Intervisibility among the Thousand Mounds of the Yambol Province

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Abstract: *Visibility and intervisibility have always been important aspects of spatial analysis in landscape archaeological studies but remain hampered by poor inputs such as small-scale study area, edge effects, and bare-earth models. This paper assesses intervisibility in a dataset of ~1000 burial mounds in the Middle Tundzha River watershed addressing these very issues via a regional analysis of several vegetation-simulating terrain models that include mounds beyond the region to nullify edge effects.*

Keywords: visibility, landscape archaeology, burial mounds in Yambol Province

Ключови думи: видимост, ландшафтна археология, надгробни могили в Ямболска област

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VISIBILITY IN LANDSCAPE STUDIES

In landscape archaeology, two approaches have governed the study of visibility. The first sees visibility as an attribute of the environment while the second interprets visibility as an embodied perceptual act, one that is dependent on a person's knowledge, visual acuity, and scale within the landscape[1]. Each approach requires different operationalization in GIS software. Viewsheds and lines of sight comprise the usual suite of computational tests of visibility calculated on digital elevation models[2]. Yet, many such studies lack inferential rigor, failing to prove whether intervisibility occurred by random chance[3]. Often, they forget to account for weather and other complicating criteria such as edge effects or vegetation permeability[4]. These shortcomings owe to the sheer computational intensity of such tests for randomness[5].

When seen as an embodied perceptual act[6], visibility is impacted by the observer's personal attributes. Her age, vantage point, speed, type of movement, time of the day, and expectations determine what she sees and whether she is seen,

[1] *Tilley* 1994; *Hodder* 1986; *Higuchi* 1988.
[2] *Van Leusen* 1999; *Wheatley* 1995; *Williams* 1999.
[3] *Lake, Woodman* 2003; *Madry* 1996; *Gaffney, Stančič* 1991.
[4] *Skov-Petersen* 2007; *Verhagen* 2018.
[5] *Lake, Ortega* 2013; *Llobera et al.* 2010.
[6] *Shanks, Hodder* 1995; *Tilley* 1994.

and such factors are much harder to model and generalise, requiring a combination of approaches ranging from the line of sight, probabilistic viewsheds, intervisibility networks to prominence and virtual reality simulation[7]. Implementation of these approaches is computationally intensive.

In this paper I try to get beyond some of the pitfalls of visibility studies[8], such as the edge effects, small-scale analysis, and the use of bare earth models. Using custom functions and established spatial libraries in R, I calculate mutual intervisibility in 1000+ burial mounds in the Yambol Province, comparing the results from a bare earth elevation model with two different vegetation-covered simulations. The aim is to explore how well current computational methods accommodate the rigorous testing of inter-visibility and to assess how much intervisibility mattered to mound-builders in Yambol through time.

MOUNDS IN THE YAMBOL PROVINCE

'Will to visibility' has been noted in funerary monuments across a number of cultures[9]. Burial mounds in Bulgaria have been raised over grave sites since the Early Bronze Age until the Middle Ages and represent the most numerous type of immovable cultural heritage in the country.

In the Yambol Province of southeast Bulgaria burial mounds cluster on the ridges and lower rocky outcrops, near and above settlements along Tundzha River tributaries[10]. Excavations and DNA analyses reveal that mound necropolises have been reused over millennia[11], confirming that communities constructed new landscape features with respect to pre-existing sites and monuments as well as natural components of the environment. The combination of prominence, high density and reuse is hardly unique to mounds in southeast Bulgaria. Their thorough digital documentation at regional scale, however, is rare and offers a dataset that can support a rigorous large-scale visibility analysis.

