The Economic Development of the Rhine River Basin in the Roman Period

30 BC – AD 406

Tyler V. Franconi
Christ Church

VOLUME I: TEXT AND BIBLIOGRAPHY

Submitted for the degree of Doctor of Philosophy in Archaeology

University of Oxford

Trinity Term 2014

ABSTRACT

The Economic Development of the Rhine River Basin in the Roman Period
30 BC – AD 406

Tyler V. Franconi

Christ Church

Submitted for the degree of Doctor of Philosophy in Archaeology
University of Oxford
Trinity Term 2014

ABSTRACT: The economic development of frontier regions has been neglected in the study of the Roman economy. Traditional core/periphery models suggest that frontiers were marginal zones dependent on a wealthy Mediterranean core, and this view has dominated scholarship for more than thirty years. In light of recent work on the Roman economy, it is clear that many old models need to be reappraised; this thesis examines the economic development of frontiers through the case study of the Rhine River Basin. This region formed one of Rome's northern frontiers for more than 400 years and has a rich tradition of detailed archaeological and historical research. Using data from the Rhine frontier, this thesis re-examines the nature of frontier economies, arguing that they were dynamic, versatile, and complex rather than subaltern and undeveloped. A new model, based in the analytic framework of economic geography, is suggested as a replacement in order to appreciate the realities and potential of frontier economies.

For my grandmother,

Charlotte Ryan.

(1929-2013)

TABLE OF CONTENTS

Contents

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

AE – *L'Année épigraphique.*

CIL – *Corpus Inscriptionum Latinarum.*

Finke - Finke, H. 1927. "Neue Inschriften," *Berichte der Römisch-Germanische Komission* 17: 1-107 and 198-231.

Ness-Lieb - Nesselhauf, H., and Lieb, H. 1959. "Dritter Nachtrag zu CIL XIII: Inschriften aus den germanischen Provinzen und dem Treverergebiet," *Berichte der Römisch-Germanische Komission* 40: 120-228.

RGZM – Römisch-Germanisches Zentralmuseum.

ACKNOWLEDGEMENTS

The four years involved in the research and writing of this thesis are truly only the tip of the iceberg, for it has been a long road of nearly 30 years. The list of those who deserve to be thanked for their support and inspiration along the way is equally long and I cannot do it justice here.

First and foremost, Andrew Wilson has my eternal gratitude for his patient support and encouragement in the process of conceiving, researching, and writing this thesis. My examiners, Alan Bowman and Michael Fulford, provided much useful feedback and an enjoyable viva. Janet DeLaine and Damian Robinson provided invaluable advice along the way during the transfer and confirmation process. William Harris, Bruce Hitchner, Lisa Fentress, Penny Goodman, Arietta Papaconstantinou, Gary Farney, Miko Flohr, Fred Hirt, Francis Morris, Jerome Mairat, and Ben Hellings have each read or discussed substantial portions of the research and have greatly improved the project. John Pouncett was an incredible help with GIS. David Kendrick at Hobart and William Smith Colleges and Wilfried Wiechmann of the Bundesanstalt für Gewässerkunde (Koblenz, DE) were both instrumental in shaping my approach to rivers. Julie van Kerckhove (Amsterdam) and Joost van den Berg (Nijmegen) very generously shared their research and data, as did Johan Åhlfeldt from the *Digital Atlas of the Roman Empire*. I would also like to thank Jim Wright, Alice Donohue, and Darby Scott of Bryn Mawr College and Ann Kuttner at the University of Pennsylvania for their support during my time there, and for encouraging me to pursue my interests in Roman archaeology at Oxford.

My research while at Oxford was generously funded by the Clarendon Fund, the History Faculty, the Craven committee of the Faculty of Classics, the Meyerstein fund of the School of Archaeology, and Christ Church. I owe my thanks to the governing bodies of each of these institutions for their generosity and support.

My friends at Oxford and elsewhere, especially Ryan Valentine, Steve Karacic, George Ludlow, John Lansdowne, Andrew Brown, Sanda Heinz, Elsbeth van der Wilt, Charlotte Potts, Ali Potts, Meike Weber, Ben Russell, Dirk Booms, Nichole Sheldrick, Mike Maclean, Boris Chrubasik, Liz Ferguson, Swii Lim, Jack Hanson, and Carmela Franco have kept me sane and to them I am deeply indebted, not only for their support but for the fun had along the way. Nothing would have been possible without the unwavering support of my family who have always fostered my interests in history and the natural world and have stood by me through the trials and tribulations of academic pursuits. I love you all.

Finally, I must thank Candace Rice, whose love, support, and inspiration made this project both possible and worthwhile. I could not wish for a better partner by my side; truly, *ohne Dich kann Ich nicht sein*.

1

Introduction

The Roman Empire's frontiers stretched for over 5,000 km from Scotland to Arabia to the Sahara. The study of these frontiers has a long history, and the archaeology of certain frontier zones is some of the best studied in the Empire.[1] These frontiers varied in their form, organization, and conception, covering a wide array of landscapes and cutting across a number of different cultures. Traditional frontier studies have often focused on military sites and history, and more recently have expanded to include cultural issues such as the question of Romanization.[2] Economic questions, however, are often overlooked or oversimplified.[3] As an index, an examination of the 19 volumes of the *International Congress of Roman Frontier Studies* reveals that only 8% of the 1,175 published papers deal with economic topics (**fig. 1.1**). The economies of Roman frontiers remain largely under theorized and un-discussed.[4]

The study of the Roman economy (discussed further below), meanwhile, has progressed by leaps and bounds in recent years, but still, for the most part, focuses on Mediterranean provinces. The vast size of the Roman Empire makes comprehensive study difficult, but historians and archaeologists interested in the Roman economy have often preferred Italy, France, Spain, and the littoral of North Africa, thought by some to be "most fruitful sources of data,"[5] to those of the "economically un-sophisticated regions,"[6] i.e. the frontiers. This perceived division of regions has perpetuated the belief that there existed a productive 'core' and a marginal 'periphery'. Other fields such as anthropology have rejected the

---

[1] *E.g* Whittaker 1994; Birley 2002; James 2002.
[2] Attributed to an increased influence of the *Annales* school and post-colonial archaeological thought by Wheeler 1993a, 16.
[3] Hopkins 1980; 1983; Whittaker 1983; 1989; 1994; Cherry 2008. Some exceptions to this rule exist, including, *inter alia*, Fentress 1979; Fulford 1989; Morris 2010; Fentress 2013; Wells (ed.) 2013.
[4] Mattingly 2011, 20.
[5] Bowman and Wilson 2009, 3.
[6] Hopkins 1980, 102.

core-periphery model of interaction,[7] yet Roman archaeology, particularly the study of the Roman economy, has not done so. Many models and theories developed for the Roman economy have not been tested outside of the Mediterranean 'core,' so their applicability to temperate Europe must be considered.

The strength of frontier archaeology has long rested on its material-oriented studies; vast quantities of published data detailing ceramic and other material categories exist from hundreds of frontier sites around the Empire. These data are often presented in catalogue format as sections of excavation reports, with rare interpretations of the material's larger significance.[8] As a result, this material is best known by material specialists who, with some exception, rarely engage with more complex historical issues. Conversely, much economic history of the Roman world is written without reference to archaeological data,[9] despite the obvious importance of material studies to the subject.

This thesis reassesses the nature of frontier economies in the Roman Empire, focusing on the Rhine River Basin in the Roman period, roughly 30 BC – AD 406, and rejects models of economic marginality. The Rhine was perhaps not a typical frontier, being densely settled and often at the centre of key historical events. Nevertheless, a detailed examination of its economic development will provide comparative insight by which other frontiers can be assessed. Using an archaeological data set within a historical narrative, a new model of regional economic development and integration is presented, borrowing its analytical framework from the field of economic geography. This study demonstrates that the Rhine frontier was capable of significant development due to a number of factors, and this development can be documented through its chronological progression.

---

[7] *E.g* Lightfoot and Martinez 1995.
[8] See Chapter 6 below.
[9] *E.g* Finley 1973; Whittaker 1993; 1994; Morley 2007; Bang 2009.

Modelling the Roman economy

Existing models of the Roman economy rarely take explicit account of the relationship between different regional variation, and it is rarer still to discuss the frontier zones directly. This is largely because one model, formulated by Keith Hopkins over 30 years ago,[10] still dominates the field. The so-called "taxes and trade" model outlined three zones of economic activity in the Roman world: the city of Rome, the rich Mediterranean provinces, and the outer frontier zones. Hopkins argued that the developments in trade and economic activity seen in the period between roughly 200 BC-AD 200 were the result of the Roman government imposing (relatively low) taxes upon newly conquered provinces in order to provide revenues which could then be spent either in the city of Rome or on the frontier zones where the military was stationed.[11] Taxation required provincials to generate enough revenue above the subsistence level in order to pay, and to do this they turned to various productive enterprises and inter-regional trade. The increase in trade also caused an increase in monetization,[12] which was integrated into an Empire-wide fiscal system. It was the collapse of this system in the third century AD which caused general economic decline.[13]

Hopkins offered some revisions to his model in 1996 in response to critics,[14] but the basic tenets remained—the imposition of taxation on provinces resulted in increased production and long-distance trade, thereby resulting in a more economically-integrated empire. This model emphasized growth and the importance of trade, coinage, and transport within the Roman world, marking it out as being substantially ahead of its time. At its core, however, is the implicit assumption that the Mediterranean region was rich and successful while the frontier zones were poor and required support. This assertion has never been substantially challenged but, if it could be shown to be false, would significantly

[10] Hopkins 1980; 1983; 1996.
[11] Hopkins 1980, 101-2.
[12] *Ibid*., 106-13.
[13] *Ibid*., 123-24.
[14] Hopkins 1996.

alter scholarly understanding of the relationship between different regions in antiquity.

This model was extremely influential, and is still preferred by many as the best explanation for the development of the Roman economy.[15] There have certainly been critics, however, who have questioned its applicability for, as Bowman and Wilson state, the model "is based on unverifiable assumptions,"[16] a fact of which Hopkins himself was well aware.[17] Harris commented that the model "is at least—and at most—thought provoking," but doubts its accuracy.[18] Lo Cascio, despite stating that the model cannot generally be disproved,[19] objected to it on the grounds that it lacks the ability to account for changes and dynamism.[20]

Relatively few other models have been proposed which integrate both Mediterranean and non-Mediterranean provinces. Notable contributions have been made within the Mediterranean, perhaps most importantly by Horden and Purcell in *The Corrupting Sea*. Examining the *longue durée* of the Mediterranean, the authors argue that the sea was an integral factor in promoting connectivity throughout its basin due to an uneven distribution of climatic conditions and resources.[21] These micro-regions, as they call them, were forced to interact and trade in order to secure the goods and commodities that they needed. Connectivity is a key concept in their argument, but was often discussed in the abstract. An archaeological view of connectivity, and a reconsideration of Horden and Purcell's argument, is offered by Rice in her doctoral thesis,[22] where she compares data from Mediterranean port ceramic assemblages, shipwreck cargos, and epigraphy to document the lived experience of connectivity in the Roman period at both local and long-distance scales. Her methodology will be discussed below.

---

[15] *E.g* Wickham 2000; Morley 2007; Rathbone 2008.
[16] Bowman and Wilson 2009, 15 n.30.
[17] Hopkins 1996.
[18] Harris 2011a, 292.
[19] Lo Cascio 2008, 622.
[20] *Ibid*., 646.
[21] Horden and Purcell 2000, 5. Also explored in continental Europe by Cunliffe 2001a and Morris 2010.
[22] Rice 2012.

Since connectivity was introduced as a concept, the focus has become less on models and more on outlining causes and determinants of economic performance. For many scholars, the debate over the importance of long-distance trade to the Roman economy was ended by Horden and Purcell. Yet explanations of growth and decline have yet to reach such a consensus. Market integration forms a key point in this discussion. Temin argued that the Roman world was a large conglomeration of interconnected markets.[23] Under the Empire, both market (non-centric/instrumental) exchange and imperial redistribution (centric/command) took place along parallel and complementary avenues.[24] Temin distinguishes between the well-integrated market regions of the Mediterranean and inland areas which were less firmly connected, citing Vindolanda as an example of the latter.[25]

Scheidel has argued that Roman economic growth was facilitated by institutional development, mainly the influence of the Roman state over the Mediterranean which introduced peace and lowered predation costs on trade.[26] He further argues that economic growth was eventually truncated by Malthusian pressures such as epidemics and resource availability. In this scenario, Scheidel still paints a picture of core and periphery, especially when discussing the end of economic growth: "What matters is that growth ceased in the core areas, thereby predicting similar if delayed outcomes in the periphery."[27] He goes on to write that "there is no such thing as an economic history of the Roman Empire, only of zones of development whose asynchronicity requires regionalizing periodization."[28] Unfortunately, Scheidel himself has yet to produce much in the way of regional discussions which will clarify his arguments. His involvement in large, multi-authored projects has, however, helped bring others into such discussions, in particular the *Cambridge Economic History of the Greco-Roman World* and the *Cambridge Companion to the Roman Economy*, both of which

[23] Temin 2001; 2012 with reviews by Erdkamp 2013 and Thonemann 2013.
[24] Temin 2001, 170-72.
[25] *Ibid*., 180.
[26] Scheidel 2009; 2012.
[27] *Ibid*., 26.
[28] *Ibid*., n. 37.

examine a number of different factors contributing to economic growth and regional trends, including ecology, demography, institutions, technology, and the state.[29]

Other authors have sought the cause of growth in the development and dissemination of technology throughout the Roman period. Harris has referred to this as the 'Greene-Hitchner model,' in which "relatively extensive diffusion of productive technological innovation and large spurts of growth"[30] are common. Wilson has perhaps been the strongest proponent of such a model, with his important work on technological advancement in addition to his extensive work on the archaeological traces of trade.[31]

Wilson's work, together with Bowman, has formed part of the larger Oxford Roman Economy Project, which, in addition to technology, examines a wide range of factors including economic policy, coinage and monetization, commercial institutions, trade, markets, social integration, integration within industrial sectors, investment, labour, urbanization, demography, agricultural production, and mining.[32] The project aims to "consider to what extent the Roman economy was integrated across the whole empire rather than a number of disparate but linked regional economies,"[33] though Bowman and Wilson state that "a micro-regional approach shines only very narrow beams of light and no one would think it feasible (if only because of the very uneven spread of evidence and the huge gaps in our knowledge) to combine these narrow beams into one vast flood of illumination."[34] Furthermore, OXREP hopes to avoid approaches (such as world-systems theory) which obscure regional differences,[35] instead they hope to "illuminate by quantitative methods" the "considerable regional diversity across

[29] Scheidel, Morris, and Saller (eds.) 2008; Scheidel (ed.) 2012.
[30] Harris 2009, 261-62, naming the model after papers by Greene 2000 and Hitchner 2005 which both emphasize technological developments as economic motivators.
[31] Wilson 2002a; Bowman and Wilson 2009, 33-38; Wilson 2009a; Wilson 2009b.
[32] Bowman and Wilson (eds.) 2009; Bowman and Wilson 2009; Bowman and Wilson (eds.) 2011; Bowman and Wilson (eds.) 2013.
[33] Bowman and Wilson 2009, 3-4.
[34] *Ibid.*, 8.
[35] Bowman and Wilson 2009, 8.

the Roman Mediterranean."[36] No single model of regional activity has come out of this, but the celebration of diversity is a step in the right direction.

Finally, Mattingly has outlined what he has called "discrepant economies" in the Roman world. He argues that economic activity existed in three spheres in the Roman world: imperial, extra-provincial, and provincial.[37] The imperial economy controlled taxation, the fiscus, the military, annonary redistribution, and monetization. Extra-provincial economies involved the production and distribution of goods between regions on the free market, and provincial economies were local responses to taxation and trade that occurred within provincial borders. Mattingly argues that this model achieves "a clearer appreciation of how it was that the Roman economy could appear both so modern and so primitive at the same time, why scholars can recognize both formalist and substantivist elements, and how it was capable of generating both globalized and highly localized distributions of material culture."[38]

While there have been many developments in scholarly attention to economic interaction, there have been few attempts to model regional interaction since Hopkins, and indeed many of these (like Temin and Scheidel) simply change what they see as the motivators of growth (the Roman state, market integration, technological development) instead of only taxation. Other approaches which abandon Hopkins' model have yet to produce an alternative, partly because of the massive amounts of data which have become available in the past 30 years, but also partly because any one model is antithetical to the dynamism and variation seen in the Roman world. This does not, however, detract from the value of models as heuristic devices, and they should not be totally discounted in current discussions.

---

[36] *Ibid*., 51.
[37] Mattingly 2011, 138-45.
[38] *Ibid*., 140.

Frontier economies

Elements of Hopkins' model formed the background of Whittaker's work on frontiers.[39] Whittaker began with the idea that the frontier provinces were poor, periphery regions which consumed taxes from the Mediterranean core.[40] He argued that frontiers were generally established in regions where intensive agricultural production ceased to be possible, and thus were marginal zones.[41] Whittaker recognized that these zones were not simply barriers, but often encouraged interaction on both sides of the Roman boundary, creating zones (*Vorlimes*) of cultural exchange necessitated by scarcity of resources.[42] In Whittaker's view, it was competition for these resources which ultimately led to the repeated invasions of Roman frontiers by barbarians in the later periods of Roman history.

The military played a central role in this model. Because frontier zones were so marginal, in his view, the Roman army was unable to rely on local production to feed itself.[43] The Roman state, therefore, had to supply goods to the frontier garrisons through subsidized transport routes which were not subject to market forces.[44] Civilian markets in frontier zones had access to the goods which "spilled over" from military markets, as did those people living beyond the frontier line who were involved in active exchange with the Roman world.[45] Be that as it may, Whittaker also argued that soldiers were relatively isolated from the civilian population,[46] echoing sentiments voiced elsewhere by Shaw.[47]

---

[39] Wheeler 1993a; 1993b; Birley 2002, 7 n. 10. It is notable that the spike seen in fig 1.1 in the 1995 volume of the *Limes Kongresse* came the year after the publication of Whittaker's major work on frontier economies. It should also be noted that, two years after the publication of this book, Hopkins (1996, 56) himself referred to Whittaker as a "static minimalist" who viewed the Roman economy as a command economy rather than a market economy.
[40] Whittaker 1983; 1994; 2004.
[41] Whittaker 1983, 113.
[42] *Ibid*., 114-18.
[43] Whittaker 1994, 101.
[44] *Ibid*., 130.
[45] *Ibid*..
[46] *Ibid*., 128.
[47] Shaw 1983, 148.

This same model of frontier economy is repeated by other scholars such as Remesal Rodriguez,[48] Morley,[49] and Cherry.[50] Others, however, have raised objections.[51] Early on, Fulford took issue with Whittaker's model, pointing out that archaeological evidence contradicted many of his points about agricultural production, hinterland assignation, and trade goods.[52] Fulford's own work on the economy of Britain was influenced by Hopkins' model of tax redistribution, though he was able to demonstrate change over time and space, utilizing a wide range of material similar to that discussed below for the Rhine.[53] Work by Fentress and Wierschowski, amongst others, has also taken issue with the idea that frontier troops could not be self-sufficient or were not well integrated into local communities.[54] Despite these objections, Whittaker's model is still the most commonly cited, and its basic tenets hold sway over many archaeologists and historians working along frontiers. The recent contribution by Cherry is a case in point—nearly repeating Whittaker's arguments verbatim.[55]

Previous study of economic activity within the Rhine Basin

Most existing accounts of the economic life of the Rhine frontier are qualitative and descriptive rather than systemic or explanatory. Rothenhöfer has so far offered the most thorough examination, exploring the economic development of southern Lower Germany, that is, the part of Lower Germany within modern German borders.[56] Its limited geographic scope of study creates an artificial zone of activity which must be compared against the wider region, though the systemic approach used in his work is exemplary, examining factors such as agriculture,

---

48 Remesal Rodriguez 1986; 1997; 2002.
49 Morley 2008.
50 Cherry 2008.
51 In particular, the review by Freeman (1996) which argues that Whittaker's approach is too generalizing and obscures regional and chronological variation while ignoring the effects of frontier developments on inner provinces. Wheeler (1993a, 14) also notes the core-periphery model implicit to Whittaker's work in addition to his debt to the *Annalistes*.
52 Fulford 1989a.
53 Fulford 1984; 1989b; 2004. See also Mattingly 2007.
54 Fentress 1979; Wierschowski 1984; Drummond and Nelson 1994; Wierschowski 2001; Tchernia 2002 for a summary of the positions taken by Remesal Rodriguez and Wierschowski.
55 Cherry 2008.
56 Rothenhöfer 2005.

resource production, and craft production. His conclusion, that the agricultural production of Cologne's hinterland was the dominant economic activity of the region, is perhaps overly simplistic in light of the evidence covered in the book, but still presents a serious challenge to scholars arguing for a marginal periphery.

Elsewhere, Carroll's examination of commerce and trade in the German provinces,[57] Rüger's on the economic history of Roman Germany,[58] and book sections on the economic life of Roman Nordrhein-Westfalen,[59] Rheinland-Pfalz,[60] Hessen,[61] Baden-Württemburg,[62] north-eastern France,[63] Belgic Gaul,[64] and Switzerland [65] provide descriptive accounts of economic activity, mainly focused on craft production and ceramic trade, but generally lack analysis of actual economic importance or structure.

Other scholars such as Martin-Kilcher, Höpken, or Ehmig have approached economic issues through detailed material studies which provide high resolution data,[66] though these works largely remain the province of material specialists.[67] A better integration of material evidence into analytical frameworks of investigation is the only way to move substantially beyond descriptive accounts and begin to understand the economic structures which dictated activities like production and trade.

Why the Rhine Basin?

When the French geographer Brunet developed his concept of the "Blue Banana" in European economics—a zone of intense settlement, wealth distribution, and industrial activity stretching from Milan to Liverpool—he highlighted the basic

[57] Carroll 2001, 84-101.
[58] Rüger 2000, 504-8.
[59] Horn 2002.
[60] Roller 2005.
[61] Baatz 2002.
[62] Martin-Kilcher 2005.
[63] Bromwich 2003.
[64] Polfer 2005.
[65] Drack and Fellmann 1988; Amrein *et al*. 2012.
[66] *E.g* Martin-Kilcher 1987-1994; Ehmig 2003; Ehmig 2005; Höpken 2005.
[67] Though see Tchernia 2011, 115-20.

fact that the Rhine River Basin is currently an important economic centre for Europe and the world.[68] This is, perhaps, not just a phenomenon of the industrialized world. McCormick, in his study of the medieval European economy, argued that the origin of European economic activity was to be found in the eighth century AD, when Carolingian Europe and the Byzantine and Arab East reconnected into a large trading network.[69] While the exact timing of the economic 'origin' is debated,[70] the Carolingians are often thought to have been at the centre of it. It is interesting to note that the central region of the Carolingian kingdom was the Rhineland and many of the economic activities which McCormick sees developing in the eighth century could be interpreted as a re-ignition of many old Roman traditions. It was the cities of the Roman Rhine that the Carolingians occupied, the roads of the Roman Empire along which the Carolingians moved, and the natural resources that had been worked since the Bronze and Iron Age upon which the Carolingians relied. It is important to understand the foundations on which the Carolingians built, most of which were firmly Roman. Therefore, understanding the reasons that dictated Roman economic structure in the region will in turn provide some additional illumination of the continuity of the economic activity in this central economic zone of Europe.

By studying the Rhine Basin with the methodological approaches laid out here, a new model of regional and frontier economies will be created. The model and arguments presented in this thesis are not meant to be exhaustive or in any way fully inclusive of all of the archaeological data available for the Rhine; the region is too large and the data are too plentiful. The data and approaches selected were chosen in the hopes that they would provide a sufficient structural view against which other material studies can then be assessed. In doing so, it is hoped that this model can be utilized in a comparative manner to establish how accurately it accounts for other regions even in other times and inspire discussions about the how and why of economic development and regional integration in the Roman world.

---

[68] Brunet 1989.
[69] McCormick 2001.
[70] *E.g* papers in James, ed., 2003.

Colonial views of Roman frontiers

A common thread throughout both Roman economic history and provincial archaeology is that the non-Mediterranean provinces and frontiers were less successful than those around the inner sea.[71] This *a priori* determination of provincial performance permeates most levels of research, especially from Hopkins' model onwards. In this line of thinking, the frontier provinces were less productive, less advanced, less economically integrated, and less wealthy—they were, indeed, the very essence of the term *provincial*. Models of this kind produce "polarized and schematic views, in which frontiers and their inhabitants were often reduced to passive recipients of innovations and ideas streaming from the core."[72]

Such colonialist approaches to frontiers have been heavily criticized in anthropological literature,[73] but are rarely addressed in Roman scholarship. Post-colonial approaches to other topics in Roman studies, particularly Romanization, have received more attention in recent years,[74] but frontier archaeology is still largely dominated by colonial views of military history, conquest, and conflict. Work such as Bhaba's "Third Space" emphasizes frontiers as zones of hybridity, where new constructions of identity occur and result in a new society that is neither *native* nor *other*.[75] Similar post-colonial theories and models have yet to penetrate economic thought.

The division of the Mediterranean and temperate European provinces in such a hierarchical way distorts several different realities.[76] First, no two provinces were exactly alike, so classing them into groups that basically divide between 'well-off' and 'poor' is detrimental; provincial success existed across a broad spectrum of possibilities. This thesis offers a case study in recognizing the

[71] Wheeler 1993a, 13-14; Freeman 1996, 469-70.
[72] Naum 2010, 104-5.
[73] *E.g* Lightfoot and Martinez 1995; Naum 2010.
[74] *E.g* Millett 1990; Webster 2001; Roymans 2004; Revell 2009; Mattingly 2011.
[75] Bhaba 2004; Naum 2010.
[76] Wilson 2002b on the division of Mediterranean and European economies.

range of economic successes possible in a provincial and frontier setting, and in doing so suggests model alternatives to simple core-periphery divisions.

Economic Geography

Regional economic activity is not an issue of interest only in the Roman world. An entire field of study known as Economic Geography exists to study regional economics. As a discipline, "Economic geography seeks to explain the riddle of unequal spatial development," because "that spatial diffusion of economic and social development has been, and still is, very uneven." [77] The field developed as a response to those economists who viewed economic activity only in perfect terms, where space and distance often played no part in equations.[78] Despite its regional focus, it is also critical to pay attention to the wider, global context in which these regions existed.[79] A textbook on the topic outlines five key issues which the field aims to address:[80]

1.) *Defining the spatial unit of reference*: how do we delineate economic regions which are both relative and changing? These are often distinct and less corporeal than administrative districts.
2.) *Mobility of production factors*: how are regions and their inhabitants affected by the mobility of goods and economic agents? The locations of economic agents become endogenous factors of economic development.
3.) *First- and second-nature inequalities*: the natural differences among regions (raw materials, climatic features, topography) form what Cronon called first-nature inequalities,[81] as differentiated from those second-nature inequalities which are created by human actions to improve upon first-nature.
4.) *Interactions between agglomeration and dispersion forces*: the countervailing forces which cause the clustering of human activities and

[77] Combes *et al.* 2008, xiii.
[78] Krugman 1992, 2-3.
[79] Mackinnon and Cumbers 2007, 2.
[80] Combes *et al.* 2008, xiv-xvi.
[81] Cronon 1991.

forces which tend toward their dispersion act upon economic landscapes and both the natures of the forces and their interactions must be determined. The relationship is often circular and cumulative.

5.) *Increasing returns and imperfect competition*: on the supply side, population growth allows for more than a proportional growth in level of production. Furthermore, on the demand side, economic agglomerations are a portfolio of differentiated goods, services, and jobs, leading to imperfect competition.

A critical underpinning of economic geography is the principle of comparative advantage. Comparative advantage states that when resources are distributed unevenly,[82] a region will benefit from producing the good which it is able to produce at a lower relative or opportunity cost when compared to other potential locations.[83] This enables specialization in production so that regions are able to benefit from trade most efficiently with other regions that produce different goods. Comparative advantage is listed as one of the three primary determinants of economic spaces, alongside externalities and imperfect competition (either monopolistic or oligopolistic).[84]

Transport costs play a critical role in facilitating this development.[85] In order for trade to be possible at all, especially in large volumes, the cost of transport needs to be acceptably low. As McCormick has stated, “transport is the bridge that links the critical factors of supply and demand over distance.”[86] As such, transport costs are a significant factor in determining the economic viability of incorporating new regions into markets and supply chains.[87] A region must be able to transport its own products to trade with other regions which hold different comparative advantages.

Adapting modern economic models to the Roman past is not always straightforward, particularly as economic geography often utilizes formulae which

[82] Krugman *et al.* 2012, 80.
[83] Combes *et al.* 2008, 42.
[84] *Ibid*., 42-43.
[85] Mackinnon and Cumbers 2007, 3-7.
[86] McCormick 2001, 64.
[87] Combes *et al*. 2008, 44, 81; Rodrigue *et al*. 2006, 45.

cannot be applied due to a lack of data. Approaches utilizing modern economic theory have, in the past, sometimes been met with derision from ancient historians.[88] However, the basic tenets of comparative advantage hold great promise as a way to explain regional economic variation in the Roman world beyond simple core-periphery divisions.

It is clear that many scholars of antiquity have already been interacting with the field of economic geography without ever knowing it, as many of these issues have formed the core of investigations in the Roman economy for decades. Overt integration of economic geography into the study of the Roman economy will help give a structure to investigations of Roman regional variation. It would also, presumably, help inform some economic geographers who consider only post-industrial economies to be developed, as, alledgedly, "preindustrial economies are characterized by a low and roughly equal level of activity everywhere, with high transport costs and little trade."[89] While the volume of trade in the Roman world did not equal that seen in modern economies, many archaeologists and historians would surely take issue with this statement.

Rice used this approach in her doctoral thesis in order to explain the demonstrable results of connectivity seen in the archaeological record of the Roman Mediterranean.[90] Her study included a comparison of the economic development of the coastal regions of southern France and southern Turkey (corresponding to the provinces of Gallia Narbonensis, Lycia and Pamphylia, and Rough Cilicia), revealing that production in both regions tended towards specialization under the Roman Empire—wine in France and olive oil and textiles (particularly murex dye) in Turkey. Producers in these regions were able to focus their efforts on specific commodities precisely because the Roman Empire incorporated them into an inter-regional trading network in which they did not need to produce everything for themselves. By applying these principles to Roman archaeology, she was able to clarify and explain key issues and concepts like connectivity which were previously being used in the abstract or as

---

[88] Finley 1986, 17-34.
[89] Combes *et al.* 2008, xix.
[90] Rice 2012.

generalizations. We can further posit the same forces at work when we consider the specialized production of olive oil in Baetica or Tripolitania, or terra sigillata production in Italy, Gaul, and Africa.

Thus, while not a simple model, economic geography is able to frame and explain the complex, dynamic economic activity seen in different regions of the Empire. Using this framework, it should be possible to outline the economic trajectories of different regions as Rice did for southern France and Turkey and then compare them in meaningful ways, to explore how and why regional economies developed in the Roman world.

New directions in the study of Roman frontier economies

A new explanation of frontier economies is needed. Work by Fulford and Fentress on Britain and Numidia has helped outline the possibilities of some frontier zones,[91] yet this research has not been widely acknowledged or followed up. Scholarship must acknowledge its underlying theoretical biases and move beyond the core-periphery paradigm. This thesis addresses these problems, proposing an approach based in the methodology and models of economic geography but utilizing archaeological and historical data. The intention is to highlight those factors which influenced the trajectory of economic development of a given region. Economic development is not to be confused with economic growth. Economic development can be defined through qualitative and quantitative changes in economic activity that generally contribute to an expanded economic capability.[92] These can be seen through changes in the scale of productivity, the introduction of new institutions, and increased urbanization.[93] Growth, on the other hand, is one aspect of development, and can be measured through different data such as gross domestic product (GDP), and the two are not necessarily synonymous;[94] making the distinction is necessary.[95]

---

[91] Fentress 1979; Fulford 1984; 1989a; 1989b; 2004; Fentress 2013.
[92] Sen 1983, 748, 755.
[93] Jones 2011, 8.
[94] *Ibid*.

This study focuses specifically on the Rhine River Basin (**fig. 1.2**), an area of roughly 185,000 km² covering parts of modern-day Switzerland, Germany, Luxembourg, France, and the Netherlands. Under Roman hegemony a maximum of 60% of this river basin was incorporated into the Roman Empire, divided between the early- and mid-imperial provinces of Germania Superior, Germania Inferior, and Gallia Belgica and the late-Roman provinces of Germania I, Germania II, Belgica II, Maxima Sequannorum, and Raetia I. The Rhine River and its tributaries linked large areas of these provincial territories together into a single, interconnected fluvial landscape of communication and exchange enabled by the waterways. This region, thus united, formed the Roman frontier with Germany for nearly five centuries.

Before the Roman arrival, the La Tène Iron Age saw relatively high levels of growth and development, largely in response to increased contact with the Mediterranean and Baltic worlds.[96] Archaeology has demonstrated that goods of all sorts were circulating amongst Iron Age tribes—pottery, glass, weapons, metal—and that coinage was developing.[97] Proto-urban *oppida* developed as tribal centres.[98] From ca. 200 BC onwards, Italian wine was imported to the region in huge quantities,[99] widely assumed as evidence for a reciprocal export of slaves to Italy,[100] though this theory has been challenged.[101] The level of economic development and growth, however, paled in comparison to the economic activity

---

[95] Many Roman historians have sought to measure ancient economic growth, citing different factors such as GDP, GNP, real wage development, and price indexes, amongst others (*e.g* Silver 2007; Scheidel 2009; Temin 2011). Yet our data sets are incomplete, and therefore any arguments derived from them are extremely tenuous.

[96] Wells 1984, 104; Haselgrove 1987, 108-10; Cunliffe 1988; Nicholson 1989; Wells 1995a; Dietler 1992, 402-3; Cunliffe 2001b, 341.

[97] On trade and production see Collis 1984, 87; Wells 1984, 143; Cunliffe 1988, 32; Wells 1995b, 225; Haselgrove 1999, 131; Fichtl 2005, 107; Seidel 2005. On coinage see Collis 1981; Roymans 1990; Briggs 1995; Wigg & Riederer 1998; Haselgrove 1999; Wigg 1999, Howgego 2013.

[98] Woolf 1993, 224-6 on problems with defining and identifying "oppida" in Europe. Here, I take oppidum to mean a nucleated settlement which was a product of the increased organizational capacity of the late-Iron Age peoples of Europe. Collis 1984 lists 279 sites in an appendix, though this is not all-inclusive.

[99] Hundreds of thousands of Republican wine amphorae have been recovered in Gaul, interpreted as evidence for the wine-for-slave trade mentioned by Diodorus Siculus (5.26.3), Tchernia 1983; Poux 2004; Tchernia 2011, 163. The Madrague de Giens wreck, ca. 60-50 BC, was carrying 6-7,000 Dressel 1b amphorae bound for Gaul from Campania, Tchernia *et al.* 1978; Rice 2012, 209-11.

[100] Poux 2004. See also Poux 1999; Loughton 2003; 2009.

[101] *E.g* Loughton 2009, 87.

brought by the Roman conquest. The Roman period advances brought a dramatic increase in economic development to the region which was subject to many factors, both internal and external.

Over the course of Roman occupation, the region experienced alternating periods of trouble and calm. The initial conquest, begun under Caesar but carried out in earnest under Augustus and Tiberius, gave way to a long period of consolidation and development which included the establishment of the German provinces ca. AD 85 and expansion across the Rhine. The expansion had ceased by the late second century, and the first real floruit of Roman control lasted until the mid third century. From 260 onwards, internal trouble and external threats led the region, including the German provinces, Gaul, Britain, and even Spain, to split off into the Gallic Empire for 14 years.[102] The region was reincorporated under Aurelian and hosted an imperial seat in Trier from the Tetrarchs onwards. The establishment of an Imperial capital at Trier brought renewed growth to parts of the Rhine, and a second floruit lasted until the mid fourth century. The revolt of Silvanus in 355 at Cologne led into a new period of unrest and violence, including the campaigns of both Julian and Valentinian. Solid Roman control of the region was lost after invasion of German tribes in December of 406, though repeated attempts at re-conquest and defense occurred up to 459, when Cologne was finally lost.

Centuries of high-quality archaeological research along the Rhine have produced ample data, many of which are directly relevant to economic history. Because the Rhine basin is divided between several different countries, however, these data have yet to be synthesized into a comprehensive picture of regional activity. Traditions in Germany and France in particular remain divided, despite the fact that the region was a single entity under the Romans. Thus, a large part of this thesis is dedicated to uniting data from separate traditions in order to tell a single story.

[102] See papers in Fischer, ed., 2011 for the most up-to-date account of Gallic Empire.

The importance of agricultural production and tax distribution

Pre-existing models portray frontiers as the edge of agricultural productivity and, consequently, heavily dependent on tax redistribution. These issues are dealt with further in Chapters 4 and 6 respectively, but to contextualize the approach of this thesis within these models, these two factors must be introduced now in order to highlight the degree of relevance to the development of the Rhine basin.

Agriculture

The role and importance of agricultural production in any economy cannot be overstated. In the Roman world, scholars have long emphasized farming as the single most important economic activity,[103] often to the extent that they have neglected the study or importance of any other actions.[104] More recent approaches have emphasized that Roman agriculture was relatively advanced, to the point that production was high enough to support a substantial non-agriculturally involved population, allowing for diversification and specialization across the Empire.[105] Significant differences existed across the Empire, with regional variations in crops, crop yields, livestock breeds, and transhumance practices based upon geography, climate, and local tradition.[106] Quantifying these differences on a broad scale is difficult,[107] but regional studies have provided some interesting results. One of the most striking regional differences is the emergence of a villa-based economy in the west, in which large, rural estates dominated agricultural production.[108]

Marginal agricultural production along the frontiers is a central theme in the models of both Hopkins and Whittaker, who argue that imperial redistribution efforts directed food, supplies, and money to frontier provinces because they were too poor, both financially and agriculturally, to support themselves. Fentress,

[103] Whittaker 1994; Hopkins 1996.
[104] Greene 1986, 67.
[105]Kron 2012; Rice 2012; Bowman and Wilson 2013.
[106] Bowman and Wilson 2013, 3.
[107] *Ibid*., 10-15.
[108] Greene 1986, 88; Bowman and Wilson 2013, 7.

meanwhile, argued that the province of Numidia was capable of producing a market-oriented agricultural surplus more than capable of supplying both local civilian residents and the military garrison.[109] Fulford argued against Whittaker's claims of agricultural limits, stating that the frontiers of northern Britian, Germany, and the Danube did not mark a boundary between intensive and extensive agricultural possibilities.[110] These two opposing views set the stage for other investigations of frontier farming, many of which have now been carried out within the Rhine basin.

Within the Rhine basin, a variety of landscapes were utilized for agricultural production, from the lower slopes of the Alps in the south to the high stream ridges of the Rhine delta in the north. The low hills and fertile river valleys provided ample land for rural settlement, eventually resulting in a dense network of villas, farms, and rural settlement which helped spur agricultural production to a level previously unknown in the region.[111]

The details of the local agricultural developments will be discussed further in chapter 4, where the evidence for farming practices and the development of a wide-spread villa economy are detailed. It is against this backdrop of agricultural fecundity that subsequent economic development took place. As Mattingly and Salmon wrote:[112]

> Agriculture always left a gap, often very small but sometimes considerable, that was filled by other activities which determined the characteristics of local, regional and larger (supraregional) economies. The nature of this non-agrarian sector of the ancient economy and its potential impact merits closer scrutiny than it has traditionally received.

Because the Rhine region was so fertile, the frontier zone was able to develop above and beyond the level of subsistence, eventually creating a dense settlement network of cities and towns which acted as market centres for agricultural produce, but also as concentrations of craft producers, service providers, and centres of large-scale importation of foreign goods. This system, like the

---

[109] Fentress 1979; 2013.
[110] Fulford 1989, 82-3.
[111] Rothenhöfer 2005, 45. On villas in the region in general see: Müller-Wille and Oldenstein 1981; Gechter and Kunow 1986; Kunow 1994; Heimberg 2003; Wendt and Zimmermann 2008; Roymans and Derks 2011.
[112] Mattingly and Salmon 2001, 4.

agricultural system on which it was based, was subject to a number of factors that determined its success, which will be discussed throughout.

Taxation

A further question remains about taxation and the monetization of the Rhine frontier. As Hopkins' model emphasizes the relationship between tax-producing and tax-consuming provinces, it is necessary to examine to what extent the Rhine frontier was actually a tax consumer. There are three main issues involved in this discussion: the level of tax revenue consumed within the region, the level of tax revenue produced within the region, and the level of monetization involved in both.[113]

Additional revenue was brought into the region through the payments of *portoria*, border taxes imposed on trade goods entering and leaving the Gallic region, which included the Rhine frontier.[114] *Portoria* were collected alongside other forms of taxation which then financed the provinces and the military. Taxes could be collected either in cash or in kind and this probably largely depended on the situation and could change yearly, depending on agricultural yields and state needs.[115]

Monetization

The extent of monetization of the local economy is obviously a key part of the discussion of economic development, and this is directly related to the military, taxation, and state expenditure. Indeed, huge amounts of coin have been recovered along the Rhine frontier from the earliest phases of Roman occupation onwards.[116] Paying the army was the primary concern of the Roman state, and it did so

[113] This discussion is necessarily short, but related studies are currently underway at Oxford by B. Hellings, J. Mairat, and the latest OXREP project on coin hoards, directed by C. Howgego and A. Wilson. Their work will deal directly with many of the issues discussed here in more detail.
[114] Rüger 2000, 504; France 2001.
[115] Rathbone 1996.
[116] Wigg 1997; Aarts 2000; Howgego 2013.

through the revenue of taxes collected throughout the Empire.[117] This movement of tax revenue formed a key part of Hopkins' taxes and trade model,[118] and while this thesis generally disagrees with his model, collecting taxes and paying troops were key elements of frontier economies. Hopkins thought, however, that frontier zones were generally poorly monetized,[119] a point of view now disproven.[120] Howgego outlined a number of instances in the east (Egypt, Galilee, Judaea) where monetary exchange, not bartering, was the norm,[121] and evidence suggests the same along the Rhine frontier.

The Roman army has been described as "the first and foremost stimulus to monetization,"[122] because of the large amount of coin sent to the frontier zones as troop payment.[123] Soldiers' pay is often seen as the prime vehicle for provincial monetization, as soldiers would have spent their money in local markets for goods and services. Estimations of the yearly expense of the military vary with estimates of 400 million HS per year in the early Empire and 900 million HS in the early third century,[124] but a substantial quantity of the total would have been directed to the Rhine frontier, where roughly one quarter of the early-imperial and one eighth of the mid-imperial army was stationed. With these rough estimates, an annual influx of some 100 million HS to the Rhine frontier gives some idea of how serious this would have been. The subsequent spending of this money in the local economy had significant effects. As will be discussed, evidence from Vindolanda and elsewhere demonstrates that the army regularly paid for goods with coin,[125] and it is through such purchases that coinage entered the regional economy.

[117] See Speidel 1992a on military pay scales.
[118] Hopkins 1980, 112-14.
[119] *Ibid*., 114.
[120] Aarts 2000, Walton 2011.
[121] Howgego 1992, 16-17.
[122] Von Reden 2012, 268.
[123] Wigg 1997; Kemmers 2006; Katsari 2008.
[124] Hopkins 1980, 119; Duncan-Jones 1994, 33-37; Rathbone 1996, 310. Mattingly 2011, 132 observes that the economic achievement involved in financing such an army was not again seen until the early-modern period.
[125] Howgego 1992, 19; Whittaker 2004, 88-114.

Coins were nothing new in the region, having existed since the third century BC; but the Roman period saw changes in scale and usage.[126] As coins were brought into the region by army pay and spending, they quickly spread through all levels of society, as there is no apparent distinction between military, urban, or rural usage.[127] These injections of fresh coin were common in the first century AD, as fort sites with brief habitation periods show little evidence for the circulation of older coinage; instead it seems that new coins were minted to coincide with campaigns, building projects, and the accession of new emperors.[128] This pattern holds until the Flavians, whereafter the circulation of coinage extends, indicating a less-frequent supply of new coins to the region.[129] Wigg has interpreted this pattern as an indication that the civilian demand for coinage had been met by this period, which helped to keep older coins in circulation.[130] Further studies of coin finds from the *Agri Decumates* attest to the long circulation patterns of coins, which remained fairly even on sites after their initial foundation.[131]

The arrival of coinage into the region through military pay and subsequent dissemination into the community through military purchasing created a monetized economy which did not divide between town and country. Bronze was the most common denomination, as it was what was used in day-to-day transactions, leading scholars to argue that prices were low.[132] In fact, small coinage only facilitated purchases of low-value or small quantities of goods, and does not reveal anything directly about prices per se. Aside from prices and the purchasing of commodities, the payment of taxes is most commonly cited as the

---

[126] Iron Age coins remained in use into the Roman period – appearing on military sites until the AD 40s and civilian sites until the Flavian period. See Howgego 2013, 39.
[127] Aarts 2003, 169-70; Kemmers 2004b; Aarts 2005, 6; Kemmers 2006. Coin evidence from the Rhine region directly disputes claims made by *inter alia* Crawford 1970, Hopkins 1980, De Ligt 1990, or Andreau 2000 who each argue that monetization was a "thin veneer" which barely or rarely penetrated the countryside. See also the evidence of coin finds in Britain, substantially augmented by the Portable Antiquities Scheme; Walton 2011.
[128] Wigg 1997, 282-83.
[129] *Ibid*., 283.
[130] *Ibid*., 284. By AD 260, Antonine coins were still in heavy circulation along the Rhine; see Corbier 2005a, 349. The Roman coin hoard project and B. Hellings will clarify regional differences within this pattern.
[131] Kortüm 1998.
[132] Heinrichs 2000; Kemmers 2004b, 42.

dominant usage of coin.[133] Roman taxes could be collected in cash or in kind, and these arrangements could be flexible year-to-year based on needs.[134] The periods of agricultural fecundity discussed below demonstrate that, if required, farmers in the region could have probably produced agricultural products as a tax in kind. This depended on wider climatic and demographic influences, but probably held true into the third century and then again in the fourth. The large urban population which eventually develops in the region, however, could not have easily provided agricultural goods. Therefore, it seems probable that tax could be collected in both cash and kind simultaneously, providing the provincial fiscus with both types of revenue that could then be distributed as necessary.[135] In addition, we must remember the *portoria* collected on trade goods—2.5% within the Gallic provinces and possibly as high as 25% on goods crossing the frontier.[136] Considering the amount of inter-regional trade seen along the Rhine with items like glass, pottery, and millstones, these taxes must have been quite profitable.[137]

Patterns of circulation and use remain fairly steady until the second half of the third century, when continued debasement and political disintegration had a

---

[133] Though see Duncan-Jones 1994 on how taxes-in-kind were more common in the west because of, in his mind, a shorter tradition of coin use. A passage of Tacitus (*Agricola* 19) shows that corn was collected as a tax in Britain in the first century and then sold back to locals at inflated prices, much to their detriment.

[134] Rathbone 1996, 313-14. Along the Rhine we know that the Frisii were taxed for skins and hides (Tacitus *Ann*. 4.72) and that the Batavians provided men for the army (Tacitus *Hist.*5.25). These taxes were evidently not considered an easy burden to bear, as both led to revolts – Florus and Sacrovir in AD 21 began by killing Roman merchants because of taxation (Tacitus *Ann* 3.42), as did the Cananefates at the start of the Batavian revolt in AD 69 – itself caused by the immense burden of military demand on their men. It is possible that other tribal groups/territories were taxed in similar ways to begin with, though we do not know the details. Such situations caused Given (2004, 26) to state that "taxation lies at the heart of the experience of being ruled" across all periods.

[135] See Rathbone 1996, 320-23 on the needs and expenses of provincial fisci. In this context, it is important to remember that the Rhine Basin covered only parts of some provinces, with more than half of Gallia Belgica and a substantial portion of Germania Inferior (mainly the civitas Tungrorum) located outside the river basin. The tax revenues from these areas still contributed to the provincial fiscus, however, and could be redistributed as needed throughout the Rhine region.

[136] Rüger 2000, 504; France 2001. The *quadragesima Galliarum* applied to the zone of the three Gauls, two Germanies, and Raetia, with a toll station located near Pfaffenhoffen in Bavaria. The trans-frontier tax is best attested in the Muziris Papyrus, a document detailing the cargo of a ship trading with India from the Red Sea, where the tax on the cargo was assessed at 25%. There is no indication that this tax was uniform across all borders, but it provides some idea as to the extent of revenue possible.

[137] Discussed further in Chapters 2 and 7.

noticeable effect on the monetary economy in the region.[138] The mints of the Gallic Empire produced higher quality coins than Rome, meaning that they were more consistently hoarded by those concerned for their wealth, which caused problems for circulation and subsequent scholarly interpretation.[139] Mairat has recently shown that under Postumus, the Gallic Empire operated a closed monetary system in which coins from the central Empire barely penetrated until 268.[140] After the re-conquest of the region and the coinage reforms of the Tetrarchs, new coins were brought into the region in more erratic ways, seemingly connected to the campaigns of Julian and Valentinian and indicating a continued link with military payments.[141]

Hoarding became common practice in the late-Roman period, with Aarts noting three distinct periods of intense hoarding in Belgic Gaul and Lower Germany: the last 30 years of the third century, the Valentianic period, and the first 20 years of the fifth century.[142] This activity is clearly linked to political and military crises, but also to changing settlement patterns and the influx of Germanic peoples to the region.[143] Wider trends of population movement, especially the abandonment of the *Agri Decumates*, must have seriously disrupted established patterns of taxation and revenue. The hoarding seen in the later period may well be linked to an increasingly high tax burden on those who were left to pay it, a development that some have used to explain the appearance of the so-called *bacaudae* in the late-Roman west.[144] Aarts has suggested that increased hoarding, particularly in more remote zones of the region, could have seriously disrupted the monetary economy, taking coins out of circulation with little chance for them to be replaced, perhaps best seen in the difference between the Moselle valley where coins continue to circulate in large quantities and the Dutch river area where coins dramatically decrease.[145] Coupled with debased value,

[138] Kropff and van der Vin 2003; Corbier 2005a; Corbier 2005b.
[139] Kropff and van der Vin 2003; Corbier 2005a; Mairat Pers. Comm. 2014.
[140] Mairat Pers. Comm. 2014.
[141] See Kortüm 1998, abb. 4.
[142] Aarts 2000, 196.
[143] Aarts 2000, 196-98.
[144] Drinkwater 1992, 211-14.
[145] Aarts 2000, 223.

counterfeiting,[146] and unstable political infrastructure, the reliability of Roman coinage in this region suffered. Coins continue to appear in late-Roman forts, but their circulation outside these sites and major cities has been called into question.[147] This fracturing of the frontier monetary economy continued until the early fifth century, when it fell apart altogether following the dissolution of the Roman fiscal institution in the Rhine basin.

Factors of economic development

The Rhine region was able to develop a productive agricultural sector over the course of the first century AD, allowing for substantial surplus production. This not only meant the availability of food for the region, but also tax revenue production, which must have been substantial, implying a level of self-sufficiency rarely suggested in scholarship elsewhere. These two points taken together suggest that Hopkins' taxes and trade model does not adequately account for the developmental processes along the Rhine frontier. Developmental factors considered in economic geography include scale and specialization of production, resources, trade, and transport. These must each be considered and their roles assessed. In addition, external and institutional factors must be weighed, two of the most important being the climatic and environmental setting, and the relationships, both good and bad, with neighbouring Germanic peoples.[148]

Climate

Recent work by dendro-climatologists and other paleo-climatologists has been shedding new light on the climate and environment of the Roman world.[149] The study by Büntgen *et al*. in particular has added a large amount of data to the climatic history of the area of central Europe surrounding the Rhine basin. This dendro-chronological study utilized 7,284 samples of oak taken from northeastern France, northeastern Germany, and southeastern Germany to reconstruct spring

---

[146] See Polfer 2001, 33-34.
[147] Aarts 2000.
[148] Drexhage, Konen, Ruffing 2002, 33-35.
[149] Büntgen *et al.,* 2011; Luterbacher *et al.* 2012; McCormick *et al.* 2012; Harris (ed.) 2013.

precipitation and summer temperature variation for the region over the last 2,500 years.[150] The data specifically relating to the Roman period are reproduced here in **fig. 1.3**, where we can see several major trends. First, it is clear that the Roman conquest of the region coincided with a cool, wet period which was then followed by nearly two centuries of warmer (but still fluctuating) temperatures with a fairly steady rainfall. In the third century, rainfall dropped and temperatures took a sudden drop around AD 270. The fourth century was increasingly wetter, with some of the lowest temperatures recorded for antiquity. The authors of this study note that poor climatic conditions coincide with major political, social, and economic upheavals, including the barbarian invasions of Western Europe from the third century onwards and later the Justinianic plague of the mid sixth century.[151]

The implications of this high-precision evidence are still unfolding, but it is clear that climatic change had serious consequences for those who lived through them. For those living within a river system such as the Rhine basin, these changes could have manifested in dramatic ways including floods and droughts which would have had ripple effects on settlement, agriculture, and border security. We will return to these issues throughout the thesis, but Chapter 2 examines the relationship between the fluvial landscape of the Rhine basin and climatic change directly.

Conflict

War came to most provinces in the Roman world, but frontier provinces usually bore the brunt in the Imperial period. While Scheidel has argued that peace was one of the major drivers of Roman economic development,[152] the threat of violence and the periodic outbreaks of conflict along the frontiers cannot be ignored.[153] The Rhine frontier in particular was the scene of many military conflicts over its five centuries of occupation. A timeline of 176 historically

[150] Büntgen *et al.,*2011, 579.
[151] *Ibid*., 580.
[152] Scheidel 2009, 9.
[153] Wheeler 1993b, 219-20 argues that the reductionist and revisionist tendencies of scholars in the late 1980s and 1990s too heavily discounted the actual military reality of frontiers.

attested conflicts is shown in **fig. 1.4**,[154] where military conflicts, including Roman-initiated, German-initiated, and revolts/usurpations, are shown by year. After the initial period of conquest from the mid first century BC into the early first century AD, the next 200 years were mostly peaceful, with the major exception of the Batavian Revolt of AD 69-70. The second half of the third century was beset by revolts and usurpations in the face of German invasions, eventually settled by the time of Diocletian.[155] This peace would not last, however, and German attacks increased from the mid fourth century through to the invasion of 406 which finally severed full Roman control over the Rhine River. Conflicts persisted as Rome tried to regain lost territory, but by the second half of the fifth century, Roman control had ended. A comparison of this timeline with the climatic evidence shown above suggests some correlation between poor (colder, wetter) conditions and increased border conflict.[156] The environmental, political, and military history of the region did not occur independently from economic activity, so we must keep these events in mind when discussing economic development.

Trans-frontier trade and relations

While many regions of the Roman world may have been involved in the production of goods which were later traded outside the Roman Empire, this trade necessarily passed through frontier provinces. Therefore, the agents, products, and taxes involved in this process helped form part of the distinguishing features of Roman frontier economies. The vast quantities of Roman material in temperate

[154] This figure was constructed with an Excel spreadsheet with yearly entries from 100 BC – AD 500, with annual tallies of conflict mentioned in historical sources, coinage issues, inscriptions, and evidence of battlefields and destruction layers. The data accompanying this figure will be provided in some way. See Drinkwater 1983; 1987; 2007 for the history of the region, with reference to primary sources throughout.
[155] The evidence discussed here does not support the revisionist view of the third century that argues against 'crisis.' While regional variation in the extent of trouble in the third century surely existed, the Rhine frontier was certainly troubled, even if the effects of some invasions have been overstated. See Witschel 2004; 2011; Esmonde-Cleary 2013, 30.
[156] Noted, on a more general scale, by Büntgen *et al.* 2011, 579.

Europe are well known,[157] though the actual mechanisms of this trade are poorly understood. Recent work on trade with India via the Red Sea has helped to illuminate the trade which Pliny denounced for its drain on Roman monetary supply,[158] and Mattingly's work in the Fezzan has considerably increased our knowledge of Roman trade with the pre-desert and trans-Saharan regions of Africa.[159] European archaeology has traditionally been heavily focused on distribution maps of finds rather than serious theoretical frameworks for addressing this issue, with some exceptions.[160] *Portoria*, as mentioned above, must have been an important source of revenue along the Rhine frontier,[161] as records from elsewhere in the Empire demonstrate that these taxes could be quite high.[162] Tackling the extent of trade which crossed the Rhine frontier is enough work for a separate undertaking and, therefore, is only briefly discussed in the following analysis. It is hoped, however, that a better understanding of economic activity on the Roman side of the border will create a better basis for future research in German territory.[163]

It is important to consider the scale and volume of material crossing the frontiers. Prior to the Roman conquest, Italian wine arrived into Gaul and the Rhine region in high quantities, crossing the Roman 'frontier' from Gallia Narbonensis into the North. In North Africa, it is clear that bulk goods contained in amphorae regularly crossed the African frontiers,[164] and made their way to India via the Red Sea,[165] yet such finds are relatively rare across the German frontier.[166] High-status goods, such as pottery and metalwork, are much more commonly found in Germania Magna,[167] though this is possibly related to the

---

[157] Eggers 1951. Godlowski 1983. Kunow 1983. as well as the *Corpus der römischen Funde im europäischen Barbaricum* (CRFB) published by the Römisch-Germanische Komission.
[158] Rathbone 2001; Tomber 2008.
[159] Mattingly 2002; 2003; 2006; 2010; Wilson 2012a; Mattingly 2013.
[160] Work beyond distribution maps: Grane 2007; Morris 2011; Wells (ed.) 2013.
[161] Kerr 1989.
[162] Rathbone 2001.
[163] The forthcoming DPhil thesis of B. Hellings will examine the economic development of at least the northern section of the German Barbaricum in comparison with Roman Europe.
[164] *E.g* Wilson 2012a, 417 for more references.
[165] Tomber 2013.
[166] *E.g* Abegg, Walter, and Biegert 2011, 94-95, 215 who report small amounts of amphorae found close to the Roman frontier in Germanic settlements.
[167] *E.g* Eggers 1951, Kunow 1983, papers in Wells 2013.

predominance of gravegoods rather than reported settlement finds. Further work and publication is needed to clarify this picture in order to understand the comparative levels of trade across different frontiers.

Approach and questions

This thesis is arranged over five main chapters which explore endogenous factors of development, including transport, demography, urbanization, resource management, craft production, and trade. The role of the state and military in each of these areas operates as a further theme examined in each chapter. These issues are contextualized within the framework of exogenous factors such as climate and environmental change and warfare.

Chapter 2 investigates how the development of rivers and roads facilitated efficient transportation within the Rhine Basin. How did they connect the Rhine to neighbouring regions? Is there evidence for chronological change in the use or maintenance of either system? How were they inter-related?

Chapter 3 investigates the size and make up of the local population. How many people lived within the Rhine Basin? How was this population divided between urban, rural, and military settlements? What kind of growth was seen over the course of the Roman period within these three types of settlement? When, where, and why did cities develop, and how is urban development connected to frontier fortifications?

Chapter 4 examines the natural resources that were available within the Rhine Basin, and how they were exploited, managed, and utilized by Romans. Where were these resources located within the region? How did these resources shape local economic development, and what other activities did they enable? What was the role of the state in exploiting these resources?

Chapter 5 uses the case studies of pottery and glass production to determine how the availability of natural resources outlined in the previous chapter contributed to the range of craft production within the local economy. How important was the industrial manufacture of goods such as pottery and glass to the regional economy, and how did local production within the Rhine Basin affect neighbouring regions? What does local production tell us about long-distance trade connections?

Chapter 6 uses a database of over 70 amphorae assemblages to discuss the nature of trade and market structure within the region. How important was the military demand for imports relative to that of civilian centres? Are there discernible differences between the imported goods found on civilian sites and those on military sites? Are there chronological changes in trade connections and, if so, why did these occur? Can archaeological evidence clarify the debate over free-market trade and imperial redistribution in frontier zones?

Each of these chapters examines the relationship of soldiers and civilians within these topics in order to better understand what the role of state institutions was within local economic development. Because the military is often seen as the driving force behind frontier economies, it is crucial that this hypothesis be tested here with as much data as possible.

This multi-faceted approach seeks to illuminate the economic development of the Rhine. If we can understand how each of these factors contributed to frontier economic development with a well-studied and quantified dataset along the Rhine, we can move beyond colonialist core-periphery models of frontier economies. Moreover, such an approach also contributes to understanding the nature of regional economies in the Roman world, and the model should also be used to re-appraise Hopkin's three-tiered provincial system of taxes and trade. Regional economies, regardless of whether they were located on the frontier, were subject to many different factors that encouraged or hindered development. Only by understanding these stimuli and reactions can we begin to truly understand the effects of connectivy and economic integration on regional economies, including frontiers, in the Roman world.

2

Transport Infrastructure

Transport infrastructure is a key component of successful economic development, as it connects resources with producers, producers with traders, and traders with consumers, allowing for trade, specialization, and profit.[168] The positioning of inland frontiers across continental Europe required affordable and multi-seasonal alternatives to sea transport. On the Rhine frontier, the pre-existing network of rivers and pathways of the late Iron Age were transformed into major transit routes of the Roman Empire. These riverine and road routes enabled fast and reliable transport and communication between the frontier zone and other regions and, as such, were one of the most important elements of local economic development.

The Rhine River united the settlements within its basin into an integrated system in which movement along waterways was abundant, albeit seasonally. As will be discussed, rivers are only really usable for heavy volumes of traffic in certain seasons when there is no threat of flood, drought, or ice. For this reason, the viability of riverine transport is intrinsically linked to local climate, a topic which will be explored further below. As river basins are by definition closed systems, they are not necessarily the great connective thoroughfares that some have made them out to be. Roads or canals were needed to travel between river systems within Europe, so their development was also critical to maintaining long-distance, extra-regional connections. Therefore, distinctions between 'road' and 'river' transport are blurred as most travel would have been accomplished by both.[169] Instead, rivers, roads, and sea travel should be conceptualized as a single, interconnected network.[170]

In a frontier zone, this system must also support fast and efficient troop movement and military communication. Indeed, many of the routes discussed

[168] Rodrigue *et al.* 2006, 4.
[169] See Campbell 2012, 215-17.
[170] Adams 2012.

below were developed primarily for the purpose of establishing supply lines linking the forts along the Rhine to each other and to the Roman hinterland. The main roads were constructed by the army, while the river was regularly patrolled by the Rhine navy.[171] In the later period, the army was stationed along major routes in order to prevent incursions deep into Gaul.[172] State supervision and maintenance was critical, both for security as well as the collection of *portoria*.[173] The at least periodic necessity to import supplies and food for the military from distant sources further solidified the need for well-maintained transit routes.

As Strabo wrote (*Geo*. 4.1.2), continental Europe is blessed with a plenitude of navigable water ways which are easily linked by short distances over land. This statement is often taken at face value, especially when compared to the modern period where technological advances have drastically improved boat traffic on inland waterways throughout Europe. The invention of the steam and combustion engine made sailing and rowing no longer a necessity for travel. Towing went out of use completely. Our modern conceptions of the utility of river travel are, therefore, quite distant from the realities of river travel in antiquity, where a number of now irrelevant factors influenced riverine transport.

This chapter examines the development of this transport system and its place within the economy of the Rhine Basin. Rivers are examined first, followed by the road network. A series of different types of data are used to investigate chronological changes in these networks, including the climatological data discussed in the Introduction. Additional infrastructure such as canals, dams, bridges, and harbours are discussed throughout in order to demonstrate the advanced level of development and the opportunities it provided.

---

[171] In Britain, Haynes 2000, 112-13 referred to the construction of roads by the military as part of Britain's 'first information revolution.'

[172] Symonds 2008, 208-14.

[173] Epigraphic evidence for *stationes* for the collection of the *quadragesima Galliarum* and the *portus Lirensis* is known from seven locations on the Rhine: Cologne, Bonn, Koblenz, Bingen, Mainz, Altrip, and Ehl (de Laet 1949, 125-73), overseen at least in part by the *beneficiarii consulari* stationed along the Rhine frontier (Ott 1995, 139-40). The exact nature of the *portus lirensis* is debated, but may have been the tax charged for the Rhine, separate from the *quadragesima* at first but later incorporated into the same fee. See Campbell 2012, 286-87 for discussion.

Rivers

Environmental influences

The Rhine was one of the largest and most important rivers in the Roman Empire (**table 2.1**), simultaneously functioning as transport highway, military frontier, and cultural zone. Rivers tend to be taken for granted in classical scholarship, often discussed as historical backdrops but rarely appreciated as agents in the landscape of the Roman world. Rivers are dynamic entities, changing constantly depending on any number of factors in their environment, and these factors must be acknowledged to understand how rivers influenced life along their shores.[174]

Temperature and precipitation are both important influences on the actions of rivers, as both determine the volume of water present within a fluvial system: higher precipitation and lower temperatures cause higher basin discharge, while lower precipitation and higher temperatures cause lower discharge. A temperature increase of 1º C can lower the total volumetric discharge of a river by up to 15%,[175] and will also affect patterns of meandering, making the river wider and shallower.[176] Cooling periods, on the other hand, cause riverine discharge to increase, and cause channels to change from meandering to braiding, making navigation difficult.[177]

Relatively high-resolution records of both precipitation and temperature change over the course of the Roman period are available for the Rhine region (see **fig. 1.3**), and these data demonstrate that riverine change would have been commonplace in antiquity, though this has rarely been appreciated by modern scholars.[178] In particular, the massive increase in precipitation and decrease in temperature from AD 300 would have caused more frequent flooding, higher

---

[174] Franconi 2013, 708-9.
[175] Bravard 2006, 14; Hurkmans *et al.* 2010, 679.
[176] Klostermann 2000, 37-38.
[177] Diodato and Bellochi 2013; Tol and Langen 2000. Low water levels increased risk of running aground, as reported by Tacitus (Hist. 4.26) in the late summer of AD 69.
[178] *Cf.* Shaw 1995; Campbell 2012,12-13

River	Length (km)	Mean Discharge (m³/s)	Basin size (km^2)
Nile	6,650	2,830	3,400,000
Danube	2,860	6,500	817,000
Euphrates	2,780	555*	444,000
Rhine	1,230	2,650	185,000
Loire	1,020	850	117,000
Rhône	810	1,700	95,500
Seine	770	500	78,650
Po	650	1,540	74,000
Guadalquivir	660	229	57,530
Garonne	640	630	55,000
Meuse	920	400	34,500
Maeander	550	35	25,000
Orontes	570	75	34,750
Medjerda	480	32	23,700
Tiber	400	260	17,370
Thames	340	60	12,930

Table 2.1: Fluvial data from rivers within the Roman Empire, sorted by basin size. *Euphrates data only available from Turkish border (80% total flow).[179]

discharge levels, lower winter levels, and increased freezing.[180] These floods may have meant that rivers could no longer be relied upon for shipping, as evidenced in the report of Ammianus Marcellinus (14.10.2) of AD 354 when Constantius was unable to import grain to Germany from Aquitania due to flooding. There are also increased reports of freezing in late antiquity—Ammianus reports the Rhine as frozen in AD 356 (16.1.5), 363 (25.4.13), 367 (27.1.1), and 377 (31.10.4); he also mentions the Maas freezing in AD 357 (17.2.3). The increase in extreme variation in seasonal activity made human use of the rivers increasingly difficult.

[179] Sources: Shahin 2002; Zahar, Ghorbel, and Albergel 2008; Tockner, Uehlinger, and Robinson 2009.
[180] See Suetonius, *Dom*. 6.2, for the thwarting of a Germanic attack across the frozen river in AD 89.

Several other pieces of supporting evidence for these changes are outlined below, and similar evidence for fluvial change can be found throughout the Rhône basin in France.[181]

The Rhine and its tributaries

River	Length (km)	Mean Discharge (m^3/s)	Basin size (km^2)
Rhine	1,230	2,650	185,000
Moselle	540	315	28,290
Main	530	225	27,290
Neckar	370	145	13,900
Aare	290	560	17,620
Lahn	245	50	5,925
Lippe	220	45	4,780
Ruhr	220	75	4,485
Ill	215	50	4,760
Sieg	155	50	2,860
Nahe	125	30	4,065
Wupper	115	15	815
Erft	105	25	1,835

Table 2.2: Fluvial data for the Rhine and its tributaries, sorted by length.[182]

The Rhine River is 1,230 km long, draining a basin encompassing an area of more than 185,000 km^2 (**fig. 2.2**), discharging an average of 2,650 m^3/s into the North Sea. Of the rivers of the Roman Empire, the Rhine ranks fourth in both discharge and basin size behind the Danube, Nile, and Euphrates (**table 2.1**). The Rhine is fed by the main tributaries of the Neckar, Main, Lahn, Sieg, Wupper, Ruhr, and Lippe on its right bank, and the Aare, Ill, Nahe, Moselle and Erft on the left (**figs. 2.2-3**, **table 2.2**). The river's seasonal flow regime from four hydrological monitoring stations is shown in **figure 2.4**, and the flow regimes of its main

[181] Franconi 2013, 710-11.
[182] Belz, ed., 2007.

tributaries are shown in **figure 2.5**, with the monitoring stations labeled in **figure 2.1**. These figures demonstrate the differentiated nature of the river and its tributaries throughout the region, discussed further below.

At its Alpine source, the Rhine is actually two rivers—the Vorder- and Hinterrhein, rising from the Tomasee and Paradies Glacier respectively—which then join together at Reichenau**,** Switzerland, 15 km upstream from the city of Chur, to form the Alpenrhine. From Chur, the Rhine flows 86 km to enter Lake Konstanz near Bregenz, Austria. Over the course of this relatively short journey, the elevation of the river drops some 200 m, giving it a relatively steep slope. The river then flows another 43 km through the lake, emerging again at Konstanz, where it briefly exists as the Seerhein before entering the Untersee and then reforming as a river at Stein am Rhein, where it then flows westward as the High Rhine.

About 45 km downstream from Konstanz, the High Rhine flows over the Rheinfall, a 23 m high waterfall, the tallest in Europe. From this point on, the river becomes navigable. Another 40 km downstream at Koblenz (CH) the Rhine is joined by the River Aare, the largest tributary in Switzerland, which delivers the highest volume of water of the tributaries in the basin. The Aare is the largest contributor of water to the Rhine, adding an average of 560 m^3 /s, draining the north side of the Swiss Alps and the Swiss Plateau, stretching from Lake Zurich to Lake Neuchatel in the west. At the confluence, the Aare delivers an average of 23% higher discharge than the High Rhine.[183] The river cuts through a wide valley which divides the Jura Mountains of Baselland from the Alps, creating a convenient corridor linking the upper Rhine to the Alpine passes as well as the Rhône River via Lake Geneva.

The flow regimes of both the High Rhine and the Aare River are heavily dependent on Alpine snow melt. At Rheinfelden, near Augst, the Rhine's highest flows begin in May and run through September before falling to their lowest in winter.[184] The average discharge of the river at this point is 1,113 m^3/s, though this can vary substantially depending on climatic conditions both locally and in

[183] Uehlinger *et al*. 2009, 219.
[184] Wickert 1903, 9.

the Alps, with record floods surpassing 6,000 m^3/s .[185] The low volume of water in this stretch of river also leaves it prone to freezing, as demonstrated by Ammianus above.[186]

From Basel, the Rhine turns north and flows through the Upper Rhine Graben, part of the European Cenozoic rift system, for 258 km to Mannheim.[187] The Upper Rhine flows through a wide alluvial plain, bounded by the Vosges Mountains of France to the west and the hills of the Black Forest and Odenwald of Germany to the east. Within this rift, the river is able to meander across the flood plain, resulting in numerous oxbow lakes and old channel remnants. The wide flood plain functioned as a soak-away zone for floods caused by high levels of spring Alpine melt, and generally protected downstream stretches from floodwaters.[188] The flood activity of this zone is well recorded in the excavations conducted at Oedenburg, France, where four substantial floods are recorded between AD 20 and AD 145, probably leading to the site's virtual abandonment until the fourth century.[189] Until the early 20th century, Basel to Strasbourg was one of the most hazardous stretches as it had rapids along a relatively steep slope.[190] Canalization in the nineteenth and twentieth centuries has made this stretch more easily navigable, but also substantially reduced the Upper Rhine's ability to protect against flooding downstream.[191] The Ill River, which drains most of Alsace east of the Vosges, joins at Strasbourg, contributing water at an average of 54 m^3 /s. The Neckar joins from the east at Mannheim, draining the Black Forest and parts of the Schwabian Alb. This fourth largest tributary adds an average of 145 m^3 /s. At Mainz, 135 km north, the third largest tributary, the

[185] Wetter *et al*. 2013 for records of extreme flood activity in the Basel area since the 13th century.
[186] See page 35 above.
[187] Ziegler 1994, 100.
[188] Cioc 2002, 35.
[189] Ollive *et al.* 2006, 37; Ollive *et al.* 2008, 651-52. Floods continued into the fourth century and later, and re-settlement was limited to the fortification of the site under Valentinian. A substantial rise in the water table is evident in the fourth c. AD.
[190] Wickert 1903, 16 writes that even in the late nineteenth century only small boats (ca. 50 tons) were able to navigate the stretch of the river above Ottenheim, while up until Ottenheim ships of 120 tons could still navigate the channel. Moreover, larger crews are necessary for this stretch, either as rowers or towers, as it was impossible to pass this stretch against the current without substantial help.
[191] Cioc 2002, 35-36.

