The Logistics of Feeding the Roman Army on the Lower Danube

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Part One

I Stephen Richard Matthews declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

Signed

Date

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Abstract

This thesis sets out to quantify the logistical burden that a Roman garrison brought with it, in terms of land and transport requirements. The focus will be on arable land, both to feed the soldiers but also to provide feed-barley for the transport animals. First the needs are quantified, having considered likely ranges of key variables that impact upon agricultural productivity. Then an appraisal of the arable available in the study areas is carried out on the basis of the settlement activity seen in the archaeological record. This is used to build a model of what land was plausibly available to supply the army.

The study areas were selected according to where there had been previous landscape survey on the Lower Danube, around Novae and Nicopolis ad Istrum and also in Dobrogea, where it has long been assumed that settlement was encouraged to supply to the military. In this last case, my assessment of land available is carried out using the Romanian national database of sites – cIMeC – which aims to record all archaeological sites in the country. Although this is fraught with problems of interpretation, it is augmented both by works of traditional scholarship and by a dataset of tumuli for part of the region to arrive at a quantified, suggested solution to the needs of the garrison.

For this suggested solution and the deficit – that part not available locally – the modelling of transport solutions is carried out. This is done within ArcGIS using the Service Area function, which allocates the most effective routes to move cargoes from producer to consumer. As a result models of what land was available and how the produce of that land was moved to the garrison are arrived at.

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Weights and Measures

Weights

1 Roman pound = 0.323kg[1]

Volumes

1 *modius* = 8.62l[2]

1 *sextarius* = 0.0625 *modius* = 0.539l[3]

1 Attic *medimnus* = 48 Attic *choenices* = 52.5l[4]

1 Attic *choenix* = 1.0938l

1 Egyptian *artaba* = 48 Egyptian *choenices* = 38.78l[5]

1 Egyptian *choenix* = 0.808litres[6]

1 *culleus* = 20 *amphorae* = 517l[7]

1 *amphora* = 3 *modii* = 25.9l[8]

1 Imperial bushel = 36.37l

1 Winchester bushel = 35.239l

Areas

1 *iugerum* = 0.2517ha[9]

1 *aroura* = 0.2756ha[10]

Distance

1 Roman mile = 1.481km

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[1] Duncan-Jones 1982, p.369; Rathbone 2009, p.301.
[2] Duncan-Jones 1976, pp.51-2, 1982, p.371; Rathbone 2009, p.301.
[3] Duncan-Jones 1976, p.43, 1982, p.372.
[4] Rickman 1980, p.xiii.
[5] Duncan-Jones 1976, p.44, 1982, p.372; Rickman 1980, p.xiii; Rathbone 1991, p.465; 2009, p.301.
[6] Duncan-Jones 1976, p.44.
[7] Duncan-Jones 1982, p.372.
[8] Duncan-Jones 1982, p.372.
[9] Rickman 1980, p.xiii.
[10] Rickman 1980, p.xiii; Rathbone 1991, p.xvi.

Introduction

Logistics is the business of supplying the army with those commodities it requires, in the first case to live, and in the second to wage war. For the Romans the most important necessities were food and water, but there was also firewood, together with replacement arms and a multitude of equipment. How this was done varied, firstly, according to whether the army was on campaign or in garrison, and, secondly, according to the local topography and economy. This thesis seeks to examine the logistics of supplying the army in garrison on the Danube in the province of Lower Moesia with food. It focuses on the arable needs both because these are quantifiable, and also because the solution to these needs can be argued to be visible in part through the archaeological record. As such the thesis produces theoretical mathematical models of how the army may have plausibly been supplied. The quantification of such needs, and the means of solving them, therefore goes towards understanding the impact of the military on the provincial economy. We know less about garrison logistics than campaign logistics, because it does not normally appear in the literary record. Although on campaign enemy territory could be pillaged to provide many of the necessities, deferring the financial burden and providing the most immediate source of supply, this ceased to be appropriate when a garrison was imposed on an ostensibly friendly population of provincials even if recently subjugated. There was a permanent garrison along the river Danube during the 2nd and 3rd centuries after the Dacian wars until the 4th century Gothic invasions and probably beyond until the Hunnic incursions of the 5th century. Therefore with the Dacian wars won and peace established along the frontier, so the business of gathering, storing and transporting commodities to the standing garrisons impacted on provincials both near and far from the frontiers. My choice of Lower Moesia was driven by the existence of an accessible database of archaeological sites for Romania that allowed for a detailed assessment of Dobrogea, that part of Romania to the east and south of the Danube as it nears its mouth, which forms my main study area. For the remainder of the province there is less information, but two landscape surveys around the Roman fortress of Novae and the Roman town of Nicopolis ad Istrum provided sufficient material to carry out an initial survey.

In Chapter One I will give an overview of the geographical extent of the region that I am considering. After this I will survey the state of our existing knowledge of Roman military logistics and the literature available. I will lay out my research questions and discuss my methodology. Chapter Two will consider the needs of the garrison under different possible yield and fallow regimes. In Chapter Three the arable potential visible in the archaeological record will be surveyed and a computation of what part of the garrison's needs were available locally carried out. Chapter Four will consider the transport penalties of moving that arable potential to the garrison.

Chapter One: Preliminary considerations

1.1.1 Geography and demography

The size, shape and development of the Lower Moesian province is normally documented in relation to the territories of the major urban centres of which there were few.[11] The western boundary with the upper province in the 2nd century ran along the river Ciabrus [modern Tsibritsa or Cibrica].[12] The province incorporated the Danubian plain as far south as the Haemus mountain range, to the east was the Delioram plateau, Ludogorie and Dobrogea – the area between the Danube as it turns north and then east again and the Black Sea shore. The most westerly significant settlement was at Montana centered on a mining district with military control exercised through a *centurio regionarius,* this only developed slowly although eventually it became a *municipium*.[13] On the Danube, forts and small settlements existed at Almus [modern Lom] west of the Ciabrus, but still within the province, and Augusta [at the mouth of the modern Ogosta river]. The first significant town Oescus [modern Gigen] was founded by Trajan after *legio V Macedonica* departed for Troesmis in Dobrogea *c* AD 106; the *colonia Ulpia Oescus* is presumed to occupy the former legionary site. East of Oescus lay Dimum [Belene], the last customs station of the *portorium Illyricum*, before the *portorium Thraciae* commenced; this function looks to have been sufficient to afford Dimum autonomous status with its own *territorium*.[14] Inland the southern limits are ill-defined but included the *vicus Trullensium* [modern Kunino] some 70km south of

[11] Most recently *TIR* K35/2, pp.232-3 (Ivanov 2012a); this section unless otherwise stated was written with reference to Gerov 1988, pp.90-126; Poulter 1980, 1983, pp.74-85, pp.92-4; Zahariade & Gudea 1997, pp.72-82; Wilkes 2005, pp.140-1; Tomas 2007, pp.33-42.
[12] Ptolemy, *Geog* 3.9-10.
[13] *CIL* 3.7449, 3.7451, 3.12376; *AE* 1969-70.577, 1987.881; Poulter 1983, p.110; Rankov 1983, pp.55-9.
[14] *CIL* 3.12399; 6.32549; *ISM* 1.68; Ptolemy, *Geog* 3.10.

the river.[15] Also a *territorium Dianensium* existed on the middle reaches of the river Utus [modern Vit] around the road station of Storgosia [Kaylaka near modern Pleven].[16] Further south again the civic centre of Melta [modern Lovec] sat on the upper reaches of the Asamus [modern Osam] river; this possibly had *civitas* status, but may have remained within Thrace until *c* AD 193. Novae [modern Svishtov] was the legionary base of *legio I Italica* after AD 69; a *canabae* and *vicus* were sited nearby, one of which was granted municipal status.[17] To the south was Nicopolis ad Istrum whose territorial boundaries were contiguous with those of Novae to the north and possibly a Thracian tribal unit to the east.[18] Nicopolis was included within the province *c* AD 193, this revision probably came about to represent the agricultural supply zone to the *limes*. The land around these two settlements will form my first survey area. Within the province after AD 193, to the south-west of Nicopolis lay the *emporium Piretensium* [Gorsko Kosovo], while outside the province, to the south was the *emporium Discoduraterae* [modern Gostilitsa]. Thus the southern boundary of Nicopolis' territory and the province itself after AD 193 can be imagined to have been between the two *emporia*, less than 20km south of Nicopolis.[19] Inland there were towns at Abritus [modern Razgrad] and another foundation of Trajan's at Marcianopolis [modern Devyna] which has not been investigated in any significant way, a single inscription attesting to its possessing a *territorium*.[20] The province's southern boundary is supposed to

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[15] *CIL* 3.14412^3.
[16] *AE* 1911.16.
[17] *CIL* 3.7591; *AE* 1964.224.
[18] Gerov 1988, pp.116-18; Tomas 2007, p.33, pp.38-9 discusses the boundary markers *inter Moesos et Thraces fines* found in the vicinity.
[19] Later under Aurelian (AD 270-5) Discoduraterae came within Nicopolis' territory.
[20] *AE* 2000.1268.

Fig 1.1.1.1: Lower Moesian provincial boundaries, & civilian settlements

have continued east from Nicopolis past Marcianopolis arriving at the Black Sea shore mid-way between Mesembria [Nesebar] in Thrace and Templum Iovis [Obzor] in Lower Moesia. East of Novae there were towns on the river at Sexaginta Prista [Ruse] Appiaria [Riahovo] and Transmarisca [Tuktrakan]. Further east Durostorum [Silistra] which was originally a Getic site, was home to *legio XI Claudia* by AD 116-7, possibly as early as Trajan's Dacian wars. To the east of Durostorum is Dobrogea, the area within which the main survey region lies. From here the provincial boundaries are easily defined by the course of the Danube as it travels first north and then east, and to the east by the Black Sea coast. Three Greek *poleis* existed at Callatis [Mangalia], Tomis [Constanța], and Histria [Istria] on the coast. A detailed survey of settlement activity in Dobrogea will be given in Chapter Three. This work assumes that Dobrogea remained Roman territory throughout the Imperial period, although the re-appraisal of the date and function of the Valu lui Traian that is still ongoing does bring this into question.[21] Rankov has suggested the incursions of the Costoboci, and the Carpi in the late 2nd, early 3rd century may have necessitated such works, as well as the possibility of more widespread border insecurity over the longer term.[22] Assuming that the ramparts were built to meet specific military threats, the distinction between earthen and stone walls and their layout suggests different threats at different times that would suppose that the area to the north was on occasion no longer secure.[23] If so the settlement patterns suggested in Chapter Three may need revision; against this however, the archaeological and epigraphic evidence suggests a Roman presence throughout the 2nd and 3rd centuries and this will be the view taken throughout this thesis. The land area of the whole province was approximately 50,000km^2.

[21] Hanson & Oltean 2012.
[22] Rankov 2015, pp.74-8.
[23] Hanson & Oltean 2012, pp.314-15.

When considering the population of this area I enter the realm of educated guesswork. For the wider empire, the population estimates of Beloch are still a safe starting point; using these Frier suggested a Danube-wide population of four million by AD 164 with a density of 9.3 people per km^2, so by Frier's estimate a total population of 465,000 for the province.[24] Batty suggested one million either side of the Lower Danube, 200,000 in Wallachia, and up to 800,000 in Lower Moesia and Thrace together, but he did not elaborate further.[25] Suceveanu estimated 40,000-60,000 urbanites for the Black Sea *poleis*, a figure I will consider below as overly high.[26] Otherwise, there was little urbanization; all the urban sites together might have only had a population of 50,000, maybe 80,000 if Suceveanu is correct. Therefore, a best guess might be 50,000 urbanites and 350,000 rural inhabitants, approximately 400,000 people across the whole province with an average population density of 8 per km, slightly lower, and fittingly so, than Frier's estimate for the wider Danube, because Lower Moesia was the least developed of the Danube provinces. Of these people we might expect 80% to have been engaged in farming or to have been the dependants of farmers – most of whom would have still worked the land in some manner.

1.1.2 Summary of logistical knowledge and literature review

If an ancient writer did write about logistics, he did so in a campaign context. This is not too problematic when considering the food requirements, because these should not have changed; yet rarely are there literary references to the supply of the garrison or transport and storage solutions until after the Tetrarchy

[24] Frier 2000, pp.811-15 citing Beloch 1886, p.507 and McEvedy & Jones 1978; Morley 1996, pp.47-50.
[25] Batty 2007, p.40 follows McEvedy & Jones 1978.
[26] Suceveanu 1977, pp.41-56; 1991, pp.40-2; Chapter Three, pp.132-3.

and the creation of the *annona militaris*, which is described within the Theodosian Code. Two substantial works on Roman logistics in a campaign context appeared in the late 1990s by Erdkamp [1998] and Roth [1999]. Erdkamp focused purely on the Republican period, when consuls commanded armies and quaestors had logistical responsibilities. Although Roth considered a wider timespan into the Imperial period, reading his work, or just a review of his index of sources, makes it clear that the lion's share of his examples are focused on the Republican period also, with Polybius, Appian, Caesar, the early books of Dio, and Livy dominating over Tacitus, and an increasingly less reliable set of later sources. Roth surveys this literary evidence thoroughly to quantify the army's needs, so that he is heavily referenced in Chapter Two. However, his focus is on the army at war. As far as the mechanisms of supply are concerned, he adheres to the campaigning concept of strategic, operational and tactical supply stations. He offers little in the way of identifying supply solutions; at no point is there an attempt to consider an arable landscape, despite a Chapter entitled 'Sources of Supply'. It was his omission to do so, or to utilize the archaeological record around garrison sites, that prompted me to consider this thesis. Other quantitative studies of campaign logistics have also appeared previously. Engels [1980] considered Alexander the Great's march into Asia. Peddie [1997a, 1997b] considered the transport penalties to support Caesar's movements in Gaul, and the first century invasions of Britannia. Goldsworthy [1998] recognized the limitations of the literary sources and relegated logistics to an Appendix; although much of what he suggested within that Appendix is plausible. There is broad agreement between such works and these have all informed my discussion, but none considers the sources of supply and the mechanisms of exaction. Junkelmann [1997] also surveyed the military diet and food preparation within the army. Although he does consider agricultural landscapes in broad terms and alludes to supply solutions, he deals with the ideas of military *territoria* and *villa* landscapes, but *territoria* are far from well understood, while *villa* landscapes are not universally applicable and certainly not seen in one of my study areas.[27] Rodriguez [1986, 2002] does consider long-distance supply of olive oil to the *limes* of Germania and Britannia. He has shown that some producers had preferential status with the military and that these imports were so important that legal privileges were extended to the Spanish provincials.[28] Anderson [1992] also deals with garrison armies, but his focus is on the transport penalties and the merits of overland transport over an earlier theory of waterborne transport. None of these works quantify particular arable solutions.

Food and water were the most pressing needs of any army. A passage of Polybius stating the rations issued to soldiers in the 2nd century BC will be my starting point in Chapter Two.[29] Bread was the main component of most diets in antiquity.[30] For my area the palaeo-botanical reports are few and not particularly instructive, really only showing that the full range of cereals was consumed in a civilian context.[31] Bread was augmented by other foodstuffs known collectively as the *cibaria*; the main ingredients on campaign were cheese, oil and salt, meat either as salt pork, *laridum* or mutton, and sour wine *acetum* mixed with water to form *posca*.[32] Davies' [1971] paper that started the whole discussion of the wider military diet, first collated the literary evidence for the *cibaria*. The Vindolanda texts and the sewage deposits at Bearsden have now made it clear that the range of

[27] Junkelmann 1997, pp.73-8.
[28] Remesal Rodriguez 1986, pp.75-6, p.109; 2002, p.300.
[29] Polybius, 6.39; Roth 1999, pp.18-9.
[30] Foxhall & Forbes 1982, p.74; Garnsey 1999, p.19.
[31] Popova 2002, pp.59ff; Buysee 2007, pp.261-2, pp.278-80.
[32] Davies 1971, pp.124-5; Junkelmann 1997, p.87, p.103; Roth 1999, pp.24-6.

foodstuffs enjoyed by a garrison soldier was much more varied than that documented in the literary record. There is no reason to think that the Danube garrison was any less well provided for than that in northern Britannia. Amphorae witness the consumption of Aegean and Black Sea wine, olives and *garum*. Unfortunately, the quantity of the finds cannot offer any indication of the scale of their consumption. Once the transport penalties are considered in Chapter Four, these amphorae are thought to have carried only luxury products for the officer classes. Zoo-archaeological studies at north-west European military sites suggest that the Roman soldier enjoyed a more privileged access to meat than the native population. The older view from King's studies [1984, 1999] ventured that beef dominated the military diet.[33] More recently it has been seen that pigs were more common, at least in the period immediately after the establishment of a garrison.[34] This is also seen in the zoo-archaeological reports from Novae and Nicopolis.[35] In the case of all these foodstuffs it will only ever be possible to estimate the quantities that might have been consumed based on the dietary needs of the garrison. The availability of the other essential, water, would have impacted on when and where the army might establish a garrison, or campaign. Troops required 2l of water a day in temperate climes, more in desert theatres.[36] It is safe to assume that water was normally available to a garrison along the Danube; beyond the river itself, aqueducts are evident at several forts so that this need is not pursued further.[37]

Cavalry mounts and pack animals would have required feed, hay or pasturage. Polybius again records the barley rations for legionary and auxiliary

[33] King 1984, pp.188-201; 1999, pp.139-44; Haynes 2016, pp.182-3.
[34] Stallibrass & Thomas 2008, p.155; Thomas 2008, pp.36-7; Cavallo, *et al* 2008, p.74.
[35] Makowiecki & Schramm 1995, pp.74-6; Makowiecki & Makowiecka 2002, p.212.
[36] Engels 1980, p.125; Roth 1999, pp.36-7.
[37] Tomas 2011, pp.59ff.

cavalry troopers.[38] However, his figures are quite high so that it is thought the rations pertain to remounts and/or pack animals.[39] Additional evidence is provided by both an Egyptian papyrus and a writing tablet from Carlisle.[40] Mules were the preferred pack animal of antiquity requiring about three quarters of the rations of horses. Donkeys and camels were also used, while oxen were the normal draught animals; all would have required fodder in varying amounts.

Firewood would have been required for cooking, heating and bathing. Timber was necessary for camp buildings; the permanent garrisons needed wooden buildings replacing every twenty years or so. Some modelling to illustrate the scale of this timber requirement has previously been carried out for Britannia.[41] Finally, a steady stream of replacement non-perishables such as tents, tools, and weapons would have been needed just to replace those lost through fair wear and tear, or in combat. I do not propose to pursue the investigation of supplying any of these items. My focus is on the food and then the arable part of that.

For the agricultural potential of the ancient world, the work of the agronomists has been variously considered and interpreted, most notably by Foxhall and Forbes [1982], Garnsey [1988, 2000] and Sallares [1991]. For agricultural practices Churchill-Semple's [1928] work is still influential, as is White's [1963, 1965, 1970]. Spurr [1986] carried out a thorough examination of the Roman agricultural writers with reference to pre-mechanised farming regimes. From this he proposed models of the likely workloads and outputs of individuals. His focus was on Italy, but his work can with caution be applied to the Danube. Duncan-Jones [1982] and Clark [1987] also looked at worker productivity, the latter also

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[38] Polybius, 6.39.
[39] Roth 1999, p.63; Hanson 2003, p.204.
[40] *P.Amh*. II.107 (AD 187); *Tab Lug* 1, Tomlin 1998, p.45, p.49.
[41] Hanson 1978; Shirley 1996.

comparing antiquity against more modern but pre-mechanised periods. However, Halstead's [2014] record of agricultural practice in pre-mechanised communities, reflecting a lifetime of observation across the Mediterranean, shows how one can only theorize about yields, agricultural practices and workloads, the actuality being incredibly diverse. These will all be considered in Chapter Two.

The quantification of the army's needs has all been done before, but what has not been done is a systematic identification and quantification of potential supply solutions to the army of a particular province. For the Imperial period Roth rather glibly reports that:

> '…. the provinces supplied and paid for the provisions needed by
> the armies that occupied them.'[42]

This is not very helpful. Nearly 40 years ago, Poulter [1980] made the case for the *vici* in Dobrogea being established for the express purpose of supplying the military with food. I shall return to Poulter's argument again and again, each time confirming the centrality of the *vici* to army supply. Poulter's argument can be seen to be supported by the work of the Romanian scholar Bărbulescu whose [2001] catalogue of sites was instrumental in the assessment of agricultural activity in Dobrogea. Poulter is further supported by Suceveanu although nationalist pride by Suceveanu diminishes the role that the Romans played against the scale of pre-Roman Getic activity.

[42] Roth 1999, p.165; a position also adopted by Kooistra 1996, p.9, p.117 in her study of arable productivity in the vicinity of part of the Lower German *limes.*

> 'Il convient de retenir, enfin, que les territoires de toutes ces villes connaissaient une intense vie rurale, stimulée par l'existence de nombreux villages (*vici*) …, de l'existence d'une vie rurale florissante avant l'arrivée des Romains.'[43]

After considering the *vici* in Dobrogea Poulter's focus went west to Nicopolis ad Istrum where more recently [2007] he made the case for a *villa* economy between Nicopolis and Novae on the river. Conrad and Stanchev [2002] and Conrad [2006] also produced reports from the hinterland of Novae. Together these studies allowed me to use the region between Novae and Nicopolis as my first study region.

The views of all these scholars contrast with the opinion of Batty [2007] who dedicated a huge tome to making the case for the wider Lower Danube being the backdrop for pastoralism and transient peoples, denying the place of agriculture in the region:

> 'Whereas Rome rapidly promoted farming in many other provinces, here the agricultural base, although evident, was not pre-eminent.'[44]

> 'We can imagine large cattle drives, and significant swathes of Imperial land preserved as ranches and ranges, as opposed to farmlands.'[45]

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[43] Suceveanu 1991, p.36.
[44] Batty 2007, p.459.
[45] Batty 2007, p.472.

Batty was influenced by Whittaker's view of the *limites* being porous zones of interaction, which he argues resulted in widespread migration and only nominal Roman control.[46] This ignores the practical benefits of the Danube as a frontier, something that will be seen to be borne out by the small number of Roman period settlements beyond the river.[47] Batty acknowledges, but dismisses the view of Gerov that there was an established Thracian society practising both agriculture and pastoralism prior to Rome's arrival.[48] Gerov believed that provincial organization subsequently centered on individual civic communities. This view is not without its flaws, it assumes far too much structure in the Roman administration, but Gerov did show that the Romans had control of their province. Batty's dismissal of Poulter's work may be forgivable in the case of Nicopolis if the relative dates of publication are considered, but his failure to acknowledge the importance of the *vici* is unexplained. It is true that the Delioram plateau and Ludogorie east of Novae were seemingly underdeveloped; but it is as if Dobrogea was an anomaly that did not fit Batty's view and so is ignored.[49]

The sources of the army's food leads directly to a discussion about taxation and the wider economy. Tacitus uses two terms for tax levied in 1st century Britannia, both *frumentum* grain, as tax in kind, and *tributum* which may imply coin.[50] Some historians see tax in kind as normal, especially on the remote regions where there is little evidence for a monetary economy.[51] If this tax were a 10% tithe on grain-producing lands, this might at first suggest that a massive agricultural regime ought to have been at work. Yet the evidence that derives from Egypt

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46 Whittaker 1989, pp.62-9, 1994, pp.72-5, pp.86-97.
47 Rankov 2005a, pp.175ff.
48 Gerov 1988, pp.1-25; *contra* Batty 2007, p.460.
49 Batty 2007, esp pp.329-35, pp.347-422, pp.437-79.
50 Tacitus, *Agr* 19.
51 Erdkamp 2002, pp.59-60; Whittaker 2002, p.228.

shows forced purchase was most common. Therefore, of the 90% not directly extracted as tax, much more could have been purchased by the army. Hopkins' [1980] influential taxes and trade model argued for taxation across the empire being spent on the periphery and this in turn stimulating monetization and trade to the frontiers. This is my preferred understanding of how the Roman army was funded. Thus the tax product of the wider empire could have been spent purchasing produce on the *limes*. It may have also been used to purchase more distant supplies. For a provincial garrison beyond a general acknowledgement that responsibility rested with the procurator, how this was exercised in reality is not well understood. The painted markings of individual *negotiatores* and *nautae* on the Rhône suggest that they acted predominantly as military suppliers; in all cases they are civilians.[52] Remesal Rodriguez has also shown how certain producers were encouraged to provide to the military.[53] It would make sense for the provincial procurators to turn to trusted *negotiatores,* so that market forces certainly seem to have had a place in the supply of goods over long-distances, but with official direction. Several short papers [Adams 1999; Erdkamp 2002; Monfort 2002; Rathbone 2007, Kehne 2011] collate the epigraphic and papyrological evidence to reconstruct elements of the supply system to the army. Egypt figures high in the available evidence and should not be discounted as atypical when much that is seen seems reasonable to transfer elsewhere. To consider who was administering to army logistics, Chapter viii of Rickman's [1971] study, together with Adams [1999], who reconstructs the system in Egypt, give the best interpretations of the evidence. What these show is a plurality of methods and means; there is no evidence to suggest a central commissariat for the army. When Roth did consider these aspects of supply, he

[52] Middleton 1979, pp.81-90; Drinkwater 1983, pp.127-8; Whittaker 1994, pp.105-7, 2002, p.211.
[53] Above, p.23, fn28.

strove to make it fit his pattern of supply lines between established depots and so assumed a uniformity of organization that is not evident. As with Roman government *per se*, diversity was key. These issues will be further discussed in Chapter Two.