DATA AND METHODS

Mound data

The dataset of burial mounds was produced by the Tundzha Regional Archaeological Project (TRAP) which has operated in the Yambol Province since 2008[12]. The project digitized burial mound symbols from 1:50,000 scale Soviet topographic military maps, visited and documented their status in the field producing a dataset of 1073 burial mounds[13]. Of these 864 represent extant burial mounds, 154 extinct (excavated or looted) burial mounds and 55 small and therefore uncertain mounds. **Fig. 1** shows

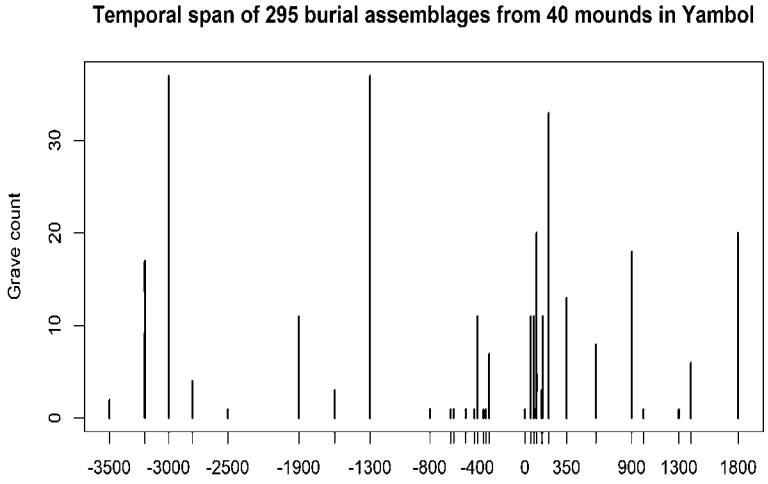

Figure 1. Chronological range of grave goods from mounds in Yambol Province as published in AOR.

[7] *Fraser* 1983; *Llobera* 2003, 2001; *Wheatley, Gillings* 2000; *Čučković* 2023.
[8] *Van Leusen* 1999; *Skov-Petersen* 2007.
[9] *Criado* 2013; *Buikstra, Charles* 1999; *Williams* 1999.
[10] *Sobotkova, Weissova* 2019, 2020.
[11] *Bakardzhiev* 2005; *Privat et al.* 2018; *Penske et al.* 2023.
[12] *Ross et al.* 2018, 2012, 2010.
[13] *Sobotkova, Weissova* 2020.

their chronology spans from the Early Bronze Age to the Mediaeval Era, with the relative frequency peaking in the Early and Late Bronze Age followed by the Roman imperial period[14].

Intervisibility

To assess intervisibility, I calculate line of sight (LoS) from each of the 1073 mounds inside the Yambol Province boundary to all other neighbors 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 observer and the observed point (see **Fig. 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 border, I also calculate their LoS to additional 1206 mounds within 25 km of the Yambol Province border. The latter 1206 mounds have also been digitized from the Soviet military topographic maps but remain unverified[15].

Digital elevation model and vegetation modeling

I use three JICA ASTER DEM[16] tiles of 30 m resolution as a digital elevation model for the LoS calculation within the Yambol Province and a buffer of 25 km around. The DEM is a bare-earth model (BOM), which maximizes intervis-

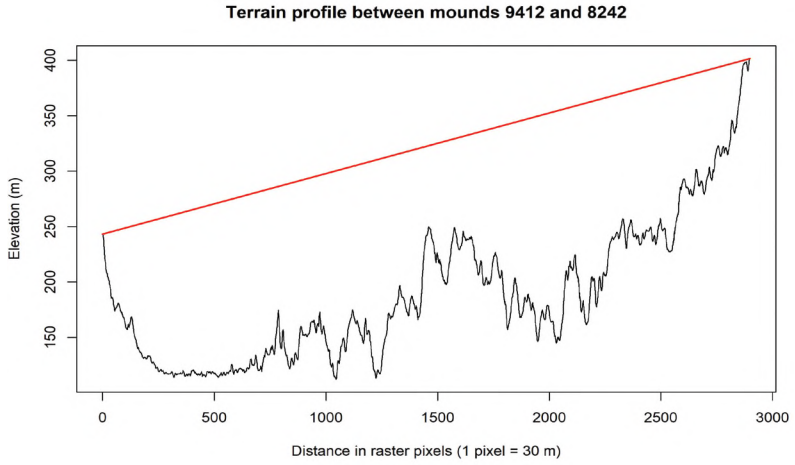

Figure 2. Raster profile from NW to SE edge of the region with positive line of sight between mounds 9412 and 8242.

