Quaternary Geomorphology and Viewshed Analysis of the Garniai I

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The Garniai I Hillfort in northeastern Lithuania was occupied from the Bronze Age during the Lithuanian Late Bronze and again disturbed during the Modern Era. The local geomorphic landscape of the site was formed by Terminal Pleistocene and Holocene glaciation and sedimentation, the majority of which predated the original occupation by millennia. These geological processes influenced the cultural development of the site in the Bronze Age and its preservation into the present. The surrounding landscape and environment of the Garniai I Hillfort is key to understanding, as best we can, the lives of the people who occupied the site. Geospatial interpretation of landscape with a specific focus on the Late Bronze Age occupation of the region are here used to interpret the effect of site Quaternary geologic history on occupation history. A viewshed analysis of three contemporary or quasi contemporary hillforts all located on glacial kame terraces including Garniai I was employed with the intention of determining their relationships to one another. This analysis resulted in the identification of the likely relationship between the sites if they were occupied contemporaneously as well as the potential identification of new areas for archaeological study within the region which would give more insight into these results.

Introduction

Hillforts in Lithuania and Latvia are unusually numerous compared to other parts of Eastern Europe, reaching a maximum in Utena County, Lithuania which has over 190 hillforts located within a 2,780 square mile area, all of which were occupied during the Late Bronze Age or later.[1] The appearance of Hillfort settlement patterns in the European Bronze Age has been associated with attempts to gain control over significant trade routes.[2] However, matching established models of societal development in Central or Northern Europe to East Baltic Bronze Age would require overlooking significant differences: first, there is significantly less bronze consumption than in neighboring regions to the South and West;[3] secondly, these communities used mostly bone or stone for their tools, weapons, and ornaments; thirdly the imitations of European Bronze Age traditions took a wide variety of forms. There are no apparent trading routes in the region of importance to Scandinavian or Polish Bronze Age groups. In a regional context, the communities in the Eastern Baltic are still largely unstudied and the regional archaeological record for the period is not directly comparable to that of any surrounding regions. The appearance of hillforts and earliest development of hillfort societies is still insufficiently documented due to the relatively paucity of modern investigations in the region on sites dating to this time period which is later than in the South or West.

Garniai I is a hillfort situated amongst the hills of the Aukštaičiai lift, near the Kriauklė rivulet that runs through the neighboring lakes Kibinėliai and Pelakys (Fig. 1). A swamp surrounds the hillfort to

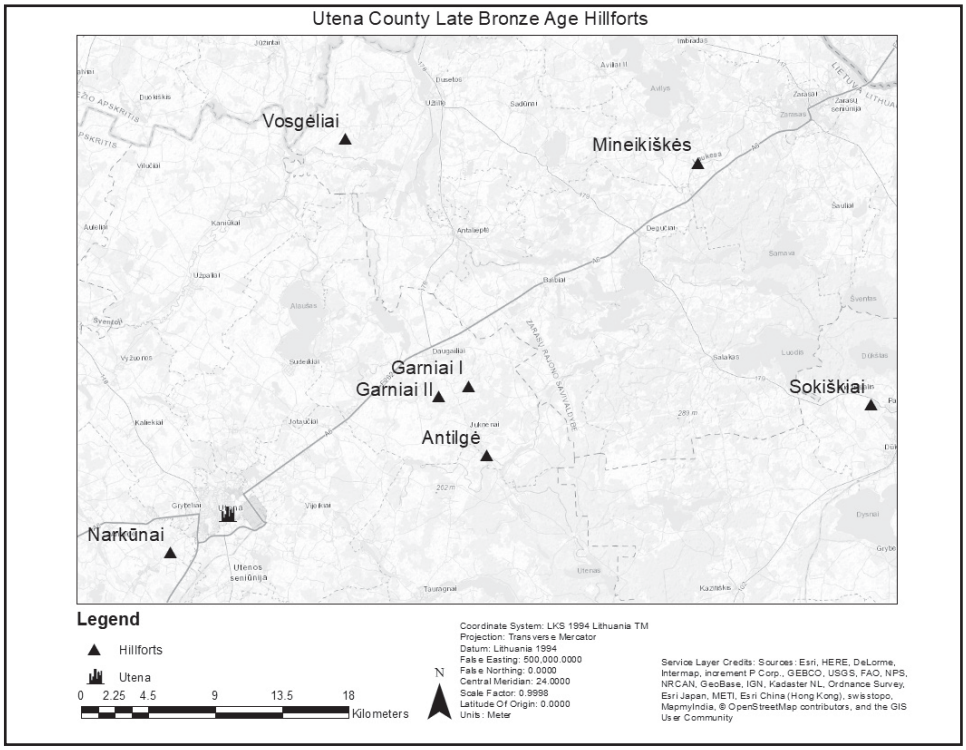


Figure 1: Potentially contemporaneous Late Bronze Age hillforts in northeastern Lithuania mentioned in the paper. Discussion focuses on Garniai I, Garniai II, and Antilgė.