For the army in garrison the problems of transportation must have made local supplies very attractive. Yet it would have been risky not to have had alternative supply lines in case of poor local crop yields, or rebellion. Additionally certain products, especially olive oil and wine, were produced only in the Mediterranean so that amphorae carrying them have become the most important indicator of trade routes in the Roman world. For the *limes* zones the most commonly seen amphorae type are Dressel 20 carrying olive oil. Again this suggests a military diet, but this should not be overemphasized, as the officer corps may have had a very different diet from the regular legionary or auxiliary. Some Dressel 20 amphorae marked with the stamps of particular manufacturers and traders have been found almost exclusively on military sites on the north-west frontiers.[54] Similarly, particular Rhodian, Campanian, [Dressel 2-4], and southern Gallic [Dressel 30] amphorae are almost all found only at military sites in the north-west provinces.[55] On both the Middle and Lower Danube there was a shift from imports of western Baetican and Istrian amphorae in the 1st, to late 2nd centuries to those from the Pontic region and the Aegean, together with local products thereafter.[56] This is unsurprising as the garrison ceased to be expeditionary and became more established. The standard works here are Bjelajac [1996] for modern Serbia corresponding to the province of Upper Moesia, and Dyczek [2001] who

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[54] Whittaker 1989, p.70; Remesal Rodriguez 1986, pp.35-79, 2002, pp.299-300; Funari 1996, pp.85-6; Carreras 2002, pp.80-1; Erdkamp 2002, p.67; Haynes 2016, p.175.
[55] Peacock & Williams 1986, p.62; Whittaker 1994, p.105.
[56] Bjelajac 1996, pp.122-4; Dyczek 2001, *passim.*

produced a comprehensive work for Lower Moesia and Dacia. Examples of one common Aegean and Pontic type, Zeest 90, are found stamped with legionary markings LEG I, LVM and LE V, which suggest organised supply of wine to the legionary units *I Italica* and *V Macedonica* posted to Novae and Durostorum respectively.[57] However, despite Dyczek's industry his work does not allow us to quantify the scale of supply of such products. What can be said is that from the later 2nd century onwards locally produced amphorae become more common and these may imply vineyards close to Novae at least.[58]

Baetican oil and Aegean wine clearly would have been moved by ship. That private individuals are seen producing and shipping olive oil to the Rhine via the Rhône, might by analogy suggest that private shippers were contracted to carry state cargoes on the open water also. There were certainly tax breaks for ship owners who supplied grain to Rome; similar arrangements for those moving food to the army are possible but un-proven.[59] It has been suggested that the major grain producing provinces such as Egypt, Africa and Anatolia supplied distant legionary garrisons.[60] If this happened then either the dispatching provincial authorities or receiving garrisons could have paid the shippers, although there is no certain evidence of this being the case. Sea-going freighters could travel at between 2-5knots, 3.7-9.25km/ph, depending on the winds, and were normally limited by the season. My preferred long-distance supply solution to Lower Moesia is the Crimea. Ships travelling from Chersonesus in the Crimea to Dobrogea, a distance of *c* 600km, at a speed in the middle of the above range would have completed the journey in 93 hours. Even allowing for loading and unloading, this was a week's

[57] Dyczek 2001, pp.173-96.
[58] Dyczek 2001, pp.225-8, pp.242-50.
[59] Gaius, *Inst* 1.32c, Digest, 50.5.3.
[60] Mitchell 1993, pp.250-1; Levick 2004, pp.186-7; Roth 1999, p.166.

work at most. With cargo capacities of between 50 and 200 tonnes, a single cargo can be seen to have provided several weeks' supply for individual military units. Ancient shipping might also often have been able to travel considerable distances up-river before transfer to smaller vessels. Strabo describes the utility of the Gallic rivers for doing so, although he also points out the trouble of travelling against the current on the Rhône.[61] Similarly, to travel against the considerable current on the Danube would have been no easy task. The amphorae discussed above show that western supplies did get to Lower Moesia, but I would suggest that they did so overland to the rivers Sava and Drava before travelling downstream. The movement of stores by river is evident from scenes on Trajan's Column where rowed boats carrying barrels, packs, and bundles, together with both troop and horse transports are depicted.[62] However, this is in a campaign context where normal economies do not apply.

Also pointing against widespread riverine commerce is a dense distribution of roads in Dobrogea; this together with the local agricultural economy that will be examined in Chapter Three implies a local supply solution utilising pack and draught animals. For the road network of the region a body of work is presented by Panaite [2006, 2010, 2011, 2012, and 2015]. Trajan's Column is routinely used as a starting point for the examination of ancient freight carriage. However, cargo capacity is impossible to discern from this and a more productive method is to consider the evidence of the recent colonial past and the developing world. This has been extensively done by Raepsaet [2002] and succinctly so by Goldsworthy [1998], in the last case with reference to 19th and early 20th century military

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[61] Strabo, 4.1.2, 4.1.14; Roth 1999, p.196.
[62] Lepper & Frere 1988, Scenes, ii-iii, xxxiii-v, xlvi-vii.

manuals.[63] The major drawback of overland supply is that, with every day travelled, the effective load is diminished by the weight of food that the animals need to consume to continue. Therefore overland supply would have been best employed when moving between established way-stations where pasture was available and fodder might have been moved in bulk in order to sustain the animals as they carried their load towards a garrison. Several Vindolanda texts show wagons supplying the garrison; a reconstruction of one suggests the wagons belonged to local hauliers who were paid for their labours.[64] Yet in Dobrogea, transportation of some state goods, not explicitly military supplies, was carried out in the 2nd century as a public duty, *munus*.[65] Again it is in a campaign context that attempts have been made to quantify the transport requirements, and Engels [1980] and Peddie [1997a, 1997b] do so most effectively.

Because transport was seasonal and heavily dependent on the weather, every Roman fort possessed at least one granary – a *horreum*. Tacitus records that those in Britannia could hold a year's supply, something broadly corroborated by archaeological evidence.[66] On the Danube Later Roman period *horrea* are known at the forts of Novae, Capidava, Iatrus and Dichin.[67] In north-west Europe some granaries had a greater capacity and probably acted as magazines or depots. These were normally positioned at the nodal points of the road systems or at ports, so that stores could have been mustered prior to onward movement to garrison forts or campaigning armies. In Germany at Rödgen, three massive granaries existed with a ground plan of 3400m^2, but to a height of 5m; as a minimum enough space for 3000

[63] Wolseley 1871; War Office Veterinary Department 1908, cited by Goldsworthy 1998, pp.293-5
[64] *TV* 3.583-584, 3.649; Adams 2003, pp.559-60.
[65] *ISM* 1.378; Stoian 1959, pp.369ff.
[66] Tacitus, *Agr* 22; Gentry 1976; Roth 1999, p.176.
[67] Klenina 2005, pp.403-4; Rizos 2013, pp.660-1; von Bulow 2007, pp.466-8; Poulter 2007b, p.92.

tonnes of grain or a year's supply for *c* 9,000 men if only piled 1m high.[68] The supply station at South Shields can clearly be seen to have housed some 24 granaries at its greatest extent, enough to hold *c* 3400 tonnes of grain.[69] This was most probably originally constructed in support of Severus' Scottish expedition of the early 3rd century. It remained in use as a supply depot, through the 3rd century into the 4th century when a third of the granaries were converted back to barracks.[70] In my study area, there is a recently discovered granary at Poşta near Noviodunum which has been suggested as being part of a similar supply station; although the site requires fuller excavation to see if, and how far, any further granaries actually extended.[71]

So, overall we have snippets of information from throughout the empire but no coherent scheme as to garrison supply. In large part this must have been driven by differences in local settlement activity and degrees of Romanisation, coupled to a pragmatic approach to the issue.

1.1.3 Research questions and methodology

Three research questions were chosen to build up a picture of the supply solutions and mechanisms based on the evidence available.

1. What quantity of land was required to support the garrison in food?
2. Where were the sources of supply?
3. What would have been the impact of moving these supplies to the garrison?

To answer the first question, requires an estimate of the garrison size, so that a review of the diplomas will produce a paper figure for the garrison size in the

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[68] Rickman 1971, pp.239-40; Roth 1999, p.177; Kehne 2011, p.333.
[69] Bidwell & Speak 1994, pp.26-30.
[70] Anderson 1992, p.70, p.73; Bidwell & Speak 1994, p.29, p.33, Hodgson 2001, pp.26-35; Hanson 2003, p.207.
[71] Lockyear *et al* 2011, p.47.

mid-2nd century when the most complete record is available. Using the already-reported figures of Polybius for rations this can be translated into a quantity of both wheat and barley required by the garrison. This figure is used for want of another closer to the time, but it is thought safe because calorific needs would not have changed significantly in the 300 years after Polybius. Then a consideration of different yields of the major grain crops and a consideration of fallow regimes will arrive at a range of possible landholdings required to supply the already calculated quantity of wheat and barley. These yields and fallow regimes shall be derived from the literary record of the Roman agronomists and checked against the practice in more modern but pre-mechanised farming communities. The productivity of agricultural workers in antiquity and the pre-mechanised world together with evidence for ancient land holdings per worker will be used to suggest a number of farm workers that would have been required to farm the land from which the garrison was fed. These workers themselves and their dependants will have also needed land turned to food, all adding to the total quantity of land required. For yields the evidence of Columella is most attractive, but high and low alternative figures will be used to arrive at parameters for the quantity of land required. An understanding of the benefits of fallow in the Roman period seem to suggest that where possible this should have been practiced, although the alternative of a no fallow regime will also be considered. Similarly a high and low landholding per worker will be considered. From these calculations it will be seen that some combinations of low yields, fallow and landholding will have been unviable, in that farm workers could not have produced a surplus at all. Further calculations will argue against higher yields and larger landholdings because farmers would have required so little land for themselves that their surpluses would have been prodigious. There is only a single reference to exports from the region, in an honorific inscription that is thought to be reporting the exceptional not the normal.[72] It is therefore possible to arrive at a pessimistic, but still viable figure for yields with an alternate fallow regime which will be taken forward. This is to be considered a low average figure, the actuality surely varied from year to year, but it is thought that by calculating the needs at such a figure it represents the worst sustainable case. Additionally the zoo-archaeological reports from the region will be consulted to suggest likely percentages of meat consumption. From this a suggested quantity of pasture for meat might also be found. It will also be necessary to consider, but not solve, the thorny question of how agricultural surplus was extracted, through tithe in the fields or as money taxes, in order to consider the total land requirement.

To answer the second research question of where were the supply sources, it is assumed that in the first instance a local supply solution was preferable for a garrison army: this is the assumption that is to be tested, together with the already stated belief that the *vici* were the chief suppliers. The whole province has not been surveyed so that in Chapter Three settlement activity in two areas, one around Novae and Nicopolis, the other in Dobrogea, will be used as exemplars of the likely scale of agricultural activity close to the *limes*. Between Novae and Nicopolis, the results of previous landscape surveys carried out by Conrad for Novae and Poulter for Nicopolis are spliced together to produce a possible agricultural landscape. In the second area of Dobrogea, the Romanian national database of archaeological sites – cIMeC provides the basis for surveying the region. This aims to record every archaeological site in the country and can be searched according to county,

[72] *CIL* 14.3608.

period and type of site among other criteria. Initially all the Roman period sites in Dobrogea will be searched for, here there are some complications because the dating is often quite wide and the follow up material either on the database itself or in the bibliographies of the sites have to be consulted to ensure that what is listed as Roman can really be considered as such. Nevertheless cIMeC provides an opportunity to draw up an initial list of sites all from one place. Then with reference to the follow up material again, and more traditional scholarship in especially Bărbulescu's, Baumann's and Suceveanu's work, the archaeological sites reported will be categorized into three artificial groupings. This is done with reference to the ground plans, and so accommodation available for agricultural workers, in the few excavated examples in Dobrogea and also with reference to similar sites in north-west Europe. The first group comprises the *vici* and *komai* type settlements, often only evidenced by inscriptions and not positively located, so not actually on the database at all. In the second category are the small farms – too often referred to as *villae* without any qualification of what this means; I only include those sites where a staff seems likely as small farms. In many cases cIMeC reports simply a settlement site – *aşezare* in Romanian – with little other information; these form the third group and are considered single family residences. Poulter has suggested a developed '*villa'* landscape with potentially very high outputs between Nicopolis and Novae, however, this is thought to be too optimistic and there will be a scaling back of the number of small farms from that which he suggests. In Dobrogea, although the garrison size was derived from a very specific point in time – AD 145-57, the dating of the cIMeC material and even that of the few excavated sites is rarely so precise, while also in many cases habitation stretched over considerable periods. Therefore all sites of a Roman Imperial date are considered as to whether they may have been providers of agricultural produce. Those few sites with just Republican artifacts are discounted, as are purely Later Roman period sites, isolated finds of all periods and coin hordes. Within cIMeC funeral tumuli are sometimes recorded, yet these are rarely located with any precision or dated, so that it is difficult to know whether to associate them with another site or treat separately; or indeed to treat as Roman at all. Additionally they are normally reported as being grouped around a particular village so that it is difficult to be sure how many tumuli or settlement sites might be in evidence. However, this can be seen to be understandable, because when very rarely, tumuli are individually reported on cIMeC the data for a particular village or commune can soon become overwhelmed by the number of these tumuli entries. Were every tumulus diligently recorded throughout cIMeC the database would soon become unwieldy. In addition to those few tumuli recorded on cIMeC, another large dataset of tumuli was provided by Dr Ioana Oltean for southern Dobrogea. A starting assumption is that these tumuli indicated settlement activity. The distance between tumuli had already been assessed within ArcGIS through the process of buffering which produces radii around each tumulus. Where these radii or buffers overlapped they were merged and the tumuli aggregated, so that in excess of 8758 tumuli had been categorized as 2244 settlement foci referred to as tumuli buffers. Then the aggregated tumuli buffers were grouped into size classes according to the level of aggregation. Those buffers of the higher aggregation classes might be indicative of larger settlement centres and will be considered further. Some new settlement patterns and likely settlement centres can also be discerned from the distribution of tumuli buffers. However, because they are undated it is difficult to apportion a part of them to the Roman period. Added to this, the issues of aligning them with the cIMeC material, and the fact that the data only exists for a third of the whole study area of Dobrogea, means that when it comes to calculating arable potential they are not included with the cIMeC material. Finally in Dobrogea a division between that land best placed to serve the *limes* and that best placed to serve the *poleis* on the Black Sea shore is necessary to acknowledge that the army would have not been the only consumer. This is carried out with reference to the physical geography and the perceived size of the *chorai* of the *poleis*.   What will be arrived at is a catalogue of sites which are divided into the three artificial categories of *vici*, small farms and individual households, and then assigned a nominal landholding. These are further allocated to either the *limes* or *poleis* providing zones from which it is possible to argue for a part of the needs of the garrison and the *poleis* being available in the local vicinity of each. It is also possible to suggest the scale of the likely deficit, that part not available locally. The end result is therefore a model of how much, and which land, was best placed to provide to the garrison.

Having identified a potential local solution to the garrison's needs the impact of moving these supplies to the garrison is measured in Chapter Four. A survey of the extensive road network of the region will first be carried out. Then with reference to limited documentary, legal and iconographical evidence, transport technology in the ancient world will be considered and four different transport methods will be chosen to investigate further: oxen-drawn wagons moving at two different speeds, mule-drawn wagons and mule-trains. There are countless permutations of which produce might have travelled to which fort and initial calculations employ radii from the forts to identify those producers closest to consumption centres. This however fails to take into account the lie of the road network, something which can be accommodated by using the Service Area function of ArcGIS. This function takes account of the supposed road network to produce irregular polygons showing the area within any given travelling distance of a consumption centre. The program measures the half-distance between two or more forts in a similar manner to Voronoi analysis, and produces irregular polygons that give a pictorial representation of the area best placed to serve each particular fort. The potential suppliers identified in Chapter Three within these areas are then counted and their arable potential allocated against the needs of the particular forts from which the Service Areas is produced. Subsequent Service Areas are produced at two to five-day intervals from those forts until all the needs are met or all the arable potential is allocated. The overall effect is to build tabular models found at Appendix B for Novae-Nicopolis and Appendix C for Dobrogea, of how the garrison might have been supplied using the four different transport methods. From these tabular models it is possible to calculate the number of wagons or mule-train travelling days and so vehicles required annually. The figures arrived at are indicative of scale only, but do show that the transport penalties of a garrison would have been much lower than that of a campaigning army.

It is a fundamental of transport management that some part of the load-carrying capacity of an ancient vehicle needed to be turned over to carrying feed-barley, and with every day travelled the effective load would have been diminished. Within the study areas some land would have had to be given over to producing the feed-barley for the animals. In calculating how much land ought to have been turned to this feed-barley there are inherent errors brought about by differing specific densities of wheat and barley. The arable potential in an area could be seen as a weight of wheat and that weight divided by wagon capacity to arrive at an estimated number of wagons required. When the necessary land to produce feed-barley for this estimated number of wagons is deducted from the arable potential originally seen, then because less land was required for a given weight of barley than wheat, a greater weight of grains would have been produced from the land than first calculated and so a higher overall load was possible. However, this in turn would have required more wagon space and more feed than initially estimated. Several repetitive calculations are necessary before equilibrium is achieved. Further repetitive calculations are required when long-distance modelling is carried out because, if any long-distance component used locally produced feed-barley to move it overland in the region, then the quantity of local land available to feed the garrison would have decreased so that the deficit increased further, but at the same time the feed-barley required to move the diminished local component also decreased. These calculations shall be carried out in Excel using logic equations to act as simple algorithms to speed up the repetitive nature and to allow key variables such as the yields, fallow regimes and also cargo capacity of the wagons to be adjusted relatively quickly. The end result is that the relative merits of how much additional land would have been required to provide feed for a particular transport method, against the number of vehicles required can be suggested. Finally the logistical price of moving higher value goods long-distances in amphorae will also be considered.

1.1.4 Summation

The précis of our knowledge of Roman military logistics to date shows above all else that diversity was the key to success. The layout of the thesis in Chapters Two to Four, address each research question in turn, Chapter Two relies most heavily on the historical record, while Chapter Three considers archaeological data and in Chapter Four mathematical modelling takes place. Tables of putative needs and other issues are provided in Part Two for reference alongside the main text, together with a catalogue of the sites identified in Dobrogea. Both the tables and catalogue are included within the total word count. Additionally, I include Appendices where the calculations for those alternative yields and productivities that are considered, but not preferred in Chapter Two and for the transport solutions modelled in Chapter Four are laid out. Because these calculations are extensive they are not included within the word count. It is to be hoped that the models produced will show how the army could have been supplied. It is further hoped that the models can be built upon, and used again to investigate other *limes* zones.

Chapter Two: The needs of the garrison and the economics of supply

Introduction

In this Chapter I am going to quantify how much land the Lower Moesian garrison would have required to be cultivated in order to be fed. I will also consider the number of farm workers necessary to till that land. It is however, obvious from the start that sufficient agricultural land was available, otherwise the army could not have remained on the frontier for the 200 years following the Dacian wars that it did. The argument for the quantity of land required for grain revolves around the writings of the agronomists, most importantly Columella. These ancient sources also provide some clues for considering how much land and how many workers were involved in producing other crops. They are less useful when considering the raising of livestock, and I have had to rely on figures pertaining to modern farming practice. Although I consider a range of possibilities, in general I have taken figures relating to the most marginal of land and assumed low carcass weights, to try and diminish the benefits of modern farm science before transferring the figures back to the ancient world. There were some scenarios that were dismissed as simply unviable, but I have sought to be realistically pessimistic throughout. Nevertheless, it is acknowledged that many of the figures used are open to debate. The second part of the Chapter is a consideration of the economic conditions that allowed this arable production to meet the military's needs.

Chapter Two Section One: How many men? How much land?

2.1.1 Garrison size

I have considered the garrison in the mid-2nd century because that is when the documentary evidence for auxiliary units is most abundant. Zahariade and Gudea catalogue 108 military sites of the Imperial period in the province. Clearly they cannot have all been occupied simultaneously by whole units, not even a full cohort, yet many show a legionary presence, so that detachments – *vexillationes* – around the province were seemingly commonplace.[73] Hunt's *pridianum* makes it clear that a third of the unit concerned, the *cohors I Hispanorum veterana equitata*, were absent from their headquarters on various duties *c* AD 105.[74] This is not at all problematic when trying to estimate the total agricultural needs of the garrison, but it will impact upon the validity of the transport solutions in Chapter Four, where I model assuming units, or parts of units were at particular forts.

There were three legionary units in Lower Moesia: *legio I Italica* at Novae, *legio XI Claudia* at Durostorum and *legio V Macedonica* at Troesmis.[75] The latter departed for Potaissa in Dacia *c* AD 167. For the auxiliaries the most informative diploma RMD 399 (RMD 165 is another less complete copy of the same constitution) of 7th April AD 145 specifically states that there were five *alae* and 11 *cohortes* in the province naming all of them; *classiarii* are also included.[76] RMD 50 of probably AD 157, also records that there were 5 *alae* listing four of them; the reconstructed text indicates that here were 11 *cohortes*, of which 9 are listed.[77]

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[73] e.g. Dimum, Krivina, Pietrosani, Trimammium, Sexaginta Prista, Tegra, Transmarisca, Tegulium, Sucidava, Sacidava, Capidava, Dinogetia, [Barboşi] Halmyris; Zahariade & Gudea 1997, pp.73-82.
[74] *P.Lond*. 2851; Lepper & Frere 1988, pp.244-9.
[75] Farnum 2005, p.79.
[76] Roxan 1994, pp.286-7; Holder 2006, p.813.
[77] Roxan 1978, pp.72-3.

