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# Establishing a method for visibility and viewshed analysis for late 4th century fortifications in *Gallia Belgica* and the Germanic provinces

By James Dodd

*Keywords:* *Late Roman / "Höhensiedlungen" / fortifications / GIS / visibility analysis*
*Schlagwörter:* *Spätrömisch / Höhensiedlungen / Befestigungen / GIS / visibility analysis*
*Mots-clés:* *Antiquité tardive / habitats de hauteur / fortifications / GIS / analyse de visibilité*

## Introduction*

Northeastern Gaul was a complex and contradictory zone during Late Antiquity – both central and marginal to the military-political operation of the Western Empire. It contained key urban centres, such as Köln and Trier but also marginal depopulated landscapes. In the northwestern provinces, Late Antiquity has traditionally been viewed through a lens of 'decline and fall', initially put forward by Edward Gibbon in the late 18th century and developed into a grand narrative in the 19th and 20th centuries that encompassed the wider end of the Roman period[1].

One of the more important elements of Late Antique *Gallia Belgica* and the Germanic provinces is the increased profile of defensive sites across the region. These installations are a common feature of the provincial landscape and appear in a vast variety of forms and types in both the lowland and highland zones of Northwestern Europe[2]. Academic debate has focused on their function, form and role for over a century with the continuity of older military bases along the *limes* and the relationship between defended settlements and *foederati* given special scrutiny[3]. Clear datasets have expanded our understanding of these new defended sites and we are now able to say that, with the possible exception of Northeastern France, there is a significant upswing in defended sites from AD 250 onwards. The generation of new datasets, chronological resolutions and excavation have, over the last 50 years, allowed us to develop distribution patterns to defensive architecture across Late Antiquity[4]. Despite the momentum in understanding these shifting defensive networks, there has been little empirical analysis of these sites on a supra-regional level, nor has GIS been marshalled to successfully develop lines of research into the period and its fortifications.

This paper aims to initiate a standardised, GIS-based visibility analysis of defended installations in Northwestern Gaul. Visibility analysis is an important tool for understanding the

* This publication was prepared under the F.S.R. project 'A culture on the defensive? The archaeology of fortification in the Northwest from Constantine the Great to Aetius' and was conducted at the CRAN, Université Catholique de Louvain, Belgium.

1 Heather 1994; 2007; Halsall 2007, 19–22 for a survey of the historiography.

2 Brulet 2019 for the difficulties of military vs. civilian in Late Antique Gaul; Dodd 2023a; 2024.

3 Roosens 1967; Böhme 1974; Bridger / Gilles 1998; cf. Esmonde Cleary 2013, 45–50 for a survey.

4 Gilles 1985; Brulet 1990; Bayard / Fourdrin 2019; Heimerl 2021.

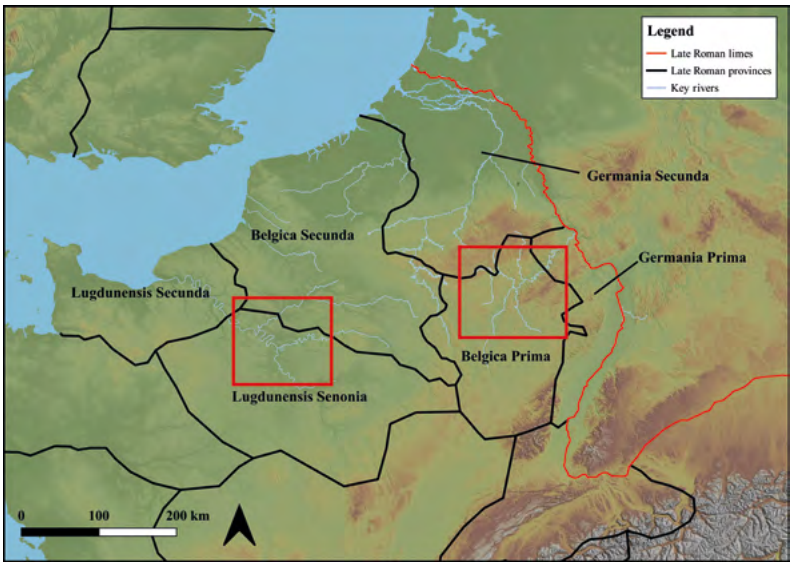


Fig. 1. The study region showing the civil administration of Northern Gaul in the 4th century and highlighting the areas under study in red.

decision-making process behind site selection for Late Antique fortifications. Defensive structures, as a group, rely heavily on visibility for control, surveillance, or simply to detect potential threats with sufficient time to respond. Late Antique defences are situated across a wide variety of landscapes, stretching from coastal wetlands to highland zones, and contain endless diversity. By establishing visibility and viewshed parameters for these defensive typologies, we can begin to understand the defensive characteristics of Late Roman landscapes and assess the extent to which siting decisions and fortification location were based upon outgoing visibility.

To achieve this first step in visibility studies on Late Roman defences, this paper will present several different elements of landscape and visibility analysis from defended installations in the northwestern provinces. Initially, this consists of a methodology for assessing visibility metrics from installations in the region. This method will see the creation of a series of different groups to classify estimated defensive heights, so they can be surveyed within the same broad network. By providing broad metrics for assessing height differentials and a method for applying this on a wider scale, we can move beyond the notorious issue of establishing typologies for classifying Late Roman defences. To examine the feasibility of this approach, the paper will test the method in two regions of *Gallia Belgica* and northeastern *Lugdunensis*; it will draw conclusions based on the analysis of late 4th century defended settlements.

To test this height and landscape methodology, this paper applies the framework to a series of case studies in the northwestern provinces. The approach involves several steps. First, generating a series of total viewshed indexes will provide a visibility map of the landscape in the selected areas. This is followed by binary viewshed analysis and site plotting to ascertain the placement, orientation and site selection of defended installations in the landscape. This will demonstrate the feasibility of different GIS methods for understanding the operationalisation of Late Antique defended installations.

To achieve this, the paper takes data from *Gaule Septentrionale* and the Germanic provinces. The northern reaches of the Late Roman Diocese of the Gauls encompass a very large zone, covering five modern countries and the territory from the Rhine to the Seine *(Fig. 1)*. This in-

cludes a diverse range of geographical landscapes, from the wetlands of the coastal region to the highland Ardennes-Eifel. Late Roman settlement across the region was equally diverse and for the interests of this study, includes a vast amount of different morphological forms of defended settlements[5]. This spread includes the *Höhensiedlungen* and *refuges* of the highland zone as well as the *burgi* and defended enclosures of the lowland areas[6].

To enact a methodological test, two smaller zones of this vast region have been selected for detailed analysis to serve as case studies for how visibility metrics might function on a broader scale. The central sectors of *Lugdunensis Senonia*, located between the fortified *enceinte* of Melun, Meaux (both Dép. Seine-et-Marne, FR), and Paris (Paris, Dép. Paris, FR), illustrate riverine defence through small, fortified centres. *Belgica Prima* on the other hand, includes a more complex range of defended towns, military installations and *Höhensiedlungen*. By applying the methodology to these fortified zones, with varying regional priorities and different forms of defensive architecture, this paper will generate both results and demonstrate the feasibility of visibility analysis for future work in the field.

## Northern Gaul in the 4th century

The 4th century witnessed the emergence of new political, economic and social units in Northern Gaul. The Early and Middle Roman settlement pattern, characterised by villas, *agglomerations secondaires*, and urban centres has been well-researched[7]. This distribution experienced significant upheaval in the late 3rd century as part of a wider shift in occupation patterns. The northern reaches of the region were largely depopulated while south of the main Köln–Bavay road, the *Via Belgica*, there was a marked appearance of new styles of occupation and widespread rural reorganisation[8]. A "Limesfall" was postulated and the abandonment of the northern zones of the provinces, destruction horizons and the fortification of rural and urban sites were all attributed to barbarian raiding[9].

Despite ongoing debate over the causes of depopulation pulses in the late 3rd century, it is clear that the dense pattern of rural settlement had largely disappeared in most regions by the early 4th century[10]. The 4th century landscape has generally been interpreted as one of increased poverty, although this is not universal, as some zones, such as the region around Trier (Kr. Trier, DE), experienced significant investment and construction[11]. From the late 3rd century onwards, new evidence suggests a heightened focus on defence in some regions. New hilltop fortifications, for example at Virton-Château Renaud (BE) developed, whilst lowland *burgi* began to appear along the roads and in strategically important areas,[12]. Notably, these new sites developed in the hinterland, away from the broader *limes* zones and mark an important departure from linear or static frontier defence. This is supplemented during the early 4th century by the fortification of urban settlements. Sites such as Paris, Bavay (Dép. Nord, FR), and Jülich (Kr. Düren, DE) all received new walls, probably in the early-mid 4th century and there

5 For wider studies of Late Roman settlement see van Ossel 1992; Dodd 2021.

6 Gilles 1985; Dodd 2024.

7 Coquelet 2011; Jeneson 2011; Roymans / Derks 2011; Habermehl 2013.

8 van Ossel 1992; Heeren 2015 for depopulation; Dodd 2021.

9 van Es 1981, 47–48; Willems 1984, 273–274; cf. Heeren 2017; Dodd 2023b.

10 Gechter / Kunow 1986; van Ossel 1992; Lenz 1999; Dodd 2021.

11 Seiler 2015; van Ossel / Ouzoulias 2000; Dodd 2021, chapter 4.

12 Brulet et al. 1995; Cahen-Delhaye 2021; Dodd 2024.

is evidence of construction programmes at Bitburg (Kr. Bitburg-Prüm, DE), Neumagen (Kr. Bernkastel-Wittlich, DE), and Jünkerath (Kr. Vulkeneifel, DE)[13]. This transformation is believed to have been a response to an intense period of raiding and unrest during the '3rd century crisis' and the development of a new military footprint that emphasised 'defence-in-depth', using space to control incursions from across the Rhine[14].

## Research Approaches

There is a long history to the study of Late Roman fortifications in the northwestern provinces, with defences identified since the earliest conceptions of archaeology as a field in the region[15]. Early work began to examine sites that did not necessarily conform to preconceived military standards, and it was rapidly realised that these buildings represented a different phase of Roman military activity[16]. Further examinations begin to piece this together in the first half of the 20th century, with the analysis of Roman wall circuits in France and Germany and the identification of Late Antique phases at some major legionary fortresses[17]. This work, partly spurred by the increasing sophistication of the work of the *Reichs-Limeskommission* on the frontier forts along the *Obergermanisch-Raetische Limes*, brought reasonable gains in our understanding of individual defences and the wider landscape[18]. This was, however, very strongly influenced by the traditional 'Gibbonist' narrative of decline and fall and the later concept of a '3rd century crisis'[19]. The narrative painted a picture of fortified settlement reacting to disruption, invasion, and crisis in the late 3rd century, with barbarians crossing into Gaul after a "Limesfall", leaving little or no room for a more nuanced approach[20]. By the end of the Second World War, this initial phase of archaeological excavation had given way to more systematic and scientific analysis[21]. Despite this, the rather bleak view of Late Antiquity remained a key element of research, with new defended sites reinforcing the narrative of an unstable, and ultimately unsustainable military footprint[22].

