# Assessing Burial Mound Intervisibility and Prominence at Regional Scale

Adela Sobotkova[1]

[1]Aarhus University, Department of History and Classical Studies, Jens Chr. Skous Vej 5, Aarhus, 8000, Denmark

**Abstract**

Visibility and intervisibility have been important aspects of spatial analysis in landscape archaeological studies, but remain hampered by computational intensity, small-scale study area, edge effects, and bare-earth digital elevation models. This paper assesses intervisibility and prominence in a dataset of over 1000 burial mounds in the Middle Tundzha River watershed in Bulgaria. The aim is to obviate the pitfalls in regional assessment of visibility through vegetation simulation and MC modelling and to gauge when intervisibility and prominence truly mattered to past mound-builders.

**Keywords**

visibility studies, burial mounds, edge effects, vegetation simulation

## 1. Introduction

'Will to visibility' has been noted in funerary monuments from the United Kingdom to Mississippi Valley, confirming that communities constructed new landscape features with respect to natural landmarks as well as pre-existing sites and monuments[4, 2, 30]. Two approaches have governed visibility studies in landscape archaeology. The first sees visibility as an attribute of the environment and employs viewsheds, lines of sight, and topographic prominence in digital elevation models (DEMs) to represent potential visibility under ideal conditions[6, 28, 30, 26, 14, 15, 5]. The second interprets visibility as an embodied perceptual act, one that is dependent on a person's knowledge, visual acuity, movement, and scale within the landscape[24, 9, 8] and requires simulations or virtual reality approaches to factor in individual attributes [29, 27]. Regardless of approach, both types of visibility studies share the same shortcomings, such as the lack of vegetation in the input DEMs, the problem of edge effects - where viewpoints along the edges of the study area are less "connected" because their visual connection to points outside the study area is not counted -, lack of tests for randomness, and small-scale focus or a massive computational overhead for regional-scale studies [11, 13, 12, 16, 7].

In this paper I use 1073 burial mounds from the Yambol Province in SE Bulgaria to assess the impact of edge effects and of bare-earth models on intervisibility in a regional context. Parallelizing custom spatial functions in R, I calculate visual connectivity among the burial mounds, comparing the results from bare-earth elevation model with two different vegetation-covered simulations. Next, I extract the topographic prominence in mounds at two different

CHR 2024: Computational Humanities Research Conference, December 4–6, 2024, Aarhus, Denmark

*Corresponding author.
adela@cas.au.dk (A. Sobotkova)
0000-0002-4541-3963 (A. Sobotkova)

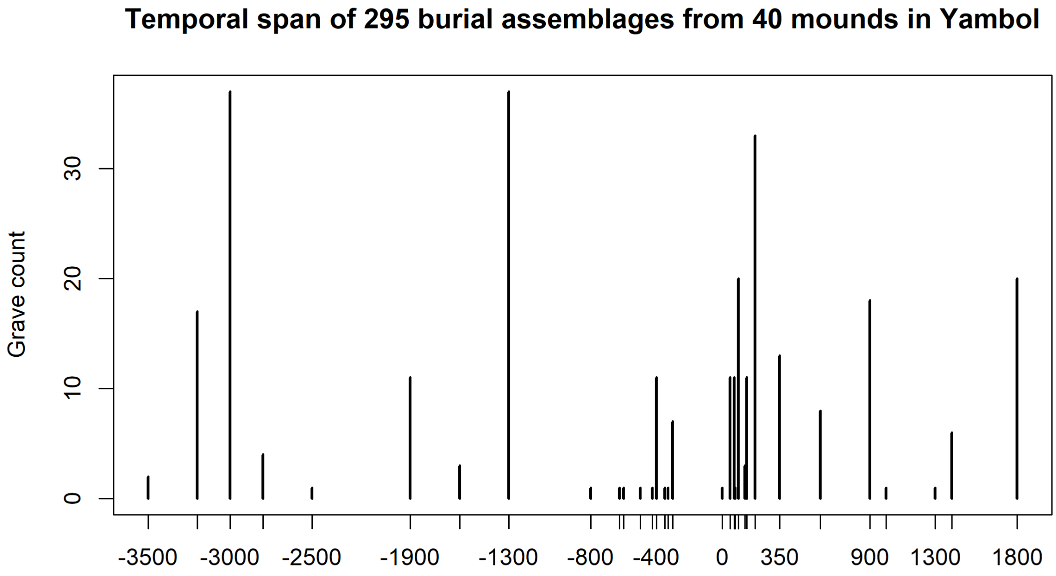


**Figure 1:** According to *Arkheologicheskite Otkritia i Razkopki*, journal that logs annual excavation reports in Bulgaria, 40 mounds were excavated in the Yambol Province in 1987-2014 yielding 295 distinct burials, whose assemblages have been dated within the chronological range above.

radii and assess it against background values through Monte Carlo modelling. My aims are to (a) explore the feasibility of rigorous testing of intervisibility and prominence at regional scale in R, and (b) to assess how much visual connectivity mattered to mound-builders across Yambol through time.