the north and a narrow dry depression lies to the southwest. An isolated ovoid hill was chosen as the prehistoric hillfort location and had been subject to different formational processes since the Last Glacial Maximum. The current hillfort courtyard, the area between the glacial berms which surround the site, is approximately 75 m in length (SW-NE) and 35 m in width (NW-SE), with a relief of approximately 20 m above the Kriauklė rivulet at the base of the hillfort slope (some 200 m above the modern Baltic Sea level). The nearest hillforts which could have been settled contemporaneously to Garniai I are Antilgė, 4.8 km to the southeast and the uninvestigated Garniai II hillfort 2 km to the SE of Garniai I, which based on preliminary testing could also represent a Late Bronze Age occupation as well. These two hillforts, which are known to have archaeological components that are contemporary or quasi- contempory with the occupation at Garniai I, are within an aerial distance to Garniai I appropriate for overlapping viewshed. They are mapped in Figure 1.

The incredibly high regional density in hillfort sites in Utena County compared to the rest of the East Baltic is likely related to a long term prehistoric settlement preference for elevated locales in the region, as well as a remarkably suitable geologic landscape for hillfort settlement. Therefore an investigation into the particulars of this geologic landscape as well as an investigation of the viewsheds of local hillfort sites with contemporaneous or quasi contemporaneous components is necessary to elucidate the relationships between hillfort settlements.

In this study the quaternary geologic landscape of Garniai I was viewshed along with its two nearest contemporary or quasi contemporary neighbors for overlap in viewshed to determine the possible relationships of the sites to each other in various configurations of cohabitation. This was done in an attempt to discern the nature and extent of the relationships of the sites to each other. This case study will serve as an example of how geospatial and geologic information may be utilized to derive information about settlement patterns within groups of sites which lack good extra-regional correlates and have relatively low excavated sample sizes.

The Nature of the Late Bronze Age Occupation of the Garniai I Hillfort

Hillforts in the South East Baltic region during Late Bronze Age (1100–500 BC) were permanent prehistoric settlements. Each housed an individual community likely representing multiple family units. Estimated community size reached from 40 to 120 in individual hillforts.[4] The chronology of the Bronze Age in the Southeastern Baltic has been reconciled with the Scandinavian dating scheme and there is a comprehensive discussion in the relevant literature.[5]

Cultural horizons at Southeast Baltic hillforts are generally well developed, thick, and rich in finds. These finds include thousands of pottery fragments, zooarchaeological remains, paleobotanicals, bone, stone and metal artifacts. Routinely recovered features include pits, postholes for buildings, and hearths. Occasionally the remains of defensive structures, generally palisades, are present.[6] It is likely that the settings and possible fortifications at Late Bronze Age hillforts in the Southeast Baltic reflect an intentional societal structure with regards to site placement. This could be either based in mutual social tension over resources between local communities or mutual networks of collaboration between local communities. There is very limited data to represent the direct interaction of outside groups within the region (which has no copper, tin, or other significant concentration of Late Bronze Age wealth or the raw materials for other prestige goods).

Since limited metal imports became more important in the region contemporary to the practice of establishing hillforts in Eastern Lithuania, the possibility of conflicts over access to metals and metallurgical technology could have been a factor in the inception of this new, more nucleated and networked settlement practice.

The layout of the structures within settlements' hillforts in northeastern Lithuania was varied but primarily focused on two modes of settlement planning. Buildings were either erected several meters from the palisade and concentrated to one side of the hillfort,[7] or they were concentrated near the palisades leaving an open court, as evidenced at the hillfort of Ķivutkalns in Latvia.[8] It is likely that the former layout mode was present at Garniai I.[9] Defensive buildings were generally still modest in the Southeast Baltic during this time period, consisting mostly of simple palisades. Therefore natural relief with an enhanced viewshed of the landscape may have been a major factor in deciding to settle at a particular location if site security was a major concern.

The Garniai I hillfort was established sometime between the 8th and 6th centuries B.C., based on regionally diagnostic artifacts and 14C dates, and represents the permanent settlement of a community for at least several decades.[10] After the abandonment of the hillfort, settlement ceased at the site and was not resumed by its previous residents or any other potential occupants. The next major evidence of land use, observed during the 2016–2017 excavations, consisted of plowmarks of indeterminate age which partially penetrated an anthropogenic clay layer containing 20th century refuse.