The rehabilitation of Late Antiquity, beginning in the 1970s and broadly agreed to have begun with the work of Peter Brown, saw the re-examination and re-engagement with defensive structures in the Late Roman Empire[23]. New research examined the transformations in defensive architecture and several works marking the beginning of re-engagement with the phenomenon, most importantly, the work of Harald von Petrikovits in 1971, who fired the starting pistol on a rapid phase of data expansion and study and was further enhanced by the publication of the controversial "Grand Strategy of the Roman Empire" in 1976[24]. The *Höhensiedlungen*, previously subjected to fragmented study, were examined holistically, whilst the Belgian *refuges* were also studied in more detail[25]. Broader work began to fill in our picture of the landscape, through excavations and analysis, with the identification of a late 3rd century phase across the region, and the development of an adapted form of 'defence-in-depth' con-

13 Hettner 1891; Perse 1998; Heimerl 2021.
14 Luttwak 1976.
15 Del Marmol 1859; Mommsen 1894; cf. Heeren 2017 for examples.
16 Peny 1881; Bequet 1887/88; Hettner 1891.
17 Hettner 1891; Blanchet 1906; Grenier 1906 for examples.
18 Klein 1925; Hagen 1931; Gose 1936.
19 For overviews of this see Heeren 2015.
20 van Es 1981, 47–48; cf. Heeren 2017.
21 Barfield 1968; Gilles 1973; Brulet 1974; Heimburg 1977; Mertens 1980 to name a few.
22 Boegers / Rüger 1974, 17–25.
23 Brown 1971; 1978.
24 von Petrikovits 1971; Luttwak 1976; Lander 1980; Johnson 1983a; Reddé 1995.
25 Mertens / Remy 1973; Brulet 1978; Gilles 1985; 1998.

sensus in the research[26]. The assumption in the 1990s and the early 21st century was that new data would continue to fill in the gaps in a pattern of defended highways and riverine corridors, fortified urban *enceinte* and elastic defence through depopulated regions, with an increasing presence of Germanic migrants in the second half of the 4th century[27].

The last decade has seen this neat model become unbalanced, due to large amounts of new data entering the circulation. New *Höhensiedlungen* have been discovered and undergone significant analysis and we are now in a much better position to understand and place them within the wider framework of defence[28]. The systematic excavations in the Rheinische Braunkohlerevier that began in the 1970s have begun to yield important results[29]. The number of known Late Antique defended sites has exploded whilst aerial photography, geophysics, and small-scale trial trenching campaigns in the last half century have identified further candidates, especially in the territory of Zülpich (Kr. Euskirchen, DE)[30]. Despite the recent flurry of work, there has been little holistic analysis of the defensive landscape within a cartographic framework, with many of the important regional syntheses being completed just before the digital revolution[31]. This has spurred more modern approaches to fortification, with the development of typological classifications underway work has also been directed at thematic issues of defensive architecture as well as larger issues of integration and we are now well-placed as a field to make further steps in analysis[32]. Visibility analysis is a good way of achieving further advances in the field that both generate new, useful data, and conform to wider 'Big Data' frameworks currently developing in Roman archaeology[33].

## Methodology

Visibility analysis presents us with an excellent opportunity for understanding the placement, orientation and defended nature of fortified sites in Late Antique Gaul. By establishing visibility parameters and indexes, it allows the assessment of whether or not these sites were being constructed based on visibility variables and will answer a long-term question in the positioning of defences[34]. The analytical approach of visibility is an important element of future work in the field and allows us to take the analysis of defence to a new level. By placing our understanding of these sites within a GIS-landscape context, we can remove subjective elements from our analysis of the period and place the evidence we have on strong methodological and spatial foundations.

### Generating a Landscape Model

To establish a basic landscape model, an initial DEM (Digital Elevation Model) and a DSM (Digital Surface Model) – both with resolutions of 10 m – were generated using data from the

26 Brulet 1990; 2016.

27 Brulet 1986; 1990; van Ossel 1995; van Ossel / Ouzoulias 2000, 143–145; Reddé et al. 2006; Deschieter 2016.

28 Böhme 2008; Brulet 2008a; Hunold 2011; Prien / Hilbich 2012.

29 Gaitzsch 2011; Gaitzsch / Haarich 2012 for two *burgi* in the Hambach mining concession.

30 Scollar 1963; Heimburg 1977; Krüger / Zantopp 1992; Andrikopoulou-Strack / Wippern 2008.

31 Brulet 1990 for example.

32 Henrich 2010; 2015; 2016/17 for typological developments; Henrich 2015; Brulet 2019 for thematic development; Heimerl 2021, 117–129 for issues of integration.

33 Lawrence 2022.

34 For example, Roller 1971.

European Copernicus satellite dataset[35]. This modern DSM was supplemented by the hydrological shapefiles created by the European Environment Agency. A series of methods were then used to build a facsimile of the Late Antique landscape and establish variables for analysis.

## Paleo-hydrology and terrain morphology

The 21st century landscape model was examined in an attempt to work back to a basic paleo-DEM. Using a range of GIS tools, terrain morphology was examined to reduce the impact of most industrial-age landscape changes, for example, rail embankments and the mining undertaken in North Rhine-Westphalia and Rhineland-Palatinate[36]. To achieve this, a range of historical, pre-industrial maps served as a starting point. Initially, the maps of "Preußische Neuaufnahme" were used to model the major changes in Western Germany, whilst the "Carte d'état-major" was used in France. Both date to the early 19th century and can be used, to some extent, to model major landscape changes. However, it is important to note that this is only a first step, sufficient for testing the parameters and structure of visibility. Further work will be needed to establish more coherent mapping of the Late Antique landscape.

The most apparent problem was modelling the hydrological network. There has been very limited work on understanding the river landscapes of Late Roman northwestern Europe. Some work has been done on the Scheldt river, the Rhine and the coastal zones of Nord and Pas-de-Calais, however, we have a limited understanding of the wider fluvial network[37]. To work around this issue, the two regions chosen were selected partly due to the limited changes in the riverscapes[38]. The Lower Mosel has had few significant fluvial changes and had, until the 20th century, been largely untouched by development[39]. The river was canalised in stages between 1938 and 1958 and limited adaption was needed to change the underlying spatial data, using the "Preußische Neuaufnahme" as a guideline. This was not possible with smaller rivers like the Kyll, which had much less controlled valleys, and instead early 19th century Napoleonic and Prussian maps were used to provide a reasonable model. In France, the Cassini map (c. 16th–17th century) provided evidence of the pre-modern river landscape and demonstrated limited movement of the Seine and Marne. Where necessary, modern river controls were removed and pre-modern meanders added, for example at Meaux, where a Roman period meander is known[40]. By analysing zones with limited riverine movement, combined with an appreciation that the valleys themselves have not changed excessively, visibility studies focusing on the river network can still be used to provide meaningful results, especially if the limitations are kept in mind. Naturally there are also problems with less tangible elements; for example, higher woodland cover is known for the loess belt and the Kempenland (modern-day Belgium and Netherlands) further north and equivalent tree cover in the test regions would have impeded views, although these are, by and large, not reproducible on the DEM given a lack of cohesive data[41].

35 This data (code: EAA-10) consists of a European DSM with 10 m resolution coverage. Downloads were made available by the European Environment Agency: doi: https://doi.org/10.5270/ESA-c5d3d65.

36 This included a process of polygon changes to the underlying height data of the DEM using the QGIS plugins *Terra Antiqua* and *Serval*.

37 Leroy / Verslype 2016; Bongers 2019; 2020.

38 Both the Mosel and Seine have received some limited studies as to their Early Medieval navigability; Elmhäuser 2002 whilst the work of the DFG-funded project Harbours from the Roman Period to the Middle Ages has open-access repositories of harbour sites for river corridor reconstructions (https://www.db-thueringen.de/receive/dbt_mods_00035239 [last access: 23.09.2024]).

39 MacIntyre 1957.

40 Couturier et al. 2021.

41 Bunnik 1999; Van Impe et al. 2005.

| Fortification type | Assumed height | Assumed visibility | Visibility radius |
|---|---|---|---|
| Urban wall with towers | 12.0 m[42] | 1.7 m | 6 km |
| Urban walls without towers | 7.5 m | 1.7 m | 6 km |
| Towers | 9.0 m[43] | 1.7 m | 6 km |
| Palisade / Rampart structures | 5.0 m | 1.7 m | 6 km |
| Stone military installations | 9.0 m[44] | 1.7 m | 6 km |

Tab. 1. Height variables for different types of Late Roman defences in the dataset.

## Visibility Parameters and method

GIS visibility analysis comprises a number of related terms and methods, each with a rich scholarship tradition and pros and cons[45]. It comprises several inter-related elements, "**binary visibility**" – the extent of a single point's view of the surrounding landscape and "**intervisibility**" – the line-of-sight between two different points[46]. To apply these methods to the dataset, several underlying elements were necessary. Firstly, a "**total viewshed**" for each region was required. This process generated a series of base maps for the region, assessing the overall visibility of the landscape. This total viewshed map assesses the outgoing views from every given point, in this case, each pixel of the DEM, in the test regions, and effectively builds a visual structure of the landscape. A range of different variables can be chosen, including observer heights. These indexes are based on the parameters set out in *Table 1*, and in some regions, generated cumulative viewshed with sites of different defensive heights. Given the processing power this requires, an entire viewshed of the northwestern provinces was beyond the scope of this paper. Instead, the test regions will suffice for initial analysis. The underlying maps generated by viewshed analysis serve as a basis to apply and generate data that explores the placement and visibility of defended sites within the landscape.

Secondly, viewshed points are necessary to develop an effective model of sites in the landscape. Viewshed points, the geographic coordinates for visibility in the landscape, need to be calculated within reasonable height parameters. The identification and creation of viewshed points was based on several variables, primarily the type of fortification under study. It was impossible to use a system of one viewpoint per site, as this would lead to issues – effectively limiting the view to a single point per site, so instead, a range of viewpoints were present at fortifications. Corner points, gate zones, and towers where present as well as mid-sections of defences were used as points to construct the viewshed. This approach is similar to recent best-practice applications in the field[47].

With such variability in the data and such a poor level of understanding of the standing structures of defended sites, this methodology had to be adapted from more traditional meth-

[42] Late Antique estimates for sites range from 9–12 m – see Heimerl 2021, 106–107 for Bitburg.

[43] Based on figures from Woolliscroft 2001.

[44] Adjusted from figures taken from the analysis of the 1st century fort at Inchtuthil as a guideline in Shirley 2000, 45 and further estimates from Heimerl 2021, 106–107.

[45] Wheatley 1995; Witcher 2000; Verhagen 2017 and Tibbs 2022, 41–42 for a good summary of the developments in the field.

[46] Tibbs 2022, 43 for a good introduction to the concepts.

[47] Woolliscroft 2001; Tibbs 2022.

ods of visibility analysis. Key work on visibility and best practice was undertaken in Scotland from the 1980s onwards, led by David J. Woolliscroft. Through assessment of literary sources and practical experimentation, D. J. Woolliscroft demonstrated that signalling and visibility between installations were limited[48]. He ascertained, through practical testing, that between 8 and 10 m high would have been the optimal height for towers on the Gask Ridge, and that signal visibility was limited to 6 km or so. This has been extrapolated and identification of individuals (approximately 1.7 m tall) from these heights (the Roman version of Friend or Foe Identification) was only reasonably possible within this 6 km radius.

The broad findings of these studies have been applied to large swaths of the Roman frontier zones, and have paid dividends in our understanding, especially on linear barriers such as the Antonine Wall. Despite this, this type of visibility analysis has overwhelmingly been applied to the Early Imperial period and to relatively well understood frontier zones[49].