RMD 399(165) AD 145	**RMD 50 AD 157**
alae	
I Gallorum et Pannoniorum	*I Gallorum et Pannoniorum*
I Gallorum Atectorigiana	*I Gallorum Atectorigiana*
I Vespasiana Dardanorum	*I Vespasiana Dardanorum*
I Flavia Gaetulorum	
II Hispanorum Aarvacorum	*II Hispanorum Aarvacorum*
cohortes	
I Bracarorum[78] *cR*	*I Bracaraugustanorum cR*
II Mattiacorum	
I Flavia Numidarum	*I Flavia Numidarum*
I Claudia Sugambrorum vet eq	*I Claudia Sugambrorum vet eq*
	I Lusitanorum Cyrenaica
II Chalchidenorum sagittariorum	*II Chalchidenorum sagittariorum*
I Cilicum sagittariorum	*I Cilicum sagittariorum*
I Thracum Syriaca eq	*I Thracum Syriaca eq*
I Germanorum	*I Germanorum cR*
II Bracaraugustanorum eq	*II Bracaraugustanorum eq*
I Lusitanorum Cyrenaica	
II Flavia Brittonum eq	

There is close agreement between these two texts, the order in which the units appear – itself an indicator of unit seniority – varies only slightly, so that these

[78] A variant spelling of *Bracaraugustanorum*; Roxan 1994, p.286.

two constitutions form the basis for the standard list of units in the 2nd century. Another diploma of *c* AD 155, although less complete, shows five of the eleven known cohorts but adds a new unit, *I Cisipadensium*, previously attested in Thrace in AD 138; it is suggested that it transferred to Lower Moesia as a replacement for *cohors II Mattiacorum* after AD 145.[79] RMD 241 of AD 127 shows that all five *alae* listed above and eight of the ten *cohortes* were already in place 18 years previously; *CIL* 78 of AD 134 is also confirmatory, recording two of the *alae* and five of the *cohortes* listed above.

Home stations for the *alae* are known for *I Gallorum Atectorigiana* at Appiaria [Riahovo], *I Vespasiana Dardanorum* at Arrubium [Măcin] and *II Hispanorum Aarvacorum* at Carsium [Hârşova].[80] The *cohors I Bracaraugustanorum/Bracarorum cR* is known in Lower Moesia AD 99-134, but also confusingly in Dacia AD 129-140, so maybe the unit was split; it reappears in Lower Moesia AD 145-157 possibly stationed at Slaveni on the modern river Olt.[81] Detachments of *cohors II Mattiacorum* are known at the forts at modern Barboşi, Dinogetia and Appiaria, while the major garrison was Sexaginta Prista [Ruse]. In the latter half of the century it was in Thrace but returned to Sexaginta Prista as a *milliaria equitata* unit by AD 198.[82] The forts of *cohortes I Flavia Numidarum,* and *II Chalchidenorum sagittariorum* are unattested. *I Claudia Sugambrorum veterana equitata* is known at Montana but with *vexillationes* at Sucidava [Izvoarele].[83] *Cohors I Cilicum Sagittariorum* was at work at Tropaeum Traiani in AD 177 but

[79] Spaul 2000, p.464; Holder 2006, p.835.
[80] Suceveanu 1991, pp.63-4; Zahariade & Gudea 1997, pp.79-80; Spaul 1994, pp.34-5, p.48, p.102.
[81] Spaul 2000, pp.88-9.
[82] Suceveanu 1991, p.66; Zahariade & Gudea 1997, p.74, pp.80-1; Roxan & Eck 1997, p.198; Spaul 2000, pp.243-4.
[83] Suceveanu 1991, p.65; Zahariade & Gudea 1997, p.77.

was also posted to Sacidava [Dunăreni].[84] *Cohors I Thracum Syriaca equitata* is known through the first half of the 2nd century at Transmarisca [Tutraken].[85] *I Germanorum* distinct from a unit of the same name serving in Germania garrisoned Capidava [Capidava] in the second century with detachments at Tomis.[86] The home station of *II Bracaraugustanorum equitata* is unknown. *Cohors I Flavia Lusitanorum Cyrenaica equitata* is evident at Tropaeum Traiani [Adamclissi], but its main base was probably Cius [Gârliciu].[87] *II Flavia Brittonum equitata* is seen throughout the 2nd century at Sexaginta Prista.[88]

As regards unit strengths, for the legionaries I have included one servant for every eight-man *contubernium,* and one for every centurion. For the auxiliary units two servants for each *decurio* and one for each *duplicarius.* I exclude the retinues of the senior officers which are difficult to quantify. At Table 2.1.1.1 below, I arrive at nominally 6059 men, including servants, per legion in garrison. With regard to the number of auxiliary cavalry horse, I add 10% for remounts, and a further two extra horses for each *decurio* and one for each *duplicarius,* which results in an additional 20% of horses. At Table 2.1.1.2, I have suggested unit sizes for auxiliary units, and the numbers of horse. These figures assume a complete complement of men, documentary evidence from around the empire regularly suggests units were below strength because of attachments elsewhere, but the full strength is the worst case scenario with respect to the quantity of food required and

[84] Scorpan 1981, pp.98-102; Suceveanu 1991, p.65; Zahariade & Gudea 1997, p.78; Spaul 2000, pp.397-8.
[85] Suceveanu 1991, p.64; Zahariade & Gudea 1997, p.75; Spaul 2000, p.366.
[86] Suceveanu 1991, p.65; Zahariade & Gudea 1997, p.79; Spaul 2000, p.256; Bărbulescu 2001, p.105.
[87] Suceveanu 1991, p.65; Spaul 2000, pp.59-60; they were present at Castellum Candida in the 3rd century.
[88] Suceveanu 1991, pp.65-6; Zahariade & Gudea 1997, p.74, pp.81-2; Spaul 2000, p.199; n.b. 3rd century *vexillationes* at Aegyssus are not included in the modelling.

these are the figures to be followed.[89] With regard to mules and oxen supporting these units, although a campaign figure might be estimated, it is not possible to guess how many would have been in use for the garrison until the likely supply sources and transport solutions are investigated in Chapter Four.

Table 2.1.1.1: Legionary complement

Legionaries (54 centuries of 80 men and 5 centuries of 160 men)[90]	5,120
Cavalrymen[91]	120
Servants one per *contubernium*[92]	640
Servants one per cavalryman	120
Servants one per centurion	59
Garrison total men	6,059
Legionary cavalry horse[93]	144 horse

Table 2.1.1.2: Auxiliary unit strengths

Type of unit[94]	No of cavalry	No of infantry	No of servants	Total men	Total horse[95]
ala milliaria	768		168	936	994
ala	512		112	624	662
cohors equitata milliaria	240	800	164	1,204	288
cohors equitata.	120	480	93	693	156
cohors milliaria		800	110	910	
cohors		480	66	546	

89 e.g. *PLond*. 2851; Breeze 1984, p.268 suggests a 15% reduction to account for diversions.
90 Goldsworthy 1998, pp.13-14; Roth 1999, pp.21-2; Campbell 2003, p.28.
91 Davies 1989, p.153; Campbell 2003, p.28.
92 Roth 1999, p.114 suggests two per *contubernium*.
93 Includes 20% as remounts and extra horses for cavalry officers; Hyland 1990, p.89 uses 10%
94 [Hyginus], *De mun castr* 16, 27-28; Arrian, *Tact* 18; Vegetius, *Mil* 2.14; Cheesman 1914, pp.25-30; Holder 1980, pp.8-10; Roth 1999, pp.335-8.
95 With 20% extra remounts and two extra per *decurio* and one extra per *duplicarius*; Davies 1989, p.153; Hyland 1990, p.89; Roth 1999, pp.335-8.

The size of the Moesian fleet is uncertain. That it had interests beyond the province at Chersonesus is well accepted: a *trierach* is epigraphically attested in AD 185, and other fleet elements are supposed.[96] Chersonesus will be discussed as a long-distance supply solution in Chapter Four.[97] There is a reference in Josephus that the northern Black Sea was patrolled by 40 long-ships and garrisoned by 3000 men, but this is part of a speech extolling the strength of Rome and looks to be hyperbole.[98] A permanent garrison was not established there until *c* AD 140; thereafter legionary *vexillationes* of all three Lower Moesian legions, together with auxiliaries of *ala I Gallorum Atectorigiana, cohortes I Bracarorum, I Cilicum, I Claudia Sugamborum* and sailors are in evidence at various times.[99] Therefore one could legitimately reduce the size of the provincial garrison by the number of men posted to Chersonesus. Despite Josephus' report, Klenina estimates nominally 1380 troops, Zubar reckons on 1000.[100] Thus the total troop numbers within the province could be reduced by as much as *c* 1500, which is a 5% reduction. However, because of the uncertainty surrounding the size of these detachments it was decided to continue with a garrison within Lower Moesia at full strength as the worst case option. That said any sailors or troops posted to Chersonesus are thought to have had ready access to food and calculations of their needs are not carried out.

There is still the fleet element within the province to consider. It is generally held that the Moesian fleet comprised *liburnae* not triremes, and an inscription from Noviodunum refers to a *liburna armata*.[101] If these vessels were river *liburnae*, scaled down versions of the sea-going *liburnae*, then a sailing crew

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[96] *CIL* 3.14214[34]; Suceveanu 1991, p.67; Bounegru & Zahariade 1996, pp.11-12, p.32, p.116; Klenina 2005, p.404; Zubar 2007, p.742; Rummel, unpublished.
[97] Chapter Four, pp.271-3.
[98] Josephus, *BJ* 2.16.4.
[99] Klenina 2005, p.403; Zubar 2007, pp.737-42.
[100] Klenina 2005, p.403; Zubar 2007, p.758.
[101] *ISM* 5.273; Suceveanu 1991, p.67; Bounegru & Zahariade 1996, p.52.

of 55-60 is thought likely, together with maybe 20 marines.[102] As far as the number of ships within the fleet, it has been suggested that because the British and German fleets had between 40 and 80 vessels and their prefects held centenary prefectures, while the Moesian prefect held a sexagenary position, then the Danubian fleet ought to be no bigger.[103] So with 40 vessels and 80 men to a vessel that would equate to 3200 *classiarii*.

Bounegru and Zahariade do not offer a number of men in the fleet; but they do suggest 20 fleet stations all along the river.[104] Recently Rummel has questioned the assumption that the fleets were wide ranging forces for frontier control and pointed out how tenuous the material, including that of Bounegru and Zahariade, is on which the existence of fleet stations is supposed.[105] Rummel's point that a few brickstamps do not a fleet station make is well made. Indeed, applying his own stringent criteria, he notes that the only truly credible fleet stations in Lower Moesia are the headquarters at Noviodunum and a likely detachment at Tomis. So although it is reasonable to infer that the fleet was used for riverine communications and had landing stations at most of the *limes* forts, it does not mean that these represent sizable detachments of *classiarii*. Several commentators however, do suggest that Axiopolis ought to have had a fleet presence, its location being too suitable not to conjecture a fleet element there.[106] Despite the lack of consensus, I assume 3200 *classiarii* in the province: 400 at the Black Sea ports, 1200 at Noviodunum, 400 at Axiopolis and another 1200 on the upper reaches, moving between Sexaginta Prista,

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[102] Rankov 2005b, p.64; Bounegru & Zahariade 1996, pp.55-6 suggest more marines.
[103] Rummel, unpublished.
[104] Bounegru & Zahariade 1996, pp.10-15, pp.82-9; *cf* Suceveanu 1991, pp.67-8.
[105] Rummel, unpublished.
[106] Matei 1991, p.150; Suceveanu 1991, p.67; Bounegru & Zahariade 1996, p.15; Zahariade & Gudea 1997, p.78; Bărbulescu 2001, p.113; Oltean, pers comm.

Novae, Dimum and Ratiaria. This is the greatest unknown in the whole calculation for troop numbers.

Thus, the assessment of total troop numbers for Lower Moesia comes in at 18,177 legionaries with 432 horse, 9861 auxiliaries with another 4090 horse, and a questionable 3200 *classiarii*. This gives a total of 31,238 men and 4522 horse.

One final desirable would be a greater understanding of the use and the garrison of the Valu lui Traian. The high number of sizable forts and fortlets on the large earthen wall has been shown to be able to accommodate the entire Lower Moesian garrison, although such a high density of occupation would only be appropriate for a particular military imperative.[107] If this did form the frontier on occasion it would impact on the productivity of this region, with many settlement sites to be discussed in Chapter Three outside of the ramparts. However, the epigraphic evidence from the vici especially points to a vibrant civic community through the 2nd and 3rd centuries. Rankov's view is that the area was never 'lost' but as raiding increased in the later 3rd, early 4th centuries the need to protect Thrace further to the south might have necessitated the use of a second defensive line.[108] The ramparts leave us with a conundrum that potentially impacts on both garrison size but also regional output, so that a greater understanding in the future might result in changes to the models proposed hereafter. Nevertheless, for the time being a possible troop disposition of the province is laid out at Table 2.1.1.3 below, from which a provincial need can be calculated.

[107] Rankov 2015, p.71.
[108] Rankov 2015, pp.78-9.

Table 2.1.1.3: Troop Distribution: Lower Moesia

Unit	Fort	Men	Horse
legiones			
Legio I Italica	Novae *vexillationes* at Montana	6059	144
Legio XI Claudia	Durostorum	6059	144
Legio V Macedonica	Troesmis	6059	144
Legionary total		**18177**	**432**
alae			
I Gallorum et Pannoniorum	?	624	662
I Gallorum Atectorigiana	Appiaria	624	662
I Vespasiana Dardanorum	Arrubium	624	662
I Flavia Gaetulorum	?	624	662
II Hispanorum Aarvacorum	Carsium	624	662
cohortes			
I Bracarorum cR	Slaveni on river [Olt]	546	
II Mattiacorum	Sexaginta Prista *vexillationes* at Dinogetia, [Barboşi] building at Appiaria	546	
I Flavia Numidarum	?	546	
I Claudia Sugamborum vet eq	Montana with *vexillationes* at Sucidava	693	156
II Chalchidenorum sagittariorum	?	546	
I Cilicum sagittariorum	Tropaeum Traiani & Sacidava	546	
I Thracum Syriaca eq	Transmarisca	693	156
I Germanorum cR	Capidava	546	
II Bracaraugustanorum eq	?	693	156
I Lusitanorum Cyrenaica eq	Cius *vexillationes* at Tropaeum Traiani	693	156
II Flavia Brittonum eq	Sexaginta Prista	693	156
Auxiliary Total		**9861**	**4090**
classiarii	Black Sea ports 400, Noviodunum 1200, Axiopolis 400, Sexaginta Prista, Novae, Dimum, Ratiaria 1200	3200	
OVERALL TOTAL		**31,238**	**4522**

2.1.2 How much food per man or horse?

Polybius, when describing the Roman campaigning army of the 2nd century BC, recorded that a Roman soldier received two-thirds of an Attic *medimnus* [52.5l] of grain a month, that is 32 *choenices* [35l].[109] One *choenix* had long been the normal daily ration for Greek troops from as far back as Herodotus.[110] Because of this and because a *choenix* [1.0938l] was almost the same as two Roman *sextarii* [1.078l], then Roth reasonably suggests that 'Polybius is probably thinking of a ration of one *choenix* a day' or 64 *sextarii* a month.[111] A similar figure is seen in Imperial Egypt where a slightly larger *artaba* [38.78l] was issued each month.[112] Cavalry soldiers in the Republic received more wheat, two *medimni* [105l] for legionary cavalry, one and one-third *medimni* [70l] for allies; the extra wheat is thought to have been to support their servants.[113]

Pliny recorded the weights of grain from particular provinces; he talks about the grain by itself; that is the naked wheat after threshing but before milling. The wheat produced closest to the Danube, Chersonesus bread wheat, had a weight of 20 Roman lbs/*modius* equating to a modern specific weight of 75kg/hl.[114] So Polybius' 1.078l ration of Chersonesus grain would have weighed 0.809kg. This grain would have had to be processed in order to make flour, the amount produced depending on the fineness to which it was ground and then sieved of bran. Moritz has made the case for army bread being whole-meal which seems reasonable: I doubt the army would have bothered to sift out the bran to produce finer flour and

[109] Polybius, 6.39.
[110] Herodotus, 7.187; Foxhall & Forbes 1982, pp.51-3.
[111] Foxhall & Forbes 1982, p.62; Anderson 1992, p.99; Junkelmann 1997, p.91; Roth 1999, pp.18-19; Hanson 2003, p.204; Kehne 2011, p.324; Garnsey & Saller 2014, p.115; *cf* Cato, *Agr* 56 whose field hands received similar quantities: 1.15l daily in winter, 1.29l daily in summer.
[112] Adams 1999, p.121; Rathbone 2007, p.170.
[113] Polybius, 6.39; Foxhall & Forbes 1982, p.62; Tomlin 1998, p.49.
[114] Pliny, *HN* 18.66.

whiter bread, which were more probably the preserve of the upper classes.[115] This is also borne out by the botanical remains found at Bearsden, where the consumption of spelt as bread, is identified by the very presence of bran fragments in human sewage.[116] There would have been some losses during the grinding process, but only in the region of a few percent, it is difficult to guess at an exact figure.[117] However, even if soldiers ate white bread, the energy from a given quantity of wholegrain is unaffected because the bran is indigestible and adds nothing to the calorific quality of the flour; this is present in the endosperm, the core of the grain that grinds finely to produce flour.[118] Therefore a smaller quantity of finely ground and sifted flour gives a similar amount of energy and protein as whole-meal flour, although retaining the bran has digestive benefits. Calories are not lost in baking.[119]

Today a soldier on active duty requires some 3600 calories a day.[120] The Roman soldier was shorter, on average older, and for much of the time in garrison, so although this figure can still reasonably be used for a campaigning soldier, it ought to be adjusted down to approximately 2900 calories for the soldier in garrison.[121]

A good guess for the normal part of the everyday diet made up of grain in antiquity is about 75%.[122] All cereals have similar energy values in the range of

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[115] Moritz 1958, pp.168-209, for a detailed consideration of extraction rates and types of meal produced; Roth 1999, p.46.
[116] Dickson & Dickson 2016, p.228, p.241.
[117] Moritz 1958, p.188; Foxhall & Forbes 1982, p.76 report 5.4% losses during grinding.
[118] Moritz 1958, p.153; Mann & Truswell 2007, p.354.
[119] Foxhall & Forbes 1982, p.80; Roth 1999, p.48 both *contra* Engels 1980, p.124.
[120] Engels 1980, p.123; Groenman-van Waateringe 1997, p.263 suggests 3400; Goldberg 2003, p.2096; Aylward, *et al* 2005, p.3; Roth 1999, p.7.
[121] Foxhall & Forbes 1982, pp.48-9; Junkelmann 1997, p.21, p.92; Roth 1999, pp.8-12.
[122] Foxhall & Forbes 1982, p.71, p.74; Garnsey 1999, p.19; Roth 1999, p.18; Garnsey & Saller 2014, p.110.

3100-3800 calories/kg; a typical value that I shall use is 3340 calories/kg.[123] Therefore Polybius' grain ration, if it were bread wheat, would have provided 2702 calories, 75% of a campaigning soldier's calorific needs and 93% of the garrison soldier's calorific requirement. Civilians surely often fared less well; following modern third world subsistence figures Garnsey has calculated a minimum requirement of 200kg of wheat equivalent *pa,* of which 75% i.e. 150kg was actually grain, while Hopkins argued for a minimum of 250kg of wheat equivalent.[124] The idea of wheat equivalent focuses on the preponderance of grain in developing world economies, to simplify needs. Therefore a 200-250kg wheat equivalent requirement implies 150-188kg of wheat per civilian. If I assume that civilians ate 70% as well as soldiers, and so consumed 0.5663kg of bread wheat a day, this would equal 207kg *pa*, well within the minima suggested. This is all quite straightforward and is the line that has been followed by Roth and others to arrive at similar daily consumption figures.[125]

The following digression goes by way of a summary of grain types found in antiquity and their uses: For a long time the most common grain was emmer, *Triticum dicoccum,* a husked grain, which could thrive in all soil types and climatic conditions; it was resistant to pests both in the fields and in storage, indeed if reaped by the ear it could be stored as such.[126] Instead of threshing it required de-hulling which often involved parching or roasting, followed by pounding before preparation as groats, *alica*, from which porridge, *puls* could be made, or ground further to

[123] Foxhall & Forbes 1982, p.46; Garnsey 1999, p.20; Mann & Truswell 2007, p.353; those in my larder today have 3160 & 3340 calories/kg.
[124] Garnsey 1988, p.91; Hopkins 2002, pp.197-8.
[125] Gentry 1976, pp.23-4; Engels 1980, pp.123-6; Evans 1981, pp.432-3; Foxhall & Forbes 1982, pp.62-5; Anderson 1992, p.99; Goldsworthy 1998, p.291; Roth 1999, p.43.
[126] Columella, *Rust* 2.6; Pliny, *HN* 18.81; Spurr 1986, pp.11-13; Garnsey 1988, pp.50-1; Sallares 1991, p.347; Thurmond 2006, pp.17-19.

make flour for flat bread.[127] The de-hulling impaired its ability to produce leavened bread, but it was still widely used into the 1st century and probably beyond among the poor. Emmer was known in Latin as *adoreum, semen* or *far*, in Greek *ζειά* and *όλυρα*; the native Egyptian variety however, could be threshed. Uncommon in the Mediterranean, spelt replaced emmer as the dominant crop in northern Europe, because it was better suited to cold conditions.[128] Because I am focusing on Lower Moesia, I shall not consider it further. Durum pasta wheat, *Triticum durum*, was hard naked wheat raised in hot arid climes such as southern Italy and Africa that produced a coarse ground material, *semidalis*, akin to semolina.[129] Bread wheat, *Triticum aestivum*, preferred wetter transitional climes than durum wheat. It had soft naked grains which were freed from the husks through threshing.[130] The ease with which this could be done resulted in bread wheat becoming the dominant grain in antiquity replacing both emmer and durum wheat.[131] Bread wheat produced leavened bread initially for the luxury market, *panis siligneus*; the grain was recorded in Latin as *siligo*. The presence of Chersonesus bread wheat in Pliny and the closeness of Chersonesus to my study regions leads me to consider this the dominant wheat for my purposes.[132]

Millet is a generic name for a species of the grass family. The most important variety today is pearl millet, *Pennisetum typhoides*; it is unclear where

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[127] Pliny, *HN* 18.81-4, 18.92, 18.97, 18.109-16; Percival 1921, p.147, p.187; Moritz 1958, p.xxii, p.25-6, pp.147-150; Spurr 1986, pp.75-6; Sallares 1991, p.371; Junkelmann 1997, p.104, p.129; Roth 1999, pp.45-6; Garnsey 1999, p.120; Thurmond 2006, p.20; Dickson & Dickson 2016, p.240; n.b. Halstead 2014, pp.136-7 cites evidence contrary to the widespread belief that emmer always required parching.

[128] Anderson 1992, p.60; van der Veen & Palmer 1997, p.180; Kooistra 1996, p.120; Dickson & Dickson 2016, p.271.

[129] Columella, *Rust* 2.6; Pliny, *HN* 18.81; Moritz 1958, p.xxv; Spurr 1986, pp.15-17; Thurmond 2006, p.19.

[130] Columella, *Rust* 2.6.; Pliny, *HN* 18.81; Moritz 1958, pp.xxiii-iv; Spurr 1986, pp.15-17; Thurmond 2006, p19; Halstead 2014, pp.136-151.

[131] Junkelmann 1997, p.107, *cf* Haynes 2016, p.177 who suggests the army was a catalyst for wheat production.

[132] Pliny, *HN* 18.66.

this was grown in antiquity.[133] There is also common millet, *Milium* or *Panicum miliaceum*; also known as proso, and Italian or Foxtail millet, *Panicum*, *Panicum italicum* or *Setaria italica.*[134] Both were grown in antiquity and had a short three-month growing cycle; they were particularly resistant to drought and poor soils, so they were the fall-back grain for ancient farmers and were made into both bread and porridge.[135] There is continued extensive cultivation of common millet or proso north of the Danube today.[136] Rye and oats were apparently uncommon in the Mediterranean in antiquity, and as such, they shall not be considered further.[137] Barley, either six-row or two-row, *Hordeum hexastichum* and *Hordeum distichum* respectively, were grown extensively; the latter had a short three-month growing cycle and was thus less susceptible to pests. Barley was eaten as un-leavened bread or porridge by the poor, but only used as a punishment ration by soldiers.[138] In the northern provinces barley was used to make beer, but most importantly it was the principal animal feed.[139]

When considering the region, Dio reports that barley and millet were the main crops in Pannonia.[140] Pliny also recorded that the Sarmatian peoples preferred millet made into porridge to all other foods.[141] Much earlier Theophrastus had recorded that in Pontus:

[133] Rachie 1975, pp.2-3, pp.7-9.
[134] Rachie 1975, pp.2-3, pp.7-9.
[135] Theophrastus, *HP* 8.1, 8.7, 8.11; Polybius, 2.14; Columella, *Rust* 2.9.17-19; Pliny, *HN* 18.100-1; Strabo, 5.1.12; Moritz 1958, p.xxi; Spurr 1986, pp.89-102; Garnsey 1988, p.52; Halstead 2014, p.28
[136] Rachie 1975, p.12; Gomez & Gupta 2003, p.3977.
[137] Moritz 1958, p.xxi ; Spurr 1986, pp.13-14.
[138] Polybius, 6.38.3; Suetonius, *Aug* 24; Haynes 2016, p.177.
[139] Columella, *Rust* 2.9.14; Moritz 1954, p.xxi; Spurr 1986, pp.14-15; Junkelmann 1997, p.107; Stallibrass & Thomas 2008, pp.164.
[140] Dio, 49.36.2.
[141] Pliny, *HN* 18.100-1.