Landscape change at Garniai I is better documented in the modern period. Local informants interviewed during the course of the archaeological investigation describe cultivation of rye during the Soviet Period and the use of heavy machinery which changed the relief of portions of the hillfort significantly. The systematic coring of the hillfort courtyard during the 2016 archaeological survey[11] revealed that most of the cultural layer remains only in the southern part of the courtyard. Much of the site is now buried in clay of anthropogenic origin that relates to Soviet Period attempts at field replenishment. These attempts both ruined the site's agricultural potential and subsequently shielded the deposits from additional deflation. There is a high possibility that the Bronze Age cultural layer was destroyed in at least half of the area of the hillfort courtyard prior to Soviet activities through agricultural land use and during the attempted Soviet Era agricultural rejuvenation. The remains of these portions of the cultural layer now either lie downslope or were pushed into the Kriauklė rivulet. For a Late Bronze Age single component hillfort in the region this is extremely good preservation within the excavated sample.

Pleistocene and Holocene Landscape Development of the Region

Eastern Lithuania was glaciated during the regional Nemunas Phase of retreat of the Fennoscandian Ice Sheet. Retreat of the ice lobe associated with the study area began at least 18 ka B.P. based on Beryllium-10 dates returned from terminal Gruda Moraine.[12] Results from the same study indicated that the Middle Lithuanian Moraine, which is of greatest significance to this paper, was formed as a moraine position ca. 13.5 ka B.P.[13] The Middle Lithuanian Moraine Belt is important to this study as the Pleistocene geomorphology related to the formation of both the landform on which the Garniai I hillfort is located and the surrounding region would have formed during this period.

Moraine positions do not represent static passive events in glacial ice retreat, rather they represent periods of time when the glacier was alternately advancing and

ablating forming a multitude of depositional environments along the ice margin. These features, commonly referred to as *kames* or *kame terraces* are often tectonic in nature. This results in the creation of high elevation till deposits via the deformation of earlier deposited till. These landforms are then subjected to lacustrine, alluvial, and eventually aeolian processes.[14] These deposits are distinguished either by stratigraphically undifferentiated mixed till or by alternating deposits of material related to secondary postglacial depositional processes occurring on previous morainic landforms which are characterized by a non-uniformitarian relationship with Walther's Law of the lateral conformity of depositional environments with vertical stratigraphy. This is because these deposits have been thrust tectonically by glacial readvance on top of each other, forming a landform comprised of unconformable early periglacial landform deposits.

These glacio-tectonic landforms can and should be classified separately from stratified sand and gravel deposits, which can also form in ice marginal settings and be set above the deglacial landscape as representing completely different mechanisms for deposition.[15] In the Utena County Region of Lithuania, where the Garniai I hillfort is located, the vast majority of Higher landforms are associated with tectonic kame formation against stagnant ablating chunks of ice abandoned by the glacier.[16] These can be identified by numerous associated kettle hole depressions which have or had formed postglacial and holocene lakes in the region. Large regional lakes occur in periglacial depressions caused by seasonal glacial fluvial scour of basal till in the river valleys between upland morainic landforms, which were subsequently impounded when isostatic uplift cut off their outlets from local base level.

Following the retreat of Nemunas Ice from the region to the North Lithuanian Moraine System ca. 13.3 ka B.P. the area surrounding the Garniai I hillfort was a primary discharge area for a significant amount of glacial frontage. During this period of time large braided river systems should have been active in the region creating the conditions for the deposition of Loessic and very fine sandy deposits in sheltered areas.[17] This loess cover, which was less pronounced, would have formed less noticeable thinner deposits or been quickly integrated into the local existing topography through soil development or brought again into aeolian transport for deposition elsewhere in less exposed locations.

The landscape of Eastern Lithuania went through a normal series of vegetation regimes following deglaciation, with the initial tundra being superseded by coniferous forests, followed by mixed/broadleaf forests in the uplands with continued pine dominance in regions of coarser till. This has been documented in a series of pollen cores.[18] By the Middle Bronze Age a typical subboreal regime covered the upland slopes while open areas consisted primarily of prairie/meadow species in varying amounts. Human activity can be noted by the presence of Cerealia-type pollen and its associated weeds in a number of the cores. Woodland clearance would have started to affect both soil development and sedimentation by this time.