There has been little empirical GIS-analysis of sites in the Late Roman period, with some limited work in the immediate post-Roman West and at individual sites[50]. The reasoning behind this is not entirely clear. While the Late Roman period seems well-suited for the application of more comprehensive GIS methods, as this paper explores, the uncertainty of some variables may have hindered our study.

## Uncertain variables

Establishing the viewshed variables to be used in this paper is a complex process. Several elements, linked to the types of visibility analysis listed above are present. Firstly, "**binary visibility**", both the outgoing views and incoming views from and to defensive architecture is important, as it establishes the fields of view from defences and identifies the incoming visibility of a site. Secondly, equally important in this is "**horizon metric**", which marks the edge of a total field of view from a site. Finally, communication between defensive sites is modelled through "**intervisibility**". This line-of-sight metric is used to establish levels of integration from sites, for example modelling the communication and support ability each site can give within a linked framework. When connected together, these variables can be used to clarify the roles, parameters, and decision chains behind the selection of sites and orientations.

To build these basic groups, a series of distance and height variables were needed to act as standard parameters. Based on Woolliscroft's work on the Gask Ridge, his 6 km variable was chosen as the primary distance for visibility and identification at an individual level. To augment this, a second distance metric of 20 km was added. This represents a long-range view which, in an ideal world, models a radius for visible indicators of activity, for example the presence of fires, smoke signals or dust clouds. Naturally, these viewshed metrics assume clear days with low atmospheric refraction as well as constant observation, all of which can shift. The changeability of weather in northwestern Europe, especially during the winter and autumn months, as well as a somewhat idealised model of human behaviour means that visibility studies will always provide a starting point for future research. In reality, viewshed radii will have been far more variable and inconsistent due to these factors.

On the level of the individual sites, the variety of defensive types present in the dataset make it much more difficult to apply generalising parameters than Early Roman forts, which by and

[48] This work was applied to various Early Imperial fortifications in Northern Britain: Woolliscroft 1989; 1994; 1996; Murphy et al. 2018.

[49] Graafstal 2020; Linck / Fassbinder 2022; Tibbs 2022 for a few examples.

[50] Bell 1999; Seaman / Thomas 2020.

large had similar patterns and formats[51]. There is high level of diversity, including everything from small palisade or rampart enclosures such as Zülpich-Rövenich to large, heavily fortified installations, complete with towers, for example, at Bitburg[52]. Establishing observer heights therefore required a set of different site types and classifications with different variables, and therefore, varying levels of visibility.

To represent the wide diversity of defended sites, five different groups were created, modelling different potentialities at fortifications *(Tab. 1)*. This approach initially assumes an observer height of 1.7 m, representing the average height of a human. Although there is likely some variation of individual defences within these categories, this represents an assumed medium height to serve as a basis for analysis. Although in many cases, these variable heights are extrapolated, especially given the lack of Roman walls surviving to their full height, they do represent our current thinking in the field. Naturally, these variables could be changed as future work perhaps brings more data.

By utilising these different groups, the visibility landscape can be examined in much greater resolution than a blanket single figure for observer height across different diverse settlements. Naturally, the incomplete nature of defences poses a challenge; many sites are not well explored and our understanding of the defences is poor in places. A good example of this is Arlon. A 4th century wall circuit is known and at least four towers have been identified, however, we do not have a complete circuit, although further towers are likely[53]. We cannot necessarily assume towers on all sides in the absence of evidence so the data must be selected on a case-by-case basis, rooted in factors such as dating, landscape, and fortification morphology.

One final variable is the issue of visibility and site selection itself. Defensive strategies have a wide range of different trajectories, both martial and non-martial. There are examples from across Late Antiquity of irrationality and inertia in the decision chains of fortification constructions – walls with towers on one side (London, GB; possibly Tournai, BE), walls with more towers than could be possibly usable (Bitburg, Aachen, DE; probably Arlon, BE) and sites selected in questionable locations (Altrier-Komeshaus, Goeblingen-Miécher, LU) or augmented with over-engineered defences (Keszthely-Fenékpuszta, HU; Bartringen-Burmicht, LU)[54]. Moving beyond designs, defensive structures in some areas show limited viewsheds, located deep in valleys or without good local visibility and it cannot be assumed that maximum visibility was a primary aim of defensive creations. Other factors, whether river crossings, the presence of local rural populations, the proximity to resources or even simply poorly thought-out construction programmes will have also played an important role. What the paper then intends to do is assess to what extent visibility is a consideration in the first stage of a landscape model of the Late Antique West and future work will continue to explore other elements of this defensive pattern.

[51] Although something of a generalisation, see Woolliscroft / Hoffmann 2006; examples in Reddé et al. 2006; Jones 2012.

[52] Brulet 1990 for the variability of Late Antique defence; Heimburg 1977 for Rövenich; Heimerl 2021 for Bitburg.

[53] Mertens 1973; Henrotay 2011; 2022.

[54] London: Barker et al. 2021; Tournai: Mertens / Remy 1974; Bitburg: Heimerl 2021; Aachen: ongoing work, see Kyritz / Schaub 2016; Arlon: ongoing work, see Henrotay 2022; Altrier-Komeshaus: largely unpubl., see Dövener 2008; 2010; Goeblingen-Miécher: largely unpubl., see Metzler et al. 1973; Henrich 2010; 2015; Keszthely-Fenékpuszta: Thomas 1964, 60–72; Bartringen-Burmicht: largely unpubl., see Kremer 2009.

### Data collection

Settlement data was selected from a variety of sources. Site data was collected and compiled from works on Northeast Gaul and the German provinces and supplemented by a phase of primary data collection from excavation reports and national heritage repositories[55]. In most cases, Late Roman fortifications are initially easy to identify, with clear, if complex, styles of construction and identifiable material culture, however, there are problems in chronological resolution, especially when identifying the *burgi* and enclosure structures of the Rheinische Lössbörden[56]. Equally, there is something of a problem in identifying where a *Höhensiedlung* was located. This has resulted in many sites with Late Roman finds material on hilltops being identified as such[57]. This paper will take a sub-section of this wider dataset, only analysing hilltop sites where there is "**appreciable evidence**" for defensive architecture rather than finds.

Data collection focused on two regional case studies to give a broad flavour of the different defensive dispositions, including the local defence of Trier, which combines a number of diverse hilltop sites as well as fortified towns (s. *Appendix: List of sites*). The second region, the upper Paris Basin, focuses on a landscape relatively devoid of fortified sites, where there is little evidence of defence beyond the urban *enceinte*.

## Results

Temporally, this analysis focused on the second half of the 4th century, a period where there is clear evidence for a range of different types of fortifications, rather than projecting occupation backwards or forwards. This was chosen in order to minimise the risks from the chronological issues of the late 3rd century and the early 5th century respectively, especially given the poor chronological resolution of many late 3rd century fortifications[58]. The wider shift in the defensive footprint is well documented. Large numbers of new sites appear, both along the highways and rivers, and are well represented in the regions under study.

### Positioning and visibility

Total viewshed analysis, conducted on the two target regions, demonstrates the importance of landscape in siting decisions. Outgoing views demonstrate that visibility and landscape prominence, unsurprisingly, played an active role in the initial selection and placement of defended sites[59]. The two regions under study have relatively different visibility profiles: The Paris basin, dominated by well-drained plateaux and low floodplains, has a high degree of overall visibility, whilst the Mosel-Eifel, with its disjointed watersheds, river valleys and eroded ridges, has a much more fragmented level of visibility.

These different profiles have a knock-on effect on the positioning and selection of sites for defence. Overwhelmingly, and unsurprisingly, defended settlements are located in high prominence zones, with greater levels of overall visibility. This is most apparent in the Mosel region, where sites are primarily located on sites with high local visibility, often to the detri-

[55] Major reference works include the catalogues of Gilles 1985 and Brulet 1990.

[56] Darvill 2008, 68; Dodd 2024 for a definition of *burgi* and *burgus*-like structures; van Wereveke 1965 for the etymology.

[57] Rheinbach-Tomburg, Rhein-Sieg-Kreis, DE: Gilles 1985, 180–183 for an example.

[58] Brulet 1990 for a range of sites.

[59] Only outgoing views were modelled in this initial study; however, future work will also focus on incoming views.

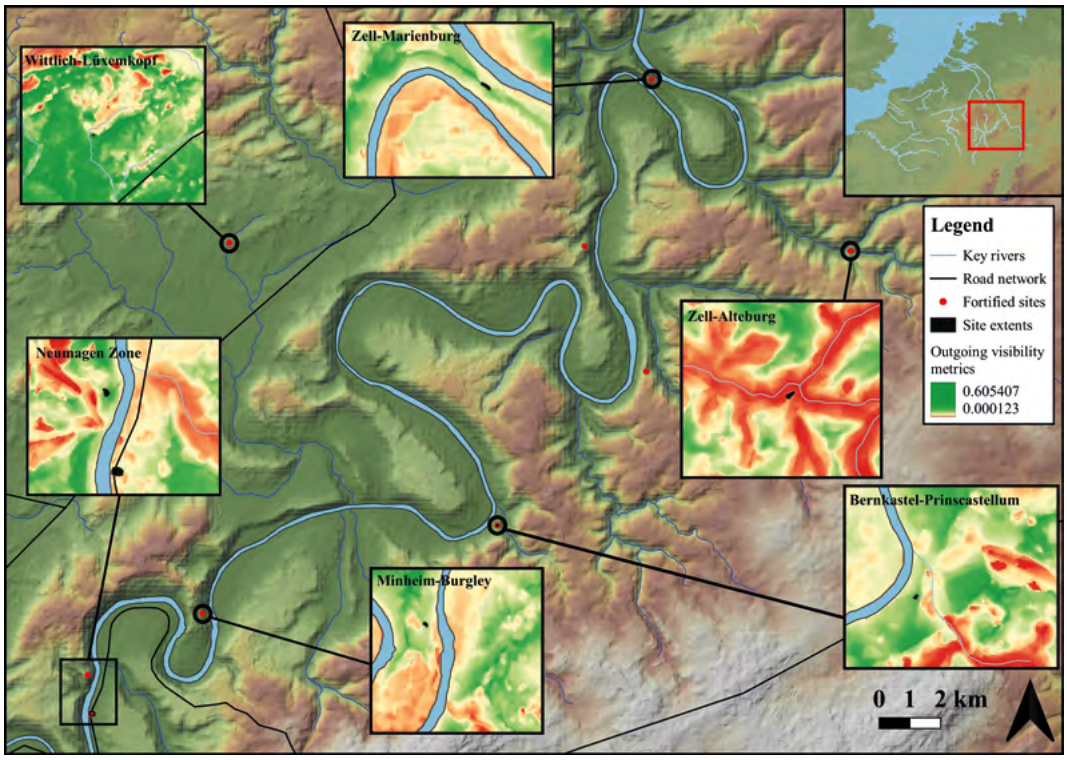


Fig. 2. The outgoing visibility metrics (max: 0.605407; min: 0.000123) of selected late 4th century defended installations in the Middle Mosel between Neumagen and Pünderich / Zell set against the DEM / DSM model (10 m resolution).

ment of defensibility. This is well illustrated by the case of sites along the Mosel river itself. The majority of sites along the river are located in higher visibility zones, with reasonable viewsheds over the transportation corridor of the Mosel *(Fig. 2)*. These installations include both smaller sites such as Starkenberg-Schloßberg, Kröv-Burgberg (both Kr. Bernkastel-Wittlich, DE), and Zell-Marienburg (Kr. Cochem-Zell, DE) as well as more heavily defended installations such as Bernkastel-Prinscastellum (Kr. Bernkastel-Wittlich, DE) and are located on high prominence spurs with good overall visibility[60]. In some cases, this focus on visibility is detrimental to the defence of the site. Minheim-Burgley (Kr. Bernkastel-Wittlich, DE) for example, is located on a spur overlooking the river, and sacrifices the more imposing natural defence of the saddle of the river meander for a less defendable site with better riverine visibility to the north[61].