Main, enters from the east, contributing an average of 145 m^3 /s. The discharge levels at Mainz are significantly higher than those at Rheinfelden, with an average rate of 1,736 m^3 /s. The seasonal regime of the river no longer depends on Alpine snow melt; instead winter rains from the Black Forest and the Vosges contribute to higher water levels in spring and autumn.

Below Mainz, the Middle Rhine enters the hilly region of the Rhenish Massif, a geological formation which includes the Ardennes of Belgium and France, the Eifel, and the Hunsrück west of the Rhine, as well as the Siegerland, Sauerland, Westerwald, and the Taunus mountains to the east. Within this stretch, the Rhine is confined to its narrow, rock-cut course. At Bingen, 30 km below Mainz, the Nahe River enters from the south, and the "Romantic Rhine" begins, cutting past the Lorelei rock and the numerous medieval castles established to enforce taxation on the river between Bingen and Koblenz. At Lahnstein, 5 km before Koblenz, the Lahn River enters from the east. Both the Main and the Lahn drain the Rhenish Massif east of the Rhine, with the Lahn reaching the Taunus and the Main reaching beyond these into the Wetterau and Thuringia. The Moselle River enters the Rhine from the west at Koblenz, originating 544 km to the south from the western slopes of the Vosges, joined by the Saur and Saar just upstream of Trier, and eventually discharging an average volume of 315 m^3 /s. The Middle Rhine flows onwards to Bonn where the Sieg enters from the east.

From Bonn onwards, the landscape enters the Lower Rhine Basin of the Roer Valley Graben, part of the same rift as the Upper Rhine Graben, where the river is once again able to meander. The Rhine flows northwest, joined progressively from the west by the Erft at Neuss and then from the east by the Wupper above Cologne, the Ruhr at Duisburg, and the Lippe at Xanten. The seasonal flow regime is similar to Mainz, but with higher volumes. The spring peak is more evident, with additional peaks in summer and fall. The average discharge at Cologne measures 2,287 m^3/s. The later months of the year see a higher flow rate than anywhere else yet seen on the river, corresponding to fall and winter rainfall in the more northerly latitudes of Germany.[192]

[192] Grabs, ed., 1997, 14.

The Lower Rhine, like the Upper Rhine, is prone to channel movement due to various environmental factors. Gerlach has shown that a combination of deforestation and bank erosion in the Roman period led to a high level of sediment in the lower reaches of the river.[193] Increased sediment loads change a river's flow patterns from meandering to bifurcating because of the buildup of sand bars along its course, resulting in a shallow, multi-armed, complex river course.[194] Constant dredging is needed to maintain channels, without which the bifurcations can become very dangerous for ships. The bifurcations of the lower Rhine eventually led to Xanten being cut off from the Rhine in the third century,[195] and doubtlessly affected other nearby settlements. With the end of the Roman period, decreased settlement density and higher precipitation patterns cleared out much of the sedimentation and allowed the river to return to meanders. One of these meanders destroyed the Roman fortress of Vetera II near Xanten in the fifteenth century.[196] From Xanten, the river begins a turn to the west, crossing the Dutch border just west of Emmerich, 164 km downstream from Cologne. The seasonal flow regime at this point is similar to that of Cologne, with a slight volumetric change—the average discharge at the Dutch border measures 2,453 m^3 /s, or roughly 93% of the total water volume of the river.

The Lower Rhine enters its delta zone across the Dutch border, and the river is soon split between three channels leading to the sea: the Waal River takes approximately 65% of the flow, while the Lek takes 23%, and the Ijssel the remaining 12%.[197] The current situation is the result of centuries of damming, diking, and canal cutting that have seriously altered the course of this section of the river since Roman times.[198] Archaeological and geological work allows the Roman delta to be reconstructed rather differently than the modern river courses.[199] The Roman Rhine split at Rijnwaarden, with the Nederrijn connecting

---

[193] Gerlach 1995, 100.
[194] *Ibid*.
[195] Klostermann 2008, 27-30.
[196] Schmitz 2009.
[197] Uehlinger *et al*. 2009, 220.
[198] Mostly begun in the 10th century in order to reclaim land for agricultural use in response to growing settlement. Henderikx 1986, 447.
[199] Henderikx 1986.

north to the Kromme Rijn and then to the Oude Rijn, emptying into the sea at modern Katwijk. This course can be seen in the positioning of Roman forts along the old river course, stretching from Rijnwaarden to Katwijk. A distributary of the Rhine, the Vecht, split off to the north at Utrecht to end in the Zuidersee. The Oude Ijssel was probably first connected to the Rhine in the early Roman period by the construction of the *Fossa Drusiana* by Drusus *ca*. 12 BC (discussed below),[200] though this branch is no longer connected to the Rhine today. To the south, the Waal flowed into the Maas, taking a southerly course via the Oude Maas to connect to the North Sea at modern Rotterdam. The courses of these rivers changed quite regularly, often to the detriment of settlement. The effects of tides on the river vary with the season; in times of low flow rates from the Rhine, the tidal zone can extend up the river for over 100 km,[201] almost to Nijmegen. At times of higher fluvial discharge, the force of the river stream pushes the tidal zone further down the river towards the sea.[202] The nature of the delta meant that sediment deposition was constantly changing the landscape and course of river flow, and by AD 1000, the Rhine delta was completely different from that of the Roman period.[203]

Riverine Technology

Canals

While the effects of modern canalization on the basin have been noted, there are several Roman-era canals along the Rhine which deserve mention (**see fig. 2.5**). Canals were cut in many river networks across the Roman Empire, with examples known from the Rhône, Tiber, Po, Nile, and Danube.[204] Canals served a number of different purposes. They could bypass hazardous stretches of rivers, as Trajan's canal through the Iron Gates on the Danube, or, more often, they provided alternative routes through river deltas which were theoretically more stable than

[200] Huisman 1995, 189.
[201] Van den Berg *et al*. 2007, 289.
[202] *Ibid*, 288-9.
[203] Henderikx 1986, map 2.
[204] Šašel 1973; Laurence 1999, 114; Wikander 2000, 328-30; Adams 2007, 21-22; Grewe 2008, 334-36; Harris 2011, 195-6.

the natural channels which were prone to sedimentation and movement. The relatively flat nature of river deltas also allowed for easier engineering solutions than dealing with rugged topography. Lacking the technology of pound locks, Roman canals were not able to traverse significant changes in elevation. Canals could also be cut parallel to the shore to allow for safer and easier navigation than sailing along the coast would allow.[205]

The earliest canal cut along the Rhine was the *fossa Drusiana,* constructed by Drusus in 12 BC to assist his campaigns north of the Rhine delta. This canal is mentioned by both Suetonius (*Claudius*, 2) and Tacitus (*Ann.* 2.8), though no archaeological traces remain today. The ancient authors differ on their details; Suetonius refers to canal*s*, while Tacitus refers to a single canal, leading to debate over the number of canals Drusus originally constructed.[206] Moreover, there is debate over another structure apparently built by Drusus, the *moles* mentioned by Tactitus (*Hist.* 5.19). This structure, perhaps best translated as "dyke" in this context, seems to have been a dam built at the bifurcation of the Nederrijn and the Waal rivers near Rijnwaarden in order to divert a larger volume of water north along the course of the Nederrijn.[207] The *moles* apparently controlled so much water that when Civilis destroyed it in AD 69, it caused significant flood damage to the region.[208] While the locations of the Drusan canals are uncertain, it seems that the most plausible candidate for the original course of the *fossa Drusiana* would have been between the Rhine and the Ijssel at Westervoort, creating a direct river route between the Rhine and the Zuidersee. [209]

This project either went unfinished or was renovated in AD 51, as Tacitus (*Ann.* 13.53) records that Paulinus Pompeius completed the works begun by Drusus 63 years earlier. Civilis destroyed this dam in AD 69 (Tacitus, *Hist*. 5.19.3) in an attempt to thwart his Roman pursuers. The dam was apparently not rebuilt, as Ausonius does not mention these constructions when he writes of the

[205] Laurence 1999, 114-19.
[206] Huisman 1995; Wells 1972, 115-6.
[207] Wells 1972, 112.
[208] Tacitus *Hist.* 5.19.
[209] Grewe 2008, 335.

"*geminis ripis*" which stretch to the North Sea,[210] implying that the Ijssel was no longer connected to the Nijderrijn at this time.

Under Claudius, a second canal, the *fossa Corbulonis*, was built by the general Corbulo (**see fig. 2.5**), which connected the Niderrijn to the Maas River.[211] Tacitus (*Ann.* 11.20) mentions this work as part of the withdrawal of Corbulo's forces from enemy territory in AD 47. The path of the canal started at Leiden on the Oude Rijn, heading south to Voorburg (Forum Hadriani) and then connecting with the Maas delta at Naaldwijk some 34 km further on, utilizing natural channels when possible to minimize labour.[212] Cassius Dio (*Hist* XL.30.6) states that this canal acted as a flood control, meant to protect against high tides causing either river to flood, while Tacitus (*Ann.* 11.20.3) states that it provided a safer path of travel than sailing the coast.

Excavations have revealed the general shape and design of the canal. [213] The channel measured approximately 12-15 m wide and about 1.4 m deep, with slightly-sloped banks and some indications for a towpath along the west bank. Furthermore, there is evidence of at least two dams or locks which would have forced portage.[214] These installations, whatever their exact nature, would have helped balance water levels between the Rhine and Maas. It seems that one of these obstructions broke, and may have contributed to the siltation and eventual abandonment of the canal.[215] Siltation broke the link between the Maas and Rhine by the middle of the second century,[216] though dendro-chronological dates taken from the docks at Voorburg show that the city was still at least connected to the Maas delta in the beginning of the third century.[217]

In AD 55, an ambitious canal project was reportedly begun by Lucius Vetus, co-commander with Paulinus Pompeius of the German armies, to connect

[210] Ausonius, *Mosella*, 432.
[211] Hettema 1951, 242-57; Kort and Raczynski-Henk 2014, 59-60, recent work suggests that an earlier canal of Caligula may have been replaced by Corbulo's, though this is unclear.
[212] Kort and Raczynski-Henk 2014, 65.
[213] *Ibid*., 61.
[214] *Ibid*., 63.
[215] *Ibid*.
[216] Buijtendorp 2010, 145 suggests that the Roman city of Forum Hadriani was "het oudste voorbeeld van de strijd van een stad tegen het water" which later determined much of the settlement of the Medieval Netherlands. Kort and Raczynski-Henk 2014, 60-61.
[217] Buijtendorpp 2010, 145.

the Saône to the Moselle. Had this canal been completed, it would have opened a continuous river route from the Mediterranean to the North Sea, following the route of the Rhône, Saône, Moselle, and Rhine rivers. This canal was never finished, as Tacitus (*Ann*. 13.53) reports that the then governor of Gallia Belgica, Aelius Gracilis, put an end to the project, possibly out of jealousy.

Harbours

Multiple harbour installations have been excavated along the Rhine, giving some insight as to how the docking, loading, and unloading process would have transpired. At Xanten, a wooden pier was found projecting into the old Rhine bed perpendicular to the shore and city walls (**fig**. **2.6**).[218] Wooden shoring was also found along the river front, indicating that the bank had been reinforced to protect against erosion.[219] Shallow draught boats would have probably been able to dock against this as well. While probably only a small piece of the installation which once lined the front of the town, it would have been easiest for boats to moor directly to the end of the pier due to the river current. This implies that other piers must have existed as well so that multiple boats could dock simultaneously, but they have not yet been found. The harbour of Cologne was situated in the narrow channel between the eastern wall of the city and the long, narrow island which once existed in the Rhine; the channel between them is now silted up (**fig**. **2.7**).[220] Excavations in this area revealed a wooden mole structure very similar to that seen at Xanten, allowing ships to dock in this channel and transfer goods either into the city or the *horrea* which were built upon the isle.[221] Scant remains of a boat were found during the excavations of the harbour, though not enough to reconstruct it. Judging by the L-shaped side board, it was a flat bottomed barge similar to those discussed below.[222] This channel silted up during the second century, and was further obscured by the construction of the Constantinian bridge

[218] Leih 2008.
[219] *Ibid*., 464-66.
[220] Neu 1985.
[221] *Ibid*., 155.
[222] *Ibid*., 152-3.

linking the city with the fortification of Deutz on the opposite shore. The harbour of this period must have moved to the banks of what was once the island.

At Mainz, a series of harbour installations have been found along the left bank of the Rhine, two directly in front of the city *am Brand* and *am Kappelhof*, one just north of the Roman settlement *am Dimesser Ort*, and a fourth south of the city at Mainz-Weisenau (**fig**. **2.8**).[223] Several military ships, discussed below, were recovered from the harbours *am Brand* and *am Kappelhof*, suggesting a naval harbour in the fourth century.[224] Remains of wooden piers have been found in the *am Brand* harbour.[225] Wooden posts were found at the Dimesser site in the nineteenth century, though these went undocumented and were destroyed by the construction of the modern harbour, and wooden shoring was found at the Kappelhof site.[226]

Several military harbours have also been excavated. At Velsen, a fort in the Rhine delta occupied from roughly AD 15-28, the harbour was defined by two outer moles which extended from a central, flat quay (**fig**. **2.9**).[227] Boats could dock against this platform and unload their goods there rather than approaching the shore.[228] Velsen, being located in an inlet off the North Sea, could have been supplied by sea-going vessels. The warships, on the other hand, were kept in ship sheds on shore. Evidence for dredging has also been found, indicating that the draught of ships entering this harbour was a concern. Ship sheds were also built at Haltern during the Drusan offensive under Augustus, but supply vessels probably beached on the shore alongside the Uferkastel at Hofestatt, where a fortified landing spot has been found (**fig**. **2.10**).[229] The naval base of the *Classis Germanicae* at Cologne-Alteburg has so far not produced much evidence for the arrangement of the actual riverside, though some substantial docking facilities must have existed, along with ship sheds (**fig**. **2.11**).[230] A similar arrangement to

[223] Höckmann 1986.
[224] *Ibid*., 372.
[225] *Ibid*., 372-73.
[226] *Ibid*,, 376-77.
[227] Morel 1986, 200.
[228] *Ibid*., 207-8.
[229] *Ibid*., 239-40.
[230] Höckmann 1998, 318-20.

that of Haltern can be seen at the fourth-century fortified *Burgus* at Ladenburg on the Neckar River, where the walls of the fort were built right out into the river, providing a safe landing zone for supply ships (**fig. 2.12**).[231] The use of beaches to land boats of this period suggests that these forts continued to be supplied by flat-bottomed barges, and the fortification of these sites gives insight into the dangerous realities of late Roman ship transport on the Rhine.

Several sites in the southern parts of the Rhine basin were situated on or near lakes. Avenches was located on a hill 1 km south of Lake Murten (**fig. 2.13**), but as the lake was directly connected to the Aare River it provided a good point for a harbour, despite the distance from the city proper. The distance was evidently not an issue, as both a road and a canal connected Avenches to its port.[232] The structures found on the lakeside—including a wooden pier—were dated to ca. AD 5 by dendrochronology, and a nearby building was dated to the second half of the second century AD.[233] The wooden lining of the canal also dates to this period, with dendro-chronological dates of AD 146, with repairs evident in 157 and 168.[234] Storage of goods was apparently entirely within the city walls, as no storehouses were found along the lakeside.

Major cities like Cologne and Trier are known to have had large store buildings in close proximity to their waterfronts, undoubtedly for building up winter stores of goods. Other, smaller sites also had various store buildings, a good example being the late-Roman warehouse on the High Rhine at Rheinfelden-Ausgarten.[235]

Ships

A total of 39 ships have been excavated throughout the basin (**fig. 2.14**), most from the Rhine delta, where sedimentation has aided the preservation of the wood. Several types of ships have been found, the most numerous being barges, of which

[231] Heukemes 1981; Höckmann 1986, 402.
[232] Bonnet 1982, 127.
[233] *Ibid*.
[234] *Ibid*, 129.
[235] Asal 2005.

19 are known (**appendix 2.1; fig. 2.15**).[236] These boats were generally long and flat-bottomed with low sides, ideal for carrying bulk cargoes and navigating shallow rivers. Military boats, distinguished by their banks of oars, have also been found at Mainz, Vechten, and Woerden, seven in total.[237] The others are mainly the so-called *Einbäumer*, or dugout log canoes. Iconographic evidence, common on stone monuments throughout the region, shows a number of other boat types in use on the Rhine, and probably shows the wider range of possibilities in existence for shipping. Comparisons between the two data sets—iconographic and archaeological—have already been done, and do not need to be repeated here.[238]

The barges are the most relevant to matters of transportation, particularly their cargo capacities and propulsion methods. Bockius has graphed the capacities and draughts of the barges which could be fully reconstructed, showing that while they were vaguely similar, the boats were certainly not standardized.[239] The barges' lengths ranged from 6.5 m (Wantzenau, FR) to as much as 40 m (Mainz K1, Kapel Avazaath), with widths of 2.3-5 m.[240] The load-capacities of some of these barges can be estimated; the Mainz K1, for instance, had an estimated full load capability of some 85 tons, while the Zwammerdam 4 is estimated to have carried up to 110 tons.[241] The Woerden 1 was slightly smaller, with a capacity of ca. 65 tons.[242] The draughts at these capacities were very low, with the empty draught of the Mainz K1 estimated at less than 10 cm, and only ca. 50 cm with a full load.[243]

The propulsion of these barges is a topic of some debate. Until recently, it was thought that many of these boats were used only for one-way journeys downstream—purpose-built for a single trip and then scrapped at the end.[244] The barges were thought too simple to be intended to make return journeys upstream, and therefore they were just disposed of as "packaging" for their cargo. While

[236] Bockius 2000.
[237] Muller 1895; Bockius 2006; 2002a; 2002b.
[238] Ellmers 1969; Höckmann 1986; Höckmann 1998; Bockius 2000.
[239] Bockius 2000, 480.
[240] Bockius 2000, 445-6; Vos *et al*. 2011, 104-5.
[241] Bockius 2000, 482.
[242] *Ibid*., 480.
[243] *Ibid*.
[244] Vos *et al*. 2011, 111-12.

most of the remains indicate that the boats were mainly propelled by a sail (demonstrated by preserved mast blocks) it would have been very difficult for these ships to move against the current by sail alone.[245] The recent find of the Woerden 7 ship, however, has significantly challenged this idea, as it is clear that this barge had oars and rowing benches as well as a sailing mast.[246] Since recognizing these elements in the better preserved Woerden 7 barge, the same pieces have now also been recognized on the earlier excavated Zwammerdam 6 wreck.[247] Moreover, the uni-directional conclusion only works for those boats found in the Netherlands, and does not explain the rather different situation of barges evidently used on lakes, such as the Yverdon A found in Lake Neuchatel in Switzerland. This particular boat must have either been self-propelled by oars or was towed by another oared ship to carry cargo across the lake. Punting around the edges of the lake was also an option, albeit a slow one, but the lake is too deep to cross in this manner. Futhermore, the Wantzenau ship, found near the confluence of the Ill and Rhine Rivers, carried a cargo of lava quern stones far upstream from the Eifel region.[248]

It is clear from the remains of these barges that they could be sailed and some, at least, could be rowed. Punting and towing were also options, both best known from iconographic depictions rather than archaeological remains.[249] To date, no boats with surviving towing masts have been recovered in the Rhine basin, though stone reliefs show how they were used (**fig. 2.16**). It is possible that sail masts could double for towing masts. Towing deserves further discussion here, as it is a clear indication that these barges were quite capable of transport in both directions on a river. To tow a boat, two things are required. The first is a stable, well-maintained tow path along the river bank. Little evidence exists for these outside pictorial representations, as any movement of the river in the last two millennia would have eroded away the path.

[245] Bockius 2000, 456.
[246] Vos *et al*. 2011, 111-12.
[247] *Ibid*., 112.
[248] Ellmers 1969, 92-5.
[249] Ellmers 1979, 10-11.

The second requirement is the power to tow–usually animals or men along the shore. Figures from the nineteenth century suggest that a single horse was capable of towing a barge of up to fifteen tonnes, while seven or eight men would be required to tow the same weight.[250] Estimates place the towing capability of oxen at approximately 38 tonnes for four pair, 95 tonnes for five, and 140 tonnes for six, though these are inconsistent.[251] The towing capability of a human was much lower than that of beast, though it was evidently often sufficient. In the ninth century, Wandalbert von Prüm records an instance in the *Vita et Miracula Sanctis Goaris* of a Frisian merchant who was towed up the Rhine by his slaves: [252]

> Negotiator ex supradicta Fresonum gente nauem per Rhenum flumen agebat et, *ut moris est, quia aduerso flumine nauigabat*, fune a suis nauem circa litus trahendam curauerat.
>
> "A merchant from the above-mentioned Frisian tribe led his ship up the Rhine and, *as is customary when navigating upstream*, he left it to his slaves pulling the ship by rope from the shore (emphasis added)."

This was apparently common enough to state it as the norm when traveling upstream, and is in line with the Roman reliefs which depict the same action.

Towing masts are shown on a number of reliefs, and the reliefs from the Igel Column on the Moselle, Avignon on the Rhône, and the statue of the Tiber from Rome which is now in the Louvre show boats actively being towed by manpower (**fig. 2.17**).[253] The Igel Column base (**fig. 2.18**) and the Avignon relief (**fig. 2.19**) show at least two towers, though a third is implied judging from the number of ropes, while the Tiber relief shows three. Ellmers takes his argument so far as to say that only human power was ever used along the Rhine,[254] but it is possible that animals were used in the Roman period as they were in more recent periods and elsewhere in the Roman Empire.[255] That all three reliefs are in agreement on this may be evidence of artistic trope, but since they line up well

[250] Böcking 1980, 30.
[251] Casson 1965, 39; DeLaine 1997, 108-9.
[252] McCormick 2001, 654 n.64; *Vita et Miracula Sanctis Goaris* 29.2.
[253] Casson 1965, Pl. II.
[254] Ellmers 1979, 10.
[255] *E.g* Strachan 1972, 85.

with the Frisians mentioned at St. Goar, it may be that three men were able to tow a common small-sized boat. Judging from the estimated tonnages of the wrecks, however, most Roman boats probably had to have more than three men towing them.

The Road Network

The nature of a river basin dictates that it exists in isolation from those river basins adjacent; while they may only be separated by a narrow ridge, they are still geologically and hydrologically distinct. While Strabo suggests it was the rivers of Gaul which made transport easy, this is an oversimplification. A river network may provide good (seasonal) connectivity within a basin, but it does not provide connections to adjacent basins or regions. In order to travel between these regions, overland movement was necessary, and it is therefore the network of Roman roads which truly facilitated travel across Roman Europe.[256]

In most cases, the routes of these roads are only generally known (**fig. 2.20**),[257] based on the combined evidence of excavations, milestones, itineraries, written sources, and the Peutinger Table. The various rivers combined with the new Roman roads led to the development of a cohesive network of transport routes throughout the region. Since the shortest path between two points was rarely the winding course of a river, roads enabled more direct routes, though this was sometimes over difficult terrain.

While roads could closely follow rivers, as they did along the Rhine or the Moselle, they also cut across broad swaths of land not reachable by waterways. The Pfalz region, located between the Rhine and the Moselle, was one such region where, excepting the short Nahe in the north, no waterways enabled crossing. Likewise, the southern Eifel, occupying the triangle of land between the Moselle, Rhine, and Maas, was largely dependent upon roads. In some special cases, as in the case of the Alps and other rough terrain, the course of a road can be better

[256] Quilici 2009; Raepsaet 2009; Hitchner 2012.
[257] For the Rhine basin, see Hagen 1931. More generally, the Barrington Atlas (Talbert 2000) is the most comprehensive map of Roman roads.

ascertained, as a specific course had to be taken through mountain passes or specific valleys.

Major routes

The road network of the Rhine basin was composed of a handful of main roads with many branching secondary routes (**fig. 2.20**). The major roads of this network were built during Agrippa's governorships of Gaul from 39/38 BC and again in 20/19 BC.[258] The strong military presence in the region meant that direct routes had to be available for fast and efficient movement. The establishment of forts along the Rhine between the years 16-13 BC required direct routes between them, as well as direct supply routes from Gaul. It was due to this military need that most of the road network initially developed, and it has been argued that the eventual annexation of the *Agri Decumates* under the Flavians was partly aimed at creating a more direct route between Mainz and Regensburg.[259]

The farthest reaching road of these projects was that which linked Marseilles to Cologne, following the river valleys of the Rhone and Saône north before reaching Langres and then traveling along the Moselle valley as far as Trier, where it then split off to the north across the southern Eifel to Cologne. This road, some 1,170 km long, was the most direct route from the Mediterranean to the Rhine. Every major city that it passed through was a hub of other road connections. Langres, located between the headwaters of the Saône, Moselle, Maas, and Seine, was connected laterally to Besançon and Reims. Metz, some 150 km beyond, had connections east to Strasbourg through the Vosges via the Col de Saverne, and to Worms and Mainz via the Kaiserslauterner Senke, as well as a road heading west to Reims. Trier was connected to Mainz and Koblenz, across the Hünsruck and through the Moselle valley respectively. The road to Cologne split off to the north of Trier, cutting across the Eifel to meet the Rhine road south of Cologne.

[258] Hagen 1931, II.
[259] Schönberger 1969, 156.

The Rhine road was the most important road within the basin, connecting Voorburg in the north to Augst 865 km to the south. This road was critical to the Augustan period establishment of permanent military bases along the Rhine at Mainz, Neuss, Xanten and Nijmegen, amongst others, in the second decade BC under Drusus.[260]

A third major road, the so-called *Via Belgica* led west out of Cologne to Tongeren and eventually reached the English Channel at Boulogne-sur-mer, some 450 km later. This road was another Augustan establishment, and was later fortified to protect against Germanic raids into Gallia Belgica.[261]

In the south, the Alpine passes offered few routes between Italy and the Rhine basin. Roads passed through the mountains via the St. Bernard pass from Aosta, and the Splügen and Julier passes from Milan. The road from Aosta led first to Lake Geneva, and then headed north to Avenches, Solothurn, and Windisch. From the Splügen and Julier passes, the route led along the river valley of the Hinterrhein, passing through Chur to Bregenz, before heading west to Konstanz and Windisch. From Windisch, these southern routes could connect to the Rhine road, and head north via Augst. The small number of possible routes out of the Alps led to traffic being funnelled through very specific cities on the northern edge. Geneva, Nyon, Avenches, Windisch, and Augst greatly benefited from their location along these roadways, and it is precisely their location along these routes which explains why these cities were so successful throughout the Roman period.

When the Flavians advanced the Roman border across the Rhine new roads were built which provided easier connections between the Rhine bases and those on the Danube. River crossings were established at Zurzach, Augst, Strasbourg, Karlsruhe, and Mainz, with others possibly located at Speyer and Worms.[262] A new road was built along the right bank of the Rhine, running from Mainz-Kastell to Augst, about 290 km long. The topography of the Black Forest

[260] *Ibid*, 144. Hagen 1931, III.
[261] Symonds 2008.
[262] An important crossing point since the Iron Age, first controlled by the legionary fortress at Dangstetten and then abandoned following AD 9 (Wells 1972, 42) and re-opened following the Flavian conquest (Nuber 2005, 414).

and Odenwald meant that only a few routes could support heavy traffic heading east. These roads led east from Strasbourg along the Kinzig valley (*Kinzigtalstrasse*) and from Karlsruhe through the Kraichgau and into the Enz valley (*Rhein-Neckar-Donaustrasse*), crossing the Neckar River at Rottweil and Stuttgart respectively before connecting with the long road which ran along the southern bank of the Danube. From Strasbourg, this route to the Danube measured about 110 km, and from Karlsruhe about 170 km. These routes meant that towns like Heidelberg, Stuttgart, Rottenburg, and Rottweil were able to develop as critical crossing points when heading east or west. Another road, running north-south, ran from Windisch (*Neckar-Alb-Donaustrasse*), crossing the Rhine at Zurzach and joining the Neckar at Rottweil, whence it followed the river north to Wimpfen before splitting off and heading north towards Nida on the Main River.[263]

Milestones

A total of 68 milestones are known from the Rhine Basin (see **fig. 2.20-21**).[264] Twenty-two emperors are named on the stones, providing accurate dates between the reigns of Vespasian and Licinius. The peak in milestone erection came under Septimius Severus, probably in conjunction with a wider building programme along the *Limes Germanicus*.[265] Another group was set up in the middle of the third century, between Philip I and Postumus (AD 244-268), and the motivations of towns proclaiming loyalty to the emperor(s) during times of political unrest cannot be underestimated.[266] Sauer has recently suggested that milestones dating between the Severans and Diocletian in the Northwest provinces were completely politically motivated and were not related to building activity at all.[267] That said, it seems that the third century was a time when much road repair was underway, notably clustered between Strasbourg and Cologne, possibly in an effort to

[263] Nuber 2005, 414.
[264] Collected from the Epigraphik-Datenbank Clauss Slaby. Raetia is included here for comparison with Germania Superior.
[265] Discussed further in Chapter 4.
[266] Dey 2012, 301-2.
[267] Sauer (forthcoming) 2014, 15.

maintain critical routes between the legionary fortresses in Strasbourg, Mainz, and Bonn. The final cluster came between Carus and Licinius (282-308), roughly coinciding with the Tetrarchic overhaul of many fortifications along the Rhine and the movement of the imperial capital to Trier. After this period, few stones are preserved which shed further light on roads in the region.

It is difficult to link these stones with any specific building activity, especially as only one stone within the Rhine basin actually records repair of roads.[268] This is in contrast to Raetia, where eighteen stones record repair of roads and bridges, many of them Severan. Moreover, milestones do not corroborate road work that is otherwise archaeologically evident within the Rhine basin, as in the Trajanic repairs to the *via militaria* in the Netherlands (discussed below in chapter 4), or bridge construction/repair (discussed in the next section).

Accepting that many of these milestones may not actually demonstrate road repairs, it is difficult to understand their place within transport infrastructure as anything more than monuments. However, it is worth considering the wider context of transport in the third century. Even if many of these stones were erected as acts of loyalty to the emperor, some may well also commemorate unnamed road repair, as one explanation does not necessarily preclude the other. It is possible that increased precipitation washed out and damaged roads, thereby disrupting supply and communication routes and requiring intervention. It is also possible that increased precipitation made rivers increasingly erratic and inconvenient for transport, necessitating better maintenance of overland routes. These explanations are not mutually exclusive and are obviously largely speculative, but we will see below that other evidence suggests a change in long-distance connections over the course of this century,[269] so it is important to keep in mind.

---

[268] *CIL* 17.2, 548 from Niederimmel, near Trier records the repair of old bridges and roads by Caracalla.
[269] Discussed further in Chapter 6.

Bridges

Bridges were an obvious necessity in a fluvial landscape, but their locations and chronologies reveal certain aspects of regional infrastructure. There has, in the past, been some debate over the nature of rivers as frontiers,[270] part of which was centred on the Roman attitude towards building bridges over river frontiers. Rankov argued that Romans did not maintain bridges across frontiers except for invasions throughout the Principate,[271] but the Rhine suggests otherwise (**fig. 2.22**). The remains of at least six bridges across the Rhine are known from Cologne,[272] Koblenz,[273] Mainz,[274] Kembs,[275] Augst,[276] Bad Zurzach,[277] and Eschenz,[278] with others mentioned in literature at Xanten in AD 15 by Tacitus (*Ann* 1.69)[279] and at Bonn under Drusus by Florus (4.12.26).[280]

These early bridges mentioned in the literature may have existed only briefly, much like Caesar's bridge near Andernach in 55 and 53 BC, related to campaigns in Germany. The earliest archaeological evidence for a permanent bridge comes from Mainz, where preserved timbers date the earliest known bridge to ca. AD 27.[281] The first, "upper," bridge at Augst was possibly built around this time.[282] In the middle of the first century AD, subsequent bridge building at Koblenz (AD 49)[283] and Eschenz (AD 50)[284] enabled crossings on the Middle and High Rhine. The second bridge at Augst, linking the city first with the Insel Gwerd and then the opposite bank of the Rhine, was probably built ca. AD 70.[285]

---

[270] *E.g* Rankov 2006; Campbell 2012.
[271] Rankov 2006, 178.
[272] Eck 2004, 605-08.
[273] Fehr 1981.
[274] Mikler 1998/89; Bauer 2004.
[275] Hatt 1952.
[276] Drack and Fellmann 1988, 323-26.
[277] *Ibid*., 575-78.
[278] Bengueral 2011, 88-92.
[279] Rankov 2003, 178 cites this example as being related to Augustan campaigns in Germany, and assumes it was destroyed afterwards.
[280] Rösger and Will 1985.
[281] Bauer 2004.
[282] Salathe *et al*. 2007, 60.
[283] Fehr 1981.
[284] Bengureal 2011.
[285] Salathe *et al*. 2007, 62.

These bridges were each critical for the eventual expansion across the river, enabling both easy troop movement but also subsequent routes for travelers and traders. With five road routes across the river, the dividing effects of the Rhine decreased. It is notable that no bridge remains have been found within the Upper Rhine flood plain area, which may well be because seasonal flooding and changes in the river bed, like those seen at Oedenburg/Biesheim in Alsace, made bridging impossible. In these cases, ferries would have been far easier. These trans-river connections were critical to maintaining Roman life in the *Agri Decumates* until AD 260. There was little need for bridges below Koblenz as, after AD 9, the Romans had no real reason to cross the river in this area.

In later history, bridge heads became critical elements of frontier fortification on the Rhine. After the Romans withdrew from the *Agri Decumates,* they maintained fortified positions at Mainz-Kastel and Grenzach, opposite Mainz and Kaiseraugst respectively. New bridges with fortified bridgeheads were built at Cologne under Constantine and Zurzach under Valentinian. These, alongside fortified landing positions on the opposite bank allowed for easy Roman access across the river, but restricted German access.

In addition to the large bridges across the Rhine, the regional infrastructure included bridges across all of the major and minor tributaries of the system, with notable examples across the Moselle at Trier (first wooden bridge in 17 BC, subsequent stone bridge in AD 45) and Koblenz (AD 131), across the Nahe at Bingen (AD 70), across the Main at Gustavsburg (AD 163-164) and Großkrotzenburg (AD 100), across the Neckar at Heidelberg (AD 70), Riedstadt-Goddelau (AD 142), and probably also at Wimpfen, Walheim, Pforzheim, and Rottweil.[286]

Bridges formed the interface between road and river, enabling easier, safer crossing than fording or ferrying. The initial and periodic usefulness of these structures for the military must be seen alongside the civilian possibilities—easier crossing meant reduced transport costs for trade goods. One only has to remember the experience of the Allied forces in World War II who, after waiting for months

[286] See plans in Planck 2005.

for the Rhine to subside, finally bridged the river in March of 1945.[287] Without these bridges, the allies could not have invaded Germany.[288] The situation was the same 1900 years earlier—the Romans could not have held the river frontier without controlling all manner of access.

Transport Costs

The ability to move goods cheaply and quickly from point A to point B is the end goal of all economic infrastructures. If the costs are too high, however, they will hinder any economic development. As such, transport costs are a significant factor in determining the economic viability of incorporating new regions into markets and supply chains.[289]

It is common to discuss transport costs in the Roman world in three different categories: maritime, riverine, and overland, though often trips involved two or all of these options. The copy of Diocletian's Edict of Maximum Prices of AD 301 found at Aphrodisias records values for each sort of transport, and these have been much discussed.[290] The resulting relative cost index between them, estimated to be approximately 1:5:10:34-42, shows the supposed differences in transport costs.[291] DeLaine converted these figures into actual cost of one tonne/ mile to 1.2 *denarii* by sea, 5.9 *denarii* down river, 12 *denarii* up river, and 52 *denarii* by ox-cart.[292]

This evidence cannot be taken too far outside its original context; it is debatable whether or not these figures are applicable to the rest of the Empire or earlier periods.[293] As Arnaud has noted, these rates differ in how they are computed; land transport is measured in weight and distance, river transport with

---

[287] Atkinson 2013, 420-24.
[288] Allied engineers referred to crossing the river as "a short sea voyage," Atkinson 2013, 420.
[289] Rodrigue *et al*. 2006, 45; Combes *et al*. 2008, 44, 81.
[290] Roueche 1989; DeLaine 1992; Laurence 1999; Arnaud 2007; Russell 2008. This version of the Price Edict was not yet known to Duncan-Jones in 1982, and therefore his figures on river trade had to be inferred based on much earlier papyrological evidence from AD 42 (Duncan-Jones 1982, 368). The basis for the comparability of this evidence, more than 250 years apart, is limited.
[291] *Ibid*, with slight recalculation.
[292] *Ibid*, 208.
[293] Arnaud 2007, 321.

volume, distance, and direction of stream flow, and sea transport with volume, with specific costs for each route taken.[294]

There are problems with taking this information at face value. The Edict is, of course, a maximum price list, so lower prices are possible. Removing the evidence of Diocletian's Price Edict from its particular geographic context is dangerous, as we have no evidence for its applicability to the western Empire. More important, however, is the disconnect between the Edict and the realities of transportation and the complications that could arise in calculating costs. Bureaucratic ideals aside, a number of additional factors influenced not only the cost but also the timeliness and efficiency of transport in the Roman world.

First, we must consider seasonality. The changes in river conditions outlined above make it clear that riverine transport was not possible at all times of the year, and even fairly recently the Rhine had only a narrow window of ideal shipping conditions.[295] The Nile offers a more extreme example, where annual floods made river travel off limits for the summer months.[296] In these situations, the cost of road transport relative to river transport was less important than the fact that it was the only mode possible, and we must remember that this would have been a common situation throughout most of the year.

Second, actual transport costs must factor in transaction costs.[297] These include the costs covered by merchants and those covered by customers. Aside from necessary investments in boats, wagons, and equipment, we must also factor in the cost of feeding the animals or slaves which pulled them. Since long-distance river travel often required passing between river basins, the cost of portage and transshipment must also be factored in. Any travel along the Rhine or, later, the Main or Neckar may also have required the cost of hired security to protect from Germanic raids.

---

[294] *Ibid*, 325. For the costs of specific sea routes see 336.
[295] Wickert 1903.
[296] Cooper 2011, 195-96; Adams 2007, 18.
[297] Scheidel 2011, 23; Wilson 2011a, 232; Scheidel (34-35) also concludes that the Edict cannot be interpreted as valid representations of real costs. Moreover, as both of these discussions focus on the Mediterranean, it may well be that predation costs were much higher on any frontier, where cross-border banditry, raids, and war could seriously inhibit riverine transport.

If information regarding the costs of transport is flawed, how then are we supposed to estimate the importance of efficient transport systems in economic development? The issue of transport speed may be a useful indicator and, probably, the second most important factor of transport behind cost. Speed is easier to discuss as it derived from technology rather than social norms, and particular insight is offered through the travel accounts of later authors.

Transport Speeds

The differences in speed between sea, river, and road transport depend on a number of factors.[298] River travel is affected by mode of propulsion, whether by sail, oars, poling, or towing as well as the speed of current and the volume of water through which the boat is trying to move. In addition, wind gusts could help or hinder, and daily travel was regulated by daylight hours as it was unsafe to travel by river after dark. Travel upstream was obviously more difficult than downstream, but this could vary by degrees based upon these factors. Historical comparisons, discussed below, indicate that an oared boat could travel upwards of 100 km a day, while a boat sailing with the current could still manage 60-70.[299] Towing against the current was much slower, with speeds ranging from 5-15 km a day,[300] depending on season and the method of tow, as discussed further below.

The speed and efficiency of road transport, whether by foot or animal, has been well covered by several recent works which outline the efficiency of the Roman road network and reject the notion that overland transit was prohibitively expensive.[301] Still, the cost and efficiency of overland travel depended on the season and the quality of road. Heavy rains could wash out roads, mountain passes could be blocked by snow, and ice could make travel dangerous. The terrain

---

[298] The ORBIS project of Stanford University (www.orbis.stanford.edu) has created an online resource for calculating travel routes, speeds, and costs in the Empire. The resource is not as complete as one may hope (it does not, for instance, include the entirety of the road linking Arles and Trier, making calculations of this important route impossible with this tool), but it is still a useful tool for discussing these issues.
[299] Scheidel, Meeks, and Weiland 2012, 23-24.
[300] *Ibid*.
[301] Raepsaet 2009; Hitchner 2012.

traveled, animal used, and type of cart or wagon were all important factors.[302] Overland travel speed could vary immensely depending on mode of transport; a person walking can cover 30 km a day, while an ox-pulled cart averages only 12 km a day.[303]

The question of riverine travel speed in the Roman period is hindered by a lack of original accounts in historical sources. Ausonius, our most detailed Roman-era source, did not indicate how long it takes for him to go between Koblenz and Trier on the Moselle.[304] More recent literature provides better detail, particularly two early-modern travel journals, one written by Antonio de Beatis,[305] companion to Cardinal Luigi d'Aragona on his journey through Europe in 1517, and another by Thomas Coryate,[306] the famed Oxonian traveller who walked from London to Venice and back in 1606.

To make the most of travelling times, planning routes in accordance with seasons must have been extremely important.[307] It is notable that both de Beatis and Coryate travelled downstream through the region in summer when water levels and currents would have been most manageable, and daylight would have been the longest. De Beatis embarked from Konstanz on June 7th, and departed Cologne on June 29th.[308] Coryate passed through slightly later, embarking from Zurich on August 17th, and departing Cologne on September 19th.[309] De Beatis travelled between Konstanz and Basel by road, and Coryate too arrived at Basel by foot, not boat.[310] Both travellers opted for travel by river boat from Basel to Strasbourg. De Beatis left Basel at sunrise on June 14th and arrived in Strasbourg at sunset,[311] and he estimated the journey at 20 German miles, or 154 km in about 14 hours.[312] He then traveled to Mainz by road via Speyer and Worms, before

[302] Raepsaet 2009.
[303] *Ibid*., 20.
[304] ORBIS calculates the journey at 182 km, taking about 12 days by towed boat.
[305] Hale 1979.
[306] Coryate 1905.
[307] *E.g* McCormick 2001, 80.
[308] Hale 1979, 188: one German mile was equal to 7.72 km.
[309] Strachan 1972.
[310] Probably because of the obstacle of the Rheinfall at Schaffhausen.
[311] Sunrise on June 14th is typically around 5:30 and sunset at 21:32, totalling 16 hours of daylight.
[312] Meander-cutting has since shortened this distance to about 137 km, close to Coryate's estimation of 80 miles or 128 km.

again boarding a boat to head down river. He boarded a ship in Mainz on the morning of June 27th, arriving in St. Goar in the evening, a journey of about 56 km, but through a number of toll stations, slowing his trip. On the 29th he left Bonn by boat, arriving in Cologne for lunch, 33 km further on. De Beatis then left the Rhine and headed west, overland. His journey by boat on the Rhine totalled about 250 km in roughly 2.5 days.

About a century later, Thomas Coryate travelled from Basel to Strasbourg, 80 English miles by his estimation, in a day and a half by boat, leaving Basel at 6 am on September 1st and arriving in Strasbourg at noon on the 2nd.[313] He then walked to Mainz via Heidelberg, Speyer, and Worms, where he then took a boat to Frankfurt at 7 am on the morning of September 13th, traveling twelve miles upstream before disembarking four miles before the city, walking the last stretch and arriving at 5 pm. The next day, interestingly, he walked back to Mainz, leaving at 10 am and arriving at 6 pm, making as good time by land as he did by river going upstream. On the morning of September 17th, he again boarded a boat at Mainz set for Cologne, a journey of 78 English miles accomplished in two and a half days, stopping in Boppard and Oberwinter, but also being held up at the eleven toll stations between Bingen and Bonn. On September 22nd he departed Cologne, and eventually making his way to Flushing, Zealand on September 29th, stopping in Rees, Nijmegen, Dordrecht, and Walcheren along the way. The Rhine proved to be too dangerous for travel on September 23rd, and Coryate was stranded in Rees for another day. On October first he left Flushing at 4 pm, arriving in London on October 3rd, exactly two days later. Overall, Coryate sailed or rowed 317 English miles down the Rhine, with a 12-mile trip up the Main and a 120-mile crossing of the Channel.

These two travel accounts provide some insight into mobility on the Rhine, and while both men travelled long after the Roman period, their routes and itineraries are easily mapped onto the Roman Rhine. As both of these travellers made their journeys through the region largely by river boat, one must expect that the trips were planned to coincide with the period when the flow rates made the

---

[313] Coryate 1905, 440ff. Sunrise on September 1st is typically at 6:45 and sunset at 20:11, totalling 13.5 hours of daylight.

Rhine most navigable. It is also noteworthy that, excepting Coryate's short trip to Frankfurt, no attempt was made to sail against the flow of the river by either traveller, who in both cases chose other routes south before utilizing the Rhine as an easy way north. It is clear from their stories that it was very easy to connect between the different cities along the river by boat, a journey which would have been even easier in the Roman period because of the lack of toll castles between Bingen and Bonn. From these accounts, we can see that journeys of 100 km per day were easily accomplished downstream, allowing downstream travel from Basel to the Dutch border, an overall trip of about 700 km, in just seven days.

Coryate's 12 mile trip from Mainz to Frankfurt in 10 hours demonstrates that it was a much slower trip upstream, taking as long to row against the current as it did to walk back the next day. In the summer of 1794, Ann Radcliffe made this same trip in nine hours, despite the apparently calm state of the Main.[314] This short trip, however, is not enough to argue substantially for the situation on the Rhine. McCormick, citing Ellmers, estimates as much as 11 weeks to travel from Rotterdam to Strasbourg against the current, a journey of about 750 km.[315] Ann Radcliffe recorded that the currents between Bonn and Mainz were so strong that a loaded vessel could often only be towed six miles a day, and that while the journey from Mainz to Cologne could be accomplished in two days, the journey from Cologne to Mainz took a fortnight or more.[316] Frederick Leopold Count Stolberg traveled between Düsseldorf and Frankfurt am Main in August of 1791, mostly by foot but partially by oared boat. The boat ride between Remagen and Andernach, a journey of about 20 km upstream, was accomplished in an afternoon, though high winds slowed their journey: "As the wind was against us, we were obliged to traverse the river, from shore to shore, till we came to Andernach."[317] Rowing a small boat of passengers, however, was far easier than moving a loaded cargo barge and the slower speeds of towing would have applied. For comparison, Coryate, boarding a boat at Gorinchem in the Netherlands, wrote:

[314] Radcliffe 1795, 392.
[315] McCormick 2001, 654.
[316] Radcliffe 1795, 267.
[317] Stolberg 1797, 31.

> All passengers which descend do pay but a small price for their passage; but…all that ascend doe strive very painfully against the streame. So that all their vessels are drawen by horses with great might and maine. For this cause all passengers that ascend into the higher parts of Germany doe pay much more for their carriage.[318]

Ausonius, writing some 1100 years earlier, similarly described the differences between downstream and upstream travel on the Moselle:

> For thee two modes of voyaging are appointed: this, when boats move down thy stream with current favouring and their oars thrash the churned waters at full speed; that, when along the banks, with tow-rope never slackening, the boatmen strain on their shoulders hawsers bound to the masts.[319]

These accounts closely resemble the iconographic and archaeological evidence otherwise known in abundance from the region for towing. The two authors differ, however, between the means of towing—men in Ausonius' account and horses in Coryate's.

Downstream travel was capable of up to 100 km a day if there were no hindrances, while speeds of 7-10 km/day against the current were possible by towing,[320] and could be much slower in worse weather.[321] Speed up river would clearly depend upon the means of propelling the boat—towing being much slower than rowing—but given the evidence of the shipwrecks so far recovered along the river ways of continental Europe, it appears that cargo ships were rarely rowed. These speeds are clearly widely divergent, and could have been exacerbated by weather and hydrological conditions.

We must also remember that a single wagon could not carry anything near the load that a barge could, and multiple wagons would be needed if the cargo of a full barge was to be unloaded and moved overland.[322] A barge such as the

---

318 Strachan 1972, 90.
319 Ausonius, *Mosella,* 39-42.
320 De Izarra 1993, 166 cites nineteenth century figures of canal transport where boats of 80-100 t could be towed 14 km a day by men, double that if towed by horses.
321 Russell 2008, 114 notes that travel up the Rhône could vary from one month in summer to two in the winter.
322 Raepsaet 2009 states that carts of ten tons or more were possible.

Zwammerdamm 4, with its estimated capacity of 110 tons,[323] would require something like ten carts to transfer its full cargo load overland. Transfers such as these would have added time to transport, and would have been required when passing between river basins during long-distance transport voyages.

Trade Routes

As many frontiers were often the farthest spots from seaports, the maintenance of long-distance, inland trading routes was critical for trade, supply, and communication. For the Rhine frontier, the most important route to the Mediterranean was via the Rhône-Saône-Moselle corridor, linking the cities of Trier, Metz, Langres, Lyon, and Arles along one of the major *viae Agrippae* through Gaul.[324] This route allowed for both fast overland communication as well as the transportation of bulk cargoes via river with a short overland portage between the Saône and Moselle rivers. Alternatively, one could travel east from Lyon to Lake Geneva and across the Swiss Plateau to the High Rhine near Augst, or east from Chalon-sur-Saône via the Doubs River to the Upper Rhine near Kembs. The choice of route depended upon the traveller's final destination, but each provided relatively easy connection between the Rhine and the Mediterranean.

These corridors were used extensively (Chapter 7 discusses bulk trade along these routes), each developing well-used infrastructural installations to improve efficiency and time. The above-discussed issues of seasonality in transport make it clear, though, that all routes were not created equal. Routes that depended upon riverine transport could prove difficult at the wrong time of year, so it was always necessary to have alternatives in place.

[323] Bockius 2000, 482.
[324] The Atlantic and North Sea undoubtedly provided additional seaborne trade routes, not only locally but also from the Mediterranean, as discussed by Carreras & Morais 2010; Carreras 2010; Morris 2010.

Journey	Mode	Upstream (km)	Downstream (km)	Road (km)	Duration (days)
Arles-Cologne	Road	0	0	1,000	83
Arles-Cologne	Road/River	590	600	30	71
Augst-Cologne	Road	0	0	500	42
Augst-Cologne	River	0	533	0	8
Cologne-Augst	Road	0	0	500	42
Cologne-Augst	River	533	0	0	53

Table 2.3: Journey times by road and river

The main corridor linking Arles and the Rhine along the Rhône-Saône-Moselle corridor offers a prime case study. Arles, situated near the mouth of the Rhône in southern Gaul, was described as "the port of Trier" in the *Expositio Totius Mundi et Gentium* (58), and Ausonius (*Ordo* 10) described how Arles accumulated the wealth of the Roman world and distributed it throughout Gaul. The importance of the linkage of this city to the Rhine cannot be overstated. Many of the milestones discussed above were found along this route, indicating continued work to keep the roads open, as well as the fact that traffic along this route was so great that it was a prime location to build monuments.

Travel between Arles and the Rhine was a long journey, roughly 1,000 km in total to the city of Cologne. This trip could be accomplished solely by road, or a combination of river and road travel (**table 2.3**).[325] For a lone traveller, overland travel would be cheaper and faster, and a steady walker could make the journey in about a month's time, skipping the long upstream journey on the Rhône. Cargo, however, would be better served by the river routes which offered easier bulk transport. The 500 km upstream journey from Arles to a portage point on the Saône would have been slow, taking roughly 50 days to accomplish, followed by an overland portage of roughly 30 km to the Moselle. Depending on the size of the cargo, this portage could have required a substantial wagon team which, if

[325] The following computations use the speeds suggested by Scheidel, Meeks, and Weiland 2012 for different sorts of travel – 12 km/day for an ox-cart, 30 km/day for a person walking, 10 km/day for a boat towed upstream, 65 km/ day for a boat downstream.

poorly organized, would have drawn out the process. Once on the Moselle, a downstream journey past Trier to Koblenz, and then down the Rhine to Cologne could have been accomplished with minimal effort, completed in under three weeks. In total, the journey by boat would have taken about 70 days by rough estimation, compared to about 80 days by road-travel alone.

For the sake of comparison, we can also discuss a hypothetical journey solely along the Rhine, between Cologne and Augst (**table 2.3**), located roughly 500 km apart. A journey downstream from Augst took only 8 days, while a trip upstream could take as much as 53! The journey overland was the same each way, taking about 42 days by ox cart.

For the shipment of cargo, neither option was a small undertaking: shipping required investment in a boat, crew, and towing team with potential days lost to inclement weather or poor river conditions, overland travel required more carts or wagons plus the animals to pull them and their feed. Long-distance transport, therefore, required substantial investment and organization. Transporters not only had to deal with the technological aspects of their job, but also the environmental conditions which helped or hindered their movement. Considering the variable nature of rivers and their proclivity for change, any alteration to their flow regime or seasonal activity may have seriously disrupted established transportation schedules. The instance of Constantius being unable to ship grain to his troops along the Rhine in AD 364 is a case in point—Ammianus (14.10.2) records that the rivers in between were too flooded to allow transport. The alternative option of road transport was more costly and more complicated, but was, at least hypothetically, always available.

Traders and Transporters

The high level of organization required to maintain and traverse these trade routes led to the organisation of dedicated transport corporations across Gaul who, evidence suggests, handled most if not all aspects of transportation between the Mediterranean and northern Europe. These groups divided across the different regions and rivers of Gaul, suggesting a high level of organization and specialization which paralleled organizations in cities like Ostia and elsewhere in the Mediterranean for maritime transport.[326] As these groups are well known, what follows is only a brief overview.

Many rivers of Gaul seem to have been controlled by groups of *nautae*, with specific corporations known for the Rhône and Saône, Moselle, Aare, Ouvéze, Ardèche, Durance, and Loire rivers. Groups are also known from Lake Geneva, Lausanne, Paris, and Vechten (**fig. 2.23**).[327] The fact that these groups are repeatedly mentioned in epigraphic sources suggests that their influence and control of these trade routes was widespread. The *nautae* doubtless handled the organisation of shipping along their designated rivers, ensuring the safe transport of goods guaranteed by societal pressures of reputation. Their existence within the transport network probably also meant that they were closely involved with the Roman state and the management of the *cursus publicus* through state contractors.[328]

The details of how these shippers operated remain largely unknown. Nor is it fully understood why no *corpus nautarum Rhenorum* is known, despite the appearance of *nautae* at Mainz, Ettlingen, Marbach am Neckar, and Vechten.[329] It is possible that the *classis Germanica* had something more to do with managing transport along the river frontier, but we do not know. Otherwise, whether or not these institutions existed as monopolies is also unknown, though evidence of competitors is non-existant.[330] It seems probable, therefore, that these groups oversaw riverine transport in Gaul, establishing themselves as the go-to groups when a merchant or the state needed to send cargo along a certain riverway. Their firsthand knowledge and experience of the rivers would have helped ensure swift and safe delivery of cargo.

---

[326] Rice 2012; Terpstra 2013, with review by Rice forthcoming a; Rice forthcoming b. Particularly worth noting are the *negotiatores transalpini et cisalpini* who specialized in trans-Alpine trade, known from a series of inscriptions in northern Italy and Switzerland.

[327] Schmidts 2011, 28-29.

[328] Kolb 2000; Kolb 2002; though Schmidts 2011, 118-22 emphasizes that these were civilian groups who operated with a market economy, not solely state contracts.

[329] Schmidts 2011, 14.

[330] It is unclear what role *negotiatores* or other merchants played within this system. It seems probable that the *nautae* handled contracts, while individuals could still move their own goods.

On the other end of the system, similar specialization is evident in merchants who traded across the Channel with Britain.[331] Inscriptions of *negotiatores* who explicitly traded with Britain are known in Cologne, Domburg, Colijnsplaat, and Bordeaux.[332] Sailing across the channel would have required different skills and different vessels than navigating only on the rivers, so specialization in this route is unsurprising. Specialization is evident in the goods traded: allec, pottery, salt, and wine are all mentioned on altars recovered from the sites.[333]

Merchants are very commonly attested elsewhere along the Rhine frontier,[334] and Verboven has argued that the Rhine garrisons attracted their commerce and created a locally-significant 'business class.'[335] The Rhine armies were undoubtedly good for business, as he argues, but their existence alone does not explain why 30% of all inscriptions naming *negotiatores* are found along the Rhine.[336] A local appreciation for the public advertisement of one's business success seems a more probable explanation; otherwise we should expect all frontiers to have produced a similar number of inscriptions. A recent interpretation by Schmidts suggests that rather than the army, it was the cities of the region that attracted and promoted such high levels of merchant activity.[337] Whatever the reason for their high visibility, *negotiatores* operated within a system that must have been heavily influenced and impacted by the business of the *nautae*.

In pre-modern societies lacking in developed-communications, many business ventures rested on reputation alone.[338] These corporations put a name to transport and added a human element to the transport infrastructure within the Rhine basin and across Gaul. By handling the logistics of movement through the rivers and roads of Gaul and Germany, these transporters helped promote

---

331 Stuart and Bogaers 2001; Morris 2010, 109-10.
332 Schmidts 2011, 96-97.
333 Morris 2010, 109-10.
334 Schlippschuh 1974; Verboven 2007; Schmidts 2011.
335 Verboven 2007, 313.
336 On the distribution of negotiatores in the Empire see Verboven 2007, 299; Rice 2012, 114.
337 Schmidts 2011, 121-22. See discussion below in ch. 3 for urban and military population sizes.
338 Terpstra 2013.

economic development on both the Rhine frontier and within the Mediterranean zone.

Conclusions and Summary

Well-functioning transport infrastructure was a critical element in the establishment and maintenance of Roman hegemony along the Rhine frontier. Through a combination of rivers and roads, the Rhine basin connected with the neighbouring regions of Gaul, Italy, Raetia, and (across the Channel) Britain. These two systems of transport were inextricably intertwined—the division of “road” and “river” transport is an artificial construct of scholarship.

This chapter has demonstrated that there was much more to transport than simply solid roads and flowing streams—canals, harbours, and bridges were critical elements imposed on the landscape to enable easier movement. The interfaces of rivers and roads at bridge-crossings or harbour towns were perhaps the most critical nodal points in this system, allowing transfer options and the development of specialist groups of shippers and haulers. This institutional side of transport—seen in both state intervention in infrastructure and the development of *corpora* and *collegia* of transporters—added a further, human element of infrastructure to the system

The transport system was not impervious to the elements. This chapter explored the various climatic factors that affected seasonal and inter-annual variation in river flows and shed some light on the longue-durée changes that influenced the activity of the Rhine and its tributaries. A climatic downturn in the third century occurred alongside increased road repairs, perhaps coincidentally, but the riverine evidence suggests increasingly difficult transport situations due to changing river conditions in later antiquity. The road network, therefore, became increasingly more important, especially as the political and military security of the frontier collapsed and fast troop movements became more commonplace.

The relatively short window of ideal shipping conditions in the late summer and early autumn emphasized the annual necessity of overland-options. Because of these factors, issues of transport cost were evaluated and, largely, dismissed. Instead, it was argued that transport times, best demonstrated through comparative studies with other periods, were a deciding factor in the route taken. If a critical cargo could move substantially faster overland than it could by waterway, the importance of cost was reduced. This was especially true with upstream movement, where overland hauling was an easier alternative to upstream towing, especially in dangerous stretches of the river like those near the St. Goar on the Middle Rhine or south of Strasbourg on the Upper Rhine. This system functioned ably throughout the Roman period and, indeed, well beyond. Many of the stone bridges throughout the region remained in use well after the Roman era, as did their connecting roads.

3

Military and Civilian Settlement and Population

In order to understand the size of the human element of the regional economy, it is necessary to study both the civilian and military populations of the Rhine in comparison. The presence of the Roman military is one of the defining characteristics of the Rhine region which helped set it apart from other regions of Gaul. Understanding the relationship between the two groups is essential to understanding the overall direction of development in the region.

The Roman Empire was a world of cities,[339] as commonly stated, and these settlements played an important part in economic activity. The role of cities in the Roman economy has long been a topic of discussion.[340] Recently, the role of urbanism and urban populations in economic activity has been re-emphasized,[341] and while this discussion continues, some pertinent points can be made. As cities were centres of population which did not focus entirely on agricultural production, they demonstrate a level of progress beyond subsistence. Because they did not focus on agriculture, those living within cities often focused on other economic activities—craft production, manufacturing, construction, and other services.[342] Therefore, the growth of urban populations has been suggested as a proxy measure for the growth of both agricultural and non-agricultural production.[343] Simply put, growth of urban populations requires substantial economic development to be supported. The temporal fluctuation of this population can, therefore, be used as a base measure to which we may compare other economic developments to determine the effects of demographic change.

---

[339] Ward-Perkins 1974, 8; Finley 1977, 305.
[340] From a long list, consider Finley 1973 compared to Bowman and Wilson 2011.
[341] Scheidel 2007; Bowman and Wilson 2011; Holleran and Pudsey 2011.
[342] Hitchner 2005, 216-17.
[343] Lo Cascio 2009; Morley 2011; Wilson 2011b.

The sites considered in this chapter span the full range of settlements in the region,[344] from the colonies of Trier and Cologne, to the *civitas* capitals of Nida or Worms, to the *vici* of Bern or Rheinzabern, and the *canabae* of Bonn and Neuss. This cross-section is intentional but also simply follows the availability of evidence. Most of the small settlements surrounding auxiliary forts are not considered, however, as excavation is rarely so complete as to offer sure estimates of their size. The existence of these small centres needs to be remembered, though they cannot be easily accounted for here.

As settlements are administratively linked to provincial hierarchies, we must note that this chapter will only deal with those located in the Rhine basin (**fig. 3.1**), and not the entirety of Germania Inferior, Superior, and Gallia Belgica. It is difficult to separate fully the cities of the Rhine basin from those of the surrounding territory. The province of Germania Inferior is basically split in half between the Rhine and Maas basins, while roughly a third of Gallia Belgica is within the Rhine basin. The justification for this division falls upon the river network; as discussed in the last chapter, the Rhine basin united settlements in a way that roads did not equally do. It is important to note that urbanism was only a feature of the Roman territory of the Rhine basin; cities did not develop in German territory during the period under investigation here.[345]

This chapter is arranged in two sections, the first covering the period from the Roman conquest to the middle of the third century and the second to the beginning of the fifth century. The first examines the development of civilian administrative centres, the size of these centres, and the hypothetical size of the population living in them. The military is also considered, examining the size and distribution of the garrison through time. The second section considers developments in Late Antiquity where changing socio-political circumstances affected these populations. By examining these issues over the long term, we can understand how changes in urbanism and demography both affect and reflect wider economic developments.

[344] See Wilson 2011b for the debatable definitions of a "city."
[345] Drinkwater 2007, 82 ff.

Urban and administrative development to AD 260

Prior to the Roman conquest, the Rhine region was a "world of villages."[346] Beloch estimated that eastern Gaul had a population of some 1.25 million at the time of Caesar,[347] but few of these lived in any sort of urban setting. The Roman conquest brought urbanism, though not initially through any cohesive plan.[348]

Most of the early settlements along the Rhine were military in nature; the first civilian settlement founded in the basin was the colony at Augst in 44 BC, and others would not develop until nearly 30 years later. Tradition holds that Agrippa settled the Germanic tribe of the Ubii at Cologne in 38 BC to fill the depopulated area of the Eburones,[349] though the earliest archaeological remains at Cologne do not date until AD 4/5.[350] Early civilian settlement is assumed at Trier from the time of Caesar onwards, though only a military camp dating from ca. 30 BC has so far been securely dated.[351] Major sites along the Rhine were established during the preparation for Drusus' campaigns in 14-12 BC, including Nijmegen, Xanten, Neuss, Bonn, Mainz, Strasbourg, Basel, and Windisch (**fig. 3.2**). These military sites became permanent and encouraged the development of nearby civilian populations over the next century. Forts were also positioned across the Rhine, along the Lippe and Main Rivers, and also in the south at Dangstetten. The first town across the Rhine was founded at Waldgirmes ca. 4 BC, but was only briefly inhabited until AD 9.[352]

Under Augustus, the first *civitates,* administrative districts governed by capital cities that functioned as legislative and juridical centres outside the

---

[346] Woolf 1998, 111.
[347] Beloch 1899, 438. *Cf.* Beloch 1886, 507 where he estimates that eastern Gaul at the time of Augustus had been reduced to one million. He estimates these figures based on written accounts of tribe sizes in Europe, specifically the censuses conducted by Caesar in 57 BC and 52 BC. While there is no guarantee of accuracy in these figures, Beloch's estimate does provide a starting point to which we can compare other population estimates made for the same region.
[348] Vittinghoff 1994, 68.
[349] Strabo *Geo*. IV.4.
[350] Carroll 2003, 23.
[351] Löhr 2003.
[352] Becker 2005 links the abandonment to the *clades Variana* in AD 9. Recent and yet unpublished work, however, has now proven occupation until AD 15.

provincial capitals, were established along the Rhine (**fig. 3.3**).[353] In Gaul and Germany, these were often named for the tribes which originally inhabited the territory.[354] The initial provincial organization of this region was also established by the time of Augustus. At this time, Gallia Belgica included much of the Rhine basin, with the exception of a narrow strip along the Rhine which belonged to the military.

The foundation of the city of Avenches under Augustus coincided with the organization of the Civitas Helvetiorum, bordering on the Civitas Rauricorum with its capital at Augst. The Civitas Tribocorum, centred at Brumath, was probably also established at this time.[355] The Civitas Treverorum, along with the Mediomatricorum and Leucorum, all located along the Moselle, were also Augustan establishments, with their capitals at Trier, Metz, and Toul. The Civitas Ubiorum was probably organized under Claudius, with the raising of the Oppidum Ubiorum (Cologne) to colonial status ca. AD 50.[356] The territories north of Cologne, belonging to the Cugerni and the Batavi tribes were probably also organized into *civitates* under the Julio-Claudians, but their exact foundation dates are unclear (**fig. 3.4**).[357]

More *civitates* were established under Vespasian, as Rome expanded across the Rhine (**fig. 3.5**). The movement of many garrisons across the river opened older sites for civilian development. When the forts at Speyer and Worms were abandoned, their territories were reorganized into the Civitas Vangionum and Nemetonum respectively. Pliny lists the Triboci, Nemetes, Vangiones, Ubii, Cugerni, and Batavi along the Rhine, indicating that the entire *civitas* network west of the Rhine was organized by the end of Vespasian's reign.[358]

---

353 Vittinghoff 1994, 81.
354 Roymans 2004, 199-200.
355 While Brumath was initially the capital of this Civitas, Strasbourg took over by late antiquity, as the Notitia Galliarum names it as the Civitas Argentoratensium. See Scharf 2005, 13.
356 Vittinghoff 1994, 71.
357 Roymans 2004, 195-208. Roymans argues that the Civitas probably existed from the time of Drusus onwards, but was substantially reorganized following the revolt in AD 69, at which time the territory of the Cananefates was separated and the initial settlement on the site of Voorburg was founded.
358 *NH* 4.31.17

Around AD 85, Domitian established new provinces, separating Germania Superior and Inferior from Gallia Belgica. Mainz and Cologne became the provncial capitals. As part of this organization, Domitian re-divided some administrative districts, and the area near Mainz was split off from the Civitas Treverorum,[359] as the territory was now split between two provinces. In the north, the Civitas Cananefatorum was established with its capital at Voorburg around AD 90.[360] By the end of Domitian's reign the left bank of the Rhine had been completely organized into civilian administration districts.

From the Flavian period to the middle of the second century, the Romans focused on annexing territory across the Middle and Upper Rhine. The administrative ordering of this region was very different from the left bank. Instead of ad-hoc organization, there was a clear progression of military line and civilian hinterland.[361] The Flavians established the first forts across the river, Trajan continued the advancement, and finally Antoninus Pius established the outer line of the *Limes Germanicus* around AD 160. As this military line moved, the recently vacated lands were allocated to new administrative districts. Under Trajan (**fig. 3.6**), the territories closest to the Rhine were divided between the Civitas Ulpia Mattiacorum with its capital at Wiesbaden, the Civitas Ulpia Taunensium with its capital at Nida-Heddernheim (near Frankfurt), and the Civitas Ulpia Sueborum Nicrensium with its capital at Ladenburg. It is also probable that an unknown *civitas* was established further south at Riegel.[362]

The Antonine advancement of the military further east opened more territory for civilian settlement, and new *civitas* capitals were developed for the Civitas Auderiensium at Dieburg, the Civitas Alisinensium at Bad Wimpfen, and the Civitas Summelocensis at Rottenburg (**fig. 3.7**).[363] The Civitas Aurelia Aquensis was evidently formed under Marcus Aurelius, centred at Baden-Baden,

[359] Possibly the civitas Aresacorum, though this is unclear; Mainz was not a civitas capital until later and there is no other administrative centre in the region. See Klumbach 1959 on the Aresaces.
[360] Buijtendorp 2010, 166.
[361] Sommer 1999, 183.
[362] Planck 2005, 275.
[363] Sommer 1999, 187-8.

as was the Civitas Aurelia G[…], with its capital at Neuenstadt am Kocher, and probably another with its capital at Pforzheim. [364]

Figure 3.8 shows the full extent of the *civitas* organization of the region at the end of the second century, and **figure 3.9** summarizes the chronological development of the *civitates* and their capitals over the course of the Roman period. The initial Augustan activity finally culminated in the full ordering of the left bank of the Rhine by Domitian when the German provinces were finally established. The subsequent expansion across the river allowed for new regions to be settled between Trajan and Marcus Aurelius. The fully developed provinces of Germania Inferior and Superior did not come to fruition until Marcus Aurelius established the final *civitates* in the late second century AD, nearly 200 years after the initial Roman conquest.

City sizes

Some 180 settlements are known within the Rhine basin,[365] including 24 *civitas* capitals, of which there were five colonies and four *municipia*. Beyond these, thousands of rural farms and villas are known.[366] Considering the relatively small size of the Rhine basin, this was a fairly densely settled zone.

It is possible to measure the size of 40 of these settlements (**figs. 3.10-11**), including all the colonies, *municipia*, and almost all *civitas* capitals, listed in **table** 3.**1**. This is clearly not a majority of settlements, but it does cover the major centres and therefore allows us to make several useful observations. Most of these estimates are based on known wall circuits, a fact which is not without issue.[367]

---

[364] Schmidts 2007.
[365] Talbert 2000. This figure does not include the *canabae* of various forts, discussed below.
[366] No single overview exists for villa settlement in the Rhine region, but see: Müller-Wille and Oldenstein 1981; Gechter and Kunow 1986; Kunow 1994; Heimberg 2003; Roymans and Derks 2011.
[367] Marzano 2011, 202; Wilson 2011b, 170.

NAME	Size (ha)	Pop (100/ha)	Pop (216/ha)	Pop(varied)	Status	Civitas C.
Trier	270	27,000	58,320	58,320	Col.	x
Strasbourg	240	24,000	51,840	51,840		(4th c.)
Toul	120	12,000	25,920	25,920		
Augst	103	10,300	22,248	22,248	Col.	x
Metz	100	10,000	21,600	21,600		x
Cologne	95	9,500	20,520	20,520	Col.	x
Mainz	77	7,700	16,632	16,632	Mun.	(4th c.)
Avenches	73	7,300	15,768	15,768	Col.	x
Xanten	73	7,300	15,768	15,768	Col.	x
Worms	67	6,700	14,472	14,472		x
Windisch	53	5,300	11,448	11,448		
Nida	46	4,600	9,936	9,936		x
Ladenburg	40	4,000	8,640	8,640		x
Mayen	40	4,000	8,640	8,640		
Koblenz	39	3,900	8,424	7,020		
Wiesbaden	36	3,600	7,776	6,480		x
Brumath	35	3,500	7,560	6,300		x
Nijmegen	35	3,500	7,560	6,300	Mun.	x
Rottweil	32	3,200	6,912	5,760	Mun.	x
Bonn	32	3,200	6,912	5,760		
Rottenburg	28	2,800	6,048	5,040		x
Riegel	27	2,700	5,832	4,860		x
Bern	27	2,700	5,832	4,860		
Solothurn	27	2,700	5,832	4,860		
Speyer	25	2,500	5,400	4,500		x
Rheinzabern	24	2,400	5,184	4,320		
Dieburg	23	2,300	4,968	4,140		x
Neuenstadt a. K.	20	2,000	4,320	3,600		x
Bliesbruck	20	2,000	4,320	3,600		
Dalheim	20	2,000	4,320	3,600		
Andernach	20	1,950	4,212	3,510		
Bad Wimpfen	18	1,800	3,888	3,240		x
Baden	16	1,600	3,456	2,880		
Pforzheim	12	1,200	2,592	2,160		x
Voorburg	11	1,100	2,376	1,980	Mun.	x
Neuss	10	1,000	2,160	1,800		x
Basel	9	920	1,987	1,196		(4th c.)
Totals:	1943	194,270	419,623	399,518		

Table 3.1: City sizes and population estimates in the Rhine basin (excluding any attached forts). Pop(varied) column calculated using densities from Marzano 2011. All sizes measured in Etakeoff.