‘the hard crops are those of spring, the soft ones those of winter.’[142]

Hard wheat is normally taken to mean durum pasta wheat, while soft wheat normally refers to bread wheat.[143] Archaeological findings confirm that emmer was replaced predominantly by bread wheat in the Crimea and northern Black Sea coasts.[144] Bread wheat, millet and barley are also known from the Sarmatian region; durum wheat was evident but not common suggesting that Theophrastus’ spring-sown hard wheat was a minor crop.[145] It was the cultivation of bread wheat that ensured the importance of the region to the Greek and Roman world from the time of the Athenian empire onwards.[146] Returning to the Danube, charred remains of especially bread wheat, durum wheat, and millet are seen at Nicopolis ad Istrum in contexts of 2nd- 4th century date.[147] At nearby Dichin [Gradishteto] a 5th- 6th century site, barley, bread wheat, and common millet have all been found in large quantities.[148]

Pliny provides a list of specific grain weights with which to continue my investigation.[149] Unfortunately he sometimes contradicts himself, either through copying the work of others or because numerals are poorly transmitted through the literary tradition.[150] In the case of bread wheat I shall use his already mentioned figure of 75kg/hl for Chersonesus bread wheat, which is comparable to modern bread wheat with specific weights of 72-79kg/hl, and so continue with my ration of

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142 Theophrastus, *HP* 8.4.5-6.
143 Churchill-Semple 1928a, pp.73-4; Spurr 1986, p.15; Sallares 1991, pp.331-2.
144 Janushevitch 1984, p.269, p.271; Pashkevitch 1984, p.277.
145 Herodotus, 4.17; Pashkevitch 1984, pp.281-2; Sallares 1991, pp.331-2.
146 Garnsey 1988, pp.123-4; Moreno 2006, pp.189, 206-8.
147 Buysee 2007, p.261, p.269, p.278.
148 Popova 2002, pp.59ff.
149 Pliny, *HN* 18.66.
150 Moritz 1958, p.169 cautions against accepting Pliny’s figures too readily.

0.809kg a day.[151] Pliny gives a similar figure 20.33lbs a *modius* for African and Alexandrian wheat, which were probably durum wheat equalling 76kg//hl. Therefore, the Egyptian ration of a single artaba, 38.78l per month would equate to 29.5kg, so 0.982kg a day, a figure 21% higher than Polybius' ration. Elsewhere Pliny gives a barley weight of 15lbs/*modius* equalling 56kg/hl, this is a not impossible, but it is a very low figure: modern barley is typically in the range 60-67kg/hl.[152] Following Sallares, I will use a modern figure of 64kg/hl.[153] For emmer, Pliny says at one point that it is heavier than barley but lighter than bread wheat; yet he goes on to record that in northern Italy it weighed 25-26lbs/*modius*, which would equal an incredibly high 93-97kg/hl, much greater than the figures he cites for bread and durum wheat.[154] This is all suspect. Modern emmer weights are typically between 35-50kg/hl; the low specific weight is explained because the hulls, which are not normally removed through threshing, are lighter than the endosperm of the grain itself.[155] I will take a halfway house and use a high modern figure of 50kg/hl. Pliny gives no usable weight for millet, so a modern figure of 68kg/hl is used.[156]

Bearing these specific weights in mind, Polybius' volumetric ration of 1.078l would have varied in weight according to the type of grain issued. This is important because the calories are to be found in the denser endosperm of the grain,

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151 http://www.hgca.com/content.template/23/0/Varieties/Varieties/Varieties%20Home%20Page.mspx accessed 25/05/10.

152 Pliny, *HN* 18.62. http://www.hgca.com/content.template/23/0/Varieties/Varieties/Varieties%20Home%20Page.mspx accessed 25/05/10; http://eservices.afbini.gov.uk/recommendedvarieties/cereals/varieties accessed 25/05/10.

153 Sallares 1991, p.79.

154 Pliny, *HN* 18.62, 18.66-7.

155 Percival 1921, p.191; Stallknecht *et al* www.hort.purdue.edu/newcrop/proceedings1996/v3-156.html accessed 26/01/10.

156 Pliny, *HN* 18.54 records 60lbs, 19.38kg of bread from one *modius* of millet, but he explicitly reports that some of this weight came from the water; Spurr 1986, p.97 fn34 uses 70kg/hl.

whereas in the case of emmer the bulky but light hull adds no nutritional value, being indigestible. All cereals have similar energy values per kg, but the volume of a kilogram of each can vary significantly. Therefore, nutritional value is more closely related to the weight of the grain than the volume. If the date of Polybius' work is considered, bread wheat was still a luxury food; the literary tradition makes it clear that emmer was widely consumed during and after Polybius' time and although soldiers were privileged they were not significantly so.[157] Polybius uses *πυρός* for wheat, not *ζειά* and *όλυρα* the normal words for emmer, so he, as a member of the governing classes was probably thinking in terms of naked bread wheat, but it is far from certain that that is the type of grain which the soldiery themselves received at his time. If a part of the military diet included emmer, that in itself would not have been problematic, but if the ration remained at 1.078l the soldiers concerned were going to be somewhat short of calories in comparison to their counterparts issued bread wheat as Table 2.1.2.1 below illustrates. This uncertainty can however be sensibly qualified if I assume that emmer, durum wheat and millet were consumed in quantities equal in weight to those quantities of bread wheat derived from Polybius' volumetric ration; thus 0.809kg of any cereal is the ration to be assumed, providing, if bread wheat for argument's sake, 2702 calories. Because of this, for continued modelling I will only consider bread wheat for human consumption. I shall also assume that Polybius' figure continued into the Principate; this is for want of other evidence, but neither the calorific requirement nor the dominance of grain in the diet will have changed in that time. A reduced figure of 70% of this 0.5663kg which will be used for civilians supplying services

[157] Columella, *Rust* 2.6.3-4; Cato, *Agr* 10.85; Pliny, *HN* 18.81-4, 18.97, 18.109-16; Dickson & Dickson 2016, p.228 report the consumption of both emmer and spelt in the 2nd century fort at Bearsden.

to the military would have still produced 1891 calories, a quantity thought sufficient for many a healthy adult.

Table 2.1.2.1: Weight and calories of Polybius' volumetric ration by grain type

Grain type	Specific weight kg/hl	Weight in kg of 1.078l	Calories in 1.078l[158]
Emmer	50	0.539	1800
Chersonesus bread wheat	75	0.809	2702
Alexandrian durum wheat	76	0.819	2736
Millet	68	0.733	2500

I shall go on to consider other foodstuffs that might together have made up and probably exceeded the remaining calories required, but by following these figures probable losses in transport and through stock spoilage in storage can be negated. Furthermore, Polybius' figure may have sufficed as a planning assumption to ensure that the required quantity was always available.[159]

In addition to calories, grains provide considerable amounts of protein, B and E vitamins, and other nutrients including calcium and iron, so a predominantly grain diet can be healthy, although there are some illnesses associated with flour of high bran content such as emmer if it is habitually consumed as un-leavened bread.[160] Yet a high grain diet would be very dull, something a peasant might have to endure, but soldiers under the Principate were a privileged class and might expect more. That part of the diet not made up of grain was known as the *cibaria*. This comprised of salted meat, normally belly pork (*laridum*), pulses (*faba*), cheese

[158] 3340cal/kg assumed except for millet where Rachie 1975, p.48 suggests 3410 calories.
[159] Foxhall & Forbes 1982, pp.56-7, p.73.
[160] Foxhall & Forbes 1982, p.44; Sallares 1991, pp.275-6; Garnsey 1999, pp.20-1; Thurmond 2006, p.16; Mann & Truswell 2007, p.354 with un-leavened whole-meal bread, phytate acid in the bran impedes the absorption of iron and other minerals and can induce iron-deficiency anemia, dwarfism and rickets.

(*caesus*), salt (*sal*), sour-wine (*acetum*), or mixed with water (*posca*) and olive oil (*oleum*).[161] It is now well known through the Vindolanda texts and the sewage remains from Bearsden that soldiers on the northern frontier of Britannia enjoyed a full and varied diet; their colleagues on the Danube were no more remote so we might expect all manner of foodstuffs to have been consumed there also.[162] Davies' article that started the discussion about the military diet suggested that men in garrison ate the same types of foods as their civilian neighbours, but probably enjoyed easier access to these foods.[163] Diet changed regionally and seasonally, so that vegetables and pulses were indigenous varieties.[164] Olive oil was more commonly consumed around the Mediterranean than further afield, although there is good evidence for military supply patterns of olive oil to the north-western provinces.[165] In the north-west provinces, beer was more readily available than wine, and meat was probably consumed in greater quantity.[166] King has shown the relative consumption of different meats in the north-west frontier garrisons. Cattle being most popular, pigs a little less so, while sheep and goats were consistently the least popular food.[167] However, he can in no way suggest a likely daily intake. Recently it has been shown that pigs were more common in the period immediately after the establishment of a garrison, possibly because they were easily reared, although the presence of Italian legionaries rather than foreign auxiliaries might

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161 Scriptores Historiae Augustae, *Hadr* 10.2, *Avid Cass* 5.3, *Pesc Nig* 10. 3-4; *Tyr Trig* 18.6-9; Josephus, *AJ* 14.408 *BJ* 299; Appian, *Hisp* 9.54; Davies 1971, pp.124-6; Roth 1999, pp.24-6 elaborates.

162 e.g. *TV* 2.182, 2.191-3, 2.203-4, 2.302, 3.581-2, 3.586-8; Pearce 2003, p.935; Dickson & Dickson 2016, pp.231-2, pp.271-2; see also Körber-Grohne *et al* 1983, pp.50-1 table 7 for the variety of diet at German sites.

163 Davies 1971, pp.136-7.

164 Dickson & Dickson 2016, pp.272 suggest a uniformity of military diet that may be applicable to the north-west but I do not believe would have been practicable empire wide.

165 Remesal Rodriguez 1986, pp.35-79, 2002, pp.300-5.

166 Garnsey 1999, pp.125-6.

167 King 1999, pp.139-44; Roth 1999, p.28.

have also commanded more pork on the menu.[168] With reference to the Danube, the bone assemblages from excavations at the legionary site of Novae show that pig was still the most common animal type during the 2nd and 3rd centuries, followed by cattle then sheep, although fishes and birds also made up a considerable 30% part of these finds.[169] Estimates of meat consumption can only ever be speculative; daily allowances of 63, 162, and 450g have been put forward by separate scholars over the years.[170] These are really only guesses, but the evidence of the sewage deposits at Bearsden certainly points to meat being only a small part of the military diet.[171] The calories provided would have varied further according to the type and cut of meat, so 100g of roasted sirloin beef averages 280 calories, while 100g of belly pork averages 400 calories, but a chicken leg of 100g weight has only 180 calories. Modern minima are only 70g of all protein a day.[172] So despite the elevated status of soldiers, meat was probably still only eaten by most people in small quantities and I would favour a possible ration in the region of 100g, providing on average *c* 300 calories. This alone if added to Polybius' grain ration would have exceeded the calorific needs of a soldier in garrison.

Olive oil is rich in calories, a single tablespoon, 0.014kg providing 120 calories; some evidence of a ration might be suggested by a Later Roman papyrus which gives an allowance of 0.043kg daily so about 360 calories.[173] However, olives require a Mediterranean climate so that olive oil would have had to be imported to Lower Moesia. Some amphorae clearly show that this happened, but what they cannot prove is the quantity consumed or whether all soldiers, or only the

[168] Thomas 2008, pp.36-7, p.39; Cavallo, *et al* 2008, p.74; Stallibrass & Thomas 2008, pp.154-5.
[169] Makowiecki & Schramm 1995, pp.72-4, Makowiecki & Makowiecki 2002, pp.211-13.
[170] Davies 1997, p.271; Groenman-van Waateringe 1997, p.263; Roth 1999, pp.32, 43; Kehne 2011, p.324; *cf* Hanson 2003, p.205.
[171] Dickson & Dickson 2016, p.227, p.240; Breeze 1984, p.269.
[172] Roth 1999, p.8.
[173] *P.Beatty Panop* 2.245-9; Roth 1999, p.35.

officers, enjoyed it.[174] Wine contains on average 770 calories a litre, beer only 410 calories; half a litre of either adds again to the calorific intake of the garrison.[175] Legumes and pulses, being high in proteins, were until recently the poor man's meat; in antiquity they were also more commonly consumed because of the absence of new world vegetables.[176] Spurr notes that from a dietary perspective only a sixth as many legumes are needed as cereals, so I shall assume a daily allowance of 0.135kg.[177] Fruit and other vegetables were surely consumed by the army, possibly in similar quantities. My figures above are of course speculative, and in the case of a garrison soldier he would be getting far more calories than he needed. Table 2.1.2.2 below refers. If the lower figures of 0.5663kg of grain and 70% of all the other products were used, then still *c* 2800 calories could have been provided, these figures will be used for the civilians. Although a garrison soldier might have also survived on this low ration, I will assume the higher ration as the worse case.

Table 2.1.2.2: Putative daily ration

Food type	High Ration		Low Ration	
	Quantity	Calories	Quantity	Calories
Grain, bread wheat	0.809kg	2702	0.5663kg	1891
Meat	0.100kg	300	0.070kg	210
Olive oil	0.043kg	360	0.03kg	251
Wine	0.5ltr	385	0.35ltr	270
Pulses, fruit and other vegetables	0.270kg	200	0.189kg	140
Total		3947		2762

The cavalry mounts would have required fodder, of which there are three types: hard fodder is grain, normally barley, although beans and acorns soaked in

[174] Dyczek 2001, *passim*; Chapter Four, pp.270-1.
[175] Cato, *Agr* 57 suggests 0.92-1.32 *sextarii* 0.5-0.71l of wine daily; Roth 1999, pp.37-8.
[176] Junkelmann 1997, p.137 *cf* Körber-Grohne *et al* 1983, pp.50-1 for finds of thousands of beans, peas and lentils at the fort at Neuss in Germany.
[177] Evans 1981, p.433; Spurr 1986, p.111; Garnsey 2000, p.682; Roth 1999, p.33.

water also suffice; green or dry fodder is a product grown specifically for animals, such as bitter vetch, hay and straw; finally there is pasturage, crops eaten directly from the field.[178] Polybius again records that a legionary cavalryman received seven Attic *medimni* and an auxiliary cavalryman five Attic *medimni*, that is 42 and 30 *modii* of barley a month; these are considerable quantities, but a cavalryman probably had a remount and/or, a pack animal, so dividing the legionary figure by three and the auxiliary figure by two, a single animal more probably consumed 14-15 *modii* a month, equating to about 2.5kg of barley daily.[179] This figure is broadly supported by an Egyptian papyrus and a Carlisle writing tablet.[180] I shall follow Roth and assume 2.5kg of barley was consumed per horse daily.[181]

Mules were the preferred pack animal of antiquity. Modern comparative evidence from the late 19th century suggests a daily ration of 4.5kg barley, but at other times only 2.3kg; Roth's assessment is that these are still excessive and 2kg daily is the figure that I will pursue.[182] Oxen were the normal draught animals, for which Cato recommends 2.758kg of soaked acorns day, or better simply that they were put to pasture, together with various green fodder options.[183] The comparative evidence here suggests only between 1.4 and 2.7kg of barley, to augment grazing as the preferable way of feeding oxen, assuming of course that grazing was available.[184] I will assume a daily intake of 2.25kg of hard fodder for oxen. The range of possibilities in these cautions us to take any average figure as indicative

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178 Roth 1999, pp.61-7, p.125; Halstead 2014, pp.50-4.
179 Polybius, 6.39; Hyland 1990, p.90 equates this to 1.5kg a day assuming an unspecified number of remounts; Johnstone 2004, p.45 suggests 1.65kg; *cf* Hanson 2003, p.204.
180 *P.Amh*. II.107, 20,000 *artabae*, 775,600l *pa* if divided by 662 horse assuming remounts = 3.21l x 0.64kg/hl, 2.05kg daily; Adams 1999, p.120; *Tab. Lug.* 1 Tomlin 1998, p.49.
181 Roth 1999, p.64 followed by Kehne 2011, p.325; *cf* Engels 1980, p.18, p.126 who assumes 4.5-5.5kg hard fodder 4.5-5.5kg green fodder; Rathbone 2007, p.170.
182 Wolseley 1871, p.47; Junkelmann 1997, p.53, p.64 suggests 3kg; Roth 1999, p.66; Kehne 2011, p.325.
183 Cato, *Agr* 54, 60.
184 Wolseley 1871, p.47; Goldsworthy 1998, p.293 fn25; Roth 1999, p.66.

only, so that my assumptions are made in order to progress the argument.

Considering green fodder or pasturage, the quantity depended on the size of the animal and the work it was turned to, and average figures of 5kg a day for equines, 11kg for oxen are suggested.[185] Any vegetative material might suffice: barley, emmer and millet were all used for grazing or cutting green as fodder, together with certain legumes and vetches; also the straw and chaff left over from cereal crops was used.[186] Grass and clover could be provided in meadows, *prata*, through part of the year. If hay were to be grown for the winter months, then by the end of May animals would have to be excluded to allow the grass to grow and then be cut.[187] This might happen two or three times before the autumn when animals were allowed back to graze, before being fed from the stored hay.[188] However, a great deal of land was probably never managed but could still be used for grazing until depleted and then left to recover.

Both men and animals would also have required water, the quantity depending on the work they were doing, the climate and, in the case of animals, the form their feed was provided in.[189] It is safe to assume that sufficient fresh water was available along the Danube, either from the river, or as is known from Novae, Oescus and Durostorum, through aqueducts fed from the surrounding hills.[190]

Therefore, for the purposes of moving the argument forward the Lower Moesian garrison, of 31,238 men consuming 0.809kg of bread wheat daily would

[185] Hyland 1990, p.90 suggests 4.5kg; Junkelmann 1997, p.53 suggests as much as 10kg; Goldsworthy 1998, pp.293-4; Roth 1999, p.62, pp.66-7; Johnstone 2004, pp.53-4 follows Hyland; Rathbone 2007, p.170 suggests 7kg.
[186] Cato, *Agr*, 27, 30, 54, 60; Columella, *Rust* 6.3.3-4, 7.3.22; Varro, *Rust* 1.31.4-5; Pliny, *HN* 18.120, 18.142; Spurr 1986, p.12, pp.107-8, p.114, pp.119-20; Halstead 2014, pp.50-5, p.78, p.133.
[187] Pliny, *HN* 18.67.
[188] Cato, *Agr* 8.1, 149.1; Varro, *Rust* 1.37.5; Columella, *Rust* 2.17-18; Pliny, *HN* 18.258; Spedding 1983, p.646 for similar modern practice; Fox 1986, pp.532-3 for similar Medieval practice Spurr 1986, pp.122-5; Hyland 1990, pp.91-2.
[189] Hyland 1990, p.96; Roth 1999, pp.35-6.
[190] Tsarov 2007, pp.217-24; Tomas 2011, pp.61-6.

have required some 9,224 tonnes *pa*, while the 4,522 cavalry mounts would have required 4,126 tonnes of barley *pa*.

2.1.3 How much land did the army need?

This requires a consideration of the likely yields of particular cereals, but such estimates of yields are compromised by uncertainties in the qualities of the grains used, the soil characteristics, and farming methods.[191] There is however, the relatively detailed evidence of the Roman agricultural writers, the agronomists. Medieval records, and more modern but pre-mechanised reports, also offer comparable data sets. In addition, experimental archaeology in the Butser farm project can be considered. Modern yields can be seen to have significantly increased in the recent past, particularly as a result of the so-called green revolution, because of which direct comparison with modern examples is to be avoided; figures are included for illustration only. I shall have to return to the specific weights already discussed, because from antiquity until modern times grain yield was measured by volume, although the nutritional value is more easily identified in terms of weight as I have done above. Specific weights change according to the stage at which the grain is being processed, whether it is threshed, winnowed, ground or tamped down, therefore I will keep to a whole grain requirement.[192]

The literary evidence of the agronomists is the starting point for investigation into ancient crop yields.[193] That Varro and Columella both continue to quote Cato indicates a certain continuity of farm practice in the period 200 BC - AD 100 and the acceptability of all three.[194] Their views represent richer

[191] Rathbone 2007, p.170 notes the uncertainties of doing so.
[192] Moritz 1958, p.169; Foxhall & Forbes 1982, p.78.
[193] Goodchild 2013, p.61.
[194] Laurence 1998, p.138.

landowners with larger farms, arguably the sort of agriculture that could have produced a surplus to direct to the army, and these views ought to reflect real conditions in antiquity. These authors were dealing with Italy where, excluding the very south of the country, the climate was not dissimilar to continental Europe. The European climate as a whole was warmer in antiquity: known as the Roman warm period, it is thought to have peaked *c* AD 150, possibly being 2^0 C warmer than today and also having higher annual rainfall; both factors should have been favourable to cereal production.[195] Today along the Danube winters are colder than in much of Italy, spring is cooler, and only in high summer are the temperatures similar.[196] Rainfall on the Lower Danube is on average 500-750mm annually, comparable with Tuscany and the Po valley, both areas considered by the agronomists.[197] The main study region of Dobrogea and the Scythian plains to the north of the Lower Danube are the driest regions, having less than 500mm rainfall annually, but they are also the hottest in summer; these do not present the best conditions for arable production.[198] It is impossible to say with any certainty how different the climate of the Danube might have been from that of Italy, but I do not believe it was so significantly different as to rule out the evidence of the agronomists.