The position of defences on zones of high outgoing visibility, is, by and large, repeated across both the Mosel and Bitburger land. This is at odds with the situation on the Seine-Marne network. The three key defended sites – Meaux, Melun and Paris, are not necessarily located in very high prominence or visibility zones. Other factors appear to be at play in this area.

The river network appears to be the common denominator in site selection at the three sites. The wall networks have limited evidence for visibility acting as the primary factor for site location. This is most apparent at Paris and Melun, both of which were placed on islands in the river (the Île de la Cité and Île Saint-Etienne respectively, *Fig. 3* for Paris). Other likely

[60] See Gilles 1985; 2016 for the sites.

[61] Gilles 1985, 159–162.

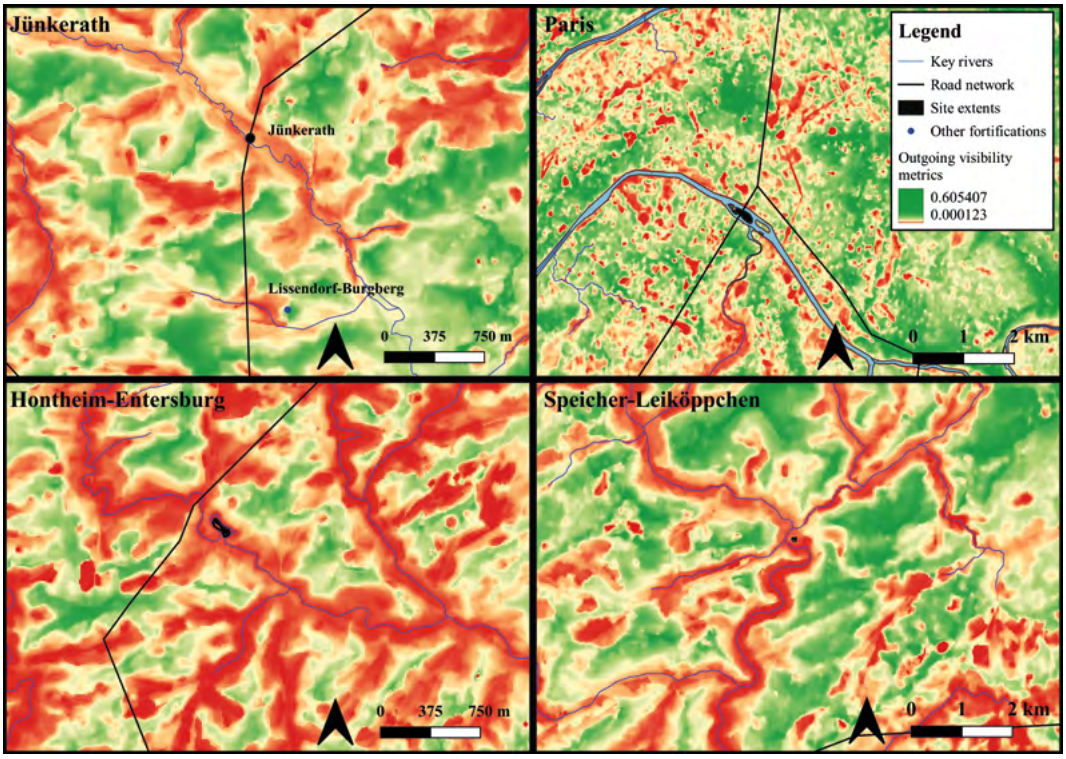


Fig. 3. Low priority visibility? An illustrative selection of sites with limited settlement visibility (max: 0.605407; min: 0.000123).

factors are the increased defensive security of islands in the river, as well as the communication importance of the river corridor.

In the Mosel-Eifel zone, an important minority of installations also appear to be considering other criteria in their site selection. The larger fortifications at Neumagen and Jünkerath *(Figs 2; 3)* are good examples of this. Both sites are located in deep river valleys (the Mosel and the Kyll) on former 1st–3rd century *vici* and are located in zones of low visibility. The presence of these installations on *vici* is a common theme throughout the northwestern provinces and probably reflects landscape movement and continuity within the road network[62]. Neumagen has long been suspected to be a key crossing point across the Mosel, reflected in the many river or ship themed *spolia* in the walls[63]. This likely also played an important role in controlling key communication corridors, with these considerations taking priority over visibility on a local level, something explored further below.

A range of other sites also appear to be utilising other selection criteria. This includes Hontheim-Enterburg (Kr. Bernkastel-Wittlich, DE), where a *burgus*-like tower and associated *Höhensiedlung* were located on a ridge spur above the Üßbach river valley and close to the main Trier–Andernach road *(Fig. 3)*[64]. The site has a rather limited outgoing metric and high

[62] For other examples, see Jülich: Perse 1998; Aachen: Kyritz / Schaub 2016; Billig, Stadt Euskirchen, DE: Andrikopoulou-Strack / Wippern 2008.

[63] Numrich 1997; Bockius 2008.

[64] Gilles 1985, 128–133.

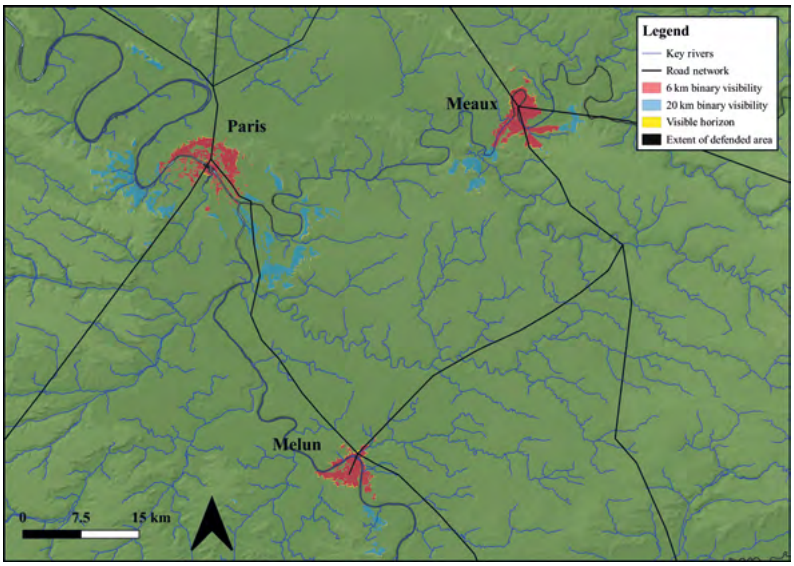


Fig. 4. 6 km and 20 km binary visibility from sites in the Paris Basin.

exposure from incoming views. This suggests that proximity to the road network was more important and that the site was primarily focused on surveillance along the road. Hontheim-Entersburg, along with the similar installation at Hambuch-Burgberg (Kr. Cochem-Zell, DE), can perhaps be seen as analogous to the road forts of the *Via Belgica* further north[65].

Further widespread study of the visibility metrics of the Late Antique landscape would pay dividends, especially when exploring the coastal defences, both in Britain and along the continental North Sea littoral. Assessing the viability of defensive sites could help to isolate and identify the potential locations of missing installations. This section has demonstrated the potential for placing Late Roman defences on a total visibility map and a great deal of further work is needed to explore and expand this small test demonstration.

## Binary visibility

Binary visibility, the visible radius from a single point, further illustrates the variability of site selection. There is significant regional variation in the data, partly due to the distribution of defended installations across the different regions. In the Seine-Marne zone, defensive architecture is focused on *civitas* capitals, most of which received walls from the second half of the 3rd century onwards[66]. On the face of it, visibility is relatively localised across the three fortified sites *(Fig. 4)*. Local approaches to the settlements are visible on both the north and south sides of the rivers Seine and Marne, with the positioning of each site exploited to provide reasonable 6 km visibility of the immediate surroundings and importantly, monitor movement up and down the rivers, most notably at Paris and Melun. These sites are located on islands, are by their very nature, geographical controls on movement along the Seine. The visibility from the walls reinforces this riverine control, with viewpoints placed strategically to give binary view-

[65] Brulet 1990; Brulet et al. 1995.

[66] Butler 1959; Johnson 1973; 1983a, 94–101; Bayard / Fourdrin 2019.

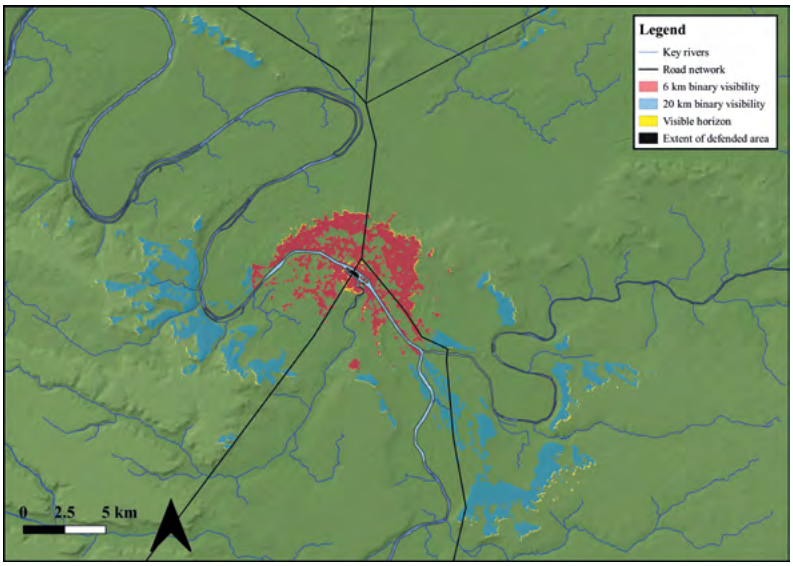


Fig. 5. 6 km and 20 km binary visibility and the visible horizon from the walls of Late Roman Paris, illustrating the riverine control from the defences.

sheds along the channel and likely dominate communication and traffic. This is most apparent at Paris, where the defences were placed to give a long-range view of the confluence of the Seine and Marne rivers *(Fig. 5)*. Although this is less pronounced at Meaux, located within a large meander and possibly set on an island itself, there is still evidence of significant positioning for downstream visibility on the Marne.

