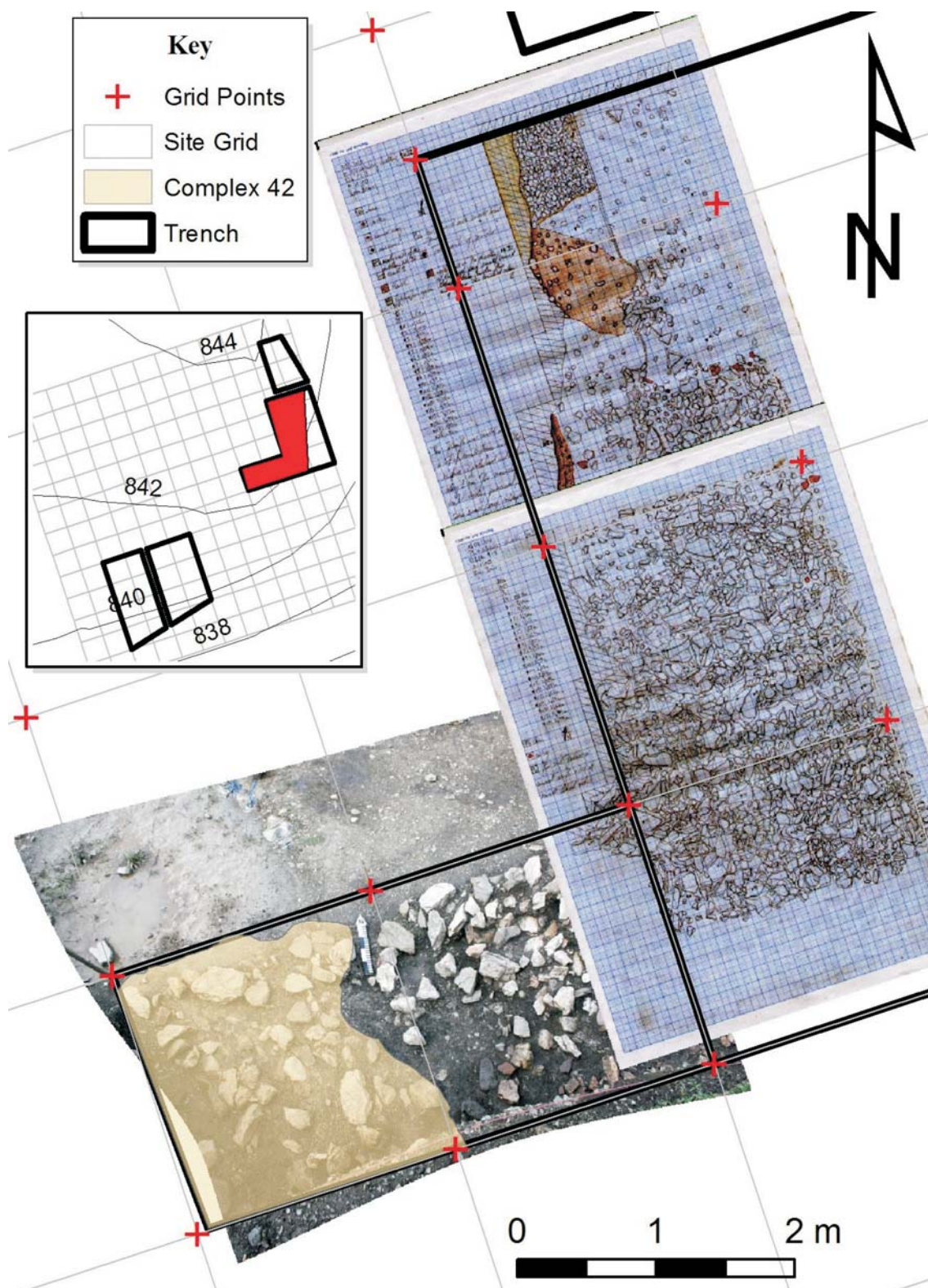*Schema bazei de date pentru Păuleni Ciuc*

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Figure 3 / *Figura 3*
Georeferenced plans and photos. The plans are georeferenced using a first order polynomial transformation,
and the photo with a third order polynomial transformation
*Fotografii și planuri georeferențiate. Planurile sunt georeferențiate folosind transformări polinomiale de ordin prim,
iar fotografiile cu transformări polinomiale de ordinul trei*
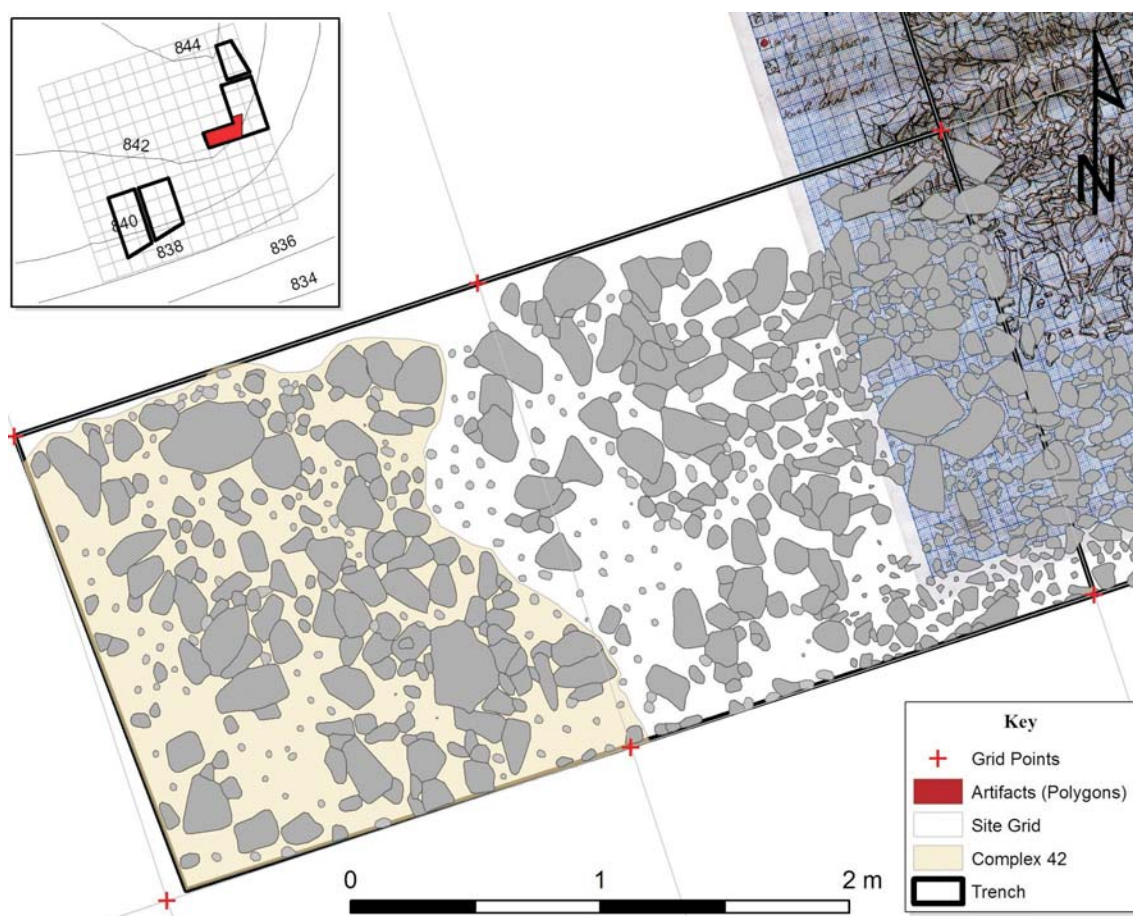
Figure 4 / *Figura 4*
Shapefile (polygon) of the stone horizon and associated complexes, created from the digitized and georeferenced