In some cases, city walls were built well in excess of what the city needed, as in the case of Avenches where the Flavian-era wall enclosed some 230 ha, but the settlement only covered 73.[368] In most cases, however, the walls were added later and probably truncated settlement. At Trier, for instance, the 270 ha area enclosed by the second-century wall excludes the settlements across the Moselle as well as some to the north of the city, but without clear delineation, the size of these areas is harder to estimate. These figures are therefore only estimates, but do provide some idea of site hierarchy.

The five colonies (Trier, Augst, Cologne, Avenches, and Xanten) rank amongst the largest centres, with Trier the largest. The colonies averaged a size of 122 ha, while the *municipia* are substantially smaller, averaging 39 ha. Mainz,[369] Toul, and Metz are also included in the ten largest settlements, unsurprising for a provincial capital and two *civitas* capitals. Strasbourg, a city initially founded as a legionary fortress, developed to a substantial size, ranking as the second largest settlement in the region.

The measurable *civitas* capitals (22 of 24; Baden Baden and Bad Canstatt are not able to be measured) vary widely from the largest (Trier, 270 ha) to the smallest (Voorburg, 11 ha). The cities founded under Augustus were the largest, owing to their long occupation history and continued importance over the course of five centuries. The *civitas* capitals west of the Rhine average 81 ha in size, which can be compared to the Trajanic capitals which average 44 ha, and the Antonine capitals which average 22 ha. These size differences should possibly be attributed to the duration of occupation (450 years for those cities east of the Rhine, 160 for the Trajanic foundations, and approximately 100 for the Antonine foundations).

The three capitals along the Moselle—Trier, Metz, and Toul—are the largest, averaging 163 ha. The 14 sites of Germania Superior west of the Rhine

---

[368] Pury-Gysel 2011.

[369] Mainz did not gain any legal status until late in the third century when it was made a municipium. Later on, the *Notitita Galliarum* mentions the *Metropolis Civitas Magontiacensium*, indicating an elevated status for the late antique capital, as well as a new *civitas*. Similarly, the same document names Strasbourg as the capital of the *Civitas Argentoratensis*. See page 101 below.

average 58 ha, while the ten founded across the river average a substantially smaller 28 ha. The ten sites of Germania Inferior are about halfway between these, averaging 43 ha. The largest sites of the Rhine basin thus were located either on the Moselle River into the middle Rhine region or along the Aare River on the Swiss Plateau.

Population estimates

How many people lived in these cities? Macro-demographic studies have sought to estimate population across the Roman world, reaching estimates ranging between 45 million and 75 million inhabitants.[370] Such macro-scales obscure local patterns,[371] however, making it worthwhile to compare these figures against regional trends. Lacking secure ancient data, however, any effort to estimate population must be taken cautiously, and such estimates are hypothetical.

Several recent studies have sought to estimate populations based on city sizes using population density multipliers,[372] but this is not straightforward. How many people occupied the space of one hectare in an urban centre? Is this density the same for each city, for each decade, for each century? The answer is certainly no, but there are very few ways to clarify these issues. What follows is first a summary of past attempts at quantifying population within and around the Rhine study region, emphasizing the extremely tenuous nature of such estimates, many of which border on guesses and must not be taken as fact. Following this, I pose a series of figures meant only to be taken as an order of magnitude to describe the potentialities of population growth and development within the Rhine basin. The hypothetical nature of such an exercise does not mean, however, that it cannot produce important conclusions.

Scheidel estimated the population of the Roman world in the second century between 60 and 70 million,[373] of which 9-12 million resided in Gaul and

[370] Beloch 1886; Scheidel 2007, 44; Frier 2008, 811-12; Bowman and Wilson 2011, 2.
[371] Bowman and Wilson 2011, 4.
[372] Hanson 2011; Marzano 2011; Wilson 2011b.
[373] Scheidel 2007, 47.

Germany.[374] He cites a population density in this region of 13-18/ km², which would produce a population of 1.4-2 million within the Rhine basin.[375] This is only just higher than the population estimated by Beloch at the start of the Roman period in this region, calculated from figures in Caesar.[376] Scheidel goes on to argue for an urban population of some 7 to 9 million in the Roman world, or one-eighth or one-ninth of the total population.[377] Taking the same ratio, this would imply an urban population of 175,000 to 220,000 within the Rhine basin. He is not explicit about how he calculates this density, nor does he make any distinction between the different zones of Gaul. Settlement varied widely across this expanse, so his grouping surely obscures regional patterns.[378]

More recently, Wilson has taken another look at the problem and turned the approach around.[379] Instead of using the overall population of the Roman world to reconstruct urban populations, he estimated minimum urban populations to give an idea of the possible size of the population of the Roman world. Using a population multiplier of 100/ ha for selected urban areas,[380] Wilson estimated an urban population of Gaul and Germany at 298,000 for the second century AD, with specific estimates of 23,000 for Gallia Belgica, 40,000 for Germania Inferior, and 36,000 for Germania Superior.[381] He estimated a rate of urbanism at 12-13%,[382] which would produce a total population of Gaul at 2.3 million, of which roughly 800,000 lived in the provinces which cover the Rhine basin. Wilson proposes this number as a minimum range of possibility and his approach leaves open the possibility that the reality could be much higher, especially as one considers more settlements than the handful that he was able to cover in the space allotted.

---

[374] *Ibid*, 48.
[375] Estimated at roughly 60% of the total 185,000 km² basin extent, or 111,000 km², based on measurements made in arcmap.
[376] See n. 9 above. Either Beloch is extremely high or Scheidel is extremely low, but there is no way to reasonably suggest zero population growth between 55 BC and AD 150.
[377] Scheidel 2007, 79.
[378] A fact which Beloch 1899, 438 points out, estimating a density of 7.4/ km² for "Belgien und östliche Keltengaue," lower than any other region of Gaul.
[379] Wilson 2011b.
[380] *Ibid*., 181.
[381] *Ibid*., 188-9 following Bekker Nielsen 1989.
[382] *Ibid*., 193.

Recent studies by researchers from the University of Cologne have offered insight into local variation in settlement and population density within certain regions of the Rhine region over the *longue durée*, from the Neolithic to Medieval periods.[383] Relevant to this study are their conclusions regarding population development between the late Iron Age and the early medieval period, which they base upon a series of calculations related to soil suitability, land carrying-capacity, excavated rural and urban settlements, and GIS analyses. Their study zones included the Aldenhovener Platte, the Hambach Forest, the Kromme Rijn, the Wetterau, and the Neckar valley. These zones revealed a range of local conditions and differences which determined settlement density and highlighted the shortcomings of broad-stroke estimates of population such as those by Scheidel and Wilson.[384]

These authors found that rural settlement was densely concentrated within the loess zone north of the Rhenish Massif, along the *via Belgica* between Cologne and Tongeren, a region encompassing both the Aldenhovener Platte and the Hambach Forest, with rural settlement densities of up to 34 people/ km^2.[385] The Neckar valley, also rich in loess deposits, with numerous villae known, had a lower settlement density at around 10 people/ km^2.[386] The authors further calculate a population of roughly 150,000-240,000 living within the cities and *vici* of their study zone.[387] The methods of estimating urban populations varied, utilizing methods such as p/ha estimates as used by Wilson above and explored further below, to using number of houses excavated within a settlement multiplied by a hypothetical number of inhabitants and then extrapolated to the population of the town.[388] These studies resulted in an estimation of a range of 70-140 p/ha of

[383] Wendt & Zimmermann 2008; Zimmermann, Wendt, Frank, and Hilpert 2009;Zimmermann and Wendt 2009; Wendt and Zimmermann 2009; Wendt, Hilpert, and Zimmermann 2012.
[384] It must be emphasized that neither their zones nor their research goals cover the full extent of this thesis, and therefore their numbers must be fitted into the wider Rhine region.
[385] Zimmermann, Wendt, Frank, and Hilpert 2009, 11. The villa density of this zone is well known, discussed further in the next chapter.
[386] *Ibid*.
[387] *Ibid*., 15. These numbers are compiled from other sources and the authors of this article emphasize that these sources do not always agree, therefore suggesting caution in taking these figures as fact.
[388] Zimmermann, Wendt, Frank, and Hilpert 2009, 15-17. See also studies by Sommer 1998; Kortüm and Neith 2004;

urban space in *vici*.[389] Similar figures are used by Rothenhöfer in southern Germania Inferior, where he prefers an estimate of 80-100 p/ha.[390] In the end, the authors of these studies conclude that within their study regions, despite micro-regional variations in rural settlement density and allowing for varying urban densities, a total population range of 70,000-140,000 rural, 150,000-240,000 urban, and about 26,000 soldiers, for an average population of about 330,000 people in this single zone in the second century AD.[391] Taking the average rural (105,000) and urban (195,000) population figures, these studies suggest an urbanization rate of 53%!

The broad scope of the studies by Scheidel and Wilson obscure local variance, while the work of Wendt *et al*., favour the most populated zones of the Rhine region while leaving out broad swathes of other territory. A more detailed study is needed which is regionally focused, incorporating both wider scholarly interests and local archaeological conditions. I propose such an approach here, using Wilson's methodology of measuring urban space, using population multipliers to estimate urban populations, and then extrapolate a range of rural settlement from that number. I must again emphasize that this is an exercise in magnitude to prove a simple point: there were more people living in the Rhine basin than have previously been appreciated.

Using the sites listed in the last section, I have relied mainly upon the *civitas* capitals of the region, though also included some larger *vici* and *canabae* settlements (**see table 3.1**). Smaller settlements, especially the *vici* surrounding auxiliary forts, have been excluded, making these figures only minimum estimates; much like Wilson's study cited above,[392] the addition of further sites will only increase my figures and prove my point further. Only 40 of the ca. 180

[389] *Ibid.*, 17.
[390] Rothenhöfer 2005, 26, also appendix 5.
[391] Zimmermann, Wendt, Frank, and Hilpert 2009, 18.
[392] Wilson 2011b. These sites are often so poorly excavated that their extents, and therefore population sizes, remain unknown. Some authors (Czysz 2005, 209; Zimmermann, Wendt, Frank, and Hilpert 2009, 15) estimate a mulitplier of 1.5 *vici* inhabitants per soldier in a fort, though since neither the number of troops in a fort nor the number of civilians in the vici can be definitely proven, this ratio remains only a basic rule of thumb.

settlements of the Roman Rhine can be measured with some degree of accuracy, producing a total "urban" area of some 1,943 ha.[393]

Using multipliers of population density, we can calculate rough figures for the urban population of these centres. Estimations of urban densities in Roman northern Europe range from the 80-100 p/ha of Rothenhöfer to Millet's figures for Roman Britain which range between 137-216 p/ha.[394] These are notably less than the Mediterranean estimates between 150-400 p/ha,[395] possibly attributable to the fact that Roman cities in northwestern Europe tend, on average, to be much larger than those in the Mediterranean region, possibly because of a wider availability of space, therefore requiring less-dense living.[396]

Using a selection of these density figures (**table 3.1**), we can establish an urban population range of 195,000-420,000. If we follow Scheidel's estimate of an 8-9% urbanization rate, this would imply a total population of 2.4-3 million, while Wilson's estimate of 13% places the total at 1.5-3.2 million. The high figure shown by Wendt *et al.* above is surely too high to apply to the entire region, but importantly highlights the sort of regional variation that broad-stroke approaches gloss over. These figures show a substantial range, but Marzano's suggestion that certain classes of settlements can have different densities may be useful; she proposes that settlements above 40 ha have a density at 216/ha, settlements between 39-10 ha have a density of 180/ha, and settlements below that measure below 10 ha have a density of 130/ha.[397] This calculation brings the total urban population to about 420,000, which can be extrapolated to a total regional population of 3.2-4.6 million, using the 13% and 9% urbanism rates respectively. This range suggests a growth of 1.95-3.35 million from Caesar to ca. AD 250 from Beloch's original estimate of 1.25 million.

This estimate, it must be emphasized, is only based on approximately 20% of the total settlements in the region, and while it does include nearly every major

[393] Sites were measured using the Etakeoff architectural computer programme, using scanned plans of sites. Waldgirmes is excluded from the total figure, as it was only inhabited briefly.
[394] Millett 1990, 182-3; Marzano 2011, 206.
[395] Wilson 2011b, 171-72.
[396] Pers. comm. Jack Hanson, 2014 who has calculated the average city size in the Roman Empire at roughly 55 ha, with an average density of 150 p/ ha.
[397] Marzano 2011, 206.

settlement, it does not factor in the population of most *vici* and rural inhabitants. It is therefore probable that these estimates are lower than the reality of the civilian population in the late-second century AD Rhine basin. That said, it is still a substantial increase from the figures proposed by Wilson (0.8 millon) and Scheidel (1.4-2 million).[398] The figures of Zimmermann *et al*. are not calculated on the same scale, only some 10,000 km^2 or about one-eleventh of the Roman Rhine.

While the calculation of these figures has been an act of informed guesswork, several pertinent details cannot be denied. The first two and a half centuries of Roman rule along the Rhine saw an unprecendeted growth in urban space and, consequently, growth in urban population. The size of the urban population has important implications for the size of the rural population. Several ratios were explored here and, when combined, suggest an extensive settlement density across the region. The exact size of this population cannot be proven, though several different attempts to outline the possible order of magnitudes suggest that the peak population was impressive, and far above what many scholars have considered.[399]

The relationship between urban and rural residents is explored further in the next chapter where agricultural production is discussed. The above discussion has made it clear, however, that the rural residents of the region must have been capable of producing a substantial food surplus in this period in order to sustain such a high urban and, as discussed below, military population.

It is important to recognize urban centres along the Rhine not only as monumentalized administrative centres at the *civitas* and provincial level, but also as centres of commerce. Cities, towns, and villages functioned as market centres for the sale of rural produce, helping to link producer with consumer. Estimates place the maximum distance between farm and market up to 25-35 km, a one-way journey that a farmer with cart or animal could make in one day, provided decent

[398] Though this really only proves his argument, as estimates can be larger but not smaller than his figures.
[399] *E.g.* Woolf 1998, 137-38 for wider Gallic estimates.

road access.[400] The organisation of these settlements within the transport network outlined in the previous chapter was therefore of critical importance—access to roads and rivers meant that goods could be easily moved from rural farms to large cities. Likewise, the positioning of these settlements within this network meant that goods and services produced in the urban sphere could be sold in markets throughout the region and disseminated into the countryside. Cities were, therefore, important nodes in a number of different systems, both physical and conceptual. The Rhine, unlike other frontiers in northern Britian or Africa, was relatively highly urbanized. The existence of so many civilian settlements alongside major military sites is, therefore, an aspect of existence worth further exploration, especially as it helps define the character of economic life within this region.

Military garrisoning

A large contingent of troops existed alongside this civilian population,[401] and their continued presence set the Rhine apart from Gaul for most of its history.[402] The Rhine garrison occupied forts which were located in or near civilian settlements, and changes in its size greatly influenced the demography of the region. This section examines how the size of the Roman army changed over time in order to understand the relative proportions of military and civilian in the region. This approach is absent from many other considerations of population. Such a comparison also allows an assessment of the relative role of the military in economic development, as Drinkwater and others have argued that they "fired-up the Gallic economy."[403]

The size of the Roman army is often taken for granted, but remains hypothetical. Many estimates exist for the size of the entire army—usually

---

[400] Frayn 1993, 25.
[401] Particularly Nesselhauf 1960; Alföldy 1968; Schönberger 1969; Schönberger 1985; Kortüm 1998; Baatz 2000.
[402] For the most recent discussion of military sites in the Northwest in general, see Reddé *et al.* 2006. On the development of the Saxon Shore forts on the continent, see discussions by Mertens 1977 and other papers in Johnson 1977, as well as Petrikovits 1971, 82.
[403] Drinkwater 2002, 138.

estimated at about 300,000 in the Augustan period, 350,000—450,000 under the Severans, and possibly 450,000 under the Tetrarchy.[404] Agreement fades in later periods, with Jones estimating some 600,000 men and MacMullen a lower 400,000.[405] The figures for the early and high Empire are derived from the number of known legions with an assumed equal number of auxiliary troops.[406] The numbers for the late Empire derive from the *Notitia Dignitatum*, the usefulness and accuracy of which is debated.[407] There are fewer specific estimates for the Rhine armies. It is generally assumed that the military was divided evenly between the Upper and Lower Germany, 80,000 at first, eventually reducing to half that number.[408] These generalizations can be improved by careful consideration of the archaeological evidence.

Counting forts

Despite MacMullen's claim that archaeological data are of almost no use in determining the size of the army,[409] the substantial number of excavated forts can tell us much about the changing size of the garrison.

The approach taken here is, like the civilian estimates above, hypothetical, but grounded in several hypotheses. First, any known fort was occupied by at least one unit while in active use. Second, this unit had a nominal strength which was standard throughout the Roman army. Third, the provincial garrison occupied only forts, and no units were stationed in towns or elsewhere (except where explicitly noted). These points allow us to count known forts, ascertain the unit stationed in them, and then estimate that unit's strength. By this methodology, we

[404] MacMullen 1980; Strobel 2007, 268; Gilliver 2007, 186; James 2011, 130, 182, 246.
[405] Jones 1964, 683; MacMullen 1980, 458.
[406] Gilliver 2007, 186.
[407] Macmullen 1980; Southern and Dixon 1996; Scharf 2005.
[408] Verboven 2007, 303. The reduction in legions actually finished under Trajan, not Domitian; *cf.* Schönberger 1969; 1985 as well as the excavations of the Flavian legionary fortress at Mirebeau in Burgundy: Goguey and Reddé 1995.
[409] MacMullen 1980, 452.

can add up the total garrison of the region for any time period based on fort occupancy.[410]

A note on unit type and size is useful. Imperial unit types have generally agreed-upon nominal strengths, which will be used as the criterion for calcutation– legions had 5500 men, quingenary cohorts had 500, milliary cohorts had 1000, cavalry *alae* had 500, and *numeri* about 120. It must be remembered that these figures are maximum figures, and realistic unit strengths could have been much lower for any number of reasons, as preserved strength reports reveal.[411] Lacking any such evidence from the Rhine, it is best to leave it at nominal strength. Following the reforms of the Tetrarchs in the beginning of the fourth century, unit sizes are generally held to have been much smaller, with legions reduced to 1000 men and auxiliary cohorts around 400.[412] The field armies of this time were irregular, and therefore it is difficult to estimate continuous garrison size.[413]

In total, some 135 forts are known from Upper Germany and 79 from Lower Germany from the time of Augustus to AD 260 (**fig. 3.12, 3.13**).[414] New forts are occasionally discovered, as the Augustan fort at Olfen discovered in 2011,[415] but those discussed here represent the majority of those which once existed.

These forts can be divided into foundation periods. The first forts known within the Rhine basin date to the early Augustan period (see **appendix 3.1** and **fig. 3.2**), the earliest being the fort on the Petrisberg in Trier, dating to about 30-29

410 A series of articles by Richardson (2000; 2002; 2003) argued that the internal measurements of a fort could predict the size and type of the unit stationed within the fort. His formulae, designed using British forts, do not ably translate to Germany, where forts are generally larger. Therefore, his methodology is referenced here, but not followed.
411 MacMullen 1980, 453; Bowman and Thomas 1991; Adams 1994.
412 Nuber 2011, 82 n. 24; MacMullen 1980.
413 See particularly Elton 1996b.
414 These forts have been compiled from a number of sources into one database. Primary sources were Schönberger 1969; Petrikovits 1971; Bogaers and Ruger 1974; Johnson 1983; Schönberger 1985; Kortüm 1998; Talbert 2000; Baatz 2000; Gechter 2003; Reddé *et al.* 2006. Fortlets and watchtowers have not been included in this investigation, but see Symonds 2008 on their form and function along the German border.
415 Not yet published, but reported by the Landschaftsverband Westfalen-Lippe online at: http://www.lwl.org/pressemitteilungen/mitteilung.php?25644 last accessed on 31/5/2012.

BC.[416] The subsequent fortification of the Rhine under Drusus in the years 19-14 BC established many of the legionary bases which would be used for the duration of Roman occupation. Drusus' campaigns across the Rhine between 12-10 BC established lines of fortifications along the Lippe River in the north and through the Wetterau and Taunus near the Middle Rhine, evident as far as the Weser River where a series of forts at Hedemünden confirm Roman presence ca. 9 BC.[417] In total, fifteen forts are known so far in Lower Germany and 21 in Upper Germany. These can be split between those located on the Rhine (seven in Lower Germany, twelve in Upper Germany) and those located across the Rhine (eight in Lower Germany, nine in Upper Germany). It is generally agreed that all of these forts were not occupied simultaneously; instead the forts across the Rhine were active campaigning bases in the summer while the forts on the Rhine acted as winter quarters.[418] The forts across the Rhine were mostly abandoned following the defeat of Varus in AD 9, but it is now becoming clear that those located in the Wetterau were occupied at least through the campaigns of Tiberius and Germanicus, with the civilian site of Waldgirmes now believed to have been abandoned in AD 15.[419] Interestingly, very few auxiliary forts are known in Lower Germany, where only three (Vechten, Moers-Asberg, Bonn) are known, and these are not exactly contemporary; meanwhile 13 are known from Upper Germany. Overall, the known fort sites allow us to estimate a garrison size of roughly 40,000 men for Lower Germany and 32,000 men for Upper Germany under Augustus.[420]

The Tiberian period saw a consolidation of Augustus' Rhine defenses (**appendix 3.2**). Three forts were built in Lower Germany, a legion was permanently stationed in Strasbourg, and several new auxiliary forts were added along the Upper and High Rhine. Overall, the garrison size seems to stay constant

[416] Löhr 2003; Morscheiser-Niebergall 2009, 106.
[417] Becker 2005; Fischer 2009.
[418] Reddé *et al.* 2006, 29-32.
[419] Pers. comm. Becker 2012.
[420] Haynes 2013, 14 emphasizes that garrisons at this point could include a number of different units, especially auxiliaries and legionaries, in a single fort, and the organization of this system is poorly understood.

in Lower Germany, but drops slightly in Upper Germany, with a total of 70,000 men.

Some important changes happened under Claudius (see **appendix 3.3** and **fig. 4**), particularly in Lower Germany. At least 18 new forts were built along the Lower Rhine and within the delta, but only five in Upper Germany. The activity in Lower Germany can be related to preparations for the invasion of Britain in AD 43 and the campaigns of Corbulo against the Cherusci and Chauci in AD 47 (Tacitus, *Ann.* 11.18-20) which permanently established the Oude Rijn as the northern border of Germania Inferior.[421] The legion stationed at Nijmegen was moved to Britain, but it was replaced by a number of auxiliary troops now stationed between Cologne and the North Sea. This period is the peak in building activity in the province, and basically established the full fortification network, which would only be marginally added to or repaired later. The forts of this period suggest a garrison of 33,000 in Lower Germany and 28,500 in Upper Germany.

Following the destruction caused by the Batavian Revolt in AD 69, many settlements--military and civilian--along the Rhine had to be rebuilt. It is therefore not surprising that the reign of Vespasian saw large amounts of construction (see **appendix 3.4** and **fig. 5**). At least 12 forts are built in Lower Germany and 19 in Upper Germany. The Legio X Gemina was placed at Nijmegen in a new fortress to keep track of the Batavi, and a new legionary fortress replaced the Augustan double-legion fort at Vetera outside of Xanten. The activity in Upper Germany saw the first serious push across the Rhine since the time of Augustus, incorporating the lower valley of the Main River and surrounding Taunus and Wetterau regions, as well as the right bank of the Rhine up to the foothills of the Black Forest along the upper Rhine. A new legionary fortress was constructed a considerable distance behind the Rhine frontier at Mirebeau in Burgundy, where the Legio VIII Augusta were stationed, presumably to protect Gaul from any further revolts like those of the year AD 69.[422] Fort occupation for this period suggests garrisons of 35,150 for Lower Germany and 27,500 for Upper Germany.

[421] Kunow 2002, 56-9.
[422] Goguey and Reddé 1995.

Domitian's reign presents a problem. It was originally thought that the formation of the *Limes Germanicus* began under Domitian, following his Chattan war in AD 83-5,[423] leading to the establishment of permanent forts in the Taunus, Wetterau, and along the Neckar River. Under this hypothesis, 29 new forts were built in Upper Germany and four in Lower Germany. Klaus Kortüm challenged this long-held tradition in 1998 when he published a study of dendrochronology and coin assemblages in Upper Germany.[424] He argued that the *limes* did not, in fact, begin under Domitian, but rather was established almost entirely under Trajan.[425] In his study, forts previously held to have been founded under Domitian, such as Stuttgart-Bad Cannstatt or Walheim, were shown to be Trajanic by coin-loss series.[426] This new chronology shows relatively little activity under Domitian (**appendix 3.5**), who only maintained the forward points established by Vespasian in the lower Main and upper Neckar valleys.

Kortüm argues for a massive building project under Trajan, which resulted in some 45 new forts in Upper Germany,[427] and another two in Lower Germany (see **appendix 3.6** and **fig. 6**). This new chronology makes more sense, as otherwise a large hole existed in the Domitianic *limes* between the Main and Neckar Rivers.[428] It also means that the garrison apparent from fort sites stays relatively constant, contradicting the idea that Trajan removed a large portion of the border garrison.[429]

The Antonines continued to build along the Upper German *limes*, with 15 new forts and one in Lower Germany (**appendix 3.7**). It is at this time that the line of the Odenwald-Neckar-Alb *limes* is given up and the border moved eastwards, establishing the so-called outer *limes* around AD 160.[430] These forts are entirely built for auxiliary cohorts, though the *numeri* still made up a large percentage of

[423] Schönberger 1985, 370; Baatz 2002, 71-6.
[424] Kortüm 1998.
[425] *Ibid.*, 50-51.
[426] *Ibid.*, 28-29.
[427] *Ibid.*, 12-13.
[428] *Ibid.*, 57 outlines a number of problems posed by a Domitianic date which are solved by a Trajanic origin.
[429] Compare to the above-mentioned traditional view as stated by Verboven – the legions may have been reduced, but their numbers were made up for by auxiliaries.
[430] Kortüm 1998.

the Taunus and Wetterau stretches. Forts suggest garrisons of 24,650 in Lower Germany and 28,600 in Upper Germany.

The final additions to the Upper German *limes* came at the end of the second century (see **appendix 3.8** and **fig. 3.7**). These new constructions do not significantly change the size of the armies present, and Lower Germany stays about the same with 24,650 men and Upper Germany with about 30,000, stationed in about 285 ha of fort space. These forces stay constant until AD 260 when the *Limes Germanicus* is abandoned.

The construction and occupation phases of these forts are shown in **figures 3.14 and 3.15**, where developmental phases can be seen, leading into periods of relatively stable fort occupation in the second century. In total, the occupation of these forts implies the general patterning of garrisoning shown in **figures 3.16-17,** and **3.21**: a drop from 40,000 to 25,000 in Lower Germany, while Upper Germany stays around 30,000 with an increase under Domitian. These forts also tell us something about the sorts of troops stationed in the region (**fig. 3.18-19**), particularly the evident division between legionaries and auxiliaries (**fig. 20**). Over time, the proportion of legionaries falls as legions are moved out of the region, resulting in higher numbers of auxiliaries from Domitian onwards in both Upper Germany and Lower Germany. The addition of the *numeri* at the same time also changed the face of the Upper German frontier, where more of these smaller units were stationed. The positioning of the military also changes greatly over time and between the two Rhine provinces. As the Upper German army moved eastwards under Vespasian, the Middle, Upper, and High Rhine became largely demilitarized. While two legions held the Rhine from Trajan onwards, the other 25,000 men were all stationed on the *limes*, away from the major settlements of the region. In Lower Germany, on the other hand, the military continued to be stationed amongst the major cities of the Rhine, where 25,000 soldiers lived side-by-side with civilians. The fluctuations in the size of the garrison are important, and while this has been a fairly rudimentary outline, it goes some way to demonstrating how the military developed over time. The gradual draw-down of troops occurred simultaneously with the growth of the civilian population and general development of the provincial sphere.

We should also consider another connection between military and civilian settlement besides simple proximity, and that is veteran settlement. Estimates place veteran discharge at ca. 120 men per legion per year,[431] and many of these men chose to remain in the territory where they were stationed.[432] We may infer up to 30,000 veterans residing along the Rhine in the first century and a slightly lesser number in the second and beyond.[433] Veterans melded into the civilian world and helped blend the two groups.[434]

The late-Roman population on the Rhine, AD 260-406

In AD 260, the Upper German and Raetian *limes* were abandoned, along with all territory in the *Agri Decumates* (**fig. 3.22**).[435] By 260, this territory had at least 30,000 soldiers, 50,000 urban dwellers, and up to half a million rural residents. This implies a massive shift in population, both civilian and military, but we are poorly equipped to understand where people went. Many presumably retreated back to the Rhine, but there is no evidence that the cities of Upper Germany swelled with an influx in population nor were there available fortifications for the army to re-inhabit.[436] Historical sources have little to say on the subject, and it is not until the reign of Diocletian that there are substantial efforts at rebuilding. We also do not know to what extent the violence of this period affected the size of the population, but we might hypothesize that the overall number of people living in the region was reduced by the end of the third century.

---

[431] Duncan-Jones 1994, 34.
[432] Derks and Roymans 2006.
[433] Verboven 2007, 304.
[434] See Haynes 2013, 339-68 for a re-assessment of the role of veterans in society.
[435] Hind 1984; Baatz 2002, 217; Witschel 2011; Mathisen 2011; Reuter 2012.
[436] See Hind 1984 for the relation between the Agri Decumates of Tacitus and the Decem Pagi of the Peutinger Table, where the suggestion is made that those living across the Rhine were resettled between Metz and Strasbourg in this period. This is refuted by Mathisen 2011.

Military sites

Following the events of the third century, the Rhine garrison underwent substantial changes. On the Lower Rhine, some fortifications in place since the Claudian period were given up. Frankish attacks in the 270s ended occupation at many sites which had been long-standing pieces of the Lower German *limes*. The legionary camp of Vetera II was occupied to ca. AD 270, the fleet base at Köln-Alteburg was abandoned ca. 280,[437] and almost all auxiliary camps between Xanten and the North Sea were given up at about the same time. Overall, this represents a loss of forts for approximately 15,000 men, but where did they go?

The schism of the Gallic Empire substantially blurs our understanding of the period, especially as archaeology has rarely been able to focus on the Gallic Empire.[438] The *Historia Augusta* (*Tyrants* 5.4) records that Postumus founded a number of forts "*in barbarico*" during his ten years of rule, but these forts have not been located surely.[439] However, some 17 towns west of the Rhine were fortified,[440] and at least some of the displaced troops from across the Rhine may have occupied these. The development of the so-called *Höhensiedlungen*, fortified rural retreats, also offered rural defenses in the late third century.[441]

It is not until Diocletian and the military reforms of the Tetrarchy that serious attention was again paid to the fortification of the Rhine frontier. Over the next century, about 70 new forts were built and many more towns were walled (**fig. 3.23**). Generally speaking, these fortifications were on a very different scale than earlier examples (**fig. 3.24**).[442] The initial development of the so-called

[437] Höckmann 1998, 323.
[438] Drinkwater 1987, 215; Fischer 2011.
[439] Drinkwater 1987, 219-23 concedes the possibility of the fortifications at Qualberg and Villenhaus as projects of Postumus, alongside the beginnings of the *limes Belgicus* and the *litus* Saxonicum, but is wary of assigning most sites specifically to the Gallic Empire, instead preferring a general late-third century date.
[440] Butler 1959; Petrikovits 1971; Mertens 1977; Johnson 1983; Brulet 1995; Reddé *et al*. 2006; Bachrach 2010.
[441] Petrikovits 1971, 191-3; Gilles 1985; Brulet 1995; Reddé *et al*. 2006. Drinkwater 1987, 223-24 suggests that these positions were in use only until the restoration of central Imperial power in the beginning of the fourth century.
[442] Nuber 2011, 80-84.

Donau-Iller-Rhein *limes* began under Diocletian,[443] with some 13 new forts built along the Rhine. The Upper and High Rhine had been left largely undefended in the years following the abandonment of the *Agri Decumates*, so this project was badly needed.[444] We can assume that some of those displaced units contributed to the garrisons of new forts at Basel, Kaiseraugst, Stein am Rhein, Eschenz, Zurzach, Oberwinterthur and Konstanz which, alongside a number of small watch posts, guarded the Rhine from Strasbourg to Konstanz. The substantial climatic variation seen in the third and fourth centuries may help account for the increased Alamannic pressure in this region, as the High Rhine would have been the easiest part to cross, especially when frozen in winter. This posed a serious problem for Italy, as an unprotected High Rhine opened easy routes across the Alps. Diocletian's forts aimed to end this threat.

Constantine continued to fortify the Rhine with at least 16 new forts both along the river and deeper in the provincial hinterland. The fort at Köln-Deutz and possibly the rebuild of Mainz-Kastell were his most important contributions, but the defense of the Cologne-Tongeren road, as well as the roads connecting Trier to Cologne and Koblenz was evidently also pressing.[445]

A number of forts are possibly attributable to Constantine or Julian in his time as Caesar, notably at Koblenz, Bingen, and Worms. Julian is thought to be responsible for serious efforts at Xanten (Tricensimae), Neuss, Bonn, and Andernach, amongst others in AD 357-8 (Ammianus 18.2.4).[446] Ammianus also records (17.1.11) that Julian rebuilt fortresses of Trajan in the territory of the Alamanni, though only temporarily. There are an additional nine fort sites which may be attributed either to Julian or to his successor, Valentinian, including Bad Kreuznach and Alzey, which continued to provide depth to the frontier defenses along the Rhine.

Valentinian I enacted the last real building campaign on the Roman Rhine (Ammianus 28.2.1-4), with some 20 forts built between AD 368-9, the largest

[443] Garbsch 1970; Asal 2005.
[444] Drinkwater 1987, 226-28.
[445] Petrikovits 1971, 184; Symonds 2008, 208.
[446] Petrikovits 1971, 184.

project since the time of Trajan. These included sites on both side of the Rhine, with forts located across the Rhine at Wiesbaden, Altrip, and Breisach plus smaller ship-landing sites at Rüsselsheim, Mannheim-Neckerau, and Zullestein.[447] Valentinian's efforts of fortification were aimed at securing not only the western bank of the Rhine but also the river itself for continued Roman use. He also added strength to the Swiss Plateau and Alpine passes. These forts helped to secure the Rhine and surrounding territory for another thirty years, but renewed attacks in the 390's overran many of these sites and ensured the fall of the Rhine frontier in AD 406.

Garrison size

Estimates of garrison size in the late period are hindered by the cessation of auxiliary diplomas and a general drop in military epigraphy. Rare insights are provided by historical authors, but these are minimal. The changes in military structure instituted under Diocletian and Constantine further complicate matters, removing the old unit structure and replacing it with a new system of border troops (*limitanei*) and provincial field armies (*comitatenses*) who could be anywhere, along the frontier or deep in provincial territory.[448] Legions were reduced to 1,000 men and auxiliary units fluctuated between 150 and 500. Further additions of barbarian irregular units, the *foederati* or *numeri* (not to be confused with the earlier units), meant that the actual garrison stationed within a given border at a certain time becomes extremely difficult to estimate.

We are best informed of the situation in AD 357 surrounding Julian's defeat of the Alamanni at the battle of Strasbourg, where Ammianus' (16.12.1) account allows for an estimate of 13,000 men in Julian's army.[449] A half century later, the Notitia Dignitatum records 11 auxiliary units under the control of the *Dux Mogontiatensis* ca. AD 425, allowing for an estimate of some 4400 men stationed between Selz and Andernach along the middle Rhine.[450] The same

[447] Scharf 2005, 41.
[448] Southern and Dixon 1996. Elton 1996b.
[449] Elton 1996b, 106.
[450] Scharf 2005, 44.

information is not provided for the neighbouring realms of the *Comes tractus Argentoratensis* or the *Dux Germaniae primae*, so their numbers are unknown. We might hypothesize two forces equal to that of the *Dux Mogantiatensis*, resulting in an overall garrison of 17,400, but this cannot be verified. This number is thought to be lower than what was present in the region before Stilicho removed forces to Italy,[451] but we are unable to estimate by how much.

Late Roman forts were very different from their predecessors of the early and middle Empire as they were smaller, yet structurally stronger.[452] The smaller size of these forts can generally be attributed to smaller units, as already discussed, but also a change in conception of border defense. Forts were now positioned in extremely defensive positions, as opposed to their earlier preference for offensive locations which were often exposed.[453] The stronger structural defenses of the forts also makes this apparent, with walls now up to 3 m thick, projecting towers on corners and walls, and limited gate access.[454] Mackensen has made some tentative estimates of the size of the garrison of these forts, stating that forts with an area between 0.15-0.30 ha held garrisons of 120-160 men, while forts with areas of 0.80-1.00 ha held around 300.[455] This suggests a density of about 300-360 men/ ha, a serious reduction in the space available for soldiers compared to earlier forts, where an *ala* fort generally contained 125 men/ha, an auxiliary cohort about 217 men/ha, and a *numerus* fort about 200 men/ha, and the legions around 240 men/ha.

As we know very little about the size of the frontier garrison in late antiquity, we can attempt to estimate the size of the garrison based on fort sizes, as already done for the earlier period above. Of the 72 late-Roman forts discussed above, 58 can be measured (**appendix 3.9**), and the Constantinian and Valentinian periods are the most complete. We can estimate the garrisons of these periods based upon the forts known.

---

451 *Ibid.*, 4-5.
452 Southern and Dixon 1996; Elton 1996b; Nuber 2011, 80-84.
453 Petrikovits 1971, 193.
454 Petrikovits 1971; Elton 1995; Southern and Dixon 1996; Mackensen 1999.
455 Mackensen 1999, 221. In addition, Brem 2008, 21 estimates the occupation of Pfyn at 520 men in a fort of 1.6 ha, for a density of 325 men/ ha, which is about in line with Mackensen's suggestion.

In some cases, it becomes difficult to separate clearly military sites from clearly civilian. Xanten provides an interesting case, where a major colonial settlement of 73 ha and accompanying legionary fortress of probably ca. 25 ha were destroyed ca. AD 275 and replaced under Constantine with a 16-ha fortification covering the centre of the city which, judging from finds, held both soldiers and civilians in the fourth century,[456] much like Bonn to the south.[457] Cologne, still standing despite a number of Frankish efforts, saw the installation of a new legion across the Rhine at the 1.8 ha fort of Köln-Deutz.[458] Elsewhere, legions still occupied Bonn, Mainz, Strasbourg, and Kaiseraugst, in total only about 8000 legionaries along the frontier. Smaller forts were built between these, and their sizes allow us to estimate an additional body of some 3,000 men. To this we can add the garrisons of pre-existing forts built under Diocletian, a force of probably some 3,000 others, mainly stationed between Strasbourg and Lake Constance. In total then, we can argue for a force of maybe 12,000 men along the Rhine under Constantine. If additional men were stationed in the fortified towns, we do not know their numbers.

Later, the Valentinian fortification effort was responsible for some 20 new forts, the largest being at Boppard and Breisach, with other substantial fortifications at Bad Kreuznach and Alzey in the Rhine's hinterland. In total, we can estimate that a total of 17.5 ha were fortified, providing new space for about 6,000 men in addition to those already stationed in pre-existing forts. The number may be about the same as that under Constantine, but it is unclear. Only a decade before, we have Ammianus' account of Julian's force of 13,000 men at Strasbourg, which represented the size of the provincial army, not the border force, though of apparently equal size.

Overall, while we only have partial information for the late period, we can see that the military garrison permanently stationed along the Rhine was substantially reduced in the fourth century. When the *limes* Germanicus was abandoned ca. AD 260, there were still some 55,000 soldiers in the region. A

[456] Otten and Ristow 2008.
[457] Müssemeier 2011.
[458] Carroll 1993.

century later, this number was less than one-third its original size. We can attribute this to a substantially different frontier system, where a smaller number of *limitanei* guarded the border while a much deeper defensive network incorporated fortified cities and road stations much deeper into Gaul, where the provincial field army waited in the event of serious incursions. This system meant that fewer men had to be stationed in forts directly on the front line, so the border force was substantially reduced. That said, fort building was still probably the single largest building activity in the fourth century Rhineland, despite the fact that it never reached the heights of the campaigns of Domitian and Trajan. When Stilicho removed what was left of the Rhine garrison in 401 to protect Italy against Alaric, he effectively opened the region to the invasion of 405 which ended Roman possession of the length of the Rhine.[459] While subsequent campaigns were made to regain lost territory in the fifth century, a permanent Roman garrison was never again present.[460]

Civilian population

The abandonment of all territory across the Rhine in AD 260 meant the loss of a substantial tract of land and a number of urban centres, including eleven *civitas* capitals. Diocletian's re-division of the Gallic provinces further affected the administrative layout of the Rhine basin, as Germania Inferior was now renamed Germania Secunda, with the capital maintained at Cologne, and Germania Superior was split between Germania Prima (everything north of Strasbourg) with its capital still at Mainz and Maxima Sequanorum (everything south of Strasbourg) with its capital at Besançon. The *civitates* of the Cananefates, Batavi, and Cugerni in Germania Secunda were dissolved into the Civitas Ubiorum,[461] while the previous layout of Germania Superior was split between Germania Prima and Maxima Sequanorum.

---

[459] Schönberger 1969, 187.
[460] Elton 1992. The settled *foederati* of Frankish, Burgundian, or Alamannic origin defended the Rhine (now, realistically, *their* Rhine) against 'enemy' forces while the field army, like that of Aëtius dealt with deeper threats.
[461] Harries 1978, 41.

Most civilian settlements of the fourth century looked substantially different from those of the third and second (**table 3.2** and **fig. 3.25**). While the

NAME	Size ca. AD 250 (ha)	Size ca. AD 350 (ha)	Percentage of original
Trier	270	270	100%
Cologne	95	95	100%
Mainz	77	77	100%
Metz	100	70	70%
Worms	67	23	34%
Strasbourg	240	20	8%
Xanten	73	16	22%
Speyer	25	13	52%
Toul	120	10	8%
Andernach	20	6	29%
Avenches	73	5	7%
Koblenz	39	5	14%
Nijmegen	35	4	11%
Basel	9	4	39%
Augst	103	4	3%
Solothurn	27	1	5%
Olten	5	1	24%
Zurich	16	1	5%
Nida	46	0	0%
Ladenburg	40	0	0%
Wiesbaden	36	0	0%
Rottweil	32	0	0%
Rottenburg	28	0	0%
Riegel	27	0	0%
Dieburg	23	0	0%
Neuenstadt a. K.	20	0	0%
Bad Wimpfen	18	0	0%
Baden	16	0	0%
Pforzheim	12	0	0%
Voorburg	11	0	0%
Totals:	1,801	626	34.77%

Table 3.2: Changes in Urban space AD 250-250, sites measured wtih Etakeoff.

full extent of earlier settlements cannot be traced in this period, those that can generally show a substantial decline in size, in the realm of 65%. By the end of the third century, a number of sites along the lower Rhine were abandoned. Frankish attacks on the region from the 260s onwards made continued settlement difficult.[462] Voorberg, Nijmegen,[463] and Xanten did not survive the Frankish raids of the late third century. Xanten was re-inhabited following the Constantinian fortification of Tricensimae,[464] but was never again an administrative centre. Instead, Cologne acted as the main centre for this region, with most settlement now located south of the Cologne-Tongeren road. Andernach shrank to 5.6 ha, and Koblenz to 5.4 ha.

Further south, Mainz was walled in the mid third century,[465] with repairs under Julian and Valentinian,[466] becoming capital of the civitas Mogantiacensium in Late Antiquity.[467] Strasbourg was reduced to a fortification with an area of 20 ha under Constantine,[468] though it became the capital of the new Civitas Argentoratensium.[469] The earlier colony at Augst was replaced by the 3.5 ha fortification at Kaiseraugst at the same time,[470] and the administrative centre moved west to Basel. Solothurn dropped from 27 ha to a walled space of 1.3 ha.[471] Avenches was considerably damaged by Alammanic raids in the 270s,[472] and while there now seems to have been more fourth-century inhabitation than previously thought,[473] it was still reduced.[474] Similarly, Chur was reduced to a walled burgus under Valentinian, shrinking to 1 ha.[475] With the destruction of the main cities of the previous Civitas Helvetiorum, a new administrative centre had to be found. The *Notitia Galliarum* records that this *civitas* was divided into several new regions; Basel became the centre of the Civitas Basiliensium by the middle of the fourth century, and Nyon the centre of the Civitas Equestrium.[476]

---

462 De Koning 2003, 75.
463 Willems and van Enckevort 2009, 95-6.
464 Otten and Ristow 2008.
465 Heising 2012, 166-69.
466 Knöchlein 2011, 272-75.
467 Harries 1978, 41.
468 Gissinger 2002a, 100; 2002b, 55.
469 Harries 1978, 41.
470 Drack and Fellmann 1988, 281.
471 *Ibid*., 348
472 Drinkwater 1987, 217.
473 Pury-Gysel 2012
474 Schönberger 1969, 187.
475 Drack and Fellmann 1988, 382-3
476 Harries 1978, 41; Drack and Fellmann 1988, 296.

On the Moselle, the *vicus* at Neumagen was walled, incorporating the well-known grave monuments into its wall, surrounding 1.28 ha.[477] Trier, with its new status of Imperial residence and capital maintained the large size of its second- or third-century walls,[478] though this might have been difficult at times.[479] Finally, the late third-century walls of Metz reduced the city to 70 ha.[480]

Overall, settlements of the fourth and fifth centuries along the Rhine were quite different from what came before. With the territory east of the Rhine lost, a substantial amount of urban space was lost with it. West of the Rhine, most cities experienced substantial reductions in space—at least as far as walled spaces are concerned—from the time of the Gallic Empire onwards (**fig. 3.25**). Trier emerged as the dominant centre of the region, with its massive 270 ha area more than twice the size of the next largest city, Cologne. The establishment of an Imperial capital at Trier under the Tetrarchy surely made this dominance a reality, and may qualify the city for the region's "primate centre" for this period,[481] suggesting a substantial regional break from the earlier urban system. Loseby and others have referred to this period in Gaul and Germany as one of "urban failure,"[482] but it is important to remember that the majority of these sites were not simply abandoned in favor of dispersed, rural living. Instead, the Romans tried to hold on to their urban centres at all costs, as at Cologne in AD 356 or Strasbourg the following year.

It is very difficult to know how to use these new urban sizes to determine population. Any population density used would be a guess, and therefore I hesitate to commit to a number here. We can, however, experiment with the figures already calculated. In order to maintain the urban population of ca. 425,000 from AD 250, cities in AD 350 would have had an average population density of roughly 680 people/ha, more than a 300% jump in density in the span of a

---

[477] Cüppers 2005, 492-4.
[478] Johnson 1983, 142. The dating on Trier's walls is unclear, with some suggesting a Trajanic date, others arguing for Constantinian (Butler 1959, 38). Based on the dating of finds from around the Porta Nigra, the second century date is adopted here.
[479] Drinkwater 2007, 326; Goodman 2007, 205.
[480] Harries 1978, 42. Metz and Toul were not originally included in the list of the *Notitita Galliarum*, but were added later. Harries explains that this was for the benefit of later clergy.
[481] Marzano 2011, 199.
[482] Loseby 2000.

century. This seems extremely unlikely. Instead, it is safest to say that there was a substantial drop in the urban population of the Rhine basin over the course of the fourth century, though this surely needs to be nuanced by further research.

Conclusions

Using settlements and population as a proxy measure for economic growth is not without risks, and both the approach and its drawbacks have been explored here. It is, however, useful to examine changes in settlement patterns over time make educated inferences regarding contemporaneous population changes. The Rhine basin saw a dramatic rise in urbanized space from the time of Augustus to the middle of the third century AD. Developing well beyond the proto-urban centres of the Iron Age, 25 *civitas* capitals were founded over the next 250 years, resulting in a settlement network that stretched from the Alps to the North Sea with at least 2,000 ha of urban space and a substantial urban population. That such a population was able to survive without a purely agriculturally-focused occupation speaks to the economic development seen by the region in those centuries of Roman rule.

At the same time, the extremely large military presence of the Augustan period (ca. 80,000 men, or one-quarter of the total Roman military at this time) slowly reduced its garrison to about 55,000 (one-eighth of the total army) by the middle of the third century. Despite a number of substantial setbacks, this slow draw-down of men suggests a calm peace along the Rhine frontier over this period. While the overall garrison was reduced, the frontier was still held by an intricate system of fortifications which protected the civilian settlements of the region, and also provided for civilian-military interaction which gave the region much of its character, perceptible through any number of strands of archaeological and historical inquiry.

The problems of the late third century substantially disrupted this growth and development. As a result, a large amount of urban space was lost or given up, and measurable settlement for the late-Roman period is reduced by 65%. Many urban centres contracted into new fortifications. The towns with substantial pre-existing fortifications—Cologne, Mainz, Trier—were those that best survived this process and maintained their size from the early to late period. Others were not so lucky. The new emphasis on fortifications demonstrates a marked change in the function of cities; as certain functions of the earlier Imperial era cities fell apart—entertainment, pagan religion, monumentality—cities became centres of safety from barbarian (and sometimes Roman) threats.

With this in mind, it remains difficult to make estimates about the urban population in this period as it is unclear if population contracted along with urban space. It is probable that it did drop from AD 260 onwards, as otherwise the population densities would have increased at unrealistic rates. Rural surveys in the region support this trend (**fig. 3.26**).[483]

These fortifications make the separation of military and civilian in the late period difficult, as the nature of military sites changed. Soldiers were no longer kept separate from civilian centres, and most of the force of the army was no longer stationed directly on the frontier. The system of defense-in-depth which developed in the late period stretched not only along the Rhine, but also along the major roads leading to it. New forts were built along these zones, mostly much smaller and less populated than their earlier imperial predecessors. Alongside these sites, fortified cities held garrisons as well. Because the dating on so many of these forts is contested, it is difficult to know how many were inhabited contemporaneously. Judging from the building campaigns of Diocletian, Constantine, and Valentinian, it seems that we may estimate a frontier garrison of ca. 16,000 men throughout the fourth century. This is in addition to a number stationed along the roads away from the frontier, plus a regional field army of probably another 15-20,000, judging from historical accounts. This new system of defense held the Rhine until the late fourth century, until Stilicho removed the majority of the garrison to defend Italy against Alaric, sealing the region's fate for the invasion of AD 406.[484]

Overall, the information presented in this chapter suggests an inverse relationship between the civilian and military population. As civilian settlement

---

[483] Gechter and Kunow 1986, abb. 7; Päffgen 2011.
[484] Halsall 2008, 195-200.

grew, the military garrison reduced. From Augustus to the mid third century, the general peace allowed the region to develop, particularly after the provincial establishment of AD 85, when regions were given administrative powers and local centres were able to develop. As more people moved out of the country and into the city, economic life in the region changed; resources had to be successfully managed to support an urban network, and specialized production grew, as discussed below in Chapters 4 and 5. This in itself suggests a substantial advancement of agricultural production, as it now had stretched far beyond mere subsistence level.

These developments both enabled and necessitated a complex market structure to develop, linking the settlements and tying their activities together. Over the duration of this period, the relationship between soldiers, civilians, and trade activity changed as well. The archaeological evidence for trade will be better discussed in Chapters 5 and 6, but the growth of urban centres while military presence decreased suggests a changing pull of urban and military sites for merchants and trade goods. Chapter 6, in particular, demonstrates that cities throughout this region were massive consumers of foreign goods, with a far wider availability of goods than that seen in contemporary military sites. This fact, so far unappreciated within wider scholarship, seriously challenges notions of the military's influence over frontier market activity.

This era peaked in the early third century, when military presence was at its lowest and urban populations at their highest. Subsequent social and political developments severely truncated urban settlement, and a new military strategy reduced the military presence immediately along the Rhine. The difficulties of the late third and fourth centuries undoubtedly disrupted the human base of economic activity in the region and removed the stability present for nearly 250 years. Life along the frontier was no longer so attractive, and a massive population movement began. The abandonment of the *Agri Decumates* and subsequent depopulation of the countryside elsewhere coincided with the influx of new settlers from Germany. The foundation of an imperial capital to Trier in the fourth century sustained the Moselle valley, where continued development can be seen to ca. AD

400. The effects of these changes on systems of resource exploitation, production, and trading systems will be further explored in the following chapters.

4

Resource Availability and Management

Having discussed the changing size of the local population, this chapter examines the ways in which local geography influenced productive enterprise. Local availability of natural resources—fertile ground, minerals, forests—was a crucial factor in shaping regional economic activity in the Roman world, allowing for not only local specialization, but reducing the need for importing raw materials over long distances. The geographic distribution of natural resources was beyond Roman control, but the Empire made conscious efforts to gain control of as much natural wealth as it could. Often, this desire to control resources led to the annexation or attempted annexation of neighbouring regions.

When Caesar began the conquest of the Rhine region in the mid first century BC, the Roman government gained first-hand knowledge of the local landscape and its mineral resources. Augustus incorporated the land west of the Rhine into Roman control and also tried to expand Roman control beyond the river into Germany. Knowledge of the local geology and resources drove initial efforts to incorporate selected regions of Germany, particularly as the Augustan invasions targeted the eastern half of the Rhenish Massif (**fig. 4.1**). Subsequent consolidation of rule in the region led to the long-term exploitation of agricultural and mineral resources along the Rhine frontier.

Much has been made of the Roman Empire's demand for natural resources, including the almost immediate uptake of extractive actions upon the conquest of an area,[485] or the subsequent management of resources over time for payment of taxes in kind.[486] Complex systems of administration and management were set up to control the mining of metals and quarrying of stones throughout the

[485] Wilson 2012b, 142.
[486] Mattingly 2011, 130.

Empire,[487] testifying not only to the intense demand put upon the earth's resources under the Romans, but also to the ever present need of the Roman state for mineral resources.[488]

The mineral resources of the region were relatively low-value, lacking most precious metals and consisting mainly of non-argentiferous lead veins and iron. Aside from metals, stone and timber existed throughout the region in ample supply, from the Alps to the Lower Rhine. The local availability of resources is one of Cronon's first-nature inequalities which shaped regional economies.[489] Resource availability is also what economists term an "agglomerative force," helping cluster industry and productive enterprise.[490] The identification, exploitation, and management of these basic resources provided the strong foundation of regional development, enabling the construction of ornate urban centres, luxurious rural life, and frontier fortification. In addition, resources could be distributed as needed within the region in order to make up for micro-regional disparities which otherwise would have hindered development. The presence of these basic resources allowed for extensive industrial production to take hold in certain regions, allowing for the local production of building materials and metals as well as other industries such as glass and pottery production, which are discussed in the following chapter.

The organization of the management and administration of these resources was at least periodically linked to provincial administration. Epigraphic evidence, discussed throughout this chapter, demonstrates close involvement of the military and other state officials in many stages of production during certain periods. It is also clear, however, that private civilian enterprise also played a role in exploiting natural resources, particularly evident in iron production, discussed below.

This chapter explores the distribution of natural resources within the Rhine Basin through a detailed examination of the major geological feature within the landscape. The chapter then outlines the different strategies through which the

[487] Hirt 2010.
[488] Mattingly 2011, 138-39.
[489] Cronon 1991.
[490] Combes *et al*. 2008, xv.

region was exploited: through agricultural production, the extraction and smelting of of lead and iron, the harvesting of timber, and finally the quarrying of stone.

Geological formations in the Rhine basin

The Rhine and its tributaries cut through a varied landscape (see **fig. 4.1**), starting in the Alps and the Jura, descending to the plains of Alsace, bounded by the hills of the Vosges and the Black Forest, continuing north into the Central Rhenish Massif between Mainz and Cologne where the Hünsrück and Eifel ranges border on the east and the Taunus, Sauerland, and Siegerland border on the west, and then flowing through the lowlands of northern Germany and the Netherlands before draining into the North Sea. Each of these geological formations has a long history, and each contributed to the mineral resources of the region in their own way. The Romans identified and exploited many different resources throughout this area, though not always in a uniform fashion. What follows is a south to north journey through the geological formations of the region, with particular reference to their mineral resources. The entire region was heavily wooded, a topic to which we will return below.

The Alps, Swiss Plateau, and Jura Mountains

The headwaters of the Rhine and Aare rivers are situated high in the Alps, Europe's tallest mountain range, with multiple peaks above 4,000 m elevation. The Alps formed out of the Alpine Orogeny, an uplift event which began about 300 million years ago in the Tertiary period. Continued uplift has been caused by the collision of the European and Apulian subplates, causing approximately 1 mm of growth each year. The range is divided between the eastern, central, and western sections, with the waters of the Rhine basin mainly draining from the central alpine region. The landscape as it exists today is relatively young, having been formed by successive ice ages over the last two million years, creating the fertile Swiss plateau in the northern foreland basin, known as the Molasse Basin, that stretches from Lake Geneva into Bavaria and Austria. The numerous glacial lakes which surround this basin were also formed as the result of these ice ages.

The central Alps are composed largely of sedimentary stone, with large swaths of sandstone and limestone, with occasional igneous and metamorphic outcrops of granite and gneiss. The Swiss plateau is composed largely of sands and sediments delivered through glaciation and alluviation, with occasional boulders of granite brought down by glaciers. Despite the long geological history of the formation, the area of the Alps contained within the Rhine basin offered little in the way of mineral resources. Building stone was quarried near Augst and Avenches, with some fourteen quarries known in the region in total.[491] Most other resources, however, had to be imported.

The Jura Mountain range divides the Swiss plateau from the Upper Rhine Graben and the plain of Alsace. It also separates the Aare and Doubs watershed, and more generally divides the Rhône and Rhine basins. The Jura is part of the same geological formation as the Alps, though it is younger, formed during the Jurassic period about 200 million years ago. Similarly the creation of the collision of the European and Apulian tectonic plates, the highest peak in the Jura, the Crêt de la Neige of France, is 1,720 m, with the elevation gradually diminishing as the range moves northeast into Switzerland and Germany.

The Jura range is largely composed of limestones and marls, formed by sediment from the Tethys Sea, in existence during the Mesozoic period. Some rock salt deposits are currently worked near Rheinfelden and Basel on the northern side of the formation near the Rhine; discovered in the early nineteenth century, there is no evidence for Roman use. Stone was quarried near Augst for building material, but little other Roman mining or quarrying is known.

The Vosges, Black Forest, and Kaiserstuhl

North of the Jura, the Upper Rhine Graben divergence has caused the Upper Rhine valley to be flanked by north-south running ranges of low to medium height mountains—the Vosges in France and the Schwarzwald or Black Forest Hills of Germany. Both were formed in the middle Eocene period, roughly 45 million

[491] Staehelin 1948; Löhr 1976; Bedon 1984; Russell 2009.

years ago, as the spreading of the Upper Rhine Graben caused isostatic uplift on either side.

The Vosges Mountains run approximately 130 km north-northeast, divided into the upper, middle, and low Vosges, and have a high peak of 1424 m at Grand Ballon in the Haut Vosges. The range divides the Rhine from the Moselle watersheds. The Vosges have been substantially shaped by glacial activity, which in some areas has eroded away a substantial portion of the original height. This is most obvious in the Haut Vosges of the south which today are largely composed of Carboniferous stone, including granite, gneiss, and some volcanic inclusions. The northern stretches, less severely glaciated, are composed of Triassic and Permian red sandstone, the *grès vosgien* used to construct the cathedral in Strasbourg in the fifteenth century. This stone was quarried in the Roman period, with several stone quarries located in the Haut Vosges and several in the Bas Vosges near Strasbourg.[492]

Across the river, the hills of the Schwarzwald/Black Forest of Germany were formed by similar geological processes to the Vosges. This range, extending from the High Rhine to Karlsruhe 150 km to the north, has a high peak of 1493 m at the Feldberg near Freiburg im Breisgau near the south of the range. Eocene rifting resulted in the uplift of the range, which is composed largely of sandstone, with overlaying deposits of gneiss and granite. Unlike the Vosges, however, the Black Forest saw more developed Roman interest in local resources. Stone was quarried near the Roman settlements of Riegel and Baden-Baden, while iron ore was mined at Bad Bellingen-Hertingen in the south, at Freiburg, Denzlingen, and Ettenheim near Riegel.[493] The history of iron production in the region stretches back into pre-Roman times to the fifth c. BC, with some 20 Iron Age furnaces found at Neuenburg alone, along with 20 tonnes of Iron Age slag, south of Pforzheim.[494] The iron abundance was due to the layers of the so-called *Buntsandstein*—red-coloured sandstone containing on average 4% iron ore.[495]

[492] Other mineral resources of the formation, including silver and lead, were not mined until much later; cf. Fluck 1993, 270-71.
[493] Wagner 1993; Goldenberg 1993.
[494] Gassmann 2004, 102-106; Gassmann and Wieland 2008.
[495] Emmermann and Ree 1971, 28.

Lead was also mined at Badenweiler and Sulzburg in the south, and at Prinzbach, Elztal, and Kinzigtal in the central area of the range.

Between the Rhine and the hills of the Schwarzwald near Freiburg im Breisgau stands the extinct volcano known as the Kaiserstuhl. This impressive mound stands obviously in the flat floodplain of the Upper Rhine, having been active between 19-16 million years ago. It is composed largely of Jurassic and Tertiary sedimentary stone with volcanic inclusions. Today, the extinct volcano is mined for rare minerals, but in the Roman period it does not seem to have had much activity aside from the farming activity which took advantage of its fertile loess soils, accumulated in the last glacial period.

The Schwäbischen Alb

The Schwäbischen Alb is a low mountain range found east of the Black Forest, divided by the Neckar River, in the region bisected by the *Limes Germanicus* in the second century AD. The range, extending approximately 140 km on a SW-NE orientation, divides the Rhine Basin from that of the Danube, and has a high peak of 1,015 m at the Lemberg. The Alb is mostly formed of Jurassic limestone, and was formed in the same period as the Jura Range to the southwest.

Like the Jura, the Schwäbischen Alb has produced little evidence for Roman mineral extraction. Unlike the Jura, however, this region was only under Roman control for about a century. That said, the iron ores which were worked in the Iron Age and in the Alammanic period seem to have been largely untouched during the Roman period.[496] Iron furnaces and slag were found at the forts of Burlafingen and Nersingen, both from the mid-first century AD, on the Danubian *limes* just south of the Alb;[497] the iron may have come from the Alb deposits, but has not been positively sourced. Some stone was quarried on the fringe of the range near Rottenburg at Hechingen-Stein, though this region was generally unproductive in the Roman period.

[496] Böhm, Kempa, and Hauptmann 1995; Gassmann *et al*. 2005.
[497] Mackensen 1987.

The Pfalzerwald and Odenwald

North of the Vosges and Schwarzwald are geologically similar formations known as the Pfalzerwald/Palatinate forest and the Odenwald, both in modern-day Germany. West of the Rhine, the Pfalzerwald is separated from the Vosges by the Col de Saverne, extending roughly 100 km on a north-northeast orientation, with a high peak of 673 m at Kalmit. The range is predominantly *Buntsandstein* and to a lesser extent the older Permian *Zechstein*, a sedimentary stone. Sandstone was quarried at the Kreimhildenstuhl near Bad Durkheim, and iron was mined and smelted extensively at Eisenberg and Bliesbruck, both on the edges of the range.[498]

Across the Rhine, the Odenwald was divided from the Black Forest by the Neckar River and is bracketed by the Main River approximately 75 km to the north. The highest peak is 626 m at Katzenbuckel, located near the Neckar River in the south of the range. The Odenwald is largely composed of the *Buntsandstein* of the Lower Triassic period, with localized granite deposits. Granite was quarried at the Felsberg, and was used extensively for sculpture and inscriptions throughout the region.[499] There is little other evidence of resource production in the region.

The Rhenish Massif

The largest geological structure of central Europe, the Rhenish Massif is a massive slate formation which stretches from the Ardennes in Belgium to the Weser River in Germany. The massif formed during the Hercynian Orogeny, about 300 million years ago, when Pangaea was formed. The formation is quite distinct from the others so far discussed, being largely composed of Devonian slates, with older outcrops in some regions and multiple volcanic zones. The formation can be broken down into sub-regions, including the Eifel and the Hünsrück to the west of the Rhine, and the Siebengebirge (including the Sauerland, Siegerland, and Westerwald), Taunus, and Wetterau to the east of the

---

[498] Forrières, Petit, and Schaub 1987; Forrières, Petit, and Schaub 1989; Cüppers 2005, 358-62; Roller 2005, 284-85.
[499] Baatz 2002, 102.

Rhine. Roman rule only briefly extended to the Siebengebirge region under Augustus; imperial ambitions were halted by the defeat of Varus in AD 9. The Taunus and Wetterau, as discussed earlier, were part of Roman territory for the better part of two centuries.

Each of these zones offered its own range of mineral resources and possibilities. The Eifel range, located north of the Moselle River, was perhaps the most productive area within the Roman Rhine. The hills are composed mostly of Devonian slates, with outcrops of Cambrian and Ordovician stone in the Hohen Venn to the north and Carboniferous stone near Aachen. An abundance of slate, limestone, quarzite, and sandstone is augmented by the volcanic deposits of the so-called Vulkaneifel, a region centred on the town of Mayen, where over 100 extinct volcanoes active between 700,000 to 11,000 years ago provided pumice, basalt, and tuff. The Eifel is also rich in lignite deposits, the open-cast mines for which stretch across the landscape west of Cologne. The area was heavily exploited under the Romans, to the extent that some scholars believe it to have belonged to an imperial estate producing for the fiscus,[500] a point to which we will return below. The main industries seen in the archaeological and historical record revolve mainly around the extraction of lead, iron, and basalt, with lesser productions of copper, zinc, silver, and even gold.[501] This activity took place not only within the Rhine basin, but also extended into the neighbouring Maas basin, particularly near the Rur tributary, centred on the towns of Düren and Aachen, located along the *Via Belgica*. A large number of basalt quarries are known around Mayen and Andernach, tapping into the extinct volcanic fields in this area. These quarries were particularly used to craft millstones, which were used extensively throughout the region, in Germany, and in neighbouring provinces.[502]

South of the Moselle, the Hünsrück was also composed of Devonian and Carboniferous quarzite, slate, and shale. This region was not as productive as the Eifel, though iron and lead were both mined and smelted here. Lead smelting sites have been found at Bundenbach, Masterhausen, and Werlau, where Variscan lead

[500] Von Petrikovitz 1958, 599; Horn 2002, 154.
[501] Horn 2002, 154-60; Ritzdorf 2003; Rothenhöfer 2005, 77-119.
[502] Gluhak and Hofmeister 2008; Mangartz 2008; Gluhak and Hofmeister 2009; 2011.

veins were tapped.[503] Iron smelting furnaces have been found at Serrig, Horath, and Hochscheid, used to smelt iron found in deposits of hematite and limonite which run throughout the region.[504]

Across the Rhine, the Taunus and Wetterau regions form the southeastern part of the Massif. These hills were incorporated into the Roman frontier fortifications of the second century, though there is little evidence for mining or quarrying in the region. Lead was mined and smelted in the Lower Lahn valley, near the confluence with the Rhine at Lahnstein. A handful of sites are known at Bad Ems, Braubach, Lahnstein, Artzbach, and Holzappel, each located within the same Variscan mineral veins tapped in the Hünsrück.[505] Farther up the Lahn, near the Augustan settlement of Waldgirmes, is the Lahn-Dill area which is characterized by a high iron mineralization,[506] though the extent of exploitation under either the Romans or neighbouring Germans is mostly obscured by intensive mining activity in the middle ages and modern period.[507]

To the north, the adjoining region known as the Siebengebirge which includes the smaller zones of the Sauerland and Siegerland seems to have maintained an interesting relationship with the Roman Empire, despite being located outside its territory for most of history. The relatively brief incursions into the region under Augustus saw the establishment of the forts and fortresses along the Lippe River, which forms the northern boundary of the Sauerland. These forts, despite their brief existence, seem to have already been in direct contact with lead-producing Germans who were operating mines and smelting sites near Brilon, more than 100 km east of the Rhine.[508] After the establishment of the Rhine as the Roman frontier in AD 9, this German lead was still brought into the Empire over the course of the first century AD.[509] More than 20 lead-producing sites are

[503] Durali-Müller 2005, 3.
[504] Schindler 1976, 55-58.
[505] Durali-Müller 2005, 3.
[506] *Ibid*.
[507] Jockenhövel 1993b; Jockenhövel and Willms 2005, see now also Abegg *et al.* 2011 on Germanic mining in the Upper Lahn valley.
[508] Hanel and Rothenhöfer 2005.
[509] Rothenhöfer 2003a, 644-45.

known in the Sauerland and Siegerland,[510] making the Siebengebirge region a very productive neighbour of the Roman Empire.

The Rhine River valley and its tributaries

The valley of the Rhine River contains different sorts of resources from the other geological formations discussed here. The narrow valleys of the Alpine Rhine and High Rhine are cut through the surrounding Alps, Swiss Plateau, Jura, and southern Black Forest formations. Once the Rhine enters the Upper Rhine Graben, however, the wide floodplain offers a variety of sands, clays, and gravels.[511] The same can be said of the Lower Rhine, flowing through the continuation of Cenozoic Rift known as the Roer Valley Graben. In both these areas, the flood plains act as natural sponges for flooding, allowing for the deposition of sediment and silt which the otherwise narrow valleys of the Middle, High, and Alpine Rhine do not.

These sections of the Rhine valley allowed for different sorts of industry to develop. The fine clays of the Upper Rhine determined the location of the Rheinzabern terra sigillata factories, and similar situations can be seen farther downstream at Sinzig, and even up the Moselle at Trier.[512] Near Cologne, large sand deposits at Frechen and surrounding towns were instrumental to the city developing a large glass-producing industry.[513] As recently as WWII, the Frechen sand pits were producing over 100,000 tonnes of sand per year.[514] Both of these industries will be discussed in detail in the next chapter.

Clay—fine grained soil deposits commonly deposited by rivers with a heavy sediment load in floodplain areas—was widely available throughout the Rhine basin, particularly along the Upper and Lower Rhine. Major ceramic-producing centres, such as Rheinzabern, Trier, Cologne, Nida-Heddernheim, or Mainz (discussed in Chapter 6), were situated near major claybeds. The quality of clay was largely up to those working with it, depending on an artisan's ability to

---

[510] Durali-Müller 2005, 31-32.
[511] Preusser 2008.
[512] Roller 2005, 283-84.
[513] Fremersdorf 1965; Röttlander 1990.
[514] Fremersdorf 1965, 35.

refine their material to the grade that they needed. In addition to ceramic vessel production, claybeds enabled widespread production of building materials.[515]

The topographical relief caused by the incision of river valleys allowed for the deposition and concentration of loess soils (**fig. 4.2**). Loess—aeolian-deposited soils mostly post-dating the last ice age—is estimated to cover 10% of Europe today, and is both extremely fertile and extremely susceptible to erosion due to deforestation.[516] The latest map of loess distribution shows that the Upper Rhine Graben, Neckar basin, and the flatlands around Cologne are particularly rich in these deposits, so it is no coincidence that these are the areas where particularly dense farming settlement has been recorded.[517] The band of loess which skirts the northern edge of the Eifel range, the so-called Northern-European Loess Belt, formed the part of the *via Belgica*, running through the dense villa landscapes of the Aldenhover Platte, the Hambach Forest, and the region around Tongeren. Indeed, it was these villa landscapes which managed one of the most important resources of the region: agricultural fecundity.