The Stratigraphy at Garniai I

A stratigraphic sequence was obtained by bisecting the natural and cultural deposits at Garniai I during the 2017 field season. This geological trench was cut into the natural glacial rampart of the site and may be viewed as representative of site stratigraphy as it relates to the nature of the landform on which the hillfort was located and the nature of the geologic deposits on that landform which were available to residents during the period of Late Bronze Age Occupation and the concurrent formation of

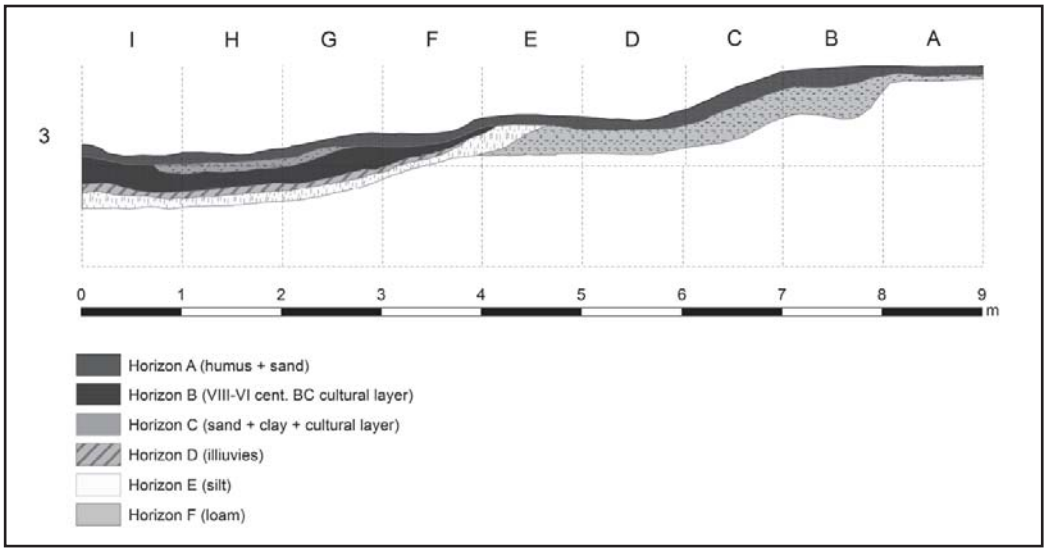


Figure 2: Cross section of Geologic Trench, Garniai I hillfort (2017). Horizon F is till of glacial origin (loam being a mixture of sand, silt, gravel, and clay), Horizon E is the Aeolian Silt Mantle which forms the matrix of the overlying cultural layer. The superpositioning of the silt layer in this section indicates that it formed after the initial glacial landform blanketed the original topography (Drafted by Vytenis Podėnas, used with permission).

the archaeological deposits. A cross section of the Geologic Trench may be found in Figure 2.

The hill chosen for the hillfort location is a typical morainic kame composed of a mixed (multi depositional environment) ground moraine tectonically pushed into an upland till landform composed of poorly sorted gravel, sand, silt and clay. It is likely that this accounts for the saddle or rampart at the site which is geologic in nature and the central court, which mark the hillside as unique. This bowl-shaped court, which formed the majority of the settlement area, was partially filled or filled and partially ablated with a unit of a uniform white silt with fine sand which likely dates to later Moraine positions and is pre-occupation in age. The stratigraphic superposition of this white silty unit is clearly visible in the geologic trench dug in the 2017 field season (see Figure 2).[19] It was likely much thicker prior to the Bronze Age habitation and disturbance from modern agricultural activities, resulting in deflation and minor cultural mixing. All Bronze Age features are embedded into this layer and it serves as the matrix for the Bronze Age cultural horizon.

Deposition at the site during the Terminal Pleistocene was fixed by tundra vegetation followed by successions of vegetation of the hillside. It was most likely opened for erosion again with deforestation associated with the Bronze Age cultural layer, which is not a uniform feature of the site but appears to be restricted to those areas which contain the white silty layer. This is unlikely to be a factor of the tyranny of preservation, but rather a deliberate choice by Bronze Age residents as this layer is much easier to work with for the construction of structures and the digging of pits than the underlying till. There is a discontinuity in the stratigraphic sequence which is obscured by limited modern and potentially pre-modern plowing of the site. This is evident in the presence of plow traces between the dark cultural layer

and the overlying nearly uniform clay. This clay is of modern anthropogenic origin and it is unknown how much of the cultural layer was lost to anthropogenic activity before the failed Soviet Era attempt at field replenishment effectively capped the site with this clay. The clay appears geologically homogenous and was of great consternation in the development of a geological profile of the site as no depositional process for its emplacement could be identified until its origin was determined as anthropogenic through ethnographic interview in the 2017 field season.