Stratul (poligon) de pe orizontul cu pietre şi complexele asociate, creat din planurile digitizate şi georeferenţiate
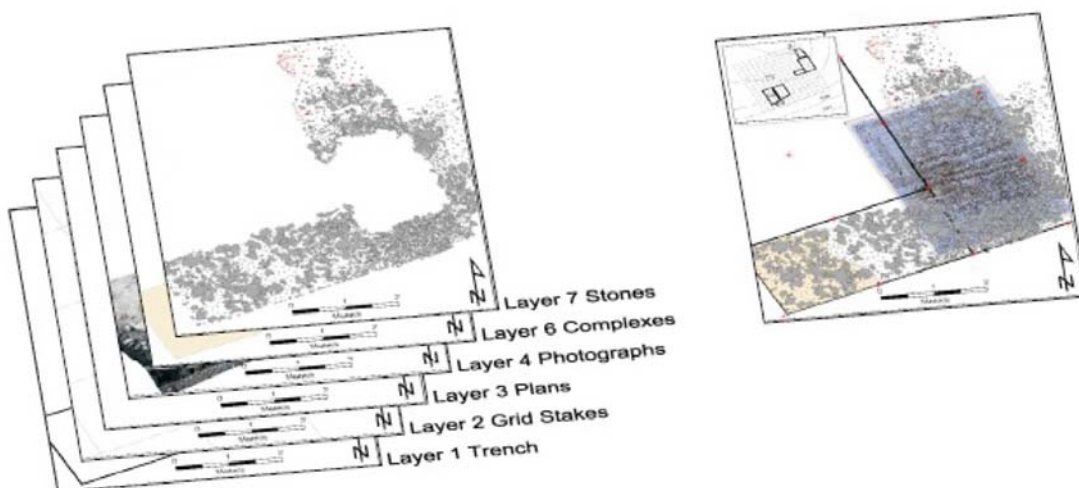
Figure 5 / *Figura 5*
Multiple layers (shapefiles) combined to create a finished map. Data from each layer may be selected and added to
the map individually to create different displays
*Straturile multiple combinate pentru a crea o hartă finală. Datele din fiecare strat poate fi selectat şi adăugat hărţii
individuale pentru crearea unor prezentări diferite*
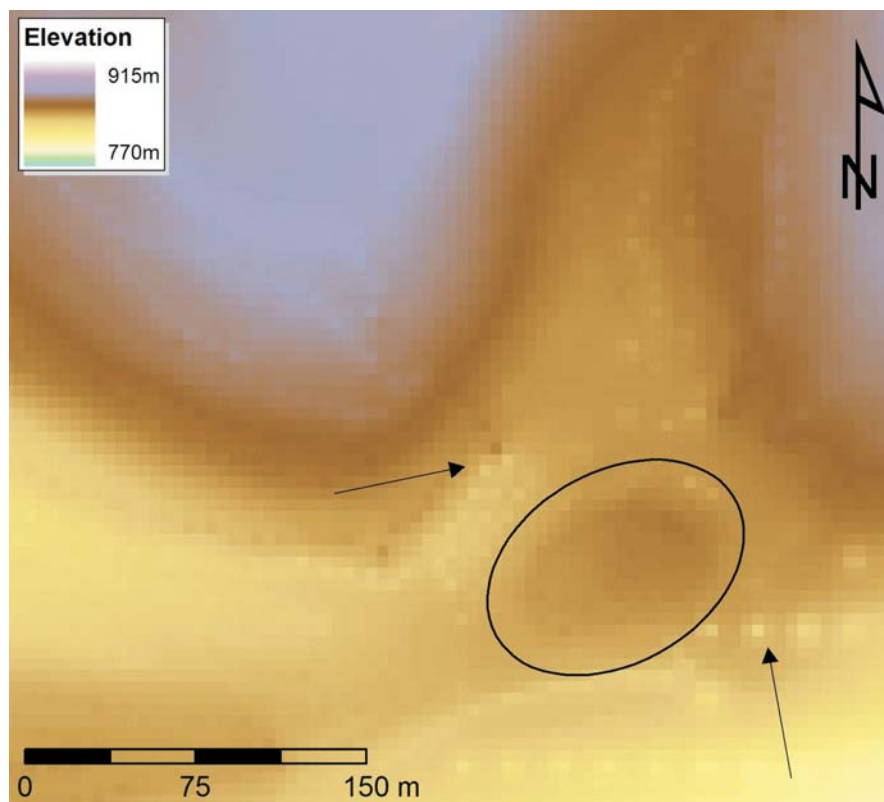
Figure 6 / *Figura 6*
Results of the Inverse Distance Weighted Interpolator used with the topographic survey data. The oval indicates the