Agriculture

Of all the natural resources present within the Rhine basin, none was more important than the fertile soils of the region that allowed for the widespread agricultural development that fed the rest of the region. Widely acknowledged as the backbone of the Roman economy by primitivists and modernists alike,[518] advances in agriculture under the Roman Empire allowed for production above and beyond subsistence level that allowed for diversification and specialization of economic activity.[519] The Rhine basin saw substantial intensification of

[515] On the production of CBM in the region see Drack and Fellmann 1988, 201-3; Baatz 2002, 102-3; Horn 2002, 175-76; Cüppers 2005, 286-88; Rothenhöfer 2005, 152-62; Amrein *et al*. 2012, 40-48.
[516] Haase *et al*. 2007.
[517] See pages 81-3 above.
[518] *E.g* Finley 1973; Greene 1986; Rothenhöfer 2005; Bowman and Wilson 2013.
[519] *E.g* Greene 1986; Salmon and Mattingly 2001; Kehoe 2007; Raepsaet 2009, 13-14; Roymans and Derks 2011, 18; Rice 2012; Bowman and Wilson 2013; Kron 2013.

agricultural production over the course of the first century AD, with continued innovation and development over the duration of the Roman era.[520]

The villa system

One of the most notable aspects of agricultural development within the region was the introduction of the villa system of production.[521] Villas, aside from being lavish country homes of the wealthy, are often seen as indicative of a system of agricultural production linked to large-scale agrarian production intended for market sale.[522] In Italy and elsewhere, villa estates are closely linked with a social hierarchy of wealthy landowner, tenant farmers, and slaves, though those studying other regions have questioned whether this model is universal.[523]

The usage of the Latin term 'villa' is not without problems,[524] as it has been used to describe structures ranging from small farms to the largest estates. Non-anglophone scholarship sometimes favours other terminology which adds to confusion—the German terms *Gutshöfe* and *Landgüter* are often used interchangeably with *Villen* to describe rural farm estates with no strict rule for any term. The difference between a villa and a farm is, therefore, rather subjective and difficult to establish as a solid rule, both in scholarship and in excavation.[525] Roymans and Derks distinguish four categories of rural farms in Gaul and Germany: large villas with double courtyards, small, post-built farmsteads within villa landscapes, small, single-compound villas, and post-build byre houses.[526] Some examples of the first group are discussed below.

The villa mode of production was a Roman introduction to the region, as it lacked any comparable system. By the second century, however, villas of various types and sizes were located throughout many parts of the Rhine basin (**fig.**

---

[520] See papers in Bender and Wolff 1991; Rothenhöfer 2005; Roymans and Derks 2011.
[521] Roymans and Derks 2011, 1.
[522] Slofstra 1991, 170; Roymans and Derks 2011, 21.
[523] Millett 1990, 94; Woolf 1998, 148; Roymans and Derks 2011, 21.
[524] Roymans and Derks 2011, 2.
[525] Though, as Rothenhöfer 2005, 45 notes, it is often impossible to identify and excavate the full extent of farming settlements, the Hambach Forest lignite-mining area being a rare exception.
[526] Roymans and Derks 2011, 23-24.

4.3).[527] These villas were particularly clustered within the zones of thickest Loess deposits—the Neckar Valley, the Upper Rhine Graben, and the North European Loess Plateau between Cologne and Tongeren where cereal production was most efficient due to topography. Other zones, like the Moselle valley, were also densely settled, using the slopes of the river valley and the Eifel hills for sheep grazing, particularly along the roads that linked Trier with Cologne. These zones produced grain, livestock, and, eventually, wine. Other regions, particularly the Dutch river area of Lower Germany, did not develop villa landscapes.[528] Instead, local environmental conditions favoured livestock over cereal production, and local traditions of post-built byre houses persisted.[529]

The richest of these villas matched those in elsewhere in Gaul and the Roman west in size, decoration, and undoubtedly production. The villa complex at Fliessem offers an example of the extravagance reached in the Rhine villa system.[530] Located just east of the road connecting Trier and Cologne in the Eifel, the estate was built sometime in the second half of the first century AD and inhabited until ca. AD 400. The Fliessem villa falls into the first category of villas outlined by Roymans and Derks and was a large, double-halled axial structure. The main house had at least 66 rooms in its final phase of construction, with at least 14 mosaics. The villa was part of an extensive estate with numerous other buildings and a perimeter wall that enclosed 5 km^2.[531] Other examples of villas with enclosed farmyards similar to that seen at Fliessem are known from Borg (DE) and Oberentfelden (CH), but are generally more common in France and Belgium than within the Rhine basin (**fig. 4.4**).[532] These villas were the largest and most luxurious, leading Roymans and Habermehl to conclude that they "were the residences of the upper social echelon of Gallo-Roman societies."[533]

527 This map lacks sufficient data for France, where data has yet to be made available in comparable form to Germany, Switzerland, Belgium, and the Netherlands.
528 Kooistra 1996; Roymans 2004; Roymans and Derks 2011.
529 Groot 2008a, 4-5; Roymans and Derks 2011, 2-4.
530 Wightmann 1971, 189-92; Cüppers 2005, 370.
531 Cüppers 2005, 368.
532 Roymans and Habermehl 2011.
533 *Ibid.*, 87.

The question of rural labour in the Rhine basin is an important one, but remains rather intangible.[534] The largest of the estates in the region, such as the double-halled villas described above, probably employed slaves to run the farm. The existence of slaves in and around the Rhine basin is documented through epigraphy, iconography, and, if interpreted correctly, shackle finds.[535] It is less clear whether the smaller villas and farm settlements of the region used slaves as well; often these farms were small enough that they could be managed by a family and not incur the added cost of buying and feeding slaves. Seasonal labour by itinerant workers is also relevant, as farmsteads would not need extra help through many stretches of the year, so permanent employment of excessive farmhands would have been difficult for many.[536] As Roymans and Zandstra conclude, much more work needs to be done on the labour force of farms and villas in the Roman north.[537]

Farming was widespread and, in some cases, could evidently be quite profitable. The owners of the above-mentioned villas were obviously wealthy, and this wealth is manifest in other monuments such as the Igel Column, a grave monument from the Moselle near Trier that commemorates the Secundinii, a family of successful wool producers in the Eifel region.[538] Other such monuments of wealthy rural residents and their associates are known throughout the region, from the monuments of the Moselle valley to the arch of Dativius Victor, dedicated by a *frumentarius* in Mainz.[539]

Imperial estates and the colonate system

The existence and organisation of imperial estates within the Rhine Basin is a matter of debate. Many have argued that some district(s) of the Eifel mining areas belonged to the Roman fiscus as imperial estates.[540] The evidence of imperial

[534] Roymans and Zandstra 2011.
[535] *Ibid*.
[536] Jeneson 2011, 271; Van Dinter *et al*. 2013, 28.
[537] Roymans and Zandstra 2011, 175.
[538] Drinkwater 2000.
[539] See Frenz1981; Crowley 2011; Krier and Henrich 2011.
[540] Petrikovits 1958, 599; Rothenhöfer 2007, 558.

involvement in lead mining is discussed below, where stamps on lead ingots suggest their origin in imperially owned mining districts ranging from the Augustan to Valentinianic period.[541] Whether this control was periodic, as is suggested below for other state involvement in resource management, or sustained is unclear.

Elsewhere, inscriptions from Germania Superior reveal the existence of several *saltus* in the region: the *saltus Nidensis,*[542] *saltus Sumelocennensis,* [543] and the *saltus t(ranslimitani)* in the civitas Alisinensis.[544] These estates were located in the territories of Nida-Heddernheim, Rottenburg, and Bad Wimpfen respectively. The traditional model of *saltus* organization is imperial ownership of land which is managed by wealthy *conductores* who collected rent from the *coloni* who worked the land.[545] Further evidence in the region comes from inscriptions naming *coloni* found at Kalhouse near Metz (*coloni Aperienses*)[546] and at Pachten on the Saar River (*coloni Crutisiones*).[547] These inscriptions, like those naming *saltus*, are the only references to these systems known, and no inscriptions of *conductores* have been found.[548] An inscription from Lyon, however, does name a man who, amongst other titles, served as *procurator patrimonii provinciarum Belgicae et duarum Germaniarum* under Alexander Severus,[549] suggesting that there were such estates in operation at this time, possibly the result of imperial land seizures following the Severan civil war.

With few examples, the involvement of the Empire in land management is tenuous, and it is perhaps this ambiguity that has led to the subject being largely ignored by scholars.[550] Given the density of villa settlement in the region combined with the natural wealth of the region, it is not surprising to find

[541] Hanel and Rothenhöfer 2005, 60-64; Rothenhöfer 2005, 93.
[542] *AE* 1913, 123.
[543] *CIL* 13, 6365.
[544] *CIL* 13, 6482.
[545] Kehoe 1988; 2007.
[546] *AE* 1919, 85.
[547] *CIL* 13, 4228.
[548] Johne 1994, 80 outlines supposed iconographic evidence of *coloni* from the Moselle region. Both Johne 1994, 79 and Rothenhöfer 2005, 42 hypothesize that a similar system must have existed in Germania Inferior, though it is not evident outside of lead production.
[549] *CIL* 13, 1807; Woolf 1998, 43; Eck 2004, 548
[550] There is no mention of imperial estates in the recent volume by Roymans and Derks (ed) 2011.

evidence for the involvement of the imperial fiscus in land management. The organization of this system along the Rhine remains elusive, however, and the extent of imperially-owned land is unknown. It is believed that many of the villas of the region, particularly within the northern loess belt and around Cologne, were owned by private individuals, many of whom were probably veterans.[551] The evidence discussed here suggests that a multitude of land-management systems probably existed within the region, and these could well have changed over time.

Surplus production

The relevance of this discussion of villas and villa economies rests on the goods that these estates, no matter their size or labour organization, produced. Research into the productivity of different zones within the Rhine region is varied and tends to have interested scholars in the Netherlands more than in Germany or France. While this section explores what evidence there is for productive capacities, it must be understood to be fragmentary and, at times, necessarily inferential. Regardless, much like the settlement and demographic data discussed in the last chapter, the evidence discussed below reveals an estimate of productivity that may be easily increased, but is difficult to lower.

Nearly two decades ago, Kooistra investigated the agricultural potential of two diverse landscapes along the Rhine frontier: the Dutch river area around the Kromme Rijn and the loess plateau west of Cologne.[552] Both of these zones were densely settled, with some 86 farmsteads known near the Kromme Rijn and at least another 60 between Cologne and Maastricht.[553] The farms in these two regions were quite different; in the Dutch river area, they were mainly post-built byrehouses where families and animals often shared one roof, while in the loess

[551] Woolf 1998, 163-64; Roymans and Derks 2011, 20-21.
[552] Kooistra 1996.
[553] More recent research by Jeneson 2011 has demonstrated a much higher density of settlement in this region than previously thought, due to an underappreciation of timber-built farms alongside the more-visible stone counterparts. Densities reached upwards of three or more farms per km^2, particularly near the vicus of Iülich just beyond the edge of the Rhine watershed.

zone, large villas developed.[554] By calculating land availability, crop yields, and population densities, she concluded that both of these zones were capable of producing an agricultural surplus above and beyond what could be consumed locally.[555] The loess zone in particular produced a large crop of mainly spelt wheat, though barley, emmer, and bread wheat were also common,[556] and grain originating from this area is thought to have been widely distributed.[557]

An influx of veterans to this area from ca. AD 50 onwards helped spur the agricultural development,[558] probably including land centuriation at least as far away as Tongeren from ca. AD 70.[559] In the Dutch river zone, settlement was forced to cling to the higher river levees as they were the only land dry for most of the year, and while they did not have access to as much farmland as more southerly regions, a dynamic mix of cereal production and animal husbandry also meant that this region could produce a surplus.[560] Subsequent investigations of agriculture in the Rhine delta have augmented these conclusions, demonstrating that barley and emmer became the dominant cereal crops by AD 100, with both cattle and horses being raised on the low-lying flood plains surrounding the river levees.[561]

Recent work by Wendt and Zimmermann, mentioned in the previous chapter, on settlement density and surplus production has argued that it was not just the Dutch river area and the loess belt that were densely settled and productive.[562] Focusing mainly on the Rhineland, but also including areas of the Wetterau and Neckar, the authors conclude that with 304,000 ha of agricultural land under cultivation, modest estimates suggest a surplus of over 16,000 t of cereal would be produced each year in this area alone.[563] This study also produced a map (**fig. 4.5**) of rural farm density within their study region (which

[554] Kooistra 1996, 66, 95.
[555] *Ibid*., 72-3, 103.
[556] *Ibid*., 96.
[557] Cavallo, Kooistra, Dütting 2008, 77; Kooistra *et al*. 2013, 15.
[558] Rothenhöfer 2005, 47.
[559] Bonnie 2009, 93.
[560] Kooistra 1996, 72-3.
[561] Cavallo, Kooistra, Dütting 2008; Groot 2008; Vossen and Groot 2008; Groot *et al*. 2009; Kooistra *et al*. 2013; van Dinter *et al*. 2013.
[562] Wendt and Zimmermann 2008.
[563] *Ibid*., 23.

unfortunately does not include France) which, with almost 4000 villa sites included, demonstrates just how intensively farmed the Rhine basin was, particularly near Cologne and in the Neckar basin.[564] This can be viewed in conjunction with a map of villa settlement in France (**fig. 4.6**), which shows a high density in the Lorraine region.

The Roman period saw a massive increase of land under cultivation along the Rhine, alongside the development of large farming estates (like Voerendaal Ten Hove (NL),[565] with an estate of ca. 450 ha or Bellach (CH), with an estate of ca. 2200 ha)[566] with some contingent of slave labour.[567] Technological developments such as the reaping machine known from several reliefs from Buzenol, Arlon, Trier, Reims, and Koblenz meant harvesting was faster and more efficient.[568] Diverse and dynamic agricultural practices adapted to local conditions—cattle and horses in the river delta, grain along the loess zones, wool and wine along the steep slopes of the Moselle valley (discussed in the next section).[569] New crops were introduced—rye, oat, opium poppy, dill, celery, beets, garlic, a variety of fruits, walnuts, and domestic fowl are all found on Roman sites, but not before.[570] Simply put, this was not the agricultural regime of a subsistence society.

There was certainly chronological variation in the agricultural productivity of the region. Already mentioned was the effect of veteran settlement outside Cologne in the mid first century AD leading to intensification of production in that region. Also mentioned was the fact that, by AD 100, rural communities in the Netherlands were focused on what the landscape could best produce—barley and livestock. Widespread settlement in the second century, most notably enabled by the annexation of the Agri Decumates in modern Baden-Württemburg, meant that the period between ca. AD 150 and 250 saw the height of rural settlement and

[564] *Ibid*., 21.
[565] Rothenhöfer 2005, 49.
[566] Schuchany 2011, 279.
[567] Roymans and Zandstra 2011.
[568] Greene 1986, 87; Roymans and Derks 2011, 19.
[569] Drinkwater 2000; Brun and Gilles 2001; Brun 2005.
[570] Kooistra 1996, 64-5; Bakels and Jacomet 2003, 543.

production within the Rhine basin.[571] The troubles of the third century caused a noticeable decline of rural settlement in Lower Germany, already noted in Chapter 3,[572] but also seen in the Netherlands.[573] These effects were local, however, and other regions, such as the Moselle valley, saw continued prosperity through the fourth century, particularly as viticulture became a key part of this region's economy.[574]

Two passages of Ammianus suggest that the Rhine frontier zone was not producing enough grain to support campaigning armies in the mid fourth century. In AD 354, Constantius tried to import grain from Aquitania to supply his troops, but was unable due to high floodwaters in Gaul.[575] Several years later, British grain was imported under Julian to support his campaigns in AD 359.[576] It is unclear how common these instances were,[577] though Ammianus' phrasing "*a Brittannis sueta transferri"* (accustomed to being transferred from Britain) suggests that it happened more than once. It is possible that the depopulation seen in the countryside outside of Cologne (see Chapter 3) from the third century on, led to a decline in agricultural output.

Wine Production

Today, the Moselle valley and Middle Rhine regions are well known for their vineyards and in the period 1990-2011, Germany was ranked as the seventh largest producer of wine in the world.[578] The fertile soils of the banks and vineyards of the Moselle were remarked upon by Ausonius in his *Mosella* of AD 379, and indeed archaeological investigations have since revealed impressive wine-pressing installations between Trier and Koblenz on the Moselle, in addition

571 Rothenhöfer 2005, 73.
572 Gechter and Künow 1986; Jeneson 2011.
573 Kooistra 1996.
574 Van Ossel 1992, 74; Esmonde-Cleary 2013, 273.
575 Ammianus (14.10.2).
576 Ammianus (18.2.3).
577 Fulford 1989b, 196; Fulford 2004, 316.
578 Deutscher Wein Statistik 2011, 13: http://www.deutscheweine.de/icc/Internet-DE/med/68a/68a3098f-c19f-0931-7124-5cc6f135e25d,11111111-1111-1111-1111-111111111111.pdf

to elsewhere along the Middle Rhine.[579] The soils of the region, with a mixture of lime and volcanic deposits courtesy of the local Vulkaneifel, in conjunction with a climate composed of abundant sunny days and long autumns created good conditions for wine growth.[580] The slopes of the Moselle also helped provide maximum sun exposure and shield vines from winter winds, creating an ideal place for vineyard development. Two centuries after Ausonius, the Merovingian poet Venantius Fortunatus similarly described the bountiful vines of the Moselle region (10.9.16-45), and his contemporary Gregory of Tours mentioned the wine of Alsace (Hist. Franc. 9.38).

The origins of Roman viticulture along the Rhine are obscure. Scholarly tradition holds that an edict issued by Domitian, mentioned by Suetonius (*Dom.* 7.2), forbade provincial wine production and, two centuries later, was repealed by Probus in AD 276.[581] Provincial wine production elsewhere in the Empire was never seriously affected by Domitian's edict, and there is no reason to suspect that any potential viticulturalist would have not grown wine along the Moselle while others were already doing so in central Gaul and southern Britain in the second century.[582]

Several lines of evidence must be drawn together to better understand the development of viticulture along the Rhine frontier: first, the local production of wine amphorae from the early second century into the late third, second, the sudden appearance of large-scale wine-pressing installations along the Moselle in the late third and fourth centuries and, finally, changes in the importation of foreign wine over time. The issues of amphorae production and wine trade are discussed in depth in Chapters 5 and 6, so suffice it to say here that the local production of amphora forms Gauloise 4 and a closely-related flat-bottomed form known as the Niederbieber 74/75 in the early second century at a number of kiln sites along the Moselle, Main, Rhine, and Neckar is highly suggestive of contemporaneous production of commodities to fill them. Judging from the

---

579 Brun 2005; Brun and Gilles 2001; Reuter 2005b;
580 Brun and Gilles 2001, 165-66. It is currently unclear if climate change played any role in improving growing conditions.
581 Laubenheimer and Brun 2001, 7.
582 Brun and Laubenheimer 2001, 211.

contents of other flat-bottomed, Gallic amphorae, wine seems to be the most probable candidate.[583] There are, however, no vineyard sites known from this time period in the Rhine region. By the time that wine production becomes archaeologically visible, amphora production ceased, indicating that local wine must have travelled in barrels.

The lack of production sites could well be a problem of archaeological visibility. While lever- or screw-presses like those found elsewhere stand out as clear evidence of wine production, such remains are more indicative of a higher production scale and investment.[584] Wine can, however, be produced with much simpler technology, with the most basic method being treading grapes manually on prepared surfaces. Such surfaces may be multi-purpose and therefore hard to identify firmly for wine production. Furthermore, given the apparently confined space of Roman wine production in this region, it may well be the case that earlier vineyards underlay those of the third and fourth centuries which have been excavated largely through rescue work,[585] or remain underneath modern vineyards that cover the river valley.

The excavated production centres of the late third and fourth centuries in the region reveal impressive capabilities of production (**fig. 4.7**).[586] Dozens of sites have been identified on the Moselle and, to a lesser extent, Middle Rhine with wine presses or pressing elements in addition to storage facilities for barrels. The villa at Bad Durkheim-Ungstein (see **fig. 4.7**), located between Worms and Speyer in the Pfalz, produced wine in a large press-room that contained a pressing floor measuring 14 x 4.5 m, fronted by three settling tanks, and storage space for barrels measuring 23 x 15 m from roughly the end of the third to the middle of the fourth century.[587] The pressing capacity suggests a vineyard of roughly 30-40 ha.[588] On the Moselle (see **fig. 4.8**), a late-Roman wine pressing installation of the fourth and fifth centuries was discovered at Piesport with two large treading floors

583 See Laubenheimer 1995 on Gallic amphorae forms.
584 See Marzano 2013b on investment in pressing facilities.
585 Gilles 1995; Brun and Gilles 2001.
586 Brun and Gilles 2001; Brun 2005.
587 Bernhard 1984; Brun and Gilles 2001, 167-68; Cüppers 2005, 318-19.
588 Bernhard 1984.

(25 m^2 each) situated above a lever press whose baskets flowed into at least six settling tanks with a combined capacity of some 75,000 L, suggesting a vineyard of up to 60 ha size.[589] These figures are of course maximum estimates, but instructive nonetheless.

While many other sites have been found with notable remains of wine production throughout this region, the two examples cited here give clear evidence to two important details. First, the vineyards of this period could be sizeable—30-60 ha of vine growth compares to the 40-50 ha of cereal production suggested by villas in the Eifel range,[590] though the wine was certainly more valuable. Second, the production infrastructure required to produce this volume of wine, including the large lever press at Piesport, suggests serious investment by landowners in equipment, facilities, and productive output.

One of the most tangible effects of the establishment of an imperial capital at Trier in the agricultural sphere is the intensification of wine production along the Moselle valley. Serious investment in local wine production came relatively late to the Rhine region. The region was already wealthy, but the proximity of the imperial court with its associated demands meant that the Moselle turned into the new imperial hinterland, much like Rome and Latium centuries earlier.[591] That this chronology directly overlaps with the development of Trier as an imperial capital cannot be coincidence, and must be seen as a serious motivator to the developments seen here in wine production.[592] While local ceramic evidence suggests an early-second century start date, the production evidently was not of a sufficient level to leave identifiable archaeological remains. Local producers must have had difficulty competing with larger-scale vineyards in southern and central Gaul, whose products continued to be consumed in large numbers along the Rhine through the mid third century.[593] As Trier's power and demand grew, however, local vine growers responded in kind, investing in their productive facilities and

[589] Brun and Gilles 2001, 169.
[590] Rothenhöfer 2005, 47-48.
[591] On the effects of the demands of the city of Rome on its hinterland see, *inter alios*, Morley 1996; Marzano 2013a.
[592] Kuhnen 2003.
[593] See Chapter 6 below.

increasing their output, setting the scene for nearly two millennia of wine specialization in the region. The regional influence of Trier also set the Moselle valley and surrounding region apart from the rest of the Rhine basin in the late period, reflected also in ceramic and glass production discussed in the next chapter.

Lead Mining and Production

Lead was one of the most commonly mined minerals within the Rhine Basin (**fig. 4.9**). The widespread availability was due to the many Variscan and post-Variscan geological formations of the region, particularly within the Rhenish Massif. The deposits in the Eifel and the Black Forest were worked already from the Iron Age period, with unbroken continuity into the Roman era.[594] Because of its low silver content, German lead is not widely known.[595] Tacitus (*Ann*. 11.20.3) relates the story of Curtius Rufus, *legatus propraetore* of Germania Superior, who conscripted his soldiers into digging for silver near Wiesbaden, only to have his troops come near revolt for the hardship of the work with little return. Recent research has shown, however, that the importance of local lead sources within the Rhine region must be reconsidered, and it is argued here that they were a critical factor in the conquest of the region as well as the development of the local economy.

Lead normally occurs in galena ores which generally contain, on average, 86.6% lead by weight. Galena was mined in the North Eifel and the northern Black Forest. Other ores, such as cerussite (77.5% lead by weight) and anglesite (74% lead by weight) are derivations of galena after surface weathering, and these were also extracted within the Rhine Basin.[596] Other minerals such as zinc, copper, and silver were often found in conjunction with lead ore. The process of lead production started with the extraction of the ores. In the Rhine area, ores occurred fairly close to the surface and were exploited through open pit mining,

[594] Duralli-Müller 2005, 7-8.
[595] Duralli-Müller *et al* 2007, 1555.
[596] Duralli-Müller 2005, 10-11; Bode 2008, 7-8.

which in some areas (near Heidelberg) could go as deep as 37 m. Once extracted, the ore had to be crushed and sorted by weight.[597] Once the lighter dross was removed, the crushed ore was then smelted in order to extract the metal and sublimate impurities. To produce lead, ore had to be "roasted" within a smelting furnace to a temperature near 1000º in order to produce lead oxide and sulfur dioxide gas.[598] The gas was expelled through the top of the furnace, while the lead accumulated in the bottom.[599] The lead could then be cast into ingots or "pigs" for transport. This chain of production typically took place close to the site of extraction, as moving anything but the ingot was inefficient.

The locations of lead mines have already been outlined above, with particular concentration in the Eifel and Sauerland, and lesser activity in the Black Forest and Hünsrück. The Eifel and Sauerland deserve more attention, as both demonstrate interesting administrative and chronological developments in the production of lead in the region. In the Eifel, the largest mines seem to have been based near Gressenich, Berg vor Nideggen, and Mechernich, all located in the northern edge of the range where both galena and cerussite was available. At Gressenich, work began around AD 75 and continued into the third century.[600] A five-meter thick slagheap alongside a deep extraction pit was discovered in the nineteenth century, with other slag heaps found in the nearby towns of Werth and Mausbach.[601] Just south of Berg vor Nideggen, mining pits, remains of furnaces, and slag heaps demonstrate Roman activity dated from the second to the fourth centuries.[602] At Mechernich and the surrounding region, mines tapped into the so-called "Mechernicher-Triasdreieckt", a deposit of sandstone impregnated by lead ore.[603] Two sites in particular, the Tanzberg bei Keldenich and the aptly named Bleiberg bei Kommern, demonstrate the largest amount of activity, both located along the Trier-Neuss road built in the second decade BC.[604] A 20 m deep

[597] Craddock 2008, 101.
[598] Bode 2008, 9-10.
[599] Durali-Müller 2005, 10-11.
[600] *Ibid*., 7-8.
[601] Rothenhöfer 2005, 90, n. 100.
[602] Petrikovits 1956; Bachmann 1977.
[603] Rothenhöfer 2005, 88.
[604] *Ibid*., 88.

opencast mining pit was found north of Mechernich.[605] An ingot found in the excavations of the Augustan fortress at Haltern on the Lippe has been matched to these sources by isotopic analysis,[606] a topic to which we will return below. Of particular interest is a lead ingot found at Mechernich weighing 268 g (about 10 Roman *unciae*) which was stamped "LEGXVI", indicating the involvement of the sixteenth legion in lead production.[607] This legion was stationed at Neuss from AD 41-70, and rebuilt their fortress in stone around AD 50, requiring a large amount of lead as well as stone from the Brohltal near Bonn.[608] Activity in the region continued into the fourth or fifth century, with the latest clear activity coming from the villa at Ahrweiler, to be discussed more below, where lead production is evident in levels ca. AD 400.[609]

Across the river, the Sauerland produces equally intriguing evidence for lead production. Unlike the Eifel, however, this region was only briefly integrated into the Roman Empire, and was given up after AD 9. Despite the brief occupation, the region produced a large amount of lead from the late first century BC into the first century AD, demonstrated through multiple pieces of evidence. First, despite the fact that Germanic tribes generally did not use lead, Germanic settlements in the Sauerland region produce a large amount.[610] Particularly around the towns of Brilon and Soest, located between the Lippe and Ruhr rivers approximately 100 km east of the Rhine, lead objects are commonly found. One of the most interesting artifacts yet recovered is a lead ingot which preserves a stamp reading "L.FLA[--]" found in the town of Bad Sassendorf, south of the Lippe River.[611] This ingot has been related, on account of its size, shape, and partial inscription, to the 5.5 tonnes of lead ingots found on the Augustan-era St. Maries-de-la-Mer 1 wreck found off the coast of southern France stamped with

---

[605] Durali-Müller 2005, 8.
[606] Bode *et al*. 2003, 202. The ingot must predate AD 9, as this legion was destroyed in and the fortress was abandoned following the Teutoburg defeat.
[607] Horn 2002, 156; Rothenhöfer 2005, 89.
[608] Rothenhöfer 2005, 89.
[609] *Ibid*., 91.
[610] Rothenhöfer 2003a.
[611] *Ibid*., 643-44.

"L(vcii) FLAVI(i) VERVCLAE PLVMB(vm) GERM(...)".[612] These ingots, in turn, have been matched with another lead pig found near the mouth of the Rhône stamped "SOCIORVM PL(v)MB(vm) GER(...), as well as a dozen ingots on board a shipwreck located north of Sardinia at Rena Maiore which bore the inscription "AVGVSTI CAESARIS GERMANICVM" and one other stamped "PVDENTIS GERM(...).[613] That same name, Pudens, is also known on a lead object found in Brilon, Germany, stamped "PVDENT".[614] Hanel and Rothenhöfer have argued that the final words on the ingots from the St. Marie-de-la-Mer 1, the mouth of the Rhône, and the wreck north of Sardinia should be reconstructed as GERM(anicvm), as the other ingots on the Rena Maiore wreck were stamped. This is contrary to Domergue's original interpretation of PLUMB(vm) GERM(anvm), that is, 'genuine lead'.[615] The link, then, between these wrecks and the Sauerland is L. Flavius Verucla, documented in Germany and the Mediterranean, who may have been a contractor operating lead extraction in the trans-Rhenian region under Augustus. The lead produced in these mines made it as far away as the Mediterranean, possibly bound for Rome.[616] The proximity of the Roman camps along the Lippe River, especially at Kneblingshausen only some 10 km north of Brilon, further supports the idea of direct Roman involvement in the production before AD 9 when Roman activity in the Sauerland was abandoned.[617]

Isotopic analyses of lead ingots add further weight to this argument. A large number of objects from Germany and farther afield have now been sampled by researchers interested in determining their source. In one study, the above-mentioned lead ingots with possible trans-Rhenian origins were sampled in conjunction with lead finds from Germanic settlements in the Sauerland, Roman military camps along the Lippe, and Roman camps on the Rhine.[618] It was found that the lead deposits of the Rhenish Massif were indistinguishable from each

[612] *Ibid*.
[613] Rothenhöfer 2005, 92.
[614] Hanel and Rothenhöfer 2005, 56-57.
[615] Long and Domergue 1995; Rothenhöfer 2003a, 642-43.
[616] Hanel and Rothenhöfer 2005.
[617] *Ibid*., 61-62.
[618] Bode 2008.

other, but quite distinct from other lead sources in the Empire. The stamped ingots from the Mediterranean were found to have originated from the deposits in the Rhenish Massif, adding isotopic evidence to the epigraphic and archaeological arguments posed by Hanel and Rothenhöfer, but Bode was not able to prove their Sauerland origin in this manner. Bode concluded, however, that based on the ample evidence suggesting Germanic production of lead in the region, that it was very possible that at least some of this material was produced across the Rhine.

A second study collected lead from other regions of the Rhine, with 240 lead artifacts from the sites of Dangstetten, Wallendorf, Waldgirmes, Mainz, Martberg, and Trier analyzed.[619] These sites ranged in date from late Iron Age to late Roman, providing a useful time series for comparison. It was found that lead sources in the Rhenish Massif were already being used at Wallendorf by Celtic tribes before the conquest and these same sources were taken over almost immediately by the Romans. Lead objects from the Augustan-era sites of Waldgirmes and Dangstetten—located nearly 330 km apart—already showed clear use of the Massif lead in both sites. Lead from the Massif Central of France was also found at Dangstetten, suggesting multiple suppliers at this period. The material from Mainz, dating from AD 100-400, came entirely from the Rhenish Massif, though the material from Trier and the Martberg, roughly contemporaneous, was split between local sources and lead from the southern Pennines in Britain. The authors hypothesized a chronological narrative where the earliest Roman settlements in the region either directly controlled lead extraction or traded with locals who were already exploiting the sources. Lead from other sources was also used, notably from central France. Over the course of the following century, control moved firmly into Roman hands and lasted into the third century at least, judging by evidence found in mining districts. At this point, lead from Britain entered the system, possibly to augment or supplement the Massif production.

This narrative is compelling, but it can be fleshed out more. The history of lead production within the Rhine Basin began long before the Romans, but local

[619] Durali-Müller *et al*. 2007.

knowledge was absorbed following the conquest. Eifel lead quickly made its way into Roman hands, and the impetus of trade possibly spurred Germans residing across the Rhine to start similar production. Following the Teutoburg defeat east of the Rhine, Roman control focused on the Eifel region, whence lead was distributed throughout the region and even farther afield into the Mediterranean. The military, it seems, particularly benefitted from this production, especially when rebuilding their forts in stone. Production spread as the Romans moved back across the Rhine, tapping into several deposits in the northern and southern extents of the Black Forest. After the contractions and changes of the third century, the mines across the Rhine were lost, and the Eifel production may have slowed, possibly explaining the appearance of British lead in the region in the late-Roman period. It is, however, possible that this lead was simply brought into the region by traders crossing the Channel, as continuing activity is evident in the Eifel range at Ahrweiler ca. AD 400. In addition, lead ingots found along the Moselle near Cochem-Zell in a hoard dating to the fifth century AD have also been sourced to the Eifel deposits at least to the time of Valentinian II (425-455).[620] Lead was a basic requirement for all building activity throughout the region, in addition to many other daily uses. The local production of the material was a benefit to the region, and formed a crucial part of the productive landscape of the Rhenish Massif.

Iron Mining and Production

Lead was not the only important metal mined in the Rhine Basin; iron was similarly exploited throughout the region, with equal significance to the local economy (**fig. 4.10**). Like lead, iron was produced in the Rhine Basin long before the Romans arrived. Substantial remains of iron production are evident from the Hallstatt period onwards, with some sites, like that of the previously mentioned Neuenbürg in the Black Forest (seventh – fourth c. BC), demonstrating large-scale

[620] Rothenhöfer 2007, 556-58.

production of iron.[621] Other sites, such as Hillesheim (Hallstat D3) in the Hünsrück, demonstrate that production was widespread, utilizing multiple ore sources from early on.[622] The distribution of pre-Roman iron ingots further shows that this production was not just aimed at local use, but already was integrated into a regional trading network.[623]

The widespread availability of iron in the region was due to the presence of several geological layers, the lower-Permian *Rottliegend* (sandstone), the mid- to upper-Permian *Zechstein* (sedimentary stones including halite and shale), the lower-Triassic *Buntsandstein* (red sandstone), the middle-Triassic *Muschelkalk* (limestone), and then the upper-Triassic *Keuper* (shale). Each of these layers can be highly ferrous, containing *Brauneisenstein* (limonite) and *Roteisenstein* (hematite). Roman-period activity in the deposits within the Black Forest, the neighbouring Schwäbischen Alb, the Hünsrück, and the Eifel is particularly evident, as outlined above. These ores were available in surface deposits which could be mined through shallow pits, so-called *Pingen*, which are found throughout the southwestern Black Forest near Wiesloch,[624] in the Eifel near Ahrweiler,[625] Bad Münstereifel-Arloff, Eschweiler-Hastenrath, Nettersheim, and Berg bei Nideggen,[626] as well as near the Eisenberg at the northern end of the Pfalzerwald.[627] These *Pingenfelden* could be quite extensive—at Ahrweiler they covered some 20 km², interspersed with smelting sites composed of furnace remains and slag heaps.[628]

The production of iron was similar to that of lead. Deposits of hematite and limonite were mined for ore, which would then need to be crushed and separated. The iron ore would then be placed into a bloomery furnace with charcoal at a 1:1 ratio and heated to about 1,000-1,200º C for about twelve

621 Gassmann 2004; Gassmann and Wieland 2008.
622 Haffner 1971; Emmermann and Ree 1971.
623 Kleemann 1977; Wells 1995a; Wells 1995b.
624 Wagner 1993, 32.
625 Roller 2005, 284-85.
626 Horn 2002.
627 Roller 2005, 284-85.
628 Ritzdorf 2003; Roller 2005, 284.

hours.[629] A single furnace could produce about 20-30 kg of iron and another 4 kg of slag per firing.[630] Dozens of Roman furnaces have been found throughout the region, unsurprisingly concentrated around the iron ore sources in the Eifel, Hünsrück, Pfalzerwald, and Black Forest.[631]

A comparative study of medieval iron production in the Lahn-Dill region suggests a model of organization which may have been in place as far back as the Roman period, to judge by site layout.[632] The basic technology in use to produce iron was the same from the Iron Age until the introduction of the blast furnace in the fourteenth century.[633] In this area, ore could be transported up to 15 km from mine to smelting site, which was often determined based on the availability of fuel for the smelting process. Smelting sites generally measured 200-250 m², including ore-dressing stations, charcoal stores, smelting furnaces, and a slag dump. These were generally located away from settlements, and could be operated by small groups of workers. If a furnace could produce between 25-35 kg of iron per roughly two-week firing period, a furnace could produce upwards of 800 kg per year, meaning that the production of a multi-furnace site could produce tons of iron each year. As fuel sources ran out, a smelting site could move, and this may well account for the large size of production zones at sites like Ahrweiler.

Ahrweiler and surrounding sites deserve further discussion in conjunction with iron production, as excavations of several villas in the region have produced substantial evidence for iron production with important implications for the organization and scale of production in the region. The Ahr is a small tributary of the Rhine which flows out of the northern Eifel range, its mouth located about halfway between Andernach and Bonn. The lower stretch of this river valley has produced some two dozen smelting sites along with mining pits and slag heaps, dating between the first and fifth centuries AD.[634]

---

[629] Gassmann and Wieland 2008, 142-43.
[630] *Ibid*., 143.
[631] Schindler 1976; Ritzdorf 2003.
[632] Jockenhövel and Willms 2005, 610-15.
[633] *Ibid*., 610-11.
[634] Ritzdorf 2003.

The site of Ahrweiler 5, discovered in the mid-twentieth century, was a Roman villa with a perimeter wall enclosing 0.8 ha. Several slag heaps were found outside the main villa building, one measuring 198 m^2, another 82 m^2, and a third measuring 140 m^2, in total roughly 1,050 tonnes of slag, two of which included Mayen pottery of the fourth c. AD.[635] This amount of slag suggests a total production of about 300 tons of iron.[636] In addition, nine smelting furnaces were found, all of similar construction with an inner diameter of 0.5-0.7 m.[637] The iron ore used at this site came from the nearby Breite Kopf, a hill to the north of the villa.[638] The Breite Kopf is surrounded by mining pits, some as large as 50 x 30 m and reaching depths up to 2 m.[639] Iron production was well integrated into the micro-regional economy, with *Pingen* at two other sites, "Schnälzhardt" and "im Turmrott", 8 ha and 12 ha respectively,[640] as well as a dozen other sites with slag or furnace fragments dating to the third – fifth c. AD.[641]

North of the Ahr valley, sites in the already mentioned Mechernicher-Triasdreieckt were producing iron alongside lead, particularly near Berg vor Nideggen, where a 9 km² area produced 12 production sites and nearly one hundred *Pingen* from which limonite was mined.[642] Ceramic evidence suggested use from the mid second century until the end of the fourth, similar to the chronology of lead production outlined above. At Bad-Münstereifel and the surrounding area, including Mechernich and Blankenheim, further slag heaps and furnaces were found, including a large *Pingenfeld*, measuring 450 x 180 m, at Nettersheim, with ceramic evidence ranging from the second to fifth centuries.[643]

South of the Moselle River, several iron-producing sites are known.[644] The area between Freudenberg, Saarburg, and Schillingen is rich in both limonite and hematite, and numerous Roman settlements in the area produced slag and furnace

[635] *Ibid*., 37-42.
[636] *Ibid*., 56.
[637] Ritzdorf 2003, 43.
[638] *Ibid*., 60.
[639] *Ibid*., 61.
[640] Rothenhöfer 2005, 80-81.
[641] Ritzdorf 2003, 70-73.
[642] Petrikovits 1960; Ritzdorf 2003; Rothenhöfer 2005.
[643] Ritzdorf 2003, 87-91.
[644] Schindler 1976.

remnants.[645] A large furnace was excavated at Bengel, dating to the late third/ early fourth c. AD, and others of similar design and date are known at Wichten in Luxembourg and Weyer in Germany. A villa at Horath had two furnaces, dated between the second and fourth centuries, and another was found at a temple in Hochscheid.[646] Finally, a site at Serrig produced both slag and a furnace dating from the second c. AD.[647]

To the south, the well-named vicus of Eisenberg was located at the northern end of the Pfalzerwald, located on the road between Worms and Metz.[648] The settlement measured a mere 4.5 ha, but was heavily involved in the production of iron, thanks to the local availability of ferrous *Rottleigend* and *Buntsandstein*, the latter up to 30% iron by weight.[649] Production of iron is noted from the mid first century onwards, and was probably the reason for the founding of the vicus in the first place.[650] Three furnaces were excavated in the nineteenth c., one of which is now preserved in the Historischen Museum der Pfalz in Speyer.[651] Excavation also recovered a reportedly "massive" slag heap 5 m deep, though other dimensions were not recorded.[652] Production continued in the town into the mid fourth century, when the town was destroyed, presumably by the Alamannic incursions of Chnodomar in 352/53.[653]

Across the Rhine in modern Baden-Württemburg, deposits of poor-quality limonite were mined and smelted at Pforzheim on the northern tip of the Black Forest, near Haueneberstein and Ebersteinburg near Baden-Baden, Etfenheim and Denzlingen near the Kaiserstuhl, and Bad Bellingen-Hertingen and Dettinghof in the southern Black Forest.[654] Similar to the sites in the Ahr Valley in the Eifel, the work sites are associated with villa settlements; a half-dozen villa sites are associated with working deposits of limonite near Baden-Baden, where

645 *Ibid*.
646 *Ibid*., 67-58.
647 *Ibid*., 56.
648 Himmelmann 2003; Kreckel 2004; Roller 2005; Bernhard 2007.
649 Himmelmann 2003, 14-15.
650 *Ibid*., 218.
651 Roller 2005, 284-85.
652 Himmelmann 2003, 219; Cüppers 2005, 359.
653 Himmelmann 2003, 219-220; Kreckel 2004, 7.
654 Wagner 1993; Hildebrant 2005.

Pingenfelden were dug to extract the ore.[655] Other sites are less well known and certainly less published. It is hypothesized that the ore deposits in this region may have generally been of such poor quality that locals chose to import iron rather than produce it locally.[656]

This evidence paints a picture of iron production within the Rhine Basin being small scale and loosely organized. The fact that iron was being mined by villa estates and produced on their grounds suggests a different organization from that seen in lead mining, which was overseen by the military and state. Two inscriptions found at Mainz, however, complicate matters. An altar dated to AD 220 names Domitius Antigonus, legionary legate of the 22nd legion, stationed in Mainz, who was a *procurator augusti ferrariarum.* [657] Hirt links Antigonus with the *procuratores ferrariarum gallicarum*, an office probably stationed in Lyon, though this is unclear.[658] A second inscription from Mainz, this time a (second-century?) tombstone gives evidence of the presence of an *adsessor ferrariarum* of equestrian rank,[659] an uncommon title which has been linked to the *arca ferrariarum tres provinciae Galliae*, an independent mining administration linked to the council of the three Gauls from which some percentage of the revenues of iron mining contributed.[660] The presence of an organized administration of iron mining in Gaul, paralleled by other such organizations throughout the Roman Empire, begs the question of a similar organization within the German provinces. The fact that the *iudex arca ferrariarum* specifies the three Gauls suggests his jurisdiction did not extend to the Rhine frontier, so what are we to imagine in its place? Did these positions identified in Mainz serve the Rhine provinces, or were they simply Gallic officials dedicating away from Lyon? It is tempting to see them acting in conjunction with local mining activity in the region. We will return to this issue below.

---

[655] Wagner 1993.
[656] Hildebrant 2005, 399.
[657] *AE* 1986, 262.
[658] Hirt 2010, 144.
[659] *CIL* XIII, 11833.
[660] Hirt 2010, 89.

It is unclear whether these sites were producing iron for sale at a regional level—not enough work has been done in terms of ore sourcing or ingot trade to identify much movement of material. However, like lead, iron was widely worked throughout the region, and where it could not it must have been acquired through trade. Its close geological occurrence with lead probably meant easy transfer of technology, and those producing lead could easily have also produced iron, and vice-versa. The ore-rich Eifel range in particular is an ideal example of industrial agglomeration, where skills, technology, and resources could easily move between different sites.

Rothenhöfer argues that the iron mines of Lower Germany were not terribly important,[661] as their output must have paled in comparison to other regions in the Empire. However, a mine does not have to be globally significant to have an impact on the local economy, and there can be little doubt that iron was produced in the Rhine Basin because it was a useful and efficient thing to do. Even if it was not traded on the same scale as German lead, the local availability of iron resources would have been extremely important to the local civilian and military populations, supplying material for things as mundane as nails right up the armor and weapons of the military.

Timber

More readily available than lead or iron, the forests of the region provided building material and fuel critical to the construction and maintenance of the region. Romans distinguished between wood for building and construction (*materia*) and wood for fuel (*ligna*).[662] The Roman world had a huge demand for both, and there is debate over whether the Roman Empire caused widespread deforestation.[663] The most recent work on the topic has argued against this idea,[664] as there is ample evidence, both environmental and historical, that Romans were

[661] Rothenhöfer 2005, 86-88.
[662] Meiggs 1982, 6.
[663] Compare, for example, the positions of Kaplan *et al*. 2009 with Veal 2013 or Harris 2013. The approach used by Kaplan *et al*. does not adequately account for historical realities in their computer-generated model, making the data cited here and in the authors cited much more important to understanding the complex history of human influence on European forests.
[664] Harris 2013.

well versed in strategies of forest management.[665] As will be shown, there is little evidence of sustained deforestation within the Rhine region under the Romans.

The forests of the Rhine were famous, from Caesar's description of the Hercynian Forest (*BG* 6.24-25), to Strabo (*Geo*., 7.3) commenting on its large trees, to Pliny who describes the Hercynian Forest as inferior to none (*NH* 4.28).[666] Pliny goes on to write that trees cover all of Germany (*NH* 16.2.1), specifically mentioning fine oaks both in the Hercynian Forest and along the northern coastal regions (*NH* 16.2.2). Even in the fourth century Ammianus still describes the area around Lake Constance as being surrounded by "dread forest wilderness" (15.4.2).

While the forests of the region no doubt became a literary trope, they were a cornerstone of local life and economic activity, providing both *materia* and *ligna*. Forests varied substantially across the region (**fig. 4.11)**; [667] the southern mountains, including the Alps, Jura, Black Forest, and Vosges were and are characterized by coniferous forests of beech, fir, and spruce, due to general elevation, rainfall, and soil conditions. The lower altitudes are characterized by mixed deciduous forests of beech, oak, and hornbeam, and these continue into the Middle Rhine and Eifel zone, extending to the North Sea Coast. These forests were rather different from those within the Mediterranean basin,[668] and contributed substantial qualitative and quantitative differences to local life. The utilization of forests throughout the region influenced not only the general character and reputation of the region, as demonstrated by the descriptions of ancient authors outlined above, but also helped shape the lives of those living in the Rhine Basin, where forests, timber construction, and wood- or charcoal-fueled heating systems were part of daily life. The pyrotechnic industries of lead and iron production, to say nothing of ceramic, glass, and brick production, would have also required an immense amount of fuel. It is, therefore, safe to imagine that one

[665] Visser 2010; Veal 2012; Harris 2013.
[666] The Hercynian Forest is generally taken as synonymous with the forests which began in the Black Forest and continued east, north of the Danube.
[667] Ludemann 2003, 648; Ludemann, Michiels, and Nölkien 2004, 288; Metzger *et al.* 2005; Ludemann 2010, 156.
[668] Veal 2012.

of the most critical elements of resource management within the region would have been concerned with timber.

Timber production

The production of timber for construction (*materia*) is estimated to have taken up only approximately 10% of ancient wood use within the Mediterranean.[669] This estimate, however, may greatly underestimate the importance of timber in northern Europe, where wood construction was much more prevalent. The availability of wood surely helped determine timber as the primary building material of most construction in this region, rather than stone or brick. The differences between Mediterranean and European environments are further clarified by the immense amount of timber preservation throughout the Rhine Basin—from the bridges and boats discussed in Chapter 2 to houses in town centres to frontier fortifications—timber is preserved everywhere in the region. Excavations in the waterlogged sites of the modern Netherlands, in particular, produce large amounts of ancient timber.

Because of the prominence of ancient wood on archaeological sites, an extensive dendrochronological dataset has been developed for the region, distributed across a number of labs in the region. These data, already referred to in the previous discussion on climate reconstruction in Chapter 1 above, are critical for understanding the production of and trade in timber in the study region throughout the Roman period (**fig. 4.12**). Aside from climatic information, dendrochronology can help determine the age at which a tree was cut, the year and season in which it was cut, the forest from which it came (if there are sufficient comparative data to narrow the search). The decades of dendrochronological research throughout the Rhine basin have revealed several crucial facts about the use of timber in the region and its place within the local economy.

The evidence suggests that timber was systematically harvested throughout the region. Oak and fir trees were particularly prevalent in use. Fir trees are especially instructive in determining patterns of timber usage in the

[669] Veal 2013, 40.

region. Fir is the tallest tree in central Europe, capable of reaching more than 50 m in height.[670] Pollen diagrams from different areas within Roman territory on the Rhine suggest a declining fir population over the course of the Roman period in some areas,[671] which corroborates with the large amount of fir found on Roman sites. The second-century bridge at Trier used fir timber,[672] as did the second-century harbour works at Voorburg.[673] Elsewhere, fir was used in cremation burials in Germania Inferior and Gallia Belgica, also imported.[674] Fir has also been documented at Xanten.[675] As fir only grows in the southern part of the Rhine basin, this timber was clearly desirable enough to be transported over a long distance.

Oak was also transported over long distances for use as timber. It has been suggested that Trajanic and Hadrianic building projects along the Lower Rhine, particularly the *via militaris*, exhausted local timber resources, which had consisted of bog oaks and other oak forests located along the coast.[676] Evidence for this depletion can be found in dated timbers from the region: the De Meern 4 boat was constructed of local bog oak, felled around AD 100,[677] but the Woerden 7 boat, built ca. AD 162-3 was constructed from timber from the Saar-Moselle region.[678] Similarly, the first phase of harbour construction at Voorburg used oak imported from the Neckar region ca. AD 159, while the second phase ca. AD 218 used oak from the Saar-Moselle region.[679]

Timber was presumably brought to the Netherlands by floating it down the Rhine. Timber floats from antiquity have been hypothesized,[680] but no firm evidence exists as to their size or assembly point. Early modern examples may be

---

670 Küster 1994, 24.
671 *Ibid.*, 26-27. He suggests that the fact that some pollen diagrams show a decline while others do not is indicative of regional management of fir trees, where some forests were maintained and others were not.
672 *Ibid.*, 29
673 Dominguez-Delmas *et al*. 2014, 643.
674 Deforce and Haneca 2012, 1343-44
675 Hollstein 1980, 180.
676 Haalebos and Willems 1999, 251-54; Visser 2007; Jansma and Visser 2009, 89.
677 Jansma 2007, 76.
678 Vorst 2005; Vos, Morel, and Hazenberg 2011, 113.
679 Dominguez-Delmas *et al*, 2014, 651.
680 Küster 1994, 29; Dominguez-Delmas *et al*. 2014, 652.

instructive. In 1791, the English physician Thomas Cogan related how the timber trade functioned in his day while travelling through the Rhine valley, when in each spring timber from Germany was floated to the Netherlands:[681]

> *Andernach is the place where smaller floats of timber, conveyed from the forests adjacent to the Rhine, the Neckar, the Main, Moselle, etc. are assembled, to be formed into greater floats: some of these are immensely large. I am assured that they are not less than from seven to eight hundred feet in length; from one hundred to one hundred and fifty in breadth, and from five to seven feet in thickness, or depth: they draw about four feet of water.*

And while this description may not match the exact method in which timber from the Upper Rhine reached the Netherlands in the Roman period, it is at least informative to realize the possible timber production of the forests of the region, particularly after centuries of intensive use.

Project	**Size/length**	**Timber required**	**Forest**	**Yield**	**Reference**
Limes palisade	100 km	38-85,000 m^3	-	-	Ehmig 2012
Mainz Rhine wall	1.6 km	2,000 oak trees	-	-	Ehmig 2012
Auxiliary fort	1.6 ha	623 m^3	6.5-12 ha	95-52 m3/ ha	Hanson 1978
Legionary fort	20 ha	16,000 m^3	1,895 ha	8.5 m3/ ha	Shirley 2000
Aalphen fort	1 ha	17,950 m3	110 ha	163 m3/ ha	Visser 2007
LR limesweg	204 km	77,520 m^3	978 ha	79 m3/ ha	Visser 2007

Table 4.1: Military timber building project estimates on Rhine frontier with size, timber requirement, forest requirement, and forest yield.

The construction of new towns and fortifications would periodically have required huge quantities of material (**table 4.1**). The Trajanic and Hadrianic road works along the Lower Rhine are one example. Recalling the fort construction chronologies discussed in the previous chapter, the building projects of Claudius on the Lower Rhine, Vespasian and Trajan on the Upper Rhine, and Valentian along the entire length must have required the mobilization of huge amounts of material. Estimates of material demand and per-hectare yield vary greatly. Visser

---

[681] Cogan 1794, 382.

estimated that a single 2 ha fort required approximately 110 ha of forest,[682] Hanson estimated that a 4 acre (1.6 ha) fort would require between 16-30 acres (6.5-12 ha) of forest,[683] and Shirley estimated that the 22 ha legionary fortress of Inchtuthil in Scotland would have required approximately 1,895 ha of forest.[684] The timber requirements for these fort-building programs must have been staggering, to say nothing of the nails and other fittings required.[685] Additional projects such as the *via militaris* flood prevention, the Trajanic frontier construction project including 45 forts and 75 watch towers,[686] the Antonine and Aurelian construction of the outer *limes* with its 300 watch towers and 20 forts,[687] or the eventual construction of the *Pfalgraben* palisade along the entire 550 km-long stretch of the *Limes Germanicus* between Hadrian and Septimius Severus.[688]

Military building, especially of new forts, would have required large-scale clearance of land for visibility and construction anyway, and Hanson suggests that the timber requirements per fort did not significantly exceed what would be produced by clearing the building site,[689] though this clearly would have varied widely depending on the project and resources available. We may expect, then, that timber forts built during phases of expansion would not have required long-distance transport of timber in most circumstances, considering the projected forest cover of the Rhine Basin in antiquity.

It is, therefore, no surprise that we find evidence of imperial and military interest in managing forest resources within the region. Epigraphic evidence shows that forests between the Alps and the North Sea were managed by a diverse range of agents, including *saltuarii*, *dendrophori Augustales,* and legionary vexillations of tree cutters (**fig. 4.13**). The so-called *saltuarii* are known across the Empire, generally being associated with caretaking responsibilities on Imperial

[682] Visser 2007, 109.
[683] Hanson 1978, 298.
[684] Shirley 2000.
[685] Inchtuthil required nearly 12 tons of nails for the timber phase (Shirley 2001, 143).
[686] Kortüm 1998.
[687] Thiel 2006, 115.
[688] Schallmayer 2005; Thiel 2006, 120.
[689] Hanson 1978, 297.

estates and, in this region, timber.[690] Two inscriptions name *saltuarii*, a tombstone from Waldfischbach in the northern Pfalzerwald and a dedicatory inscription to Diana from Weilerwist in the northern Eifel.[691] Elsewhere, two men with the title of *dendrophori augustalis*—literally "tree bearing" Augustales—are known from inscriptions at Amsoldingen in Switzerland and Nida-Heddernheim on the Main River.[692]

Perhaps most interesting, however, is a series of four inscriptions from three forts located on the Main River at Obernburg, Trennfurt, and Stockstadt that name vexillations of the *Legio XXII* from Mainz, each named with the title of *agentes in lignariis*.[693] Unlike the *saltuarii* or the *dendrophori*, these four inscriptions are the only known attestation of such a title.[694] Each inscription is closely dated by consular dates to the short period from AD 206-214,[695] tying them closely to the building program of Septimius Severus along the outer *limes*, during which the frontier fortifications were substantially bolstered by ditch, palisade, and wall.[696] Corroborating dendro-dates for this activity are known from Butzbach, Mainhardt, and Rainau-Buch,[697] as well as at Dambach.[698] These inscriptions offer a rare glimpse into the military interest in timber management which, given the intense need during specific periods, was very necessary. These men, each stationed at a fort along the Main River on the edge of the Empire, could have overseen the movement of timber from surrounding forests, and indeed timber from this region was used as far away as the Netherlands, as outlined above. Aside from the military *agentes*, the clustering of wood workers in this region is indicative of the value in local forests.

---

[690] Visser 2010, 15 cites a tombstone (*Finke* 328) of a *saltuarius*, where the deceased is depicted holding a woodsman's axe as a mark of his trade.
[691] *Finke* 328; *AE* 1929, 55.
[692] *CIL* 13, 5153; *AE* 1962, 232. Charalampidis 1995, 30-33. A. Wilson, pers. comm., suggests that these tree specialists could also double as forest workers when not involved in cult activities.
[693] *CIL* 13, 6618, 6623, 11781,
[694] Speidel 1992a.
[695] *Ibid*.
[696] Schallmayer 2005, 804; Thiel 2006, 120. Schallmayer points out that these units could also have been procuring timber to construct Severus' fleet for his British campaigns.
[697] Kortüm 1998, 61-63.
[698] Czysz and Herzig 2008.

Elsewhere, a *materiarius*, a trader in building timber, is named in a curse tablet from Bad Kreuznach,[699] and members of the *collegium fabrum tignuariorum* are known in Cologne,[700] Nijmegen,[701] and Baden Baden.[702] Obviously, carpenters would have been fairly common given the ubiquity of wooden construction. These inscriptions simply give evidence to their existence and participation in local life. Aside from military demands, these merchants and tradesmen were part of a system that helped supply cities, towns, and rural settlements with timber. Ehmig estimates that the urban demand for timber in the Rhineland area would have exceeded 1.7 million cubic meters with an additional million for the ca. 4000 rural dwellings in the region at the peak of settlement in the late second and early third centuries AD.[703] Successful management of the region's timber resources was, therefore, vital.

Wood and charcoal for fuel

The topic of wood and charcoal for fuel will be touched upon further in the next chapter, but several points are relevant here. Fuel wood was almost entirely locally sourced, except in some rare instances.[704] Within the Rhine Basin, this was certainly true, as analyses in fuel deposits consistently demonstrate the usage of local wood, excepting the rare instances of fir usage outlined above.[705] Historically, charcoal has also been produced from local trees and then consumed locally.[706] Daily activities such as heating a home, heating baths, and cooking generally utilized raw wood, while pyrotechnic industries requiring high temperatures like iron smelting or raw glass production would have required charcoal.[707] Charcoal production is an inefficient practice, and generally requires

---

[699] *CIL* 13, 7553.
[700] *CIL* 13, 8344; 8346.
[701] *Ness-Lieb* 252.
[702] *CIL* 13, 6303.
[703] Ehmig 2012, 190-91.
[704] Harris 2013, 177.
[705] Deforce and Haneca 2012.
[706] Ludemann 2003; Ludemann, Michiels, and Nölkien 2004; Ludemann 2010.
[707] Veal 2013, 45.

six or seven tons of wood to make one ton of charcoal, and higher grade charcoal requires longer charring periods.[708]

Historical figures from elsewhere in the Roman world suggest an urban usage of wood/charcoal at a ratio of 20%/ 80%, while rural dwellers tend to use the reverse, at 80% wood and 20% charcoal.[709] Veal has suggested that Pompeii and its territory, with an estimated population of 30,000 people, would have required close to 60 km² of forest per year, using these ratios.[710] If we expand these figures to the tentative population figures for the Rhine ca. AD 180 discussed in Chapter 3 (425,000 urban and 4,250,000 rural, 60,000 military), we can arrive at a very rough figure of an annual requirement of 54,625 km² of woodland to support fuel consumption. This number is only meant as an estimation of order of magnitude, as there are too many unknown variables involved in such a calculation ever to be accurate, but even this rough figure accounts for nearly half of available land in the region at the time (roughly 111,000 km²). If we factor in the demands for building timber put in place for frontier fortification and infrastructural works, as well as the fuel wood required for industrial activity, this number continues to climb.[711]

It is obvious, considering these rough estimations, that Romans could not simply go out and cut down trees on a whim, but rather they had to manage their woodland resources. Many authors have argued that Romans practised silviculture strategies such as coppicing or pollarding.[712] Uniform ages at felling seen in timbers used in the bridge at Cuijk and wells at Oudenburg suggest coppicing, as well as forest management since forests were still producing large timbers in the fourth and fifth centuries, requiring hundreds of years of management. [713] As a counterpoint, however, the early second-century construction projects along the Lower Rhine, including the renovation of the *via militaris* with wooden revetment

---

[708] Veal 2012, 42-43.
[709] Veal 2012, 41.
[710] *Ibid*., 45.
[711] Harris 2013, 176 cites figures which estimate 80,000 tons of iron would require 26,000 km² of forest as fuel. Based on this ratio, the 300 tons of production suggested for the villa at Ahrweiler would have required roughly 97.5 km² of forest.
[712] Visser 2010; Veal 2013
[713] Visser 2010, 17; Haneca, van Acker, and Beeckman 2005, 802-4.

to protect it from river floods,[714] may well have exhausted local timber stands, requiring later projects such as the construction of the Woerden 7 ship or the Voorburg quay to import timber from the Middle Rhine oak forests.[715] Much like the continuous demand for fuel wood, the demand for timber required close management of forests in order to allow long-term availability.

Stone

Quarry site	Inscriptions	Legions	Auxilia	Fleet	Date
Brohltal	34	19	7	8	Flavian
Kruft	16	14	2		Flavian
Kriemhildenstuhl	8	8			Severan
Norroy	5	5	1		Flavian
Reinhardsmünster	1	1			Trajanic
Moulin-de-Champagne	1	1			Unknown

Table 4.2: Military involvement in quarrying in Rhine basin with number of inscriptions per site, and number of references to different types of units within those inscriptions (data from Clauss-Slaby).

The quarrying of stone for building was the most widely distributed extractive work within the Rhine basin and, of all the extractive enterprises detailed here, most visibily demonstrates military involvement (**table 4.2**). Stone quarries are known from the Alps to the Eifel (**fig. 4.14**), with many located in close proximity to major settlements. Every geological feature within the Rhine Basin provided suitable building stone, whether sandstone, limestone, trachyte, basalt, or tuff. Stone, like timber, had innumerable daily functions, from walls and pavements to altars to bridges. While requiring substantially more investment, time, and skill than timber construction, stone construction was common in urban centres, later military fortifications, and infrastructure projects such as the major bridges at Trier, Mainz, and Cologne.

[714] Willems and Haalebos 1999, 251-54.
[715] Vorst 2005, 1; Jansma and Visser 2009, 89; Visser 2010, 14; Dominguez-Delmas *et al.* 2014, 652.

Like timber, there were also periods of substantial demand for stone during phases of intensive building. The fortification and renovation programmes of the Flavians, Trajan, and the Severans are reflected in the periodic epigraphic visibility of soldiers in quarries, and the later construction of dozens of urban fortifications in the late third century required a massive amount of resources.[716] Bachrach estimated that for the fortification of Bordeaux alone, the 2.3 km long wall required 200,000 metric tons of stone.[717] The 6.4 km long wall of Trier, the 3.9 km wall of Cologne, 3.4 km wall of Xanten, or the 5.6 km wall of Avenches each required a massive amount of material, to say nothing of the hundreds of forts and dozens of other urban fortifications. It is no wonder, then, that so many later projects chose to use *spolia* rather than quarry entirely new stone.[718]

While many smaller quarries existed for local use, several major sites warrant further details. The trachyte quarries at Drachenfels, located on the right bank of the Rhine between Remagen and Bonn, were in operation from the beginning of the first to third centuries AD.[719] This quarry is estimated to have produced somewhere between 400,000 and 500,000 m³ of stone,[720] with work overseen by soldiers of the *legio I Minervia* based in nearby Bonn.[721] The quarry had a separate harbour on the Rhine, where stone could be easily loaded and shipped to its destination. Stone from this quarry was used to construct the Tiberian phase of the Praetorium in Cologne, as well as the city wall and amphitheater.[722] This stone was also used to construct the forum at Xanten in the second century.[723]

Across the Rhine, the volcanic fields of the east Eifel (Pellenz) produced abundant basalt resources, most famously utilized for millstones (discussed below), but also quarried for building at Erpeler Ley, Unkelsteine, Rolandsbogen, and Berkum. A substantial amount of building stone was produced from these

[716] Linthout, Paulick, and Wijbrans 2009; Bachrach 2010.
[717] Bachrach 2010, 59.
[718] Dey 2012.
[719] Röder 1974; Rothenhöfer 2005, 104.
[720] Horn 2002, 525.
[721] *Ibid*., 159.
[722] *Ibid*., 525.
[723] Rothenhöfer 2005, 105.

quarries, and is commonly found *inter alia* in the second- and third-century renovations of forts and watch towers along the Lower Rhine.[724] Furthermore, stone from these quarries was being carried downstream on the De Meern 4 boat when it sank in the Netherlands sometime after AD 148.[725] The Netherlands did not have any substantial stone availability, so while building in this area was able to use local timber for the first century or so of occupation, the stone always had to be imported.

The east Eifel also produced tuff from quarries at the Brohltal, Kruft, and Kretz, near Andernach, which was used in AD 4/5 to build the Ubii Monument in Cologne.[726] These quarries were extensive, and were also administered by soldiers from Bonn, Mainz, and Koblenz.[727] Stone from these sites reached Cologne, Krefeld-Gellep, Nijmegen, and Xanten, where the entirely stone-built city wall was built required an estimated 50,000 tons of stone.[728] In addition, the rebuilding of many forts destroyed during the Batavian revolt of AD 69/70 was completed using stone from the Brohltal.[729] The *Classis Germanica* is present in epigraphy from the quarry, indicating their participation in the movement of stone on the Rhine, which they undoubtedly did for other quarries and building projects as well, indicated in particular by an inscription from Bonn which mentions the fleet as participating in rebuilding part of Xanten destroyed by fire.[730]

Further south, one of the most impressive monuments of Roman quarrying in the region can be found near Bad Dürkheim at the Kriemhildenstuhl, where an estimated 20,000 cubic meters of sandstone was cut out of a cliff some 25 m high.[731] Soldiers from Mainz are known here from inscriptions left in the quarry, indicating continued military supervision of the works well into the third century.

[724] Linthout, Paulick, and Wijbrans 2009.
[725] *Ibid*.
[726] Rothenhöfer 2005, 105.
[727] Röder 1957; Röder 1959; Horn 2002, 159; Russell 2009, 34.
[728] Rothenhöfer 2005, 106; Müller 2008.
[729] Hirt 2010, 175.
[730] *CIL* XIII 8036; Hirt 2010, 175.
[731] Cüppers 2005, 313-14.

Stone from this quarry was taken to Mainz and used to construct parts of the legionary camp in the late first century.[732]

Several quarry sites in the Moselle valley were important for projects in Trier. Limestone quarries at Norroy provided building material for the city wall, amphitheater, and baths.[733] Stone from Norroy was sent as far away as Bonn, Mainz, Nijmegen, Strasbourg, and even Colchester.[734] Norroy was administered by soldiers of multiple legionary and auxiliary units from the first to third centuries,[735] demonstrating yet again the role that the military played in directing quarrying activity. The involvement of the military at this site, hundreds of kilometers from the frontier, is indicative of the administrative and logistical skills provided by the Roman army in such operations, as well as the vitality of this quarry to the major cities which it supplied.

Volcanic millstone production

The extinct volcanoes of the Vulkaneifel, located in the southeastern zone of the Eifel range near to the confluence of the Moselle and Rhine, provided extensive basalt resources which had been exploited since the Neolithic. Three separate areas within this region were important for production: the west Eifel (600 km^2), the Hocheifel, and the east Eifel (400 km^2), of which the east Eifel was the most important as it exceeded the others in availability.[736] The extinct volcano now known as the Laacher See specifically provided more magma by volume than the entirety of the west Eifel.[737] Even before the Roman period, these sites were worked extensively, with estimates placing Iron Age production at some 3.6 million stones.[738] During the Roman period, these basalt fields were worked extensively and became an important centre of millstone production. These millstones became a widely traded commodity, stretching across northern Europe into Britain and across the *Limes* into Germany because of their superior

[732] Sprater 1929, 86; Russell 2009, 51; Hirt 2010, 175.
[733] Cüppers 2005, 283.
[734] Bedon 1984; Russell 2009, 226-27.
[735] Russell 2009, 34; Hirt 2010, 175.
[736] Gluhak and Hofmeister 2009, 1775.
[737] *Ibid*., 1775.
[738] Crawford 1955, 72; Mangartz 2008, 95.

quality.[739] Some sixteen quarry sites have been located, with the most productive located in the east Eifel, tapping into the Bellberg volcanic flows in the Mayener Grubenfeld, Ettringer Lay, and Kottenheimer Winfeld, just north of the town of Mayen.[740] North of these sites, two further quarries were active between the Laacher See and the Rhine, located at Mauerley and the Hohe Buche, near the town of Andernach.[741] The millstones produced from these quarries were widely traded. In the west Eifel, quarries have been found at Römerberg, Mosenberg, Goosberg, Mühlenberg, Rossbüsch, Eichholz, Dietzenley, and Rother Kopf, though these were much smaller than those to the east.[742]

Once quarried in rough form, millstones had to be finished in workshops. Twelve such workshops have been identified in the vicus of Mayen, located south of the major quarry sites (**fig. 4.15**).[743] This concentration of workshops provides some insight into the structure of this industry, where stones were roughly quarried in the numerous sites surrounding Mayen, then transported to specialized workshops in the town where they were perfected by dedicated artisans who not only finished their carving but added the wood and metal fixtures. Only after this were the stones exported out of Mayen for wider consumption. From Mayen, stone could have traveled either by road or by river to Andernach, where a suitable harbour was active throughout the Roman period (and indeed, well defended).[744] At Andernach, a similar *chaîne opératoire* is clear, with a number of workshops in the town indicating the finishing of stones.[745] From Andernach, stones could easily be loaded onto ships to transport them throughout the region.

Petrographic analyses conducted via XRF on millstones recovered from archaeological contexts as well as production sites have demonstrated that the basalt from the east and west Eifel can be differentiated with high confidence.[746] Importantly, stones from other basalt quarrying regions of Europe, such as the

[739] Gluhak and Hofmeister 2008; Mangartz 2008; Gluhak and Hofmeister 2009; Gluhak and Hofmeister 2011.
[740] Gluhak and Hofmeister 2009, 1776.
[741] *Ibid*., 1776.
[742] Hörter 1994; Gluhak and Hofmeister 2009, 1776.
[743] Mangartz 2008, 74-75.
[744] *Ibid*., 89.
[745] *Ibid*., 76-78.
[746] Gluhak and Hofmeister 2009, 1780.

Massif Central in France or Orvieto in Italy, can be distinguished.[747] There is, however, a distinct lack of comparative data from other basalt producing regions in the northwest, making firm identification of non-Eifel stones sometimes difficult.[748] Of the 60 examples so far tested, none has so far been sourced to the west Eifel quarries.[749]

Finally, the chronology of production shows intensive development under the Romans (**fig. 4.16**).[750] Like the lead resources of the Rhenish Massif, the Eifel basalt quarries were in action shortly after the Roman occupation of the region in the first decade BC, with documented examples found at Haltern, Oberaden, and Anreppen.[751] Numismatic and ceramic finds throughout quarry sites also suggest such an early start; indeed, production probably continued unbroken from the late Iron Age.[752] The next century saw increased production as Eifel millstones were traded extensively throughout the Rhine Basin and neighbouring regions (**fig. 4.17**).[753] During the second century, Eifel millstones were increasingly imported into Germany, reaching as far away as the Elbe River,[754] as well as into Britain.[755] A brief glimpse of this trade is provided by the cargo of the Wantzenau ship, found near Strasbourg, dating to the late third c. AD, which contained Eifel stones.[756] Production of these stones continued with little apparent break in activity through the end of Roman rule and onwards into the Medieval period. The Roman period, however, saw the majority of production, with Mangartz estimating it at some 17 million stones, equivalent to 3.4 million m³.[757] Medieval production dropped, with an estimated 2.25 million stones from AD 450-800.[758] Despite this drop, Eifel stones are still known from major trading centres such as

[747] *Ibid*., 1781.
[748] *Ibid*..
[749] *Ibid*..
[750] *Ibid*..
[751] *Ibid*., 1616.
[752] Mangartz 2008, 52.
[753] *Ibid*..
[754] Mangartz 2008, 102-5; Morris 2010, 201; Gluhak and Hofmeister 2011.
[755] Morris 2010.78, 107, 133.
[756] Ellmers 1969, 92-5.
[757] Mangartz 2008, 95.
[758] *Ibid*., 95.