In the 30 years since that capping event a poorly developed but relatively deep loamy inceptisol, with modern artifacts and a few Bronze Age artifacts eroded or turbated out of context, has formed out of the clay parent material. This represents the terminal deposit at the site at the time of excavation in 2016 and 2017.[20]

Cultural Deposits

The finds recovered from the excavations at the Garniai I hillfort represent a fairly large sample considering the size of the site and the area excavated. The previous recovery of limited bronze casting materials at the site indicated that it was likely regionally important as it had any bronze working material at all. The recovery of an antler double button[21] (Figure 3) reinforces this interpretation. Regionally produced double buttons made of antler, bone or amber from this time period are known from the Baltic countries. They trend north to south from the Estonian coast into the Eastern Baltic interior and are in imitation of styles of similar bronze buttons recovered from further west into the Nordic Bronze Age Sphere in Sweden.[22] These buttons in the Eastern Baltic Context have associations with an elite status for burials in Baltic states.[23] It is likely that, in the absence of available bronze in the East Baltic, these buttons served as high-status items as local cultures were exposed to and to some extent adopted Nordic and Lusatian Bronze Age ideas. In this context the use of these items may have been culturally restricted.

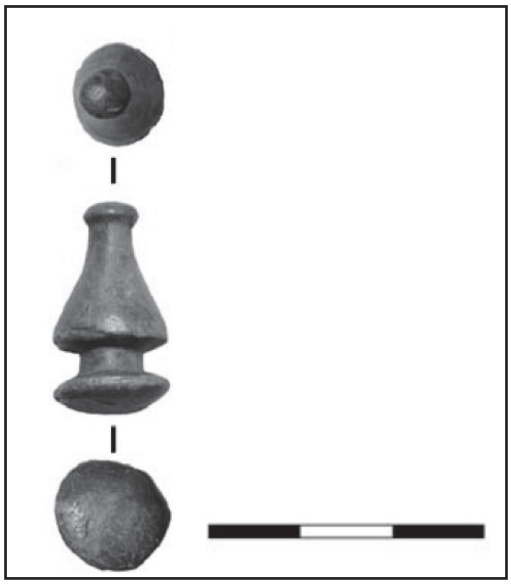


Figure 3: Double button recovered during the 2016 field season. Modified from Civilyte et al. 2017.

Geospatial Analysis of the Garniai I Hillfort Region

Viewshed is defined as the area that can be seen from a given point or series of points. Viewshed analysis was conducted on the Garniai I, Garniai II, and Antilgė hillfort sites. Open source GIS software (QGIS 2.18) and ESRI ArcMap 10.4 was used. High resolution (1 m) LIDAR data allowed for the creation of a topographic vector layer. The Geospatial Data Abstraction Library (GDAL) from the Open Source Geospatial Foundation allowed for the creation of a contour layer using the LIDAR data in QGIS. Once the contour layer was created, it was saved as a shapefile for analysis in ArcMap. In order to do any kind of viewshed analysis, a raster file format is usually needed.[24] In ArcMap, Spatial Analyst was used to create a 1m resolution raster file using the Topo to Raster function. The

LIDAR vector file was used as the feature layer, with the field changed to elevation. The output cell resolution was changed to 1 meter to reflect the native resolution of the LIDAR data. All other parameters were kept at default. Once the raster file was created, observer points could then be used for the viewshed analysis. This was done utilizing the Viewshed function in 3D Analyst in ArcMap. Observer points consist of the longitude and latitude of the Garniai I, Garniai II and Antilgė sites. Output of this analysis is illustrated in Figures 4, 5, and 6.

Discussion

The Viewshed analysis offers several interpretations of the relationship between Late Bronze Age hillfort communities in Eastern Lithuania. If the hillforts analyzed were not occupied contemporaneously, the viewshed overlap or lack thereof is irrelevant and they merely represent an expression of choice in location during the period.

The data recovered about general practice if the sites were not occupied continually points towards a preference towards sites with a two tiered viewshed, a more intense viewshed of the area immediately surrounding the site and an extended viewshed for several kilometers. All sites had vision within some portion of their viewshed of a major body of water. Sites were oriented in such a manner that they had views of both storm tracks coming into the region. Somewhat surprisingly they all had extended viewsheds along the axis where storms may be viewed most extensively to the North and East.