## 2. Data and Methods

### 2.1. Burial mounds

The present dataset is one of the outputs of the Tundzha Regional Archaeological Project (TRAP) which has operated in the Yambol Province since 2008[20]. The project digitised burial mound symbols from 1:50,000 scale Soviet topographic military maps and then verified their status in the field, yielding the locations and descriptions for 1073 mound features in a region of 3,355 sq km[23, 22]. According to annual archaeological reports, only 40 of these mounds have been excavated to date, offering limited chronological control. Figure 1 shows that excavated burial assemblages span from the Early Bronze Age to the Mediaeval Era, peaking in the Early and Late Bronze Age followed by the Roman imperial period.

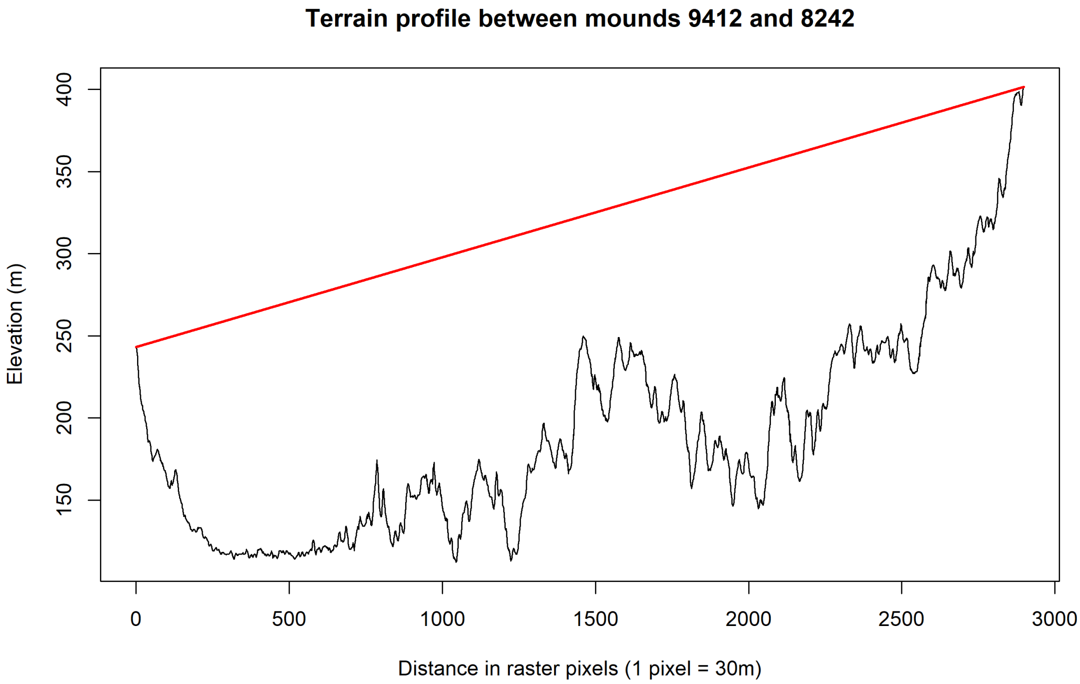


**Figure 2:** Raster profile of the Yambol ASTER DEM in map units (pixel is 30m) with a visibility line showing unobstructed view.

## 2.2. Prominence

For mound prominence I use Llobera's (2001, 1007) definition of "topographic prominence as a function of height differential between an individual and his/her surroundings as apprehended from the individual's point of view"[14]. Replacing an individual with individual mound height, I translate this calculation into R. The resulting value for each location is a percentage that expresses the proportion of locations that lie at or below the mound top's location within a given radius. I calculate prominence at two different radii of 250 and 2000 m respectively to gauge landscape affordances for various scales within the Yambol Province. An additional test of burial mound visual dominance can be achieved by comparing the prominence distribution of mounds with that of the entire region. Such bootstrapping was undertaken previously for a subset of Bronze Age mounds in Yambol[25]. Including all mounds here, I iterate 99-times the measurement of prominence within a 250 m buffer at 1200 random locations in the region and compare the resulting values to those from a random sample of the burial mound locations.