ibility. To challenge this model I simulate vegetation following Connor et al.'s palaeoecological study[17] which attests to patchy forested landscape within the Tundzha watershed. I generate two different surfaces: first, trees of 10 m height distributed randomly over 50 % of the landscape, and second, vegetation of variable height from 1 and 20 meters (with a mean at 10m) randomly covering 50 % of the landscape. Both surfaces have the same average height, but the second is more 'permeable'. I overlay the vegetation surfaces over the BOM and re-calculate mound intervisibility. Results allow me to gauge the drop in mounds intervisibility due to vegetation.

Intervisibility calculation workflow is coded and parallelized in R and is available for review in Github (https://github.com/adivea/Visibility).

Results

Results for the BOM show most mounds highly intervisible. The group with lowest intervisibility – having only 1-10 visible counterparts – is small at 143 features out of 1073 (13 %).

[14] According to *Arheologicheski otkritia i razkopki*, 40 mounds were excavated in Yambol region in 1987-2014 yielding 295 burials.
[15] *Sobotkova et al.* 2023.
[16] ASTER Global Digital Elevation Model.
[17] *Connor et al.* 2013.

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 see 250+ other mounds. Their lines of sight extend across the entire region, up to 60 km far. The mound with the highest visual dominance, no. 9412 west of Yambol city has an unobstructed line of sight to 491 mounds, visible in **Fig. 3**. We can reasonably doubt the real possibility of recognizing anything at such a distance, except perhaps fire beacons at night or smoke during daytime. In reality the large-scale of such a distance would reduce even a 7 m high mound to an insignificant and unrecognizable dot.

In addition to considerations of scale and limits of human vision, vegetation changes the situation dramatically (see **Fig. 4**). In the first simulation (static 10m tall vegetation), intervisibility drops by 35-90 %. Over 400 of 1073 (40 %) mounds lose 90 % of their field view due

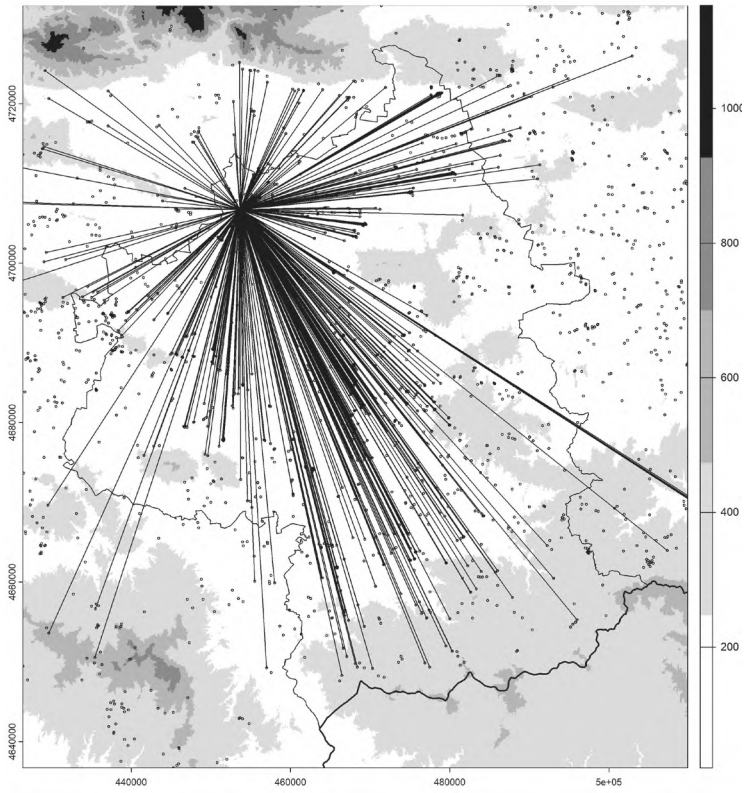

Figure 3. Mounds in the Yambol Province and within 25 km buffer of it visible from mound 9412 (n = 491).