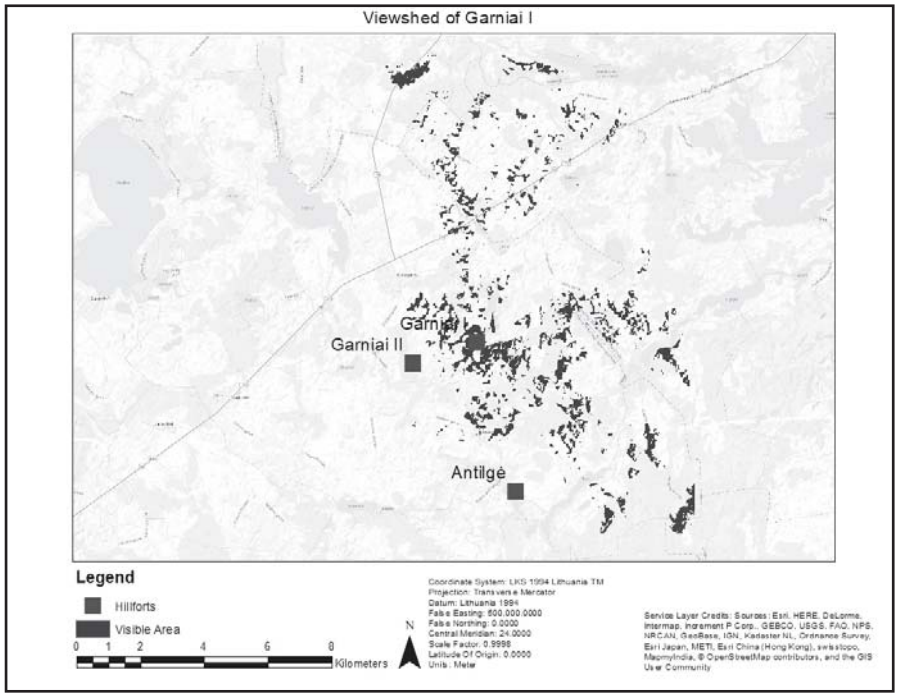


Figure 4: Viewshed of Garniai I hillfort.

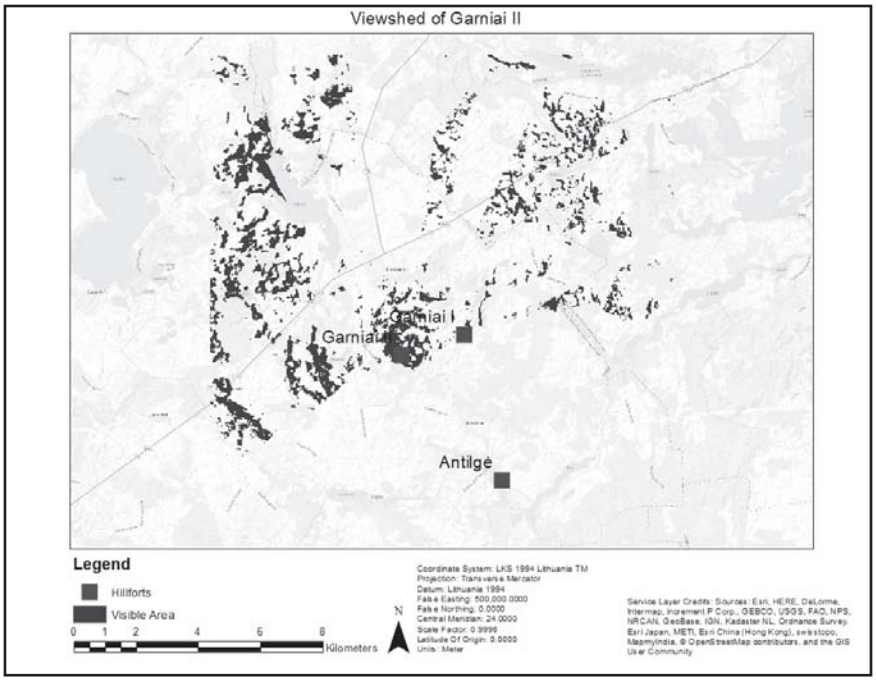


Figure 5: Viewshed of Garniai II hillfort.

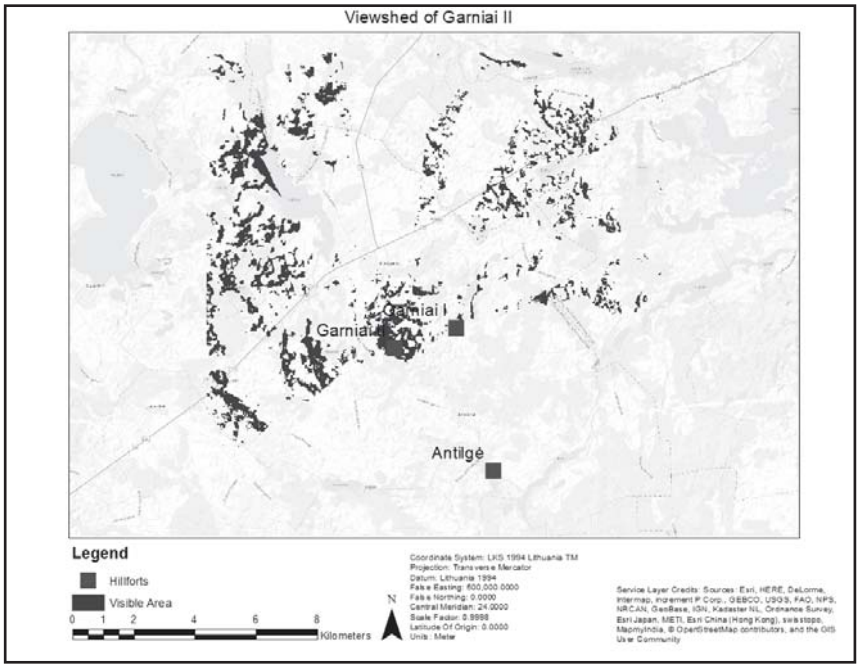


Figure 6: Viewshed of Antilgė hillfort.