## 2.3. Intervisibility

To assess intervisibility, I calculate line of sight (LoS) from each of the 1073 mounds inside the Yambol Province boundary to all other neighbours within the region. A positive LoS means that the view from point A to point B is unobstructed, meaning there is no higher elevation between the two mound tops (see Figure 2). I translate this approach into R as the comparison of elevation at location A to the elevations encountered on a straight line to location B, derived from a raster profile. In order to reduce edge effects in 341 mounds located within a 5 km buffer of the regional administrative border, whose view is constrained by the arbitrary boundary, I also calculate their LoS to additional 1206 mounds within 25 km buffer outside the Yambol Province border. The locations of the latter 1206 mounds have also been digitized from the Soviet military topographic maps but remain unverified[22].

### 2.4. Digital elevation model and vegetation modeling

I mosaic together three ASTER DEM tiles[10] of 30 m resolution to produce a digital elevation model for the Yambol Province and a buffer of 25 km around it. This DEM is a bare-earth model (BOM). The lack of vegetation maximizes intervisibility of landmarks within this model[21]. To challenge this model I simulate vegetation following a regional paleoecological study which attests to patchy forested landscape within the Tundzha watershed[3]. I generate two different surfaces: first, trees of 10m height distributed randomly over 50% of the landscape, and second, vegetation of variable height from 1 to 20 m (with a mean at 10 m) randomly covering 50% of the landscape. Both surfaces have the same average height, but the second is more gradual and 'permeable'. I overlay these vegetation surfaces over the BOM and re-calculate mound intervisibility. Results allow me to gauge the drop in mound intervisibility due to vegetation. Intervisibility calculation workflow is coded and parallelized in R and is available for review in Github.

## 3. Results

Topographic prominence calculations using the bare-earth DEM confirmed that mounds were built in fairly prominent locations throughout the Yambol Province. As table 1 shows, more mounds appear more visually dominant within the 2000 m than in the reduced 250 m radius.

**Table 1**
Mounds that enjoy 50%, 95%, and 99% prominence in the region

| Radius\|Prominence | **50%+** | **95%+** | **99%** |
|---|---|---|---|
| 250 m | 592 (54%) | 81 (3.5%) | 12 (1.1%) |
| 2000 m | 853 (80%) | 61 (5.6%) | 19 (2%) |

The drop in prominence in smaller radius calculation runs contrary to Llobera's expectation of prominence decreasing as we calculate over a greater aggregate area. One explanation could be that the scale of area covered by 250 and 2000 m buffers is negligible compared to the scale of the region which routinely affords expansive vistas over 40 km radius. Maybe mound builders positioned their monuments carefully with an idea to longer-distance rather than short-distance visual control. A more realistic explanation, however, is that my calculation is spurious: percentage of lower elevation within a given radius is not a replacement for line of sight calculation, but is a simplistic way chosen to make the computational analysis

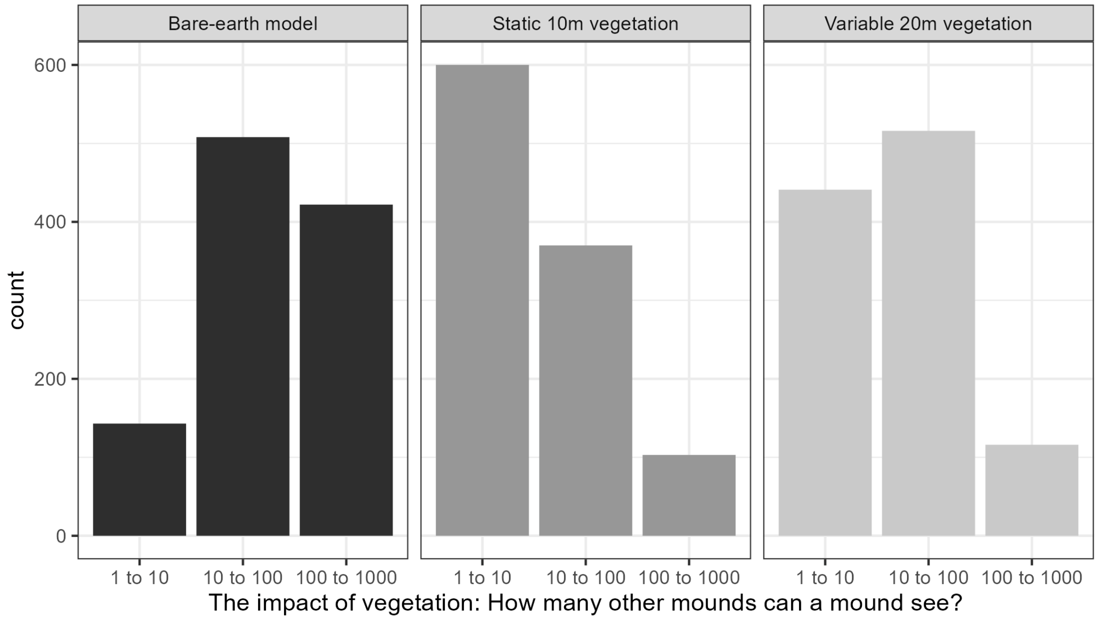


**Figure 3:** Topographic prominence percentage in 1200 locations randomly distributed in the Yambol landscape (dark grey band) and the 1200 values randomly sampled from the burial mound dataset (red band).

feasible for a vast area (2000 m radius means a moving window of 132 x 132 raster cells enters in the calculation for each discrete mound point). To avoid misrepresenting reality, I evaluate bootstrapped data for prominence within 250 m radius alone.