Two elements of this are worth exploring in more detail, firstly, the continuity of settlement around the defences, and secondly, the wider role played by the defences in riverine communication and control. The *étiage* of sites did not see immediate population decline, nor did the entire remaining population move inside the wall networks. Activity continued outside the newly constructed circuits. Paris has significant evidence of habitation into the 4th century at Sainte-Geneviève and there is sporadic evidence for activity in the former 1st–3rd century urban zone at Melun[67]. Binary visibility from Melun and Meaux is focused over the former townscapes and although this is less clear at Paris, there is still some evidence of visibility on the south bank of the Seine, where undisputable 4th century activity was located. This does suggest that control of the transforming towns played some role in the organisation of defence at these sites. The rationale behind this is difficult to establish, especially if they were mostly abandoned or only partly occupied. The shift in these zones for productive or habitational to resource-rich is a likely reason for this. The re-employment of *spolia* from 1st–3rd century townscapes and graveyards are widespread across every part of the Roman West in Late Antiquity and the Seine-Marne sites are no different, with large amounts of *spolia* used in their construction[68]. Control of this resource may have rapidly become a primary goal of local authorities organised enough to control its movement and use and these quarried zones needed to be monitored and controlled[69].

[67] Duval 1989 for Paris; Besson et al. 2017 for Melun.

[68] Laneluc 2005; Besson et al. 2017, fig. 5 for examples from Melun.

[69] See Clemens 2009 for examples from Germany; Mertens 1973 for Arlon; Henrich 2010 for the demolition processes of a comparative grave monument.

The preoccupation with riverine control ties these defended settlements into broader defensive narratives. The defence of rivers and estuaries was common practice in Late Roman *Gallia Belgica* and *Britannia*[70]. Strategic decisions were being made from the late 3rd century onwards to control estuarine access, with varying commands in the 4th or 5th century *Notitia Dignitatum* pointing towards this and plenty of archaeological examples of river control[71]. New forts, towers, and signal stations dominated the Channel coast with evidence from Étaples for the presence of a *Praefectus Classis Sambricae* and associated naval unit[72]. Entry to the Seine hydrological network was controlled from the fortified town at Rouen *(Rotomagus)*[73]. This installation appears under the command of the *Dux Tractus Armoricani et Nervicani*, however, its characteristics are unclear[74]. Although outside the direct control of the littoral commands, it is probable that Paris, Melun and Meaux fed into this defensive system, controlling access and movement up and down the rivers. It seems likely that troops or militia were stationed at Melun and Meaux, something suggested, but not yet proven[75]. Paris, however, does indicate literary evidence of military units. The *Notitia* lists the site as the base for a *praefectus classis Anderetianorum* as well as possibly the headquarters for a *foederati* overseer[76]. It is, however, unknown what form this took, as no archaeological evidence for ships or docks have been recovered. The potential for penetration up the Seine network was clearly a priority in the region, with the defences orientated to visualise much of the river. This policy on the coast seems to extend well inland, and the reduced urban *enceinte* of the Paris Basin were used as bases, as well as within a 'hands-off approach' in order to help police and control the upper navigable reaches of the rivers.

This desire for river control is reinforced in the Mosel Valley, where there is ample evidence for river and valley surveillance. The Mosel was an important social and economic corridor during Late Antiquity. It acted as a political centre, dominated by the administrative and literary elites of Northern Gaul[77]. The region was heavily fortified with a range of different site types. The majority of installations focused on the Mosel river and its transportation corridor. Both Hambuch-Burgberg and Hontheim-Entersberg have *burgus*-like towers and are located close to a main Trier-Andernach, displaying visibility profiles similar to the road-forts of the *Via Belgica (Fig. 6)*. Their structures have clear parallels to installations further north[78]. The wider river zone was densely fortified by *Höhensiedlungen*. These complex installations ranged from heavily militarised installations such as Bernkastel-Landshut-Prinscastellum to more improvised defences such as St. Aldegund and developing patterns is difficult[79]. Work has generally focused on placing them within a defensive structure, as signal posts and control points for traffic, however, there is now some backlash against this, with internal features at some sites perhaps suggesting some form of elite display – a combination of the two may be most likely[80]. The visibility evidence does, however, point towards some role for these sites in defence and surveillance. The majority overlook river valleys, with some, especially in the Mosel Valley, able to act as extremely important

70 Wider discussions of this include White 1961; Johnson 1983a, chapter 8; Breeze et al. 2022 for a good appraisal of the scholarship along the North Sea coasts.

71 For example, the commands of the *Comes litoris Saxonici per Britannias*, *Dux Belgicae Secundae* and *Dux tractus Armoricani et Nervicani*. For examples of this, see Burgh Castle, UK: Johnson 1983b; Pevensey Castle, UK: Pearson 1999; Heeren 2018 on the Maas corridor.

72 Breeze et al. 2022, 82; *Not. Dig.* OC XXXVIII, 8.

73 Guillot / Follain 2004.

74 *Not. Dig.* OC XXXVII, 9–12.

75 Brulet 2016.

76 *Not. Dig.* OC. XLII, 23.

77 Ausonius, *Mosella.*

78 Barfield 1968; Brulet et al. 1995; Dodd 2023a; 2024.

79 Gilles 1985, 184–185; Prien / Hilbich 2012; Gilles 2016.

80 For example, Böhme 2008; for the backlash, see Prien / Hilbich 2012.

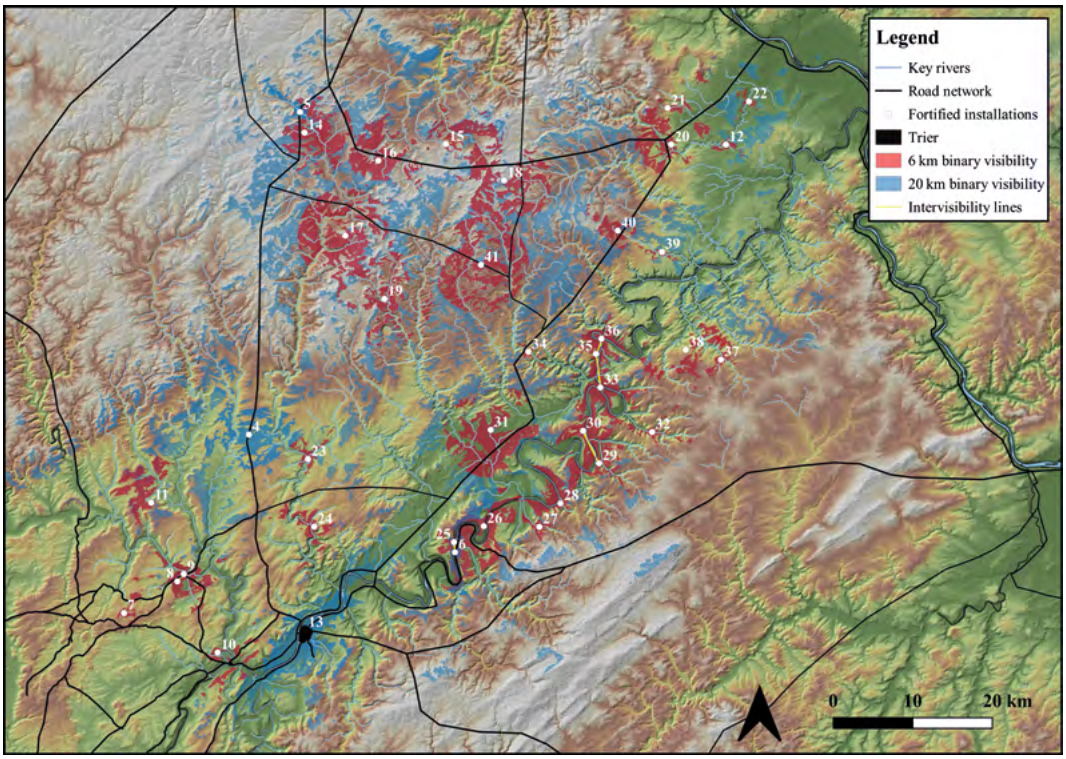


Fig. 6. 6 km and 20 km binary viewshed from the defended sites in the Mosel transportation corridor and Bitburger Land in the second half of the 4th century.

viewpoints for controlling access and when combined with other forms of defended settlement, paint a picture of a tightly surveyed river network from the Rhine to the Western Eifel *(Fig. 6)*.

The defensive profile of the valley suggests a preoccupation with control along the entire river network, with the repeated presence of broadly contemporaneous hilltop installations pointing towards a strong desire for security along the river at various points rather than single entry corridors and confluence surveillance. This may suggest that the Mosel was not necessarily secure in the second half of the 4th century, and that mobile groups were using tributaries to access the river and escape the notice of entry-exit installations such as Koblenz, hence requiring surveillance of the entire network.

A notable and somewhat surprising example of this riverine obsession is the installation at Jünkerath[81]. The site is a small, sub-circular forthwith towers set into a curtain wall, probably dating to the early 4th century and placed on an abandoned or destroyed 1st–late 3rd century *vicus*. It is generally interpreted as one of a series of road forts between Trier and Köln and stylistically it has common characteristics with Bitburg, Neumagen and probably Zülpich although notably, this differs significantly when considering visibility.[82]. The defences have almost no visibility along the north-south road, especially when compared with its near neighbours, Bitburg *(Fig. 7)*, which dominates the highland zone and Zülpich, which has excellent visibility in the Rhine floodplain. Instead, Jünkerath has a very similar viewshed profile to Neumagen *(Fig. 8)*.

[81] Koethe 1936 for the best summary of the site.

[82] Hettner 1891; Gechter et al. 1979; Heimerl 2021.

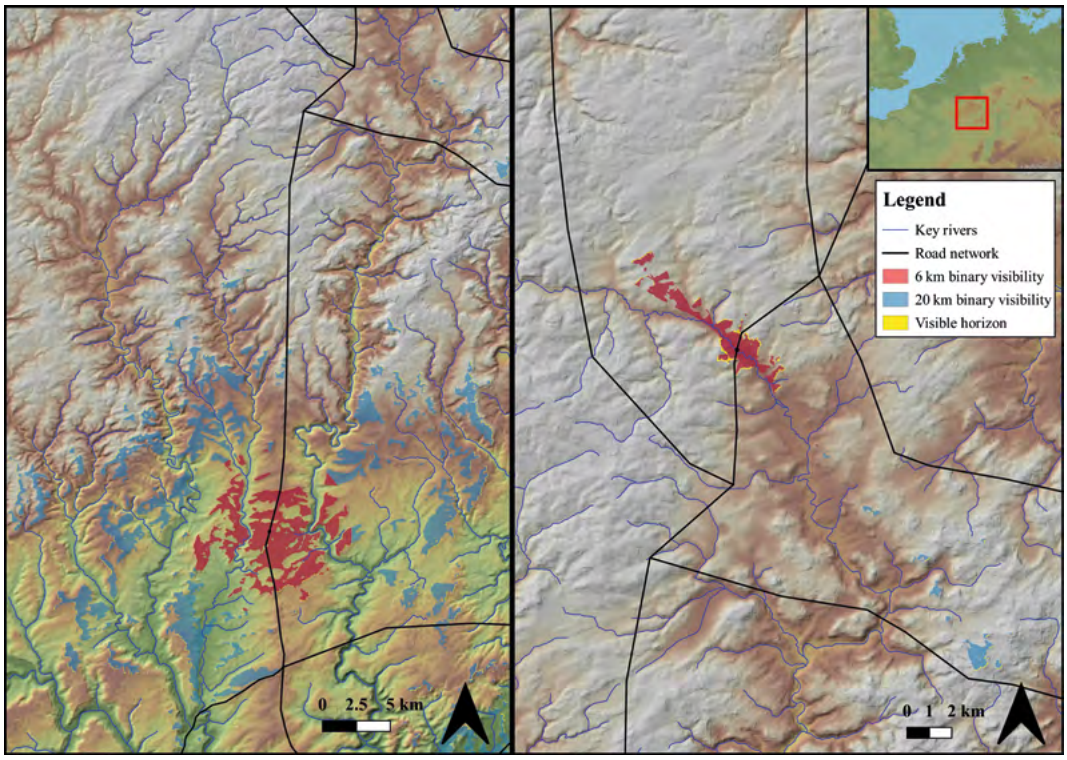


Fig. 7. 6 km and 20 km binary visibility and visible horizons at Bitburg (left) and Jünkerath (right), showing the river network and the Roman roads.