The viewshed suggests that the hillforts were multifunctional sites which would allow for an extended viewshed over the nearby topography. This would include, but is not limited to, bodies of water in the foreground and background and pastures for herding fauna. None of the three hillforts examined had a viewshed which allowed for the direct observation of their neighbors. Instead, they were situated in a manner which maximized the viewshed of their surrounding environment. This would allow for the detection of friendly neighbors, insidious neighbors, non-neighbors, or untended herds of animals from a distance allowing the time necessary for a socially appropriate response. This would include both violent and non-violent interaction and the likely quiet appropriation of animals conflict. The viewshed configuration would have been highly useful in the management and protection of grazing animals, which was most likely their primary function in active viewing. Additionally, all three sites are oriented for an extended visual warning of inclement weather, which commonly moves very quickly and violently through the region from a limited number or directions seasonally. Where viewsheds do overlap it is at least several kilometers from the site itself in the extended areas of both of the site's catchments. This is too far off to allow for either to have easy vision of the ground terrain which is hummocky. The terrain also would not allow for a rapid response to the areas at the peripheries of the viewshed.

The viewshed represents a lack of concern about the everyday goings on of neighboring settlements. The combined viewsheds form a nearly 360 degree arc of shared vision (see Fig. 7). There is a conspicuous additional gap in the viewshed coverage of the combined viewshed of all three sites of the region immediately to the west of the sites. There is an additional smaller gap in the North. One possible explanation for these gaps is that they represent missing settlements within the network which have not yet been discovered and excavated. Neither are lowland areas. These areas are labeled A and B in Figure 8.

A critical note must be made here that these relationships rest on the assumption that the visual inventory components of this viewshed analysis are discrete and non-universal. Essentially the assumption that the viewshed from any point above a critical elevation will not contain an identical assemblage of landscape features. As noted above, the regional geomorphology is heavily influenced by glacial processes which leave a non-random patterning of the environment at a landscape scale. The authors freely acknowledge that such a result is possible but not probable as all such points are assumed to not contain archaeological sites and the viewsheds of the known sampled archaeological sites show identical variation with respect to orientation (Fig. 4, 5 & 6). They also acknowledge a certain provisional circularity to this logic which will be discussed in more detail below.

Conclusions

This study represents a very basic attempt at employing geospatial analysis to the Late Bronze Age Period sites in Northeastern Lithuania. Considering the coarseness of the data and the relatively understudied nature of the time period in the region, the study illustrates the utility of geospatial analysis, in this case viewshed analysis, at even very early stages of archaeological project arcs. The analysis offers the preliminary conclusions that the three hillforts used in this study were not actively observable to one another, but rather there were some shared points in the viewshed at the periphery of the study area. If the sites were occupied contemporaneously, it also suggests, based on their spatial position and their viewshed alignments, that they formed part of a laterally organized settlement network with no hierarchical settlement organization.