The resulting prominence density chart in Figure 3 shows that the Yambol landscape data (represented by the dark grey band enclosed by light gray confidence interval) forms an arc with the main mode at 30-60% prominence and a secondary tight peak at 80%. The burial mound curve rises to a tight global maximum at 70% and escapes the bounds of randomness in the 60 to 85% prominence band as well as the 10 to 30% band. From this visual investigation alone, we can see that the mound locations differ from a random sample taken from the landscape of the Yambol Province both in the low and high values. The next question is how significant is this result, really? T-test and Mann-Whitney test in Table 2 show the prominence simulation results are robust and statistically significant except in the case of upper confidence interval. The p-value for upper confidence interval is above the threshold of 0.05 indicating that there is some uncertainty here. Given the robust lower and median values, I would lean towards a significant difference between the prominence of burial mounds and the overall landscape for most but not all of the confidence interval.

When modelling intervisibility, the results for the bare-earth model (BOM) deliver on expectations: when there is no vegetation, most mounds in Yambol are highly intervisible. The group with the lowest intervisibility - having only 1 to 10 visible counterparts - is small at 143 features out of 1073 (13%). Out of the 1073 mounds, 508 (47%) can see 10 to 100 counterparts and 422 (40%) mounds see over 100 other mounds. The most visually dominant 60 mounds can

**Table 2**
T-test and Mann-Whitney test results of topographic prominence in Yambol burial mounds. Significant p-values are in bold.

| test | Lower CI | Median | Upper CI |
|---|---|---|---|
| t-test U-Statistic | 1.483944149 | 2.04568119 | 2.95154358 |
| p-value | **0.0016** | **0.0205** | 0.0699 |
| Mann-Whitney test U-Statistic | 595288.450 | 605842.50 | 0.830611 |
| p-value | **0.0017** | **0.0178** | 0.0858 |

see over 250 other mounds. Their lines of sight extend across the entire region, as far as 60 km away, and probably further if the study area were extended.

The mound with the highest intervisibility: 9412, west of the Yambol City, has an unobstructed line of sight to 491 mounds across the region, visible in Figure 5A. Yet, we can reasonably doubt the real possibility of recognizing anything over 15 km distance, except perhaps fire beacons at night or smoke stack from a burning village during daytime. Anything else - even a 7 m high mound - would be reduced to an insignificant and unrecognizable dot especially under less than ideal atmospheric conditions [8].

In addition to considerations of scale and limits of human vision, vegetation changes the situation dramatically (see Figure 4). In the first simulation with static 10m tall vegetation, intervisibility drops by 35-90%. Over 400 of 1073 (40%) mounds lose 90% of their field view due to a patch of trees. Intervisibility groups get radically adjusted. Most mounds now fall in the lower intervisibility group, seeing 1-10 mounds. Their count having risen three-fold over the BOM. The middle rank drops by over 20%, but is still strong at 370 (36%) mounds with 10 to 100 intervisible counterparts. Only 103 mounds (10%) remain in the visually dominant rank seeing over 100 other mounds. This considerable drop in intervisibility makes sense in light of the 50% tree coverage and is consistent with Skov-Petersen's [21] findings despite difference in relief between the two study areas.

In the second scenario with variable 20m (10m mean) vegetation, the decline in visibility is also present, but less pronounced. Intervisibility group membership shuffles again. Compared to BOM, the lowest rank doubles to 41% with 441 mounds, the middle rank remains almost the same at 516 mounds (48%) and the highest rank of mounds attenuates to 116 (11% of total). Even though some trees in second scenario are higher than in the first, the overall vegetation variability makes this overlay more 'permeable'. This contributes to a less dramatic drop in the middle intervisibility rank, shuffling the class membership gradually.

Now that we have addressed the groups, what effect does vegetation have on individual mound ranking, especially the formerly leading ones?