Păuleni Ciuc site, and the arrows indicate the artificial steps and peaks created by the IDW interpolation
*Rezultatele interpolatorului IDW folosit cu datele ridicării topografice. Ovalul indică situl de la Păuleni-Ciuc, iar săgeţile
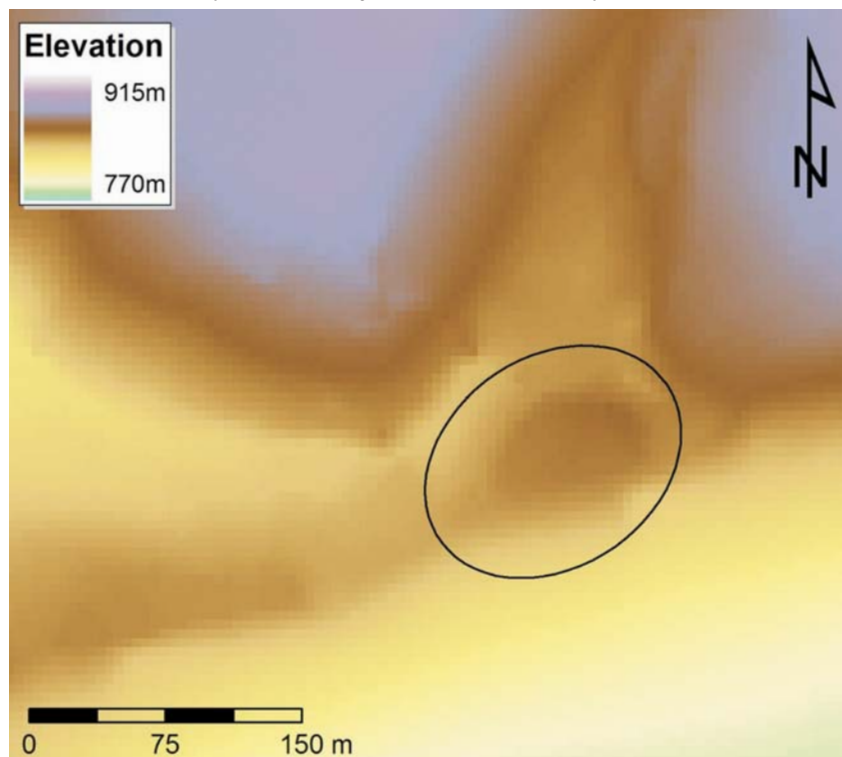indică treptele artificiale şi culmile create de interpolarea IDW*

Figure 7 / *Figura 7*
Results of the Natural Neighbors interpolator used with the topographic survey data. The oval indicates the Păuleni
Ciuc site
Rezultatele interpolatorului natural învecinat folosit cu datele topografice. Ovalul indică situl de la Păuleni–Ciuc

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Figure 8 / *Figura 8*