Farming methods and timings will have varied according to climate, local topography and crop type. Emmer, durum and bread wheat were normally sown in the autumn, to allow for germination and sufficient growth to survive winter.[199] Growing commenced again in the warmth of spring and rain fortified the crops,

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[195] Martinez-Cortiza *et al* 1999, pp.939ff; Reale & Dirmeyer 2000, p.165, p.171 argue it was wetter but not warmer.
[196] www.metoffice.gov.uk/weather/europe accessed 6/03/10.
[197] Churchill-Semple 1928a, pp.63-5; www.icpdr.org accessed 6/03/10.
[198] Churchill-Semple 1928a, pp.63-5; Oltean & Hanson 2007, p.77; Ivanov 2012b, p.46; Hanson & Oltean 2012, p.318; www.icpdr.org accessed 26/04/10.
[199] Columella, *Rust* 2.8.1-2; Pliny *HN* 18.201-6; Spurr 1986, p.21, pp.42-3; Roth 1999, p.137.

before drying weather preceded a May or June harvest in the warmer Mediterranean.[200] In Dobrogea, the grain harvest today comes in July to the end of August, and this probably reflects the conditions in antiquity.[201] Where winters were harsh or followed autumn rapidly then spring-sown bread wheat might have been used, but the autumn sown crops generally produced better yields having spent a greater period in the ground to grow.[202] Because of their short growing cycle common millet and barley were normally sown in the spring.[203]

The agronomists do not fully agree about crop performance, but some sense can be derived from them. They report yields as the ratio of seed to return, that is a so-many-fold return, something which can only be pursued if the sowing rate is known. Columella and Varro both emphasize the importance of local topography, climate and season, on particular sowing regimes.[204] Great variation is also reported in the pre-mechanised Mediterranean.[205] Nevertheless, for average land Columella recommends sowing five *modii* of wheat, *Triticum*, which could mean either bread, or durum wheat, five *modii* of six-row barley, six *modii* of two-row barley, and ten of emmer per *iugerum*; millet was to be sown particularly thinly at only four-five *sextarii*, 0.25-0.3125 *modii*/*iugerum*.[206] Varro and Pliny broadly agree.[207] These figures equate to 8.56-10.7, 171, 171, 205 and 342 litres per hectare for millet, bread or durum wheat, six-row barley, two-row barley and emmer respectively. A sowing rate of 171l/ha for bread wheat at 75kg/hl equals 128kg/ha

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200 Churchill-Semple 1928a, pp.73-4; Spurr 1986, pp.42-4, p.66; Garnsey 2000, p.685; Roth 1999, p.137.
201 https://cereals.ahdb.org.uk/media/801669/Romania-competitor-report-FINAL.pdf accessed 13/04/17.
202 Columella, *Rust* 2.6.2, 2.9.7-8; Pliny, *HN* 18.69, 18.183; Churchill-Semple 1928a, pp.73-4; Spurr 1986, p.21, p.43; Sallares 1991, p.329.
203 Theophrastus, *HP* 8.1.2; Pliny *HN* 18.250; Spurr 1986, p.21, p.96; Halstead 2014, p.28.
204 Columella, *Rust* 2.9.2; Varro, *Rust* 1.44
205 Halstead 2014, pp.21-31.
206 Columella, *Rust* 2.9.1-6, 2.9.15-18, 11.2.75.
207 Varro, *Rust* 1.44; Pliny, *HN* 18.198.

and for durum wheat at 76kg/hl equals 130kg/ha. In the case of barley sowing at 171-205l/ha with a specific weight of 64kg/hl, this equals 110-132kg/ha. For emmer, assuming a specific density of 50kg/hl sown at 342l/ha, then 171kg/ha would have been required. Finally, in the case of millet at a modern 68kg/hl, a mere 5.82-7.28kg would have sown a hectare. This accords with the low end of modern sowing rates, typically 5-40kg/ha according to Spurr.[208] The greater sowing volume of emmer, and to a lesser degree barley, is explained by their being sown with the husks on and therefore being bulkier.[209]

So, returning to the yields, unless otherwise stated, I shall assume the sowing rates just cited. Columella expected returns of only four-fold on unspecified grain, *frumentum*; this would result in a return of 20 *modii/iugerum*, in modern terms 685l/ha or more usefully by weight 514kg/ha of bread wheat and 521kg/ha of durum wheat.[210] Cicero recorded yields on rich volcanic Sicilian soil sowing at six *modii/iugerum* of between eight and ten-fold, amounting to 48-60 *modii/iugerum*, or 1644-2055l/ha, equalling 1233-1541kg/ha if bread wheat, and 1249-1562kg/ha if durum wheat.[211] Varro also reported optimistic yields of 10-15 fold in parts of Etruria while still sowing at 5 *modii/iugerum*, equalling a return of 50-75 *modii/iugerum*, or 1284-1926kg/ha if bread wheat and 1301-1952kg/ha if durum wheat.[212] There is also evidence from Egypt where the nature of the annual inundation produced high average yields. Private land in Egypt was normally taxed at one *artaba* of wheat [38.78l] per *aroura* [0.2756ha], equating to 107kg per ha; because tax is generally thought to have been a 10% tithe, this would indicate a

[208] Spurr 1986, pp.96-7; https://www.ag.ndsu.edu/crops/other-crops/2007-proso-millet accessed 14/04/17; Halstead 2014, p.28.
[209] Spurr 1986, p.56.
[210] Columella, *Rust* 3.3.4.
[211] Cicero, *Verr* 2.3.112.
[212] Varro, *Rust* 1.44.1.

1070kg/ha yield.[213] An assessment of rents at Oxyrhynchus concluded that yields were a little higher, 12 *artaba* per *aroura* on average, 1283kg/ha.[214] Additionally the evidence from the Arsinoite estate of Aurelius Appianus shows an average of 11.5 *artabas* per *aroura*, 1230kg/ha.[215] In these cases the calculations have assumed durum wheat. Another document, from Palaestina Tertia, albeit from the Later Roman period, gives wheat returns of 6.7-7.2 times of that sown: although the sowing rate does not survive, assuming this was 5 *modii/iugerum*, then a return of 33.5-36 *modii/iugerum* would have been achieved, that is 872-937kg/ha if durum wheat.[216] Some very much higher yields are also cited by ancient sources that probably refer to seeds on single plants that have tillered extensively without any competition; these will not be considered further.[217] For barley yields there is no explicit literary reference. If Columella's expected four-fold return for grain is applied to his stated sowing rates of 5-6 *modii/iugerum*, then a 20-24 *modii/iugerum* return would equal 438-526kg/ha. Alternatively, if Varro's expected 10-15 fold return was applied to barley, then on his stated 6 *modii* sowing that would equate to 60-90 *modii/iugerum* or 1315-1973kg/ha. The Palaestina papyrus gives barley returns of 8-8.7 fold which, assuming Columella's sowing rates, would equate to 877-1144kg/ha. There is no specific ancient reference to emmer returns either; anything between Columella's four-fold and Varro's 10-15 fold returns might have applied. Neither is there any record of millet's likely yield. The reported returns are tabulated in Part Two at Table T.1.1.1a-c.

As a comparison, English Medieval account rolls are worth considering because work was still mostly done by hand and there is a considerable body of

[213] Rowlandson 1996, p.29, p.37, p.54; Rathbone 2000, p.51, 2002, pp.168-9.
[214] Rowlandson 1996, pp.248-51 Fig 6.
[215] Rathbone 1991, p.243 followed by Rowlandson 1996, p.247.
[216] *P.Colt* 82; Meyerson 1984, pp.243-5.
[217] Pliny, *HN* 17.41; 18.94-5; Varro, *Rust* 1.44.2; Strabo, 17.3.11; Sallares 1991, p.377.

detailed evidence within them.[218] However, because emmer had long been abandoned by this time, and durum and millet were not northern crops, the evidence is only applicable to bread wheat and barley. I know of no Medieval records from the Danube. Seed rates recommended by the anonymous author of the *Hosebonderie* were 131-163kg/ha for bread wheat and 223kg/ha for barley.[219] Similar figures are recorded on the account rolls of the Winchester Abbey manors, while the Battle Abbey manors' records show a thicker sowing regime: commonly wheat was sown at 196kg/ha and barley as thick as 334kg/ha.[220] Thus the Medieval English sowing regime was not dissimilar to that of Columella and Varro for wheat, but barley was apparently sown considerably thicker.

Figures recording Medieval English yields generally exclude a one-tenth tithe taken in the field; because of this I will add one-ninth to the figures cited.[221] The Winchester manors' records show that there was a huge range in annual yields: sometimes less, or only just more, than the amount sown was reaped, yet occasionally nine-fold returns were achieved. The average yields for both wheat and barley between AD 1200 and 1500 was 3.8 fold; adding one ninth, this becomes 4.22 fold.[222] This equates to 551-688kg/ha for wheat and 941kg/ha for barley. The records of the Battle Abbey manors from the same period average returns of 3.78 fold plus one ninth, so 4.2 for wheat and 3.206 plus one ninth that is 3.56 for barley.[223] These equate to 823kg/ha of wheat and 1190kg/ha of Barley. These broadly agree with the 10 bu/acre, 653kg/ha that Walter of Henley suggested and 11

[218] *cf* Garnsey & Saller 2014, pp.103 are dismissive of such comparison believing in better performance in Roman times.
[219] Wheat 2-2.5 Winchester bushels/acre, barley 4 Winchester bushels/acre; Brandon 1972, p.409.
[220] Slicher van Bath 1963, p.173; Brandon 1972, pp.408-9 Table 2.
[221] Slicher van Bath 1963, p.172; Titow 1972, pp.8, 37; Brandon 1972, p.413.
[222] Slicher van Bath 1963, pp.13-176; Titow 1972, p.4 Tables 1, 13, 2a, Appendices C, D, G & H; Farmer 1977, pp.555-66; this data is now available online at Campbell 2007 http://www.cropyields.ac.uk accessed 23/03/2010.
[223] Brandon 1972, pp.412-19; Farmer 1977, p.561.

bu/acre, 718kg/ha that the *Hosebonderie* deemed a proper return for wheat.[224] Thus the recorded data show that when the sowing density was similar, yields exceed the ancient material by 35-50%; this is not so great as to dismiss the transferability of the agronomists to the Danube. Again Table T.1.1.1a-c summarizes.

The agronomists may also be compared with more modern yields prior to mechanisation and the use of fertilizers.[225] In Sicily and Tuscany in the early 20th century returns in excess of ten-fold caused White to argue against Columella in favour of Varro's higher returns.[226] However, Spurr showed that over the whole country from the Medieval period until the mid-20th century, yields were generally lower.[227] Halstead provides a range of figures from around the pre-mechanised Mediterranean; it is his view that modern estimates of ancient yields below 650kg/ha are actually pessimistic.[228] In the early 20th century average bread wheat returns were 1280kg/ha in Romania and 1011kg/ha in Bulgaria.[229] In Dobrogea which is drier than Romania as a whole, the average figure for the 1943-1944 crop was 750kg/ha for bread wheat and 600kg/ha for barley.[230] For illustrative purposes only, by the 1970s Bulgaria's average yields had increased to 3670kg/ha, Romania's were 2490kg/ha, while the former Soviet Union, including the northern Black Sea coast, only managed an average of 1520kg/ha.[231] When, briefly under the Communist regime, irrigation systems were employed in Dobrogea wheat yields rose to 3800-4000kg/ha [232] Also from the modern epoch, but considering the developing world, it is possible to see average wheat yields of only 700 kg/ha in the

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224 Brandon 1972, p.417.
225 Although see White 1970, p.145 for use of natural fertilizers.
226 White 1963, pp.207-10, 1965, p.102.
227 Spurr 1986, pp.85-8.
228 Halstead 2014, pp.240-2, p.250.
229 Percival 1921, p.415.
230 Lup & Miron 2013, Table 1.
231 Hazell 1989, pp.20-5 Table 2.4.
232 Lup & Miron 2013, Table 3, 2015, p.204.

1950s, rising to 2241kg/ha by 1996.[233] The dramatic increase resulted from the selective use of particular varieties (the green revolution), together with the widespread use of fertilizers and increased mechanisation.[234] Therefore, there is a wide range of reported yields, but excluding 1940s Dobrogea and the developing world in the 1950s, these figures far exceed the ancient evidence and ought not to be taken any further.

At the Butser farm experiment, emmer was grown in accordance with believed Iron Age technologies. The seeding rate of 63kg/ha was significantly lower than Columella's recommended 171kg/ha. Considerable annual yield variations were observed that could be directly attributed to weather, but over a 14-year period the average return was 1740kg/ha, an impressive seed-to-return ratio of 1:28, with a lowest recorded yield of four-fold.[235] However, it must be remarked that the well-drained chalk soils at Butser were particularly well-suited to cereals, the climate was wet but still warm, and most critically the soil had been virgin prior to the experiments and probably had a high content of organic matter.[236] These returns achieved at Butser do however show what might have been produced in antiquity when conditions were good. Emmer was also grown as spring-sown dinkel in early 20th century Germany; when sown at a rate of 220kg/ha yields averaged 1250kg/ha.[237] In northern 20th century Spain 1250kg/ha was considered a poor return, 1875kg/ha normal, and 2500kg/ha good for emmer.[238] Other modern reported yields for emmer as an alternative crop are extremely variable 225-

[233] www.fao.org/inpho/content/compend/text/ch06.htm accessed 29/05/10.
[234] Hazell 1989, p.13, p.19 Table 2.3.
[235] Reynolds 1985, p.399; 1992 Table 4.
[236] Anderson 1992, p.100; Sallares 1991, p.386.
[237] Percival 1921, pp.326-7.
[238] Halstead 2014, p.239.

3700kg/ha.[239] This wide range, limited data sets, and the use of modern techniques and fertilizers, mean that little can be argued from these figures.

In the absence of an ancient yield for millet, a modern figure of 1:50, if applied to Columella's recommended lower sowing figure of 5.82kg/ha, would result in 291kg/ha.[240] In the mid-20th century, yields in Russia of unspecified millet, most probably proso or common millet, were recorded as averaging 450kg/ha; the world average yield in 1981 was 680kg/ha.[241]

Whilst overall favouring the ancient material, my preference is for Columella's four-fold over Varro's 10-15 fold return. The main reason is the closer agreement with the Medieval data, which is in itself quite secure. Another influence is that it is lower than the yields obtained in 1940s Dobrogea and the developing world of the mid-20th century. Finally I prefer to err on the side of caution in all my calculations and adopt the worst-case scenario. That is not to say that Varro and Cicero were reporting falsely or were being overly optimistic, simply that they were considering particularly fertile regions, the exceptional, whereas Columella was looking to the norm.[242] But whether it was a four-fold or ten-fold return, one part would need to be returned to seed. Thus, for bread wheat, a four-fold return of 514kg/ha less one part for seed is reduced to a net return of 385kg/ha, which is the figure I shall use; for durum wheat, 390kg/ha. With regard to barley, the greater volumetric yield of the Middle Ages can be explained by a thicker sowing density, but in terms of a so-many-fold return the Medieval data broadly agrees with Columella again. Thus for six and two-row barley, a four-fold return on

239 Troccoli & Codianni 2005, p.297; Stallknecht *et al* www.hort.purdue.edu/newcrop/proceedings1996/v3-156.html accessed 26/01/10.
240 Columella, *Rust* 2.9.18, 11.2.75; Spurr 1986, pp.96-7.
241 Rachie 1975, p.44; Kent 1983, p.14; https://www.ag.ndsu.edu/crops/other-crops/2007-proso-millet (accessed 25/05/10).
242 Evans 1981, p.434; Duncan-Jones 1982, p.49 fn4; Sallares 1991, p.378.

a five-six *modii* sowing equals 438-526kg/ha, less one part seed corn, gives an effective return of 329-395kg/ha. With emmer, the modern material does not help and again the choice is between Columella and Varro. Sticking with Columella, a four-fold return on a 10 *modii* sowing results in a yield of 685kg/ha less a quarter for seed, so 514kg/ha. A 50-fold return on millet sown at 5.82kg/ha produces 285kg/ha after seed, a lower figure than that recorded in early modern Russia.

There is no known record from antiquity of what might have been a normal pasturage or hay yield; modern yields are in the region of 3700kg/ha.[243] Considering the low return on other crops, I can suggest at most a figure of 1000kg/ha over the year, either eaten directly from the field or gathered in over several cuttings for winter use.[244] In the earlier 20th century when oxen were commonly used for tillage, Mediterranean farmers routinely put over 0.2-0.5ha to grow, most commonly, bitter vetch as green fodder for a yoke of oxen.[245] Bitter vetch can today produce very high yields up to 30 tonnes/ha, but in semi-arid conditions less than a tonne: 2000kg/ha is suggested.[246]

When considering ancient yields, modern scholars have mostly come up with similar figures. Early modern estimates for ancient Greece are reported at 390-900kg/ha for wheat and 670-1270kg/ha for barley.[247] For the north-west provinces Rivet suggested an ancient yield of grain of 10bu/acre which, having allowed for seed corn, labourers' food, and turning the fields to fallow every third year, he reduced to 5bu/acre, equating to 337kg/ha net product; although not specific, the figures suggest bread wheat.[248] Brunt followed Columella's figures to arrive at

[243] Hyland 1990, p.93.
[244] Johnstone 2004, p.54 suggests 2000kg/ha.
[245] Halstead 2014, pp.50-5.
[246] Mihailovic *et al* 2006, p.256; Haddad & Snobar 2011, p.78.
[247] Reported by Garnsey 1988, p.95.
[248] Rivet 1969, p.197.

385-771kg/ha of bread wheat.[249] Likewise Duncan-Jones following Columella, suggested a net yield after seed of 402kg/ha for wheat with a specific density of 78.19kg/hl, so either bread or durum wheat.[250] Hopkins also came in at a four-fold return on 130kg sown, so 390kg after seed.[251] Sallares was happy with Columella's sowing rate and a four-fold return resulting in a net average yield of 375kg/ha of bread wheat.[252] However, Garnsey and Saller are far from convinced of the applicability of Columella, thinking that his preference for viticulture over agriculture caused him to belittle arable returns, and so they argue for a higher average nine or ten-fold return in Italy.[253] Halstead's view of yields in excess of 650kg/ha has already been reported.[254] Breeze has suggested 824kg/ha in Britannia.[255] Millett taking a pessimistic view of the Butser material suggested returns of 1000kg/ha of emmer.[256] Similarly high, for barley Hanson has taken two thirds of early modern yields to suggest as much as 2500kg/ha.[257] So there is a considerable variation in modern opinion, although more commentators settle on Columella's figures than anything else. I would also prefer to follow Columella at 385kg/ha for bread wheat and 395kg/ha for barley. However, to test this point of view, I will also consider alternatives of low 200kg/ha and high 600kg/ha yields further below in this Chapter.

Table T.1.1.2 shows land needs by unit according to the type of grain used. It is apparent that more or less arable land would have been required depending on the crops raised, with emmer needing 25% less land than bread wheat to produce a

249 Brunt 1971, p.194.
250 Duncan-Jones 1982, pp.370-1.
251 Hopkins 2002, p.203 fn27.
252 Sallares 1991, pp.374-5.
253 Garnsey & Saller 2014, pp.103-7.
254 Above, p.73.
255 Breeze 1984, p.269.
256 Millett 1990, pp.56-7.
257 Hanson 2003, p.205, p.212.

given tonnage, and millet needing 35% more. The agronomists make it clear that monocultures were to be avoided; crop diversity was surely key to survival, and a combination of grains were very probably grown alongside pulses and vegetables.[258] It is however, impossible to suggest given ratios of particular crops grown in the region, but at least it can be argued that the effects of growing different cereal crops ought to have in some part evened themselves out. Therefore to progress the argument, the figures given for bread wheat might be considered as representative of all grain crops, and for simplicity of argument I will continue to talk in terms of bread wheat and barley for the animals only, not pursuing figures for emmer, durum wheat and millet further.

The traditional view based on early modern practice in the Mediterranean was that the ancients used bare fallowing to allow two years' worth of moisture to be gathered in the ground.[259] This has more recently been challenged with the suggestion that crops were rotated with pulses, fodder and spring-sown crops.[260] The agronomists certainly recognized that land recovered and carried a better crop if either left alone, or if sown with a nitrogen-fixing crop such as beans, so that several different fallowing regimes are recorded.[261] Additionally, vegetative matter could be ploughed in as green manure after the crop itself was picked.[262] Medieval records also show crop rotation with legumes and the use of integrated sheep farming.[263] The evidence from Egypt makes it clear that two-crop rotation with wheat sown against either fodder, in itself a very important crop in such an arid

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[258] Spurr 1986, pp.117-25; Halstead 2014, *passim.*
[259] White 1970, p.113, pp.119-21; Brunt 1971, p.194; Osborne 1987, pp.41-3 shows that this was sometimes the case in classical Greece.
[260] Garnsey 1988, p.94; Sallares 1991, pp.385-6; Spurr 1986, pp.117-18; Halstead 2002, pp.61-66; Kooistra 1996, pp.120-1; Goodchild 2013, pp.68-9.
[261] Cato, *Agr* 37.2; Columella, *Rust* 2.9.4, 2.9.15; Pliny, *HN* 17.40-1, 18.187, 18.191.
[262] Theophrastus, *HP* 8.9.1; Varro, *Rust* 1.23.3; Columella, *Rust* 2.13.1-2, 2.17.4, 11.2.60; Pliny, *HN* 17.54-6; White 1970, pp.135-6, p.145; Spurr 1986, p.127; Sallares 1991, p.300.
[263] Brandon 1972, pp.418-19.

country, or leguminous plants was very common.[264] Fodder will become more important in Chapter Four when I consider the transport requirements. I will assume that green fodder was provided from land lying fallow or the wider countryside, and only land for feed-barley is included in my calculations. I will however, consider both an alternate fallow regime where absolute needs ought to be doubled and a no-fallow regime.

Appendix A.1.1a details the needs of the Lower Moesian garrison of 31,238 men and 4522 cavalry horses, if yields were as low as 200kg and alternate fallowing was practised. I assume that the Roman soldier required 0.809kg of bread wheat a day, and a horse required 2.5kg of barley. In this case 133,504ha of arable land would have had to be farmed. Appendix A.1.1b depicts the situation with yields of 385kg/ha wheat and 395kg/ha barley, where 68,810ha of arable would have been required. Appendix A 1.1c shows the needs if yields were as high

Table 2.1.3.1 Garrison arable needs summary

	Arable land for garrison
With alternate fallow	
Low yield 200kg/ha	133,504ha
Mid yield 385kg/ha	68,810ha
High Yield 600kg/ha	44,501ha
Without alternate fallow	
Low yield 200kg/ha	66,752ha
Mid yield 385kg/ha	34,405ha
High Yield 600kg/ha	22,251ha

[264] Rowlandson 1996, p.238.

as 600kg/ha with a combined arable need of 44,501ha. If alternate fallowing were not the case and land was used continuously, then half as much land would have been required for arable. Calculations for this scenario are laid out at Appendices A.1.2a-c. Both these possibilities are summarised in Table 2.1.3.1 above. The area of land required to feed the garrison of Lower Moesia with grain alone is therefore calculated to have been in the range of 22,251-133,504ha or 0.45-2.67% of the estimated 50,000km^2 land area of the whole province, which does not seem an unreasonable burden. If the grain were extracted purely as a 10% tithe then that would imply that some 2225-13,350km^2 of arable would have been required, representing 4.5-26.7% of the province's area. This is such a wide range that little can be argued from it, other than that, even in the worst case, it is not an impossible figure. However, I will argue below that the army purchased a considerable part of their food, and did not exact all of their needs as tax. It is therefore thought very unlikely that the army presented such a significant drain as to require 26.7% of the provincial land mass and it is the absolute area of arable required that will be pursued. On a final point, the palynological evidence points to the land being predominantly covered in mixed forest during the Roman occupation, but arable does not show up easily in palynological sampling and even if as much as a quarter of the land area was turned to arable this is unlikely to dent the dominance of the forests in this evidence.[265]

2.1.4 How many animals, how much pasture and land for other agriculture?

If the troops consumed on average 0.1kg of meat a day, 31,238 men would have required 1140 tonnes/*pa*. Considering the bone assemblages from Novae from

[265] Reale & Dirmeyer 2000, p.174; Reale & Shukla 2000, p.191.

the 2nd-3rd century, 67% came from domestic mammals, more specifically 33.5% pig, 18.8% cattle and 14.7% sheep or goats, together with a high, 30% incidence of fish and birds.[266] If the later contexts at Novae are considered, the percentage of domesticated bones increases at the expense of the fish especially. More comprehensive reports are available from Nicopolis 50km to the south, where from the mid-Roman period onwards, AD 175-250, pig also dominates the bone assemblages.[267] Of particular note at Novae, sturgeon and catfish bones were found of specimens estimated to have been of 100-150kg weight; this is not an unusual size for sturgeon or catfish on the river.[268] It has also been suggested that at both Novae and Nicopolis, carp were farmed for food.[269] Even if the usable weight of the fish were only 1-5kg, then they could still have provided a ready alternative to meat. I need to correct these percentages of bones seen to account for the differing quantities of meat found on each animal type to arrive at relative quantities of different meats eaten. For any animal, the live-weight and thus carcass-weight depends on breed, age and feeding regime.[270] Although withers' heights are calculated for cattle at both sites, without an indication of breed it is difficult to predict a carcass weight from these. Considering age, the mortality profiles of animals at military sites from northern Europe suggest that pigs and sheep were primarily bred for meat and killed as young adults.[271] At Novae the majority of pigs were however, mature; at Nicopolis there were more immature examples suggesting more intensive rearing there.[272] In contrast to the zoo-archaeological material, the

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[266] Makowiecki & Schramm 1995, pp.72-4, p.79, Makowiecki & Makowiecki 2002, pp.211-13.
[267] Beech 2007, pp.154-97.
[268] Makowiecki & Iwaszkiewicz 1995, p.52.
[269] Makowiecki & Iwaszkiewicz 1995, p.53; Beech & Irving 2007, p.229, p.236.
[270] Spedding 1983, pp.214, 645-51, 660, 677; http://www.ukagriculture.com/livestock/livestock.cfm accessed 14/04/10 for modern carcass weights.
[271] Thomas 2008, p.39.
[272] Makowiecki & Schramm 1995, p.77; Beech 2007, pp.168-9.

agronomists suggest that sheep should be bred for wool and milk primarily and would therefore be more likely eaten when mature.[273] I will assume carcass weights of 200kg for cattle, 50kg for pigs and, to reconcile the two opposing views of sheep age at death, a middling carcass weight of 20kg for sheep.[274] The ratio of weight is thus 4:1:0.4 cattle to pig to sheep which, if applied to the percentages of bones identified from the 2nd century context, corresponds in terms of the total meat consumed to some 65% from cattle, 29% pig and only 5% from sheep. So although pig dominates the bone finds, beef would have still provided the greatest quantity of meat. I have not dismissed the fish and bird percentages but despite the sturgeon finds, pending more detailed information which is unlikely to appear about the size and percentages of particular species, I have assumed an average weight of only *c* 2kg and thus only allocated about 1% of the total weight of animal products to these. Extrapolating these corrected percentages as applied to the requirement for 1140 tonnes of meat, then 741,123kg of beef from 3706 cattle, 330,654kg of pig from 6613 animals, and 57,009kg of mutton from 2850 sheep would have nominally been required, together with 11,402kg of fish.