The observer view is blocked along the north-south road and visibility is primarily focused on the east-west corridor of the Kyll river valley. This preoccupation with riverine defence goes well beyond the surveillance of large rivers. It indicates a concern regarding the incursion of water-borne raiders into the provinces, or at the very least, the belief that smaller rivers could potentially be exploited for such purposes, to a degree that has not been previously recognised. What makes Jünkerath an even more complex situation is that there is limited to no evidence that the Kyll itself was navigable during pre-modern times, although it is possible that flat bottomed boats or small craft may have been able to make this journey[83]. Other factors such as control of the water supply or simple inertia may have been an element of decision making. This differentiation in viewshed indicates different functions at these sites, and paints a more nuanced picture of defence developments. Road visibility is clearly not a primary concern at some sites traditionally associated with the Roman state. Neumagen and Jünkerath are clearly orientated and sited to control and conduct surveillance on the river network, whilst Bitburg dominates the road.

## Intervisibility

Intervisibility, the capacity of one site to see another, is at best, a limited factor in the decision-making process of siting Late Roman fortifications. Outside the Mosel corridor, there is little evidence for visibility connections between individual sites. The sites of the Paris basin *(Fig. 4)*

[83] Peter Henrich, pers. comm.

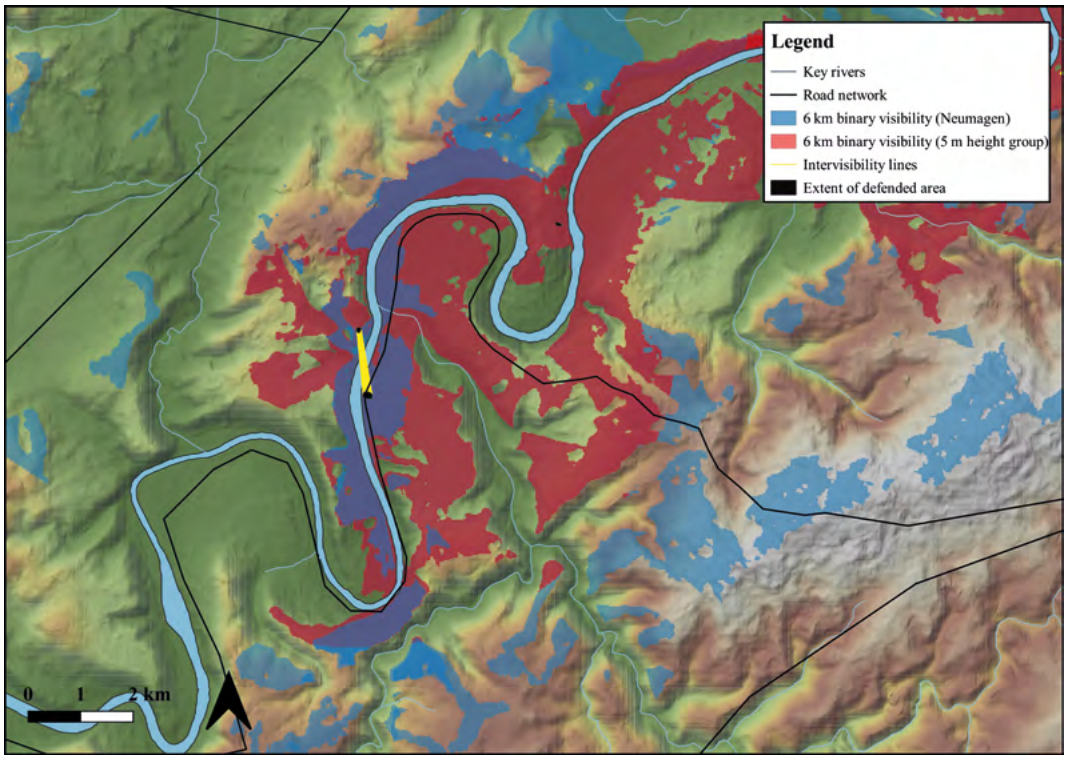


Fig. 8. Integrated planning around Neumagen; 6 km binary visibility metrics and intervisibility in the late 4th century and the surveillance of the Mosel River.

are too far apart for intervisibility, whilst limited examinations of other regions suggest that there is evidence of very minor intervisibility in some small microregions.

The sites in the Mosel corridor show the most evidence for intervisibility affecting siting decisions of Late Roman installations, although it is still fragmentary and localised. Evidence for intervisibility is well illustrated in two zones of the valley: the meanders around Neumagen and the sector between Erden and Pünderich.

The fort at Neumagen is relatively poorly understood. The 1st–3rd century *vicus* was abandoned and possibly destroyed before a new fortification was built on top of it. This installation comprised a curtain wall studded with towers and is notable for the vast number of grave monuments used as *spolia*[84]. Constructed sometime between the end of the 3rd century and the mid-4th century, the site has generally been seen as part of a wider fortification programme[85]. Taken in isolation, the fortress does not command long-distance views and was built on ground with a low visibility metric *(Fig. 2)*. Located in the deep valley of the Mosel, the viewshed is blocked by the surrounding hills with a visible horizon close, and in some cases, directly above the fort. There is little evidence for wider binary visibility, something at an opposition with similar sites such as Bitburg. As with Jünkerath, the focus is overwhelmingly on the control of the river, with excellent visibility upstream and downstream and the site controlled the crossing point of the Ausoniusstraße.

[84] von Massow 1932; Numrich 1997.

[85] Hettner 1891; von Massow 1932; Heimerl 2021. This includes sites morphologically similar and depending on the source, can include Jünkerath, Bitburg, Zülpich, Aachen, Jülich and Aarlon.

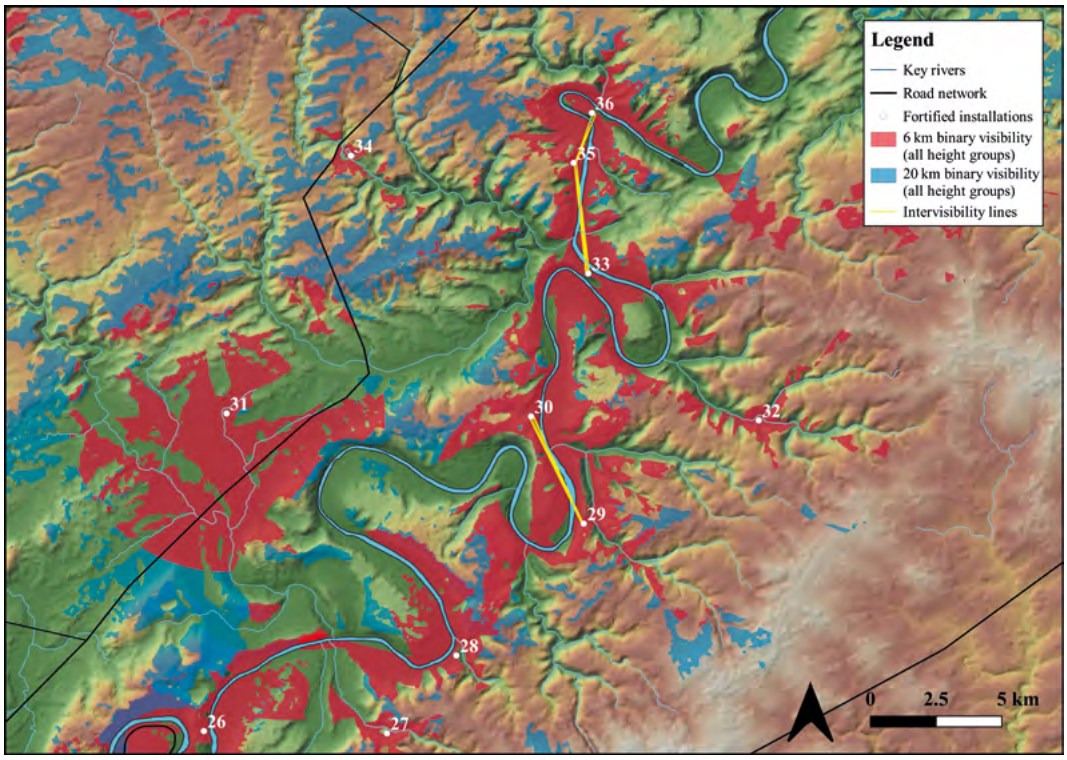


Fig. 9. 6 km binary visibility and intervisibility at defended sites between Erden and Pünderich on the Middle Mosel.

Placing Neumagen within the wider contextual of surrounding defensive sites paints a different picture. Whatever the reasons for placing Neumagen, be they continuity from the *vicus*, a desire to control the river and road junction, or simple non-rational elements such as bad planning and inertia, the site had limited visible control of the surrounding area. There is, however, some evidence of a more coherent approach. Neumagen is surrounded by a series of broadly contemporaneous 4th century *Höhensiedlungen*, notably at Neumagen-Dhron-Tempelkopf and Minheim-Burgley (*Fig. 8)*. Both hilltop sites have good binary visibility on the surrounding area, the Mosel corridor and the Neumagen-Wederath road and to some degree support greater visibility of the surrounding landscape[86]. Both sites are located on the crest of the ridge above the river, able to survey traffic on the river and road, and it is notable that Tempelkopf, located directly opposite and above Neumagen, had a direct line of sight to the fort.

This opens the possibility of an integrated signalling system, something confirmed as possible by intervisibility analysis *(Fig. 8)*. Although it is unlikely that these elements were planned together, it seems likely that the lack of long-distance visibility from Neumagen may have prompted developments on the Tempelkopf. Both of the hilltop sites display evidence of a more 'military'-like material culture. As a whole, there is patchy evidence in the *Höhensiedlungen* data-set for a unified material culture, with the majority of finds being coins or unidentified metalwork[87]. However, both these hilltop installations display unequivocal evidence of

[86] Gilles 1985, 159–162 and 170–172 for a more detailed discussion of both sites.

[87] Gilles 1985; Hunold 2011 for a well-excavated example.

military artefacts, including chain mail fragments at Tempelkopf, and elements of Late Roman chip-carved belt sets, generally associated with the Roman state, have been recovered and perhaps suggest the influence or activity of groups associated with authority organisation[88].

Integrative elements are repeated in the middle Mosel valley, where a range of diverse hilltop sites act as control and surveillance points along the river. Between the Late Roman installation at Koblenz on the Rhine-Mosel confluence and Bremm, there is limited evidence of defences along the river corridor. Upstream of this however, there is a string of late 4th century sites, located on hilltops and control points *(Fig. 9)*. This concentration further reinforces the control of the river as priority for both the state and civilian groups. Although hilltop sites are found in other regions of the Eifel, notably to the north of the Mosel Valley, there is little evidence of overlapping visibility of transportation arteries in the same way. Only in the Meuse valley in Wallonia have similar defensive footprints been encountered[89]. Many of these sites cannot be defined as 'military' in a meaningful way, with little evidence of objects identified with the Roman army or state or a morphological similarity to clear military installations in the hinterland. There are exceptions to this, with some sites, such as Bernkastel-Landshut-Prinscastellum. The site, occupied in the second half of the 4th century, sits on a spur overlooking the river and has yielded an important belt set. Morphologically, the site also displayed evidence of military construction in the form of large bastion towers and a plan similar to the Upper Rhine fort at Altrip (Rhein-Pfalz-Kreis, DE)[90].