Triangular Irregular Network created from the topographic survey Digital Elevation Model. The black line indicates the extent of the topographic survey. The 2010 research trenches are displayed on the map
Reţeaua neregulată triunghiulară creată din ridicarea topografică Model de Elevare Digitală. Liniile negre indică extinderea ridicării topografice. Apar pe hartă şi secţiunile care au fost cercetate în anul 2010
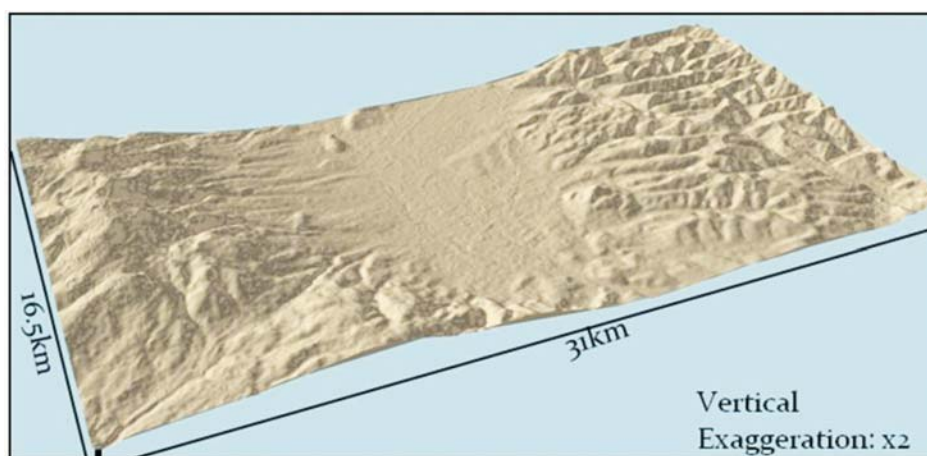

Figure 9 / *Figura 9*
The TIN of the Ciuc Depression, made by combining the 5 m resolution survey TIN with a 30 m resolution TIN created from ASTER GDEM imagery