Haithabu and Dorestadt.[759] The distribution of these stones down the Upper Danube, across the Channel into Britain, and across the frontier into Germany speaks to both the high quality of the Eifel basalt stones as well as the range and development of export connections from the Rhine.

State involvement in resource management

Material	# Attestations	# Sites	Special titles
Stone	72	5	
Timber	4	3	*agentes in lignariis*
Lime	3	1	
Lead	2	2	
Iron	1	1	*procurator augusti ferrariarum*

Table 4.3: Military involvement in resource management in Rhine basin.

There is ample evidence that the region's resources, both mineral and forest, were managed by the local government and at least periodically by the military (**table 4.3**). State interests from the onset of Roman control in the region are demonstrated by the imperial stamps on Augustan lead ingots found throughout Germany and Gaul. The third-century iron procurators known from Mainz further indicate imperial control, with close parallels throughout neighbouring Gaul, with procuratorial offices based in Lyon. Fourth-century ingots from the Moselle reveal continued state management of metal resources, probably through the end of Roman control of the Eifel range. Even forests were monitored by the state, with *dendrophori Augustales, saltuarii,* and *agentii in lignarii*s distributed throughout the Rhine Basin. Agricultural estates administered by the state fiscus are possible, though the evidence is inconclusive.

The continuity of military involvement in these matters is less secure. The periodic nature of military control of resources is clear in the epigraphy, and was probably directly linked to the military building projects discussed in Chapter 3. Clear examples occur under the Flavians and Trajan in the Brohltal and Kruft quarries following the destruction of the Batavian revolt and fort building of

[759] Gluhak and Hofmeister 2011, 1618.

Trajan. Trajanic and Hadrianic renovations to the Lower Rhine limes used so much timber that it had to be imported from another province; contemporaneous expansions in Upper Germany must have required huge amounts of material as well. Later Severan military campaigns and fortification plans saw activity along the Main River and in the Kriemhildenstuhl quarry by legionary vexillations. Subsequent building projects under the Tetrarchs and Valentinian are simply missing from the epigraphic record, but must have seen significant mobilization of resources.

Conclusions

The distribution of natural resources within the Rhine Basin was not uniform, as their availability was determined by the many geological features throughout the region. The river valleys and plains of the Rhine basin provided ample space for agricultural production, leading to a developed villa economy that produced a substantial agricultural surplus to feed the local market. This system benefitted from the soil and climatic conditions of the region in addition to the constant demand of cities and forts. While cereal crops were the most widely cultivated, livestock and vines formed important parts of the agricultural economy of certain regions within the Rhine basin. The diversity of agricultural approaches seen was directly related to environmental factors, and micro-regions benefitted from regional integration and trade in goods.

While not particularly rich in precious metals, the mineral deposits east and west of the Rhine produced iron, lead, copper, and some silver. Many of these deposits were worked to some degree during the Bronze and Iron Ages, but Roman rule saw widespread efforts to tap into multiple deposits in order to produce what raw metals were possible within the local territory. The hills of the Eifel range were most the most productive within Roman territory, but the neighbouring Sauerland and Siegerland deposits also had great potential which was more or less realized by those Germans living within them. It is striking that it is this region—the eastern expanse of the Rhenish Massif—that was initially targeted for incorporation into the Roman Empire under Augustus and not the expanses of the Black Forest and Alb regions to the south. It stands to reason that the intention of expansion towards the Elbe River was not simply a desire to have more land, but rather for the Roman Empire to bring the full expanse of the mineral resources of this area into their control. These hopes were dashed by the defeat of Varus in AD 9.

It is difficult to quantify the output of these mineral deposits. The wide geographic and chronological distribution of extraction and processing efforts, however, suggest a substantial output that must have supported local demand in some substantial part. The later import of British lead seen in Trier and other sites along the Moselle may indicate that the deposits were no longer enough to meet local demand, possibly because of the large-scale Imperial building initiated in this period. Remains of iron slag found within the Eifel at Ahrweiler or at the Eisenberg in the northern Pfalzerwald speak to high levels of iron production at these sites, with smaller levels of activity at other deposits in the Black Forest. More work needs to be done on the measurement of these slag remains in order to better estimate their size and relation to actual iron output.

Both of these metallurgical productions were made possible largely in part by the wide availability of wood throughout the region. The forests of the Rhine were famous in the Roman world and, indeed, formed a cornerstone of local life. Timber construction was common, whereas stone was often reserved for infrastructure, urban buildings, and military fortifications. Timber was cut throughout the region and apparently moved extensively, though this is also difficult to quantify. The appearance of southern trees in the Netherlands, including both oak and fir, in the mid-second century constructions at Voorburg and surrounding region suggest local depletion, probably due to large scale building projects and strengthening of fortifications under Trajan and Hadrian. The fact that timber could be mobilized from farther south speaks to the regional integration of economic activity, not to mention the successful use of riverine transport infrastructure to enable this movement.

Stone, like timber, was a fairly common resource. High quality stone, however, was to be found in several concentrated deposits located in the

Pfalzerwald, Upper Moselle valley, and Rhenish Massif. Quarries in these areas literally provided the building blocks for the surrounding settlements, sometimes transported over long distances. The largest of these quarries were at least occasionally overseen by detachments of the provincial armies, demonstrating the state's interest in maintaining efficient, well-functioning stone quarries for civilian and military building projects. An offshoot of the stone resources, the basalt deposits of the east Eifel, provided an additional aspect of the local economy and allowed for the long-term specialization of millstone production. These stones were widely distributed across northern Europe, in both Roman and non-Roman territory. The quantity of stone produced in this industry meant that the Mayen and Andernach regions developed as industrial centres, tied closely to stone and metallurgical resources. Stone, like timber, was crucial for large-scale building projects such as those seen along the fortifications of the frontier in the second, third, and fourth centuries and enabled the prolonged defense of the region.

We must not forget the villa organization of iron production or the *negotiatores* who distributed timber and stone. From the top levels of state officials down to the ordinary rural inhabitant, the natural resources of the region permeated daily life and formed a critical element of the local economy.

Moreover, the uneven distribution of resources within the region helped shape other economic activities. The density of extractive and smelting industries within the Eifel range are a clear example of agglomerative factors, in which the closely related technology and skill set of metallurgy led to a proliferation of extraction, smelting, and subsequent working of many metals. In addition, other activities such as quarrying and lime burning took place in close proximity. All of these pyrotechnic processes consumed large amounts of fuel wood and charcoal which, in addition to the trade in building timber mentioned above, helped tie together regional management of resources. It is easy to imagine, in this context, the cargo of basalt quern stones from the Andernach region found on the Wantzenau wreck near Strasbourg being sent south in return for fir timber which was sent north. In addition, the agglomeration of pyrotechnic know-how and technology went hand in hand with the location of industrial production of goods such as ceramics and glass. As will be demonstrated in the next chapter, these productive industries were also closely related to the distribution of resources and fuel.

Finally, it is important to realize that the close availability of critical resources, particularly those needed for construction, maintenance, and repair, is a crucial factor to ensuring the long-term viability of settlement. When considering the settlement continuity discussed in Chapter 3, it becomes apparent that those towns and cities located in the Eifel region lasted longer than those located on the Swiss Plateau or deep in the Black Forest. There is no monolithic explanation for this, but the simple observation that local availability of iron, lead, stone, and timber is a determining factor in the longevity of habitation cannot be overemphasized.

5

Industry and Craft Production

The economic importance of craft production in the Roman world was long downplayed by many historians as a result of the primitivist-modernist debate in ancient history. Finley's model of the consumer city imagined a world in which urban centres existed in a parasitic relationship with their hinterland: the urban elites survived off taxes and rents in their territory, agriculture was the only significant economic activity, and all else was of minor significance.[760] Medieval historians, meanwhile, have argued for the existence of producer cities where craft production within the city generated income with which the producers could pay the ruling elite who lived in the countryside.[761] Greene commented early on that such a minimalist view of the ancient economy was made untenable by archaeological research,[762] while the dichotomy of producer or consumer cities was challenged by other scholars who argued for the simultaneous existence of 'service' cities and Roman-period producer cities.[763] Silver criticized such models as being "unproven, economically irrelevant as typically specified, and temporally misplaced and misinterpreted."[764] Wilson challenged the necessity of these labels, arguing that no city will fit one or the other perfectly, and the application of such terms obscures the reality of archaeological materials and their interpretation.[765] Indeed, it is hard to imagine a city that did not produce, consume, provide services, and house merchants all at the same time.

Most scholars have agreed on the shortcomings of the terms of the debate, and the discussion of the role of production in the Roman economy has become more nuanced. The term craft production covers a number of different activities, including the production of ceramics, metals, glass, bone, and stone objects

[760] Finley 1973, 123-27.
[761] Wilson 2002c, 231 for summary.
[762] Greene 1986, 170.
[763] Engels 1990; Mattingly and Salmon 2001.
[764] Silver 2006, 128.
[765] Wilson 2002c, 234.

which, when taken together, represented a substantial part of the ancient economy. Indeed, Flohr has pointed out that the aggregate demand for manufactured goods was second only to food products,[766] and the production of these goods occupied a substantial portion of the ancient population, particularly in non-rural settings. The specialization seen in Roman craft production, demonstrated through a number of lines of evidence, including reliefs and inscriptions, indicates that craft production was important enough and profitable enough in the Roman world to be able to dedicate one's life to such a career. Specialization is a pre-requisite for large-scale investment, rationalization, and economies of scale to develop.[767] Investigation of the Roman world reveals specialization not only at the workshop or household level, but also within the workplace. Flohr has demonstrated that workshops employed workers with specific tasks within the production process.[768] On a regional scale, specialization in production, such as that documented by Rice in southern Turkey and southern France,[769] indicates involvement in a large, interregional integrated market system which both required and enabled long-distance trading connections.[770]

The level of labour involvement and capital investment seen in craft-producing industries across the Empire demonstrates both that a significant portion of the population was potentially involved in craft production and that these activities were economically viable. Chapter 3 demonstrated that a large urban population developed along the Rhine frontier, creating a sizeable labour force available for non-agricultural production. These activities were important for local economic development for a number of reasons: they were often based upon the local availability of natural resources, they shaped the economic life of settlements, and they provided the region with locally manufactured goods and reduced the need to import certain goods from afar. Understanding this division of the economy is crucial for reconstructing views of frontier economies; if it can be demonstrated that frontiers were not only agriculturally productive, but also

[766] Flohr forthcoming b, 1.
[767] Flohr forthcoming b, 12.
[768] Flohr forthcoming a, 25.
[769] Rice 2012.
[770] The trading system argued for by Temin 2011 and Wilson in Wilson *et al.* 2012,

produced enough goods and services to supply regional and supra-regional markets, then surely the traditional view of the marginal frontier zone must be reassessed.

Craft production within the Rhine Basin

Research on craft production on the Rhine frontier and in continental Europe more generally has tended to avoid the producer-consumer city debate which dominated anglophone scholarship for so long.[771] Instead, the material remains of productive enterprises have been intensively studied and documented, leaving no doubt that such activities were critical to local and regional economic life. Major surveys of craft production have been published for Gallia Belgica and Switzerland,[772] and these have demonstrated the wide range of materials produced not only in cities, but in towns, villas, and farms as well. The range of sites involved in these activities immediately discounts any model city-type, and reveals the true complexity and depth of craft production in the Roman world.

Polfer's study of crafts in Gallia Belgica documented at least 15 different types of production visible in the archaeological record (**fig. 5.1**).[773] Ceramic production was the most commonly attested activity, with 66 sites documented, followed by iron and bronze working found on 54 and 39 sites, respectively. Two-thirds of the craft producing sites documented were rural, and half of the total sites were located within the territories of the civitas Treverorum and civitas Mediomatricorum along the Moselle River (**fig. 5.2**).[774] The largest number of sites date to the second and third centuries, with the lowest amount known in the fourth and fifth (**fig. 5.3**).[775]

Roman Switzerland shows broad similarities with the evidence from Gallia Belgica, with the production of a dozen different commodities documented from

[771] Polfer 2005; Flohr forthcoming a, 8.
[772] Polfer 2005; Amrein *et al*. 2012.
[773] Polfer 2005, tab. 4a, 33-34.
[774] *Ibid*., 29 tab. 2.
[775] *Ibid*., 97, tab. 26.

236 sites.[776] Ironworking was the most commonly found activity, located on 162 sites, followed by ceramic production which was documented on 127 (**fig. 5.4**). Most of the evidence dates to the first and second centuries AD.

Both of these studies are, obviously, reliant on excavated material. As Flohr is right to point out, the extent to which this material can be considered as representative must be judged carefully, keeping in mind the amount of evidence, extent of excavation, care in documentation, etc.[777] The compilation of excavated material from Switzerland is staggering in its volume and detail, at least partly made possible because of the rather limited extent of settlement in the region—along the rivers and on the plateau. Gallia Belgica is less secure as a greater number of modern cities overlay Roman settlements and fieldwork is much more focused along the Moselle than in other parts of the province. The detail available for the Belgic *civitates* within the Rhine Basin is, at least, ample.

Similar studies of such scope have not yet been carried out for the remaining parts of the German provinces, though Rothenhöfer has discussed craft production within southern Germania Inferior, where he documented the evidence for the production of metalwork, ceramics, building material, glass, woodwork, stonework, bakeries, lime slaking, worked bone, leather, and textile.[778] Because craft production is only one aspect of his investigation, he does not cover the topic in the same manner as the other studies mentioned above. Like Gallia Belgica, the material covered in his study area shows a peak in the second and third centuries,[779] though the spatial distribution is skewed by the city of Cologne, where over 100 pottery kilns have been excavated.[780] In a much shorter article, Schmidts examined craft production in Roman Baden-Württemburg, again documenting activities such as building, metalwork, shoe-makers, woodworking, bone working, butchers, traders, tile makers, though in a purely descriptive manner.[781]

---

[776] Amrein *et al*. 2012, 29.
[777] Flohr forthcoming a, 11-15.
[778] Rothenhöfer 2005, 119-93.
[779] *Ibid*., 192.
[780] Höpken 2005.
[781] Schmidts 2005.

Elsewhere, separate studies by Wirtz and Clerbaut studied the distribution and typology of pottery kilns across an area roughly equivalent to Gallia Belgica and Germania Inferior where they documented over 300 kilns from 151 sites,[782] though these are not complete lists.[783] The study of ceramic production in the region is generally thorough,[784] though not always synthetic, and the centres of terra sigillata have been particularly well studied.[785] Other crafts from regions not covered in the above-mentioned volumes are less well studied, and await future evaluation and synthesis.[786] Regardless of how well a certain craft industry or region is studied or published, however, the economic context is often neglected. Archaeologists, perhaps in reaction to debates on topics such as the consumer city, have tended to discuss craft production and the subsequent trade in commodities as though they were the entire economy. This tendency has certainly downplayed the wider economic importance of these activities.

An all-encompassing study of the areas of the Rhine frontier not covered by Polfer, Rothenhöfer, or Amrein *et al.* is not possible in the space of this chapter, despite the obvious need for such work. Instead, this chapter compares the large body of evidence for ceramic production and the smaller amount of evidence for glass production along the Rhine frontier. The intentions are twofold: first, to synthesize the material for each craft within the study region including the source of materials, location of production, and chronology of development. This discussion provides the opportunity to bring together a wealth of recent scientific publications related to glass production in the Roman Empire, which has yet to be fully appreciated within archaeological circles. Second, this chapter compares the development and importance of these two complementary crafts in order to understand how they interacted and contributed to the local economy. The quantity of evidence for the ceramic and glass industries is substantial, offering the opportunity to discuss the issues presented by Flohr with extensive

[782] Wirtz 1998, 215-351; Clerbaut 2010, 16-24.
[783] Their catalogues can be supplemented with Biegert 1999, Heising 2000, Polfer 2005, Rothenhöfer 2005, Heising 2007.
[784] *E.g* papers in Strobel, ed., 2000.
[785] *E.g* Mees 2002; Weber 2012.
[786] Papers in Polfer, ed., 1999 and Polfer, ed., 2001 cover many aspects of craft production across the Roman west.

evidence.[787] Through investigating these two crafts, this chapter demonstrates that, even in frontier zones, extensive and complex craft industries could develop and shape the nature of local economies to a significant degree.

Production of pottery

The production of pottery was one of the most widespread craft activities within the Rhine basin. As mentioned above, it was the most commonly attested craft in Gallia Belgica, while in Switzerland it was the third.[788] Pottery was produced in major cities, smaller towns, and in the countryside throughout the region and, over time, would become one of the most notable products of the region. Indeed, over 1200 kilns have been excavated at 121 different sites within the Rhine basin, with another 26 sites identified as producing pottery but without kilns so far excavated (**fig. 5.5**).[789] Products ranged from simple, hand-made pottery to a range of coarsewares including amphorae to high-quality terra sigillata, and many of the ceramic types produced in the Rhine region were widely distributed. As such, pottery production and trade are well studied and often discussed in general works on the local economy.[790] These activities are not, however, commonly discussed in relation to wider economic context, that is, the reasons *why* pottery production became so widespread and so prominent within the regional economy.

The location of ceramic production is dependent on three factors: the availability of critical resources (clay, water, and fuelwood), access to transport infrastructure, and the proximity of other ceramic production centres.[791] The distribution of production centres is, therefore, closely tied to river valleys, particularly along the Aare, Moselle, Neckar, and Rhine, where clay was easily

[787] Flohr forthcoming a, 11-15, emphasizes issues of determining scale, demand, and performance when dealing with archaeological remains related to production within the Mediterranean.
[788] Polfer 2005; Amrein et al 2012.
[789] These data taken from Wirtz 1998; Biegert 1999; Biegert 2000; Heising 2000; Polfer 2005; Höpken 2005; Kaiser 2005; Rothenhöfer 2005; Heising 2007; Clerbaut 2010; Pastor 2010; Amrein *et al.* 2012.
[790] Eg Rüger 2000; Carroll 2001; Esmonde-Cleary 2013.
[791] Pastor 2010, 32; Goodman 2013, 121.

available.[792] In addition, ease of access to transport infrastructure was key for distributing the finished products, so centres often developed on major roads. Pottery production was carried out at a wide variety of site types: inside the military forts of Dangstetten, Haltern, and Beckinghausen, at villas like Heitersheim, in the *vici* of Bliesbruck, Bern, and Dambach, and in the major settlements of Trier, Cologne, and Frankfurt. Distinguishing between producer and consumer sites is, therefore, rather pointless. The distribution of production sites and particularly kilns suggests that the remains so far identified are only part of the equation. If a site, particularly a city, has yet to reveal evidence of pottery production it is probably only because it has not been found, not because it was not present. As Flohr has argued, interpretation of material remains of production in a positivistic manner is not without problem, as it relies heavily on the material at hand, cannot account for what is missing, and often lacks a comparative context.[793] In this situation, however, an explicit acknowledgement that the 1260 ceramic kilns discussed here are not the whole picture is hopefully mitigated by the fact that, at the same time, 1260 kilns and 147 sites is a substantial dataset which can allow for, at the very least, general statements about chronology, distribution, and organization. However, because this total dataset is not as complete as that presented for Switzerland or Gallia Belgica, statements of absolutes are avoided.

Pottery production rarely occurred in isolation and, when it did, should be considered as meeting an individual need.[794] More often, pottery was produced in workshops which were part of larger industrial quarters. In the Rhine Basin, it is common to find pottery producing sites clustered together, often on the periphery of settlement. Agglomeration of production facilities more easily enabled economies of scale than dispersed shops. Nucleation of potters allowed for specialization and diversification of labour— in large workshops, the work could be divided between clay gathering, pot forming, and kiln firing which would

[792] The clay resources mentioned in Chapter 4, deposited by fluvial activity, dictated the placement of these centres.
[793] Flohr forthcoming a, 12, 29.
[794] Polfer 1999; Flohr forthcoming b.

increase efficiency and output. In addition, easier control of resources, particularly firewood, was streamlined by the clustering of pyrotechnic industries. The same is true, as will be shown, of glass centres discussed below.

The largest concentrations of ceramic kilns are found in major cities— Nida-Heddernheim (150 kilns), Trier (108 kilns), Cologne (100 kilns), Mainz (90 kilns), Bad Cannstatt (80 kilns) (see **appendix 5.1**). Trier, Cologne, and Mainz also had some of the longest runs of production, spanning the better part of three centuries each (**fig. 5.5**). The model of producer/consumer cities falls apart in these instances and it seems probable that the abundance of archaeological material documenting craft production in cities in this region is the reason why such arguments never really entered into northern European scholarship.

The ceramic industry developed soon after the Roman conquest (**fig. 5.6**). The earliest kilns found thus far date from military sites— Dangstetten, Haltern, Beckinghausen, and Vetera I.[795] Two kilns at Mainz have been securely dated to the period 30/20 BC – AD 1,[796] though elsewhere most production begins in the Tiberian or Julio-Claudian periods.[797] The highest number of active sites came in the second century AD, with over 60 sites producing pottery between AD 100 and 200. Site numbers begin to fall in the third century, and 91 of the 107 datable sites have ended their production before AD 260. Only ten sites bridge the period of the Gallic Empire, and only ten carry on into the fourth century (**figs. 5.7, 5.8**). This gap, to my knowledge, has never been commented upon, but reveals a rather striking example of the actual effects of the political instability of the period.

The location of ceramic industries on the edge of settlements in this region is probably linked to the location of resources and the safety of the production process.[798] Pyrotechnic industries are not often located within settlement centres because of the risk of fire. The import of clay and firewood was equally made easier by being located on the edge of settlements rather than in busier centres.

---

[795] Wirtz 1998; See appendix 5.1 for specifics on sites.
[796] Heising 2007, 227.
[797] Wirtz 1998; Höpken 2005, 54-56, Amrein *et al*. 2012,
[798] Goodman 2013.

Such industrial suburbs are known at many sites across the region. Major cities like Cologne tended to have their potters arranged outside the main gates of the city, notably clustered along the Via Belgica outside the western gate (**fig. 5.9**).[799] In Trier, the vast majority of its substantial ceramic production was located south of the city centre, both inside and outside the walls, along the Moselle (**fig. 5.10**).[800] At Mainz, the southern suburb of Mainz-Weisenau was the centre of most of its production for nearly 300 years (**fig. 5.11**).[801] Nida-Heddernheim had potters' quarters to the south and north of the city, along the Main River and road to the north respectively.[802] Elsewhere, clusters of pottery workshops are known in the towns of Rottweil, Bad Wimpfen, Walheim, and Bad Cannstatt in Baden-Württemburg,[803] and at Brumath, Strasbourg, Dambach, and Bourgheim in France.[804]

Rheinzabern, undoubtedly one of the most prolific production centres in the region, developed as a specialized pottery-producing settlement after an initial establishment as a military brickyard in the first century. While only a small portion of the settlement has been excavated, some thirteen sigillata kilns have been located (**fig. 5.12**).[805] The kilns were located within the back yards of the so-called *Streifenhäuser*, or row houses, which were arranged along the main road through the vicus. The kilns presumably belonged to those who lived in the house, suggesting a different mode of craft organization from that seen in larger cities.[806] Similar arrangements can be seen in the *vici* of Walheim, Güglingen, Wimpfen, and Köngen.[807] Like the Pompeiian *domus*, these row houses combined domestic and craft-producing spaces, with some including shops along the street.[808]

[799] Höpken 2005, abb. 1.
[800] Luik 2002, abb. 1.
[801] Heising 2000, abb. 2.
[802] Baatz and Herrmann 2002, 285.
[803] Kortüm 2005.
[804] Pastor 2010, 263-75.
[805] Reutti and Schulz 2010.
[806] Mees 2002; Cüppers 2005, 534-36; Reutti and Schulz 2010; Goodman 2013, 134.
[807] Luik 2004, 128; Kortüm 2005, 159-64; Greiner 2005.
[808] Schmidts 2007.

This household level of production is qualitatively and quantitatively different from workshops excavated at Augst with nine ceramic kilns,[809] the twelve kilns from Bonn-Bastion Sterntor/ St. Maria,[810] or the shop at Cologne-Bahnhofsvorplatz with thirteen.[811] These instances represent a substantial investment in infrastructure, resources, and labour to produce their goods. They suggest a more formal organization of hierarchy and, probably, differentiated specializations. Though we know almost nothing of the potters themselves from this area, the archaeological evidence suggests a wide range of organizational possibilities.

Terra Sigillata production

The production of terra sigillata on a number of these sites has received substantial attention since Dragendorff's studies in the late nineteenth century.[812] Terra sigillata was a red-slipped fineware produced from high-quality clay and fired at high temperatures in order to produce a glossy red surface, often decorated with stamps or mould-made motifs, and was produced on 27 sites within the Rhine Basin (**fig. 5.13**).

The history of this ceramic type stretches back to the Hellenistic east, where it was produced in the region of the Syrian coast.[813] Later products were produced in massive quantities by centres in Italy at Arezzo and Pisa, [814]and this Arettine sigillata is one of the earliest trade goods to arrive into the Rhine frontier during Augustus' reign (**figs. 5.14-15**).[815] Production centres spread to southern Gaul and were established at Montans, Banassac, and the major centre of La Graufesenque which was established under Augustus.[816] La Graufesenque was a major source of terra sigillata found along the Rhine frontier in the first century

[809] Amrein *et al*. 2012.
[810] Wirtz 1998.
[811] Wirtz 1998; Höpken 2005.
[812] Dragendorff 1896.
[813] Malfitana, Poblome, and Lund 2005.
[814] Kenrick 2000.
[815] Mees 2011.
[816] Weber 2013, 8.

AD (**fig. 5.16**).[817] The central Gallic products from Les-Martres-de-Veyre, Vichy, Lubié, Toulon-sur-Allier, and Lezoux were common across the Northwest from the Trajanic period through the middle of the third century.[818]

Production of terra sigillata within the Rhine Basin begins with the so-called East Gaulish samian workshops, located at La Madeleine, Chémery-Faulquemont, Dinsheim-Heiligenberg, and Blickweiler from the late first century AD into the second half of the second century.[819] These sites were located around the Middle and Upper Moselle, and their products, particularly those of Dinsheim-Heiligenberg, are well documented throughout the Rhine region in the first half of the second century AD (**fig 5.17**).[820]

Rhine workshops came to dominate the production of terra sigillata in the Northwest from the middle of the second century onwards, with the large centres of Rheinzabern and Trier producing pottery which quickly took over the Rhine market. Rheinzabern pottery was distributed from northern Britain to the Black Sea for over 150 years (**fig. 5.18**) and effectively drove the other centres of production in Gaul out of the Rhine markets. The distribution of Rheinzabern sigillata not only locally, but far down the Danube and into Barbaricum, has been explained through military contracts during the Marcomannic wars, though this remains hypothetical.[821] Only 13 kilns have been excavated,[822] but more than 300 different potters are known from stamps on Rheinzabern sigillata, with 90 individuals who had particularly prolific productions.[823] The production of decorated vessels declined in the late third century, though the production of plain vessels continued into the fourth.[824]

The terra sigillata factories at Trier began ca. AD 130 and produced decorated vessels until the end of the third century, and undecorated into the

[817] Mees 2011.
[818] Weber 2013, 10.
[819] *Ibid.*, 11-13.
[820] Bémont and Jacob 1986; Delage and Mees 2009; Weber 2013.
[821] Weber 2013, 249.
[822] Reutti and Schulz 2010.
[823] Mees 2002, 79-113; Weber 2013, 14-15.
[824] Bernhard 1981; Mees 2002; Reuter 2005, 213-16; Gschwind 2006; Weber 2013, 15.

fourth.[825] Over 100 kilns have been excavated around the southern wall of the city,[826] though the actual chronology of production is not well understood.[827] Trier sigillata was distributed along the Rhine frontier and into Britain (**fig. 5.19**), though it never matched the wider distribution of Rheinzabern. Other ceramic types, like the Spruchbecherkeramik, were produced from the first through fourth centuries, and distributed more widely, reaching from Britanny in the west to the Middle Danube in the east in the mid third century (**fig. 5.20**).[828] It seems probable that potters from Trier had something to do with the establishment of a short-lived production at Sinzig, as both centres shared dies and stamps. Sinzig was active around the middle of the second century, and its distribution matches that of Trier, leading some to hypothesize some kind of market or merchant sharing (**fig. 5.21**).[829] It is possible that the Sinzig pottery was created as an extension of the Trier industry in order to tap into new clay resources, a phenomenon documented elsewhere in Gaul.[830]

A similar explanation has been posed for the development of the Schwäbische terra sigillata factories at Waiblingen, Nürtingen, and Kräherwald, located on the Neckar River south of Stuttgart in the second and third centuries.[831] Many of the potters known from these workshops also worked at Rheinzabern, leading Riedl to suggest their establishment as satellite centres to supply the local region of the Neckar Valley and the Swabian Alb.[832] Indeed, these products did not extend much beyond this fairly localized distribution (**fig. 5.22**). Production ceased with the abandonment of the *limes* in 260.

Contemporaneously, potters at Bern and Baden in Switzerland produced their own sigillata, referred to as 'Helvetische Ware.'[833] Stylistically, this sigillata differs from Rheinzabern but shows similarities with the Raetian centre at

[825] Huld-Zetsche 1972; 1993; Brulet, Vilvorder, Delage 2010; Weber 2013.
[826] Polfer 2005, 105-7.
[827] Weber 2013, 15.
[828] Künzl 1997, 107-19. The widest distribution came with Gruppe II, dated AD 260-280, while the latest group, Gruppe V, had a more limited distribution in the Rhineland and Moselle Valley.
[829] Mees 2007.
[830] Goodman 2013, 125.
[831] Kaiser 2005; Riedl 2011; Weber 2013.
[832] Riedl 2011, 260-72.
[833] Roth-Rubi 1986; Schmidts 2007.

Westerndorf, which have contributed to its dating of the late-second/early-third centuries.[834] The products of these centres were distributed mainly within the Swiss plateau (**fig. 5.23**), demonstrating a localized trade network like that seen for the Schwäbische Ware. The reasoning behind the distribution patterns of these ceramics is discussed below.

Amphorae production

The production of amphorae within the Rhine Basin is a little known and rarely discussed topic.[835] Amphorae production has been identified at eighteen sites within the Rhine basin (**fig. 5.24**), located mainly on the Moselle, Upper Rhine, and Neckar Rivers. Amphorae were produced at sites otherwise known for their fineware production, such as Rheinzabern and Waiblingen, and at sites with less well-known and less high-quality products such as Mainz, Heidelberg, Jagsthausen, and Heldenbergen.[836] The distribution of amphorae-producing kilns is striking, as they are not all centrally located on major trade routes. The kilns of Jagsthausen and Heldenbergen in particular, being located in the *vici* of outer *limes* forts, are particularly puzzling, especially as their products have not so far been identified outside Roman territory.[837]

These sites produced only a small number of amphorae types, mainly the Dressel 20 *similis* (Gauloise 14), the Gauloise 4 *similis*, the Niederbieber 74/75, Dressel 2-4, and imitation Mid-Roman 1 amphorae in both full size and miniature forms.[838] The distribution of many of these forms is not well understood as they have only been distinguised as imitations of well-known forms rather recently.[839] Most date to the second and early third centuries.[840] The Gauloise 4 *sim*ilis, in particular, has only been recognized outside of the central Rhine zone at

[834] Schmidts 2007.
[835] The main work on the subject is Baudoux *et al*. 1998, supplemented now by work by Ehmig 2003; 2007a.
[836] See appendix 5.1 for references for kiln sites.
[837] Abegg, Walter, and Biegert 2011.
[838] Baudoux *et al*. 1998; Ehmig 2003; Ehmig 2007a; Heising 2007.
[839] The distribution of Dressel 20 sim and Niederbieber 74/75 is discussed in Chapter 6.
[840] Baudoux *et al.* 1998.

Xanten,[841] and wider differentiations of Rhine fabric from the well-known southern Gallic fabrics have yet to be undertaken. Research by Baudoux *et al*. and Ehmig has helped to roughly sketch the distribution zone of the Dressel 20 *similis* and Niederbieber 74/75, which, at least so far, have been found mainly in Upper Germany and are particularly common in late-second- and early-third-century military assemblages.[842] The production of Dressel 2-4 amphorae at Augst briefly occurred in the Tiberian period,[843] while a single kiln at Mainz produced full-sized Mid-Roman 1 amphorae ca. AD 275-285,[844] and a fourth-century kiln at Cologne produced miniature versions of the same amphora.[845] The contents of these short-productions and the reasoning behind them are both unknown.

What these local amphorae held is equally poorly understood. Ehmig has suggested beer as the main product transported in the Dressel 20 sim, though she admits that they could have been used for many products.[846] The Dressel 2-4, Gauloise 4, and Nieberbieber 74/75, to judge from the common contents of other flat bottomed amphorae in Gaul, should have held wine, though, as discussed in the previous chapter, the evidence for contemporaneous local vine cultivation is lacking.

Pottery production and the regional economy

Considering the size of the dataset discussed here and the long history of research into this field, this brief examination of only two ceramic types produced within the Rhine is cursory at best. Some important points can be made, however, which tie this discussion back into the topic of the role of pottery production within the wider economy. The full extents of spatial distribution, chronological development, and scale of production have not been well understood within the region. It is clear that pottery production was a widely practised craft within the Rhine Basin, due largely in part to the abundance of clay resources along the

841 Carreras Monfort 2006.
842 See discussion in Chapter 6.
843 Amrein *et al*. 2012.
844 Heising 2007, 108-9.
845 Höpken 2005, 58.
846 Ehmig 2003, 133-161; Carreras Monfort 2004, 508-509; Ehmig 2007a, 57-74.

Rhine and its tributaries. Integration of these resources into a regional transport network meant that these resources could be exploited efficiently and that the products of the workshops could easily reach consumers. The location of pottery workshops across all manners of site types demonstrates the ubiquity of the practice, but also the fact that pottery production was a typical cornerstone of urban life in the region. The fact that the largest concentrations of evidence have been found in the largest cities of the region suggests that the level of investment in production facilities was directly related to the size of the market consuming their goods. Most production sites did not produce high-value terra sigillata, and most did not even produce finewares at all. Instead, the most common product across the region was coarsewares—everyday vessels for storage and cooking—which would be used daily in every household.[847] Most of these products were produced with the intention of being consumed locally, so production centres were of course located either near or in major settlements.

The more specialized production of terra sigillata was understandably less common, involving a higher knowledge and skill in clay preparation, decoration, and kiln firing. Local centres were able to take over production and trade from potteries in central and southern Gaul, effectively reducing transaction costs. The products of centres like Heiligenberg, Trier, or Sinzig targeted the Rhine as a market area, as did the various high-quality ceramics from Cologne. These potteries were regionally successful, and can be contrasted with production sites in Swabia or Switzerland which were only locally successful. On the other end of the spectrum is Rheinzabern, whose products distributed to supra-regional markets. Why the differentiation in apparent success? Rheinzabern had the advantage of scale, both in terms of a completely specialized economic activity and in terms of the number of potters working at the site. While most of the town has yet to be excavated, the small portion exposed revealed intensification of sigillata production at the household level across the site. Without a direct centre of consumption attached to the site, Rheinzabern potters were able to direct all of their products to longer-distance networks. There is also the possibility, judged

[847] Amrein *et al*. 2012, 36.

from the heavy distribution of finds along the Danube, that these potters became involved in selling pottery to the Roman military on campaign during the Marcomannic Wars.[848]

The production of amphorae required equally specialized production knowledge but also required cooperation with producers and merchants who were supplying the goods to fill the vessel. If little is known about amphorae production, less is known about the contents. The development of amphora production, therefore, acts as a proxy measure for the development of other aspects of the local economy as well: beer, at the least, and probably also wine (see discussion in Chapter 4). If the flat-bottomed forms did hold locally-produced wine, they seriously challenge what is known about the chronology of wine production in the region.

The overall chronology of pottery production shows a peak in the second century and a substantial disruption in the late third, with little evidence in the fourth and fifth centuries. Conflict and crisis are two obvious explanations, but the reality of this situation may have been more systemic. Aside from the threat of physical violence, crises may well have affected merchant networks, transport infrastructure, market centres, population distributions, and resource access. Any one of these was possible to adapt to, but all of them taken together posed a serious problem for potters making their living in the regional market. The subsequent retreat of many potteries from the Rhine frontier into the Gallic hinterland, especially the sigillata production in the Argonne, may well have been an effort to avoid subsequent disruptions of the actual manufacturing process.

In sum, the production of pottery in the Rhine aimed at local, regional, and supra-regional markets. Many potteries produced for local consumers in their town or *civitas*, while more specialized products were able to dominate regional markets. Potters invested in their industry in order to improve the efficiency and reach of their goods. As every settlement, urban, rural, or military, needed pottery on a daily basis, the production of vessels was a common and lucrative industry.

[848] Weber 2013, 256.

The abundance of specialized pottery traders in the epigraphy of the region makes it clear that the sale of these wares was an important part of commerce.[849]

Production of glass

In comparison to ceramic production, glass production took place on far fewer sites and has left far less evidence (**fig. 5.25**, **appendix 5.2**). Unlike pottery, which could be made in vast quantities with commonly available resources, glass production required a much higher level of technical proficiency and resource access, both of which acted as limiting factors on the spread and uptake of glass manufacture. Like pottery, the main archaeological evidence for glass production is kilns, though raw glass, glass frit (waste), and crucibles can also suggest glass working on a site. Only eight sites in Switzerland and thirteen in Gallia Belgica have produced evidence for glass working,[850] to which another twelve can be added from elsewhere in the Rhine Basin, bringing the total number of sites within the Rhine Basin to 24. At least 90 glass furnaces have been excavated, with major centres of production documented in Cologne, Augst, and the Hambach Forest, and others hypothesized at Trier and Mayen.

Primary and seconday glass production

Glassware was commonly used throughout the Roman Empire, accompanying terra sigillata and metalware as fine table sets. The production of glass was, however, less common than ceramics or metal as it required a more complicated production process as well as access to rare resources. Unlike clay or metal ore, raw glass required three main components for production, 70% of which was a high-silicate sand (silica could be added if necessary), and 30% of which was a flux agent added to reduce the melting point of the sand. Natron was the only flux used in the Roman world, with its main sources being found in Egypt.[851] To

[849] Schlippschuh 1974.
[850] Polfer 2005, 33-34; Amrein *et al*. 2012, 52-56.
[851] Shortland 2004; Shortland *et al*. 2005; Shortland *et al*. 2011. The deposits of the Wadi el Natrun (Lake Fazda) are mostly composed of the mineral burkeite, which has been demonstrated

produce raw glass (the glass equivalent of metal ingots) sand, silica, and natron were mixed together inside a tank furnace and fired at 1300º C for an extended period of time.[852] Only the top layers of the resulting product would be useable, the rest being recycled as cullet into the next firing. Once the quality glass had been separated, it could then be moved directly into secondary production or it could be sold and transported to other glass workshops across the Empire.

The local availability of natron in the south-east Mediterranean allowed for the large-scale production of glass from the Roman period onwards, with a large amount of evidence for late-antique production, particularly along the Levantine coast and in Egypt.[853] Some scholars have argued that this region was, in fact, the sole producer of raw glass in the Roman world, exporting glass ingots as well as finished vessels across the Mediterranean and farther afield.[854] This position has been seriously contested in the last decade by the introduction of glass isotope studies. While still a developing field, a number of studies have proven the origin of raw glass by matching the isotopes of the sand used in glass making with sand sources throughout the Mediterranean and Europe.[855] These studies have, crucially, demonstrated that glass could be and was produced outside the eastern Mediterranean, but the viability of production was linked to the availability of sand of a suitable quality. Outside the Mediterranean, several other studies have suggested that primary glass production was taking place in northern Europe, including several sites within the Rhine Basin.[856] We will return to this below.

through experimental work to be unsuitable for forming glass (Shortland *et al*. 2011, 925). Instead, the burkeite had to be mixed with lime and charcoal in order to convert it to useable trona prior to being used to make glass (ibid., 926).

[852] Firing time depended on the size of the furnace. A modern example from northern India required a month of sustained firing in order to produce a three-ton slab of glass, see Fischer 2009.

[853] Nenna 2000; Nenna 2003; Foy 2003.

[854] Stern 1999; Picon and Vichy 2003.

[855] Degryse and Schneider 2008; Brems *et al*. 2012; Ganio *et al.* 2012; Brems *et al.* 2013a; Brems *et al.* 2013b. This work has demonstrated the value of Sr and Nd isotopes for identifying different sand sources used in the production of Roman glass, and has positively differentiated between sources in the western and eastern Mediterranean.

[856] Rottländer 1990; Gaitzch *et al.* 2000; Wedepohl and Baumann, 2004; Wedepohl, Simon, and Kronz 2011a; Wedepohl, Simon, and Kronz 2011b.

Once raw glass was formed, it required additional stages of production in order to produce vessels. Fragments of glass were placed inside a ceramic crucible made of high-quartzite clay that was then put into a furnace and fired at 1000º C until malleable. The liquid glass could then be shaped, moulded, or blown into vessels.[857] The molecular composition of these vessels was still weak, however, and must undergo an annealing process to increase their durability. This required a third furnace heated to 600º C and then allowed to cool to room temperature, usually taking about 18-20 hours.[858]

Secondary production of glass could be accomplished using newly formed raw glass or by using recycled old glass.[859] Large-scale recycling is demonstrated by the Grado shipwreck found off Italy's Adriatic coast, containing a barrel of nearly 11,000 broken glass vessels.[860] The ship was on its way to Aquileia, a major glass-producing centre, where the glass was probably intended for recycling. Several large pits of broken glass were also found in the *canabae legionis* in Nijmegen, dating to ca. AD 104, where glass production is otherwise unattested.[861] These have been interpreted as collections waiting to be recycled, either in the town at an as-yet undiscovered glass workshop, or in a regional glass centre such as Cologne. Recycling poses a problem of interpreting isotopic analyses, as glass of different sources could be combined. Lead isotopes have shown promise in identifying glass which has previously been recycled, but only in specific circumstances.[862] Recycling also poses a problem when considering site assemblages, as older material is less probable to be found as it would have been recycled.

The traditional model of Roman glass supply was that all primary glass manufacture took place in the eastern Mediterranean; raw glass was then shipped to secondary glass workshops across the Empire, from which individual vessels

[857] Stern 1999, 451-52.
[858] *Ibid*., 455.
[859] *Ibid*., 450-51 on the historical development of recycling; the exact methods were apparently unknown to Pliny (*NH* 36.199).
[860] Parker 1992, 197. Giacobelli 1997, 311; Silvestri 2008; Silvestri *et al*. 2008.
[861] Bloemers in Isings 1980, 341-44.
[862] Degryse *et al*. 2006.

were created and distributed.[863] Glass production certainly began in the eastern Mediterranean earlier than in the west, with glass ingots found on the Ulu Burun shipwreck from the Bronze Age.[864] Pliny (*NH* 36.191) recounts a story that glass production began on the Phoenician coast where traders used natron blocks to prop up their cooking pot—the fire fused the natron with the sand and thus created glass for the first time. By his time, however, Pliny (*NH* 26.194) also tells us that sands from Italy, Gaul, and Spain were being used to create raw glass. Despite this statement, no centres of raw glass production have yet been located in the western Mediterranean.[865] The above-mentioned work by Brems and others set out to test this statement by sampling over 70 sand sources in Spain, France, and Italy to determine their suitability for glass making. This study located only a handful of sites with suitable sand: two in Spain, one in France, and three in Italy.[866] In addition, they found that sand from the Basilicata and Apulia regions of Italy was nearly identical to those of the Levantine coast.[867] This study helps clarify the extent of possibilities in Mediterranean glass manufacture—while the glass factories of the east were important, Pliny's statement about sands in the west in conjunction with the new isotopic studies demonstrates western production as well.

The situation in northern Europe is more tendentious. In 1965, Fremersdorf argued for primary glass production in Cologne using rich sand deposits in Frechen adjacent to the city.[868] These sand pits were still producing 100,000 tons of sand per year prior to WWII.[869] In the years since, over 200 glass samples have been sourced from the Rhine region. In 1990, Rottländer tested 70 samples of glass from Cologne and Hambach and found that their composition closely matched that of the local sand from Frechen, and concluded that Cologne was indeed producing raw glass using local material.[870] Since then, Wedepohl and

---

[863] Stern 1999; Fleming 1999, 16; Foy and Nenna 2001, 35.
[864] Nicholson 1997.
[865] Brems *et al.*2013a, 214.
[866] Brems *et al*. 2013b, 461.
[867] *Ibid*., 462.
[868] Fremersdorf 1965, 24.
[869] *Ibid*., 35.
[870] Rottländer 1990, 567.

colleagues have tested another 80 samples from Hambach, Cologne, and Krefeld and come to similar conclusions, specifying another sand source to the west of Hambach along the Rur River in Iülich based on iron signatures.[871] These researchers have all, so far, concluded that primary production of glass was taking place at different sites within the German provinces.

Glass production in Cologne

The difference in scale between the production of glass and the production of pottery allows for a more detailed examination of the production centres. Excavations in Cologne have produced abundant evidence for glass production in the city, identified at six different workshops with kilns and an additional eight sites with finds of glass frit or glass crucibles (**fig. 5.26**). [872] A total of 23 kilns have been found in the city, one at Gereonstraße, five at Eigelstein 14, three within the Praetorium, two at Waidmarkt 18, eleven at Eigelstein 35-39, and one on the Helenenstraße.[873] These workshops date from roughly the Neronian period through the third century, and only a single find of a crucible on the Lowengasse can be dated to the fourth century. There are undoubtedly many other workshops and kilns waiting to be found throughout the city, as the spectrum of glass products from the city is enormous.[874] No tank furnaces for primary glass production have been found, but, as stated above, Cologne has long been thought to have been a source for primary glass production and scientific analyses suggest that this was the case.

Products from Cologne were prevalent in the Rhine glass market from the middle of the second century AD (**fig. 5.27**).[875] Bottles stamped with CCAA, assumed to stand for "Colonia Claudia Ara Agrippenensium" have been found in both the Rhineland and in Britain.[876] Museums in Bonn, Trier, and Mainz are full

[871] Wedepohl and Baumann 1999; Gaitzsch *et al.* 2000; Höpken and Paz 2008; Brüggler 2009.
[872] Höpken and Schäfer 2006, 83-4.
[873] Fremersdorf 1965; Doppelfield 1966; Höpken and Schäfer 2006; Höpken and Paz 1998.
[874] Fremersdorf 1958a; 1958b; 1959; 1961; 1962; 1967; 1984.
[875] Rütti 1991, 147; Hoffmann 2002, 268-69.
[876] Price 1978, 70.

of glass matched to products from Cologne.[877] It is, however, extremely difficult to match a form to a production centre without either a stamp or isotopic tracing, so much of this remains conjecture.

Glass production at Augst

Two glass workshops have been excavated in the lower city of Augst (**fig. 5.28**).[878] The two buildings faced each other across one of the main streets of the settlement; the north building (referred to as 17c) contained a circular crucible kiln and ten fragments of crucibles.[879] This complex was dated to the period AD 160-220 and was probably used for secondary glass production. The southern building, 17b, contained 14 kilns—three tank furnaces, eight crucible furnaces, and three annealing furnaces, in addition to 53 fragments of crucibles.[880] These kilns were not all used contemporaneously; rather, their arrangement suggested to the excavators that they were used in groups of 3-4 for three successive periods of use of about 4 years each. The workshop was only in use for roughly 30 years between AD 130 and 160. Analysis carried out on the tank furnaces revealed that they had been fired at temperatures above 1300º C, which would only be necessary to form raw glass.[881] The crucible fragments recovered suggest that they held, on average, 4 litres of glass (10 kg) each, and the crucible furnaces could fit four crucibles at a time, meaning each firing would yield 16 litres (40 kg) of glass. The products of this workshop are, unfortunately, not well researched at all, so it is impossible to discuss their distribution.

Glass production in the Hambach Forest

Extensive opencast mining of brown coal 35 km to the west of Cologne revealed a densely settled villa landscape in the region of the Hambach Forest along the route of the Via Belgica between Cologne and Iülich (**fig. 5.29**). This region

[877] Goethert-Polaschek 1980; Follman-Scholz 1988; Harter 1999.
[878] Fischer 2009.
[879] Fischer 2009, 95-107.
[880] Fischer 2009, 25-35.
[881] Fischer 2009, 82-88.

experienced intensification of settlement from the first century AD and at least six of the villas started producing glass at the beginning of the fourth century.[882] A total of 37 glass kilns have been found—three tank furnaces, 27 crucible furnaces, and seven annealing furnaces.[883] Only sites HA 132 and HA 111 had examples of all three furnace types. The presence of these tank furnaces suggests primary production of raw glass.

The site of HA 132 is worth particular discussion.[884] The site, with its 12 or 13 furnaces, is the largest example of glass manufacturing in the area. All were set under posted-roof structures, presumably with open walls for ventilation. Of these, ten were crucible furnaces, two were annealing furnaces, and one or two were tank furnaces. The last is unclear because of the poor condition of the foundation. This site is particularly important because it also provides the most direct evidence for regional supply for this period (**fig. 5.30**),[885] as stamps reading "ECVA" were found on site. Jugs stamped with ECVA on their bases are known throughout the Middle and Lower Rhine region. Since there is little evidence of production in Cologne contemporaneous with the production in the Hambach Forest, it seems that these villas took over the production and market supply of glass products in the fourth century.

Glass production at other sites in the Rhine basin

Kilns have been excavated at five other sites: Trier, Bonn, Riegel, Goch-Asperden, and Avenches. These are all crucible furnaces, and there is no sure evidence for primary glass production outside the three areas outlined above. Both Trier and Mayen have been suggested as centres of primary glass making, with some isotopic evidence from Mayen suggesting a common isotopic signature, but no archaeological evidence of this production has been located.[886] At least sixteen other sites in the region have produced evidence of glass working, either through

[882] Gaitzsch 1991; Gaitzsch 1999; Gaitzsch *et al.* 2000; Brüggler 2006; Brüggler 2009.
[883] Gaitsch *et al.* 2000.
[884] Gaitzsch *et al*. 2000; Brüggler 2009.
[885] Gaitzsch *et al.* 2000, 123-30.
[886] Wightman 1970, 204; Hartmann and Grünewald 2010.

the finding of crucibles or glass frit. An examination of the dating of kilns and site activity shows that the first and second century saw an initial rise in production (**fig. 5.31**), followed by a lack of evidence for the third which probably skews that picture. A large number of sites were active in the fourth century, particularly around the Moselle Valley, suggesting that they were linked with the success of Trier as an Imperial seat. Indeed, some of the most spectacular glass finds from the Empire come from the Rhine region in late antiquity, such as the diatrite cups from Cologne, Piesport, and Trier. These were possibly made at Cologne, Trier, or in the region.[887] The tradition of glass manufacture carried on into the post-Roman period in the region, and indeed well beyond.[888]

Glass production and the regional economy

Primary production of glass was a rare craft throughout the Roman world, and the concentration of production facilities in the Rhineland is unusual. In the Mediterranean, dispersed centres of primary production are hypothesized based on Pliny's statement and the viability of sand resources along the coastline. In northern Europe, less is known or understood, though this chapter has helped summarize and clarify the evidence as it stands today. Glass, unlike pottery, cannot be made in most places. Sand of the correct composition is needed in addition to the flux element natron. Natron is a key element to the puzzle of glass production in the region; if Cologne, Hambach, and Augst were producing raw glass, they were still importing natron from Egypt.[889] This is a trade otherwise unattested in the Roman world. Therefore, despite the local importance of glass manufacturing, the Rhine's glass production was directly tied into an Empire-wide trade network. In turn, the Rhine supplied glass vessels along the frontier region and even into Britain.

---

[887] Lierke 1995a; 1995b.
[888] Haberey 1960; Pirling 1981; Päffgen and Wedepohl 2004.
[889] Wedepohl and Baumann 2004, 130 demonstrate that all sampled Roman-era glass used natron, not vegetal (potash) flux.

Conclusions

While only pottery and glass have been covered here, it is obvious that the production of crafts formed a major part of the non-agricultural economy of the Rhine basin. The resources of the river valleys were ideal for facilitating these crafts, as sand and clay deposits were widespread. While pottery production was widespread, specialty products were made in a fairly limited number of workshops. These workshops achieved supra-regional distribution of their products because of their quality and access to the developed transport networks that linked the Rhine basin to neighbouring regions, as discussed in Chapter 2. The Rhine potters took over their markets from Gallic producers and effectively held onto them for over 150 years. This is a clear demonstration of import replacement, in which expensive, 'foreign' goods which require long-distance transportation are cut out by local producers able to produce similar products more cheaply. Glass was a similar situation, as Rhine products ousted Mediterranean goods to supply the local market. Few centres provided an apparently large quantity of glass to the region, and this industry was successful for more than four centuries as the Franks took over.

Glass and ceramics were complementary in a number of ways—relying upon local resources, utilizing pyrotechnic technology, and distributing through the same network. Glass and ceramic vessels were both used throughout the household, for drinking, serving, and storage. Contents of such vessels are rarely preserved, but a chance grave find at Speyer sheds light on some of the daily use of glass (**fig. 5.31**). The so-called Römerwein of Speyer, now held in the Historisches Museum der Pfalz in Speyer, was found in a fourth-century grave in 1867; the bottle (form Isings 100a/Trier 140) still contained its 1500-year old wine. This bottle form is otherwise known from Bonn, Trier, and the Hambach Forest; is its distribution linked to local wine production? It is often assumed that barrels replaced amphorae in European wine transport, and they may well have for bulk shipment. The Römerwein shows, however, that people probably actually purchased wine in glass bottles. The production of amphorae in the region which declined at the end of the third century may well have been replaced by smaller, recyclable glass bottles. Glass and pottery are often discussed completely separately, though in actuality they were closely linked. Both formed key elements of the Rhine economy, and we can clearly document substantial investment and specialization. These products very nearly completely took over the local market until late antiquity when potteries located in the Argonne region of Gallia Belgica start to provide for Rhine markets. Import replacement, however, cut prices and increased availability of these goods for most of the imperial period. This not only applied to ceramic and glass vessels, but also what they carried.

There was no division of producer/consumer cities—this model, sufficiently disproven in the Mediterranean, was never even considered along the Rhine because of the abundance of archaeological remains. A wide variety of other crafts remain to be explored, and doing so will surely increase appreciation for how crucial craft production was within the economy of the Roman Rhine.

6

Trade and Market Structure

Understanding the nature of market activity in frontier zones is essential to understanding not only life along the outer limits of the Roman world, but also to understanding how the different regions of the Roman Empire connected to each other.[890]

Different sorts of market organizations are possible; Temin outlined three main types seen in historical economies: instrumental, customary, and command.[891] Instrumental market activity consists of human agents with specific aims and goals (for example, profit) which create a high rate of change in market activity.[892] When agents are less ambitious and change is slow, market activity becomes customary—exchange tends to be reciprocal.[893] Command economies exist where the movement of goods is controlled through institutionally-controlled redistribution and individual agents have a low impact.[894] Temin argued that a market economy typified by instrumental behavior existed within the early Roman Empire where loans, prices, and the exchange of goods through trade were commonplace and fluctuated in response to supply and demand.[895] He was careful to say, however, that this did not preclude the existence of other types of market activity, indeed "it is hard to conceive of an economy composed entirely of market exchanges."[896]

More recently, Mattingly argued for the existence of three different types of markets in the Roman world: an "Imperial Economy" which was responsible for taxation, the military, and administration, "extra-provincial economies" in which goods moved inter-regionally across tax and provincial boundaries, and

[890] See the various articles in Papi 2007 as well as Morley 2007; Mattingly 2011, 144-45; Tchernia 2011, 101-110, Temin 2012.
[891] Temin 2001, 171-72. See also Polanyi 1977, 35-36 on reciprocity, redistribution, and exchange.
[892] Temin 2001, 171.
[893] *Ibid*.
[894] *Ibid*., 171-172.
[895] *Ibid*., 181.
[896] *Ibid*., 180.

"provincial economies" in which local market systems developed.[897] Like Temin, Mattingly argues that these systems were not exclusive, and trying to separate them may obscure their interdependence.[898] Both of these studies stand in opposition to the Finley tradition where market activity was downplayed[899] or Bang's model of the "Roman bazaar" where exchange was a casual affair lacking institutionalization.[900] Temin, Mattingly, and McCormick (though for a slightly later period), support the idea of multiple systems co-existing, suggesting that there need not be a single mode of trade or exchange.

Scale plays an important issue in determining the route of this discussion. For the Roman Empire, it is easy to state that multiple systems existed, but it is much less helpful on a local scale where there is a higher resolution of data which can perhaps allow for a more nuanced appreciation. Along the Rhine, the interplay of "command" and "instrumental" economies is an important one, and clarifying the nature of state-directed redistribution versus market oriented exchange is a critical element in outlining economic growth and development.

The army and state play a pivotal role in this discussion, as they are often seen as the main impetus for economic development in frontiers.[901] Scholars disagree on the importance of this role:[902] one side believes that the state controlled the distribution of goods into frontier regions as supplies to the army which were levied from provinces as tax in kind,[903] while the other argues that state control was minimal and the goods which arrived in frontier zones did so through a free market.[904] The first group either downplays the importance of civilian markets, arguing that they were supplied secondhand by surplus from the army, or ignores them entirely, while the second group argues that both civilians

---

[897] Mattingly 2007, 138-140.
[898] *Ibid*., 140.
[899] Finley 1973.
[900] Bang 2009.
[901] Fentress 1979; Whittaker 1994;Thomas and Stallibras 2008.
[902] See Wierschowski 2001, 37-43 and Tchernia 2002 for a summary of arguments.
[903] Hopkins 1980; Remesal Rodriguez 1986; Whittaker 1994; Remesal Rodriguez 1997; Remesal Rodriguez 2002; Whittaker 2004; Morley 2008; Cherry 2008; Carreras Monfort 2010. Of further issue is when such a supply started—originally thought to have been a third-century initiative (Pavis d'Escurac 1976; Herz 1988, Wierschowski 2001), but Remesal Rodriguez argues for an Augustan origin (Remesal Rodriguez 1986, 1997, 2002).
[904] Martin-Kilcher 1994; Wierschowski 2001; Verboven 2007; Schmidts 2011.

and soldiers were engaged in the same system which supplied both equally. To date, this discussion has relied heavily on written evidence such as the Vindolanda tablets, inscriptions, and *tituli picti* on amphorae.[905] Scholarship also tends to focus on the Roman frontiers in broad terms instead of regional case studies,[906] obscuring regional or chronological variation.

This discussion has stagnated; the issue is rarely raised in new studies and many articles and books continue to cite the same material outlined in the last paragraph and earlier in the introduction. Studies focusing on archaeological material are rare. Furthermore, because of the very general approach taken by previous work, there are few in-depth, regional studies that can be used to establish comparative studies of different frontier zones. We are left with a qualitative feeling that frontiers were different from other regions in the Roman world, but we have very little firm evidence with which to support that impression or to really explain why it would be the case. Therefore, research which attempts to address the nature of frontier markets and the mechanisms of distribution acting within them will be limited until new studies provide material basis for theories.

This chapter is an effort to fill this gap and assess market structure and distribution mechanisms by examining several aspects of trade within the Rhine basin. While the relevant issues of monetization and traders have already been discussed in Chapters 1 and 2, and local production and the distribution of these goods were examined in Chapter 5, it is also necessary to examine assemblages of trade goods. Here, in order to establish a quantified material base for discussing trade in a frontier zone, a large dataset of amphorae is critically examined. Because amphorae contained some of the most commonly traded and consumed food products in antiquity—olive oil, wine, fish sauce and other fish products—they represent a significant portion of traded commodities. These commodities, especially olive oil, have long played an important role in the discussion of military supply,[907] so their presence must be critically analyzed. It must be emphasized that this discussion only applies to amphorae, and the conclusions

[905] Remesal-Rodriguez 1986; Bezeczky 1996; Remesal-Rodriguez 1997; Broeckart forthcoming.
[906] Cherry 2009, 720.
[907] Wierschowski 2001 for summary.

cannot be directly extended to deal with other commodities, such as grain, which may well have had different supply organizations.[908]

Previous research on amphorae in the Rhine basin

The quantity of published ceramic reports available is evidence enough that material studies have a long history in the study region. Despite the general availability of published material, there is little synthetic work to tie it all together and produce long-term or regional overviews. It would be impossible to consider all of the published material in one thesis, but a single study which considers the many quantified amphorae assemblages is enough to make important progress.

Such a project would not be possible without the pioneering work of several scholars in the region. Siegfried Loeschke took care in typing and illustrating the amphorae found in his excavations at the Augustan fortress of Haltern on the Lippe in 1909,[909] and published the ceramics from the nearby contemporary fort of Oberaden with Christoph Albrecht some years later in 1942.[910] These typologies became the standard throughout the region, used in place of Dressel's, which was more commonly used in the Mediterranean.[911] Within two years of the publication of the Hofheim ceramics by Ritterling,[912] Franz Oelmann published an important volume on the ceramics from the Antonine fort at Niederbieber in 1914,[913] and two years later the ceramics from the vicus and Late Antique burgus at Alzey were published by Unverzagt.[914] Excavations at the legionary fortress at Windisch, particularly in the rubbish dump known as the Schütthugel, published by Elisabeth Ettlinger and Christoph Simonett helped clarify ceramic material in Switzerland.[915] In the following decade, P. Stuart wrote his thesis at Nijmegen on the classification of pottery found during those

[908] See page 125 above.
[909] Loeschke 1909.
[910] Loeschke and Albrecht 1942.
[911] Van der Werff 1984, 350.
[912] Ritterling 1913.
[913] Oelmann 1914.
[914] Unverzagt 1916.
[915] Ettlinger and Simonett 1952.

excavations.[916] These sites helped establish chronologies and typologies for many ceramic forms which were not always found in the Mediterranean where other typologies were being developed, and were thus critical in the identification of otherwise unknown amphorae forms.

More recently, building on this older scholarship, the work of Stefanie Martin-Kilcher at Augst has set the standard for amphora studies.[917] Her wider studies on amphorae in the Northwest provinces were groundbreaking, though most lack the quantification published at Augst.[918] Juliette Baudoux has published quantified syntheses of amphorae in Alsace, but did not compare the area with neighbouring regions.[919] Ulrike Ehmig has recently studied the amphorae from the museums in Mainz as well as those from the surrounding area, filling an important gap around the Middle Rhine.[920] On the Lower Rhine, the assemblage from Xanten is currently under study by Carreras Monfort,[921] while the forts of the Lippe are currently being reassessed for new publication,[922] and the first-century legionary fortresses of Neuss are also forthcoming.[923] Finally, an updated view of the "exotic" material (mainly eastern Mediterranean) from Nijmegen has recently been published.[924]

Stamped amphorae, most importantly the Spanish Dressel 20, have attracted substantial attention from Spanish researchers who are interested in the distribution of Baetican olive oil. Remesal-Rodriguez has documented stamps present along the Rhine in a number of studies,[925] in conjunction with those from Britain studied by Monfort and Funari,[926] in an attempt to work out the organization of Baetican oil trade. In her study of stamps from the Middle Rhine

---

916 Stuart 1963.
917 Martin-Kilcher 1987; 1994; 1997.
918 *Inter-alia* Desbat and Martin-Kilcher 1989; Martin-Kilcher 1991; 1994; 2004; 2005; 2006a, 2006b.
919 Baudoux 1992; 1996; 1998.
920 Ehmig 2003; 2007.
921 Carreras Monfort and Morais 2012, 437; a preliminary report of this work is found in Carreras 2006.
922 Carreras Monfort and Morais 2012, 437.
923 Carreras Monfort and Morais 2012, 437, and another study presented briefly in Wegert 2010.
924 Carreras Monfort and Morais 2012, 437; Van der Berg 2012. For the initial Nijmegen amphorae report see van der Werff 1984 for a (somewhat) quantified report.
925 Remesal-Rodriguez 1986; 1997; 2002.
926 Carreras Monfort and Funari 1998; Carreras Monfort 2000.

region, Ehmig has argued against the idea that certain oileries in Baetica were directly linked to findsites.[927] Stamps are often published, even where quantified assemblages are not, as at Cologne.[928]

There is a wealth of information available, but with few exceptions it is not yet wholly integrated into a discussion of economic activity with big questions and chronological precision.[929] What follows is an attempt to do both by building upon the studies outlined above.

The amphorae data and their limitations

In total, quantified assemblages from 71 different sites (**fig. 6.1**), of which 57 come from within the Rhine basin and an additional 14 from neighbouring Gaul and Raetia for comparison, have been compiled into a database which registers site type (military, urban, vicus, villa), dating of assemblage, the amphora forms present, their origin and contents, and their quantification (both method and count). The total assemblage can thus be studied by site, by form, by origin, or by contents. From the Rhine basin, 31 forts, 11 cities, eight *vici*, and five villas are included, ranging from the time of the Augustan conquest to Late Antiquity. The site-by-site breakdown of site type, origin, and contents for all 71 sites is included in **appendix 6.1**.

Unfortunately, because these sites have been excavated in different countries by different excavators with different research questions over the last half-century or more, there are several caveats about the data. Not all reports are standardized and quantification methods vary; of the 55 sites, 47 are quantified by minimum number of individuals (MNI) and eight by counting some combination of rims, bases, and handles (RBH). Different levels of detail are often given in these reports, sometimes allowing for various modes of quantification. In these cases, particularly Xanten and Walheim, the published tables allowed for the figures to be converted to MNI, although the original authors did not provide

[927] Ehmig 2007a.
[928] Ehmig 2007b; 2009.
[929] Baudoux 1996 and Laubenheimer and Marlière 2010 are exceptions.

these figures. Kaiseraugst provides a singular case where its figures for origins and contents can be derived from figures in the publication,[930] but the specific forms from the fort are not published separately from those of Augst,[931] obviously creating some error in dividing the military assemblage off from the civilian. Similarly, Mainz presents a difficult case not only because of its quantifications,[932] but because it combines some (sparse) material from the legionary fortress with the (plentiful) material from elsewhere in the city.[933] This is because the publication was based on museum holdings which either had no context or lost their records in the Second World War. The assemblage is treated here as urban, though again some caution must be used.

In order to account for the different recording methods instead of simply throwing out large sections of the data, I will tend towards discussing sites in percentages rather than raw numbers. This will also help to compare assemblages of widely varying sizes, ranging from 10 MNI at Oedenberg to 5354 RBH at Augst. Because only quantified assemblages are used, many sites, though excavated, are left out of this discussion. For this reason, major cities like Cologne and Trier are unfortunately missing, despite their obvious importance to the region. Reference to unquantified amphorae from these sites will be made in the discussion where possible. Moreover, most of the assemblages are not phased, meaning the assemblage represents 400+ years of occupation. However, because many sites (particularly forts) have very specific occupation chronologies, we can at least provide a reasonable chronology by establishing *termini post quos* which can be compared to those few sites where phasing is published.

Finally, it must be remembered that amphorae are only one type of container which was used to transport bulk products to the Rhine basin. Barrels remain a largely unquantifiable alternative (discussed below), but we must

[930] Martin-Kilcher 1994 abb. 211.
[931] Martin-Kilcher 1987; 1994; the figures for the assemblage from Kaiseraugst were calculated from Martin-Kilcher 1994 abb. 209 & 211.
[932] Ehmig 2003, 17-18 provides three categories of quantification, one for whole amphorae along with rims and bases, one for wall fragments and handles, and one for total sherd count accounting for totals of 1987, 2834, and 4821 respectively. Schimmer 2009 calculated a total rims, bases, and handles total for Mainz at 4408, but his tabulation combines too many forms to be accurately used here. Instead, Ehmig's full, rims, and bases total is used in this discussion.
[933] Ehmig 2003, 20-22.

remember that they were used and probably travelled in high quantities possibly equal to or greater than (at certain times) the number of amphorae in use, and carried larger quantities of goods. Moreover, amphorae were probably not used to distribute the products beyond initial bulk purchase—individuals probably would have bought jugs, skins, or glass bottles in much smaller volumes than amphorae otherwise carried. The small jugs which mimic the Sicilian MR1a amphora which were produced in Cologne were possibly used to distribute Sicilian wine on a local market,[934] and we must remember the fourth-century glass wine bottle from Speyer, discussed in Chapter 5, as evidence for the decanting of wine.[935] A study of bottle and jug forms across both ceramic and glass assemblages should someday be carried out in order to assess the distribution of household-sized containers, but this is beyond the scope of this project. It must be remembered, therefore, that this chapter deals with one aspect of container transport that, due to the visibility of amphorae, is more easily studied than others. This topic is dealt with again later in this chapter when explaining possible reasons for chronological change.

Despite these drawbacks, the database offers many new insights into where, when, and how amphorae circulated. This chapter offers an admittedly optimistic interpretation of the data, but not an uncritical one. The following sections analyze the assemblage first in regional terms, and then breaks down by site types, in each instance investigating common forms, the products contained by those forms, and their areas of origin. Following this, I examine the chronological changes evident in the assemblages, and finally end with a comparison to neighbouring regions and a discussion on the nature of the market system(s) which allowed for the importation of these vessels.

[934] Liesen 2001; Höpken 2005; Franco forthcoming.
[935] This form is distributed around the Rhineland in the fourth c. AD with examples also known from Bonn and Hambach villa 132, where it was being produced. In light of the Speyer example, we might consider these to be local fourth-c. wine bottles.

Regional overview

The importation of Mediterranean products in amphorae to the Rhine began in the La Tène period, when Italian wine was traded in massive quantities into Gaul in return for slaves.[936] Excavated oppida in the Rhine basin as at Titelberg, Breisach, and Basel all demonstrate the quantity of material which arrived in the region from ca. 120/110 BC onwards.[937] Around 30 BC, a wider range of Mediterranean products began to appear, particularly from Spain,[938] as Roman settlement and control expanded. The database is concerned with the material that would arrive after this date.

The sites in the database are from across the Rhine basin, with sites in Germania Inferior and Superior, Gallia Belgica, and Raetia. If we sort the entire assemblage by region of origin and momentarily ignore chronological changes (**fig. 6.2**), we can see that the majority of amphorae come from Spain, accounting for 57% of the total. Products from Gaul and local products from the Rhineland account for another 30% of the assemblage when taken together. The remaining 13% is made up of amphorae from Italy (4%), the eastern Mediterranean (4%), and North Africa (1%). Approximately 4% of the assemblage cannot be linked to production zones. When broken down by contents (**fig. 6.3**), olive oil amphorae account for 37% of the total. Wine amphorae are the next most common at 31%, while fish sauce amphorae account for only 18%. Those amphorae whose contents are unknown account for 7%, while those carrying fruit, beer, and alum round out the final 7%.

This apparent diversity in products should be contrasted with the range of forms present in the region (**fig. 6.4**). In total, about 140 different types of amphorae have been identified within the region, but 69% of the assemblage is actually made up of only five different forms. The most common form is the Spanish olive oil amphora form Dressel 20 at 36%, while the Gallic wine amphora form Gauloise 4 is second at 15%. The Spanish fish containers in the Dressel 7-11

[936] Poux 2004. See also Poux 1999; Loughton 2003; 2009.
[937] Laubenheimer 1998; Deschler-Erb 2008; Wendling 2012.
[938] Deschler-Erb 2008.

range are the third most common at 9%, while the locally produced Dressel 20 *similis*, probably containing beer,[939] made up 5% and the Spanish Haltern 70 for *defrutum* slightly less at 4%.[940] Only 3% of the assemblage is unidentified, the remaining 28% is made up of small quantities of the other 133 forms found.

Urban sites

The sites qualified here as "urban" are those settlements which held some legal status above that of a vicus—all at least holding the title of *civitas* capitals, shown in **figure 6.5**. The largest and best-studied assemblages included here are those from Augst,[941] Mainz,[942] and Nida-Heddernheim.[943] It is lamentable that no assemblages have been studied from Cologne or Trier (outside of the fourth-century Kaiserthermen),[944] but the other urban centres studied here offer a reasonable context for comparison. These sites account for almost half of the total data, demonstrating the importance of urban markets in the regional economy, a topic returned to below.

As mentioned above, some urban sites also held military garrisons. Both Mainz and Strasbourg are included under the cities category because, despite their legionary garrisons, because the assemblages have not been divided between material recovered from the fortresses and those recovered from the town.[945] Ehmig's distribution map of amphorae with recorded find spots suggests that most are from the civilian settlement around the fortress, and those published from the Rue du Hanong excavations in Strasbourg are well outside the legionary camp.[946] In any case, both assemblages closely resemble the urban average.