The downward adjustments contribute to reshuffling among the leading mounds. Given the one time run, these results are merely illustrative of the general tendency and probability. In the present iteration of 20m variable vegetation model, the former total winner no. 9412 moves into a second place with 249 intervisibile mounds, a decline of 46% over BOM. It is superseded by 9044, a 6m tall mound near Botevo, with 291 visible mounds. Only four of the ten leading mounds retain their dominant position: 9412, 9411, 9044 and 8700. The remaining

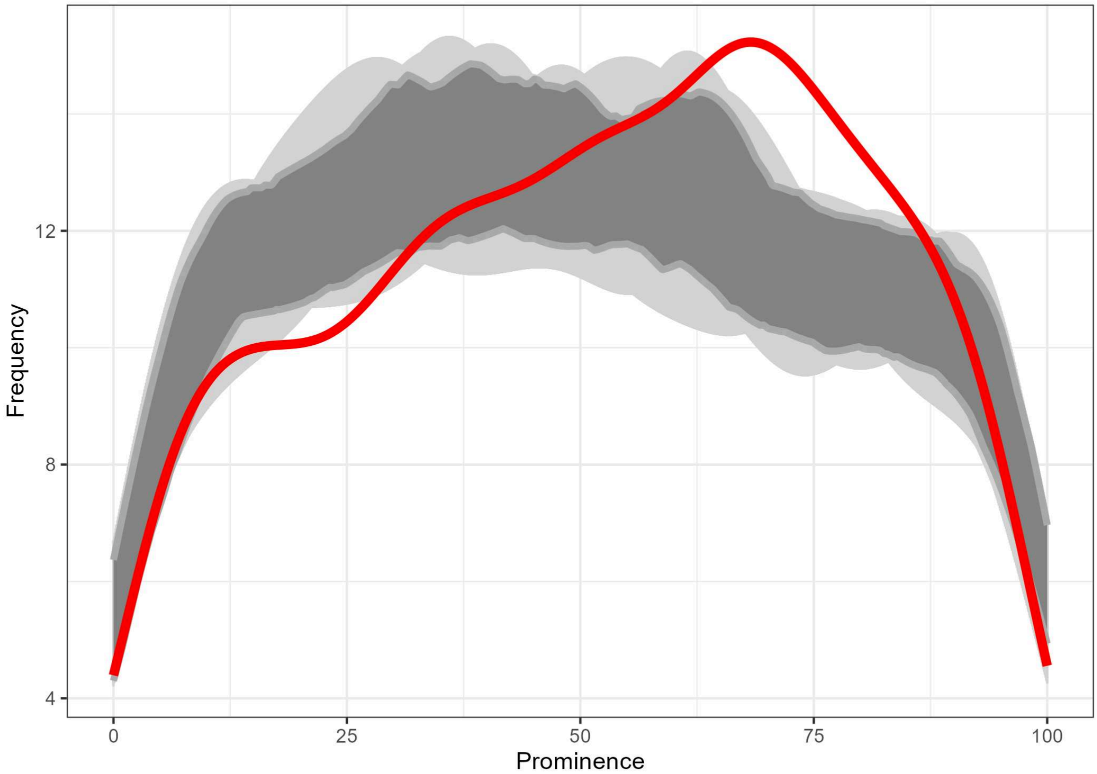


**Figure 4:** Change in the intervisibility group membership among 1073 mounds in Yambol across three different digital elevation models: bare earth, simulation with static 10m tall vegetation, simulation with variable 1-to-20m tall vegetation.

six sink in status with their line of sight obscured by trees, while others take their place. The specific winners depend on vegetation configuration, but they are always selected from the top-ranking group. In the end a rule emerges: unless the mound location happens to be covered by vegetation, once in a commanding position, always highly intervisible.

Likewise, accounting for the edge effects does not massively alter the order of the leading mounds. While many of the border region mounds grow in visual dominance, the absolute winners' field of view grows too. To illustrate the point, 9412 dominates intervisibility with a line of sight to 409 other mounds inside the region in the bare-earth model. When we extend the vision beyond the region to limit edge effects, 9412 continues its lead with a line of sight to 491 other mounds (an increase of 20%). In the top ten mounds, eight retain their positions when we extend the view beyond the border of the Yambol Province. While the arbitrary limit on vision imposed by the regional boundary suggests that edge effects will be considerable for mounds in immediate proximity of border, it is the relief that is the decisive factor. Extending the view 25 km outside the region makes the intervisibility numbers go up by as much as 20%. However, they go up for many mounds in the region, not perturbing the regional order dramatically.

These results confirm two points: (1) landscape affordances in the Yambol Province drive the intervisibility and prominence results, with vegetation having considerable effect on individual mound field of view, and (2) ancient mound builders were aware of these landscape attributes and exploited them (or not) intentionally, building in just the right locations. Visibility mattered, but was not the only criterion. To underscore the point, locations exist in the region that offer supreme visual dominance of 99%, such as the peak of Bakadzhitsite or the Dodoparon hill. Scaling these peaks, however, is clearly beyond the needs for ancestral worship or territorial signaling of the local communities.