TIN în Depresiunea Ciucului, făcut prin combinarea a supravegherii TIN la rezoluţia de 5 m cu TIN la rezoluţia 30 m creat de reprezentarea ASTER GDEM
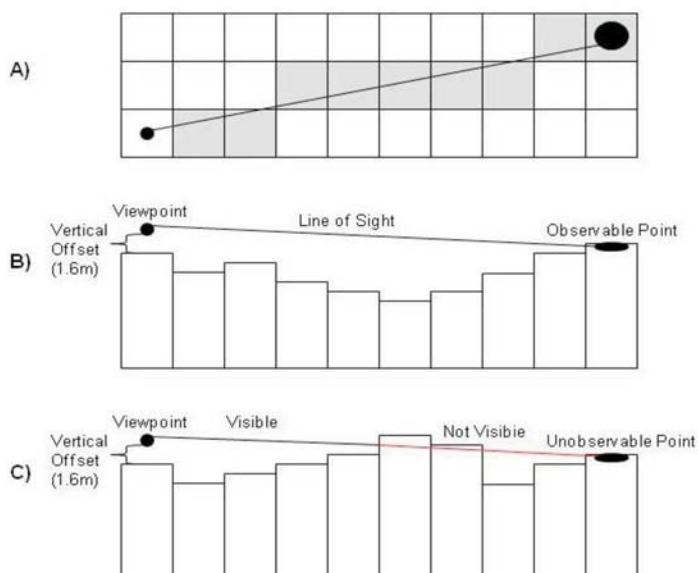

Figure 10 / *Figura 10*
The Line of Sight Function. A) A line is drawn from the viewpoint to the observable point to determine which grid cells the line of sight passes through; B) An example of an observable point – the line of sight does not pass through any intervening cells; C) An example of an unobservable point – the line of sight is interrupted by the 5th cell
Linia funcţiei de vizibilitate. A. O linie este desenată din punctual de vedre al punctului observabil pentru determinarea prin care celulă a caroiajului