The five most common forms on urban sites are the Dressel 20, Gauloise 4, Dressel 7-11, Dressel 20 *similis*, and the Dressel 9 *similis*, making up 69% of the total assemblage (**fig. 6.6**). Only 3% of the assemblage is unidentified, while

939 Ehmig 2003, 133-161; Carreras Monfort 2004, 508-509; Ehmig 2007a, 57-74.
940 Carreras Monfort 2003, 88.
941 Martin-Kilcher 1987; 1994.
942 Ehmig 2003.
943 Ehmig 2007a.
944 Hussong-Cüppers 1972.
945 Baudoux 1996; 1998; Ehmig 2003.
946 Baudoux 1998.

small amounts of 113 other forms account for the final 28%. The total assemblage from urban sites by origin is shown in **figure 6.7**, and we can see that there is slightly less Spanish and slightly more Gallic material than the regional total, but the basic hierarchy of percentages remains—Spain (50%), Gaul (30%), Germany (8%), Eastern Mediterranean (4%), Unknown (4%), and North Africa (1%). When viewed by contents (**fig. 6.8**), however, urban sites are almost exactly the same as the regional total, due in part to their large sample size.

In general, most cities produce fairly standard assemblages that are close to the overall urban averages for origin (**fig. 6.9**) and contents (**fig. 6.10**). There are two main exceptions to this—salted fish amphorae and locally produced amphorae. Fish sauce amphorae are present on sites that were established at some point before the end of the first century AD, but are notably absent or present only in very small quantities in towns founded after this period. This is already evident at Worms, founded under Vespasian, but clear at Dieburg and Nida-Heddernheim, both Trajanic-era *civitates*. The later assemblages from Voorburg and the Trier Kaiserthermen similarly lack any trace of these products. At Augst, it is clear that imported fish products peak between AD 30-70 and decline substantially thereafter.[947] Recent investigations have documented the production of fish products along the Channel coast in Flanders and Zeeland in the second and third centuries AD.[948] It is probable that these fish products were packaged in barrels, and therefore have left little evidence for their trade or distribution.[949] If this North Atlantic fish was being traded into the Rhine region, then the barrels would explain the disappearance of amphorae, offering another example of import replacement. As fish amphorae disappear, amphorae produced locally in the Rhineland begin to show up in assemblages, most notably at Dieburg, Worms, Nida-Heddernheim, and the Trier Kaiserthermen, with lesser, but significant, proportions at Mainz. These local amphorae forms are particularly concentrated in the Middle Rhine area (**fig. 6.11-12**), though this may be more due to documentation than reality—some specimens are known from Xanten, where the

[947] Martin-Kilcher 1994, abb. 208.
[948] Wilson 2006; Van Neer, Ervynck, and Monsieur 2010.
[949] *Ibid*. 187.

full publication will help clarify the percentages, but also at Voorburg, so this material did travel some distance. Overall, this evidence suggests that the decline of foreign imports matched a contemporaneous rise in local products.

Military Sites

Military sites are the most numerous type considered here, with 32 examples contained in the database, shown in **figure 6.13**. These include both legionary fortresses and auxiliary forts. The availability of this information reflects the long-standing tradition of research into military forts in the region as well as the high standard of finds publication. As mentioned earlier, the specific occupation chronologies of these forts provide a view of temporal change which is not so readily apparent in the other site types. Grouping them purely by their foundation dates, there are ten from the Augustan period, six from the Julio-Claudian, four from the Flavian, five from the Trajanic, three from Antonine, and then four from the fourth century. This is obviously not an even distribution across time, but does provide us with points of chronological focus through much of the Roman period. Obviously missing are assemblages from new forts of the third century, of which, as discussed in chapter 3, very few are known and none has published assemblages. The Antonine forts and some of the Trajanic forts were occupied until AD 260, and therefore provide some material evidence for the third century, but the period between 260 and roughly 300 remains obscure.

The most common form (**fig. 6.14**) on military sites was the Dressel 20, followed by the Dressel 7-11, then the Gauloise 4, the Haltern 70, and the Dressel 28 with 3% of the assemblage unidentified and 74 other forms making up the remaining 24%. When all the sites are graphed by origin (**fig. 6.15**) Spain dominates at a higher percentage (67%) than the regional total, followed by Gaul (14%), Germany (5%), Italy (6%), the Eastern Mediterranean (4%), unknown (3%) and North Africa (1%). When graphed by contents (**fig. 6.16**), military sites are very close to the regional total, with olive oil most common at 36%, wine at 33%, fish at 22%, other contents at 4%, and unknown at 5%.

There is clear chronological change in this dataset and we are able to say quite a bit about how imports changed over time. The phasing of this material and the comparison of individual sites will be discussed below in the chronology section.

Vici sites

The picture starts to change as we move into more rural occupation sites. The eight *vici* discussed here (**fig. 6.17**) are mainly grouped in northern Switzerland, Baden-Württemberg, and Alsace. Several comparable assemblages exist from northern Gallia Belgica, but none yet from Lower Germany. The only partial evidence is from Heimberg's chart mentioned above, which includes material from the vicus at Jülich alongside mixed material from the *canabae* and forts at Bonn, Neuss, and Kalkar, Gellep, and Dormagen; these are compared below.

Dressel 20 remains the most common form (**fig. 6.18**), though the local Niederbieber 74/75 is the second most common,[950] followed by the Gauloise 4, Dressel 1, and Dressel 20 *similis*. Only 2% are unknown, and the remaining 14% is made up of the remaining 30 forms so far found. When graphed by origin (**fig. 6.19**), the changes in composition are obvious—Spain (48%), Germany (23%), Gaul (18%), Italy (8%), unknown origins (2%), and the eastern Mediterranean (1%). When viewed by contents (**fig. 6.20**), oil is still most common at 44%, followed by wine (23%), unknown contents (because of the Niederbieber 74/75) at 20%, fish at 7%, and other at 6%.

In the review of Martin-Kilcher's amphorae reports from Augst, Heimberg offered a brief comparison from nine sites in Lower Germany.[951] Her figures, reproduced in **figures 6.21** and 6.**23**, are not comparable to other assemblages in the region because of the method she used to group the amphorae (only by contents), and are therefore not included in the database. Her content information is, nonetheless, cautiously relevant to the vicus discussion. Wine dominates at

[950] This amphora is known to have been produced at a number of sites around the central Rhine area, including Mainz-Weisenau from ca. 160-280. Its contents are unknown, though both wine and beer have been suggested. See Heising 2007, 81.
[951] Heimberg 1997, 304.

48%, then oil trails at 37%, fish at 12%, while *defrutum* makes up 2% and only 1% is unknown. When viewed in a site-by-site comparison (**fig. 6.22-23**), there is remarkable similarity, and when viewed alongside the other *vici* from the Rhine, the assemblages of Heimberg's sites are not so different from those at Solothurn, Chur, and Bliesbruck. This picture will need to be clarified by future research in the *vici* of Lower Germany before definite conclusions can be drawn.

Like urban sites, individual site assemblages vary by foundation date. Vici founded after the Trajanic period are noticeably different from those existing prior to this period. Fish products are absent at both Pforzheim and Bad-Wimpfen, while the unidentified products of the Niederbieber 74/75 make up a substantial portion of the assemblages.

Villa sites

The five villa sites with quantified assemblages (**fig. 6.24**) also differ substantially from the regional totals. Villas differ from the other site types in that they should, theoretically, have been inhabited by a very small number of people with particular interests and tastes. They also, potentially, are the only site type here where amphorae would not have been readily available for purchase—instead the inhabitants would have had to travel to a market to purchase their amphorae. The range of amphorae found at villas, therefore, represents a rather different kind of assemblage than that at forts, cities, or towns, and should, therefore, be more diverse between sites.

Villas are the only site type where the assemblage is not dominated by Dressel 20 amphorae (**fig. 6.25**)—instead, Gauloise 4 is the most common form, accounting for 35% of the total, while Dressel 20 is slightly behind at 33%. The Dressel 20 *similis* makes up 11%, while the Niederbieber 74/75 accounts for 3% and the Pélichet 46 accounts for 2%. Villas have a higher percentage of unknown forms, at 6%, and 24 forms make up the remaining 10% of the assemblage. When viewed by origins (**fig. 6.26**), Gaul and Spain are almost equal, at 36% and 35% respectively, with Germany at 15%, North Africa at 3%, the eastern Mediterranean at 2%, Italy at 1%, and a further 8% from unknown regions. When viewed by contents (**fig. 6.27**), wine dominates at 39%, oil at 33%, unknown at 14%, other at 11%, and fish at 3%. This is the lowest proportion of both fish and oil on a site type, while wine is the highest.

When broken down by site (**fig. 6.28**), Bad Kreuznach differs from Hummetroth and Niederursel substantially when viewed by contents (**fig. 6.29**), and Nieder Eschbach and St. Ulrich are also quite diverse. The villa at Bad Kreuznach is itself a peculiarity with its fanciful North-African styled Oceanus mosaic, and Ehmig argued that the owner may have made his apparent fortune as a wine trader from the Mediterranean.[952] Conversely, the villas at Hummetroth, Niederursel, and Bad Kreuznach are vaguely similar in content proportions, though they differ substantially from those at St. Ulrich in France and Nieder Eschbach in Hessen. There is obviously quite a bit of choice in the amphorae consumed at these sites, a point to which we will return.

Chronology

Augst is the only urban site discussed here which has amphorae from the full extent of the site phased into different periods—it is by far the largest assemblage in the database and one of the best studied. Therefore, the chronological shifts seen at this site will be used as the backdrop to discussing chronology across the rest of the sites in order to see if similarities exist across the region.

From figures **6.30 and 6.31**, it is clear that Augst received most of its amphorae during the first century AD, particularly between the Augustan and Flavian periods. During this period, the origins of the amphorae imports remain fairly constant (**fig. 6.32**), with Spain accounting for more than 50% of the assemblage, Gaul approximately 25%, the eastern Mediterranean about 15%, and Italy around 5-10%. Spanish material peaks between AD 30-50, Gallic between AD 50-70, Eastern from AD 30-50, and Italian between AD 50-70, but North African material does not become significant until the fourth century, where it peaks between AD 310 and 340. From AD 70 onwards, there is a clear drop in

[952] Ehmig 2005.

amphorae importation, until they mostly end in 280 with the destruction of most of the city. We must wonder whether this decline is due to an increase in the use of barrels or other containers, though this answer remains elusive. Following the Constantinian establishment of a legionary base along the river at Kaiseraugst, amphorae importation resumes, but the picture is quite different. North African products had already been on the rise since about AD 210, but they become prominent from AD 310 onwards. Spanish imports continue to be important, accounting for 50% and more from 310 onwards. The noticeable difference here is the quantity of imports—only 2% of the total assemblage arrived after AD 280.

Next to Augst, the best long-term view of chronology is provided by fort sites which have known foundation periods and therefore provide *termini post quos* for their assemblages. I have already mentioned how the 32 fort sites distribute across chronology, and it is obvious that the Augustan period is the best represented and the third century is left vague due to a lack of newly founded forts. In order to understand how forts of various foundation periods compared to each other, the most common forms of each period were tabulated and graphed, then their content and origin data was separated by period and grouped, these groups were then graphed in stacked 100% bar charts in order to understand how proportions changed over time.

Looking first at the forms (**fig. 6.33**), we can see substantial variation by period in the most common forms found at these sites. In the Augustan period, the Dressel 7-11 accounts for over a quarter of the material, while the Dressel 20 is slightly less. These are followed by the Haltern 70, Dressel 28, and Dressel 6a; 43 additional forms make up the final 21%. In the Julio-Claudian period, Dressel 20 begins to reach its dominance, accounting for 32% while the Dressel 7-11 falls to 17%, these are followed by the Camulodunum 184 at 16%, then the Gauloise 4 and Haltern 70—20 other forms make up the final 17%. In the Flavian period, the Dressel 20 accounts for 58% and the Gauloise 4 for 26% of the assemblage, followed by small quantities of Dressel 7-11 and the first appearance of the Dressel 20 *similis*, as well as the Pélichet 46, with 19 other forms making up 6% of the total. In the Trajanic period, Dressel 20 and Gauloise 4 maintain their prominent positions, and the Niederbieber 74/75 appears at 6%, the Dressel 20 *similis* and Dressel 7-11 round out the top five, with only ten other forms making up the remaining 2%. In the Antonine period, a dramatic shift occurs. The Dressel 20 falls to only 15% while the Dressel 20 *similis* takes over as the dominant form, the Nieberbieber 74/75 increases to 15% of the assemblage, while Gauloise 4 fall to 6% and with negligible amounts of Augst 17 and Dressel 2-4—only 6 different forms have been identified from the forts of this period.

Some of these sites had occupation phases that spanned the third century, so some of their imports will date to that period. It is difficult to say anything about them, however, since there are no assemblages from forts founded in this century. The data begin again near AD 300 with the Tetrarchic and Constantinian building projects along the Rhine. As at Augst, there is a substantial shift in these late assemblages. Dressel 23 (Spain, oil) becomes the dominant form, followed by Dressel 30, Augst 17, Gauloise 4 (residually, surely), and the Africana 3a. Unlike other periods, the 5 most common forms only account for 56% of the assemblage. The small sample size makes interpreting these data difficult, but we will return to them for origins and contents.

Graphed by changing proportions of origin (**fig. 6.34**), Spanish imports dominate the Augustan foundations at 74% of the assemblage and then hold steady at about 65% through the Julio-Claudian and Flavian foundations before dropping over the course of the second century. Gallic imports appear in significant quantities first on Julio-Claudian foundations and then rise to nearly a third of the assemblage under the Flavians and Trajan, falling off by the Antonine period. Italian and eastern Mediterranean products are only substantially present on Augustan foundations and both drop sharply thereafter. North African material is only present in the fourth-century forts. Locally produced material first starts to appear on Flavian foundations, and then rapidly increases to 70% of the assemblage on Antonine sites.

When viewed by contents (**fig. 6.35**), fish products account for a third of the Augustan assemblage and then decrease until they virtually disappear by the Trajanic period and reappear in the fourth century. Olive oil accounts for about a quarter of the Augustan assemblage and grows to over 50% by the Trajanic period, after which it then decreases on Antonine sites, before again being over 50% of the fourth-century assemblages. Wine accounts for 38% of the Augustan assemblage, 40% on Julio-Claudian foundations, then drops to 30% for the Flavian and Trajanic periods, yet is barely present at Antonine forts. "Other" products, mainly those contained in the Dressel 20 *similis* form are only a substantial presence in Antonine forts, while vessels with unknown contents similarly peak in the late second century.

When viewed individually, fort assemblages occasionally vary within the same foundation period. Augustan sites (**fig. 6.36**) all share a high percentage of Spanish material, though Vechten and Winsum, both late-Augustan foundations in the Netherlands, have more Gallic material than the others. This increase in Gallic products is also visible between the early-Augustan and middle-Augustan phases of the legionary fortress at Vindonissa.[953] The legionary fortress of Vetera I,[954] founded under Augustus and occupied until AD 69, is almost entirely composed of Spanish material, as are Rödgen and Neuss.[955] Augustan era sites do, however, share a fairly standard spread of products (**fig. 6.37**), where fish products are between 30-40%, oil between 20-30%, and wine between 20-30%.

Forts founded under the Julio-Claudians (**fig. 6.38**) continue to show Spain's dominance, as well as the rising influence of Gallic material. Spanish material accounts for between 55-90% of the assemblages, while Gallic products range between 5-30%. Alphen aan den Rijn, Velsen, and both phases at Oedenburg are fairly similar, though the fleet base at Köln-Alteburg and the fort at Biesheim produced more Gallic material. Other origins are mostly negligible, though Italian products are still known from all sites of this period, and some eastern Mediterranean material is still present. The relatively similar proportions of products seen in the Augustan period become more varied (**fig. 6.39**), with oil

---

[953] Martin-Kilcher 2003.
[954] Hanel 1995a.
[955] Ehmig 2007a; Fitzlinger 1972.

generally becoming more prevalent than either fish or wine, though both phases at Oedenburg in France show substantially higher fish percentages.[956]

By the Flavian period (**fig. 6.40**), sites show a fairly uniform split between Spanish and Gallic products while other sources are marginalized. Fish sauce becomes less common (**fig. 6.41**), oil grows in prevalence, and wine accounts for roughly 20-30% of each site's assemblage. Spain begins to give way to Gallic and local German products in Trajanic forts (**fig. 6.42**). Hesselbach stands out with its high proportion of Gallic material, though Altenstadt, Hanau, and Heldenbergen show fairly similar assemblages—Walheim is notable for its high percentage of local products already at this time. Trajanic assemblages show more variation in contents (**fig. 6.43**), particularly in terms of oil, which varies between 15% and 65%.

The Antonine forts show almost a complete switch to locally produced material (**fig. 6.44**), a pattern already seen at Walheim. Kleiner-Feldberg and Holzhausen both have high percentages of local material, while Haselburg's publication is muddled by a high number of unidentified forms.[957] The semi-quantified assemblage from Niederbieber suggests a similar pattern, where the Niederbieber 74/75 dominate, with the Dressel 20 (though it should be questioned whether these are Spanish or local) accounting for most of the rest.[958] Spanish material accounts for much more of this material than at the other two sites. Likewise, Haselburg has more olive oil than either Holzhausen or Kleiner-Feldberg (**fig. 6.45**), where the Dressel 20 *similis* is the dominant form. Wine is far less important in these assemblages than previously, though the Niederbieber 74/75 form may bring this percentage up should they be identified as wine containers.

Finally, in the fourth century, there is substantial variation in the origin of forms (**fig. 6.46**). Breisach, Rheinfelden, and Kaiseraugst have similar quantities of North African and Spanish material, though the presence of Gallic, eastern Mediterranean, and Italian material creates three fairly dissimilar assemblages.

---

[956] Viroulet and Baudoux 2009.
[957] Fleer 2011.
[958] Oelmann 1914, 63-66.

Breisach and Kaiseraugst do have rather analogous assemblages when viewed by contents (**fig. 6.47**), though Rheinfelden does not—again hampered by a number of unidentified forms.[959] The fact that Rheinfelden evidently served as a supply base rather than a garrison probably also affects this picture.

Overall, the chronological shifts seen at these military sites offer a rough comparison to the assemblage at Augst, though the trajectories seen are quite different. Augst, as we may expect from a single site, shows much smoother and gradual transitions in products than any of the fort sites do—this is due to the temporal resolution available at Augst which is simply not possible for many of the forts discussed above. Reuse and residual pottery deposition also surely helps to smooth the long-term shifts which abrupt fort occupations and abandonments do not.

When compared to Augst, we can see that the drop in Spanish imports in the second century is much more pronounced in military sites than in the city, as is the rise in Gallic material. The locally produced forms from Germany are not recorded at Augst and, indeed, the distribution of the Niederbieber 74/75 and Dressel 20 *similis* does not seem to stretch that far south. Because so little third-century material is available from military sites, we cannot see the rise of North African products seen at Augst from the early third century onwards. Italian and eastern products also maintain a presence in Augst far longer than they do in forts. It is difficult to judge how widely applicable these differences between military and civilian are. Without phased assemblages from other major civilian sites there is no way to assess the inter-site variation that we can see in military assemblages.

Schimmer sought a way to circumvent this issue by comparing the rim forms of Dressel 20 amphorae recorded at Mainz, Augst, and Kempten.[960] The chronological changes in rim morphology of this amphora have been well researched particularly by Martin-Kilcher from the Augst assemblage.[961] At all three sites, Schimmer found the same pattern of rim chronology (**fig. 6.48**), where Dressel 20 amphorae have a sharp peak between AD 30-70, followed by a

[959] Asal *et al*. 2007.
[960] Schimmer 2009, 103.
[961] Martin-Kilcher 1987.

substantial decline following this period, before eventually dropping off after AD 200.[962] The successor form, Dressel 23, is never present in large quantities in the Rhine in the same way as the Dressel 20.[963] This pattern closely matches the general Spanish import chronology at Augst,[964] and can also be seen in the military assemblages discussed above. Monfort demonstrated the decline of Spanish Dressel 20 imports to Walheim over the course of the second century, where the Spanish imports decrease as local imitations rise,[965] particularly in the period after the military leaves the site, from AD 150/160-230. This is paralleled in Antonine fort assemblages, where Spanish material is substantially less than any other period. All of this suggests a similar, supra-regional pattern of supply in Spanish olive oil.

As a final chronological comparison, we can return to the urban sites and *vici* discussed above which were founded more recently than the Augustan period. Five urban sites and three *vici* demonstrate that fish products were rarely imported after the Flavian period, while vessels of "other" and "unknown" contents make up more substantial portions of these later sites' assemblages, most of which were locally produced. Assemblages dwindle in real numbers over the course of time, and fourth-century imports are rare. These patterns also parallel those seen in military sites and Augst.

Overall, we can summarize these data into some general patterns. Imports of amphorae are at their highest in the first century AD, coming from Spain, Italy, the eastern Mediterranean, and Gaul in a large number of different amphora forms. Eventually Spain and Gaul come to dominate, as the Dressel 20 olive oil amphora and the Gauloise 4 wine amphora become the most common forms in the region. From the Flavian period onwards, the total number of imports begins to drop and fewer amphora forms (and, therefore, variety of products) are present. In the beginning of the second century AD, local production of amphorae begins and these eventually become the dominant forms on sites in the area by the end of the

[962] Schimmer 2009, abb. 9.
[963] Cesteros 2010.
[964] Martin-Kilcher 1994, abb. 208.
[965] Carreras Monfort 2004, fig. 1-2.

century, though some have fairly localized distribution around the central Rhine. This area of distribution may expand as fabrics are better recognized. The third century is difficult to read, but at sites with evidence we see that the dwindling imports come to a stop sometime after AD 250, and are never substantial again. In the fourth century we see a return of Spanish imports, though greatly reduced, and some small evidence for North African imports. Military sites in particular show great reduction of quantity in the fourth century. The Dressel 23 was never a popular container in the region,[966] and many other well-known late-Roman forms from North Africa and the eastern Mediterranean have not yet been found in the region.[967]

Explaining chronological change

Attempting to ascribe any single explanation for the shifts in imports seen here would be misguided, and untangling the many possible explanations is complicated. Several major factors should be discussed, however, as they all would have affected trading patterns and connections in some way.

There is a clear trend towards importing increasingly local / regional products into the Rhine basin over time. The Augustan-era medley of pan-Mediterranean products quickly falls off to a market which is dominated by Spanish and Gallic products, marginalizing the eastern Mediterranean, Italy, and North Africa. In the second century, locally produced amphorae dominate assemblages, a trend which continues into the first half of the third century. Following a hiatus in material evidence, we can see that fourth-century sites pull in material from a wider geographical basis, though in much smaller quantities.

Until the mid third century, this situation suggests a pattern of specialization and import replacement. During the developmental period of the

[966] Remesal Rodriguez 2002, 306; Cesteros 2010. For an overview of a similar situation in Britain, see Williams and Carreras 1995.

[967] Papaioannou 2011 for distribution of Maeander LR 3a-c amphora forms, many of which are noticeably absent within the Rhine basin. From his distribution maps, it is clear that the earlier form LR 3a was traded into the Rhine, present at Augst and Trier, though the later forms 3b and 3c do not extend beyond the Rhône valley, despite their appearance in Britain. River routes did evidently not play a part in this trade from the fourth c. onwards. Other LR forms only appear at Augst (LR 1, LR 4), Trier (LR 4), and Bad Kreuznach (LR 1) in miniscule quantities.

region, there were no strong, pre-existing trading connections in place which could easily move products into the region, resulting in a wide range of material from all over the Empire moving to the Rhine. It is possible that the Roman state had some hand in this,[968] as it was the military that first established trading connections to this region for supply during the Augustan and Julio-Claudian campaigns, and therefore the costs of long-distance transport would not be the immediate burden of the consumers.

However, if it was the military that first drew trade into the region, it was the civilian network that maintained these connections beyond the initial settlement of the Rhine. The volume of material moving to the Rhine via the roads and rivers of Gaul led to a developed infrastructural network, particularly at the transshipment point of Gallia Narbonensis which acted as a funnel for all goods headed north. This network afforded new possibilities to the regions through which it passed, and it is probable that improvements in infrastructure enabled local producers to increase the spread of their products.[969] The Guadalquivir Valley effectively dominated olive oil production in the western Mediterranean, but wine production lacked a clear monopolizing producer. By intensifying production of wine, southern France was able to significantly reduce transport costs for the Rhine which in turn created a focused market of consumers for Gallic vineyards, a mutually beneficial relationship. This specialization of production has been taken as evidence for a strongly integrated trade network in the Roman Mediterranean,[970] the effects of which can be clearly seen in the amphora assemblages of the Rhine basin. The dominance of Gallic products in the north cut off the importation of Eastern forms, though they continue to appear in southern and central Gaul into the mid-third century.[971]

This pattern of import replacement continued until Antonine assemblages became dominated by products made in the Rhineland. Gallic and Spanish imports continued, but local production steadily grew. Seen most clearly in the

[968] Verboven 2007, 305.
[969] Tchernia 2011; Rice 2012, 265-72.
[970] Rice 2012.
[971] Brun 1992 on Toulon; Lemaître 2002 on Lyon and Saint-Romain-en-Gal; Bats 2006 on Olbia, Brentchaloff 2009 on Frejus.

Dressel 20 *similis* and Niederbieber 74/75 forms, import replacement was also readily apparent in the establishment of terra sigillata production at Rheinzabern and Trier in the middle of the second century.[972] Even salted fish production moved up the North Sea coast in the mid second century.[973] Local products, not just those involving amphorae transport, further reduced the impact of transport costs for the Rhine market and were able to supply military and civilian centres with their goods.

The third century saw changes to all of the areas involved in this trading network. Production of olive oil in Baetica slowed dramatically in the second half of the century, and the latest Dressel 20 *titulus pictus* known in Rome dates to AD 259,[974] and the earliest Dressel 23 arrives in Augst around AD 280.[975] Southern Gallic wine production ceases in the early third century, seen both in amphorae-producing sites,[976] and at vineyard estates.[977] Neither the Dressel 20 *similis* nor the Nieberbieber 74/75 appears in sites after the fall of the *Limes* in AD 260. From the middle of the third century onwards, amphorae imports slow to a trickle and never match the quantities seen in earlier periods. Why the change?

Several factors may be to blame, not the least of which is significant political turmoil which started with the Severan civil wars in Gaul, culminating in the battle of Lugdunum in AD 197, but also included the Gallic Empire of Postumus and his successors (AD 260-274), and ended with the re-conquest of Gaul by Aurelian in AD 275. These events were perhaps not directly responsible for, but certainly could have contributed to, a decline in stability between the links of producers, transporters, and consumers. State subsidies in olive oil production, argued by some to be the explanation behind the massive accumulation of Spanish amphorae at Monte Testaccio in Rome since Augustan times,[978] were undoubtedly bolstered by the Severan addition of olive oil to the *annona* for Rome.[979]

---

972 Huld-Zetsche 1972; 1993; Mees 2002; Weber 2013.
973 Van Neer, Ervynck, and Monsieur 2010, 175.
974 Carreras Monfort and Williams 2003, 64.
975 Martin-Kilcher 1987, 58.
976 Laubenheimer 1985; Laubenheimer and Schmidt 2009; Rice 2012: Chapter V.
977 Laubenheimer and Brun 2001.
978 Bowman and Wilson 2009, 19-20.
979 Bowman and Wilson 2009, 20.

Subsequent political instability in Rome and the provinces over the course of the century could have disrupted the government's connection to Baetican producers, with ripple effects for the frontier markets along the Rhine.[980]

We may also investigate the role that climate change played in this century and how it affected the production of goods as well as their movement. As discussed in Chapter 1, the third century was dry with fluctuating temperatures, both factors which could have helped end Gallic wine production and severely reduce Spanish oil. Moreover, this climate change would have had impacts on the hydrological regimes of those rivers which were so integral to the transport network of Gaul. Cooling periods result in higher floods and increased stream braiding, and these are documented at numerous sites throughout the Rhône and Rhine basins—at Arles,[981] Lake Le Bourget,[982] Biesheim,[983] and Xanten.[984] As discussed earlier, riverine transport was already dependent on the seasons, allowing a fairly narrow window for optimal transport;[985] any exogenous shock to this system would have disrupted an already fragile connection between different rivers. Climate change on the scale seen in the third century would surely have provided such a shock, and it may be that shipping conditions deteriorated to the point that the long-distance import of heavy and bulky products was no longer tenable. Combined with the political issues already mentioned, a disruption to the transport network may have effectively cut off the Rhine market.

An alternative suggestion argues that while amphorae importation ceases, the importation of those products contained in amphorae does not. Instead of using ceramic containers, barrels and skins became the preferred method of transport.[986] Barrels are certainly known from archaeological sites in Gaul and Germany, but their chronology does not easily match the scenario of a wholesale

---

980 This is not to say that oil was or was not being supplied to the Rhine frontier as part of an *annona militaris* arrangement, but rather that if a major contracted consumer of Baetican products was suddenly disrupted, the supply of all other markets connected to the same production zone would be effected.
981 Loseby 1996; Provansal *et al*. 1999.
982 Arnaud *et al*. 2005; Cheyette 2008.
983 Ollive *et al.* 2006; 2009.
984 Petrikovits 1952, 158; Gerlach 1995, 100; Klostermann 2000, 41.
985 Wickert 1903.
986 McCormick 2012, 74-77.

container switch (**fig. 6.49**). We might expect a peak in barrels after the peak in amphorae, but the opposite seems to be the case. This may be a result of a change in well-lining technology, as many of the barrels so far recovered come from early Roman wells, but it is difficult to say. It is true that barrels are evident in the second- and third-century grave monuments from Neumagen, famously adorning the Neumagen *Weinschiff* (**fig. 6.50**), but we cannot forget the contemporaneous reliefs of amphorae from the same site (**fig. 6.51**) as well as at Domburg and Colijnsplaat.[987] While it may be possible that Gallic wine was switched to barrels, it does not explain why those amphorae forms which are being produced from the third century onwards do not appear in the Rhine basin.

Barrels are, however, a probable suggestion for the transport of local wine produced along the Moselle and middle Rhine from the end of the third century onwards.[988] These vineyards were obviously producing wine in high quantities,[989] and it is no coincidence that their establishment coincides with the movement of the Imperial court to Trier in the final years of the third century. There is no evidence, however, of amphorae production to match the wine, and therefore we must expect that the late-Roman wine production in the region utilized barrels for transport which are completely invisible in the archaeological record.

For the late period, the little evidence that we have suggests that the Rhine region either could no longer rely solely on locally produced goods or was incorporated into a state-subsidized distribution network that reached farther-afield. The existence of a late-Roman *annona militaris* has been suggested in the East,[990] and it is possible that something similar existed in the West, though the small quantities of material seem unlikely to be the result of state-organized supply. If such a system had been in place, one would expect to find amphorae in the legionary fortresses of this period, though over a century of excavations in Köln-Deutz have not produced a single sherd.[991]

---

[987] Stuart and Bogaers 2001.
[988] Brun and Gilles 2001; Brun 2005.
[989] Brun and Gilles 2001, 177.
[990] Karagiorgou 2001, 149-156.
[991] Pers. comm. M. Carroll 2011.

Comparison with neighbouring regions

How did the Rhine compare to its neighbouring regions, and were the effects of these historical issues localized or more widespread? To address these questions, amphorae assemblages are compared from Gaul and Raetia.

Five sites located within the Maas basin (western Germania Inferior and Gallia Belgica) produce an assemblage which is composed of 42% Spanish, 24% Italian, and 22% Gallic amphorae (**fig. 6.52**). More than half of the Italian material comes from the Iron Age layers at the Titelberg and demonstrates the overwhelming dominance of Italian wine in the final La Tène period,[992] and the assemblage is similar to that of the oppidum/*vicus* at Basel discussed above.[993] Oil only accounted for 29% of the containers, fish sauce 11%, and wine 43% (**fig. 6.53**). Bavay is the only site with phasing, dividing between the high and late Empire.[994] The main difference between the two phases is the appearance of local products in the later period, particularly the Gauloise 13.[995] This increase came at the expense of Spanish material, which was significantly reduced at that time. Consequently, the percentage of local forms with unknown contents in the later period is high (**figs. 6.56-57**).

To the south, two sites of the Upper Rhône valley, the Vespasianic legionary fortress at Mirebeau in Burgundy and the *civitas* capital of Geneva, show some similarities to those within the Rhine and differences from those along the Maas (**figs. 6.54-57**). Mirebeau, founded under Vespasian, can be directly compared to the contemporary fortress at Nijmegen, though this comparison is complicated by the high percentage of unidentified amphorae at Mirebeau. Otherwise, the fortress in Burgundy is similar to Nijmegen, particularly with regards to its Italian percentage, which is otherwise comparable to the fort at Rottweil.[996] Geneva's assemblage is similar to many other urban sites in the Rhine, unsurprising as it was an important nodal point on the route from Lyon to

992 Laubenheimer 1998.
993 Deschler-Erb 2008.
994 Marliere 1998, 55.
995 *Ibid.*, 58-59; Baudoux *et al.* 1998, 26-36.
996 Franke 2003.

the Upper Rhine. These two sites are quite different from those of the Maas basin, as Spanish materials, especially oil, dominate the assemblage. Again, their locations on or near the Rhône River helped link them to the Rhine, but we cannot forget their small sample size in comparison.

Eight sites in Raetia were studied by Schimmer in order to establish a context for the assemblage from Kempten.[997] Most of these sites are forts that date from the first century AD, but also the vicus of Auerburg and the urban centre of Augsburg. The total assemblage is dominated by Spain and Gaul, though with a fair amount from Italy and the eastern Mediterranean (**fig. 6.58**). Oil is still the most prominent commodity, and fish shows a fairly high percentage (**fig. 6.59**). There is a fairly high degree of inter-site variation in origins, owing to chronology (**fig. 6.60**), but the breakdown of contents shows less (**fig. 6.61**). In a similar pattern to the Rhine, Raetia has not yet produced a large amount of late material.[998]

Comparing the three regions (**figs. 6.62-63**), we can see both similarities as well as differences. The percentage of Gallic material is fairly standard across each region, and Spanish material is similar between the Rhine and Raetia. Gaul imported more Italian material, though this figure is largely due to the late Iron Age, and Raetia more from the eastern Mediterranean. The circulation of German material did not enter Raetia, but did sometimes enter the Gallic market. The Rhine and Gaul are fairly similar in terms of the contents of their assemblages, though Gaul has more wine and less oil, but Raetia stands apart. Raetia shows evidence for far less wine than either the Rhine or Gaul, and shows the highest percentage of fish products.

Overall, this comparison suggests that the Rhine and northern/eastern Gaul shared similar trading contacts while Raetia did not. This difference was already apparent from the Augustan period, where Ehmig observed differences which she attributed to trans-Alpine routes starting from the northern Adriatic.[999] It is interesting that Raetia does not demonstrably link with the Rhine during the high

---

[997] Schimmer 2009.
[998] Martin-Kilcher 2006b; Schimmer 2009, 104-105.
[999] Ehmig 2010, 155-156.

Empire when it began importing huge quantities of Rheinzabern and Trier terra sigillata.[1000] Perhaps further research will help clarify this issue, but for now it seems that the two regions maintained rather different trading networks throughout the Roman period, though both saw the same overall import drop-off in Late Antiquity.

As a final note, something should be said about quantities of material present in these regions. Laubenheimer and Marlière produced a similar study on amphora distribution in northern France, where 281 sites were studied and published together.[1001] All of these sites produced a total of 3,500 amphorae which, as the authors point out, is less than Augst or Mainz alone.[1002] The northernmost territories of Gallia Belgica apparently did not draw in as much trading contacts as the Rhine region, a fact which we might relate to population size, the guarantee of military consumers, and the ease of transport along the Rhône-Rhine corridor. Located at some distance from the main river and road routes that traversed Gaul north and south, northern France was not as well connected to Mediterranean supplies, and consequently relied heavily upon local products.[1003] Like the Rhine and Raetia, northern Gaul did not receive many late-Roman amphorae forms,[1004] suggesting that this region was similarly disconnected from Mediterranean trading routes sometime after the third century.

Marketing goods to the Rhine frontier: conclusions

This chapter has analyzed and compared 71 amphorae assemblages from the Rhine and neighbouring regions. This analysis has revealed substantial shifts in amphorae assemblages throughout the dataset and several explanations were proposed for the different trading patterns found.

The purpose of this analysis is to understand what these trading patterns suggest about the market structure of the Rhine region—the types of institutional

[1000] Mees2002; Weber 2012.
[1001] Laubenheimer and Marlière 2010.
[1002] *Ibid*., 99.
[1003] *Ibid*.
[1004] *Ibid*., 101-103.

agents and behaviors which resulted in its size, shape, and reach. Recalling Temin's instrumental, customary, and command market behaviors as well as Mattingly's imperial, extra-provincial, and provincial market structures, we can now structure these discussions with quantified evidence.

Starting with Temin's behaviours, the evidence is not as clear as we might like for differentiating between command and instrumental economic activity controlling the importation of amphora-borne products. While many have argued that the Rhine armies were supplied through a command economy at the hands of the state, the amphora evidence does not confirm this theory. If this were true, we would expect to see fairly uniform assemblages across military sites that are noticeably different from those of settlements surrounding fort sites, or at least some characteristic which clearly differentiates military assemblages from other sites. Instead, however, we see many similarities in both form and contents between military and urban settlements and their overall assemblages are nearly identical in proportions.

The most notable difference between the two site types comes in the variety of forms present over time, where military assemblages do gradually narrow to a select range of forms present by the end of the second century. To some extent, the comparison between urban and military sites is hampered by a lack of chronological study, but where sites can be compared, i.e. Augst or Strasbourg, urban sites continue to import a wider range of material than contemporary fort sites. The forms present on military sites are always also present on urban sites—there are no special forms suggestive of direct supply. Vici and villas do differ from forts and cities, but again do not do so in a way that presents firm evidence for behavioral differences. The assemblages of these sites present different proportions of material by content and origin, but for the most part present the same range of vessels seen in forts and cities. Villas, in particular, demonstrate much more personal habits of consumption and, unsurprisingly, favour wine.

We will return to Temin's behavior models below, but let us consider Mattingly's market levels, as the amphorae do present good evidence for these. It is clear that all site types throughout the region are tied into both extra-provincial and provincial markets which are able to import goods from all corners of the Empire. To some extent, it is possible to differentiate the market zone of the Rhine region from that of Raetia and the neighbouring Gallic provinces. This is surely due to transportation routes, where the Rhine and eastern Gaul benefited from many of the same throughways, whereas Raetia was more linked to the Adriatic and Danubian corridor. The density of settlement along the Rhine also presented a favorable market, whereas the other regions were less populated.

That the Rhine market increasingly turned to more local amphora-borne products does not, I think, suggest a disintegration of these extra-provincial market ties, but rather suggests a prevailing rationale of import replacement which favoured lower prices over exotica. There were always foreign goods available for purchase—the villa at Bad Kreuznach shows this clearly—but that does not mean that most of the population wanted or needed them, thus cheaper goods produced closer to home were favoured. By the end of the second century AD, the Rhineland and neighbouring regions were producing enough goods to handle most local demand. In later periods, this pattern became more pronounced as foreign amphorae nearly cease to be imported, suggesting a heavy reliance on local goods.

It is in this economic rationale that we can perhaps find some evidence for the roles of different economic behaviors as well as differentiate between imperial and regional markets. It is entirely possible, and indeed probable, that the newly conquered Rhine basin was intentionally supplied at first with products via a command economy.[1005] The wide variety of products evident on Augustan and early Julio-Claudian sites is suggestive of a wide-reaching integration made possible by a negation or reduction of transport costs through state supply. During this period, extensive military campaigns would have maintained the attention of the Imperial government and, since there was not yet a burgeoning urban population, the soldiery would have formed the core consumers of imported goods. To support this demand, transport infrastructure was established by the state along the Rhône-Rhine corridor.

[1005] For a similar scenario in the invasion of Britain, see Frere and Fulford 2001.

Once campaigning stopped and the German provinces were established under the Flavians and multiple *civitates* began to grow, civilian populations increasingly dictated the flow of imports. The Roman state had no reason to supply these centres with goods, not while it was focusing its attention on the urban population of Rome, and as the military was no longer engaged in frequent conflict, it seems probable that any state-controlled importation of goods tapered off. It is from this period onwards that we see the contraction of production zones from the entire Mediterranean to essentially only Spain and Gaul, and it is extremely possible that this was dictated by lower transport costs made possible by utilizing the now developed transport network of Gaul. Urban centres increasingly became the dominant centres of consumption, and numerous social institutions developed to handle the volume of trade necessitated by the population, as discussed earlier in Chapters 2 and 3. Vici and villas derived their own local markets from the goods present in larger cities, and rural populations were able to access much of the same goods, if on a smaller scale.

As centres of civilian population increasingly dictated the import practices of the region, military sites came to depend upon the resulting product availability. This scenario offers a contrary view to Verboven's; I argue that the evidence here suggests that it was in fact the civilian centres with their large purchasing power and demand for foreign goods that gave the merchants a notable status in local society.[1006]

This all changed in the Late Empire. New provincial organization, new military deployments, new climatic conditions, and new systems of taxation changed the market connections of the Rhine region. While we know that an *annona militaris* was in place in Egypt in this period,[1007] and it has been suggested that one functioned in the eastern Mediterranean and Lower Danube,[1008] and indeed imported grain to the Rhine when necessary,[1009] it is much less obvious that amphorae moved in a similar system along the Rhine. The lack of amphorae

---

[1006] Verboven 2007.
[1007] Mitthof 2001; Hirt 2005.
[1008] Karagiorgou 2001.
[1009] See page 125 above.

from Köln-Deutz makes it extremely difficult to imagine that the state was concerned with supplying amphora-borne products to the garrisons in the region. The paucity of evidence from other forts makes it difficult to say, and urban centres were clearly not still interested in importing large quantities of such material. The influence of local vineyards must have been high, especially during the Imperial residence at Trier, but the usage of barrels is difficult to detect.

Returning again to Temin's economic behaviours and Mattingly's imperial economy, there is no firm evidence found amongst amphorae that a command economy existed with any sort of permanence or frequency in the Rhine region. Instead, we see a strong instrumental tendency—one that favours free-market exchange where prices and availability were the determining factors. The region maintained connections to both extra-provincial and provincial markets, until its own provincial market became sufficient to support the needs of the local populace.

Therefore, it seems misleading to argue for a dichotomy between some sort of annonary supply and market exchange. If the *annona militaris* existed, it existed as a complementary system to that operating within the civilian realm, and ultimately paled in importance. If a state supply initially spurred the eventual wide-spread market integration suggested here, then such a dichotomy is further exaggerated. The evidence is not as "hopelessly ambiguous" as some have claimed,[1010] but it does require analysis that goes beyond simply publishing site reports.

[1010] Whittaker 2004, 109.

7

Conclusions: Economic Development in a Frontier Zone

This thesis began on the premise that existing core/periphery models were insufficient to describe or analyze the economic activity of different regions in the Roman world. Instead, it has been argued that archaeological data can be used to clarify a series of complex developments across the Roman Empire. Using the Rhine Basin as a case study, this thesis has examined the ways in which various factors interacted to create a provincial economy which was anything but a standard core/periphery model. The Rhine frontier developed a dynamic, complex economy which was both socially embedded and inter-regionally connected. In light of this conclusion, the traditional picture of a marginal economy dictated by agents of the imperial state and reliant upon the continual supply of a command economy can no longer be upheld.

This economy existed at a number of different levels and involved many different aspects. In the space available for this thesis, I have been able to examine only a handful of these, but each line of evidence pursued added depth to our understanding of frontier economies. Utilizing a combination of archaeological, environmental, and scientific data in conjunction with economic models and assessment methodologies, this thesis examined the development of transport infrastructure, urbanism and demographic issues, natural resources, craft production, and trade. Each of these examinations involved the critical examination of quantified datasets, resulting in highly detailed and, generally, new interpretations of evidence documented over the last century or more in the Rhine region. A review of the conclusions of each of these investigations is pertinent before moving on to wider discussions.

Summary

When the Romans arrived in the Rhine Basin in the mid first century BC, they found a landscape divided between different tribal societies who had achieved relatively high levels of economic interaction through the management of local resources and trade in both luxury and everyday goods. Development was highly varied across the region, differentiated by various local traditions, tribal warfare, and natural conditions. The Roman conquest was violent and substantially disrupted the Iron Age setting along the Rhine, depopulating some regions and moving groups to new lands. Under Roman hegemony, the region was united into a coherent system that was able to take advantage of the full range of resources available.

With a large part of the river basin unified under a single state, riverine travel became safer and more efficient. This was augmented by the early construction of roads through the region under Agrippa, linking the Rhine with the Mediterranean, Gaul, and Raetia. Further infrastructural development followed with the building of bridges, harbours, and canals throughout the region. Local traditions of boat building led to a Gallo-Roman construction ideally suited for navigating the waterways of the Rhine and for the conveyance of bulk cargoes. These two networks, river and road, merged into a single system that provided multiple transport options throughout the region. Riverine travel was dictated by climatic conditions and could only be safely accomplished in some parts of the year. There were, undoubtedly, good years and bad years, making the reality of seasonal and inter-annual variation a critical component of understanding riverine travel. Fortunately, the road network always provided a good alternative which was evidently not restrictive in cost or effort. Milestones may reveal periods of road repairs throughout the region, peaking in the third century. Whether this peak was related to the climatic downturn or not, it is clear that maintenance and upkeep of the transport system was a key concern through the fourth century.

Situated at key nodal points throughout this system were dozens of cities, towns, and rural settlements. Over the first two centuries AD, the Rhine basin

developed an urban system the likes of which it had never experienced before, culminating in an administrative system including 24 *civitas* capitals, five *coloniae*, and four *municipia* in addition to a number of other towns. In total, more than 2000 ha of urban space developed, including all the trappings of Roman urban life. It is difficult to estimate population numbers for antiquity, but it is possible that this settlement network sustained an urban population of over 400,000 at its peak in the late second century, with a total regional population in the realm of several million. A substantial military garrison was stationed on the Rhine frontier alongside this civilian population, with a force of about 80,000 under Augustus which was reduced to about 55,000 in the late second century. Composed of legionaries, auxiliaries, and naval troops, this force tried to keep the peace along the German frontier for 400 years. The close positioning of military bases to civilian settlements meant that the two groups were closely entwined and both contributed significantly to local economic life.

The traditional model of frontier economies has emphasized the dominance of the military and the necessity of a state supply of goods in these areas. Such a view is difficult to maintain in light of the urbanization and population growth demonstrated here. While the initial phases of Roman occupation may have seen substantially more troops than civilians in the region, this quickly changed. This growth of population, particularly in urban settings, also increased the tax base of the region as well as labour pool. Increased differentiation of labour and specialization of skills is clearly seen across the region in both archaeological remains and epigraphy. After settlement peaked around AD 200, the region underwent a massive change by the end of the third century. Settlements reduced in size by as much as 60% as fortification walls, sometimes hastily cobbled together from funerary monuments, were set up throughout the region. Rural retreats known as *Höhensiedlungen* were briefly used for safety in the late third century; clearly something had changed. In the fourth century, some sites such as Trier and Cologne maintained their earlier size, with Trier becoming a new imperial capital. Other sites were not as fortunate, and the evidence suggests widespread depopulation, contraction, and abandonment.

The roads, bridges, cities, and forts of the region were built from the ample natural resources located within the Rhine Basin. The geology of the region meant a steady supply of base metals like iron and lead in addition to small pockets of silver and other more precious minerals. It is possible that the particularly productive Rhenish Massif was an initial target of Roman annexation under Augustus because of its resources. These metals were worked in many outcrops between modern-day Switzerland and northern Germany. Where metallic resources were not available, stone quarrying and timber harvesting were particularly common. Quarries were mainly used for local purposes, though some particularly high-quality stones on the Moselle and Middle Rhine were transported over long distances. Timber was a critical resource, and evidence suggests that it was both cultivated and moved over long distances. The famed oaks of the region were particularly valuable, used for everything from boats to fortification walls. There is clear evidence of state interest in the exploitation of these resources, ranging from epigraphic attestation of officials to graffiti of soldiers in quarries to the probable existence of imperial estates west of the Rhine in the Eifel and the across the Rhine in the Saurland and Black Forest. The evidence is not entirely clear on this situation, though it seems probable that the state was only directly involved in the procurement of resources when it needed them for specific building projects. The activity of the legions in the Eifel at the time when they were converting their fortresses from timber to stone is a case in point. Otherwise, we have to imagine that quarries and mines were managed by civilian contractors. The availability of these resources, regardless of who managed them, meant that the region was largely self-sufficient in its basic material requirements.

Other types of resources, namely clay and sand, were used to develop extensive craft-producing industries. While no complete analysis of craft production has yet been done for the entire Rhine basin, specific investigations of ceramic and glass production were conducted in order to gain better insight into the chronological and spatial development of these industries. Pottery production was extremely common, attested on over 150 sites and demonstrated through excavated remains of over 1200 kilns. A wide range of products was produced, from terra sigillata to coarseware to terra nigra and amphorae. Production sites were located near clay resources, which meant that most river valleys in the region were suitable. Often potters set up districts outside the walls of major towns, though there are multiple examples of specific pottery-producing centres and dispersed rural productions as well. Production was at its highest in the second century, but many centres did not produce past the middle of the third century. Coincidentally or not, the time of the Gallic Empire saw a significant break in the previously booming ceramic industry. After this period, few sites continued any real production, though sites like Mayen and Speicher achieved supra-regional distributions. Glass production, meanwhile, was a much smaller-scale activity, located at far fewer sites across the region. Interestingly, a handful of sites suggest the primary production of glass from raw products within the Rhine Basin, an activity traditionally thought of as only happening in the East. Cologne, Augst, and the villas of the Hambach Forest each utilized local sand sources in order to take over the local glass trade effectively for most of the Roman period. Other sites, such as Trier and Mayen, may have been equally prolific in their productions, but clear evidence has yet to be found. By the second century, local glass assemblages were dominated by locally-produced glass. A number of secondary glass producing centres are also known, mostly from Late Antiquity and located around the Moselle valley, which may have been directly linked to the continued success of Trier. That both glass and pottery production continued after the Roman period at Roman-era sites speaks to the success of these industries and the wealth of raw materials available.

Finally, trade connections were examined in order to establish the level of market activity present in the region, the reach of its connections, and the role of state-instituted supply chains for the military. More than 70 amphorae assemblages from a selection of civilian and military contexts were compared. Little variation was found between site types, suggesting that both civilians and soldiers were involved in the same market system which stretched from the Alps to the North Sea. It was found that the Rhine region maintained long-distance trade connections throughout most of the Roman period with producers as far away as the eastern Mediterranean. The Augustan period saw the widest range of imports, bringing in goods from Italy, the eastern Mediterranean, Spain, and Gaul. The olive oil of Baetica came to be one of the most common amphora-borne commodities in the region and, together with southern Gallic wine, eventually shut out most other regions. It seems highly probable that transport of olive oil from Spain to Germany spurred the development of viticulture in southern and central Gaul, taking advantage of the high volume of traffic coming through. Local products started to become common in the second century, evidencing both local production of amphorae but also the products to fill them—beer and probably wine, though sufficient residue analysis has not been done. Imports gradually taper off until the mid third century when they cease to be visible in the data. Sites with high-resolution assemblages like Augst show this clearly. The fourth century saw some return to long-distance amphorae imports, including products from Africa, but in minimal quantities. It has been suggested that a change in container from amphorae to barrels explains this lack of visibility, but the answer must in fact be more complicated—while barrels may have been used locally to transport the wine produced in Gaul from the late third century on, they would probably not have been used to bring in many Mediterranean products which otherwise still moved by amphora. Therefore, a decline in long-distance trade in bulk commodities can be seen from the late second century onwards, due in part to the increased success of local products and efficient import replacement.

The topic of trans-frontier trade requires a separate thesis, but some observations can be made. There is good evidence that Germans traded lead across the frontier, and the fact that this has only recently comes to light signals future possible discoveries. Roman settlement may well have provided consumer demand for other products from Germany—slaves, furs, amber—but these are less visible. The placement of many toll stations along the frontier suggests sustained traffic, but determining its character is difficult. It seems that the volume of bulk-good trade from Roman territory was not as high as other frontier zones.

Several explanations can be proposed tentatively: evidence for high-volume, low cost commodities in Germania Magna is waiting to be found or has been poorly reported, those living across the German frontier did not want to consume Roman commodities such as wine, crossing points on the German frontier were so thoroughly monitored and goods so heavily taxed that it was simply not worth the merchants' efforts to transport such goods into German territory, or the Germans had little to trade that the Romans wanted. The first explanation seems unlikely, given the history of research in Roman finds in Barbaricum. The second explanation is plausible, given native traditions of other alcohol,[1011] yet we cannot dismiss the presence of wine-drinking paraphernalia beyond Roman frontiers.[1012] The third lacks any real proof—no tax records like the Muziris papyrus exist for the German frontier, but the concentration of *stationes* for the collection of the *quadragesima Galliarum* and the stationing of many *beneficiarii* at frontier crossing zones suggests that traffic into Germany was heavily monitored.[1013] It is clear that these questions require further investigation within the context of the material presented in this thesis.

The role of the Roman military

The involvement of the military in this economic development has been a constant point of discussion throughout this study. Many archaeologists and historians have argued for the prime agency of the Roman military in frontier economies, going so far as to argue that because of the presence of the military and the *annona militaris*, there was little impetus for civilian development. In this model, market trade is a non-entity, as civilian markets are simply supplied by overflow from military supply. This model has, however, been challenged repeatedly throughout this thesis and it no longer seems a viable argument for the Rhine frontier. That does not mean that the military was not an economically significant force within

[1011] See Tacitus' account in *Germania* 23.
[1012] As Hunter 2013, 19 points out in Scotland. His suggestion that barrels carrying wine, invisible in the archaeological record, obscure the situation may hold true in Germany as well. Furthermore, just because such paraphernalia was used within the Empire for drinking wine, there is no guarantee that this held true outside the Empire as well.
[1013] See pages 24-29.

the region. Indeed, throughout the four centuries of Roman rule, the military played a continuous role in economic activity, so some main points need to be summarized here.

Above all else, the main economic contribution of the Roman army was the security that it provided along the frontier. **Figure 1.4** showed a timeline of outbreaks of violence within the Rhine basin, particularly common in the late third and late fourth centuries. It is no coincidence that these periods of strife came up again and again throughout this investigation—outbreaks of violence substantially curbed economic success along the frontier. Scheidel and Bang have argued for the importance of the *Pax Romana* within the Mediterranean,[1014] and it was no less important on the frontier. Unfortunately, history rarely records the day-to-day successes of the Roman army, instead emphasizing their periodic misbehaviour or failures. We must assume that the two centuries of relative peace on the Rhine frontier were due to the successful defence of the Roman frontier by the army, and we cannot underestimate the importance of this fact.

Security aside, the military interacted with the civilian population daily and was well-integrated into the regional economy. Soldiers were a substantial source of money and, at least in the first century AD, were an important source of cash injection into local society. After the Flavians, this was less critical as it seems a substantial amount of coin was in circulation throughout the province from there on. However, the purchasing power of the army was large, and continued patronage of local artisans for high-price commodities like carved stone, to say nothing of their demand for food and textile supplies, meant that coin was constantly circulating into the frontier zone. Civilians surely benefitted from military pay raises and donatives as much as the soldiers, though it is difficult to see this in the material evidence.

Soldiers were highly involved in the exploitation of the region's natural resources. Multiple pieces of evidence demonstrate that the Roman military was periodically involved in the extraction of the region's resources. These projects mostly consisted of fortification efforts, though sometimes also involved urban

[1014] Scheidel 2009; Bang 2012.

building or infrastructural improvements. The widespread construction by soldiers within the Rhine region meant that civilians were able to spend their money elsewhere.[1015]

The role of the *annona militaris* has long occupied scholars concerned with the nature of trade in frontier zones. The idea that the Roman state controlled the flow of goods into the region was questioned through examinations of both the organization of traders and the distribution of imported trade goods. The developments of *collegia* and other associations of traders and shippers suggest a high level of civilian organization outside the realm of state supply lines. The presence of imported amphorae throughout the region, equally distributed between civilian, military, and rural sites suggests that these goods did not arrive exclusively through any sort of command economy. This is not to say that the state was not concerned with supplying its troops, as it surely was, particularly in times of conflict. The state could not always dedicate the time and resources to organizing a supply of wine or olive oil to troops in times of peace, especially once local market systems and merchants were already operating in the region. Evidence from Vindolanda certainly suggests that units were responsible for purchasing such goods in local markets,[1016] and the distribution of amphora-borne goods along the Rhine suggests that the same practice was in effect. As Verboven has suggested, the presence of the army with its large sums of cash made the German provinces an attractive market for merchants,[1017] who took full advantage of the market opportunities in the region. Moreover, the gradual shifts in trade connections seen in the amphorae over time suggest market forces, such as competition, comparative advantage, and import replacement, at work. Such economic logic would hardly be typical for long-distance, state-organized supply lines.

[1015] On the topic of military and civilian benefaction in frontier zones, see MacMullen 1959; Drinkwater 1979; Früêzouls 1984; Blagg 1990.
[1016] Haynes 2013, 175.
[1017] Verboven 2007.

In sum, the Roman military did not dictate the formation of the regional economy beyond the initial phases of conquest and settlement in the region.[1018] As the population of the region grew, so too did the influence of the civilian population. As local food production took off and cities grew, the state did not have to organize supply lines to the region, as merchants were already doing it for them. The spending power of the army and the wealthy citizens of the region ensured the continued importation of goods as they became part of the daily lives of those living along the Rhine. The role of the military in the economy of the Rhine frontier can, therefore, best be described as one of *maintenance*: spending money, repairing roads, and keeping the peace. Each of these roles helped lower transaction costs, thereby making economic development more efficient and sustainable. This is not an insignificant role and this re-fashioning of interpretation is not meant to suggest that the military was not a vital part of frontier economies. Instead, it is meant to shift the emphasis on the military from a role of from prime agent to part of a wider system.

An economic geography of the Rhine River Basin

In Chapter 1, a series of five issues central to the topic of economic geography were presented. These issues have been examined multiple times throughout this thesis, and now require some summary.

Defining the spatial unit of reference

For the purposes of this study, the unit of reference was the Rhine River Basin, equivalent to the majority of the provinces of Germania Inferior and Superior and a significant part of Gallia Belgica. Obviously, the selection of a region bounded by natural borders rather than political or administrative region is not without issue. The river system was favoured because it contained the entirety of the military frontier and an easily defined landscape regardless of political

1018 *Cf.* Fentress 1979; Fulford 1984; 1989b; 2004; Fentress 2013. The role of the army is emphasized in both Britain and Numidia, and while the army of Britain was, from the second c. onwards, stationed far from many of the civilian centres of the south, the Numidian garrison was perhaps better integrated with the local population.

developments—whatever happened to the Roman provinces, the river basin was always the same. Likewise, the Rhine basin can be separated from modern nation-states and their sometimes difficult attitudes towards one another. In some instances, the region was a fully integrated network—the amphorae assemblages show remarkable similarity from sites all over the region and major terra sigillata types (Arretine, Southern Gaulish, and Rheinzabern sigillata) were distributed throughout. Others, such as smaller productions of terra sigillata—schwäbische ware, helvetische ware—or the less well-known low lands ware had much more limited distributions within the larger Rhine Basin. Despite the apparent systemic unity of the frontier, this did not equate to homogeneity at all levels of experience.[1019]

Mobility of productive factors

The Rhine basin, because of its military garrison and substantial civilian population, attracted a large number of merchants and imported goods. This was encouraged by the development of infrastructure and maintenance of peaceful conditions within a zone of fertile agriculture and ample resources. As the region developed, these beneficial regional traits gradually attracted producers, artisans, and other specialists to the region. Glass manufacturing greatly reduced the import costs of similar products from the eastern Mediterranean from the first century onward. In the second century, the local production of terra sigillata replaced imported goods from Gaul, while local production of beer and probably wine gradually replaced imported alcohol from the Mediterranean. The decline of olive oil suggests contemporaneous local developments of either fat or vegetable oils. Local availability of metal, timber, and stone meant local specialization in these materials. A developed transport infrastructure reduced transport costs and connected supply with demand. The picture, therefore, is one of near regional self-sufficiency enabled first by the attraction of specialists from other regions and

[1019] As Combes *et al*. 2008, 368 emphasizes, trade was not synonymous with homogenization; instead, it increases the range of opportunities available to everyone.

then by the development of 'domestic' production to meet local demand at lower costs.

First- and second-nature inequalities

The availability of local resources discussed above in conjunction with favourable climatic conditions over the first two centuries AD meant that the region ranked well in terms of first-nature inequalities. It seems probable that the mineral wealth of the Rhenish Massif (lead, iron, building stone, basalt) was a deciding factor in initial Roman interest in the region, and thereafter played a significant role in the economic life of the region. Subsequent augmentation of the landscape with enhanced transport infrastructure, an urban system, developed farming techniques, and incorporation into an Empire-wide trading network led to rapid economic development through the mid third century AD.

Agglomerative and dispersive forces

All of these qualities outlined above functioned as agglomerative forces which culminated in the *floruit* of the region in the second and early third centuries. Merchants, trade goods, and craftsmen were all drawn to the region over time. Again, the role of peace cannot be overstated, as the later third century shows. As the region became increasingly unstable, economic activity declined—trade goods became scarcer, production centres declined, and population moved. Frontier regions, more than any other areas of the Empire, were susceptible to a persuasive dispersive force—violence. Whether caused by German attacks, troop revolts, or political usurpation, the Rhine economy could not simply weather the storm. The disappearance of craft production from major urban centres in Late Antiquity is a case in point—the large ceramic industries of Cologne, Mainz, and Trier could not survive attacks. The distribution of later productions of glass in the Hambach Forest or pottery in the Eifel hills demonstrates an effort to distance production centres from potential targets of attack. The short- and long-term effects of the third-century crisis have now been given definite shape by the data discussed here.[1020]

Climate has been emphasized here as an initial factor of agglomeration and development, but the downturn in the late third century left hints of discontent in wider economic activity. River flows became less dependable, flooding increased, stream beds moved—Xanten was cut off from the river, Oedenburg had to move to higher ground, roads and bridges had to be repaired. Freezing in the winter, particularly on the High Rhine, caused security concerns in the fourth century. At the same time, the Moselle flourished—the landscape of Ausonius produced wine which would come to define the region for thousands of years. In this zone, the imperial capital of Trier clearly acted as a major agglomerative force throughout at least the first half of the fourth century.

As others have observed, agglomerative and dispersive forces often act in cycles.[1021] Such boom and bust cycles in the Roman world have often been explained as the result of Malthusian principles, but here it seems more accurate to attribute them to a more complex development. Climate and security were equally important factors. These were mitigated, in part, by the efforts of local economic agents acting to improve local conditions through the improvement of second-nature inequalities.

Increasing returns and imperfect competition

Population growth clearly went hand in hand with the development of local industry and production. Economies of scale developed as major producers increased their yields through the implementation of more advanced technology and more specialized and differentiated labour forces. Competition between local and 'foreign' producers spurred further development, eventually resulting in, as already pointed out, a fairly self-sufficient region. Even as the nature and organization of this system changed into Late Antiquity, the hallmarks were still

[1020] *Contra*, most recently, Esmonde-Cleary 2013.
[1021] Combes *et al*. 2008, xvi.

there—specialized production centres operating scale economies, differentiated labour, competition, and comparative advantage.

AD 406-457, the end of the Roman economy

By the end of the fourth century, developments were already well underway for the removal of Roman influence from the region: the long-standing sentinels of the frontiers, the Roman legions, dissolved sometime around 375, replaced by smaller units of often unknown composition.[1022] The imperial seat abandoned Trier sometime around 388, moving first to Vienne and then to Arles.[1023] Several years later in 397 Stilicho removed a substantial force of the Rhine garrison to combat Alaric elsewhere, weakening the frontier's defence.[1024]

When the Alans, Vandals, and Suevi crossed the Rhine in the winter of 406,[1025] they entered a land vastly different from what had existed even only 50 years earlier. While some urban sites persisted, particularly those around military centres,[1026] the system was decaying. The Franks sacked Trier at least four times in the early fifth century,[1027] and they finally took Cologne in 457.[1028] Warlords and their followers replaced the Roman state and the Gallic diocese, and with this change came the end of any stable 'imperial economy.'[1029] Officially-produced coinage was already in decline from 402,[1030] and mechanisms of tax-collection had probably already turned to compulsory requisitioning directly by soldiers.[1031] Rural life had been in decline in many regions since the third century, but this was probably improved by Germanic settlement in Roman territory, as it ended

[1022] Like those listed in the *Notitia Dignitatum*. On the military changes of the period see Scharf 2005; Konrad and Witschel 2011, 22; Nuber 2011; Esmonde-Cleary 2013, 341-48.
[1023] The exact date is debated, Halsall 2008, 209-10 states that the capital had been re-established in Arles between 418-425, agreed with by Konrad and Witschel 2011, 12.
[1024] Kulikowski 2000; Drinkwater 2007, 322-23; Halsall 2008, 209-10.
[1025] The date of the crossing is traditionally listed as 406, though Kulikowski 2000 suggests 405, based on the sequence of events leading to the usurpation of Constantius III in Britain. This suggestion has gone largely unnoticed in subsequent literature.
[1026] See papers in Konrad and Witschel (eds.) 2011.
[1027] Drinkwater 2007, 326.
[1028] Halsall 2008.
[1029] Drinkwater 2007, 323-24.
[1030] Produced mainly to pay mercenary units and not circulating far outside of their fortifications, Konrad and Witschel 2011, 7; Esmonde-Cleary 2013, 348.
[1031] Esmonde-Cleary 2013, 350.

marauding and much conflict. The establishment of the Merovingian kingdom after the battle of Zulpich in 496 preserved Roman elements—the *civitas* system,[1032] for instance—and the subsequent pacification of the region would lead to continued development into the Carolingian period.[1033]

Economic development in a frontier province

The resulting picture of the Rhine economy is one of complexity, dynamism, and progress. There were certainly periods of growth and periods of contraction, usually followed by further growth. Real decline finally came at the end of the Roman period with the dissolution of the imperial economy which acted as an umbrella for all of these other economic activities. Even then, the downturn was fairly temporary, as post-Roman kingdoms continued to pursue previous economic enterprises. The Rhine frontier was not a marginal economic zone and, while it was linked to other provinces such as Spain and Gaul, was rarely dependent on a products from a 'Romanized-core.'

A variety of economic agents and forces shaped the development of the region—the state, the army, farmers, urbanites, producers, consumers—and their motives and influences have been explored. No one group possessed a real primacy, but each formed part of the whole. The imperial government exacted taxes and paid the troops, the troops protected the region, developed infrastructure, and bought goods, farmers farmed, producers produced and both groups did so with a concern for earning enough income to pay their taxes. A number of families contributed men to the army—sons, husbands, and fathers—which served as a major integrating cultural and economic factor. The success of the military and the success of civilians were inextricably linked; neither group existed in isolation. In the rare occasions when these two groups found themselves at odds, everyone suffered. The region was at its best when the army defended the land and the land supported the army.

[1032] Harries 1978.
[1033] McCormick 2001.

Hopkins was ambitious with his model, now 30 years beyond its initial formulation. That subsequent evidence has disproven its basic tenets is not a mark against his ambition, nor is it a cautionary tale against forming new models. Explicit examination of those factors which led to economic development and spatial differentiation reveals a system full of complexity. In order to produce a new explanation which encapsulates this complexity, this thesis has argued for a better integration of the framework of economic geography into the study of the Roman economy as its questions and approaches better suit the developing picture of the Roman world than simple core/periphery dichotomies. Economic development in frontier zones came as the result of the cumulative total of a series of contributing factors which included settlement, transport, resources, production, trade, climate, and peace. When these factors combined positively, they created an environment conducive to economic development which led to growth; when they combined negatively, development and growth were disrupted or stopped all together. This broad explanation can undoubtedly fit many regions of the Roman world, but the issue of peace is particularly relevant in a frontier zone; it was only through the maintenance of peacetime conditions that frontier zones could evolve beyond a strictly military character. A multi-faceted explanation such as this dispels the *a priori* determination of frontier economies as being subaltern or less developed and instead appreciates local conditions for their own sake. In this case, the Rhine frontier was shown to be responsive, adaptive, and resilient over much of its history.

Future research

The question remains as to whether or not the Rhine is representative of all frontiers or if it was a special case. It is beyond the scope of this thesis to offer many comparative views, but it is hoped that future studies will provide detailed examinations of other frontier zones. Some regional differences are obvious: the agricultural potential of the Rhine was quite different from that of the Arabian or Saharan frontiers, while the volume of trade passing over these desert frontiers may have surpassed what crossed into Germany. The close civilian-military settlement that characterized much of the Rhine has close parallels to the Middle Danube, but not necessarily to northern Britain. Numidia in the later second century may provide a comparable case to that seen here, though more work must be done to produce data of similar quality. Further differences must be illumintated by careful study of archaeological details.[1034] What is clear is that the factors acting upon local economic development were as diverse as the landscapes which they acted upon.[1035] It is only through detailed and nuanced approaches that the realities of different regions can be better understood within their local contexts. Economic geography may be only one approach to doing this, but more explicit scholarly interaction with economic models will only help to advance our field and understanding. Such advances will help further clarify the different roles of frontier economies within the Roman world.

[1034] Fentress 1987, 187 laments the lack of adequate archaeological evidence.
[1035] Horden and Purcell 2000; Morris 2010; Rice 2012.

BIBLIOGRAPHY

Aarts, J. G. 2000. *Coins or money? Exploring the monetization and functions of Roman coinage in Belgic Gaul and Lower Germany 50 BC -AD 450.* Amsterdam.

Aarts, J. G. 2003. "Monetization and army recruitment in the Dutch river area in the early first century AD," in R. Wiegels and S. Seibel, eds., *Kontinuität und Diskontinuität. Germania Inferior am Beginn und am Ende der römischen Herrschafft*. Berlin. Pp. 145-161.

Aarts, J. G. 2005. "Coins, money and exchange in the Roman world. A cultural-economic perspective," *Archaeological Dialogues* 12.1:1-27.

Abegg, A., Walter, D., Biegert, S. 2011. *Die Germanen und der Limes: Ausgrabungen im Vorfeld des Wetterau-Limes im Raum Wetzlar-Giessen*. Mainz.

Adams, C. E. P. 2007. *Land Transport in Roman Egypt—A Study of Economics and Administration in a Roman Province.* Oxford.

Adams, C. E. P. 2012. "Transport," in W. Scheidel, ed., *The Cambridge Companion to the Roman Economy*. Cambridge. Pp. 218-40.

Adams, J. N. 1994. "Latin and Punic in Contact? The Case of the bu Njem Ostraca," *Journal of Roman Studies* 84: 87-112.

Alföldy, G. 1968. *Die Hilfstruppen der römischen Provinz Germania inferior*. Düsseldorf.

Amrein, H., Carlevaro, E., Deschler-Erb, E., Deschler-Erb, S., Duvauchelle, A., and Pernet, L. 2012. *Das römerzeitliche Handwerk in der Schweiz. Bestandsaufnahme und erste Synthesen / L'artisanat en Suisse à l'époque romaine. Recensement et premières synthèses.* Montagnac.

Andreau, J. 2000. "Commerce and finance," in A. K. Bowman, P. Garnsey, D. Rathbone, eds., *The Cambridge Ancient History vol. XI: The High Empire, AD 70-192.* Cambridge. Pp. 769-86.

Arnaud, P. 2005. *Les routes de la navigation antique: itinéraires en Méditerranée*. Paris.

Arnaud, P. 2007. "Diocletian's Prices Edict: the prices of seaborne transport and the average duration of maritime travel," *Journal of Roman Archaeology* 20: 321-335.

Arnaud-Fassetta, G. 2002. "Geomorphological records of a 'flood-dominated regime' in the Rhône Delta (France) between the first century BC and the second century AD. What correlations with the catchment paleohydrology?" *Geodinamica Acta* 15: 79-92.

Arnaud-Fassetta, G. *et al.* 2005. "7200 years of Rhône river flooding activity in Lake Le Bourget, France: a high-resolution sediment record of NW Alps hydrology," *The Holocene* 15.3: 420-428;

Asal, M. 2005. *Ein spätrömischer Getreidespeicher am Rhein*. Brugg.

Atkinson, R. 2013. *The Guns at Last Light: The War in Western Europe 1944-1945*. New York.