These animals needed land to graze. It is certainly likely that animals grazed arable fields when the crops were young which in itself improves growth, and then after the grain was harvested and while fallowed, in all cases adding valuable manure as they went.[275] Yet the majority of livestock probably grazed open unmanaged grass-lands. Today, stock rates vary according to the quality of the grassland, which is normally managed and fertilized. Thus even a low modern rate

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[273] Varro, *Rust* 2.1.4; Columella, *Rust* 12.13; Ryder 1983, pp.158-9.
[274] http://smallfarms.cornell.edu/2014/01/14/what-is-the-ideal-weight-for-a-market-lamb/; accessed 14/04/10; Junkelmann 1997, p.163 for pig weights; Goldsworthy 1998, p.292 suggests some plausible alternatives.
[275] Theophrastus, *CP* 3.9.1-2, 3.20.2; Cato, *Agr* 30.1; Varro, *Rust* 1.2.21; Columella, *Rust* 2.1.7, 2.10.6, 2.13.3-4, 2.14.9, 2.15.2; Pliny, *HN* 17.50-4; White 1970, pp.125-35; Osbourne 1985, p.47; Spurr 1986, pp.126-8; Kooistra 1996, pp.120-1; Halstead 2014, pp.226-30, p.352.

of one cow to 6 hectares might be optimistic, but in lieu of another figure this shall be used, so the 3706 suggested cattle required to feed the garrison annually would have needed 22,236ha on which to be raised.[276] Pigs are reared outside today at 15-20 to a hectare, although if fed closer to the farm on household waste this density becomes less relevant – a single pig can be kept in a back yard; nevertheless the 6613 estimated animals consumed year-on-year would have required at most 441ha. Sheep and goats are often raised on marginal land unfit for arable exploitation and this would surely have been the case in the past. They were also grazed among other crops; Cato gave a stocking rate of 0.6 sheep/ha among olive groves.[277] Modern rates on unmanaged land vary enormously from 0.25-12.5 sheep/ha. I shall rather arbitrarily assume two sheep per hectare: for 2850 animals another 1425ha of grazing would therefore be required.[278] A total estimate of land used for stock-raising is 24,102ha, (Appendix A1.1a-c and A1.2 a-c refer); a rather large sum considering the relatively small daily allowance of meat, something which probably reflects the fact that animals are very inefficient at converting plant energy into food.[279] However, livestock do provide more than meat and are often central to arable farming, as traction, for manure and as a walking food reserve. Additionally they provide dairy, which would have utilised even more grassland, but this is something that has proven so far impossible to identify let alone quantify, and as such I will have to exclude it from the discussion.

I have suggested above a daily intake of half a litre of wine. So, for 31,238men, 5,700,935l would have been required *pa*. In Italy Columella records an absolute minimum yield of one *culleus*/*iugerum*, 2055l/ha, and suggests three *cullei*

[276] Spedding 1983, p.643.
[277] Cato, *Agr* 10; Ryder 1983, p.162.
[278] Ryder 1983, p.319, p.502, p.576, p.587, pp.633-5, p.638; Spedding 1983, p.665, p.669; Fox 1986, p.533 for 8 sheep/ha in Medieval times; Sallares 1991, p.313; Halstead 2014, p.229 for 1 sheep/ha.
[279] Spedding 1983, p.13; Sallares 1991, p.311; Garnsey 2000, p.688.

would be more normal.[280] Pliny and Varro record particularly profitable vineyards where yields of seven and ten-fifteen *cullei/iugerum*, 14,384 and 20,548-30,822l/ha, were possible; these latter figures are staggering, greater than many modern vineyards and ought to be discounted.[281] Because Columella's minimum figure seems to allow for the worst possible case and the presence of, let alone the conditions of, vineyards in the province are only inferred from locally produced amphorae, this is the figure I shall continue with so that at 2055l/ha, 2774ha of vineyards would have quenched the Moesian garrison's thirst.

It is difficult to come up with any suggestion of the scale of vegetable cropping. Legumes were deemed a very important crop, and as noted above possibly consumed as a sixth part to cereals.[282] Columella gives a sowing density for beans of four *modii*/*iugerum*, 137l/ha at a specific density of 79kg/hl equalling 108kg/ha, but he does not suggest a yield.[283] An average modern figure is 3750kg/ha. I have argued above that ancient wheat yields were only a fraction of modern returns in the region of four-fold and so by analogy I shall assume a yield for beans of a mere 375kg/ha after seed.[284] If the men of the Lower Moesian garrison consumed on average a sixth as many beans as cereals that would have been 0.135kg a day, then there would have been a need for 4105ha of beans or other pulses. This is of course speculative, but where fallow regimes existed, one can also speculate that because of their nitrogenizing properties leguminous plants were grown on fields that would have otherwise been lying fallow, particularly if the vegetative material was ploughed back in. When it comes to fruit and vegetables

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[280] Columella, *Rust* 3.3.10-11; Duncan-Jones 1982, p.40.
[281] Varro, *Rust* 1.2.7-8; Pliny, *HN* 14.48-52; Churchill-Semple 1928a, p.97; Johnson 1997, p.21 modern quality wines typically yield 3500/ha, vin-ordinaire as much as 8000/ha.
[282] Theophrastus, *HP* 8.5.1-4; Columella, *Rust* 2.10; Pliny, *HN* 18.117; Spurr 1986, p.111; above, p.64.
[283] Columella, *Rust* 2.10.4.
[284] http://www.ukagriculture.com/crops/field_beans_uk.cfm accessed 20/05/10.

further speculation is all I can offer. Originally farmsteads probably only sought to be self-sufficient in fruit and vegetables, yet the frontier camps would have provided a market and so increased cultivation surely took place. However, the scale is again difficult to guess; the best I can offer is a similar amount of land as estimated above for pulses, so possibly another 4105ha. It is impossible to say if this was farmed on additional land or on fallow. In those calculations where alternate fallow is considered the total land area under cultivation is not increased for legumes and vegetables, where no fallow regime is considered it is added to the total requirement.

Table 2.1.4.1 Garrison arable and other needs summary

	Arable land for garrison	Land for other agriculture	Arable + other land
With alternate fallow			
Low yield 200kg/ha	133,504ha	35,129ha	168,633ha
Mid yield 385kg/ha	68,810ha	35,129ha	103,939ha
High Yield 600kg/ha	44,501ha	35,129ha	79,630ha
Without alternate fallow			
Low yield 200kg/ha	66,752ha	43,339ha	110,091ha
Mid yield 385kg/ha	34,405ha	43,339ha	77,744ha
High Yield 600kg/ha	22,251ha	43,339ha	65,590ha

Once all these additional needs are added to the range of arable needs discussed above, then the totals would have increased by 35,129ha in the case of alternate fallow and 43,339ha with a no-fallow regime, Table 2.1.4.1 above refers. The total land required to feed the garrison is calculated as being 65,590-168,633ha, 1.3-3.4% of the total provincial land area. Obviously, the permutations of land use are infinite. Also the farmers themselves must have hoped to be self-sufficient before producing a surplus so that poly-culture must have been commonplace. Yet these figures can stand as suggestive of the percentage part of the provincial land area required just to feed the army.

2.1.5 How many men to farm this land?

Grants of land to urban poor and veteran soldiers were commonplace during the late Republic and early Imperial period; typically these were directed at single-family units with or without servants, and as such they might be used to indicate the amount of land an individual could be expected to farm. The very earliest colonists were provided with plots as small as two *iugera* 0.5ha per head. Republican veteran plots were larger, 5-10 *iugera*, 1.26-2.52ha, yet as an incentive to settle further afield significantly larger grants are recorded, such as those at Bononia in 189 BC where the infantry received 50 *iugera*, 12.6ha, and cavalry 70 *iugera,* 17.62ha each.[285] With the smaller grants it is possible that some *ager publicus* was available, at least as pasture, but also possibly through usufruct for arable.[286] Caesar's grants were in the region of 10-12 *iugera*, 2.5-3ha, which Finley suggested was suitable to support a small family unit, although he noted that most of Caesar's grants were in Italy and so free from taxes.[287] Octavian settled *c* 120,000 veterans at more than 100 colonies, and his grants were typically larger, 50-67 *iugera*, 12.6-16.8ha.[288] Variations in plot sizes probably related to the quality of the land and the

[285] Churchill-Semple 1928b, p.154; Dilke 1971, pp.147-8, pp.179-81; Brunt 1971, pp.294-7; Garnsey 1988, p.46.
[286] White 1970, p.336; Brunt 1971, p.194; Dilke 1971, p.116, p.179.
[287] Appian, *BC* 2.10; Dio, 38.1.2-4, 38.7.3; Suetonius, *Caes* 20; Churchill-Semple 1928b, p.155; Brunt 1971, pp.312-326; Finley 1999, p.81, p.105.
[288] Appian, *BC* 5.12, 5.20; *Res Gestae* 15-16; Tacitus, *Ann* 1.17; Dilke 1971, pp.114-15, pp.183-4; Brunt 1971, pp.326-42.

relative status of junior officers and also cavalrymen against infantrymen.[289] The increase in the size of grant from the time of Octavian looks to represent the use of agricultural slaves or servants by veterans. In Later Roman Egypt at the Hermopolite nome, the majority of land-holdings were less than 19 *aroura*, 5.23ha.[290] While comparative data from 19th century Egypt records that 4.5-15 *aroura*, 1.23-4.125ha, was sufficient to support a family.[291] In 1920s Thrace refugee families were allocated 3-4ha each, but often rented more to total 5-6ha.[292] Also in early 20th century Bulgaria, before mechanisation and Communism, arable farming was carried out on smallholdings of on average 5ha in size operated by single-family units.[293] Garnsey refers to both Brunt and White following unpublished calculations by Hopkins that showed how an ancient family of 3.25 individuals required 7-8 *iugera*, 1.75-2ha, without and 20 *iugera*, 5ha, with a plough and therefore oxen, to survive.[294] Halstead also estimates 2ha worked by hand could feed a family, whereas 5-7ha was needed if plough-oxen were kept.[295] The higher figures result from a need to grow fodder crops for the oxen. In the case of a working family farm, allowing for one son not fully mature until 20 and not taking over from his father completely until the latter was 50, I will assume that there were 1.7 working males at any time. If the veteran soldier kept a farm slave, his *familia* might be estimated at 2.7 working males. The Republican land grants noted above varied between 0.5-17.62ha; supposing that in the case of the smaller land grants there was only the biological family unit without slaves, but at the upper

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[289] Brunt 1971, p.295.
[290] Bowman 1985, pp.158-9.
[291] Rowlandson 1996, p.305.
[292] Halstead 2014, p.14, p.22.
[293] Dolinsky 1932, pp.355-6; After collectivization, Bulgarian peasants were allowed to retain 0.5ha subsistence plots suggesting even this would meet supplementary needs Creed 1995, p.851.
[294] White 1970, p.336; Garnsey 1988, p.46 following Brunt 1971, p.194; Alcock *et al* 1994, p.148 suggests 3.4-5.6ha for an ancient Greek family; later Hopkins 2002, p.203 uses 5ha.
[295] Halstead 2002, p.65; 2014, p.14, p.24, pp.43-4.

end of the scale there was at least one slave, then if I divide the lower end of the scale by 1.7 and the upper end by 2.7, a range of 0.29-6.53ha worked per man is arrived at. Clearly, on the smallest grants an adult male would not have been fully employed, but at the upper limit of 6ha per worker the *familia* should have been capable of producing a surplus.

I have already suggested a total provincial population of 400,000. If 80% of this population was involved in agriculture, but only 42.5% of these were actively engaged as labourers, keeping with my 1.7 labourers to a nuclear family of four that would equate to 136,000 farm labourers. If these all worked 6ha each, then 816,000ha might have been farmed, although, allowing for fallowing, only 408,000ha might have been productive in any year. This would require 16.3% of the provincial land mass to have been turned to farming, but it would have been sufficient to potentially feed a population of *c* 760,000 people, almost twice my population estimate.[296] Therefore in very broad terms there ought to have been a sizable surplus to direct towards the military.

When discussing manning ratios, Varro acknowledged that the terrain, climate and quantities of particular crops relative to each other will all have impacted on the amount of work a farm required, and that to generalize the numbers of workers required for particular areas was flawed.[297] Nevertheless he repeated Cato's manpower calculations and it is notable that they both write in terms of 100 and 240 *iugera* (25 and 60ha) units supervised by a single bailiff, which might be indicative of optimum sizes, despite it being clear from the literary record that some

[296] Assuming a civilian population only eating 70% as well as the military so requiring 0.5663kg a day, 207kg *pa*.
[297] Varro, *Rust* 1.18.

farms were considerably larger.[298] Columella reported that to work a 200 *iugera* [50ha] farm, two ploughmen might be reasonably employed throughout the year, accounting for holidays.[299] He was considering mixed farming with 50 *iugera* turned to winter-sown wheat, 30 to spring-sown wheat and another 50 *iugera* turned to legumes; the remaining land is not specified, although some fallow is probable. He also records the need for six labourers but does not elaborate on their duties; Spurr constructed a model whereby the six labourers were reasonably employed for 300 days, allowing 45 days for holiday.[300] Thus, although ploughmen and labourers were doing different work, in simplistic terms considering the whole farm each man was working 25 *iugera* or 6.29ha each, remarkably similar to the upper-end figure for land grants suggested above.

The critical period of the farming year was surely the harvest; here Columella reported that a man could reap two-thirds of a *iugerum* or 0.1678ha of wheat a day, while Varro suggested one *iugerum* or 0.2517ha a day.[301] Modern estimates are lower, only 0.1-0.13ha a day in pre-mechanised Greece.[302] Realistically, a harvest cannot have lasted much longer than 14 days, so that one man might harvest 1.4-3.53ha in a year. This would also accord with a 6ha landholding if part of a man's land was turned to fallow in any given year; but it is also quite probable that occasional labour, hired in or from the wider family, was employed at harvest.[303] More time was required to cut the straw, meeting some of

[298] Cato, *Agr* 10-11; Duncan-Jones 1982, pp.323-6 collates the evidence for larger farms; Finley 1992, p.112.
[299] Columella, *Rust* 2.12.1-9.
[300] Spurr 1986, pp.136-9.
[301] Columella, *Rust* 2.12.1; Varro, *Rust* 1.50.3.
[302] Halstead 2014, p.102.
[303] Varro, *Rust* 1.17.2-3; Spurr 1986, p.139; Halstead 2014, p.120.

the green forage needs, and carry out the threshing and winnowing, but all this could be done in slower time.[304]

Comparative evidence is available from Medieval England and the early modern world. In terms of bushels of wheat harvested, a 13th century English peasant, farmed on average 5.66ha, from which he produced 90bu/*pa*, 3171l, or 2378kg of bread wheat.[305] The quantity of land laid to other crops and fallow is unclear: if alternate fallowing took place and 2.83ha were grain-producing in any given year, this would represent a yield of 840kg/ha, which is beyond the earlier suggested range of Medieval yields, but not impossible, and if less land was fallowed the yields would be lower. In the 19th century on large eastern European estates, workers tilled about 9ha; at the same time in the US the average worker commanded 11ha.[306]

Therefore, a range of landholdings is evident, but favouring the evidence of the land grants and the agronomists, by way of a generalization, a single man could be expected to farm approximately 6ha of arable land on which he could support himself and produce a surplus. Now, assuming any labourer working arable for the garrison would have required a similar amount of calories and so the same amount of land *pa* for himself, then he would have required 1.476ha if yields were as low as 200kg/ha, 0.767ha at mid-range yields of 385kg/ha and 0.492ha at high 600kg/ha yields. These figures ought to be doubled to account for fallowing and deducted from a 6ha landholding so that effectively every labourer could work a surplus of 2.953ha, 4.466ha and 5.016ha, although only half of that would have been productive in any year. If alternate fallowing did not take place, then all of this land may have been usable and the land areas calculated for the farmers need not be

[304] Columella, *Rust* 11.2.54; Halstead 2014, pp.128ff.
[305] Clark 1987, p.420; Winchester bushels assumed.
[306] Clark 1987, pp.419-21.

doubled. By dividing the arable needs previously calculated by these figures one arrives at a number of workers required to feed the garrison, who in turn would have also required additional land to feed themselves.

The number of shepherds, swineherds and cattle hands would have varied according to the animals concerned and the terrain, with a conservative estimate of one man for every 100 animals, another 132 men are suggested.[307] With regard to viticulture Cato recommended for a 100 *iugera* [25ha] vineyard a staff of 16, including overseers and domestics; most critically he required ten labourers and one ploughman.[308] Pliny suggested one man to ten *iugera*, and Saserna reported by Varro suggested one to eight *iugera*.[309] The ratio according to Columella was one to seven; in his *de arboribus* he detailed tasks required on a vineyard although he omitted the vintage.[310] From this Duncan Jones offered an emendation that allotted 31.5 days per *iugerum* and Spurr did likewise to arrive at 35.5 days' work per *iugerum.*[311] Taking the average of the ratios cited I will assume that one man worked 8.523 *iugera* or 2.15ha, so to farm the 2774ha of vineyards suggested above another 1290 men could have been required. In the case of vegetables on Columella's farm the same farm hands worked both the wheat and legume crops.[312] Whether they also farmed other fruit and vegetables is unclear, but I think it likely because 70 *iugera* were unaccounted for on Columella's farm. Therefore, although I could include another 684 men, one for every six hectares of the 4105ha suggested for other vegetables, because I think this land was worked by the grain-producing men I shall not do so in either fallow regime. The need for meat and the tending of

[307] Ryder 1983, p.158, p.318.
[308] Cato, *Agr* 11.
[309] Pliny, *HN* 17.215; Varro, *Rust* 1.18.2.
[310] Columella, *Rust* 3.3.8; *de arb* 5.3-6.
[311] Duncan-Jones 1982, pp.327-31; Spurr 1986, pp.135-6 *cf* White 1965, pp.102-6.
[312] Columella, *Rust* 2.12.1-9.

vines and vegetables for the farm workers may have resulted in more stock hands and other agricultural workers, whose needs could again be calculated, the whole becoming an ever-decreasing set of estimates. However, I shall not take this any further, because of the uncertainty surrounding how many of the originally calculated stock hands or vegetable workers where themselves also arable workers.

Considering both the number of arable workers and the workers required for other crops, at low 200kg/ha yields for both wheat and barley with alternate fallowing, 45,235 arable workers, stock hands and vine workers would have been needed to work the land. They in turn would have required 133,572ha of arable together with 38,915ha of other land for their own stock, vines and vegetables, (the latter assumed to have been grown on land laying fallow), so that a total of 341,120ha would have been necessary. At yields of 385kg/ha for wheat and 395kg/ha for barley, some 16,830 workers would have required 25,816ha of arable and 14,479ha of other land to support themselves and so a total need of 144,234ha is arrived at. With high yields of 600kg/ha, less land would have been required to feed both the garrison and their farm workers and fewer farm labourers would have been required because they would have taken a smaller part of the overall crop. As a result a total of 98,618ha is arrived at. This is a considerable range that points away from the extremes, Table 2.1.5.1 below summarises.

If fallowing did not take place and a farmer still commanded 6ha, a situation which both the ancient and comparative evidence points against, then effectively there could have been twice as much land available to meet the needs. The number of farm workers required would have been significantly lower because each worker would have produced a greater surplus. Some additional land would have to be included for pulses and vegetables that in the earlier calculations were assumed to have been grown on land lying fallow. A range of 74,412-152,147ha is arrived at. Appendices A.1.1a-c and A.1.2a-c refer in full and Table 2.1.5.1 below summarises. Therefore the overall range of land holdings required to feed the garrison would have been between 74,412-341,120ha.1.5-6.8% of the total provincial land area.

Table 2.1.5.1: Requirements at different yields with 6ha landholdings

	Arable land for garrison	Other agricultural land for garrison	Workers required	Arable land for workers	Other agricultural land for workers	Total land required
With alternate fallow						
Low yield 200kg/ha[313]	133,504ha	35,129ha	45,235	133,572ha	38,915ha	341,120ha
Mid yield 385kg/ha[314]	68,810ha	35,129ha	16,830	25,816ha	14,479ha	144,234ha
High Yield 600kg/ha[315]	44,501ha	35,129ha	10,294	10,132ha	8856ha	98,618ha
Without alternate fallow						
Low yield 200kg/ha	66,752ha	43,339ha	16,178	23,886ha	18,169ha	152,147ha
Mid yield 385kg/ha	34,405ha	43,339ha	7997	6133ha	8982ha	92,859ha
High Yield 600kg/ha	22,251ha	43,339ha	5462	2688ha	6134ha	74,412ha

In all cases this is an achievable quantity of land, but so wide a range as to require some further consideration. The calculations also suggest a wide range of workers, between 5462 and 45,235 – a sixth to one and one-half times as many men as the garrison itself. Significantly, without alternate fallowing, at the mid-range and high yields, the number of workers required is considered very low, 5462 or 7997 workers. This is thought to argue against a man working all 6ha of a landholding every year and therefore in favour of a fallow regime on a 6ha landholding. Accepting alternate fallowing as more likely still the range of *c* 10,000-45,000 farm

313 Workers' needs 1.476ha/*pa*.
314 Workers' needs 0.767ha/*pa*.
315 Workers' needs 0.492ha/*pa*.

workers is wide, the lower figure arrived at with high yields feels too low, the upper figure is certainly thought too high. This coupled to the already noted wide range in landholdings points towards the preferability of the mid-range yield figures where *c* 17,000 farm hands, roughly half the number of workers as soldiers is calculated.

Appendices A.1.1a-c and A1.2a-c, also show that, of the total calculated need, pasture for meat made up 17-38%, of the total land requirement for the garrison. This despite only providing 10% of the calories, so that although there are benefits in the protein provided, the inefficiency of meat as a food source is made clear. Against this are the already mentioned benefits as traction animals, and producers of dairy and manure, as well as acting as a mobile food reserve, so the number of animals suggested still seems reasonable. Additionally, the cavalry can be seen to have required a significant quantity of land. In the calculations with alternate fallowing, 13,754-41,263ha was required for feed barley, the barley would have to be worked by 2742-13,537 of the farm workers, who in turn would have required 1349-39,975ha of the arable calculated for farm workers and 2115-10,444ha of the pasture land together with 244-1202ha of other land. Once the 8253ha of cavalry pasture is included 28,547-101,137ha can be said to have been required to support the cavalry, *c* 26-30% of the total calculated provincial garrison need. Without alternate fallowing the figures are 23-27% of the total calculated provincial need. This is a significant part of the whole, yet it is known that the most common units in the Roman army were the *equitata* units. Cavalry were clearly essential for communications in an un-mechanised world, but they can be seen to have come with a logistical cost that army commanders would have had to factor into their supply solutions.