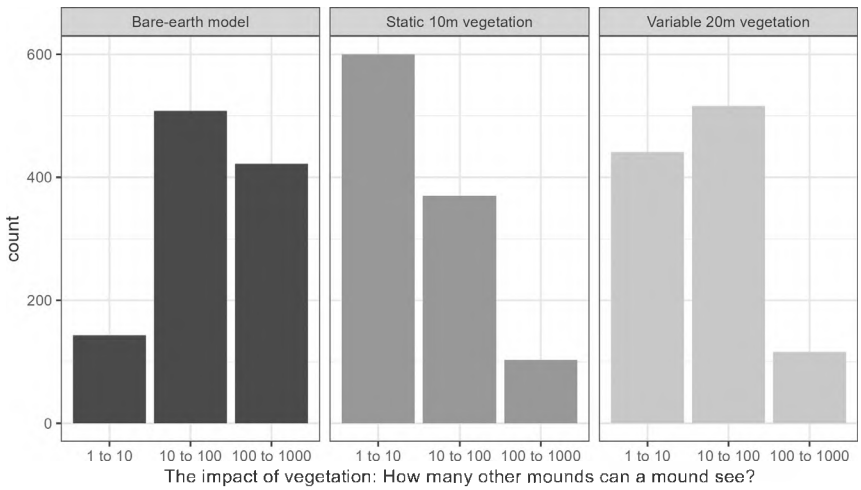

Figure 4. Histograms depict changes in intervisibility class membership under different vegetation scenarios.

to a patch of trees. Most mounds now have intervisibility of 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. This considerable drop in intervisibility is consistent with Skov-Petersen's (2007) results and makes sense in light of the 50 % tree coverage.

In the second scenario (variable 20m vegetation with 10m mean), the drop is less pronounced. 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 scenario 2 are higher in 1, their variability contributes to a less dramatic drop in the middle intervisibility rank, shuffling the class membership gradually. What happens with individual mound ranking, especially the leading ones?

The downward adjustments contribute to some shuffling among the leading individual mounds. The total winner, 9412, moves into second place with 249 mounds (decline of 46 % over BOM) when inside the 20m vegetation model. It is superseded by 9044, a 6m tall mound near Botevo, with 291 visible mounds. Only 4 of the leading mounds retain their position among the 10 leading ones, these being 9412, 9411, 9044 and 8700. Others shuffle up from below these top first places. In the end however, unless the mound location happens to be covered by vegetation, the rule applies that '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, in the bare-earth model 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-effect, 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 vertical shape and rugged boundary of the region suggests that edge effects will be considerable, and the final numbers do go up by as much as 20 %, they go up equally for most mounds involved, not perturbing the overall order dramatically.

These results confirm two points: that landscape affordances in the Yambol region drive the results and ancient mound builders were aware of and exploited these attributes (or not) intentionally. Visibility mattered but was not the only criterion. To underscore the point, there are other locations in the region that offer supreme visual dominance, such as the peak of Bakadzhitsite or the Dodoparon hill which offer a prominence of 99 %. Scaling these peaks, however, is clearly beyond the needs for ancestral worship and territorial signaling of the local communities.

Two winners emerge in the study of intervisibility, whose context merits a bit more detailed attention. Mounds 9412 and 8007 and both in locations of high relative prominence, being perched on a ridge or outcrop with an open view across the Middle Tundzha watershed (see **Fig. 3 and 5**). While 9412 sits northwest of the Yambol city, its view opens to the southeast where most of the rest of the region lies. Mound 8007 is near the geographic center of the region, with an unobstructed view of 90 % of the region. Having been investigated in a 2010 rescue campaign, C14 dates place the first use of 8007 in the Early Bronze Age[18]. After the initial construction, over 20 other bodies were interred here over the course of the next 3000 years, attesting to the place's long-term popularity. Mound no. 9412 remains intact as of the writing of this paper. Nearby mounds, however, also contained remarkable stone constructions and pit graves with burial goods dating to the EBA period[19].

[18] *Privat et al.* 2018; *Penske et al.* 2023.
[19] *Bakardzhiev* 2005.