Aubin, H. 1925. "Der Rheinhandel in römischer Zeit," *Bonner Jahrbücher* 130: 1-37.

Baatz, D. 1973. *Kastell Hesselbach und andere Forschungen am Odenwaldlimes*. Berlin.

Baatz, D. 2000. *Der römische Limes: archäologische Ausflüge zwischen Rhein und Donau*. fourth ed. Berlin.

Baatz, D. 2002. "Das Leben im Grenzland des Römerreichs," in D. Baatz and F.-R., Herrmann, eds., *Die Römer in Hessen*. Stuttgart. Pp. 84-156.

Baatz, D. and Herrmann, F.-R. 2002. *Die Römer in Hessen*. Stuttgart.

Bachmann, H. G. 1977. "Bleiglätte-Fund aus der Nordeifel. Ein Hinweis auf Silbergewinnung in der römischen Rheinzone," *Bonner Jahrbücher* 177: 617-22.

Bachrach, B. S. 2010. "The fortification of Gaul and the economy of the third and fourth centuries," *Journal of Late Antiquity* 3: 38-64.

Bakels, C. and Jacoment, S. 2003. "Access to luxury foods in Central Europe during the Roman period: the archaeobotanical evidence," *World Archaeology* 34.3: 542-57.

Bang, P. F. 2009. *The Roman Bazaar: A Comparative Study of Trade and Markets in a Tributary Empire*. Cambridge.

Bang. P. F. 2012. "Predation," in W. Scheidel, ed., *The Cambridge Companion to the Roman Economy*. Cambridge. Pp. 197-217.

Bats, M., ed., 2006. *Olbia de Provence (Hyères, Var) à l'époque romaine.* Aix-en-Provence.

Baudoux, J. 1992. "La circulation des amphores dans le Nord-Est de la France," in F. Laubenheimer, ed., *Les Amphores en Gaule: Production et Circulation*. Paris. Pp.163-69.

Baudoux, J. 1996. *Les Amphores du Nord-Est de la Gaule (territoire français): Contribution à l'histoire de l'économie provinciale sous l'Empire romain*. Paris.

Baudoux, J. 1998. "Les Amphores à Strasbourg: Fouilles récentes du tramway (homme de fer) et de la rue Hannong," in F. Laubenheime, ed., *Les Amphores en Gaule 2: Production et Circulation.* Paris. Pp. 91-105.

Baudoux, J., Bocquet, A., Brulet, R., Laubenheimer, F., Marlière, Vilvorder, F. 1998. "La production des amphores dans l'Est et le Nord des Gaules: typologie et caractérisation physico-chimique," in F. Laubenheimer, ed., *Les Amphores en Gaule: Production II: Production et Circulation*. Paris. Pp. 11-48.

Bauer, S. 2004. "Die älteste Steinbrücke am Rhein – stand sie in Mainz? Neuer Holzfund als Indiz für einen frührömischen Brückenschlag," *Antike Welt* 35.3: 83-84.

Bechert, T. 1982. *Römisches Germanien zwischen Rhein und Maas: die Provinz Germania Inferior.* München.

Becker, A. 2005. "Neue Aspekte zur Chronologie der augusteischen Germanienpolitik: Wirtschaftliche, topographische und politische Standortfaktoren einer urbanen römischen Siedlung in Waldgirmes," *Münstersche Beiträge zur antiken Handelsgeschichte* 24: 161-74.

Bedon, R. 1984. *Les carrières et les carriers de la Gaule romaine.* Paris.

Bekker-Nielsen, T. 1989. *The Geography of Power: studies in the urbanization of Roman north-west Europe*. BAR international series 477. Oxford.

Beloch, K. J. 1886. *Die Bevölkerung der griechisch-römischen Welt.* Leipzig.

Beloch, K. J. 1899. "Die bevölkerung Galliens zur Zeit Caesars," *Rheinisches Museum für Philologie 54*: 414-45.

Belz, J. U. (ed.) 2007. *Das Abflussregime des Rheins und seiner Nebenflüsse im 20. Jahrhundert: Analyse, Veränderungen, Trends*. CHR Report I-22. Koblenz.

Bémont, C. and Jacob, J.-P., eds., 1986. *La Terre Sigillée Gallo-Romaine. Lieux de production du Haut Empire: Implantations, Produits, Relations*. Paris.

Bender, H. and Wolff, H., eds., 1991. *Ländliche Besiedlung und Landwirtschaft in den Rhein-Donau-Provinzen des Römischen Reiches.* Passau.

Bengueral, S. 2011. *Tasgetium I: das römische Eschenz*. Frauenfeld.

Bernhard, H. 1981. "Zur Diskussion um die Chronologie Rheinzaberner Relieftöpfer," *Germania* 59.1: 79-93.

Bernhard, H. 1984. "Das römische Weingut "Weilberg" bei Bad Durkheim Ungstein," *Pfalzer Heimat* 35: 2-15.

Bernhard, H. 2007. *Der römische Vicus von Eisenberg: ein Zentrum der Eisenverarbeitung in der Nordpfalz.* Speyer.

Bezeczky, T. 1996. "Amphora inscriptions – legionary supply?" *Britannia* 27: 329-336.

Bhaba, H. 2004. *The Location of Culture*. London.

Biegert, S. 1999. *Römische Töpfereien in der Wetterau*. Frankfurt am Main.

Biegert, S. 2000. "Keramikproduktion in der civitas Taunensium," in K. Strobel, ed., Forschungen zur römischen Keramikindustrie. Produktions-, Rechts- und Distributionsstrukturen. Trier. Pp. 157-62.

Birley, A. R. 2002. "Fifty years of Roman frontier studies," in P. Freeman, J. Bennett, Z. T. Fiema, and B. Hoffmann, eds., *Limes XVIII: Proceedings of the XVIIIth International Congress of Roman Frontier Studies held in Amman, Jordan (September 2000)*. Oxford. Pp. 1-11.

Blagg, T. F. C. 1980. "Roman civil and military architecture in the province of Britain: aspects of patronage, influence, and craft organization," *World Archaeology* 12.1: 27-42.

Bloemers, T. 2000. "German archaeology at risk? A neighbour's critical view of tradition, structure and serendipity," in H. Härke, ed., *Archaeology, Ideology, and Society: The German Experience*. Frankfurt am Main. Pp. 378-400.

Böcking, W. 1980. *Die Geschichte der Rheinschiffahrt: Schiffe auf dem Rhein in drei Jahrtausenden*. Moers.

Bockius, R. 2000. "Antike Prahme. Monumentale Zeugnisse keltisch-römischer Binnenschiffahrt aus der Zeit vom 2. Jh. v.Chr. bis ins 3. Jh. n.Chr." *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 47: 439-493.

Bockius, R. 2002a. "Die Prähme von Woerden," in A. Mees, B. Pferdehirt, eds., *Römerzeitliche Schiffsfunde: in der Datenbank "Navis I"*. Mainz. Pp. 30-35.

Bockius, R. 2002b. "Das Wrack von Vechten," in A. Mees, B. Pferdehirt, eds., *Römerzeitliche Schiffsfunde: in der Datenbank "Navis I"*. Mainz. Pp. 60-62.

Bockius, R. 2006. *Die spätrömischen Schiffswracks aus Mainz: schiffsarchäologisch technikgeschichtliche Untersuchung spätantiker Schiffsfunde vom nördlichen Oberrhein.* Mainz.

Bode, M. 2008. *Archäometallurgische Untersuchungen zur Blei-/Silbergewinnung im Germanien der frühen Römischen Kaiserzeit.* Dissertation der Westfälischen Wilhelms-Universität Münster.

Bode, M., Baumann, A., Hauptmann, A., Mezger, K., Prange, M. 2003. "Geochemical and lead isotope investigations for lead production in Roman times in the Rhineland and in Westphalia (Germany)," in *Archaeometallurgy in Europe*. Milano. Pp. 201-209.

Bogaers, J. E. A. T. and Rüger, C. B. 1974. *Die niedergermanische Limes: Materialien zu seiner Geschichte*. Köln.

Böhm, M., Kempa, M., Hauptmann, A. 1995. *Beiträge zur Eisenverhüttung auf der Schwäbischen Alb.* Stuttgart.

Bonnet, F. 1982. "Les ports romains d'Aventicum," *Archäologie der Schweiz* 5: 127-31.

Bonnie, R. 2009. *Cadastres, Misconceptions, and Northern Gaul*. Leiden.

Bowman, A. K., and Wilson, A. I. 2009. "Quantifying the Roman economy: integration, growth, decline?" in A. K. Bowman and A. I. Wilson, eds., *Quantifying the Roman Economy: Methods and Problems*. Oxford Studies on the Roman Economy vol. 1. Oxford. Pp. 3-86.

Bowman, A. K. and Wilson, A. I., eds., 2009. *Quantifying the Roman Economy: Methods and Problems*. Oxford Studies on the Roman Economy vol. 1. Oxford.

Bowman, A. K. and Wilson, A. I. 2011. "Introduction: settlement population and urbanization in the Roman economy," in A. K. Bowman and A. I. Wilson, eds., *Settlement, Urbanization and Population.* Oxford Studies on the Roman Economy vol. 2. Oxford. Pp. 1-16.

Bowman, A. K. and Wilson, A. I., eds., 2011. *Urbanization and Population.* Oxford Studies on the Roman Economy vol. 2. Oxford.

Bowman, A. K. and Wilson, A. I. 2013. "Introduction: quantifying Roman agriculture," in A. K. Bowman and A. I. Wilson, eds., *The Roman Agricultural Economy: Organisation, Investment, and Production.* Oxford. Pp. 1-40.

Bowman, A. K. and Wilson, A. I., eds., 2013. *The Roman Agricultural Economy: Organisation, Investment, and Production.* Oxford.

Bowman, A. K. and Thomas, D. J. 1991. "A military strength report from Vindolanda," *Journal of Roman Studies* 81: 62-73.

Bräuning, A. 2004. *Riegel – Römerstadt am Kaiserstuhl: Das neue Bild von einem alten Fundplatz*. Esslingen.

Bravard, J.-P. 2006. "Impacts of climate change on the management of upland waters: the Rhône river case," *Fifth Biennial Rosenberg International Forum on Water Policy*. Banff. Pp. 1-42.

Brem, H. 2008. *Ad Fines – das spätrömische Kastell Pfyn*. Frauenfeld.

Bremer, E. 2000. "Untersuchungen zur Versorgung der römischen Militärlager an der Lippe," *Orbis Terrarum* 6: 91-126.

Brems, D., Boyen, S., Ganio, M., Degryse, P., Walton, M. 2012. "Mediterranean sand deposits as a raw material for glass production in antiquity," in D. Ignatiadou and A. Antonaras, eds., *Annales du 18e Congrès de l'Association Internationale pour l'Histoire du Verre*. Thessaloniki. Pp.120-28.

Brems, D., Ganio, M., Latruwe, K., Balcaen, L., Carremans, M., Gimeno, D., Silvestri, A., Vanhaecke, F., Muchez, P., Degryze, P. 2013a. "Isotopes on the beach, part I: strontium isotope ratios as a provenance indicator for lime raw materials used in Roman glass-making," *Archaeometry* 55.2: 214-34.

Brems, D., Ganio, M., Latruwe, K., Balcaen, L., Carremans, M., Gimeno, D., Silvestri, A., Vanhaecke, F., Muchez, P., Degryze, P. 2013b. "Isotopes on the beach, part II: neodymium isotopic analysis for the provenancing of Roman glass-making," *Archaeometry* 55.3: 449-64.

Brentchaloff, D. 2009. "Amphores et Amphorettes," in C. Goudineau and D. Brentchaloff, eds., *Le Camp de la Flotte d'Agrippa a Fréjus.* Paris, 535-557.

Briggs, N. D. 1995. "Coinage," in M. J. Green, ed., *The Celtic World*. London. pp. 244-253.

Broekaert, W. 2011. "Partners in business: Roman merchants and the potential advantages of being a collegiatus," *Ancient Society* 41: 221-56.

Broekaert,W. Forthcoming. "The soldiers' kitchen along the *limes*: fish sauce consumption and economics,"

Bromwich, J. 2003. *The Roman Remains of Northern and Eastern France.* London.

Brüggler, M. 2006. "Spätrömische Glasherstellung im Hambacher Forst," in G. Greemers, B. Demarsin, and P. Cosyns, eds., *Roman Glass in Germania Inferior: Interregional Comparisons and Recent Results. Proceedings of the International Conference, held in the Gallo-Roman Museum in Tongeren May 13th, 2005.* Tongeren. Pp. 86-90.

Brüggler, M. 2009. *Villa Rustica, Glashütte und Gräberfeld: Die kaiserzeitliche und spätantike Siedlungsstelle HA 132 im Hambacher Forst.* Mainz.

Brulet, R. 1992. "Les amphores de Braives, un vicus de Gaule Belgique," in F. Laubenheimer, ed., *Les Amphores en Gaule: Production et circulation*. Paris. Pp. 171-177.

Brulet, R. 1995. "Spätrömische Vertreidigungssystem zwischen Mosel und Nordseeküste," in T. Bechert and W. J. H. Willems, eds., *Die römische Reichsgrenze zwischen Mosel und Nordseeküste*. Stuttgart. Pp. 103-19.

Brulet, R., Vilvorder, F., and Delage, R. 2010. *La céramique romaine en Gaule du Nord : dictionnaire des céramiques ; la vaisselle à large diffusion*. Turnhout.

Brun, J.-P. 1992. Les amphores du port antique de Toulon (Telo Martius). In: Laubenheimer, F., ed., *Les Ampores en Gaule: Production et Circulation*. Paris 123-131.

Brun, J.-P. 2005. *Archéologie du vin et de l'huile en Gaule romaine*. Paris.

Brun, J.-P. and Gilles, K.-J. 2001. "La viticulture antique en Rhénanie," *Gallia* 58: 165-179.

Brunet, R. 1989. *Les villes europeénnes: Rapport pour la DATAR*. RECLUS. Montpellier.

Buijtendorp, T. M. 2010. *Forum Hadriani: De vergeten stad van Hadrianus. Ontwikkeling, uiterlijk en betekenis van het 'Nederlands Pompeji'*. PHD Thesis Vrije Universiteit Amsterdam.

Büntgen, U., Tegel, W., Nicolussi, K., McCormick, M., Frank, D., Trouet, V., Kaplan, J. O., Herzig, F., Heussner, K.-U., Wanner, H., Luterbacher, J., and Esper, J. 2011. "2500 Years of European Climate Variability and Human Susceptibility," *Science* 331: 578-82.

Butler, R. M. 1959. "Late Roman town walls in Gaul," *Journal of the Royal Archaeological Institute* 116: 25-50.

Campbell, B. 2012. *Rivers and the Power of Ancient Rome*. Chapel Hill.

Carreras Monfort, C. 2000. *Economía de la Britannia romana: la importación de alimentos*. Instrumenta 8. Barcelona.

Carreras Monfort, C. 2003. "Haltern 70, a review," *Journal of Roman Pottery Studies* 10: 85-91.

Carreras Monfort, C. 2004. "Report on the amphorae from Walheim," in K. Kortüm, ed., *Walheim I: Das Kastell II und die nachfolgende Besiedlung*. Stuttgart. Pp. 507-515.

Carreras Monfort, C. 2006. "A quantitative approach to the amphorae from Xanten: a more comprehensive view of the long-distance Roman trade," *Xantener Berichte* 14: 25-39.

Carreras Monfort, C. 2010. "The nature of the Roman trade in the Atlantic: an archaeological perspective," in C. Carreras and R. Morais, eds., *The Western Roman Atlantic Façade: A study of the economy and trade in the Mar Exterior from the Republic to the Principate.* BAR International Series 2162. Oxford. Pp. 7-19.

Carreras Monfort, C., Funari, P. P. A. 1998. *Britannia y el Mediterráneo : estudios sobre el abastecimiento de aceite bético y africano en Britannia*. Barcelona.

Carreras Monfort, C., Morais, R. (eds.) 2010. *The Western Roman Atlantic Façade: A study of the economy and trade in the Mar Exterior from the Republic to the Principate.* BAR International Series 2162. Oxford.

Carreras Monfort, C., Morais, R. 2012. "The Atlantic Roman trade during the Principate: new evidence from the Western façade," *Oxford Journal of Archaeology* 31.4: 419-441.

Carreras Monfort, C., Williams, D. F. 2003. "Spanish olive oil trade in late Roman Britain: Dressel 23 amphorae from Winchester" *Journal of Roman Pottery Studies* 10: 64-8.

Carroll, M. 1993. "Das römische Militärlager Divitia in Köln-Deutz," *Kölner Jahrbuch* 26: 321-444.

Carroll, M. 2001. *Romans, Celts & Germans: The German Provinces of Rome*. Stroud.

Carroll, M. 2003. "The genesis of Roman towns on the Lower Rhine," in P. Wilson, ed., *The Archaeology of Roman Towns: Studies in Honor of John S. Wacher*. Oxford. Pp. 22-30.

Casson, L. 1965. "Harbour and river boats of ancient Rome," *Journal of Roman Studies* 55: 31-9.

Cavallo, C., Kooistra, L. I., Dütting, M. K. 2008. "Food supply to the Roman army in the Rhine delta in the first century AD," in S. Stallibrass and R. Thomas, eds., *Feeding the Roman Army: the Archaeology of Production and Supply in NW Europe*. Oxford. Pp. 69-82.

Cesteros, H. G. 2010. "La llegada de Ánforas Hispanas a Germania durante los últimos siglos de la dominación romana. Una cuestión para el futuro," *Cuadernos de Prehistoria y Arqueología* 36: 107-129.

Charalampides, K. P. 1995. *The Dendrites in pre-Christian and Christian historical-literary tradition and iconography*. Roma.

Cherry, D. 2008. "The frontier zones," in W. Scheidel, I. Morris, and R. Saller, eds., *The Cambridge Economic History of the Greco-Roman World*. Cambridge. Pp. 720-40.

Cheyette, F. L. 2008. "The disappearance of the ancient landscape and the climatic anomaly of the early Middle Ages: a question to be pursued," *Early Medieval Europe*16: 127-165.

Cioc, M. 2002. *The Rhine: an Eco-Biography, 1815-2000*. Seattle.

Clerbaut, T. 2010. *Een inleiding tot de Gallo-Romeinse pottenbakkersovens in Gallia Belgica en Germania Inferior: Inventaris, spreiding en morfologie*. MA thesis, Universiteit Gent.

Cogan, T. 1794. *The Rhine, or a journey from Utrecht to Francfort; chiefly by the borders of the Rhine, and the passage down the river, from Mentz to Bonn*. Volume 2. London.

Collis, J. 1981. "Coinage, oppida and the rise of Belgic power," in B. Cunliffe, ed., *Coinage and Society in Britain and Gaul: some current problems*. London. Pp. 53-55.

Collis, J. 1984. *Oppida: Earliest Towns North of the Alps*. Sheffield.

Combes, P. P., Mayer, T., Thiss, J. F. 2008. *Economic Geography: the Integration of Regions and Nations*. Princeton.

Cook, A. S. 1926. "Augustine's journey from Rome to Richborough," *Speculum* 1.4: 375-97.

Cooper, J. P. 2011. "The Nile versus the Red Sea in ancient and mediaeval N-S navigation," in W. V. Harris and K. Iara, eds., *Maritime Technology in the Ancient Economy: Ship-Design and Navigation*. Journal of Roman Archaeology supplement 84. Portsmouth. Pp. 189-210.

Corbier, M. 2005a. “Coinage and taxation: the state’s point of view, AD 193-337,” in A. K. Bowman, P. Garnsey, A. Cameron, eds., *The Cambridge Ancient History vol. XII: The Crisis of Empire, AD 193-337.* Cambridge. Pp. 327-92.

Corbier, M. 2005b. “Coinage, society and economy,” in A. K. Bowman, P. Garnsey, A. Cameron, eds., *The Cambridge Ancient History vol. XII: The Crisis of Empire, AD 193-337.* Cambridge. Pp. 393-439.

Coryate, T. 1905. *Coryate’s Crudities: Hastily gobled up in Five Moneth's Travels*. Reprinted from 1611 edition. Glasgow

Craddock, P. T. 2008. “Mining and Metallurgy,” in J. P. Oleson, ed., *The Oxford Handbook of Engineering and Technology in the Classical World.* Oxford. Pp. 93-120.

Crawford, M. H. 1970. “Money and exchange in the Roman world,” *Journal of Roman Studies* 60: 40-48.

Crawford, O. G. S., and Röder, J. 1955. “The quern-quarries of Mayen in the Eifel,” *Antiquity* 29: 68-76.

Cronon, W. 1991. *Nature’s Metropolis. Chicago and the Great West.* London.

Crowley, L. 2011. “The role of mortuary ritual in the construction of social boundaries by privileged social groups within villa landscapes,” in N. Roymans and T. Derks, eds., *Villa Landscapes in the Roman North*. Amsterdam. Pp. 195-210.

Cuff, D. B. 2010. *The* auxilia *in Roman Britain and the two Germanies from Augustus to Caracalla: Family, Religion and ‘Romanization’.* Phd thesis, University of Toronto.

Cunliffe, B. 1988. *Greeks, Romans, and Barbarians: Spheres of Interaction*. London.

Cunliffe, B. 2001a. *Facing the Ocean: the Atlantic and its Peoples 8000 BC – AD 1500.* Oxford.

Cunliffe, B. 2001b. “Iron Age societies in Western Europe,” in B. Cunliffe, ed., *The Oxford Illustrated History of Prehistoric Europe*. Oxford. Pp. 336-372.

Cüppers, H. 1969. *Die Trierer Römerbrücken*. Trierer Grabungen und Forschungen 5. Mainz am Rhein.

Cüppers, H. 2005. *Die Römer in Rheinland-Pfalz.* Hamburg.

Cüppers, H. and Rüger, C. B. 1985. *Römische Siedlungen und Kulturlandschaften*. Köln: Geschichtliche Atlas der Rheinlande, Beiheft 3/1–2.

Czysz, W. 1981. *Die römische Keramic aus dem Vicus Wimpfen im Tal (Kreis Heilbronn)*. Stuttgart.

Czysz, W. 2005. “Das zivile Leben in der Provinz,” in W. Czysz, K. Dietz, T. Fischer, and H. J. Kellner, eds., *Die Römer in Bayern*. Hamburg. Pp. 177-308.

Czysz, W., and Herzig, F. 2008. “Neue Dendrodaten von der Limespalisade in Raetien,” in A. Thiel, ed., *Neue Forschungen am Limes*. Stuttgart. Pp. 183–195

De Izarra, F. 1993. *Hommes et fleuves en Gaule romaine*. Paris.

De Koning, J. 2003. “Why did they leave? Why did they stay? On continuity versus discontinuity from Roman times to the Early Middle Ages in the western coastal area of the Netherlands,” in T. Grünewald and S. Siebel, eds., *Kontinuität und Diskontinuität.* Berlin. Pp. 53-82.

De Laet, S. J. 1949. *Portorium: Etude sur l'organisation douaniere chez les Romains, surtout a l'epoque du Haut-Empire.* Brugge.

De Ligt, L. 1990. “Demand, supply, distribution. The Roman peasantry between town and countryside: rural monetization and peasant demand,” *Münsterische Beiträge zur antiken Handelgeschichte* 9.2: 24-56.

Deforce, K., and Haneca, K. 2012. “Ashes to ashes. Fuelwood selection in Roman cremation rituals in northern Gaul,” *Journal of Archaeological Science* 39: 1338-48.

Degryse, P., Schneider, J., Haack, U., Lauwers, V., Poblome, J., Waelkens, M., Muchez, Ph. 2006. “Evidence for glass ‘recyclicng’ using Pb and Sr isotopic ratos and Sr-mixing lines: the case of early Byzantine Sagalassos,” *Journal of Archaeological Science* 33: 494-501.

Degryse, P., and Scheider, J. 2008. “Pliny the Elder and Sr-Nd isotopes: tracing the provenance of raw maerials for Roman glass production,” *Journal of Archaeological Sciences* 35: 1993-2000.

Delage, R., and Mees, A. W. 2009. “Le commerce de la céramique sigillée de Dinsheim-Heiligenberg et de la Gaule de l’est,” in E. Kern, ed., *De Terra Sigillata: histoire de la céramique sigillée et des potiers Gallo-Romains de Dinsheim-Heiligenberg.* Molsheim. Pp. 99-14.

DeLaine, J. 1997. *The Baths of Caracalla: a study in the design, construction, and economics of large-scale building projects in imperial Rome*. Journal of Roman Archaeology Supplement 25. Portsmouth.

Derks, T. and Roymans, N. 2006. “Returning auxiliary veterans: some methodological considerations,” *Journal of Roman Archaeology* 19: 121-35.

Desbat, A., and Martin-Kilcher, S. 1989. “Les amphores sur l’axe Rhone-Rhin à l’époque d’Auguste,” in *Anfore romane e storia economica: un decennio di ricerche*. Coll. Ecole Française de Rome 114: 339-65.

Deschler-Erb, E. 2008. *Basel-Münsterhügel am Übergang von spätkeltischer zu römischer Zeit: Ein Beispiel für die Romanisierung im Nordosten Galliens.* University of Zurich, Faculty of Arts. Zurich.

Dey, H. 2012. “Spolia, milestones and city walls: the politics of imperial legitimacy in Gaul,” in S. Birk and B. Poulsen, eds., *Patrons and Viewers in Late Antiquity.* Aarhus. Pp. 291-310.

Dietler, M. 1989. “Greeks, Etruscans, and Thirsty Barbarians: Early Iron Age Interaction in the Rhone Basin of France,” in T. C. Champion, ed., *Centre and Periphery. Comparative Studies in Archaeology.* London. Pp. 127-41.

Dietler, M. 1997. “Commerce du vin et contacts culturels en Gaule au premier Age du fer,” in M. Bats, G. Bertucchi, G. Conges, and H. Treziny, eds., *Marseille Grecque et la Gaule: actes du colloque international d'Histoire et d'Archeologie du Ve congres archeologique de Gaule meridionale. Marseille, 18-23 novembre 1990*. Aix-en-Provence. Pp. 401-10.

Diodoto, N., and Bellochi, G. 2013. "Multiscale modelling of rainstorm-induced historical intermediate floods (June-November) in the Rhone River Basin," *Natural Hazards* 65.3: 1465-79.

Domínguez-Delmás, M., Driessen, M., García-González, Helmond, N. v., Visser, R., Jansma, E. 2014. "Long-distance oak supply in mid-second century AD revealed: the case of a Roman harbour (Voorburg-Arentsburg) in the Netherlands," *Journal of Archaeological Science* 41: 642-52.

Doppelfeld, O. 1966. *Römisches und Fränkisches Glas in Köln*. Köln.

Drack, W., and Fellmann, R. 1988. *Die Römer in der Schweiz*. Stuttgart.

Dragendorff, H. 1896. "Terra Sigillata: ein Beitrag zur Geschichte der griechischen und römischen Keramik," *Bonner Jahrbücher* 96/97: 18-155.

Dragendorff, H., and Krüger, E. 1924. *Römische Grabmäler des Mosellandes und der angrenzenden Gebiete I. Das Grabmal von Igel.* Trier.

Drexhage, J.-J., Konen, H., and Ruffing, K. 2002. "Die Wirtschaft der römischen Kaiserzeit inder modernen Deutung: einige Überlegungen," in K. Strobel, ed., *Die Ökonomie des Imperium Romanum*. St. Katharinen. Pp. 1-66.

Drinkwater, J. F. 1978. "Die Secundinier von Igel und die Woll- und Textilindustrie in Gallia Belgica. Fragen und Hypothesen," *Trierer Zeitschrift* 40: 107-25.

Drinkwater, J. F. 1979. "Gallic personal wealth," *Chiron* 9: 237-42.

Drinkwater, J. F. 1983. *Roman Gaul: The Three Provinces 58 BC – AD 260*. London.

Drinkwater, J. F. 1987. *The Gallic Empire: separatism and continuity in the north- western provinces of the Roman Empire, A.D. 260-274*. Stuttgart.

Drinkwater, J. F. 1992. "The Bacaudae of fifth-century Gaul," in J. F. Drinkwater and H. Elton, eds., *Fifth-century Gaul: A Crisis of Identity?* Cambridge. Pp. 208-17.

Drinkwater, J. F. 2000. "The Gallo-Roman wool trade and the great debate: the Igel Column revisited," in D. J. Mattingly and J. Salmon, eds., *Economies beyond Agriculture in the Classical World*. London. Pp. 297-308.

Drinkwater, J. F. 2002. "Prologue and Epilogue. The socio-economic effect of Rome's arrival in and departure from Gaul," in L. de Blois and J. Rich, eds., *The Transformation of Economic Life under the Roman Empire: proceedings of the second workshop on the international network Impact of Empire (Roman Empire, c. 200 BC – AD 476).* Amsterdam. Pp. 129-40.

Drinkwater, J. F. 2007. *The Alamanni and Rome 213-496 (Caracalla to Clovis).* Oxford.

Drumond, S. and Nelson, L. 1994. *The Western Frontiers of Imperial Rome*. London.

Duncan-Jones, R. 1982. *The Economy of the Roman Empire: Quantitative Studies*. Cambridge.

Duncan-Jones, R. 1994. *Money and Government in the Roman Empire*. Cambridge.

Durali-Müller, S., Brey, G. P., Wigg-Wolf, D., Lahaye, Y. 2007. "Roman lead mining in Germany: its origin and development through time deduced from lead isotope provenance studies," *Journal of Archaeological Science* 34: 1555-67.

Durali-Müller, S. 2005. *Roman lead and copper mining in Germany their origin and development through time, deduced from lead and copper isotope provenance studies.* Dissertation der Johann Wolfgang Goethe-Universität in Frankfurt am Main.

Eck, W. 2004. *Köln in römischer Zeit: Geschichte eine Stadt in Rahmen des Imperium Romanum*. Köln.

Eggers, H. J. 1951. *Der römische Import im Freien Germanien.* Hamburg.

Ehmig, U. 2003. *Die römischen Amphoren aus Mainz.* Möhnesee.

Ehmig, U. 2005. "Der Besitzer der Bad Kreuznacher Peristylvilla – ein Händler ostmediterraner Lebensmittel?" *Münstersche Beiträge zur Antiken* Handelsgeschichte 24.2: 175-191.

Ehmig, U. 2007a. *Die römischen Amphoren in Umland von Mainz*. Wiesbaden.

Ehmig, U. 2007b. "Tituli picti auf Amphoren in Köln," *Kölner Jahrbücher* 40: 215-327.

Ehmig, U. 2008. "Aqua Mulsa, ein exzellenter Tropfen Met," *Bonner Jahrbücher* 208: 63-72.

Ehmig, U. 2009. "Tituli Picti auf Amphoren in Köln II," *Kölner Jahrbücher* 42: 393-445.

Ehmig, U. 2010. *Dangstetten IV: die Amphoren*. Stuttgart.

Ehmig, U. 2012. "Auf dem Holzweg. Bevölkersungdichte und natürliche Ressourcen: Überlegungen zum Holzbedarf im römischen Rheinland," *Ancient Society* 42: 149-218.

Ellmers, D. 1969. "Keltischer Schiffbau," *Jahrbuch des Römisch-Germanischen Zentralmuseums* 16: 73-122.

Ellmers, D. 1978. "Shipping on the Rhine during the Roman period: the pictorial evidence," in J. d. Plat Taylor and H. Cleere, eds., *Roman Shippimg and Trade: Britain and the Rhine Provinces*. CBA Report 24. Oxford. Pp. 1-14.

Elton, H. 1992. "Defence in fifth-century Gaul," in J. F. Drinkwater and H. Elton, eds., *Fifth-century Gaul: a crisis of identity?* Cambridge. Pp. 167-83.

Elton, H. 1996a. *Frontiers of the Roman Empire*. London.

Elton, H. 1996b. *Warfare in Roman Europe: AD 350-425.* Oxford.

Emmermann, K.-H. and Ree, C. 1971. "Zur frage der Herkunft des Eisenerzes aus einer früheisenzeitlichen Schmelze bei Hillesheim, Kreis Daun," *Trierer Zeitschrift* 34: 31-33.

Engels, D. W. 1990. *Roman Corinth: An alternative Model for the Classical City.* Chicago.

Erdkamp, P. 2013. "How modern was the market economy of the Roman world? Review essay on P. Temin, The Roman Market Economy," *Oeconomia* 3: 1-9.

Esmonde-Cleary, S. 2013. *The Roman West, AD 200-500: an archaeological study*. Cambridge.

Ettlinger, E., and Simonett, C. 1952. *Römische Keramik aus dem Schutthügel von Vindonissa.* Basel.

Fehr, H. 1981. "Eine Rheinbrücke zwischen Koblenz und Ehrenbreitstein aus der Regierungszeit des Claudius," *Bonner Jahrbücher* 181: 254-87.

Fentress, E. 1979. *Numidia and the Roman Army: Social, Military and Economic Aspects of the Frontier zone.* BAR International Series 53. Oxford.

Fentress, E. 2013. "Diana Veteranorum and the dynamics of an inland economy," in L. Lavan, ed., *Local Economies? Production and Exchange of Inland Regions in Late Antiquity*. Leiden. Pp. 315-342.

Fentress, J. and Fentress, E. 2001. "The Hole in the doughnut, review of The Corrupting Sea," *Past & Present* 173: 203-19.

Fichtl, S. 2005. *La Ville Celtique: Les Oppida de 150 av. J.C. À 15 ap. J.C.* Paris.

Filtzinger, P. and Frechen. J. 1972. *Die römische Keramik aus dem Militärbereich von Novaesium (etwa 25 bis 50 n. Chr.)*. Berlin.

Fingerlin, G. 1982. "Ein römischer Töpfereibezirk in Bad Krozingen Kreis Breisgau-Hochschwarzwald," *Archäologische Ausgrabungen in Baden-Württemberg* 1982: 110-13.

Finley, M. 1973. *The Ancient Economy*. London.

Finley, M. 1977. "The Ancient City: from Fustel de Coulanges to Max Weber and Beyond," *Comparative studies in Society and History* 19.3: 305-27.

Finley, M. 1986. *Ancient History: Evidence and Models*. New York.

Fischer, A. 2009. *Vorsicht Glas! Die römischen Glasmanufakturen von Kaiseraugst.* Augst.

Fischer, T. 1999. *Die Römer in Deutschland.* Darmstadt.

Fischer, T. 2009. "Römische Militärlager und zivile Siedlungen in Germanien zwischen Rhein und Elbe zur Zeit Marbods (von der Drusus-Offensive 12/9 v. Chr. bis zu der Aufgabe der römischen Eroberungspläne 17 n. Chr.). Ein aktueller Überblick." In V. Salač and J. Bemmann, eds., *Mitteleuropa zur Zeit Marbods.* Praha/Bonn. Pp. 485-520.

Fischer, T., ed. 2011. *Die Krise des 3. Jahrhunderts n. Chr. und das Gallische Sonderreich*. Köln.

Fleer, K. C. H. 2011. *Das Kastell Haselburg*. Stuttgart.

Fleming, S.J. 1999. *Roman glass: Reflections on Cultural Change*. Philadelphia.

Flohr, M. forthcoming a. "The archaeology of urban manufacturing beyond modernism and primitivism," in A. Bresson, E. Lo Cascio, and F. Velde, eds., Oxford Handbook of Economies in the Classical World Oxford. Oxford. Pp. #-#.

Flohr, M. forthcoming b. "Manufacturing everyday consumer goods," in C. Hawkins and E. Mayer, eds., *The Urban Economy in the Roman World? Synthesizing Historical and Archaeological Approaches*. Chicago.

Fluck, P. 1993. "Montanarchäologische Forschungen in den Vogesen," in H. Steuer and U. Zimmermann, eds., *Montanarchäologie in Europa.*

Berichte zum Internationalen Kolloquium "Frühe Erzgewinnung und Verhüttung in Europa" in Freiburg im Breisgau vom 4. bis 7. Oktober 1990 Sigmaringen. Pp. 267-89.

Forrières, C., Petit, J.-P., and Schaub, J. 1987. *Étude de la métallurgie du fer du vicus gallo-romain de Bliesbrück (Moselle). Paris*.

Forrières, C., Petit, J.-P., and Schaub, J. 1989. "Une metallurgie artisnale du fer dans le vicus Gallo-Romain de Bliesbruck (Moselle)," *Archaeologia Mosellana* 1: 67-87.

Foy, D. 2003. "Les ateliers primaires syro-palestiniens", in D. Foy, ed., *Cœur de verre. Production et diffusion du verre antique*. Gollion. Pp. 28-31.

Foy, D., Nenna, M.D. 2001. *Tout Feu Tout Sable: Mille ans de Verre Antique dans le Midi de la France*. Aix-en-Provence.

France, J. 2001. *Quadregesima Galliarum: L'Organisation douanière des provinces Alpestres, Gauloises et Germaniques de L'Empire Romain*. Rome.

Franco, C. Forthcoming. *Sicilian Amphorae (AD I-VI): an economic analysis of production and distribution*. DPhil thesis, University of Oxford.

Franconi, T. V. 2013. "Rome and the power of ancient rivers," *Journal of Roman Archaeology* 26.2: 705-11.

Franke, R. 2003. *Arae Flaviae 5. Die Kastelle I und II von Arae Flaviae/Rottweil und die römische Okkupation des oberen Neckargebietes*. Stuttgart.

Frayn, J. M. 1993. *Markets and Fairs in Roman Italy: their social and economic importance from the second century BC to the third century AD.* Oxford.

Freeman, P. 1996. "Roman frontier studies: what's new?" *Britannia* 27: 465-70.

Fremersdorf, F. 1958a. *Das naturfarbene sogenannte blaugrüne Glas in Köln.* Berlin.

Fremersdorf, F. 1958b. *Römisches Buntglas in Köln*. Berlin

Fremersdorf, F. 1959. *Römische Gläser mit Fadenauflage in Köln (Schlangenfadengläser und Verwandtes).* Berlin.

Fremersdorf, F. 1961. *Römisches geformtes Glas in Köln*. Berlin.

Fremersdorf, F. 1962. *Die römischen Gläser mit aufgelegten Nuppen*. Berlin.

Fremerdorf, F. 1965. "Die Anfänge der römischen Glashütten Kölns," *Kölner Jahrbuch* 8: 24-43.

Fremersdorf, F. 1967. *Die römischen Gläser mit Schliff, Bemalung und Goldauflagen aus Köln* (2 vol.). Berlin.

Fremersdorf, F. 1984. *Die farblosen Gläser der Frühzeit in Köln 2. und 3. Jahrhundert*. Berlin.

Frenz, H. G. 1981. "Der Ehrenbogen des Dativius Victor zu Mainz und seine neue Rekonstruktion," *Bericht der Römisch-Germanischen Kommission* 62: 219-60.

Frere, S. and Fulford, M. 2001. "The Roman invasion of A.D. 43," *Britannia* 32: 45-55.

Frêzouls, E. 1984. "Evergetisme et construction urbain dans les Trois Gaules et les Germanies," *Revue du Nord* 260: 27-54.

Frier, B. W. 2008. "Demography," in A.K. Bowman, P. Garnsey, and D. Rathbone, eds., *The Cambridge Ancient History volume 11: The High Empire.* Cambridge. Pp. 787-816.

Follmann-Scholz, B. 1988. *Die römischen Gläser aus Bonn*. Köln.

Fulford, M. 1984. "Demonstrating Britannia's economic dependence in the first and second centuries," in T. F. C. Blagg and A. C. King, eds., *Military and Civilian in Roman Britain*. Oxford. Pp. 129-42.

Fulford, M. 1989a. "Roman and barbarian: the economy of Roman frontier systems," in C. Barrett, A. P. Fitzpatrick, and L. Macinnes, eds., *Barbarians and Romans in North-West Europe, from the later Republic to Late Antiquity*. Oxford. Pp. 81-93.

Fulford, M. 1989b. "The economy of Roman Britain," in M. Todd., ed., *Research on Roman Britain, 1960-89.* London. Pp. 175-201.

Fulford, M. 2004. "Economic Structures," in M. Todd, ed., *A Companion to Roman Britain*. Oxford. Pp. 309-26.

Gaitzsch, W. 1991. "Fours de verriers romains en foret de Hambach," in D. Foy and G. Sennequier, eds., *Ateliers de Verriers: de l'Antiquité a la Période Pré-Industrielle. Association Française pour l'Archéologie du Verre, Actes des 4 Rencontres, Rouen 24-25 Novembre 1989.* Rouen. Pp. 41-46.

Gaitzsch, W. 1999. "Spätrömische Glashütten im Hambacher Forst: die Werkstatt des ECVA-Produzenten," in M. Polfer, ed., *Artisanat et productions artisanales en milieu rural dans les provinces nord-ouest de l'empire romain. Actes du colloque a Erpeldange (Luxembourg) les 4 et 5 mars 1999.* Pp. 125-49.

Gaitzsch, W., Follmann-Schulz, A. B., Wedepohl, K. H., Hartmann, G., Tegtmeier, U. 2000. "Spätrömische Glashütten im Hambacher Forst – Produktionsort der ECVA-Fasskrüge. Archäologische und naturwissenschaftliche Untersuchungen," *Bonner Jahrbücher* 200: 83-241.

Galestin, M. C. 2001/2002. "Winsum-Bruggeburen, second report on the excavation. The Roman Pottery," *Palaeohistoria* 43/44: 435-67.

Ganio, M., Boyen, S., Fenn, T., Scott, R., Vanhoutte, S., Gimeno, D., Degryse, P. 2012. "Roman glass across the Empire: an elemental and isotopic characterization," *Journal of Analytical Atomic Spectrometry* 27: 743-53.

Garbsch, J. 1970. *Der spätrömische Donau-Iller-Rhein-Limes*. Stuttgart.

Gassmann, G.. 2004. "Frühkeltische Eisenproduktion im Nordschwarzwald. Rennöfen des 5. Jahrhunderts v.Chr. bei Neuenbürg-Waldrennach, Enzkreis," *Archäologische Ausgrabungen in Baden-Württemberg* 2004: 102-7.

Gassmann, G., Hauptmann, A., Hübner, C., Ruthardt, T., and Yalçin, U. 2005. *Forschungen zur keltischen Eisenerverhüttung in Südwestdeutschland*. Stuttgart.

Gassmann, G. and Wieland, G. 2008. "Weitere Untersuchungen zur frühkeltischen Stahlproduktion im Montanrevier von Neuenbürg, Enzkreis," *Archäologische Ausgrabungen in Baden-Württemberg* 2008: 94-97.

Gaubartz-Sattler, A. 1999. *Sumelocenna: Geschichte und Topographie des römischen Rottenburg am Neckar nach den Befunden und Funden bis 1985.* Stuttgart.

Gechter, M. 2003. "Die Militärgeschichte am Niederrhein," in T. Grünewald and S. Siebel, eds., *Kontinuität und Diskontinuität*. Berlin. Pp. 143-61.

Gechter, M., Kunow, J. 1986. "Zur ländlichen Besiedlung des Rheinlandes in römischen Zeit. *Bonner Jahrbücher* 186: 377-96.

Gerlach, R. 1995. "Die hydrologischen und klimatischen Bedingungen des Wassernetzes im römischen Germanien," *Archäologisches Korrespondenzblatt*, 25: 97-106.

Gerlach, R., Becker, T., Meurers-Balke, J., and Thieme, A. 2007. "Wo war der Rhein zur Römerzeit? Ein Beitrag zum Rhein-Limes Projekt," *Archaeologie im Rheinland*. Pp. 100-102.

Giacobelli, M. 1997. "I vetri del relitto di Grado," in *Atti del Convegno Nazionale di Archaeologia Subaquea. Anzio, 30-31 maggio e 1 giugno 1996.* Pp. 311-13.

Gilles, K.-J. 1985. *Spätrömische Höhensiedlungen in Eifel und Hunsrück*. Trier.

Gilles, K.-J. 1995. "Römerzeitliche Kelteranlagen an der Mosel," in K.-J. Gilles, ed., Neuere Forschungen zum römischen Weinbau an Mosel und Rhein. Trier. Pp. 5-59.

Gilliver, K. 2007. "The Augustan reform and the structure of the imperial army," in P. Erdkamp, ed., *A Companion to the Roman Army.* Oxford. Pp. 183-200.

Gissinger, B. 2002a. "Le *castrum* de Strasbourg," in J. Baudoux, P. Flotté, M. Fuchs, and M.-D. Waton, eds., *Strasbourg*. Carte Archeologique de la Gaule 67.2. Paris. Pp. 99-107.

Gissinger, B. 2002b. *Recherches sur le site forifié de Strasbourg durant l'Antiquité tardive.* BAR International series 1024. Oxford.

Given, M. 2004. *The Archaeology of the Colonized.* London.

Gluhak, T. M., and Hofmeister, W. 2008. "Provenance analysis of Roman millstones: mapping of trade areas in Roman Europe," in R. I. Kostov, B. Gaydarska, and M. Gurova, eds., *Geoarchaeology and Archaeomineralogy*. Sofia. Pp. 111-15.

Gluhak, T. M., and Hofmeister, W. 2009. "Roman lava quarries in the Eifel region (Germany): geochemical data for millstone provenance studies," *Journal of Archaeological Science* 36: 1774-1782.

Gluhak, T. M. and Hofmeister, W. 2011. "Geochemical provenance analyses of Roman lava millstones north of the Alps: a study of their distribution and implications for the beginning of Roman lava quarrying in the Eifel region (Germany)," *Journal of Archaeological Science* 38: 1603-20.

Godlowski, K. 1983. "Der römische Handel in die Germania Libera aufgrund der archäologischen Quellen," in *Untersuchungen zu Handel und Verkehr der vor- und frühgeschichtlichen Zeit in Mittel- und Nordeuropa, 1. Methodische Grundlagen und Darstellungen zum Handel in* *vorgeschichtlicher Zeit und in der Antike. Bericht über die Kolloquien der Kommission für die Altertumskunde Mittel- und Nordeuropas in den Jahren 1980 bis 1983.* Göttingen. *Pp.* 337-66.

Goethert-Polaschek, K. 1980. *Römische Gläser im Rheinischen Landesmuseum Trier.* Trier.

Gogräfe, R. 1987. "Spätantike Wand- und Deckenmalereien aus Bad-Kreuznach und Bingen," in Pictores per provincias. Actes du 3e Colloque international sur la peinture murale romaine, Avenches 28-31 août 1986. Avenches. Pp. 201-12.

Goguey, R. and Reddé, M. 1995. *Le camp legionnaire de Mirebeau*. Mainz

Goldenberg, G. 1993. "Frühe Blei-, Silber, und Kupfergewinnung im Südschwarzwald," in H. Steuer and U. Zimmermann,eds., *Montanarchäologie in Europa. Berichte zum Internationalen Kolloquium "Frühe Erzgewinnung und Verhüttung in Europa" in Freiburg im Breisgau vom 4. bis 7. Oktober 1990.* Sigmaringen. Pp. 231-48.

Goodman, P. J. 2007. *The Roman city and its periphery: from Rome to Gaul.* London.

Goodman, P. J. 2013. "The production centres: settlement hierarchies and spatial distribution," in M. Fulford and E. Durham, eds., *Seeing Red: New Economic and Social Perspectives on Terra Sigillata*. London. Pp. 121-36.

Goudswaard, B. 1990. *Amforen van Velsen 1. lnhoudaandeverpakking:een materiaalstudienaarbevoorrading.* Doctoraalscriptie Universiteit van Amsterdam.

Grabs, W. (ed.) 1997. *Impact of Climate Change on Hydrological Regimes and Water Resources Management in the Rhine Basin.* CHR Report I-16. Koblenz.

Grane, T. 2007. *Beyond the Roman Frontier: frontier influences on the northern Barbaricum*. Rome.

Greene, K. 1986. *The Archaeology of the Roman Economy*. London.

Greene, K. 2000. "Technological innovation and economic progress in the ancient world: M. I. Finley re-considered," *Economic History Review* 53: 29-59.

Greiner, B. A. 2005. "Die Kastellvici am vorderen Limes: Wohnen am Rand des Imperiums," in Archäologischen Landesmuseum Baden-Württemberg (eds.), *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 165-68.

Grewe, K. 2008. "Tunnels and canals," in J. P. Oleson, ed., *The Oxford Handbook of Engineering and Technology in the Classical World*. Oxford. Pp. 319-336.

Groot, M. 2008a. *Animals in Ritual and Economy in a Frontier Community*. Amsterdam.

Groot, M. 2008b. "Surplus production of animal products for the Roman army in a rural settlement in the Dutch River Area," in S. Stallibrass and R. Thomas, eds., *Feeding the Roman Army: the Archaeology of Production and Supply in NW Europe.* Oxford. Pp. 83-98.

Groot, M., Heeren, S., Kooistra, L. I., Vos, W. K., 2009. "Surplus production for the market? The agrarian economy in the non-villa landscapes of Germania Inferior," *Journal of Roman Archaeology* 22: 231-53.

Gschwind, M. 2006. "Späte Rheinzaberner Sigillata in Raetien," *Bayerische Vorgeschichtsblätter* 71: 63-85.

Gumiero, B., Surian, N., Maiolini, B., Boz, B., Rinaldi, M., Moroni, F. 2009. "The Italian rivers," in Tockner, K., Uehlinger, U., and Robinson, C. T., eds., *Rivers of Europe*. Amsterdam. Pp. 467-95.

Haalebos, J. K. 2000. "Traian und die Hilfstruppen am Niederrhein. Ein Militärdiplom des Jahres 98 n. Chr. aus Elst in der Over-Betuwe (Niederlande)." *Saalburg Jahrbuch* 50: 31- 72.

Haalebos, J. K., and Willems, W. J. H. 1999. "Recent research on the *limes* in the Netherlands," *Journal of Roman Archaeology* 12: 247-62.

Haase, D., Fink, J., Haase, G., Ruske, R., Pécsi, M., Richter, H., Altermann, M., and Jäger, K..-D. 2007. "Loess in Europe—its spatial distribution based on a European Loess Map, scale 1:2,500,000," *Quaternary Science Reviews* 26: 1301-12.

Haberey, W. 1960. "Das Glas im Rheinland zur Frankenzeit (5. bis 8. Jahrh. n. Chr.)," *Annales du 1er congrès de l'Association Internationale pour l'Histoire du verre.* Liege. Pp. 63-77

Haffner, A. 1971. "Ein hallstattzeitlicher Eisenschmelzofen von Hillesheim, Kreis Daun," *Trierer Zeitschrift* 34: 21-29.

Hagen, J. 1931. *Römerstrassen der Rheinprovinz*. second Edition. Bonn.

Hale, J. R. 1979. *The travel journal of Antonio de Beatis: Germany, Switzerland, the Low Countries, France and Italy, 1517-1518*. London.

Halsall, G. 2008. *Barbarian Migrations and the Roman West, 376-568*. Cambridge.

Haneca, K., van Acker, J., Beeckman, H. 2005. "Growth trends reveal the forest structure during Roman and Medieval times in Western Europe: a comparison between archaeological and actual oak ring series (Quercus robur and Quercus petraea)," *Annals of Forest Science* 62: 797-805.

Hanel, N. 1995a. "Ein römischer Kanal zwischen dem Rhein und Groß-Gerau?" *Archäologisches Korrespondenzblatt*, 25: 107-16.

Hanel, N. 1995b. *Vetera I: Die Funde aus den römischen Lagern auf dem Fürstenberg bei Xanten*. Köln.

Hanel, N. 2003. "Die Amphoren der Ausgrabungen 1998 im Hauptstützpunkt der Classis Germanica "Alteburg" bei der Colonia Claudia Ara Agrippinensium – ein Vorbericht," *Rei Cretariae Romanae Fautorum Acta* 38: 361-364.

Hanel, N. 2008. "Die Militäger von Vetera I und ihre Lagersiedlungen," in M. Müller, H. J. Schalles, and N. Zeiling, eds., *Colonia Ulpia Traiana: Xanten und sein Umland in römischer Zeit.* Xanten: Landschaftesverbandes Rheinland. Pp. 93-108.

Hanel, N. and Rothenhöfer, P. 2005. "Germanisches Blei für Rom: zur Rolle des römischen Bergbaus im rechsrheinischen Germanien im frühen Prinzipat," *Germania* 83: 53-65.

Hanson, J. W. 2011. "The urban system of Roman Asia Minor and wider urban connectivity," in A. K. Bowman and A. I. Wilson, eds., *Settlement, Urbanization, and Population*. Oxford. Pp. 229-75.

Hanson, W. S. 1978. "The organization of Roman military timber-supply," *Britannia* 9: 293-305.

Härke, H. G. H. 2000. *Archaeology, Ideology, and Society: the German Experience.* Frankfurt am Main.

Harries, J. 1978. "Church and state in the *Notitia Galliarum*," *Journal of Roman Studies* 68: 26-43.

Harris, W. V. 1993. "Between archaic and modern: some current problems in the history of the Roman economy," in W. V. Harris, (ed.), *The Inscribed Economy: Production and Distribution in the Roman Empire in the Light of* Instrumentum Domesticum. Journal of Roman Archaeology Supplement 6. Portsmouth. Pp. 11-30.

Harris, W. V. 2009. "A comment on Andrew Wilson: 'Approaches to Quantifying Roman Trade'," in A. Bowman and A. Wilson, eds., *Quantifying the Roman Economy methods and problems*. Oxford. Pp. 259-68.

Harris, W. V. 2011a. "Between archaic and modern, some current problems in the economic history of the High Roman Empire," in W. V. Harris, ed., *Rome's Imperial Economy: 12 essays*. Oxford. Pp. 288-313.

Harris, W. V. 2011b. "Trade and the River Po: a problem in the economic history of the Roman Empire," in W. V. Harris, ed., *Rome's Imperial Economy: 12 Essays*. Oxford. Pp. 188-97.

Harris, W. V., ed., 2013. *The Ancient Mediterranean Environment between Science and History.* Leiden.

Harris, W. V. 2013. "Defining and detecting Mediterranean deforestation, 800 BCE to 700 CE," in W. V. Harris, ed., *The Ancient Mediterranean Environment between Science and History*. Leiden. Pp. 173-98.

Harter, G. 1999. *Römische Gläser des Landesmuseums Mainz*. Wiesbaden.

Hartmann, S., and Grünewald, M. 2010. "The Late Antique glass from Mayen (Germany): first results of chemical and archaeological studies," in B. Zorn and A. Hilgner, eds., *Glass Along the Silk Road from 200 BC to AD 1000*. Mainz. Pp. 15-28.

Haselgrove, C. 1987. "Culture process on the periphery: Belgic Gaul and Rome during the late Republic and Early Empire," in M. Rowlands, M. Larsen, and K. Kristiansen, eds., *Centre and Periphery in the Ancient World*. Cambridge. Pp. 104-124.

Haselgrove, C. 1999. "Mediterranean influence on southern Belgic Gaul between the fifth and first centuries BC," in B. Chaume, J.-P. Mohen, and P. Périn, eds., *Archéologie des Celtes: Mélanges à la mémoire de René Joffroy*. Montagnac. Pp. 131-144.

Hatt, J. J. 1952. "Découverte des vestiges d'un pont romain en maçonnerie dans l'ancien lit du Rhin à Kembs (Haut Rhin)," *Cahiers d'Archéologie et d'Historie d'Alsace* 132: 83-87.

Haynes, I. P. 2000. “Britian's first information revolution; the Roman army and the transformation of economic life,” in P. Erdkamp, ed., *The Roman Army and the Economy*. Amsterdam. Pp. 111-26.

Haynes, I. P. 2013. *Blood of the Provinces: the Roman Auxilia and the making of Provincial Society from Augustus to the Severans*. Oxford.

Heimberg, U. 1997. “Review of S. Martin-Kilcher *Die römischen Amphoren aus Augst und Kaiseraugst. Ein Beitrag zur römischen Handels- und Kulturgeschichte, 2. Die Amphoren für Wein, Fischsauce, Südfrüchte (Gruppen 2-24) und Gesamtauswertung*,” in *Germania* 75: 298-307.

Heimberg, U. 2003. “Römische Villen an Rhein und Maas,” *Bonner Jahrbücher* 202/203: 57-148.

Heising, A. 2007. *Figlinae Mogontiacenses: Die römischen Töpfereien von Mainz.* Remshalden.

Heising, A. 2012. “Mogontiacum/Mainz im dritten Viertel des 3. Jahrhunders, ein quellenkritischer Forschungsbericht,” in T. Fischer, ed., *Die Krise des 3. Jahrhunderts n. Chr. und das Gallische Sonderreich.* Köln. Pp. 151-196.

Heising, A. 2000. “Die römischen Töpfereien von Mogontiacum, Mainz,” in K. Strobel, ed., Forschungen zur römischen Keramikindustrie: Produktions-, Rechts- und Distributionsstrukturen. Trier. Pp. 89-101.

Heinrichs, J. 2000. “Uberlegungen zur Versorgung ausgusteischer Truppen mit Münzgeld. Ein neues Modell und daraus ableitbare Indizien für einen Wandel in der Konzeption des Germanenkrieges nach Drusus,” in L. Mooren, ed., *Politics, administration, and society in the Hellenistic and Roman world.* Leuven. Pp. 155-213.

Hendrikx, P. A. 1986. “The lower delta of the Rhine and the Maas: landscape and habitation from the Roman period to c. 1000,” *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 36: 445-599.

Herz, P. 1988. “Der Praefectus annonae und die Wirtschaft der westlichen Provinzen,” *Ktema* 13: 69-85.

Hettema, H. 1951. *De Nederlandse Wateren en Plaatsen in de Romeinse Tijd*. Den Haag.

Heukemes, B. 1981. “Der spätrömische Burgus von Lopodunum,” *Fundberichte aus Baden Württemberg* 6: 433-73.

Hildebrant, L. H. 2005. “Ferrum, plumbum, et argentum: Spuren des römischen Bergbaus,” in Archäologischen Landesmuseum Baden-Württemberg (eds.), *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 399-402.

Himmelmann, U. 2003. *Der römische Vicus von Eisenberg I: die Häuser 7 und 8 sowie die dazwischenlegende Straßenparzelle*. PHD dissertation, Ruprecht-Karls-Universität Heidelberg.

Hind, J. G. F. 1984. “What happened to the ‘Agri Decumates’?” *Britannia* 15: 187-92.

Hirt, A. M. 2005. “Die Donau-Iller-Rhein-Limes und die Versorgung des Heeres,” in M. Asal, ed., *Ein spätrömischer Getreidespeicher am Rhein*. Brugg. Pp. 122-31.

Hirt, A. M. 2010. *Imperial Mines and Quarries in the Roman World: organizational aspects 27 BC – AD 235.* Oxford.

Hirt, A. M. 2012. "Procuratores ferrariarum Galliarum?" in *Die Schätze der Erde – Natürliche Ressourcen in der antiken Welt*. Stuttgart. Pp. 193-203.

Hitchner, R. B. 2005. "The advantage of wealth and luxury: the case for economic growth in the Roman Empire," in J.G. Manning and I. Morris, eds., *The Ancient Economy: Evidence and Models*. Stanford. Pp. 207-22.

Hitchner, R. B. 2012. "Roads, integration, connectivity, and economic performance in the Roman Empire," in S. E. Alcock, J. Bodel, and R. J. A. Talbert, eds., *Highways, Byways, and Road Systems in the Pre-Modern World*. New York. Pp. 222-34.

Höckmann, O. 1986. "Römische Schiffsverbände auf dem Ober- und Mittelrhein und die Verteidigung der Rheingrenze in der Spätantike," *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz* 33: 369-416.

Höckmann, O. 1998. "Das Lager Alteburg: die Germanische Flotte und die römische Schiffahrt," *Kölner Jahrbuch* 31: 317-50.

Hoffmann, B. 2002. *Römisches Glas aus Baden-Württemberg*. Stuttgart.

Holleran, C. 2012. *Shopping in Ancient Rome: the retail trade in the late Republic and the principate.* Oxford.

Holleran, C. and Pudsey, A. 2011. *Demography and the Graeco-Roman world: new insights and approaches.* Cambridge.

Hollstein, E. 1980. *Mitteleuropäische Eichenchronologie*. Mainz am Rhein.

Hopkins, K. 1980. "Taxes and Trade in the Roman Empire (200 B.C. – A.D. 400)," *Journal of Roman Studies* 70: 101-25.

Hopkins, K. 1983. "Introduction," in Garnsey *et al* (eds.) *Trade in the Ancient Economy.* London. Pp. ix-xxv.

Hopkins, K. 1996. "Rome, taxes, rents and trade," *Kodai* 6/7: 41-75.

Höpken, C. 1998. "Zu zwei romischen Glasöfen in Köln: die Fundstellen Waidmarkt 18 und Helenenstrasse/ St. Apernstrasse," *Kölner Jahbuch* 31: 427-43.

Höpken, C. 2005. *Die römische Keramikproduktion in Köln*. Mainz.

Höpken, C., and Schäfer, F.F. 2006. "Glasverarbeitung und Glaswerkstätten in Köln," in G. Greemers, B. Demarsin, and P. Cosyns, eds., *Roman Glass in Germania Inferior: Interregional Comparisons and Recent Results. Proceedings of the International Conference, held in the Gall-Roman Museum in Tongeren May 13th, 2005.* Pp. 74-85.

Höpken, C., and Paz, B. 2008. "Analysen römischer Gläser aus Köln," *Berliner Beiträge zur Archäeometrie* 21: 103-14.

Horden, P. and Purcell, N. 2000. *The Corrupting Sea: A Study of Mediterranean History*. Blackwell.

Horn, H. G. 1987. *Die Römer in Nordrhein-Westfalen*. Stuttgart.

Hörter, F., 1994. *Getreidereiben und Mühlsteine aus der Eifel. Ein Beitrag zur Steinbruch- und Mühlsteingeschichte. Geschichts- und Altertumsverein für Mayen und Umgebung.* Mayen.

Howgego, C. 1992. "The Supply and Use of Money in the Roman World 200 B.C. to A.D. 300," *Journal of Roman Studies* 82: 1-31.

Howgego, C. 2013. "The monetization of temperate Europe," *Journal of Roman Studies* 103: 16-45.

Huisman, P. 1995. "De Drususgrachten: een nieuwe hypothese," *Westerheem* 44.5: 188-94.

Huld-Zetsche, I. 1972. *Trierer Reliefsigillata Werkstatt I: Materialien zur römisch-germanischen Keramik.* Bonn.

Huld-Zetsche, I. 1993. *Trierer Reliefsigillata Werkstatt II: Materialien zur römisch-germanischen Keramik.* Bonn

Hunter, F. 2013. "The lives of Roman objects beyond the frontier," in P. Wells., ed., *Rome Beyond its Frontiers: Imports, Attitudes, and Practices*. Portsmouth. Pp.15-28.

Hupperetz, W. 1998. "Uitpakken 1: Romeinse amforen uit Venlo," *Archeologie in Limburg* 77: 48-51.

Hurkmans, R., Terink, W., Uijlenhoet, R., Torps, P., Jacob, D., Troch, P. A. 2010. "Changes in streamflow dynamics in the Rhine Basin under three high-resolution regional climate scenarios," *American Meteorological Society* 23: 679-99.

Hussong, L. v. and Cüppers, H. 1972. *Die Trierer Kaiserthermen: Die spätrömische und frühmittelalterliche Keramik*. Trier.

Isings, C. with J. H. F. Bloemers. 1980. "Glass from the *Canabae Legionis* at Nijmegen," *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 30: 281-346.

James, E. (ed.) 2003. "Origins of the European economy: a debate with Michael McCormick," *Early Medieval Europe* 12.3: 259-323.

James, S. 2002. "Writing the legions; the past, present and future of Roman military studies in Britain," *Archaeological Journal* 159: 1-58.

James, S. 2011. *Rome & the Sword: how warriors & weapons shaped Roman history*. London.

Jansma, E. 2007. "Datering, herkomst en bouwvolgorde van De Meern 4," in T. De Groot and J.-M.A.W. Morel, eds., *Het schip uit de Romeinse tijd De Meern 4 nabij boerderij de Balije, Leidsche Rijn, gemeente Utrecht. Waardestellend onderzoek naar de kwaliteit van het schip en het conserverend vermogen van het bodemmilieu*. Amersfoort. Pp. 69-77.

Jansma, E. and Visser, R. 2009. "Dendrochronologische analyse van het hout van de limesweg te Leidsche Rijn," in J. S. van der Kamp, ed., *Werk aan de weg: LR 31 Zandweg, Archeologisch onderzoek aan een verspoelde sectie van de limesweg*. Utrecht. Pp. 77-145.

Jeneson, K. 2011. "Evaluating settlement patterns and settlement densities in the villa landscapes between Tongres and Cologne," in N. Roymans and T. Derks, eds., *Villa Landscapes in the Roman North*. Amsterdam. Pp. 259-74.

Jockenhövel, A. 1993a. "Ältere Eisenzeit an der Ostflanke des Rheinischen Schiefergebirges," *Bericht der Römisch-Germanischen Kommission* 74: 258-283.

Jockenhövel, A. 1993b. "Eisengewinnung im Mittelgebirgsraum," in S. Heiko, ed., *Alter Bergbau in Deutschland*. Stuttgart. Pp. 70-74.

Jockenhövel, A., and Willms, C. 2005. *Das Dietzhölzetal-Projekt: archäometallurgische Untersuchungen zur Geschichte und Struktur der mittelalterlichen Eisengewinnung im Lahn-Dill Gebiet (Hessen)*. Münster.

Johne, K.-P. 1994. "Die Entwicklung von Kolonenwirtschaft und Kolonat mit besonderer Berücksichtigung der nördlichen Grenzprovinzen des Reiches," in H. Bender, G. Moosbauer, eds., *Ländliche Besiedlung und Landwirtschaft in den Rhein-Donau-Provinzen des Römischen Reiches*. Passau. Pp. 73-86.

Johnson, D. E. (ed.) 1977. *The Saxon Shore*. London.

Johnson, D. E. 1983. *Late Roman Fortifications*. London.

Jones, D. W. 2011. "Chapter 15: Growth," in D. W. Jones, ed., *Economics for Archaeologists*. Available at https://utk.academia.edu/DonaldJones.

Jones, A. H. M. 1964. *The later Roman Empire, 284-602: a social, economic and administrative survey.* Oxford.

Kaiser, H. 2005. "Zum Beispiel Waiblingen: römische Töpfereien in Baden-Württemberg," in Archäologischen Landesmuseum Baden-Württemberg (eds.), *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 403-9.

Kaplan, J. O., Krumhardt, K. M., Zimmermann, N. 2009. "The prehistoric and preindustrial deforestation of Europe," *Quaternary Science Reviews* 28: 3016-34.

Karagiorgou, O. 2001. "LR2: A container for the military annona on the Danubian border?" in Kingsley, S. and Decker, M., eds., *Economy and Exchange in the East Mediterranean during Late Antiquity*. Oxford. Pp. 129-66.

Katsari, K. 2008. "The monetization of the Roman frontier provinces," in W. V. Harris, ed., *The Monetary Systems of the Greeks and Romans*. Oxford. Pp. 242-66.

Kehoe, D. 1988. *The Economics of Agriculture on Roman Imperial Estates in North Africa*. Göttingen.

Kehoe, D. 2007. *Law and the Rural Economy in the Roman Empire*. Ann Arbor.

Kemke, M. 2005. "Vom Rhein an den Limes und wieder Zurück: die Besetzungsgeschichte Südwestdeutschlands," in Archäologischen Landesmuseum Baden-Württemberg (eds.), *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 44-54.

Kemmers, F. 2004a. "Caligula on the Lower Rhine: the coin finds from the Roman fort Albaniana (the Netherlands)," *Revue belge de numismatique et de sigillographie* 150: 15-49.

Kemmers, F. 2004b. "Not at random: evidence for a regionalised coin supply?" in J. Bruhn, B. Croxford, and D. Grigoropoulos, eds., *TRAC 2004*. Oxford. Pp. 39-49.

Kemmers, F. 2006. *Coins for a legion: an analysis of the coin finds from the Augustan legionary fortress and Flavian* canabae legionis *at Nijmegen*. Mainz am Rhein.

Kenrick, P. M. 2000. *Corpus Vasorum Arretinorum: a catalogue of the signatures, shapes, and chronology of Italian Sigillata*. Bonn.

Kerr, W. G.. 1989. "Economic warfare on the northern Limes: Portoria and the Germans," in V. A. Maxfield and M. J. Dobson, eds., *Roman Frontier Studies 1989: Proceedings of the XVth International Congress of Roman Frontier Studies*. Exeter. Pp 442-45.

Kleemann, O. 1977. "Das Eisenbarrendepot von Kelkheim, Main-Taunus Kreis," *Fundberichte aus Hessen* 17/18: 183-94.

Klostermann, J. 2000. "Klima und Landschaft am römischen Niederrhein," in T. Grünewald and H.-J. Schalles, eds., *Germania Inferior: Besiedlung, Gesellschaft und Wirtschaft an der Grenze der römisch-germanischen Welt*. Berlin. Pp. 36-53.

Klostermann, J. 2008. "Umwelt und Klima Xantens in römischer Zeit," in M. Müller, H.-J. Schalles, N. Zieling, eds., *Colonia Ulpia Traiana: Xanten und sein Umland in römischer Zeit*. Mainz. Pp. 21-30.

Klumbach, H. 1959. "Aresaces," in *Limes-Studien: Vorträge des 3. Internationalen Limes-Kongresses in Rheinfelden/Basel 1957*. Basel. Pp.. 69-76.

Kolb, A. 2000. *Transport und Nachrichtentransfer im Römischen Reich.* Berlin.

Kolb, A. 2002. "Army and transport," in P. Erdkamp, ed., *The Roman Army and the Economy*.Amsterdam. Pp. 161-66.

Konrad, M., and Witschel, C. 2011. "Spätantike Legionslager in den Rhein- und Donauprovinzen des Imperiums Romanum. Ein Beitrag zur Kontinuitätsdebatte," in M. Konrad and C. Witschel, eds., *Römische Legionslager in dem Rhein- und Donauprovinzen – Nuclei spätantik-frühmittelalterlichen Lebens*? München. Pp. 3-46.

Konrad, M., and Witschel, C., eds. 2011. *Römische Legionslager in dem Rhein- und Donauprovinzen – Nuclei spätantik-frühmittelalterlichen Lebens*? München.

Kooistra, L. I. 1996. *Borderland Farming. Possibilities and Limitations of Farming in the Roman Period and Early Middle Ages between the Rhine and Meuse*. Leiden.

Kooistra, L. I., van Dinter, M., Dütting, M. K., van Rijn, P., and Cavallo, C. 2013. "Could the local population of the Lower Rhine delta supply the Roman army? Part I: the archaeological and historical framework," *Journal of the Archaeology of the Low Countries* 4.2: 1-20.

Kort, J.-W. d., and Raczynski-Henk, Y., 2014. "The Fossa Corbulonis between the Rhine and Meuse estuaries in the Western Netherlands," *Water History* 6:51-71.

Kortüm, K. 1995. *Portus-Pforzheim : Untersuchungen zur Archäologie und Geschichte in römischer Zeit*. Sigmaringen.

Kortüm, K. 1998. "Zur Datierung der römischen Militäranlagen im Obergermanischen-Rätischen Limesgebiet," *Saalburg Jahrbuch* 49: 5-65.

Kortüm, K. 2005. "Städte und kleinstädtische Siedlungen: zivile Strukturen im Hinterland des Limes," in Archäologischen Landesmuseum Baden-

Württemberg (eds.), *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 154-64.

Kortüm, K. and Neth, A. 2004. "Zur Fortsetzung der Vicusgrabung in den 'Steinäckern' bei Güglingen, KreisHeilbronn," *Archäologische Ausgrabungen in Baden-Württemberg* 2004: 165–8.

Kreckel, T. 2004. *Der römische Vicus von Eisenberg II: die Baubefunde auf der Parzelle von Haus 5.* PHD Dissertation, Universität Mannheim.

Krier, J., and Henrich, P. 2011. "Monumental funerary structures of the 1st to 3rd centuries associated with Roman villas in the area of the Treveri," N. Roymans and T. Derks, eds., *Villa Landscapes in the Roman North*. Amsterdam. Pp. 211-34.

Kron, G. 2012. "Food production," in W. Scheidel, ed., *The Cambridge Companion to the Roman Economy.* Cambridge. Pp. 156-74.

Kropff, A. and van der Vin, J. P. A. 2003. "Coins and continuity in the Dutch River Area at the end of the third century AD," *European Journal of Archaeology* 6.1: 55-87.

Krugman, P. 1992. *Geography and Trade*. Boston.

Krugman, P., Obstfeld, M., Meltiz, M. J. 2012. *International Economics: Theory and Policy.* Boston.