2.1.6 Alternative farming regimes

It has been suggested that the figure of 6ha worked per farmer is too high.[316] Further calculations were carried out to represent the situation if a man only worked 3ha, so that any surplus produced was therefore smaller. In the first iteration at 200kg yields with alternate fallowing because a worker required the majority part of the 1.5ha he farmed each year, the surplus would have been so small as to require almost three million workers and their needs would have exceeded the entire provincial land area, this is therefore not a viable model. Using the mid-range yields of 385kg/ha and 395kg/ha for barley, or the high figure of 600kg/ha the total

Table 2.1.6.1: Requirements at different yields with 3ha landholdings

	Arable land for garrison	Other agricultural land for garrison	Workers required	Arable land for workers	Other agricultural land for workers	Total land required
With alternate fallow						
Low yield 200kg/ha[317]	133,504ha	35,129ha	2,831,474	Unviable	Unviable	Unviable
Mid yield 385kg/ha[318]	68,810ha	35,129ha	48,359	74,179ha	41,603ha	219,722ha
High Yield 600kg/ha[319]	44,501ha	35,129ha	23,499	23,130ha	20,216ha	122,976ha
Without alternate fallow						
Low yield 200kg/ha	66,752ha	43,339ha	45,235	66,786ha	50,803ha	227,681ha
Mid yield 385kg/ha	34,405ha	43,339ha	16,698	12,908ha	18,753ha	109,405ha
High Yield 600kg/ha	22,251ha	43,339ha	10,295	5067ha	11,562ha	82,219ha

land requirement would have been higher than that calculated with a 6ha landholding, but not even by twice as much. However, the number of workers calculated in this scenario at mid-range yields of *c* 48,000, looks to have been too

316 Alston, pers comm.
317 Workers' needs 1.476ha/*pa*.
318 Workers' needs 0.767ha/*pa*.
319 Workers' needs 0.492ha/*pa*.

great an imposition. If each man farmed 3ha and alternate fallowing was not practised, then the calculated needs would have obviously been lower than if fallowing took place. Table 2.1.6.1 above shows that if landholdings were as low as 3ha and alternate fallowing did not take place, at low yields of 200kg/ha the number of workers required was again *c* 45,000, which seems to suggest too heavy a drain.

Comparing Tables 2.1.5.1 and 2.1.6.1, and considering both 6ha and 3ha landholdings, with and without fallow regimes, at three different average yields, the calculations point away from regular low yields of about 200kg/ha. They further suggest that 6ha landholdings with alternate fallowing, or 3ha without alternate fallowing at either mid-range or high yields would have been more likely. It stands to reason that fallow regimes were less likely the smaller the plot of land that was worked by an individual, and so the greater the pressure on the land available to him. However, the use of fallowing where possible discussed above both in antiquity and the near-modern Mediterranean, makes the 6ha with fallowing figures the more preferable of the two alternatives.[320] With a 6ha landholding and with alternate fallowing both mid-range and high yields can be seen to have required plausible numbers of farm workers, so that both situations are thought possible and a range of 98,618-144,234ha is suggested. Yet, I would prefer to err on the side of caution and opt for the worst, viable case, in the mid-range 385kg/ha wheat yield and 395kg/ha barley yield that was derived from Columella, which would have resulted in a need for 144,234ha of land to feed the garrison.

Beyond the agricultural workers themselves, there were their dependants. Hopkins, when constructing an argument against high yields, pointed out that a

[320] Above, p.78-9.

yield of 650kg/ha on a 5ha peasant farm would have resulted in 3250kg produce; yet since a family of four only required *c* 1000kg, then each family would have produced more than twice as much surplus as they themselves consumed.[321] Therefore the population ought to have been only 33% involved in agriculture rather than the generally accepted 80-90%. This was at first a problematic suggestion because I have assumed that the labourers feeding the military directed all their surplus at the garrison. There is little evidence for an export market excepting a single inscription where Ti. Plautius Silvanus records a significant shipment from the province; the nature of the inscription implies this to have been a one off.[322] The most plausible outlets for any surplus would have been either the indigenous population in the Black Sea *poleis*, or the army on the *limes*. This then is not as big a problem as it may at first seem, because it is precisely because workers could produce surpluses of this magnitude that the needs of the army could have been met. However, this also requires some consideration of the dependants of these farm workers and the size of the wider population. Considering a nuclear family of four and retaining the three or six productive hectares per adult male *pa*, the needs of each individual farmer to now feed a wife and two dependants would have clearly reduced his surplus. By how much is open to question; I cannot simply multiply the farmer's needs by four, because the calorific needs of women and children are lower than that of a working man. Furthermore, women in the country have always worked the land, as have children from an early age.[323] They will have all contributed to the family output and produced, often in large part, some of that food which they themselves consumed. Another, unfortunately arbitrary, multiple

[321] Hopkins 2002, p.203.
[322] *CIL* 14.3608; Erdkamp 2002, p.53 suggests the grain was going to the army; Batty 2007, p.469 thinks it an exceptional one-off shipment.
[323] Halstead 2014, *passim.*

of a worker's needs was required to account for the needs of his family which I assumed as twice his own needs. From the land worked each year the surplus would have been reduced and as a result the number of workers required would have increased. With a 6ha landholding but still assuming alternate fallowing, at a low 200kg/ha yield, more than the 5.9ha was required for the family, so that in excess of a million farm-workers would have been required, this scenario was

Table 2.1.6.2: Land requirements with 6ha landholding and dependants

	Arable land for garrison	Other agricultural land for garrison	Workers required	Arable land for workers	Other agricultural land for workers	Total land required
With alternate fallow						
Low yield 200kg/ha[324]	133504ha	35,129ha	Unviable	Unviable	Unviable	Unviable
Mid yield 385kg/ha[325]	68,810ha	35,129ha	24,891	76,363ha	42,827ha	223,129ha
High Yield 600kg/ha[326]	44,501ha	35,129ha	12,461	24,530ha	21,440ha	125,600ha
Without alternate fallow farming all 6ha						
Low yield 200kg/ha	66,752ha	43,339ha	28,910	68,884ha	52,399ha	231,374ha
Mid yield 385kg/ha	34,405ha	43,339ha	9126	13,999ha	20499ha	112,242ha
High Yield 600kg/ha	22,251ha	43,339ha	5858	5766ha	13,159ha	84,515 ha

clearly unviable. At mid-range 385kg/ha yields the garrison might have now required 24,891 farmworkers, who would have required 76,363ha of arable and 42,827ha of other agricultural land for themselves and family, to total 223,129ha. At a high 600kg/ha yields it would have been quite possible for a worker to provide twice his own needs for his dependants and still produce a sizable surplus, the overall needs being 125,600ha about the same quantity of land as the figure for the

[324] Workers' needs 1.476ha/*pa*.
[325] Workers' needs 0.767ha/*pa*.
[326] Workers' needs 0.492ha/*pa*.

mid-value 385kg/ha yields where dependants were not considered. If no fallow regime were practised then a greater surplus would have been available year-on-year and lower overall quantities of land would have been required than with an alternate fallow regime, but not simply half as much because land was now required for vegetables, which had previously been assumed to have been grown on land laying fallow.   Again the low number of workers required at mid-range and high yields if alternate fallowing did not take place point against such circumstances. Appendices A.3.1a-c and A.3.2a-c refer Table 2.1.6.2 above summarises.

Still considering dependants, with smaller landholdings of only 3ha and an alternate fallow regime, then at the lowest and mid-range yields so much land was needed for the family that no surplus would have been available. Even with the most attractive 600kg/ha yield some 44,567 workers would have been required, a third as many men again as the garrison itself. This reinforces the point previously made that alternate fallowing with small 3ha landholdings is thought unlikely. Without a fallow regime, again at low yields the situation would have been unviable, but at mid-range and high yields the total land requirements to feed the garrison and their dependants were similar to those seen when an alternate fallow regime was practiced without considering dependants.   Appendices A.4.1a-c and A4.2a-c refer as does Table 2.1.6.3 below.

Table 2.1.6.3: Land requirements with 3ha landholding and dependants

	Arable land for garrison	Other agricultural land for garrison	Workers required	Arable land for workers	Other agricultural land for workers	Total land required
With alternate fallow						
Low yield 200kg/ha[327]	133,504ha	35,129ha	Unviable	Unviable	Unviable	Unviable
Mid yield 385kg/ha[328]	68,810ha	35,129ha	Unviable	Unviable	Unviable	Unviable
High Yield 600kg/ha[329]	44,501ha	35,129ha	44,567	87,733ha	76,682ha	244,045ha
Without alternate fallow farming 3ha						
Low yield 200kg/ha	66,752ha	43,339ha	45,235	Unviable	Unviable	Unviable
Mid yield 385kg/ha	34,405ha	43,339ha	24,891	38,180ha	55,910ha	171,834ha
High Yield 600kg/ha	22,251ha	43,339ha	12,461	12,265ha	27,990ha	105,845ha

If all these results are sumarised, although the absolute hectares required are attractively lower if alternate fallowing was not practised, the number of workers required is considered too low with a 6ha landholding in the cases of mid-range and high yields because each worker would have produced a significant surplus. This was still felt to be the case once dependants were considered. Added to this is the belief that a man could only reasonably harvest up to 3.5ha in a year, and that both the ancient and modern evidence points to the normality of fallow regimes, with some of the land not being used for grain, carrying other crops especially nitrogenating legumes. Therefore non-fallow regimes will not be pursued any further. If fallowing is assumed, then once dependants were considered, a 6ha landholding can be seen to have viable at mid-range and high yields whereas a 3ha landholding would have been viable only with high yields. If this is added to the

327 Workers' needs 1.476ha/*pa*.
328 Workers' needs 0.767ha/*pa*.
329 Workers' needs 0.492ha/*pa*.

evidence of ancient and near-modern landholdings, which are typically in the region of 5-6ha for a family, then it appears safe to progress the argument with an average 6ha owned by an individual farmer, but utilizing a fallow regime whereby only half of it was worked in any given year. Low yields of 200kg/ha were also seen to be unviable in half the scenarios, arguing against yields this low being a normal state of affairs. That is not to say they did not happen when there were bad years, but that the average yields were higher, yields of 200kg/ha will not be considered further.

Table 2.1.6.4: Summary table of total land required in possible scenarios

	Arable land for garrison	Total land 6ha holding /worker	Total land 3ha holding /worker	Total land 6ha holding /worker with deps	Total land 3ha holding /worker with deps
With alternate fallow					
Low yield 200kg/ha	133,504ha	341,120ha	Unviable	Unviable	Unviable
Workers		45,235			
Mid yield 385kg/ha	68,810ha	144,120ha	219,722ha	223,129ha	Unviable
Workers		16,698	48,359	24,891	
High Yield 600kg/ha	44,501ha	98,618ha	122,976ha	125,600ha	244,045ha
Workers		10,294	23,499	12,461	44,567
Without alternate fallow					
Low yield 200kg/ha	66,752ha	152,147ha	227,681ha	231,374ha	Unviable
Workers		16,178	45,235	28,910	
Mid yield 385kg/ha	34,405ha	92,859ha	109,405ha	112,242ha	171,834ha
Workers		7997	16698	9126	24,891
High Yield 600kg/ha	22,251ha	74,412ha	82,219ha	84,515 ha	105,845ha
Workers		5462	10295	5858	12,461

Therefore in several scenarios yields of 385kg/ha for wheat and 395kg/ha for barley seem preferable, although 600kg/ha yields for both crops would have required less land and surely sometimes were achieved. As previously stated I would prefer to use the worst, but still viable, scenario of the mid-range yields. Finally the number of workers calculated in the preferred mid-range yield situations, with 6ha landholdings, both with and without dependants range from *c* 17,000-25,000 a third to three quarters of the size of the garrison itself. If these numbers of workers are multiplied by a nuclear family with the preferred yields a population of 68,000-100,000 is arrived at. This comes nowhere close to the population estimate for the whole province of 400,000, but it is suggested that these would have been just the civilians living in proximity to the army. From all this going forward in the following Chapter I will measure the quantity of land argued to have been present in the archaeological record against these needs calculated at the preferred mid-range yields of 385kg/ha for wheat and 395kg/ha for barley with an alternate fallow regime and 6ha landholding.

Chapter Two, Section Two: The economics of exaction

2.2.1 Taxation and supply

Thus far the discussion has considered absolute needs, yet the nature of taxation in the provinces and how far market forces were at work supplying the military is central to the question of how much land would have been required. This requires a consideration, although hardly a resolution of, how the economy may have worked in the region. My thesis does not aim to solve the nature of the Roman economy, but in identifying the source of the grain required and the supply costs, I am by default re-constructing an element of the ancient economy within the *limes* zone.[330] To do so with some credibility I am at the mercy of ancient economic theory. The debate here has moved away from the primitivist and substantivist ideas of the ancient economy being status-driven towards a more rationalist stance, in turn leading to the idea of sustained economic growth during the Roman Imperial period. It is generally accepted that the majority of the ancient population, 80-90%, were agricultural workers.[331] Many of these farmers could have aimed to produce a surplus, especially if after conquest the presence of a military market and increased monetization offered profits to be made. Indeed the arrival of the army is sometimes seen as a catalyst for increasing productivity in farming regions.[332] There is no direct evidence of taxation, or of military supply from the region, so that I have need to reference other parts of the empire and marry this with the theories.

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[330] *cf* Davies 2005, p.154.
[331] Engels 1980, p.32; Hopkins 1980, p.104; 2002, p.203; Saller 2005, p.233; Garnsey & Saller 2014, pp.71, 107.
[332] Kooistra 1996, p.9 for the Netherlands; Haynes 2016, p.177.

The starting point for an economic discussion ought to be Hopkins' influential taxes and trade model.[333] The basic premise of this is that some provinces supplied goods to the frontiers (and the centre) equal in value to the taxes that they paid, which were themselves directed to the frontiers (and centre). For my purposes, this ought to mean that the Roman army had tax coin from the central provinces to spend on local grain, in addition to any tax in kind levied locally. The tax coin then ought to have percolated back to the centre through trade exchange. Hopkins also pointed out quite sensibly, that across the wider empire, tax in kind would have been less likely because the government did not need that much grain, only enough for the *annona* to Rome and the supply of frontier armies, yet it did need, and could use, coin more easily.[334] Tacitus provides a speech to Gallic provincials where taxes, *tributum*, probably referring to coin are justified to pay the army that provides their peace.[335] There has been continual discussion as to the credibility and applicability of Hopkins' model and the degree to which this suggests monetization. One view is that land tax was both expressed and largely collected in coin and that this promoted monetization and so economic growth in the provinces.[336] Temin on the basis of the abundant evidence for price variation across staple goods has made a case for increased monetization resulting in a market economy driven by financial exchange.[337] Temin's view is that the absence of a large bureaucracy involved in even the *annona* to Rome tells against state management, the corollary of which is that market forces were driving the economy.[338] These are all big-picture ideas that need to be boiled down to imagine

[333] Hopkins 1980; amended but defended again in Hopkins 2002.
[334] Hopkins 2002, pp.216-17, p.229.
[335] Tacitus, *Hist* 4.74.1 quoted by Roth 1999, p.166.
[336] Rathbone 1996, p.312; Hitchner 2005, p.212, p.219; Lo Cascio 2000, pp.81-4.
[337] Temin 2001, pp.169ff.
[338] Temin 2001, pp.176-7.

what happened on local farms in the provinces. Rathbone's interpretation of the Arsinoite estate of Aurelius Appianus is that monetization and rational economic principles promoted economic growth.[339] Rathbone has further suggested that if this were the case in Egypt then it was probably commonplace elsewhere, and in fact it was encouraged as a direct result of accountancy practices spread by the Roman army.[340]

Despite this view in favour of monetization and market forces which would have been better served if taxation in coin was more normal, that some tax was paid in kind is not in doubt. Erdkamp's view is that the army was chiefly provisioned through tax in kind.[341] In Egypt, wheat was a common tax medium on arable land and this was the case irrespective of the crop actually grown.[342] Papyri do show that tax corn was routinely directed to the military.[343] However, some papyri show that the locals were reimbursed for the supplies provided, so this is compulsory purchase rather than straight taxation.[344] Even if at a fixed price, it must have been close to a fair price for the farmers to have worked productively and survived. A fair price is further suggested in Pliny's panegyric of Trajan.[345] Erdkamp argues that this would stifle trade, but I would suggest that was not so where the garrison was one of the major markets.[346] Where there was not a significant military presence, and tax was exacted in kind, tax-grain could still conceivably be sold on

[339] Rathbone 1991, pp.394-401.
[340] Rathbone 2002, pp.166-7.
[341] Erdkamp 2002, pp.58-9, pp.65-8; Ørsted 1985, p.279, p.283, p.291 suggests but does not prove tax in kind for the Pannonian garrison.
[342] *P.Oxy.* XVII.2142 (*c* AD 293); Wallace 1938, p.12; Rowlandson 1996, p.236.
[343] Wallace 1938, p.22; *P.Amh.* II.107-9 (AD 185-6); *P.Ryl.* 2.85 (AD 185); Adams 1999, pp.120-1.
[344] *P.Amh.* II.109 *cf P.Oxy.* XIX.2230 (AD 119) reports compulsory purchase of blankets.
[345] Pliny, *Pan* 29.5.
[346] Erdkamp 2002, p.65, p.68; *cf* Remesal Rodriguez 2002, p.298 (the same volume) who points out that the scale of Roman trade diminishes the primitivist case.

the open market and the coin could be shipped to the frontiers where it was spent by the army on local grain, or elsewhere as Rome needed it.[347]

The evidence is not restricted to Egypt. Tacitus reports the exaction of both corn *frumentum* and *tributum* at the same time, although the latter can simply mean a payment, that it is distinct from *frumentum* seems to imply coin:

> 'frumenti et tributorum exactionem aequalitate munerum mollire, circumcisis quae in quaestum reperta ipso tributo gravius tolerabantur, namque per ludibrium adsidere clausis horreis et emere ultro frumenta ac luere pretio cogebantur'[348]

> (He) made the contributions of corn and tax less onerous by equalling the burden, and cutting off the ways of making profit, that were born more severely than the tax itself, for (the provincials) were compelled to go through the farce of waiting at closed granaries and what is more to buy corn and pay at a price.

The editors' of the Oxford text interpretation is that the provincials were reimbursed for the grain supplied, at a rate below market value – *frumentum emptum* – and so they normally preferred to commute their obligations.[349] Hence the reported abuse of having to purchase grain at market value and then provide it to the authorities, being reimbursed to a value of less than that which they paid for the grain in the first place. Beyond the quotation, when describing the practice of

[347] Hopkins 2002, pp.216-17.
[348] Tacitus, *Agr* 19.
[349] Ogilvie & Richmond 1987, pp.215-16; *cf* Cicero, *Verr* 2.3.163; Rickman 1971, p.271; Rathbone 1996, p.314; Roth 1999, p.232; Erdkamp 2002, p.58, p.65

delivering grain to out-of-the-way places, Tacitus further implies that in an ideal situation corn extracted in kind ought to be delivered to neighbouring forts, supporting the view of local supply. A similar reference to both coin and kind is known from Africa.[350] Hyginus also reports tax in both kind and coin:

> 'in quibusdam (provinciis) fructus partem praestant certam, alii quintas alii septimas, alii (variant reading – nunc multi) pecuniam'[351]
>
> 'in some provinces they pay part of the crop, in some one fifth, in others one seventh, while others (or now many) pay money'

The variant reading 'or now many' leads to an uncertainty as to whether paying money was a recent change at the time of Hyginus, *c* AD 100 or a later emendation, but both practices are clearly acceptable at some point.[352] A rescript in the Digest dated to Hadrian reports grain being purchased for the army from tax farmers at the direction of governor of Gaul, so this also indicates compulsory purchase, potentially for a distant garrison, since Gaul was not heavily garrisoned.[353] Garnsey and Saller, even though they do not follow Hopkins' view of tax coin travelling to the provinces, suggest that compulsory purchase of, where possible, local supplies was the normal method of army supply.[354] They further argue that all provinces paid tax in one of three ways: in kind to the army on the

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[350] *AE* 1948.109; Erdkamp 2002, p.59.
[351] Hyginus, 205L
[352] Hopkins 2002, pp.215-16.
[353] Digest, 39.4.4.1; Erdkamp 2002, pp.55-6.
[354] Garnsey & Saller 2014, p.77, p.117; Roth 1999, p.165 also favours local solutions.

frontiers, in kind to the city of Rome, or in coin, in large part to pay the army.[355] Although Garnsey and Saller are less keen on the part played by coin in Hopkins' theory, they use his figures to calculate army pay. If I do the same, the Lower Moesian garrison required approximately HS 26,500,000 annually in pay.[356] The annual arable need of just the soldiers and their horses calculated above of 13,350 tonnes of grain, nominally 2,065,032 *modii* at HS 3 per *modius*, equals HS 6,195,096, just under a quarter of the pay bill.[357] This shows that a tax liability in grain was not particularly burdensome in comparison to other army costs, so that if the Moesians were providing grain, other provincials could be providing army pay. Tax rates throughout the empire are generally considered to have been low. From the Republican period, Appian presents a claim that Rome normally required a tenth part of the produce of conquered foes.[358] Hyginus' figures above represent 14-20% rates. It has already been reported that the Egyptian land tax was roughly 10%.[359] As a result, a low 10% rate of tax is generally accepted.[360] The *limes* cannot have survived on purely local tax-grain unless a very significant market existed for the other 90% of arable produced. In the case of Dobrogea the only obvious markets other than the army were the Black Sea *poleis* which clearly would have drawn from their *chorai*. I have already commented upon the epigraphic evidence of a grain shipment from the province that appears to record the exceptional.[361] Therefore without an export market the army would have provided an attractive new market. It is difficult to imagine that the provincials of Lower Moesia were

[355] Garnsey & Saller 2014, pp.119-21.
[356] Hopkins 1980, p.125.
[357] Duncan-Jones 1982, p.146 provides the evidence for grain price; Hopkins 1980, p.119.
[358] Appian, *BC* 2.140; Erdkamp 2002, p.50.
[359] Rowlandson 1996, p.29, p.37, p.54; Rathbone 2000, p.51, 2002, pp.168-169; above, p.70.
[360] Hopkins 1980, p.119; 2002, pp.201-4; Rathbone 1996, p.322.
[361] *CIL* 14.3608; above, p.97.

taxed too onerously if they were also required to sell to the garrison, and even if this was done through compulsory purchase a fair price seems likely.