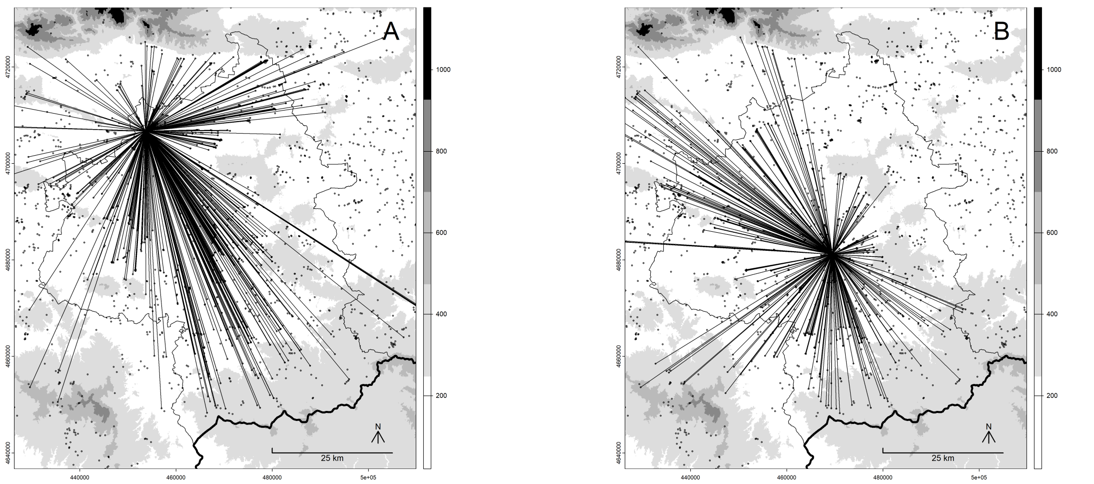


**Figure 5:** Lines of sight to mounds inside the Yambol Province (thin grey outline) and within a 25km buffer of the region visible from (A) mound 9412 (n = 491) and (B) mound 8007 (n = 378). The thick black curve represents the national border between Bulgaria and Turkey.

### 3.1. The Winners

In the comparison of intervisibility and prominence, two winners merit a bit more detailed attention: mounds 9412 and 8007 occupy the highest intervisibility rank (see Figure 5). Both are perched on an outcrop with an open view across the Middle Tundzha watershed. 8007 has over 95% prominence and 9412 has 76 to 89% across all vegetation models at 250 m radius. Mound 9412 sits close to northwest border on a slope that faces the rest of the region to southeast. Mound 8007 sits near the geographic center of the region, with an unobstructed view of the entire region. Culturally, the mounds perhaps also share a story. Mound 8007 belongs to the 40 excavated mounds in the region, having been investigated in a 2010 rescue campaign before the opening of a nearby quarry. Cultural material, DNA, and C14 results indicate it was built by the Steppe people during the Early Bronze Age [18, 17]. After the initial tomb was cut, 23 other individuals were interred here in the course of the next three thousand years, attesting to the long-term significance and popularity of the location. Survey in 2009 revealed a dense network of settlements spanning Early Bronze Age to Roman period within 5 km buffer of this location[19]. Mound 9412 remains unexcavated as of the writing of this paper. Excavated mounds in the vicinity (”Drazhevo” mounds no 1262, 1263) yielded rock-cut pit graves inside elaborate stone circles, not unlike those found in 8007. Silver embellishments and other burial goods led the excavator to attribute these burials to the Early Bronze Age period[1].

## 4. Conclusion

This study explores the impact of vegetation and of edge effects on intervisibility and prominence rates among 1073 mounds in the Yambol Province, SE Bulgaria. Two different vegetation regimes are generated to facilitate a comparison of visual connectivity among Yambol mounds within bare- and vegetated-earth models. Line of sight results show that Yambol mounds located on isolated outcrops achieve supreme visual control over their surroundings. Adding vegetation of variable height between 1 and 20 m reduces the intervisibility less than adding vegetation of static 10 m height, even if mean vegetation height remains the same. Adding vegetation into digital elevation models always wreaks havoc on the individual mound intervisibility and reduces the visually-dominant group membership by 75%. Unless hid by a forest directly, however, the ultimate winners remain largely the same thanks to the inexorable topographic properties of the local landscape. Finally, edge effect correction (adding a 25 km buffer to the region) has a negligible effect on the intervisibility results, confirming that 3,355 sq km area is large enough for a regional-scale visibility study.

The present analyses were possible thanks to dedicated spatial libraries and parallelisation options offered by the R programming language. In addition to making workflows efficient and reproducible, these libraries place compute-intense regional analysis within the reach of scholars without access to computing clusters. Others can now adapt and improve the present code, and pursue visibility explorations further, be it to investigate regional intervisibility networks or study the visual relationship between mounds and associated settlements and road networks.