Kuhnen, H., 2003. "Les grandes entreprises agricoles de la Moselle dans l'Antiquité tardive," *Revue archéologique de Picardie* 1-2: 195-202.

Kulikowski, M. 2000. "Barbarians in Gaul, Usurpers in Britain," *Britannia* 31:325-45.

Kunow, J. 1983. "Zum Handel mit römischen Importen in der Germania libera," in *Untersuchungen zu Handel und Verkehr der vor- und frühgeschichtlichen Zeit in Mittel- und Nordeuropa, 1. Methodische Grundlagen und Darstellungen zum Handel in vorgeschichtlicher Zeit und in der Antike. Bericht über die Kolloquien der Kommission für die Altertumskunde Mittel- und Nordeuropas in den Jahren 1980 bis 1983.* Göttingen. Pp. 430-50.

Kunow, J. 1994. "Die ländiche Besiedlung im südlichen Teil von Niedergermanien," in H. Bender and H. Wolff, eds., *Ländliche Besiedlung und Landwirtschaft in den Rhein-Donau Provinzen des römischen Reiches*. Passau. Pp. 141-98.

Kunow, J. 2002. "Die militärgeschichte Niedergermaniens," in H. G. Horn, ed., *Die Römer in Nordrhein-Westfalen.* Hamberg. Pp. 27-109.

Künzl, S. 1997. *Die Trierer Spruchbecherkeramik: Dekorierte Schwarzfirniskeramik des 3. und 4. Jahrhunderts n. Chr.* Trier.

Küster, H. 1994. "The economic uses of Abies wood as timber in central Europe during Roman times," *Vegetation History and Archaeobotany* 3: 25-32.

Laubenheimer, F. 1995. *La production des amphores en Gaule Narbonnaise.* Paris.

Laubenheimer, F. 1998. "Les Amphores du Titelberg," in F. Laubenheimer, ed., *Les amphores en Gaule 2: Production et circulation*. Paris. Pp. 107-142.

Laubenheimer, F. and Brun, J.-P., eds., 2001. “La viticulture en Gaule,” *Gallia* 58: 1-260.

Laubenheimer, F. and Schmitt, A. 2009. *Amphores vinaires de Narbonnaise: production et grand commerce: création d’une base de données géochimiques des ateliers*. Lyon.

Laubenheimer, F. and Marlière, É. 2010. *Échanges et vie économique dans le Nord-Ouest des Gaules: (Nord/Pas-de-Calais, Picardie, Haute-Normandie): le témoignage des amphores du IIe s. av. J.-C. au IVe s. ap. J.-C.* Besançon.

Laurence, R. 1998. “Land transport in Roman Italy: costs, practice, and the economy,” in H. Parkins and C. Smith, eds., *Trade, Traders, and the Ancient Economy*. London. Pp. 129- 48.

Laurence, R. 1999. *The Roads of Roman Italy*. London & New York.

Laurence, R., Esmonde-Cleary, S., Sears, G. 2011. *The City in the Roman West c. 250 BC – AD 250*. Cambridge.

Le Gall, J. 1944. "Les Bas-reliefs de la statue du Tibre," *Revue Archéologique* 21:115-137.

Le Gall, J. 1953. *Le Tibre, fleuve de Rome, dans l'antiquité*. Paris.

Leih, S. 2008. “Der Hafen der Colonia Ulpia Traiana,” in M. Müller, H.J. Schalles, and N. Zeiling, eds., *Colonia Ulpia Traiana: Xanten und sein Umland in römischer Zeit.* Xanten: Landschaftesverbandes Rheinland. Pp. 446-69.

Lemaître, S. 2002. “Recherche sur la diffusion en Gaule des amphores produites dans le sud-ouest de l’Anatolie, à l’époque impériale,” in F. Blondé, Ballet, P, and Salles, J.-F., eds., *Céramiques hellénistiques et romaines. Productions et diffusion en Méditerranée orientale (Chypre, Égypte et côte syro-palestinienne).* Lyon. Pp. 213-26.

Lierke, R. 1995a. “Vasa diatreta II: die Herstellung der römischen Glasnetzbecher,” *Antike Welt* 26: 251-69.

Lierke, R. 1995b. “Vasa diatreta I: ein kritischer exkurs über die Glassschneidekunst der Römer,” *Antike Welt* 26: 42-59.

Liesen, B. 2001. “Kölner Kopien afrikanischer Amphoren,” *Kölner Jahrbuch* 34: 481-84.

Lightfoot, K. G.. and Martinez, A. 1995. “Frontiers and boundaries in archaeological perspective,” *Annual Review of Anthropology* 24: 471-92.

Linthout, K., Paulick, H., Wijbrans, J. R. 2009. “Provenance of basalt blocks from Roman sites in Vleuten-De Meern (The Netherlands) traced to the tertiary Siebengebirge (Germany): a geoarchaeological quest using petrological and geochemical methods,” *Netherlands Journal of Geosciences* 88.1: 55-74.

Lo Cascio, E. 2008. “The early Roman Empire: The state and the economy,” in W. Scheidel, I. Morris, and R. Saller, eds., *The Cambridge Economic History of the Greco-Roman World*. Cambridge. Pp. 619-50.

Loeschcke, S. 1909. *Keramische Funde in Haltern*. Bonn.

Loeschcke, S. and Albrecht, C. 1942. *Das Römerlager in Oberaden und das Uferkastell in Beckinghausen an der Lippe: Heft II: Die römische und die* *belgische Keramik, Die Gegenstände aus Metall nach den Funden der Ausgrabungen*. Dortmund.

Löhr, H. 1976. "Ein römischer Steinbruch in den Katzensteinen bei Satzvey-Firmenich, Kreis Euskirchen," *Bonner Jahrbücher* 176: 319-28.

Löhr, H. 2003. "Das frührömische Militärlager auf dem Petrisberg bei Trier," *Funde und Ausgrabungen im Bezirk Trier* 35: 21-30.

Long, L., and Domergue, C. 1995. "Le 'Véritable plomb de L.Flavius Verucula' et autres lingots." *Mélanges de l'École Française de Rome,* 107: 801-867.

Loseby, S. T. 1996. "Arles in Late Antiquity: Gallula Roma Arelas and Urbs Genesii," in N. Christie and T. S. Loseby, eds., *Towns in transition: urban evolution in Late Antiquity and the early middle ages.* Aldershot. Pp. 45-70

Loseby, S. T. 2000. "Urban failures in late antique Gaul," in T. Slater, ed., *Decline and Towns, 100-1600* . Aldershot. Pp. 72-95.

Loughton, M. 2003. The distribution of Republican Amphorae in France. *Oxford Journal of Archaeology,* 22**,** 177-207.

Loughton, M. E. 2009. Getting Smashed: The deposition of amphorae and the drinking of wine in Gaul during the late Iron Age. *Oxford Journal of Archaeology,* 28**,** 77-110.

Ludemann, T. 2003. "Large-scale reconstruction of ancient forest vegetation by anthracology – a contribution from the Black Forest," *Phytocoenologia* 33.4: 645-66.

Ludemann, T. 2010. "Past fuel wood exploitation and natural forest vegetation in the Black Forest, the Vosges and neighbouring regions in western Central Europe," *Paleogeography, Paleoclimatology, Palaeoecology* 291: 154-65.

Ludemann, T., Michiels, H.-G., Nölkien, W. 2004. "Spatial patterns of past wood exploitation, natural wood supply and growth conditions: indications of natural tree species distribution by anthracological studies of charcoal-burning remains," *European Journal of Forest Research* 123: 283-92.

Luik, M. 2002. "Kunsthandwerkliche Produktion im römischen Trier," in J.-C. Béal, J.-C. Goyon, eds., *Les artisans dans la ville antique.* Lyon. pp. 139-49.

Luik, M. 2004. *Köngen-Grinario II*. Stuttgart.

Luterbacher, J. *et al*. 2012. "A review of 2000 years of paleoclimatic evidence in the Mediterranean," in P. Lionello, ed., *The Climate of the Mediterranean Region: from the past to the future*. Amsterdam. Pp. 87-185.

Mackensen, M. 1987. *Frühkaiserzeitliche Kleinkastelle bei Nersingen und Burlafingen an der oberen Donau*. München.

Mackensen, M. 1999. "Late Roman fortifications and building programmes in the province of Raetia. The evidence of recent excavations and some new reflections." J. D. Creighton and R. J. A. Wilson, eds., *Roman Germany: Studies in Cultural Interaction*. Journal of Roman Archaeology Supplement 32. Portsmouth. Pp. 199-244.

Mackinnon, D. and Cumbers, A. 2007. *An Introduction to Economic Geography, globalization, uneven development, and place*. Harlow.

Macmullen, R. 1959. "Roman imperial building in the provinces," *Harvard Studies in Classical Philology* 64: 207-35.

MacMullen, R. 1980. "How big was the Roman army?" *Klio* 62.2: 451-460.

Malfitana, D., Poblome, J., and Lund, J. 2005. "Eastern Sigillata A in Italy: a socio-economic evaluation," *BaBesch* 80: 199-212.

Mangartz, F. 2008. *Römischer Basaltlava-Abbau zwischen Eifel und Rhein*. Mainz.

Manning, J.G., and I. Morris. 2005. "Introduction," in J. G. Manning and I. Morris, eds., *The Ancient Economy: Evidence and Models*. Stanford. Pp. 1-46.

Marlière, É. 1998. "Les amphores de Bavay," in F. Laubenheimer, ed., *Les Amphores en Gaule 2: Production et Circulation*. Paris. Pp. 48-89

Marlière, É. 2002. *L'outre et le tonneau dans l'occident romain*. Montagnac.

Martin-Kilcher, S. 1987. *Die römischen Amphoren aus Augst und Kaiseraugst: ein Beitrag zur römischen Handels- und Kulturgeschichte. Vol. I: Die südspanischen Ölamphoren (Gruppe 1).* Forschungen in Augst Bd. 7.1. Augst.

Martin-Kilcher, S. 1991. "Die Amphoren," in: A. Hochuli *et al.,* eds., *Chur in römischer Zeit II*. Basel. Pp. 119-127.

Martin-Kilcher, S. 1994. *Die römischen Amphoren aus Augst und Kaiseraugst: ein Beitrag zur römischen Handels- und Kulturgeschichte. Vol. II: Die amphoren für Wein, Fischsauce, Südfruchte (Gruppen 2-24) und Gesamtauswertung.* Forschungen in Augst Bd. 7.2. Augst.

Martin-Kilcher, S. 1997. *Die römischen Amphoren aus Augst und Kaiseraugst: ein Beitrag zur römischen Handels- und Kulturgeschichte. Vol. III: Archäologische und Naturwissenschaftliche Tonbestimmungen und Katalog und Tafeln (Gruppen 2-24)*. Forschungen in Augst Bd. 7.3. Augst.

Martin-Kilcher, S. 2003. "Wein-Olivenöl-Fischsaucen: Amphoren aus den stratifizerten Befunden der 1. und 2. Holzbauperiode," in A. Hagendorn *et al*., eds., *Zur Frühzeit von Vindonissa*. Brugg. Pp. 351-60.

Martin-Kilcher, S. 2004. "Amphorae in the Roman West: Discussion and Research since 1989," in J. Eiring and J. Lund, eds., *Transport Amphorae and Trade in the Eastern Mediterranean*. Acts Int. Coll. Athens 2002. Athens. Pp. 263-72.

Martin-Kilcher, S. 2005. "Handel und Importe," in *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 426-34.

Martin-Kilcher, S. 2006a. "Amphoren: Archäologische Fragen und Fragestellungen," *Xantener Berichte* 14: 11-18.

Martin-Kilcher, S. 2006b. "Spätrömische Amphoren aus Nordafrika und Ägypten am Staffelsee (Bayern)," in M. Mackensen B. Ziehaus, eds., *Gedenkschrift für J. Garbsch. Bayerisches Vorgeschichtsblatter* 71: 13-120.

Marzano, A. 2011. "Rank size analysis and the Roman cities of the Iberian Peninsula and Britain: some considerations," A. K. Bowman and A. I.

Wilson, eds., *Settlement, Urbanization and Population.* Oxford Studies on the Roman Economy vol. 2. Oxford. Pp. 196-228.

Marzano, A. 2013a. "Agricultural production in the hinterland of Rome: wine and olive oil," in A. Bowman and A. Wilson, eds., *The Roman Agricultural Economy: Organisation, Investment, and Production*. Oxford. Pp. 85-106.

Marzano, A. 2013b. "Capital investment and agriculture: multi-press facilities from Gaul, the Iberian Peninsula, and the Black Sea region," in A. Bowman and A. Wilson, eds., *The Roman Agricultural Economy: Organisation, Investment, and Production*. Oxford. Pp. 107-42.

Mathisen, R. 2011. "*Alamanniam mancipasti*: the Roman pseudo-province of *Alamannia*," in M. Konrad and C. Witschel, eds., *Römische Legionslager in dem Rhein- und Donauprovinzen – Nuclei spätantik-frühmittelalterlichen Lebens*? München. Pp. 351- 70.

Mattingly, D. J. 2002. "Impacts beyond empire : Rome and the Garamantes of the Sahara," in L. de Blois and J. Rich, eds., *The transformation of economic life under the Roman Empire : proceedings of the Second Workshop of the International Network Impact of Empire (Roman Empire, c. 200 B.C.- A.D. 476), Nottingham, July 4-7, 2001.* Amsterdam. Pp. 184-203.

Mattingly, D. J. 2003. *The Archaeology of the Fazzan. Volume 1.* London.

Mattingly, D. J. 2006. *The Archaeology of the Fazzan. Volume 2, Site Gazetteer, Pottery, and other Survey Finds.* London.

Mattingly, D. J. 2007. "Supplying Rome and the empire: some conclusions," in E. Papi, ed., *Supplying Rome and the Empire: the proceedings of an international seminar held at Siena-Certosa di Pontignano on May 2-4, 2004 on Rome, the Provinces, Production and Distribution.* Journal of Roman Archaeology Supplement 69. Portsmouth. Pp. 219-27.

Mattingly, D. J. 2010. *The Archaeology of Fazzan. Volume 3, Excavations carried out by C.M. Daniels.* London.

Mattingly, D. J. 2011. *Imperialism, Power, and Identity: experiencing the Roman Empire.* Princeton.

Mattingly, D. J. 2013. *The Archaeology of Fazzān. Volume 4, Survey and Excavations at Old Jarma (Ancient Garama) carried out by C.M. Daniels (1962-69) and the Fazzān Project (1997-2001).* London.

Mattingly, D. J., and Salmon, J., eds., 2000. *Economies beyond Agriculture in the Classical World.* London.

McCormick, M. 2001. *Origins of the European Economy: Communications and Commerce AD 300 – 900*. Cambridge.

McCormick, M. 2012. "Movement and markets in the first millenium: information, containers, and shipwrecks," In C. Morrisson, ed., *Trade and Markets in Byzantium*. Washington . Pp. 51-98.

McCormick, M., Dutton, P. E., and Mayewski, P. A. 2007. "Volcanoes and the Climate Forcing of Carolingian Europe, A.D. 750-950," *Speculum* 82: 865-95.

McCormick, M., Büntgen, U., Cane, M. A., Cook, E. R., Harper, K., Huybers, P., Litt, T., Manning, S. W., Mayewksi, P. A., More, A. F. M., Nicolussi, K., Tegel, W. 2012. "Climate change during and after the Roman Empire: reconstructing the past from scientific and historical evidence," *Journal of Interdisciplinary History* 43.2: 169-220.

Mees, A. W. 2002. *Organisationsformen römischer Töpfer-Manufakturen am Beispiel von Arezzo und Rheinzabern unter Berücksichtigung von Papyri, Inschriften, und Rechtsquellen.* Bonn.

Mees, A. W. 2007. "Samian production in Germania Inferior," in *Transformation: The Emergence of a Common Culture in the Northern Provinces of the Roman Empire from Britain to the Black Sea up to 212 A.D.* http://www2.rgzm.de/transformation/home/frames.htm.

Mees, A. W. 2011. ˜*Dieœ Verbreitung von Terra Sigillata aus den Manufakturen von Arezzo, Pisa, Lyon und La Graufesenque die Transformation der italischen Sigillata-Herstellung in Gallien*. Mainz.

Meiggs, R. 1982. *Trees and Timber in the Ancient Mediterranean World.* Oxford.

Mertens, J. 1977. "Oudenburg and the Northern Sector of the Continental Litus Saxonicum," in. D. E. Johnston (ed.), The Saxon Shore. London. Pp. 51–62.

Metzger, M. J., Bunce, R. G. H., Jongman, R. H. G., Mücher, C. A., Watkins, J. W. 2005. "A climatic stratification of the environment of Europe," *Global Ecology and Biogeography* 14: 549-63.

Meylan-Krause, M.-F. 1995. "La céramique," in P. Blanc *et al*., eds., "Recherques sur les quartiers nord-est d'Aventicum," *Bulletin de l'Association Pro Aventico* 37: 5-112.

Mikler, H. 1998/99. "'Neues vom Holz' der römischen Rheinbrücke zwischen Mainz und Kastel," *Mainzer Archäologische Zeitschrift* 5/6: 325-35.

Milne, G. 1990. "Maritime traffic between the Rhine and Roman Britain: a preliminary note," in S. McGrail, ed., *Maritime Celts, Frisians, and Saxons: Papers presented to a conference at Oxford in November 1988*. CBA Research Report 71. Pp. 82-84.

Millet, M. 1990. *The Romanization of Britain: an essay in archaeological interpretation.* Cambridge.

Mitthof, F. 2003. *Annona militaris: die Heeresversorgung im spätantiken Ägypten: ein Beitrag zur Verwaltungs- und Heeresgeschichte des Römischen Reiches im 3. bis 6. Jh. n. Chr.*. Gonnelli.

Moeyes, G. 2007. "Laadvermogen en vaareigenschappen," in E. Jansma and J. M. A. W. Morel, eds., *Een Romeinse Rijnaak gevonden in Utrecht-De Meern: Resultaten van het onderzoek naar de plaatbodem "De Meern 1."* Amersfoort. Pp. 151-74.

Morel, J. M. A. W. 1986. "The early Roman defended harbours at Velsen, North Holland," in C.Unz, ed., Studien zu den Militärgrenzen Roms III = Internationaler Limeskongreß Aalen 1983. Stuttgart. Pp. 200-12.

Morel, J. M. A. W. 1987. "Frührömische Schiffshäuser in Haltern, Hofestatt," *Ausgrabungen und Funde in Westfalen-Lippe* 5: 221-249.

Morley, N. 1996. *Metropolis and Hinterland: the city of Rome and the Italian economy 200 BC – AD 200*. Cambridge.

Morley, N. 2007. *Trade in Classical Antiquity*. Cambridge.

Morley, N. 2008. "The early Roman Empire: distribution," in W. Scheidel, I. Morris, and R. Saller, eds., *The Cambridge Economic History of the Greco- Roman World*. Cambridge. Pp. 570-91.

Morley, N. 2011. "Cities and economic development in the Roman Empire," in A. K. Bowman and A. I. Wilson, eds., *Settlement, Urbanization, and Population*. Oxford. 143-60.

Morris, F. 2010. *North Sea and Channel connectivity during the Late Iron Age and Roman period (175/150 BC-AD 409)*. BAR International Series 2157. Oxford.

Morris, I., Scheidel, W., Saller, R. 2008. "Introduction," in W. Scheidel, I. Morris, and R. Saller, eds., *The Cambridge Economic History of the Greco- Roman World*. Cambridge. Pp. 1-12.

Morscheiser-Niebergall, J. 2009. *Die Anfänge Triers im Kontext augusteischer Urbanisierungspolitik nördlich der Alpen*. Wiesbaden.

Muller, S. F. 1895. "Verslag van de opgravingen van Romeinsche oudheden te Vechten gedaan op kosten van het Provinciaal Utrechts Genootschap van Kunsten en Wetenschappen in de jaren 1892-1894," in *Verslag van het verhandelde in de Algemeene Vergadering van het Provinciaal Utrechts Genootschap van Kunsten en Wetenschappen, gehouden en 25 Juni 1895*. Utrecht. Pp. 122-69.

Müller, M. 2008. "Die Stadtmauer der CUT," in S. Ristow, ed., *Colonia Ulpia Traiana, Xanten und sein Umland in römischer Zeit.* Xanten. Pp. 277-90.

Müller-Wille, M., and Oldenstein, J. 1981. "Die ländliche Besiedlung des Umlandes von Mainz in spätrömischer und frühmittelalterlicher Zeit," *Bericht der römisch-germanischen Kommission* 62: 261-316.

Naum, M. 2010. "Re-Emerging frontiers: postcolonial theory and historical archaeology of the borderlands," *Journal of Archaeological Method and Theory* 17: 101-31.

Nenna, M.-D. 2000. "Ateliers primaires et secondaries en Égypte à l'époque gréco- romaine," in M.-D. Nenna, ed., *La route du Verre: Ateliers primaires et secondaires de verriers du second millénaire av. J.-C. au Moyen Âge.* Lyon. Pp. 97–112;

Nenna, M.-D. 2003. "Les ateliers égyptiens à l'époque grèco-romaine", in D. Foy, ed., *Cœur de verre. Production et diffusion du verre antique.* Gollion. Pp. 32–33.

Nesselhauf, H. 1960. "Umriss einer Geschichte des obergermanischen Heeres." *Jahrbuch des Römisch-Germanischen Zentralmuseum* 7: 151-179.

Neu, S. 1985. "The Rhine front of Roman Cologne," in A.E. Herteig, ed., *Conference on the Waterfront Archeology in North European Towns 2, Bergen 1983*. Bergen. Pp. 151-156

Nicholson, P. T. 1989. *Iron Age Pottery Production in the Hunsrück-Eifel-Kultur of Germany: A World-System Perspective*. BAR International Series 501. Oxford.

Nicholson, P. T. 1997. "The Ulu Burun glass ingots, cylindrical vessels and Egyptian glass," *The Journal of Egyptian Archaeology*, 83: 143-53.

Nienhuis, P. H. 2008. *Environmental History of the Rhine-Meuse Delta*. Dordrecht.

Nuber, H. U. 2005. "Zu Wasser und zu Lande: das römische Verhekrsnetz," in Archäologischen Landesmuseum Baden-Württemberg (eds.), *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 410-19.

Nuber, H. U. 2011. "Archäologische Zeugnisse des Wandels in der militärischen Architektur," in M. Konrad and C. Witschel, eds., *Römische Legionslager in dem Rhein- und Donauprovinzen – Nuclei spätantik-frühmittelalterlichen Lebens*? München. Pp. 79-101.

Olivier, J. M., Amoros, C., Carrel, G., Malard, F., Lamouroux, N., Bravard, J.-P. 2009. "The Rhône River basin," in Tockner, K., Uehlinger, U., and Robinson, C.T., eds., *Rivers of Europe*. Amsterdam. Pp. 247-95.

Ollive, V., Petit, C., Garcia, J.-P,. Reddé, M. 2006. "Rhine flood deposits recorded in the Gallo- Roman site of Oedenburg (Haut-Rhin, France)," *Quaternary International* 150: 28-40.

Ollive, V., Petit, C., Garcia, J.-P., Reddé, M., Biellmann, P., Popovitch, L., and Chateau-Smith, C. 2008. "Roman Rhine settlement dynamics evidenced by coin distribution in a fluvial environment(Oedenburg, Upper Rhine, France)," *Journal of Archaeological Science* 35: 643-54.

Oelmann, F. 1914. *Die Keramik des Kastells Niederbieber*. Frankfurt am Main.

Ott, J. 1995. *Die Beneficiarier: Untersuchungen zur ihrer Stellung innerhalb der Rangordnung des Römischen Heeres und zu ihrer Funktion*. Stuttgart.

Otten, T., and Ristow, S. 2008. "Xanten in der Spätantike," in M. Müller, H.J. Schalles, and N. Zeiling, eds., *Colonia Ulpia Traiana: Xanten und sein Umland in römischer Zeit.* Xanten: Landschaftesverbandes Rheinland. Pp. 549-82.

Oud, S. P. 1995. "Brittenburg: hoektorens en muurstukken," *Westerheem* 44.6: 225-30.

Päffgen, B. 2011. "Die spätrömische Besiedlung im Umland von Köln," in M. Konrad and C. Witschel, eds., *Römische Legionslager in dem Rhein- und Donauprovinzen Nuclei spätantik-frühmittelalterlichen Lebens*? München. Pp. 197-229.

Päffgen, B. and Wedepohl, K. H. 2004. "Frühmerowingische Glasherstellung in Hasselsweiler bei Jülich," *Kölner Jahrbuch* 37: 835-48.

Papaioannou, T. 2011. "A reconstruction of the maritime trade patterns originating from western Asia Minor during Late Antiquity, on the basis of ceramic evidence," in D. Robinson and A. I. Wilson, eds., *Maritime Archaeology and Ancient Trade in the Mediterranean*. Oxford. Pp. 197-210

Papi, E., ed., 2007. *Supplying Rome and the Empire: the proceedings of an international seminar held at Siena-Certosa di Pontignano on May 2-4, 2004, on Rome, the provinces, production and distribution.* Journal of Roman Archaeology Supplement 69. Portsmouth.

Parker, A. J. 1992. *Ancient Shipwrecks of the* Mediterranean *and the Roman Provinces*. Oxford.

Parlevliet, D. 2002. "De Brittenburg voorgoed verloren," *Westerheem* 51.3: 115-21.

Pastor, L. 2010. *Les ateliers de potiers de la Meuse au Rhin à La Tène Finale et durant l'époque gallo-romaine.* PHD dissertation Université de Strasbourg.

Paunier,, D. 1981. *La céramique gallo-romaine de Genève: de la Tène finale au royaume Burgonde (Ier siècle avant J.-C. - Ve siècle après J.-C.).* Paris.

Pavis d'Esurac, H. 1976. *La préfecture de l'annone: Service administratif impérial d'Auguste à Constantin*. Rome.

Peacock, D. P. S. 1978. "The Rhine and the problem of Gaulish wine in Roman Britain," in J. d.Plat Taylor and H. Cleere, eds., *Roman Shipping and Trade: Britain and the Rhine Provinces.* CBA reports 24. Oxford. Pp. 49-51.

Peacock, D. P. S., and Blue, L. 2006. *Myos Hormos—Quseir al-Qadim: Roman and Islamic Ports on the Red Sea*. Oxford.

Petrikovits, H. v. 1952. "Die Ausgrabungen der Colonia Traiana bei Xanten," *Bonner Jahrbücher* 112: 41-161.

Petrikovits, H. v. 1958. "Bergbau und Hüttenwesen in der römischen Rheinzone," *Zeitschrift für Erzbergbau und Metallhüttenwesen* 11: 594-600.

Petrikovits, H. v. 1960. *Das römische Rheinland*. Köln.

Petrikovits, H. v. 1971. " Fortifications in the North-Western Roman Empire from the Third to the Fifth Centuries A.D.," *Journal of Roman Studies* 61: 176-218.

Petrikovits, H. v. 1976. "Bergbau und Hüttenwesen in der römischen Rheinzone," in *Beiträge zur römischen Geschichte und Archäologie.* Bonn. Pp. 216-28.

Petrikovits, H. v. 1985. "Römischer Handel am Rhein und an der oberen und mittleren Donau," in *Untersuchungen zu Handel und Verkehr der vor- und frühgeschichtlichen Zeit in Mittel- und Nordeuropa, 1. Methodische Grundlagen und Darstellungen zum Handel in vorgeschichtlicher Zeit und in der Antike. Bericht über die Kolloquien der Kommission für die Altertumskunde Mittel- und Nordeuropas in den Jahren 1980 bis 1983.* Göttingen. *Pp.* 299-336.

Picon, M., Vichy, M., 2003. "D'Orient en Occident: l'origine du verre à l'époque romaine et Durant le haut Moyen Âge," in Foy, D., Nenna, M.-D., eds., *Echanges et commerce du verre dans le monde antique.* Montagnac. Pp. 17-31.

Pirling, R. 1981. "Vom Römischen zum Fränkischen Glas – im Spiegel der Funde von Kreffeld-Gellep," *Annales du 8e Congrès international d'étude historique du verre*, London. Pp. 115-31.

Planck, D. 2005. *Die Römer in Baden-Württemberg : Römerstätten und Museen von Aalen bis Zwiefalten*. Stuttgart.

Polak, M. and Wynia, S.L. 1991. "The Roman forts at Vechten. A survey of the excavations 1829-1989," *Oudheidkundige mededelingen uit het Rijksmuseum van Oudheden te Leiden* 71: 125-156.

Polanyi, K. 1977. *The Livelihood of Man.* New York.

Polfer, M. ed., 1999. *Artisanat et productions artisanales en milieu rural dans les provinces du nord-ouest de l'Empire Romain*. Montagnac.

Polfer, M. ed., 2001. *L'artisanat romain: évolutions, continuités et ruptures (Italie et provinces occidentales)*. Montagnac.

Polfer, M. 2001. "L'archéologie de l'artisanat et le débat sur la nature de l'Economie romaine: quelques réflexions critiques," in M. Polfer, ed., *L'artisanat romain: évolutions, continuités et ruptures (Italie et provinces occidentales)*. Montagnac. Pp.7-17.

Polfer, M. 2005. *L'Artisanat dans l'économie de la Gaule Belgique romaine à partir de la documentation archéologique*. Montagnac.

Poux, M. 1999. Les amphores et la chronologie des sites Bâlois (Bâle-Gasfabrik- Bâle- Münsterhügel). Nouvelles données. *In:* Tuffreau-Libre, M. & Jacques, A. (eds.) *La céramique précoce en Gaule Belgique et dans les régions voisines: de la poterie Gauloise à la céramique Gallo-Romaine.* Berck-sur- Mer, 385-416.

Poux, M. 2004. *L'âge du vin: rites de boisson, festins et libations en Gaule indépendante.* Montagnac.

Preusser, F. 2008. "Characterisation and evolution of the River Rhine system," *Netherlands Journal of Geosciences* 87.1: 7-19.

Price, J. 1978. "Trade in glass," in J.d.P. Taylor and H. Cleere, eds., *Roman Shipping and Trade: Britain and the Rhine Provinces*. London. Pp. 70-8.

Provansal, M., Berger, J.-F., Bravard, J.-P., Salvador, P.-G., Arnaud-Fassetta, G., Bruneton, H., Vérot-Bourrély, A. 1999. "Le régime du Rhône dans l'Antiquité et au Haut Moyen Age," *Gallia* 56: 13-32.

Pury-Gysel, A. d. 2011. "*Aventicum* (Avenches), capital of the *Helvetii*: a history of research, 1985-2010. Part I. Early Roman *Aventicum* and its origins," *Journal of Roman Archaeology* 24: 1-46.

Pury-Gysel, A. d. 2012. "*Aventicum* (Avenches), capital of the *Helvetii*: a history of research, 1985-2010. Part II. Urban development after AD 100, crafts, and finds," *Journal of Roman Archaeology* 25: 259-296.

Quilici, L. 2009. "Land transport, part 1: roads and bridges," in J. P. Oleson, ed., *The Oxford Handbook of Engineering and Technology in the Classical World*. Oxford.

Radcliffe, A. 1795. *A journey made in the summer of 1794, through Holland and the western frontier of Germany, with a return down the Rhine***.** London.

Raepsaet, G. 2009. "Land transport, part 2: riding, harnesses, and vehicles," in J. P. Oleson, ed., *The Oxford Handbook of Engineering and Technology in the Classical World*. Oxford.

Rankov, B. 2006. "Do rivers make good frontiers?" in *Limes XIX. Proceedings of the XIXth International Congress of Roman Frontier Studies held in Pecs, Hungary (September, 2003).* Pp 175-81.

Rathbone, D. W. 1996. "The Imperial finances," in A. K. Bowman, E. Champlin, and A. Lintott, eds., *The Cambridge Ancient History vol. X: The Augustan Empire, 43 BC – AD 69.* Cambridge. Pp. 309-23.

Rathbone, D. W. 2001. ‘The ‘‘Muziris’’ papyrus (SB XVIII 13167): Financing Roman trade with India’, in *Alexandrian Studies II in Honor of Mostafa el- Abbadi* (BSAA 4–6). Alexandria, 39–50.

Rathbone, D. W. 2008. “Roman Egypt,” in W. Scheidel, I. Morris, and R. Saller, eds., *The Cambridge Economic History of the Greco-Roman World*. Cambridge. Pp. 698-719.

Reddé, M., Brulet, R., Fellmann, R., von Schnurbein, S., Haalebos, J.-K. 2006. *L'Architecture de la Gaule romaine. Les fortifications militaires.* Paris.

Remesal Rodríguez, J. 1986. *La annona militaris y la exportación de aceite bético a Germania*. Madrid.

Remesal Rodríguez, J. 1997. *Heeresversorgung und die wirtschaftlichen Beziehungen zwischen der Baetica und Germanien: Materalien zu einem Corpus der in Deutschland veröffentlicheten Stempel auf Amphoren der Form Dressel 20*. Stuttgart.

Remesal Rodríguez, J. 2002. “Baetica and Germania. Notes on the concept of provincial interdependence in the Roman Empire,” in P. Erdkamp, ed., *The Roman Army and the Economy.* Amsterdam. Pp. 293-308.

Reuter, M. 2005a. “Ein Zerstörungshorizont der Jahre um 280 n. Chr. in der Retentura des Legionslagers Reginum/Regensburg. Die Ausgrabungen in der Grasgasse-Maximilianstrasse 26 in den Jahren 1979/80,” *Bayerische Vorgeschictsblätter* 70: 183-281.

Reuter, M. 2005b. “Weinbau im römischen Südwestdeutschland?” in Archäologischen Landesmuseum Baden-Württemberg (eds.), *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 301-7.

Reuter, M. 2012. “Das Ende des obergermanischen Limes, Forschungsperspektiven und offene Fragen,” in T. Fischer, ed., *Die Krise des 3. Jahrhunderts n. Chr. und das Gallische Sonderreich*. Köln. Pp. 307-24.

Reutti, F., and Schulz, R. 2010**. “**Brennöfen für Terra Sigillata in Rheinzabern. Befunde und Rekonstruktion” Rei Cretariae Romanae Fautorum Acta 41: 567-87.

Revell, L. 2009. *Roman Imperialism and Local Identities*. Cambridge.

Rice, C. M. 2012. *Port Economies and Maritime Trade in the Roman Mediterranean: 166 BC to AD 300*. D.Phil. Thesis, University of Oxford.

Rice, C. M. (forthcoming) 2014. Review of Terpstra, T. 2013. *Trading Communities in the Roman World. Journal of Roman Studies* 104.

Rice. C. M. (forthcoming). “Mercantile specialization and trading communities: economic strategies in Roman maritime trade”, in M. Flohr, and A. Wilson, eds., *Beyond Marginality: Craftsmen, Traders and the Socioeconomic History of Roman Urban Communities*. Oxford Studies on the Roman Economy, Oxford.

Ricardo, D. 1817. *On the Principles of Political Economy and Taxation.* London.

Richardson, A. 2000. “The numerical basis of Roman camps,” *Oxford Journal of Archaeology* 19.4: 425-37.

Richardson, A. 2002. "Camps and forts of units and formations of the Roman army," *Oxford Journal of Archaeology* 21.1: 93-107.

Richardson, A. 2003. "Space and manpower in Roman camps," *Oxford Journal of Archaeology* 23.3: 303-13.

Rickman, G. 1988. "The archaeology and history of Roman ports," *The International Journal of Nautical Archaeology and Underwater Exploration* 17.3: 259-69.

Riedl, H. 2011. *Die Schwäbische Reliefsigillata : Untersuchungen zur Bilderschüsselproduktion des 2. und 3. Jahrhunderts im mittleren Neckarraum.* Stuttgart.

Ritterling, E. 1913. *Das frührömische Lager bei Hofheim im Taunus*. Wiesbaden.

Ritzdorf, H. 2003. *Die römerzeitliche Eisenmetallurgie in der Eifel*. PHD dissertation, Rheinischen Friedrich-Wilhelms-Universität zu Bonn.

Röder, J. 1957. "Die antiken Tuffsteinbrüche der Pellenz," *Bonner Jahrbücher* 157: 213-71.

Röder, J. 1959. "Zur Steinbruchgeschichte des Pellenz- und Brohltaltuffs," *Bonner Jahrbücher* 159: 47-88.

Röder, J. 1974. "Römische Steinbruchtätigkeit am Drachenfels," *Bonner Jahrbücher* 174: 508-44.

Rodrigue, J. P., Comtois, C., Slack, B. 2006. *The Geography of Transport Systems*. London.

Roller, O. 2005. "Wirtschaft und Verkehr," in H. Cüppers, ed., *Die Römer in Rheinland-Pfalz.* Stuttgart. Pp. 258-96.

Rösger, A., and Will, W. 1985. "Die Drususbrücke zu Bonn: Nochmals Flor. Epit. 2,30,26," *Bonner Jahrbücher* 185: 27-39.

Roth-Rubi, K. 1975. "Die Gebrauchskeramik von der Fundstelle Solothurn-Kreditanstalt," *Jahrbuch für Solothurnische Geschichte* 48: 241-351.

Roth-Rubi, K. 1986. "La production de terre sigillée en Suisse aux IIe et IIIe S. Problèmes de définition," in C. Bémont and J.-P. Jacob, eds., *La terre sigillée gallo-romaine. Lieux de production du Haut-Empire: implantations, produits, relations*. Paris. Pp. 269-73.

Rothenhöfer, P. 2003a. "Plumbum Germanicum – Germanic lead and the history of Augustan Germany," in Associazione Italiana di Metallurgia, ed., *Archaeometallurgy in Europe*. Milan. Pp. 641-48.

Rothenhöfer, P. 2003b. "Geschäfte in Germanien. Zur Ausbeutung von Erzlagerstätten unter Augustus in Germanien," *Zeitschrift für Papyrologie und Epigraphik* 143: 277-86.

Rothenhöfer, P. 2004. "Das Blei der Germanen, Bemerkungen zu einer neuen Fundgattung und zur Aufnahme der Bleiproduktion durch Germanen während der älteren Römischen Kaiserzeit in Westfalen," *Archäologisches Korrespondenzblatt* 34: 423 -34.

Rothenhöfer, P. 2005. *Die Wirtschaftsstrukturen im südlichen Niedergermanien: Untersuchungen zur Entwicklung eines Wirtschaftraumes an der Peripherie des Imperium Romanum.* Cologne.

Rothenhöfer, P. 2007. “Verborgen an der Mosel - Ein ungewöhnlicher Metalldepotfund aus dem 5. Jahrhundert n. Chr.,” *Archäologisches Korrespondenzblatt* 37: 549-61.

Rothenhöfer, P. 2014. “Die Wirtschaft der Römer: Produktionzentren und Handelswege in römischer Zeit,” in T. Fischer and H. G. Horn, eds., *Straßen von der Frühgeschichte bis in die Moderne Verkehrswege – Kulturträger – Lebensraum*. Köln. Pp. 109-21.

Rottländer, R. C. A. 1990. “Naturwissenschaftliche Untersuchungen zum romischen Glas in Köln,” *Kölner Jahrbuch* 23: 563-582.

Roueche, C. 1989. *Aphrodisias in Late Antiquity*. Journal of Roman Studies Monographs 5. London.

Roymans, N. 1990. *Tribal Societies in Northern Gaul: an anthropological perspective*. Amsterdam.

Roymans, N. 2004. *Ethnic Identity and Imperial Power: the Batavians in the Early Roman Empire*. Amsterdam.

Roymans, N., and Habermehl, D. 2011. “On the origin and development of axial villas with double courtyards in the Latin West,” in N. Roymans and T. Derks, eds., *Villa Landscapes in the Roman North*. Amsterdam. Pp. 83-106.

Roymans, N. and Derks, T. (eds.) 2011. *Villa landscapes in the Roman North. Economy, culture and lifestyles*. Amsterdam.

Roymans, N. and Derks, T. 2011. “Studying Roman villa landscapes in the 21st century. A multi-dimensional approach,” in N. Roymans and T. Derks, eds., *Villa Landscapes in the Roman North*. Amsterdam. Pp. 1-44.

Roymans, N. and Zandstra, M. 2011. “Indications for rural slavery in the northern provinces,” in N. Roymans and T. Derks, eds., *Villa Landscapes in the Roman North*. Amsterdam. Pp. 161-78.

Rüger, C. 2000. “Roman Germany,” in A. K. Bowman, P. Garnsey, and D. Rathbone, eds., *The Cambridge Ancient History vol. XI The High Empire, AD 70-192*. Cambridge. Pp. 496-513.

Rupprecht, G. 1980. “Die Kreuznacher Palastvilla. Kurzbericht über den Stand der Erforschung im Herbst 1979,” *Mainzer Zeitschrift* 75: 219-26.

Russell, B. 2008. “The dynamics of stone transport between the Roman Mediterranean and its hinterland,” *Facta* 2: 107-26.

Russell, B. 2009. *Sculpted Stone and the Roman Economy*. D.Phil Thesis, University of Oxford.

Rütti, B. 1991. *Die römischen Gläser aus Augst und Kaiseraugst*. Augst.

Salathe, R., Furger, A. R., Hänger, H., Königs, D., Kurmann, F., Marti, R., Peter, M. 2007. *Augst und Kaiseraugst: zwei Dörfer-eine Geschichte*. Basel.

Šašel, J. 1973. “Trajan’s canal at the Iron Gate,” *Journal of Roman Studies* 63: 80-85.

Sauer, E. (forthcoming) 2014. “Milestones and instability (mid-third to early fourth centuries),” *Ancient Society* 44: #-#.

Schallmayer, E. 1982. “Ein römischer Töpfereibezirk bei Stettfeld,” *Archaologische Ausgrabungen in Baden Wurttemburg 1982*: 106-10.

Schallmayer, E. 2005. “Zur Frage der Palisade am Obergermanisch-Raetischen Limes im 3. Jahrhundert n. Chr.,” in Z. Visy, ed., *Limes, 19. Proceedings of the XIXth International Congress of Roman Frontier Studies held in Pécs, Hungary, September 2003*. Pécs. Pp. 801-13.

Scharf, R. 2005. *Der Dux Mogontiacensis und die Notitia Dignitatum: eine Studie zur spätantiken Grenzverteidigung*. Berlin

Scheidel, W. 2007. “Demography,” in W. Scheidel, I. Morris, and R. Saller, eds., *The Cambridge Economic History of the Greco-Roman World*. Cambridge. Pp. 38-86.

Scheidel, W. 2009. “Looking for Roman economic growth,” *Journal of Roman Archaeology* 22: Pp. 46-70.

Scheidel, W. 2011. “*A comparative perspective on the determinants of the scale and productivity of maritime trade in the Roman Mediterranean,”* in W. V. Harris and K. Iara, eds., *Maritime Technology in the Ancient Economy: Ship-Design and Navigation*. Journal of Roman Archaeology supplement 84. Portsmouth. Pp. 21-37.

Scheidel, W. 2012. “Approaching the Roman economy,” in W. Scheidel, ed., *The Cambridge Companion to the Roman Economy*. Cambridge. Pp. 1-24.

Scheidel, W., ed., 2012. *The Cambridge Companion to the Roman Economy*. Cambridge.

Scheidel, W., Morris, I., Saller, R. 2008. *The Cambridge Economic History of the Greco-Roman World*. Cambridge.

Scheidel, W., Meeks, E., Weiland, J. 2012. “ORBIS: The Stanford geospatial network model of the Roman world,” http://orbis.stanford.edu/ (accessed April 2014).

Schimmer, F. 2009. *Amphoren aus Cambodunum/Kempten: ein Beitrag zur Handelgeschichte der römischen Provinz Raetia.* Wiesbaden.

Schindler, R. 1976. “Fragen zur römischen Eisenverhüttung im Moselland,” *Trierer Zeitschrift* 28: 45-59.

Schlippschuh, O. 1974. *Die Händler im römischen Kaiserreich in Gallien, Germanien und den Donauprovinzen Rätien, Noricum und Pannonien*. Amsterdam.

Schmidts, T. 2005. “Die Welt der Arbeit: Handwerker und Händler,” in Archäologischen Landesmuseum Baden-Württemberg (eds.), *Imperium Romanum: Roms Provinzen an Neckar, Rhein, und Donau*. Stuttgart. Pp. 260-69.

Schmidts, T. 2007. “Zentralorte in der Provinz Obergermanien,” in *Transformation: the emergence of a common culture in the Northern provinces of the Roman Empire from Britain to the Black Sea up to 212 AD.* http://www2.rgzm.de/transformation/home/frames.htm.

Schmidts, T. 2011. *Akteure und Organisation der Handelsschifffahrt in den nordwestlichen Provinzen des Römischen Reiches*. Mainz.

Schmitz, D. 2009. “New ideas on the possible location of the legionary base Vetera II (Xanten),” in A. Morillo, N. Hanel, and E. Martín, eds., *Limes XX: Estudios sobre la Frontera Romana, Roman Frontier Studies*. 3 vols. Madrid. Pp. 1361-70.

Schönberger, H. 1969. "The Roman frontier in Germany: an archaeological survey," *Journal of Roman Studies* 59: 144-97.

Schönberger, H. 1985, "Die römischen Truppenlager der frühen und mittleren Kaiserzeit zwischen Nordsee und Inn," *Bericht der Römisch-Germanishcen Kommission* 66: 321- 497.

Schucany, C. 2011. "The villa landscape of the Middle Aare valley and its spatial and chronological development," in N. Roymans and T. Derks, eds., *Villa Landscapes in the Roman North*. Amsterdam. Pp. 275-84.

Seidel, M. 2005. "Keltische Glasarmringe zwischen Thüringen und dem Niederrhein," *Germania* 83: pp. 1-44.

Sen, A. 1983. "Development: which way now?" *The Economic Journal* 93: 745-62.

Shahin, M. 2002. *Hydrology and Water Resources of Africa*. Dordrecht.

Shaw, B. 1983. "Soldiers and society: the army in Numidia," *Opus* 2: 133-59.

Shaw, B. 1995. *Environment and Society in Roman North Africa*. Aldershot.

Shirley, E. A. M. 2000. *The Construction of the Roman Legionary Fortress at Inchtuthil.* Oxford.

Shirley, E. A. M. 2001. *Building a Roman Legionary Fortress.* Stroud.

Shortland, A. J. 2004. "Evaporites of the Wadi Natrun: seasonal and annual variation and its implication for ancient exploitation," *Archaeometry* 46: 497–516.

Shortland, A. J., Schachner, L., Freestone, I. C., and Tite, M. S. 2005. "Natron as a flux in the early vitreous materials industry: sources, beginnings and reasons for decline," *Journal of Archaeological Science* 33: 1–10.

Shortland, A. J., Degryse, P., Walton, M., Geer, M., Lauwers, V., Salou, L. 2011. "The evaporitic deposits of Lake Fazda (Wadi Natrun, Egypt) and their use in Roman glass production," *Archaeometry* 53.5: 916-929.

Silvestri, A., 2008. "The coloured glass of Iulia Felix," *Journal of Archaeological Science* 35: 1489-1501.

Silvestri, A., Molin, G., Salvialo, G. 2008. "The colourless glass of Iulia Felix," *Journal of Archaeological Science* 35: 331-41.

Silver, M. 2006. "Thoughts on the Roman 'consumer city,'" *Münstersche Beiträge zur antiken Handelsgeschichte* 25.1: 125-29.

Silver, M. 2007. "Roman economic growth and living standards: perceptions versus evidence," *Ancient Society* 37: 191-252.

Slofstra, J. 1983. "An anthropological approach to the study of the Romanization processes," in R. Brandt and J. Slofstra, eds., *Roman and Native in the Low Countries; Spheres of Interaction.* BAR International Series 184. Oxford. Pp. 71-104.

Slofstra, J. 1991. "Changing settlement systems in the Meuse-Demer-Scheldt area during the early Roman period," in N. Roymans and F. Theuws, eds., *Images of the Past: Studies on ancient societies in Northwestern Europe*. Amsterdam. Pp. 131-99.

Smith, A. 1776. *An Inquiry into the nature and causes of the wealth of nations.* London.

Sommer, C. S. 1988. "Die römische Zivilsiedlungen in Südwestdeutschlan,". In D. Planck, ed., *Archäologie in Württemberg*. Stuttgart. Pp. 281-310.

Sommer, C. S. 1999. "From conquered territory to Roman province: recent discoveries and debate on the Roman occupation of SW Germany," in J.D. Creighton and R.J.A. Wilson, eds., *Roman Germany: Studies in Cultural Interaction*. Journal of Roman Archaeology Supplement 32. Portsmouth. Pp. 161-98.

Southern, P. and Dixon, K. R. 1996. *The Late Roman Army*. London.

Spaul, J. E. H. 2000. *COHORS 2: the evidence for and a short history of the auxiliary infantry units of the Imperial Roman army*. BAR international series 841. Oxford.

Speidel, M. A. 1992a. "Roman army pay scales," *Journal of Roman Studies* 82: 87-106.

Speidel, M. A. 1992b. "Legionsabteilungen aus Mainz beim Holzschlag im Odenwald," in M. Speidel, ed., *Roman Army Studies 2*. Mavors Roman Army Researches 8. Stuttgart. Pp. 149-152.

Sprater, F. 1929. *Die Pfalz unter den Römern, zugleich Führer durch die römische Abteilung des Historischen Museums der Pfalz*. Speier am Rhein.

Staehelin, F. 1948. *Die Schweiz in römischer Zeit*. Basel.

Stary, P. F. 1993. "Der Mittelgebirge als Transit- und Vermittelungszone," *Bericht der Römisch- Germanishcen Kommission* 74: Pp. 537-564.

Stern, E. M. 1999. "Roman glassblowing in a cultural context," *American Journal of Archaeology* 103.3: 441-84.

Stolberg, F. L. 1797. *Travels through Germany, Switzerland, Italy, and Sicily*. second ed. Trans. T. Holcroft. London.

Strachan, M. 1972. *The life and adventures of Thomas Coryate*. Oxford.

Strobel, K. ed., 2000. *Forschungen zur römischen Keramikindustrie: Produktions-, Rechts- und Distributionsstrukturen.* Trier.

Strobel, K. 2007. "Strategy and army structure between Septimius Severus and Constantine the Great," in P. Erdkamp, ed., *A Companion to the Roman Army.* Oxford. Pp. 267-85.

Stuart, P. 1963. *Gewoon aardewerk uit de Romeinse legerplaats en de bijbehorende grafvelden te Nijmegen.* Leiden.

Stuart, P. and Bogaers, J. E. 2001. *Nehalennia. Römische Steindenkmäler aus der Oosterschelde bei Colijnsplaat*. Leiden.

Symonds, M. F. A. 2008. *The design and purpose of Roman fortlets in the north- western frontier provinces of the Empire.* DPhil thesis, University of Oxford.

Talbert, R. J. A. 2000. *The Barrington Atlas of the Greek and Roman World*. Princeton.

Tchernia, A. 1983. Italian wine in Gaul at the end of the republic. In: Garnsey, P., Hopkins, K. & Whittaker, C. R., eds., *Trade in the Ancient Economy*. London. Pp. 87-104.

Tchernia, A. 2002. "L'arrivée de l'huile de Betique sur le *limes* germanique: Wierschowski contre Rémesal," in L. Rivet and M. Sciallano, eds., *Vivre, produire et échanger: reflets méditerranéens. Mélanges offerts à Bernard Liou*. Montagnac. Pp. 319-24.

Tchernia, A. 2011. *Les Romains et le commerce.* Naples.

Tchernia, A., Pomey, P., Hesnard, A., Girard, M., Hamon, E., Laubenheimer, F., Lecaille, F., Carrier-Guillomnet, A., Chene, A., Gassend, J.-M., Reveillac, G. & Rival, M. 1978. *L'épave Romaine de la Madrague de Giens (Var) (Campagnes 1972-1975)*. Paris.

Temin, P. 2001. "A market economy in the Early Roman Empire," *Journal of Roman Studies* 91: 169-181.

Temin, P. 2012. *The Roman Market Economy*. Princeton.

Terpstra, T. 2013. *Trading Communities in the Roman World: a Micro-economic and institutional perspective*. Leiden.

Thiel, A. 2006. "Die Grenze in Deutschland – die Provinzen Obergermanien und Raetien," in G. Klose and A. Nünnerich-Asmus, eds., *Grenzen des römischen Imperiums*. Mainz am Rhein. Pp. 112-22.

Thomas, R., and Stallibrass, S. 2008. "For starters: producing and supplying food to the army in the Roman north-west provinces," in S. Stallibrass and R. Thomas, eds., *Feeding the Roman Army: the archaeology of Production and Supply in NW Europe*. Oxford. Pp. 1-17.

Thonemann, P. 2013. "Who made the amphora mountain?" *Times Literary Supplement* 492.

Tockner, K., Uehlinger, U., and Robinson, C. T., eds., 2009. *Rivers of Europe*. Amsterdam.

Tol, R. S. J., and Langen, A. 2000. "A concise history of Dutch River floods," *Climatic Change* 46.3: 357-69.

Tomber, R. 2008. *Indo-Roman Trade.* London.

Tomber, R. 2013. "Pots, coins, and trinkets in Rome's trade with the East," in P. Wells., ed., *Rome Beyond its Frontiers: Imports, Attitudes, and Practices*. Portsmouth. Pp. 87-104.

Tränkle, D. 2009. "Die römische Töpferei von Bad-Krozingen "Grosser Hofacker" (Lkr: Breisgau-Hochschwarzwald)." *Société Française d'Étude de la Céramique Antique en Gaule, congrès 2009.* Pp. 113-120.

Uehlinger, U., Wantzen, K.M., Leuven, R. S. E. W., Ardnt, H. 2009. "The Rhine River Basin," in Tockner, K., Uehlinger, U., and Robinson, C. T., eds., *Rivers of Europe*. Amsterdam. Pp. 199-245.

Unverzagt, W. 1916. *Die Keramik des Kastells Alzei*. Frankfurt am Main.

Vanhoutte, S., De Clerq, W., and Dhaeze, W. 2009. "Pottery consumption c. AD 260-70 at the Roman coastal defence fort, Oudenburg, Northern Gaul," *Journal of Roman Pottery Studies* 14: 95-141.

Van den Berg, J. J., Boersma, J. R., van Gelder, A. 2007. "Diagnostic sedimentary structures of the fluvial-tidal transition zone: evidence from deposits of the Rhine and Meuse," *Geologie en Mijnbouw* 86.3: 287-306.

Van der Berg, J. 2012. "Rare and exotic amphorae in North-West Europe: finds from the Roman fort on the Kops Plateau," *Journal of Roman Pottery Studies* 15: 215-35.

Van der Werff, J. H. 1984. "Roman amphoras at Nijmegen: a preliminary report," *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 34: 347-87.

Van der Werff, J. H. 2003. "The third and second lives of amphoras in Alphen aan den Rijn, The Netherlands," *Journal of Roman Pottery Studies* 10: 107- 116.

Van der Werff, J. H. 2004. "Amphoras from Vechten (excavations 1946-47)," in F. Vermeulen and K. Sas, eds., *Archaeology in confrontation: aspects of Roman military presence in the northwest, Studies in Honour of Prof. Em. Hugo Thoen.* Ghent. Pp. 287-304.

Van Dinter, M., Kooistra, L. I., Dütting, M. K., van Rijn, P., Cavallo, C. 2013. "Could the local population of the Lower Rhine delta supply the Roman army? Part 2: Modelling the carrying capacity using archaeological, palaeo-ecological, and geomorphological data," *Journal of Archaeology in the Low Countries* 5.1: 6-50.

Van Kerckhove, J., 2015: Het Romeinse aardewerk in Voorburg-Arentsburg, een handelsstad gespecialiseerd in de bevoorrading van de militairen aan de West-Nederlandse kust, in M. Driessen and E. Besselsen, eds., *Voorburg-Arentsburg: Een Romeinse Havenstad tussen Rijn en Maas*. Amsterdam. Vol. 2. 321-469.

Van Neer, W., Ervynck, A., and Monsieur, P. 2010. "Fish bones and amphorae: evidence for the production and consumption of salted fish products outside the Mediterranean region," *Journal of Roman Archaeology* 23: 161-195.

Van Ossel, P. 1992. *Etablissements ruraux de l'Antiquité tardive dans le nord de la Gaule.* Paris.

Veal, R. 2010. "Examining continuity in landscape exploitation: Late Roman fuel consumption in Silchester's Insula IX," in M. Fulford, ed., *Silchester and the Study of Romano-British Urbanism*. Journal of Roman Archaeology Supplement 90. Portsmouth. Pp. 227-45.

Veal, R. 2012. "From context to economy: charcoal as an archaeological interpretive tool, a case study from Pompeii (third c. BC – AD 79)," in I. Schrüfer-Kolb, ed., *More than just Numbers? The Role of Science in Roman Archaeology*. Journal of Roman Archaeology supplement 91. Portsmouth. Pp. 19-52.

Veal, R. 2013. "Fuelling ancient Mediterranean cities: a framework for charcoal research," in W. V. Harris, ed., *The Ancient Mediterranean Environment between Science and History*. Leiden. Pp. 37-60.

Verboven, K. 2007. "Good for business. The Roman army and the emergence of a business class in the northwestern provinces of the Roman empire, first century B.C.E. - third century C.E." in L. de Blois and E. lo Cascio, eds., *The impact of the Roman army (200 BC - AD 476): economic, social, political, religious and cultural aspects: proceedings of the sixth workshop of the international network Impact of Empire (Roman Empire, 200 B.C. - A.D. 476), Capri, March 29 - April 2, 2005*. Leiden. Pp. 295-313.

Verhulst, A. 1977. "An aspect of the question of continuity between antiquity and the Middle Ages: the origin of the Flemish cities between the North Sea and the Scheldt," *Journal of Medieval History* 3: 175-206.

Viroulet, B. and Baudoux, J. 2009. “La céramique des camps,” in M. Reddé, ed., *Oedenburg : fouilles françaises, allemandes et suisses à Biesheim et Kunheim, Haut-Rhin, France*. Mainz. Pp. 169-229.

Visser, R. 2007. “Behoefte aan bouwhout in de Nederrijnse regio tijdens de Romeinse tijd,” in E. Gehring, D. Habermehl, R. v. Veer, and I. Venderbos, eds., *Sojabundel 2006*. Amsterdam. Pp. 107-14.

Visser, R. 2010. “Growing and Felling? Theory and Evidence Related to the Application of Silvicultural Systems in the Roman Period,” in A. Moore, G. Taylor, P. Girdwood, E. Harris, and L. Shipley, eds., *TRAC 2009: Proceedings of the Nineteenth Annual Theoretical Roman Archaeology Conference*. Southampton. Pp. 11-22.

Vittinghoff, F. 1994. “Die politische Organisation der römischen Rheingebiete in der Kaiserzeit” in W. Eck, ed., *Civitas Romana. Stadt und politisch-soziale Integration im Imperium Romanum der Kaiserzeit*. Stuttgart. Pp. 66-87.

Von Reden, S. 2012. “Money and finance,” in W. Scheidel, ed., *The Cambridge Companion to the Roman Economy*. Cambridge. Pp. 266-86.

Vorst, Y. 2005. *De constructie en herkomst van de Romeinse platbodem ‘Woerden 7’ een studie van jaarringspatronen en bewerkingssporen.* Dissertation, Universiteit van Amsterdam.

Vos, W. K., Morel, J., Hazenburg, T. 2011. “The Woerden 7: an oar powered Roman barge built in the Netherlands,” *Archäologisches Korrespondenzblatt* 41: 101-18.

Vossen, I. and Groot, M. 2008. “Barley and Horses: surplus and demand in the *civitas Batavorum*,” in M. Driessen, S. Heeren, J. Hendriks, F. Kemmers, and R. Visser, eds., *TRAC 2008.* Oxford. Pp. 85-100.

Wagner, H. 1993. “Bergbau bei Ebersteinburg, Stadtkreis Baden-Baden,” *Archäologische Nachrichten aus Baden* 49: 32-35.

Walser, G. 1969. *Die römischen Strassen in der Schweiz*. Itinera romana ; Beiträge zur Strassengeschichte des Römischen Reiches, heft 1. Bern.

Walton, P. J. 2011. *Rethinking Roman Britain: an applied numismatic analysis ofthe Roman coin data recorded by the Portable Antiquity Scheme*. PHD thesis, University College London.

Ward-Perkins, J. B. 1974. *Cities of ancient Greece and Italy: planning in classical antiquity*. London.

Weber, M. 2013. *Quo Vadis, terra sigillata? A case study in the organisation of samian supplies in the Antonine Period.* Phd thesis, University of Reading.

Webster, J. 2001. “Creolizing the Roman Provinces,” *American Journal of Archaeology* 105.2: 209-25.

Wedepohl, K. H. and Baumann, A. 2004. “The use of marine molluskan shells for Roman glass and local raw glass production in the Eifel area (Western Germany),” *Naturwissenschaften* 87: 129–132.

Wedepohl, K. H., Simon, K., Kronz, A. 2011a. “Data on 61 chemical elements for the characterization of three major glass compositions in Late Antiquity and the Middle Ages,” *Archaeometry* 53.1: 81-102.

Wedepohl, K. H., Simon, K., Kronz, A. 2011b. "The chemical composition including the rare earth elements of the three major class types of Europe and the Orient used in Late Antiquity and the Middle Ages," *Chemie der Erde* 71.3: 289-96.

Wegener, W. 1993. "Montanarchäologische Prospektion im Rheinland," in H. Steuer and U. Zimmermann, eds., *Montanarchäologie in Europa. Berichte zum Internationalen Kolloquium "Frühe Erzgewinnung und Verhüttung in Europa" in Freiburg im Breisgau vom 4. bis 7. Oktober 1990.* Sigmaringen. Pp. 167-76.

Wegert, A. 2010. "Die Amphoren aus den frühen Neusser Militärlagern," *Archäologie im Rheinland 2010*: 100-102.

Wells, C.M. 1972. *The German Policy of Augustus*. Oxford.

Wells, P. S. 1984. *Farms, Villages, and Cities: Commerce and Urban Origins in Late Prehistoric Europe*. Ithaca.

Wells, P. S. 1995a. "Resources and Industry," in M. J. Green, ed., *The Celtic World.* London. pp. 213-229.

Wells, P. S. 1995b. "Trade and Exchange," in M. J. Green, ed., *The Celtic World*. London. Pp. 230-43.

Wells, P. S., ed., 2013. *Rome beyond its Frontiers: Imports, Attitudes, and Practices.* Journal of Roman Archaeology Supplement 94. Portsmouth.

Wendling, H. 2012. *Der Münsterberg von Breisach in der Spätlatènezeit: siedlungsarchäologische Untersuchungen am Oberrhein*. Stuttgart.

Wendt, K. P. and Zimmermann, A. 2008. "Bevölkerungsdichte und Landnutzung in den germanischen Provinzen des Römischen Reiches im 2. Jahrhundert AD," *Germania* 86: 1-36.

Wendt, K. P., Zimmermann, A. 2009. "Transforming archaeological data between different geographical scales—a GIS application for the estimation of population density," in A. Velho and H. Kamermans, eds., *Technology and Methodology for Archaeological Practice: Practical applications for the past reconstruction.* Oxford. Pp. 49-59.

Wendt, K. P., Hilpert, J., Zimmernann, A. 2012. "Landschaftsarchäologie III: Untersuchungen zur Bevölkerungsdichte der vorrömischen Eisenzeit, der Merowingerzeit und der späten vorindustriellen Neuzeit an Mittel- und Niederrhein," *Bericht der Römisch-Germanischen Kommission* 91:217-338.

Wenzel, C. 2009. *Gross-Gerau. 1, Der römische Vicus von Gross-Gerau "Auf Esch:" die Baubefunde des Kastellvicus und der Siedlung des 2.-3. Jahrhunderts.* Frankfurter archäologische Schriften 9. Frankfurt.

Wetter, O., Pfister, C., Weingartner, R., Luterbacher, J., Reist, T., Trösch, J. 2013. "The largest floods in the High Rhine basin since 1268 assessed from documentary and instrumental evidence," *Hydrological Sciences Journal* 56.2: 733-58.

Wheeler, E. L. 1993a. "Methodological limits and the mirage of Roman strategy: Part I," *The Journal of Military History* 57.1: 7-41.

Wheeler, E. L. 1993b. "Methodological limits and the mirage of Roman strategy: Part II," *The Journal of Military History* 57.2: 215-240.

Whittaker, C. R. 1983. “Trade and frontiers of the Roman Empire,” in P. Garnsey and C. R. Whittaker, eds., *Trade and Famine in Classical Antiquity*. Cambridge. Pp. 110-27.

Whittaker, C. R. 1989. “Supllying the system: frontiers and beyond,” in J. C. Barrett, A. P. Fitzpatrick, and L. Macinnes, eds., *Barbarians and Romans in North-West Europe, from the later Republic to Late Antiquity*. Oxford. Pp. 64-80.

Whittaker, C. R. 1993. “Trade and the aristocracy in the Roman Empire,” in C. R. Whittaker, ed., *Land, City, and Trade in the Roman Empire*. Aldershot. Pp. 49-75.

Whittaker, C. R. 1994. *Frontiers of the Roman Empire. A Social and Economic Study.* Baltimore.

Whittaker, C. R. 2004. *Rome and its Frontiers: the Dynamics of Empire*. New York.

Wickert, F. 1903. *Der Rhein und sein Verkehr*. Stuttgart.

Wickham, C. 2000. *Framing the Early Middle Ages: Europe and the Mediterranean, 400-800*. Oxford.

Wierschowski, L. 1984. *Heer und Wirtschaft. Das römische Heer der Prinzipatszeit als Wirtschaftsfaktor.* Bonn.

Wierschowski, L. 2001. *Fremde in Gallien--Gallier in der Fremde : die epigraphisch bezeugte Mobilität in, von und nach Gallien vom 1. bis 3. Jh. n. Chr*. Stuttgart.

Wierschowski, L. 2002. “Das römische Heer und die ökonomische Entwicklung Germaniens in den ersten Jahrzehnten des 1. Jahrhunderts,” in P. Erdkamp, ed., *The Roman Army and the Economy.* Amsterdam. Pp. 264-92.

Wightmann, E. M. 1971. *Roman Trier and the Treveri*. Ann Arbor.

Wigg, D. G. 1997. “Coin supply and the Roman army,” in van Waateringe, W. G..-, van Beek, B. L., Willems, W. J. H., Wynia, S. L., eds., *Roman Frontier Studies 1995: Proceedings of the XVIth International Congress of Roman Frontier Studies*. Oxford. Pp. 281-88.

Wigg, A. 1999. “Confrontation and interaction: Celts, Germans and Romans in the central German highlands,” in J. D. Creighton and R. J. A. Wilson, eds., *Roman Germany: Studies in Cultural Interaction*. Journal of Roman Archaeology Supplement 32. Portsmouth. Pp. 35-53.

Wigg, D. G. 1999. “The development of the monetary economy in N Gaul in the late La Téne and early Roman periods,” in J. D. Creighton and R. J. A. Wilson, eds., *Roman Germany: Studies in Cultural Interaction*. Journal of Roman ArchaeologySupplement 32. Portsmouth. Pp. 99-124.

Wigg, D. G., Riederer, J. 1998. “Die Chronologie der keltischen Münzpragung am Mittelrhein,” in U. Peter, ed., *Stephanos Nomismatikos: Edith Schönert-Geiss zum 65. Geburtstag*. Berlin. Pp. 661-74.

Wikander, C. 2000. “Canals,” in Ö. Wikander, ed., *Handbook of Ancient Water Technology.* Leiden. Pp. 321-30.

Will, E. L. 2004. ‘Mediterranean amphoras in India’, in J. Eiring and J. Lund eds., *Transport Amphorae and Trade in the Eastern Mediterranean,* Monographs of the Danish Institute at Athens 5. Athens, 433–40.

Willems, J. H. W. and Enckevort, H. v. 2009. *Ulpia Noviomagus, Roman Nijmegen: the Batavian capital at the Imperial frontier*. Portsmouth.

Williams, D., Carreras Monfort, C. 1995. "North African amphorae in Roman Britain: a re-appraisal," *Britannia* 26: 231-252.

Wilson, A. I. 2002a. "Machines, power, and the ancient economy," *Journal of Roman Studies* 92: 1-32.

Wilson, A. I. 2002b. "Economy and trade," in E. Bispham, ed., *The Short Oxford History of Europe vol 2: Roman Europe*. Oxford. Pp. 170-202.

Wilson, A. I. 2002c. "Urban production in the Roman world: the view from North Africa." *Papers of the British School at Rome* 70: 231-73.

Wilson, A. I. 2006. "Fishy business: Roman exploitation of Marine resources," *Journal of Roman Archaeology* 19: 525-37.

Wilson, A. I. 2009a. "Approaches to quantifying Roman trade," in A. K. Bowman and A. I. Wilson, eds., *Quantifying the Roman Economy: Methods and Problems*. Oxford. Pp. 213-49.

Wilson, A. I. 2009b. "Indicators for Roman economic growth: a response to Walter Scheidel," *Journal of Roman Archaeology* 22: 71-82.

Wilson, A. I. 2011a. "The economic influence of developments in maritime technology in antiquity ," in W. V. Harris and K. Iara, eds., *Maritime Technology in the Ancient Economy: Ship-Design and Navigation*. Journal of Roman Archaeology supplement 84. Portsmouth. Pp. 211-34.

Wilson, A. I. 2011b. "City sizes and urbanization in the Roman Empire," A. K. Bowman and A. I. Wilson, eds., *Settlement, Urbanization and Population.* Oxford Studies on the Roman Economy vol. 2. Oxford. Pp. 161-195.

Wilson, A. I. 2012a. "Saharan trade in the Roman period: short-, medium- and long-distance trade networks," *Azania: Archaeological Research in Africa* 47.4: 409-449.

Wilson, A. I. 2012b. "Raw materials and energy," in W. Scheidel, ed., *The Cambridge Companion to the Roman Economy*. Cambridge. Pp. 133-54.

Wilson, A. I., Silver, M., Bang, P. F., Erdkamp, P., and Morley, N. 2012. "A forum on trade," in W. Scheidel, ed., *The Cambridge Companion to the Roman Economy*. Cambridge. Pp. 287-320.

Wirtz, R. 1998. *Die römische Töpferei Bastion Sterntor / St. Maria in Bonn: Vergleichende Studie zu Töpferöfen für Gebrauchskeramik*. PHD dissertation der Universität zu Köln.

Witschel, C. 2004. "Re-evaluating the Roman West in the third c. AD," *Journal of Roman Archaeology* 17.1: 251-81.

Witschel, C. 2011. "Die Provinz Germania Superior im 3. Jahrhundert – ereignisgeschichtlicher Rahmen, quellenkritische Anmerkungen und die Entwicklung des Städtewesens," in R. Schatzmann, S. Martin-Kilcher, eds., *L'Empire romain en mutation, Répercussions sur les villes romaines dans la deuxième moitié du 3e siècle.* Montagnac. Pp. 23-65.

Woolf, G. 1992. "'Imperialism, empire and the integration of the Roman economy," *World Archaeology* 23.3: 283-93.

Woolf, G. 1993. "Rethinking the Oppida," *Oxford Journal of Archaeology* 12.2: 223-34.

Woolf, G. 1998. *Becoming Roman: The origins of provincial civilization in Gaul.* Cambridge.

Woolf, G. 2000. “Regional productions in early Roman Gaul,” in D. J. Mattingly and J. Salmon, eds., *Economies beyond Agriculture in the Classical World*. London. Pp. 49-65.

Zagermann, M. 2010. *Der Münsterberg in Breisach. III . Die römerzeitlichen Befunde und Funde der Ausgrabungen Kapuzinergasse (1980 -1983), Rathauserweiterung, Tiefgaragenneubau (1984-1986) und der baubegleitenden Untersuchungen am Münsterplatz (2005-2007).* München.

Zahar, Y., Ghorbel, A., Albergel, J. 2008. “Impacts of large dams on downstream flow conditions of rivers: aggradation and reduction of the Medjerda channel capacity downstream of the Sidi Salem dam (Tunisia),” *Journal of Hydrology* 351: 318-30.

Ziegler, P. A. 1994. “Cenozoic rift system of western and central Europe: an overview,” *Geologie en Mijnbouw* 73: 99-127.

Zimmermann, A., Wendt, K. P. 2009. “Environmental suitability and land use—a diachronic comparison,” in A. Velho and H. Kamermans, eds., *Technology and Methodology for Archaeological Practice: Practical Applications for the past reconstruction*. Oxford. Pp. 101-10.

Zimmermann, A., Wendt, K. P., Frank, T., Hilpert, J. 2009. “Landscape Archaeology in Central Europe,” *Proceedings of the Prehistoric Society* 75: 1-53.

ILLUSTRATIONS

APPENDICES