trece vederea; B. un exemplu al unui punct observabil – linia vederii nu trece prin nici o celulă; C. Un exemplu de punct neobservat – linia vederii este întreruptă de celula nr. 5
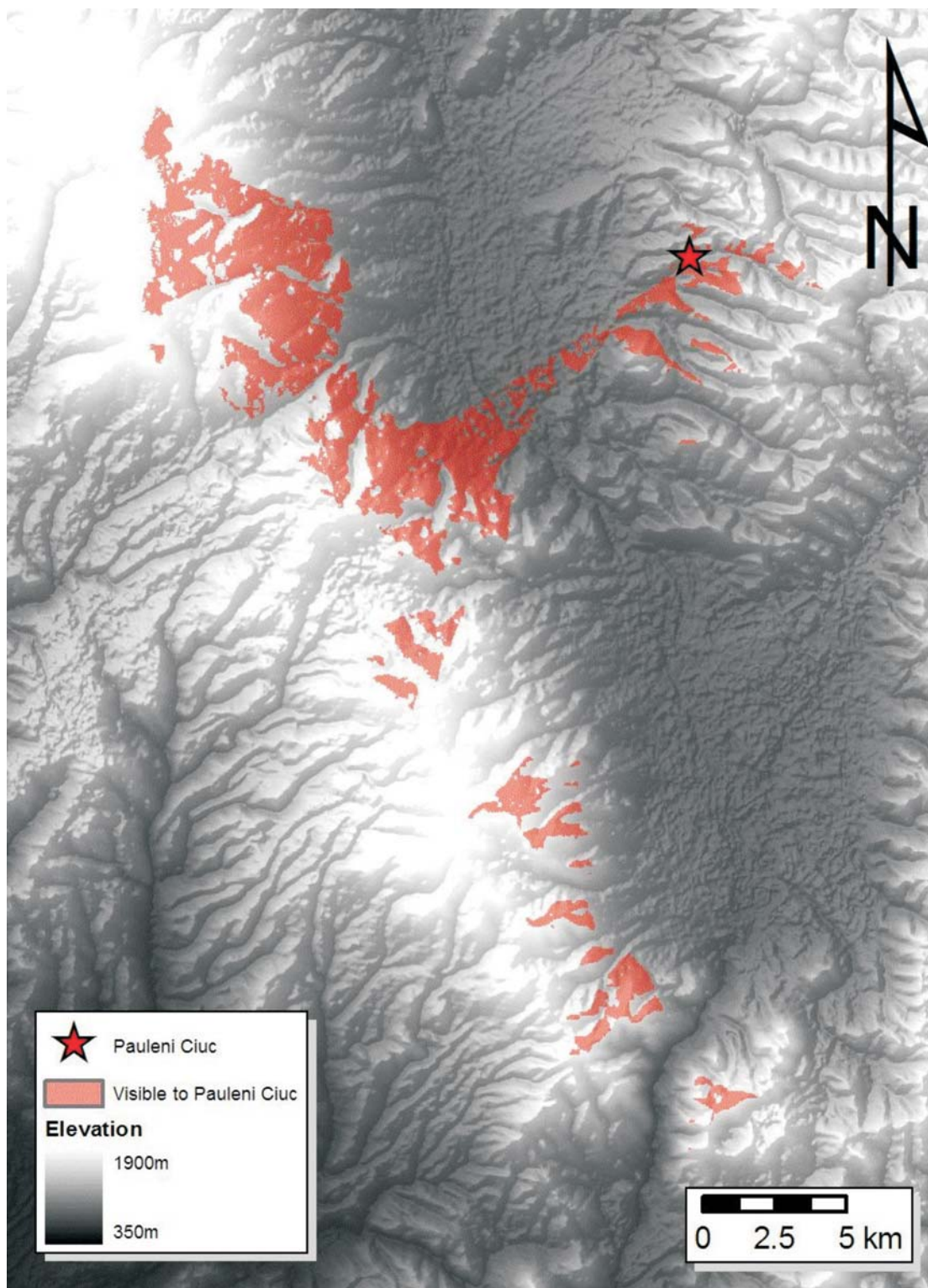
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Figure 11 / *Figura 11*
A viewshed generated for the Păuleni Ciuc site. Most of the Ciuc Depression is masked by the hill immediately to the west or by Mt. Şumuleu, leaving only the western peaks visible
O vizibilitate generală generată asupra sitului de la Păuleni-Ciuc. Cea mai mare parte din Depresiunea Ciucului este mascată de dealurile aflate în imediata apropiere spre vest a Muntelui Şumuleu, lăsând numai câteva vârfuri vizibile