## Acknowledgments

The paper was possible thanks to 10 years of fieldwork funded in sequence by the ARC Linkage project 0989901, grant no. 19686 from the Endeavour Short-Term Mobility Programme of the Australian Ministry of Education, and the Aarhus University Forskningsfond Starting grant no. AUFF-E-2018-7-22 awarded to the 'Social Complexity in the Ancient Mediterranean' (SDAM) project. It involved scholars from three continents and dozens of volunteers as well as researchers from the Regional History Museum of Yambol, Sofia University of St. Kliment Ohridski, New Bulgarian University, Aarhus University, UNSW Australia, and Macquarie University. An early version of this paper was presented at the international conference "Research of Ancient Thrace between Traditionality and Modernity: Theoretical Aspects and Scientific Methodology" on 11-13 April 2024 in Sofia, Bulgaria.

## References


[1] S. Bakardzhiev. “Spasitelni archeologicheski prouchvannia na mogilen nekropol v m. Subev bair pri s. Drazhevo, obshtina Tundzha”. In: *Arheologicheski otkritia i razkopki prez 2004 g* (2005), pp. 150–153.

[2] J. E. Buikstra and D. K. Charles. “Centering the ancestors: Cemeteries, mounds and sacred landscapes of the ancient North American midcontinent”. In: *Archaeologies of landscape : contemporary perspectives*. Ed. by W. Ashmore and A. B. Knapp. Oxford: Blackwell, 1999, pp. 201–228.

[3] S. E. Connor, S. A. Ross, A. Sobotkova, A. I. R. Herries, S. D. Mooney, C. Longford, and I. K. Iliev. “Environmental conditions in the SE Balkans since the Last Glacial Maximum and their influence on the spread of agriculture into Europe”. In: *Quat. Sci. Rev.* 68 (2013), pp. 200–215.

[4] F. Criado. “The visibility of the archaeological record and the interpretation of social reality”. In: *Interpreting archaeology*. Ed. by I. Hodder. Routledge, 2013, pp. 194–204.

[5] Z. Čučković. “Visibility Networks”. In: *The Oxford Handbook of Archaeological Network Research*. Ed. by T. Brughmans, B. J. Mills, J. Munson, and M. A. Peeples. Oxford: Oxford University Press, 2023, pp. 230–247.

[6] D. Fraser. *Land and Society in Neolithic Orkney*. B.a.r., 1983.

[7] V. Gaffney and Z. Stančič. *GIS approaches to regional analysis: A case study of the island of Hvar*. David Brown Book Co, 1991.

[8] T. Higuchi. *Visual and Spatial Structure of Landscapes*. MIT Press, 1988.

[9] I. Hodder. *Reading the Past*. Cambridge University Press, 1986.

[10] Jica. *ASTER Global Digital Elevation Model*. https://gdemdl.aster.jspacesystems.or.jp/index_en.html. 2008.

[11] M. Lake and D. Ortega. “Compute-Intensive GIS Visibility Analysis of the Settings of Prehistoric Stone Circles”. In: *Computational approaches to archaeological spaces*. Ed. by A. Bevan and M. Lake. Left Coast Press, 2013, pp. 213–242.

[12] M. Lake and P. E. Woodman. “Visibility studies in archaeology: A review and case study”. In: *Environment and Planning B: Plannning and Design* 30.5 (2003), pp. 689–707.

[13] M. Llobera, D. Wheatley, J. Steele, S. Cox, and O. Parchment. “Calculating the inherent visual structure of a landscape ( ‘total viewshed ’ ) using high-throughput computing”. In: *Beyond the artefact: Digital Interpretation of the Past. Proceedings of CAA2004 Prato, 13 -17 April 2004*. Ed. by S. Hermon and F. Niccolucci. Budapest: Archaeolingua, 2010, pp. 1–8.

[14] M. Llobera. “Building past landscape perception with GIS; understanding topographic prominence”. In: *J. Archaeol. Sci.* 28.9 (2001), pp. 1005–1014.

[15] M. Llobera. “Extending GIS-based visual analysis: the concept of visualscapes”. In: *Int. J. Geogr. Inf. Sci.* 17.1 (2003), pp. 25–48.

[16] S. L. H. Madry and L. Rakos. “Line-of-sight and cost-surface techniques for regional research in the Arroux River Valley”. In: *New methods, old problems: geographic information systems in modern archaeological research.* Ed. by H. D. G. Maschner. Center for Archaeological Investigations Occasional Paper No. 23. Carbondale: Southern Illinois University at Carbondale, 1996, pp. 104–126.