As a wider group however, it may be apt to think of these sites as individual 'civilian' groups or militias defending hilltop sites with broad views of the river either to control movement of resources, and therefore safeguard their own supplies, or as part of a more general perception of instability that required defence from raiding groups on the river itself. This 'civilian' aspect is somewhat reinforced by the lack of intervisibility between these sites, with very few signalling opportunities available.

## Conclusions: integrated defence or individual approaches?

This paper has laid out a number of examples in two test regions for how viewshed and visibility analysis can expand our understanding of the Late Roman defended landscape. Establishing a pattern to the presented data is not easy. Clearly, there are vastly different local conditions, decision-making chains, irrationality, local inertia and other choices being made in defensive organisation and integration. Visibility may not necessarily always be the primary factor in construction, siting or orientation. Some conclusions, however, can be made.

There is an overwhelming focus on the riverine corridors in both Northeastern France and the Mosel Valley. Although this has been hinted at before, partly through simple distribution maps, the scale and focus of riverine visibility has been under-estimated. Visibility at sites along the Mosel corridor and the Seine-Marne network prioritise control of the waterways. This extends far up the river network, with sites on smaller tributaries, such as Jünkerath, still focused on the control of the river. It is likely that a broader data set, taking in other defended sites would show the same patterns, especially the Belgian *refuges*, many of which are located on the Sambre, Meuse and their smaller tributaries[91]. This pre-occupation with river surveil-

[88] See Böhme 1974; 2020 for a discussion of the chip-carved belt sets of the Later Empire; Gilles 1985, Taf. 13,261 for Minheim-Burgley.

[89] Dodd 2023a for an overview.

[90] Gilles 2016; for Altrip see Stein / Schleiermacher 1968.

[91] Brulet 1990; 2008b for these sites.

lance, even at the level of localised and small-scale waterways points towards attempts to negate the potential of the river network for raiders, presumably using small boats, moving into the provinces. This surveillance of areas behind traditional defended zones forms part of a broader move towards less more non-linear defensive zones in 4th century Gaul. This phenomenon has been observed in other, more organised defensive footprints, for example, the *Litus Saxonicum*.

Although there is some level of small-scale integration between sites visible in the data, the lack of coherent communication networks on a more establish scale suggests that planned defence, where it existed, was on a localised scale and not developed within any standardised network. Some sites, notably the large road forts at Bitburg, Jünkerath and Neumagen may have been part of a wider standardised construction plan under Constantine, however, in practice, a general design may have been generated by a central organisation and handed down to local agents who made on the ground changes based local conditions, preferences, a lack of understanding or inertia[92]. Only in a limited number of cases can sites be considered part of a wide-scale, interlinked or planned defensive system in any substantial way.

The remaining defensive sites have little common compatibility. On the Middle Mosel, there is plenty of overlapping binary visibility along the river corridor and its tributaries, however intervisibility between sites is highly limited. This is suggestive of local groups, or individuals constructing redoubts independent of wider concerns, in essence, true private fortification systems ("private Befestigungsanlagen")[93]. The lack of integrated siting along the Mosel means that, based on our current knowledge level, signalling opportunities were limited to non-existent, and would require observers to notice smoking rising behind the horizon or the manual delivery of messages. Acoustic methods of signalling may also be an element to consider in the relationships between these sites in the context of wider landscape control. Although there have been limited finds of Late Roman instruments in the northwestern provinces, they are present, notably the fragmentary trumpet at Liberchies-Bon Villers (Pont-à-Celles, BE) and may have been used for command and signalling, especially in a military context[94]. Despite the benefits of acoustic signals (ability to negate signals, ease of communication use), recent work along the Dacian *limes* suggests that such communication may have worked at a very local level in open terrain, rather than enclosed valleys such as the Moselland[95]. Significant further work would be needed to establish acoustic patterns in a GIS model of the region. It is possible that sites may be missing from the network and further work may fill in the wider pattern, however, it would take a large number of new sites to demonstrate a more integrative pattern. It likely demonstrates that what we are seeing is a range of different communities acting individually to defend themselves and observe the river network, although clearly, in some cases, there is demonstrable state involvement in this surveillance (Bernkastel-Landshut-Prinscastellum, Neumagen, Jünkerath). A further approach to this would be to explore whether or not there is an appreciable morphological difference on a region-wide level between intervisible sites and whether these sites display evidence of material culture associated with the Roman state.

The restricted intervisibility places too many limits on response readiness and information flows to be a truly integrated system of riverine defence. There is plentiful evidence of Late

[92] See Hanel/Verstegen 2009; Heimerl 2021 for the wider early 4th century construction programme; evidence for local conditional changes and inertia is visible at the Yorkshire Coastal towers – Rob Collins, pers. comm.

[93] A rare 5th century inscription documenting a similar type of installation was found near Sisteron (Alpes-de-Haute-Provence) built by a praetorian prefect of the Gauls for the people on his estate – CIL XII, 1524.

[94] Brulet et al. 1995, 41.

[95] Lăzărescu et al. 2016, 295–300.

Roman naval activity on both the Seine and Rhine networks. The presence of the *classis Anderetianorum* and *classis Sambricae* in Northern France and the finds of Late Roman vessels at Mainz-Am Brand are indicative of fleets that were able to patrol and respond to threats along the rivers[96]. This opens the possibility, raised with land warfare, of ships intercepting raiders on their return journeys, having been alerted by smoke or other signalling methods. The presence of, admittedly earlier, evidence from Neumagen and Trier of naval activity certainly indicates the potential for the Mosel to be used in this way[97]. Further work to establish potential naval activity along rivers beyond the Rhine would pay dividends in understanding Roman naval activity in the hinterland of the late *limes*.

A key further zone for future work is the Rheinische Braunkohlerevier. This zone of Western Germany contained a wide range of different types of fortified settlements, ranging from palisade and ditch *burgi* (HA224) to larger towns (Jülich) and towers (Heidenburg-Hüchelhoven, Rhein-Erft-Kreis, DE). Some of these sites are situated within 2 km of each other and appear to be contemporaneous, creating an interesting and likely interconnected defended landscape[98]. Unfortunately, the current lack of a DEM for the region is a problem for analysis. The landscape has been radically changed in the last 150 years by lignite mining, and large spoil heaps, such as the Sophiehöhen (Kr. Düren, DE) and deep open-cast mines like Hambach and Garzweiler disrupt a reconstruction of Roman visibility in the territory. Understanding how and why these sites were located in such a concentrated area is key to understanding how the military road-forts of the *Via Belgica* function east of Limburg and well as the role of the 'civilian' in defence. The creation of a pre-modern DEM using 19th century Preußische Neuaufnahme for this part of the Rhineland would be a priority for exploring this. Expanding visibility analysis across the fortified settlements of the northwestern provinces will go some way to developing more nuanced analysis of the defensive network and further exploring the levels of integration at play. Further work to establish this should focus on more regional comparisons, integrating other GIS methods, for example, least-cost-path analysis, as well as by refining the hydrological and terrain models through geomorphological and landscape studies. A key plank of this would be making the data open access and available for download.

This paper has demonstrated that the second half of the 4th century shows a picture of regional diversity. Visibility is one of a range of concerns for the siting and orientation of defensive structures across both zones. Interconnectivity, is, however, a more difficult thing to establish. It is clear that there is localised integration in some regions and independent action in others, something perhaps driven by state intervention in the defensive footprint. The key takeaway of this is the importance of river surveillance. Although the importance of riverine transport has long been understood in the ancient world and Late Antiquity more specifically, the degree of importance has been somewhat underestimated. The surprising prominence of river control far upstream at places such as Jünkerath suggests a preoccupation with the control of these corridors and points towards potential threats by water-borne groups well into the provincial hinterland. The overwhelming evidence here points towards a landscape of loose or informal defensive integration. Where integration is present, there appears to be a state element in design, although further work is needed to refine this in other areas. What is however clear, is that both regions demonstrate a very loose connection to the wider footprint, and in no way can we consider, on the strength of the current evidence, that these sites form part of a wider, integrated fortified system.

[96] Bockius 2006; Rummel 2008 for the earlier evidence; Elliot 2019.

[97] Rummel 2008, 197–198.

[98] Dodd 2024.

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**Abstract: Establishing a method for visibility and viewshed analysis for late 4th century fortifications in *Gallia Belgica* and the Germanic provinces**

This paper examines the spatial distribution of defended settlements in late 4th century provinces *Lugdunensis* and *Gallia Belgica*. The variety of fortification in Late Antiquity has made it difficult to apply modern GIS analysis to the defensive pattern. Our understanding of the visibility and viewshed of the network and the fortifications is in its infancy. This paper develops a method for addressing visibility in a complex morphological environment. It will apply this to two test regions and demonstrate the validity of visibility analysis as a research tool. This will build up a picture of visibility, connectivity, and surveillance in Late Antique *Belgica Prima* and *Lugdunensis Senonia*.

**Zusammenfassung: Die Entwicklung einer Methode zur Analyse von Sichtbarkeit und Sichtfeld von Befestigungsanlagen des späten 4. Jahrhunderts in der *Gallia Belgica* und den germanischen Provinzen**

In diesem Beitrag wird die räumliche Verteilung der befestigten Siedlungen in den Provinzen *Lugdunensis* und *Gallia Belgica* im späten 4. Jahrhundert untersucht. Die Vielfalt der Befestigungen in der Spätantike hat die Anwendung von GIS-Analysen auf das Verteidigungsmuster erschwert. Unser Verständnis der Sichtbarkeit und des Sichtbereichs von Befestigungen und ihrem Netz steckt noch in den Kinderschuhen. In diesem Beitrag wird eine Methode entwickelt, um die Sichtbarkeit in einer komplexen morphologischen Umgebung zu untersuchen. Sie wird auf zwei Testregionen angewandt und demonstriert den Nutzen von Sichtbarkeitsanalysen als Forschungsinstrument. Auf diese Weise entsteht ein Bild der Sichtbarkeit, der Konnektivität und der Überwachung im spätantiken *Belgica Prima* und *Lugdunensis Senonia*.

**Résumé : Établissement d'une méthode d'analyse de la visibilité et des cônes de vue pour les fortifications de la fin du IVe siècle en *Gallia Belgica* et dans les provinces germaniques**

Cet article examine la répartition spatiale des établissements défensifs dans les provinces *Lugdunensis* et *Gallia Belgica* de la fin du IVe siècle. La diversité des fortifications dans l'Antiquité tardive a rendu difficile l'application d'analyses GIS moderne au schéma défensif. Notre compréhension de la visibilité et du champ de vision des fortifications et de leur réseau n'en est qu'à ses débuts. Cet article développe une méthode pour étudier la visibilité dans un environnement morphologique complexe. Elle est appliquée à deux régions tests et démontre l'utilité des analyses de visibilité comme outil de recherche. Cela permet de dresser un tableau de la visibilité, de la connectivité et de la surveillance dans la *Belgica Prima* et la *Lugdunensis Senonia* de l'Antiquité tardive.