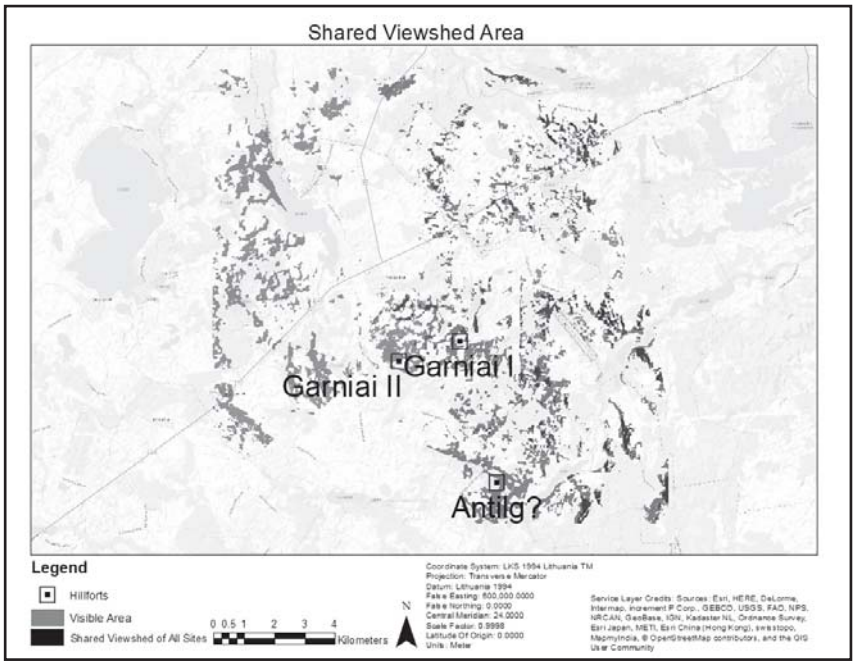
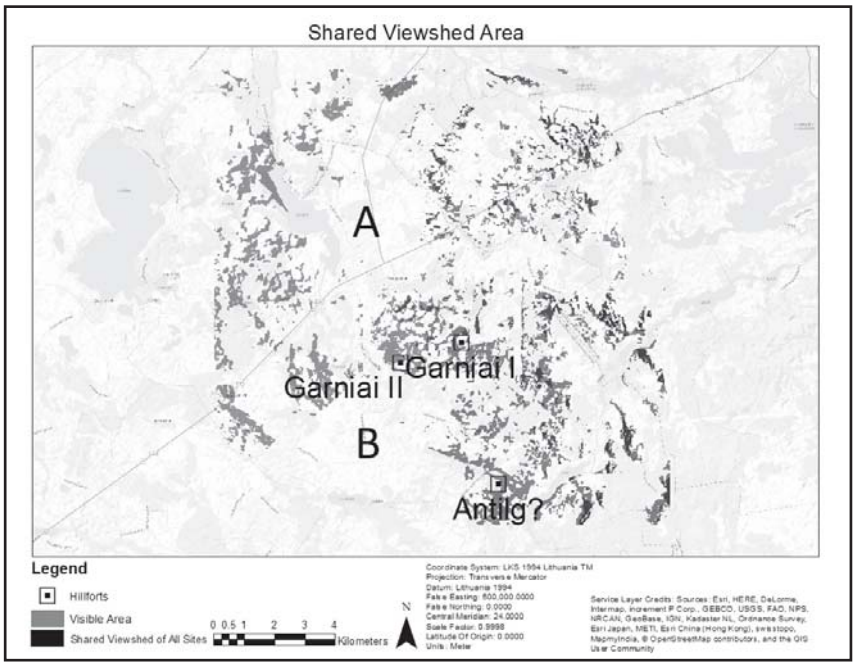


Figure 7: Shared viewshed of possible contemporaneous hillforts



Shared viewshed of possible contemporaneous hillforts with gap areas A & B.

The critical next step in corroborating the results of this preliminary study would be the construction of such a comprehensive viewshed analysis for every elevation above a certain threshold (or which met certain other conditions) to construct a comprehensive dataset that these results could then be tested against on a broad regional scale. Such an exercise was unfortunately outside the scope of available time for model construction and resources for ground truthing (for viewshed) as of the date of this publication. With such an inventory the statistical significance of recurrence of viewsheds characteristics at archaeological sites could be calculated against the background noise of the non-random geomorphic patterning of landscape itself. It would also correct for the necessary circular logical constructions for our modeling noted above. It is unfortunately also important to note that this geomorphological bias and resultant background noise is not recognized or acknowledged as often as it should be in archaeological viewshed analysis.

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Endnotes:

1 Baubonis et al. 2017.
2 Krause 2008; Earle et al. 2014; Čivilytė 2014.
3 Sidrys & Luchtanas 1999.
4 Luchtanas 1992; Lang 2007.
5 Sidrys & Luchtanas 1999; Lang 2007; Čivilytė 2014.
6 For extensive studies of representative hillforts see Krzywicki 1914a; 1914b; 1917; Tarasenka 1934; Indreko 1939; Grigalavičienė 1986a; 1986b; Volkaitė-Kulikauskienė 1986; Graudonis 1989; Vasks 1994; Sperling 2014.
7 Volkaitė-Kulikauskienė 1986; Grigalavičienė 1986a; 1986b.
8 Vasks 2007.
9 Podėnas et al. 2018.
10 Čivilytė et al. 2017.
11 Čivilytė et al. 2017.
12 Rinternecht et al. 2008.
13 Rinternecht et al. 2008.
14 Bitinas et al. 2004.
15 Bitinas et al. 2004; Bitinas et al. 2012.
16 Bitinas et al. 2004.
17 Rinternecht et al. 2008.
18 Kabailienė 2006.
19 Podėnas et al. 2018 *in press.*
20 Čivilytė et al. 2017; Podėnas et al. 2018 *in press.*
21 For a discussion on the significance of this type of find see Luik & Ots 2007.
22 Ling et al. 2012; Luik & Ots 2007.
23 Bezzenberger 1900; Šturms 1936; Denisova et al. 1985; Lang 2007.
24 Llobera 2003.

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