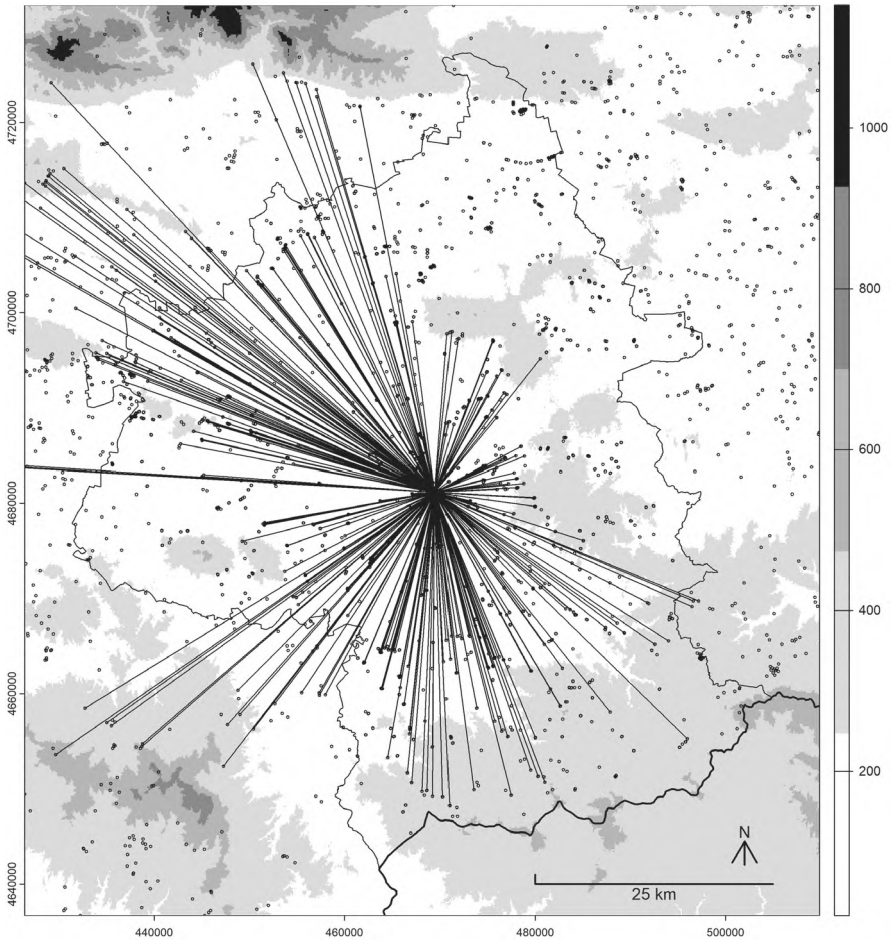

Figure 5. Mounds in the Yambol Province and within 25 km buffer of it visible from mound 8007 (n = 387).

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Видимостта между хилядата могили в Ямболска област[20]

Адела Соботкова

Проучването изследва влиянието на растителността и ефекта на периферията върху степента на видимост помежду над 1000 могили в Ямболска област. Генерирани са два различни варианта на растителна покривка за региона, като видимостта между ямболските могили е сравнена с тази на модел въз основа на терена без растителност. Резултатите от линията на видимост показват, че ямболските могили, разположени върху изолирани възвишения, разполагат с най-добър визуален контрол над заобикалящата ги среда. Калкулирането на растителност с вариращa височина между 1 и 20 m намалява взаимната видимост по-малко, отколкото калкулирането на растителност с еднородна височина от 10 m. Въпреки че калкулирането и на двата модела растителност може да доведе до хаос в класифицирането на могилите по отношение на видимостта, крайните отличаващи се могили остават същите, дори ако в калкулацията се добави и гора. Мерките за коригиране на ефекта на периферията имат сравнително слабо влияние върху резултатите, което показва, че площта от 3355 кв. км е достатъчно голяма за изследване на видимостта на регионален ландшафт.

[20] Translated from English by Julia Tzvetkova.