[17] S. Penske, A. B. Rohrlach, A. Childebayeva, G. Gnecchi-Ruscone, C. Schmid, M. A. Spyrou, G. U. Neumann, N. Atanassova, K. Beutler, K. Boyadzhiev, Y. Boyadzhiev, I. Bruyako, A. Chohadzhiev, B. Govedarica, M. Karaucak, R. Krauss, M. Leppek, I. Manzura, K. Privat, S. Ross, V. Slavchev, A. Sobotkova, M. Toderaş, T. Valchev, H. Ringbauer, P. W. Stockhammer, S. Hansen, J. Krause, and W. Haak. “Early contact between late farming and pastoralist societies in southeastern Europe”. In: *Nature* 620.7973 (2023), pp. 358–365.

[18] K. Privat, A. Sobotkova, S. Bakardzhiev, and V. Russeva. “Excavation and palaeodietary analysis of Bronze Age human remains from Boyanovo, Yambol Province”. In: *The Tundzha Regional Archaeological Project: Surface Survey, Palaeoecology, and Associated Studies in Central and Southeast Bulgaria, 2009-2015 Final Report.* Ed. by S. A. Ross, A. Sobotkova, J. Tzvetkova, G. Nekhrizov, and S. Connor. Oxford: Oxbow Books, Limited, 2018. Chap. 17, pp. 182–190.

[19] S. A. Ross, A. Sobotkova, I. K. Iliev, S. Connor, and S. Bakardzhiev. *The Tundzha Regional Archaeological Project: Elhovo 2009 Preliminary Report.* Yambol, Bulgaria: Historical Museum Yambol, 2012.

[20] S. A. Ross, A. Sobotkova, J. Tzvetkova, G. Nekhrizov, and S. Connor, eds. *The Tundzha Regional Archaeological Project: Surface Survey, Palaeoecology, and Associated Studies in Central and Southeast Bulgaria, 2009-2015 Final Report.* Oxford: Oxbow Books, Limited, 2018.

[21] H. Skov-Petersen and B. Snizek. “To see or not to see: Assessment of Probabilistic Visibility”. In: *Agile 2007.* Aalborg University Press, 2007, pp. 1–12.

[22] A. Sobotkova, S. A. Ross, C. Nassif-Haynes, and B. Ballsun-Stanton. “Creating large, high-quality geospatial datasets from historical maps using novice volunteers”. In: *Appl. Geogr.* 155 (2023), p. 102967.

[23] A. Sobotkova and B. Weissova. “Soviet topographic maps and burial mounds of the Yambol province: digital workflow for mortuary landscape verification”. In: *Archaeological Prospection* 27.February (2020), pp. 253–262.

[24] C. Tilley. *A phenomenology of Landscape: Places, paths and Monuments.* Oxford: Berg, 1997.

[25] T. Valchev and A. Sobotkova. “Landscape analysis of the Early Bronze Age mounds in the Middle and Lower Tundzha River”. In: *Moving northward: Professor Volker Heyd’s Festschrift as he turns 60.* Ed. by A.-K. Salmi. Monographs of the Archaeological Society of Finland. 2023, pp. 445–455.

[26] M. Van Leusen. “Line of Sight and Cost Surface Analysis using GIS”. In: *Pattern to Process.* Ed. by M. Van Leusen. BAR International Series. Oxford: Archaeopress, 1999, pp. 1–23.

[27] P. Verhagen. “Spatial Analysis in Archaeology: Moving into New Territories”. In: *Digital Geoarchaeology: New Techniques for Interdisciplinary Human-Environmental Research.* Ed. by C. Siart, M. Forbriger, and O. Bubenzer. Cham: Springer International Publishing, 2018, pp. 11–25.

[28] D. Wheatley. “Cumulative viewshed analysis: a GIS-based method for investigating intervisibility, and its archaeological application”. In: *Archaeology and Geographical Information Systems: A European Perspective.* Ed. by G. R. Lock and Z. Stančič. London: Routledge, 1995, pp. 5–13.

[29] D. Wheatley and M. Gillings. “Vision, perception and GIS: developing enriched approaches to the study of archaeological visibility”. In: *Beyond the Map: archaeology and spatial technologies.* Ed. by G. R. Lock. Volume 321 of NATO Science Series. Ohmsha: IOS Press, 2000, pp. 1–27.

[30] H. M. R. Williams. “Placing the dead: investigating the location of wealthy barrow burials in seventh century England”. In: *Grave Matters: Eight studies of First Millennium AD burials in Crimea, England and southern Scandinavia.* Ed. by M. Rundkvist. Gothenburg, Sweden: Archaeopress. BAR International Series 781, 1999, pp. 57–81.


# A. Online Resources

Code for this paper is available via GitHub.