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*Figs 1–9; Tab. 1:* J. Dodd. Graphics: L. Hies (RGK).

| Site no. | Site name | Description | Fortification period | Key references | Height group (m) |
|---|---|---|---|---|---|
| 1 | **Paris, Dép. Paris (FR)** | Wall network enclosing Île de la Cité. Gateways on the NE–SW axis. No known towers. | Dendrochronology secure to the early 4th century, possible late 3rd century predecessor. | Jullian 1902; Busson 1992, 395–411; Busson et al. 1993 | 7.5 m |
| 2 | **Melun, Dép. Seine-et-Marne (FR)** | Wall network enclosing Île Saint-Étienne. No gateways or towers are known with confidence. | Complex dating. Mid to late 4th century onwards. | Leroy 1865; Le Blay 2001; Laneluc 2005; Ciezar 2010 | 7.5 m |
| 3 | **Meaux, Dép. Seine-et-Marne (FR)** | Wall network now on a meander, possibly an island in Late Antiquity. Gates may correspond with later Medieval entrances. | Dating is early 4th century, possible late 3rd century phase. | Carro 1862; Laporte 2010; 2011 | 7.5 m |
| 4 | **Bitburg, Kr. Bitburg-Prüm (DE)** | Initial *burgus*-like structure, replaced with a tower and gate studded circuit. | Early 4th century, probably in the 330s or early 340s or slightly earlier, to the Medieval period. | Heimerl 2021 | 12 m |
| 5 | **Jünkerath, Kr. Vulkaneifel (DE)** | A tower and gate studded circuit. | Broad 4th century date, mint condition coins of 330 found in the foundations. | Hettner 1891; Koethe 1936 | 12 m |
| 6 | **Neumagen, Kr. Bernkastel-Wittlich (DE)** | A tower and gate studded circuit. | Broad 4th century to Medieval usage. | Hettner 1891; von Massow 1932 | 12 m |
| 7 | **Altrier-Hersberg-Kaasselt, Kt. Echternach (LU)** | *Spolia* stone wall, ramparts and ditches blocking access to a hilltop spur. | Mid-late 4th century activity. Poor resolution. | Linden 1977 | 12 m |
| 8 | **Echternach-Schwarzuecht, Kt. Echternach (LU)** | Possible *burgus* / *horreum*-like stone defence in a villa complex. | Late 4th and early 5th century chronology. | Metzler et al. 1981 | 5 m |
| 9 | **Echternach-St. Peters und Paul, Kt. Echternach (LU)** | Two-phase circular stone *burgus*, complete with towers and a gateway. | Late 3rd / early 4th century phase and a more developed late 4th / early 5th century reconstruction. | Metzler et al. 1981 | 9 m |
| 10 | **Wasserbillig / Langsur-an der Fréien, Kt. Grevenmacher (LU)** | Small villa complex with a tower-like structure ("Speicherturm"?) added later. | 4th century use of the tower structure. Resolution is poor. | Krier / Wagner 1983 | 9 m |

Appendix: List of sites.

| Site no. | Site name | Description | Fortification period | Key references | Height group (m) |
|---|---|---|---|---|---|
| 11 | **Nusbaum-Rohrbach, Kr. Bitburg-Prüm (DE)** | Hilltop site with at least one drystone *spolia* wall and a surrounding ditch. | Early / mid-4th century until mid-5th century. | Clemens / Möller 2004 | 5 m |
| 12 | **Polch-Ruitsch-Burgberg, Kr. Mayen-Koblenz (DE)** | Hilltop defended by several ditches and possible ramparts. | Mid-4th to mid-5th century activity. | Gilles 1985, 176–179 | 5 m |
| 13 | **Trier, Kr. Trier (DE)** | Large urban circuit, towers and gateways, several remodelling phases. | 2nd century circuit, some modernisation and alterations. Usage into the Medieval period. | Lehner 1896; Cüppers 1973; Hupe 2008/09; 2016/17; Linder 2018 | 12 m |
| 14 | **Lissendorf-Burgberg, Kr. Vulkaneifel (DE)** | Earth rampart and ditch around a hilltop. | Mid / late 4th century. Resolution poor. | Gilles 1985, 149–150 | 5 m |
| 15 | **Bodenbach-am Steinigen Heck, Kr. Vulkaneifel (DE)** | Fortified villa complex, at least three surrounding ditches and a probable tower at the centre, integrated into the villa building. | Late 3rd to mid / late 4th century activity. | Henrich 2016/17 | 9 m |
| 16 | **Walsdorf-Arentsberg, Kr. Vulkaneifel (DE)** | Gateway and walls recorded on a hilltop. Later Medieval overbuilding. | Mid-late 4th century fortification. | Gilles 1985, 204–208 | 5 m |
| 17 | **Gerolstein-Dietzenley, Kr. Vulkaneifel (DE)** | Reused Bronze Age stone defence around a hilltop. | Mid / late 4th century use. Earlier Bronze Age wall. | Gilles 1985, 226–227 | 5 m |
| 18 | **Kolverath-Hochkelberg, Kr. Vulkaneifel (DE)** | A wall and ditches regulating a hilltop site. | Late 3rd to early Medieval use. | Gilles 1985, 141–147 | 5 m |
| 19 | **Schutz-Buerburg, Kr. Vulkaneifel (DE)** | Hilltop site defended by several ditches and a drystone wall. | Late 4th century use. | Gilles 1985, 185–188 | 5 m |
| 20 | **Mayen-Katzenberg, Kr. Mayen-Koblenz (DE)** | Hilltop site above the *vicus* of Mayen. Very complex series of phases that include towers, a gatehouse and stone walls as well as ditches and palisades. | Roman activity from the late 3rd to the mid-5th century. Earlier prehistoric use and later Medieval activity. | Hunold 2011 | 9 m |
| 21 | **Obermendig-im Winkel, Kr. Mayen-Koblenz (DE)** | Villa complex with an additional Late Antique stone *burgus* and surrounding ditch. | Late 4th to early 5th century use of the *burgus*. | Wenzel 2012 | 9 m |

Appendix (cont).

| Site no. | Site name | Description | Fortification period | Key references | Height group (m) |
|---|---|---|---|---|---|
| 22 | **Ochtendung-Wernerseck, Kr. Mayen-Koblenz (DE)** | Ditch blocking access to the hilltop. Later Medieval accretion. | Mid-late 4th century activity. | Gilles 1985, 174–176 | 5 m |
| 23 | **Speicher-Leiköppchen, Kr. Bitburg-Prüm (DE)** | Poorly understood walls, ramparts and ditches around a hilltop. | Late 3rd to late 4th century usage. | Gilles 1985, 188–192 | 5 m |
| 24 | **Zemmer-Schanzkopf, Kr. Trier-Saarburg (DE)** | Ramparts and ditches around a hilltop. Poorly described. | Mid-4th century activity. Poor resolution. | Gilles 1985, 234–235 | 5 m |
| 25 | **Neumagen-Tempelkopf, Kr. Bernkastel-Wittlich (DE)** | A hilltop with a ditch, stone wall and embankments. | Early 4th to early 5th century. Earlier prehistoric and later Medieval use. | Gilles 1985, 170–174 | 5 m |
| 26 | **Minheim-Burglay, Kr. Bernkastel-Wittlich (DE)** | A palisade line and ditch restricting access to a hilltop spur. | Mid-late 4th century usage. | Gilles 1985, 159–162 | 5 m |
| 27 | **Veldenz-Schloß Veldenz, Kr. Bernkastel-Wittlich (DE)** | Earth rampart blocking access to a hilltop. Disturbed by later castle. | Mid-4th to early 5th century finds. | Gilles 1985, 203–204 | 5 m |
| 28 | **Bernkastel-Landshut / Prinscastellum, Kr. Bernkastel-Wittlich (DE)** | Large stone defences underneath a modern castle on a hilltop. Several phases include towers and a gatehouse. | Mid-4th to early 5th century activity. | Gilles 1985, 108–110; 2016 | 9 m |
| 29 | **Starkenburg-Schloßberg, Kr. Bernkastel-Wittlich (DE)** | Ditch limiting access to an elongated hilltop. | Early-mid / late 4th century activity. Poor resolution. | Gilles 1985, 192–195 | 5 m |
| 30 | **Kröv-Burgberg, Kr. Bernkastel-Wittlich (DE)** | Several ditches and banks restricting access to a hilltop. | Mid / late 4th century activity. Poor resolution. | Gilles 1985, 231–232 | 5 m |
| 31 | **Wittlich-Lüxemkopf, Kr. Bernkastel-Wittlich (DE)** | Rampart surrounding a hilltop. | Mid-4th century. Poor resolution. | Gilles 1985, 209–210 | 5 m |
| 32 | **Zell-Alteburg, Kr. Cochem-Zell (DE)** | Hilltop site with a stone wall and defensive ditches. | Late 3rd to late 4th century activity. | Gilles 1973; 1985, 211–220 | 5 m |
| 33 | **Zell-Marienburg, Kr. Cochem-Zell (DE)** | Series of ditches and a wall block access to an irregular hilltop. | Early 4th to early 5th century. Later Medieval use. | Gilles 1985, 220–223 | 5 m |

Appendix (cont).

| Site no. | Site name | Description | Fortification period | Key references | Height group (m) |
|---|---|---|---|---|---|
| 34 | **Hontheim-Entersburg, Kr. Bernkastel-Wittlich (DE)** | Hilltop with a series of usage periods. A number of defensive walls and ditches known. An associated stone *burgus* recorded. | Late 3rd to late 4th century activity. Earlier Iron Age and later Medieval use. | Gilles 1985, 128–133 | 9 m |
| 35 | **St. Aldegund-Hangelenberg, Kr. Cochem-Zell (DE)** | Ditch blocking access to a spur. | Late 3rd to late 4th century. Poor resolution. | Gilles 1985, 184–185 | 5 m |
| 36 | **Neef-Petersberg, Kr. Cochem-Zell (DE)** | Drystone wall enclosing the summit of a hill. | Late 3rd to mid-5th century use. | Gilles 1985, 163–170 | 5 m |
| 37 | **Masterhausen-Burgberg, Kr. Rhein-Hunsrück-Kreis (DE)** | Hilltop defended by a ditch circuit. | Early 4th to Medieval occupation. | Gilles 1985, 150–153 | 5 m |
| 38 | **Cochem-Zell-Mittelstrimmig, Kr. Cochem-Zell (DE)** | Unexcavated *burgus* over a *vicus*. Tower and ditch noted in non-invasive work. | 4th century activity, fieldworking confirmation. | Gilles 1990 | 9 m |
| 39 | **Binningen-Kuhkeller, Kr. Cochem-Zell (DE)** | Glacis, ditch and a drystone wall defended the hilltop. | Late 3rd to late 4th century activity | Gilles 1985, 111–113 | 5 m |
| 40 | **Burgberg, Kr. Cochem-Zell (DE)** | Complex series of hilltop defensive walls and ditches dating to different periods and reused at different times. An associated tower is also known. | Late 3rd to late 4th century. Earlier prehistoric and later Medieval use. | Gilles 1985, 121–128 | 9 m |
| 41 | **Steineberg-Steineberger Ley, Kr. Vulkaneifel (DE)** | Prehistoric stone wall encircling a hilltop. Reuse in Late Antiquity. | Early-mid 4th century. Possible late 3rd century usage. | Gilles 1985, 232–233 | 5 m |

Appendix (cont).