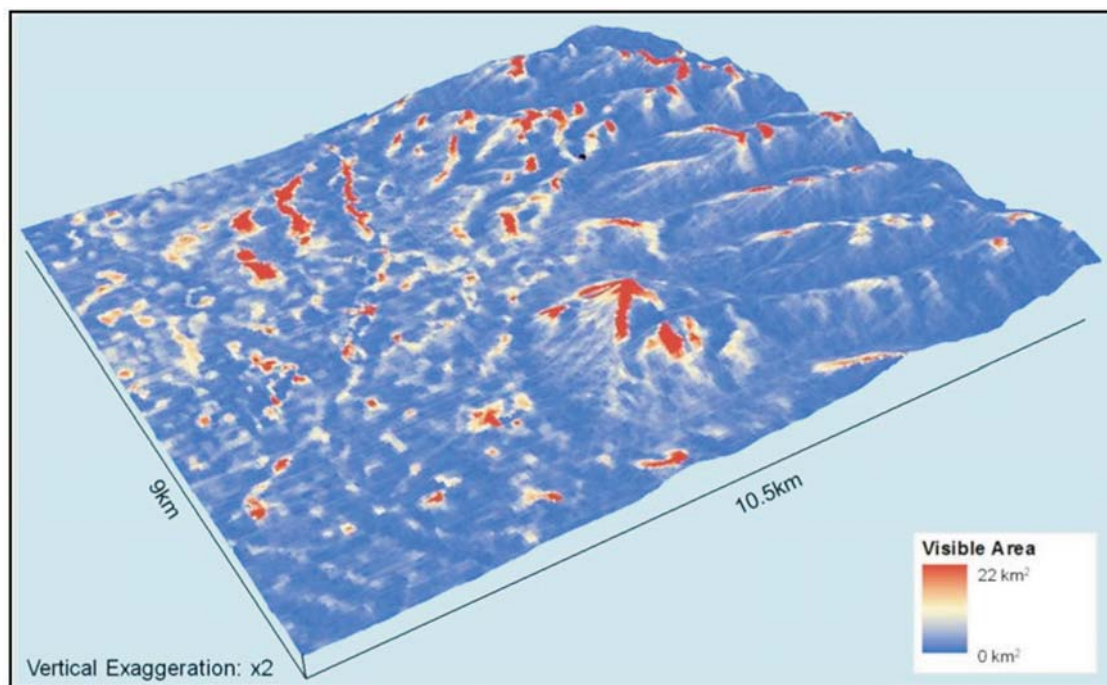
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Figure 12 / *Figura 12*
Cumulative Viewshed Analysis conducted for the area around the Păuleni Ciuc site. The Visible area indicates the expanse visible from any given points. The greatest views are commanded by areas on Mt. Şumuleu and the western ridgelines
Analiza Cumulativă a vizibilităţii conduse pentru aria din jurul sitului Păuleni-Ciuc. Aria vizibilă indică intinderea vizibilului din orice punct dat. Cea mai mare vizibilitate este de pe Muntele Şumleu şi de pe culmile vestice ale acestuia

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