Beyond the *poleis*, whose own magistrates would have managed the exaction of taxes from their *chorai*, most other agricultural land within Lower Moesia was public and could have been subject to *tributum soli*.[362] Yet there is no evidence for how, or even if, this was exacted, and the process of assessing land for taxation was often not worth the return. Neither is there evidence of any cash purchases, compulsory or otherwise, of grain from Lower Moesia itself. In Egypt the nome *strategoi* as the senior local officials are clearly seen directing the provisioning of the army.[363] Adams has made a plausible reconstruction of the system where military units petitioned the prefect of the province for their needs and his office delegated the collection to the *strategoi* of the various nomes.[364] The *strategoi* were responsible for assessing stocks in state granaries and moving it onto the military.[365] They devolved responsibility for collection onto particular villages, possibly via other officials, the *pragmatikoi*.[366] The villagers handed the required grain to military officers, but as already stated one papyrus makes it very clear that they were paid for doing so.[367] It has further been suggested that these unit needs were unchanging and so passed on from year to year by the prefect's office.[368] In contrast, from Vindolanda one tablet clearly shows a cash purchase supplying the military with 5000 *modii*, 32,325kg, of grain, in this case spelt.[369] Although the editors cannot decide if the purchaser was a soldier or a military contractor, the

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[362] Gaius, *Inst* 2.7; Suceveanu 1991, p.74 deals with the distinctions between *civitates foederatae, liberae et immunes, stipendariae;* Garnsey & Saller 2014, pp.42, 47; Gerov 1988, p.85; Ørsted 1985, p.156; Rathbone 1996, p.315; Batty 2007, p.462.
[363] *P.Oxy*. XLVI.3290 (AD 258-60).
[364] Rickman 1971, pp.271-2; Adams 1999, pp.121-2; Rathbone 2007, p.171; Haynes 2016, p.178.
[365] *P.Oxy*. XLV.3243.
[366] *P.Wisc*. I.3 (AD 257-9).
[367] *P.Amh*. II.109.
[368] Rathbone 2007, p.171.
[369] *TV* 2.343; Bowman & Thomas 1994, p.122, p.322.

language of this text implies private enterprise and not compulsory purchase, since the writer is concerned that he will lose his deposit unless the balance arrives.[370] The quantities involved are significant, equating to two and a half months' supply for the garrison in question.[371] Therefore this text points to a market economy at work in northern Britannia, and I would suggest more credibly a civilian contractor acting as a middleman between farmers and the military, although the familiarity between the writer and the recipient at the fort might suggest that the middleman was a veteran. The recipient was more probably a soldier, either a legionary or in an auxiliary context an *optio*.[372] However, this text is unique in specifically referring to such transactions. Overall the evidence is more suggestive of a part of military supplies being provided as tax in kind, with the remainder being compulsory purchased. Yet, compulsory purchase need not be thought of as being significantly different from a regulated-market. If a fair price were paid, especially in the absence of another market, then the presence of the garrison should still have been a stimulus to agricultural activity and monetization.[373] In either case compulsory purchase or market forces, tax coin from elsewhere would probably have been moved to the frontiers according to Hopkins' model to do this. As a result, the estimates of land required that were derived in Section One hold good.

2.2.2 The Logisticians

With respect to who administered the exaction of tax and the purchase of supplies, the Egyptian model has already been reported. At the top of this system it was the provincial prefect who was ultimately responsible for army provisioning.

[370] Grønlund Evers 2011, p.17 concludes that he is a civilian.
[371] The cost was HS1.56 a modius.
[372] *cf TV* 2.180; Bowman & Thomas 1994, p.122, p.322; Whittaker 2002, p.215.
[373] Whittaker 1994, p.110 argues against market forces; Rathbone 2007, p.172 suggests fair prices; Kehne 2011, p.326.

In other provinces, the provincial governor was responsible for defence, while the procurator was responsible for ensuring both that the taxes were paid and that the army was supplied.[374] However, how he did so is not clear. The procurator's *officium* contained *beneficiarii* drawn from the resident legions and it is reasonable to expect that these men had some responsibility towards assessing and providing for their comrades' needs.[375] Many writers have tried to make a link between the provisioning of the army and the *praefectura annonae* at Rome, but there is no direct evidence for this.[376] It would imply a significant commissariat that then ought to be visible in the epigraphic record, which it is not.[377] This view is discounted.

There is a considerable body of epigraphic evidence for individuals being appointed to manage military supply in a campaign context, but this falls outside my remit.[378] Yet there is no evidence of a crossover between campaign logistics – the so called *prosecutio* – and garrison supply. Despite their title, the *frumentarii* do not appear to have had any logistical function, although Rickman suggests that their name implies that they did have originally.[379] The papyri that Adams used as evidence to reconstruct his Egyptian model is one of a series of receipts issued by the same officer, a *duplicarius,* for supplies received from civic communities over a couple of years.[380] This practice is corroborated by other papyri where an *optio*

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[374] Dio, 60.24.5; Strabo, 3.4.20, Pliny, *Epist* 10.27; Digest, 39.4.4.1; Herodian, 3.7.1; Davies 1971, p.123; Adams 1999, p.120; Erdkamp 2002, pp.53-6, p.60, p.68; Monfort 2002, pp.74-5; Rathbone 1996, p.313, 2007, p.175; Roth 1999, p.166.
[375] Remesal Rodriguez 1986, p.89; Rankov 1999, pp.27-9; Roth 1999, p.274; Nelis-Clement 2000, pp.255-6; Monfort 2002, p.76.
[376] Rickman 1971, p.273; Remesal Rodriguez 1986, p.86, p.110; 2002, p.296; Funari 1996, p.85; Kissel 1995, pp.124-42 cited by Roth 1999, p.264; Monfort 2002, p.81; Erdkamp 2002, p.53; Kehne 2011, p.327 acknowledges the lack of certainty.
[377] Whittaker 1994, p.104.
[378] Erdkamp 2002, pp.51-2, p.57, pp.61-4; Roth 1999, pp.244-78; Kehne 2011, pp.331-3; Matthews 2015, p.614-16.
[379] Rickman 1971, p.275; Kehne 2011, p327; *contra*, Rankov 2007.
[380] *P.Amh*. II.207-9 (AD 185); *P.Ryl*. 2.85 (AD 185); Rickman 1971, pp.271-2; Adams 1999, p.120.

signs for supplies provided by a *curator* at Oxyrhynchus and a *procurator* of a cavalry unit receives hay from a group of contractors – *conductores*.[381] Other civilians termed *dispensatores*, (*oeconomoi* in the Greek) are also evident issuing supplies.[382] By the late 3rd century there were individuals termed *epimeletae*, overseers or supervisors of the *annona*, for the soldiers.[383] The editors of the Oxyrhynchus papyri assume throughout that the *annona militaris* was in place and, although I will consider the *annona militaris* below as a product of the Tetrarchy, some practices and terms may well have been in use earlier.[384] Nevertheless these practices reported in the papyri should still be thought of as the normal Egyptian tax in kind and compulsory purchases. Outside of Egypt the evidence thins out. A *procurator ad solamina et horrea*, is thought to have charge of an oil depot and granary in Africa.[385] It is well known that *beneficiarii* attached to the governor's staff were posted to remote parts of a province, and one of their duties could conceivably be oversight of food supplies. This would explain the presence of two such soldiers from the Moesian governor's staff at Chersonesus which will be argued below to have been a long-distance supply solution to Dobrogea.[386] Equally the presence of *beneficiarii* at road stations may indicate oversight of the road network.[387] The probable presence of a military contractor buying from locals and supplying Vindolanda has already been reported. The same text shows that the author had the power to request wagons, but whether these are civilian or military is

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381 *P.Oxy*. I.43 (AD 295); *P.Lond*. II.482 (AD 130); Adams 1995, p.121.
382 *SB*. 6.9248; *P.Clermont-Ganneau*. 4a (Fink 1971: *RMR* 79); *P.Oxy* IV.735 (Fink 1971: *RMR* 81); Rickman 1971, p. 273; Adams 1999, p.124; Roth 1999, pp.238, 266; the term is also found in a campaign context where one very senior Imperial slave commands huge financial resources: Pliny, *HN* 7.129 and attached to legionary units: *AE* 1969-70.664, 1973.83, 1973.471.
383 *P.Oxy*. XV11.2142 (*c* AD 293); XXXVI.2766 (AD 305); XLIII.3111 (AD 257); XLIII.3115 (AD 271).
384 Below, pp.115-16.
385 *CIL* 8.619; Roth 1999, p.270.
386 *IA* 1.674-6; *AE* 1967.430, 1967.434; Rankov 1999, pp.27-9; Chapter Three, pp.271-3.
387 Monfort 2002, pp.78-9.

unclear.[388] Another Vindolanda text shows carriers were paid to move cargoes, the contractors were paid half their carriage money, *vectura*, up front to bring the full consignment of goods, *velatura*, the remainder being paid on receipt of the cargo.[389] This text has been suggested as indicative of the practice of *locatio conductio* associated with the *annona* for Rome, where traders *negotiatores* or contractors, *conductors*, took responsibility for moving supplies and paid individual hauliers or shippers according to the work that they performed.[390] Inscriptions from the Rhône and Rhine show that some individuals clearly acted as military contractors.[391] It is to be expected that businessmen saw the military as an opportunity for the sale of luxury items, but it unlikely that the military was solely dependent on market forces for staples. In a campaign context civilian traders are normally referred to as *lixae* – sutlers, although one such *lixa*, is associated with V Macedonica during its time in garrison at Oescus.[392] Despite the evidence of junior officers collecting supplies for the Egyptian garrison, there are also 1st century records of civilian carters being employed to supply the army there.[393] By the later 2nd century in Egypt some supplies were moved by liturgists.[394] The use of civilians to move grain aligns with the absence of soldiers employed as carters in the epigraphic record.[395] There is of course another possibility in that if the grain was raised through taxation, then the transportation could just as well have been part of that tax levied as a *munus* on the community. The only evidence of a tax liability from Lower Moesia itself is of

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388 *TV* 2.343.
389 *TV* 3.649; Adams 2003, pp.559-60.
390 Whittaker 1994, p.108; Remesal Rodriguez 2002, p.296 who in keeping with his belief that the *praefectura annona* supplied the army does see the contracting of civilian transport agents as normal.
391 Middleton 1979, pp.84-90; Whittaker 1994, pp.106-12; Roth 1999, p.271.
392 Ivanov 1990, p.132; Roth 1999, p.93-6.
393 *O.Fawakhir*. 9; *O.Petr*. 245; Adams 1995, pp.119-20.
394 *P.Wisc*. I.3 (AD 257-259); Adams 1999, p.123.
395 http://edh-www.adw.uni-heidelberg.de/inschrift/suche accessed 20/11/14 An EDH database search only revealed one other example of *vectura*, three of *vector*, none of *advector*, one possible reading of *baiulus*: none is in a military context.

such *munera*, where an inscription records communities moving goods on the road network.[396] The inscription carries a complaint by the inhabitants of one *kome* about the duties that they have had to perform with respect to the *cursus publicus*, in AD 159; it also makes reference to another village performing the same duties *c* AD 139. Although the military are not explicitly the recipient, they are the most obvious representative of Roman authority for whom such a duty might have been carried out. Similar examples of corvée obligations well known from Egypt and are also seen in Bithynia.[397] Because a dense distribution of agricultural sites will be seen close to both the garrisons of Novae and Dobrogea, a simple alternative may have been that producers moved goods themselves to sell at the camp gates. This is the practice reported by the agronomists in Italy when dealing with a civilian market.[398] Larger producers might, of course, have wished to hire transport for the purpose. On balance, it becomes evident that the movement of supplies was a civil function, sometimes performed as a *munus*, but seemingly more frequently the carters were paid for their trouble.

At the receiving end, the provisioning of the camp would fall formally to the *praefectus castrorum* and/or the military tribunes, but this was delegated down to subordinates.[399] At a unit level, Fink collates a series of receipts from individual soldiers for food and hay for their horses. The issuing officers are *optiones* in infantry units and *curatores* in cavalry units.[400] Uniquely in Egypt, the post of *cibariator* is recorded dispensing the non-grain element of the rations, but it is not

[396] *ISM* 1.378; Stoian 1959, pp.369-90.
[397] Mitchell 1976, pp.106ff ; Rathbone 1996, p.310.
[398] Columella, *Rust* 1.3.3-4; Digest 18.1.39.1; Morley 1996, pp.161-2.
[399] Digest (Macer), 49.16.12.2; *P.Oxy.* XXXVI.2760 (*c* AD 179-80); Vegetius, *Mil*. 2.9-10; Roth 1999, pp.272-3.
[400] Fink 1971: *RMR* 76, 78.

certain if this was a civilian or military title.[401] Other officers titled *salariarius* are also considered to have had logistical responsibilities.[402] At the lowest level *immunes* were in charge of the granaries and storehouses as *horrearii*, while clerks, *actarii*, *actuarii* or *librarii horreorum* were responsible for recording both receipts and issues to and from the granaries, and *mensores frumenti* actually weighed out the supplies.[403] Hunt's *pridianum* reports Moesian soldiers being absent in Gaul securing clothing and potentially grain.[404] Gaul seems an awful long way to go for clothing, which might suggest an official supplier and requisition or compulsory purchase; it was far too far to go for grain. Others were absent at the grain ships, exactly where or doing what is unclear; some are seemingly seeing to the movement of cattle. Finally, there were the military slaves *calones*. On campaign these would have been responsible for the kit and the cooking of a *contubernium*, but in garrison, they would probably have prepared the daily bread of the men, something that could take several hours in itself.[405] So soldiers did carry out logistical duties, which is to be expected; what is not evident is a logistical corps.

It is necessary at this stage to make some comment about the *annona militaris*, which van-Berchem argued originated under the Severans.[406] Rickman penned a short but effective rebuttal of this view as long ago as 1971.[407] What has been described above, taxation in kind, forced purchase at a price, and some evidence of open-market transaction is far removed from the *annona militaris*

[401] Fink 1971: *RMR* 78; Roth 1999, p.274.
[402] *CIL* 3.4308, 3.10501, 3.11011, 3.10988, 5.8275; *AE* 1936.0012, 1951.0103, 1993.1596, 2012.1239-40; Roth 1999, p.274.
[403] e.g. *CIL* 3.3433, 13.6538, 13.7007; *AE* 1938.153, 1983.941, 1992.1872, 2004.1258; Digest 50.6.6-7; Rickman 1971, pp.273-4; Roth 1999, pp.274-5.
[404] *P.Lond*. 2851.
[405] Roth 1999, pp.101-10; Halstead 2014, p.182.
[406] van Berchem 1937, followed by Roth 1999, p.240, p.265.
[407] Rickman 1971, pp.278-83; Kehne 2011, p.326.

depicted in the Theodosian code.[408] It is certain that the *annona militaris* did not come into being all of a sudden without adopting local precedents, such as the direction of supplies to the military by local officials, performed as liturgies and *munera* as seen above. The complete overhaul of the system with an increased emphasis on taxes in kind without recompense is, however, more properly to be associated with the collapse of the monetary systems in the late 3rd century under Aurelian and Diocletian.[409] Therefore the origin of the system according to van Berchem is too early, the systemic *annona militaris* was not fully developed until the Tetrarchy and not applicable to this study.

[408] *CTh* VII.4.
[409] Rickman 1971, p.278, p.283; Erdkamp 2002, p.47; Rathbone 2007, p.173.

Conclusions to Chapter Two

So, from all that has gone before, for a Lower Moesian army of 31,238 men and 4522 horse, at the preferred yields of 385kg/ha for wheat and 395kg/ha for barley, with an alternate fallow regime on an average 6ha landholding per worker, I have suggested a total land area of 68,810ha of arable land producing bread wheat and barley would have been required, together with 8253ha of cavalry pasture, 24,102ha for stock raising and 2774ha of vineyards. Once the needs of labourers to work this land are considered then a total landholding of 144,120ha is suggested as having been required. This represents 2.88% of the provincial land area, Table T.2.1.1 refers. These figures were arrived at after considering the ancient literary and the Medieval and near-modern documentary evidence, although alternative calculations were carried out at yields of 200kg/ha and 600kg/ha to test the suitability of the preferred values with and without fallow regimes and with 6ha and 3ha landholdings per worker. All the sources suggest that some fallow regime was utilised if possible, so that although workers possessing a smaller 3ha landholding without fallowing could be seen to have produced a surplus this was thought less likely. Alternative calculations also showed that low yields of 200kg/ha would have been unviable with either small landholdings or dependants arguing against this being a long-term situation. Without a fallow regime, at higher yields of 600kg/ha the number of farm workers calculated was felt to be too few, this was less pronounced but still evident with a fallow regime. Therefore the high yields were thought less likely than the mid-range preferred yields. Once dependants are taken into account at the mid-range preferred yield and with an alternate fallow regime, the needs increase to 223,129ha, representing 4.5% of the provincial land area. The calculations also showed that without dependants *c* 26% of the total calculated land requirement would have been turned to meat production, this figure rose to 28% with dependants, yet meat only provided 10% of the calories. Although this shows the ineffectiveness of meat as a food source there were other benefits: traction, manure and walking food reserves that can be thought to have offset this. Also, despite having rejected some models because the number of farm workers required was thought to have been too low, the numbers of farm workers to feed the garrison in the scenario that is to be pursued is thought to have been 17,000 roughly half the garrison size. This is indicative of the scale of the impact of the garrison on the local economy.

The organization of supply systems remains elusive. Overall, there is no coherent scheme. The evidence points to the army receiving some tax in kind but the bulk through compulsory purchase. If a 10% tax regime existed, 90% was still available to be purchased by the military. Following Hopkins, tax coin from more distant provinces could have paid for this. Yet whether the Romans used compulsory purchase or market forces, for the economy of Lower Moesia the effect remains the same. The army must have been a major market and a stimulus to production. As a result, the arable requirements remain good and from these I can continue to quantify the logistical burden. Ultimately, the army was fed for the 200 years after the establishment of the frontier until the time of Tetrarchy. The likely suppliers and the transport penalties form the subjects of the following Chapters, but I hope to have shown thus far that the army's needs would not have been too onerous, considering the size of the province.

Chapter Three: Land Use in Lower Moesia

Introduction

This Chapter will consider which land was available to supply the Lower Moesian garrison. In so doing I will assume that a significant part of the agricultural surplus of the province was directed to the military. Recovery rates of archaeological material vary greatly through the region, so that it is not possible, nor is it my purpose to produce a definitive survey of the agricultural landscape for the whole province. Indeed whilst compiling this work there was no up-to-date catalogue available of settlement activity outside of Dobrogea until the publication of a new Tabula Imperii Romani for Bulgaria in 2012.[410] However, it was possible to look at two specific areas: firstly, that between the legionary garrison at Novae and the town of Nicopolis ad Istrum, where two landscape surveys have been carried out. Secondly Dobrogea, which benefits from being catalogued on the Romanian national database of archaeological sites – cIMeC. Going beyond cIMeC for the southern portion of Dobrogea, I consider a large dataset of settlement sites evidenced by tumuli recorded through remote sensing by Dr Ioana Oltean. Prior to this, in my Preliminary Section I have made an assessment of the limitations of the archaeological evidence in demonstrating the scale of the agricultural landscape. I have also derived likely landholdings for different generic settlement types that I have subsequently applied to the survey regions. Overall it will be shown that, even when erring on the side of caution, within each survey region a sizable majority part of the agricultural needs of the garrison can still be argued to have been available from the sites known from the archaeological record.

[410] *TIR* K35/2 = Ivanov 2012a.

Chapter Three, Section One: Preliminaries settlement and agricultural activity

3.1.1 Problems of survey

The geographical limits of the province have been discussed in Chapter One. The total land area of Lower Moesia is taken to have been approximately 50,000km^2 after the inclusion of Nicopolis and Marcianopolis, and even before that formally happened I am including their agricultural potential as being available to the garrison. It has also been shown in Chapter Two that the garrison, which comprised nominally 31,328 men and 4,522 horse, required the arable product of 68,810ha assuming alternate fallowing and mid-range yields of 385kg/ha for wheat and 395kg/ha for barley, only l.38% of the provincial land mass. From here on in, for want of space it is only the arable needs of the garrison, their service providers, the individuals who worked in direct support of the garrison, and the labourers, who provided the food for both groups, that I will consider. There are only occasional literary references to the agricultural fecundity of Lower Moesia, but always in passing whilst discussing pillaging armies, and so they appear to be a literary motif.[411] Batty argued, chiefly on the basis of the writings of Ovid, that the region was subject to large scale migrations accompanied by violent raiding.[412] As a result of this he believed the social conditions did not favour investing time in arable agriculture even after the Roman arrival, but his argument is chiefly from silence resting on the absence of territorial boundary markers. Although Gerov accepted pastoralism was commonplace, he also argued for continuity of occupation and agriculture in the region, which, under Rome, was bolstered by forced migrations of

[411] Ammianus Marcellinus, 31.3.8, 31.6.5, 31.12.8; Solinus, 21.3; Gerov 1988, p.29 fn49; Batty 2007, p.474.
[412] Ovid, *Tr* 3.10.54-60, *Pont* 1.3.49-56; Batty 2007, pp.329-37.

people from outside of the *limes*.[413] Batty also completely ignores Poulter's argument for the establishment of the *vici* in support of the garrison in Dobrogea.[414] He argued that the Lower Danube was an area of overwhelming pastoral activity rather than an arable one.[415] He went further to suggest very briefly that the supply solution to the army was not only local, but pastoral.[416] This is too much; it has already been seen that the arable needs of the garrison would have been but a small part of the total provincial land area. Furthermore the evidence presented below is of extensive arable exploitation, so much so that a significant, indeed a mostly sufficient, quantity of rural settlement will be seen to have existed in the region.

To go beyond the historical record it is necessary to concentrate on areas where there has been some field survey. While it is possible to fully excavate a site and record how far houses and barns might have extended, it is impossible to see how much land was actually worked. Some attempts can be made through the distribution of pottery fragments discarded with manure that form a halo about a site; but this has been shown to be a far from certain method.[417] The presence of ploughmarks or erosion phenomena can also be instructive. In more intensive surveys it is possible to impose more prescriptive criteria by which to define an agricultural site. Such criteria require information about how the soil surrounding a site has been worked, the soil's organic composition and archaeobotanical information which is routinely lacking from the reports from my study area.[418] Without such data the best that I can hope to do is suggest landholdings from the

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[413] Gerov 1988, p.9, pp.23-5.
[414] Poulter 1980, pp.729-44.
[415] Batty 2007, pp.459-79.
[416] Batty 2007, pp.472.
[417] Osborne 1987, p.70; Alcock *et al* 1994, pp.137-70
[418] *cf* Kooistra 1996, pp.14-18, if the same criteria as Kooistra used were applied to the evidence for Lower Moesia, the lack of detailed site reports would make it would be impossible to advance my argument.

size of working populations, themselves derived from the area and density of settlement centres, and also from the size of granaries where they exist. It is acknowledged at the outset that there are limitations to this approach. Firstly, the surviving remains are quite clearly biased towards the upper levels of settlement activity because of the durability of brick and stone built structures in comparison to earth and timber buildings. Then individual surveys have been carried out according to different criteria and methodologies, so that the comparability of results is difficult. The classification of buildings will impact on the number of agricultural workers assumed, but there is no standard measure of, for instance, when a single family dwelling became the problematically defined *villa*. Most *villae* might better be referred to as small farms, but even then of what size is open to debate. Also barns and other agricultural buildings may easily be interpreted as dwellings for workers when they were never so. Because of these factors and post-depositional degradation it is common in archaeological and demographic studies to talk in terms of recovery rates and to assume quite rightly that what is seen now is only a percentage of what was present in antiquity, so that the visible results are multiplied by a survivability factor.[419] Yet, as a result, models of ancient agricultural activity can be overly optimistic if all the settlement seen is assumed to have been of the same magnitude as the few excavated examples and increased by a multiple.[420] Whilst I am certain that only a percentage of ancient agricultural activity is now apparent in the landscape, I have to balance perceived recovery rate against the fact that it is impossible to say with certainty which of the sites produced any surplus at all and which others did direct their surplus to the military. Furthermore, the dating of sites is imprecise, and although continuity of occupation,

[419] *cf* Witcher 2011, pp.35-42 for discussion.
[420] Morley 2004, p.39.

in Dobrogea at least, can be seen to have been normal, it is highly unlikely that every site was in use contemporaneously. When considering Lower Moesia in particular, Poulter specifically cautions that:

> 'region specific surveys cannot provide a secure foundation upon which to reconstruct the state of the economy'.[421]

Unfortunately, to reconstruct the scale of the agricultural economy at least in that part which served the military is exactly what I am attempting. What I hope to do is quantify the potential arable activity within selected survey areas, and to produce models of how much land was providing for the needs of the military. To achieve this I have chosen to define three artificial and broad categories of sites: firstly, larger semi-urban settlements, the *vici* type sites, including military *vici*, the *municipia*, and the inland *poleis,* secondly the small farms and finally isolated farmsteads. It is acknowledged that this is artificial, but for clarity of calculations it is felt to be necessary.

3.1.2 Larger settlements

The title of this section might appear rather vague, but it was found that the rural *vici*, the civil settlements alongside the garrison, and the few *coloniae*, *municipia* and inland *poleis*, were all, with one exception, small settlements with populations in the hundreds, or low thousands. These few urban centres that did exist retained a rural feel. There are in excess of 70 rural *vici* type settlements

[421] Poulter 2007a, p.45; he has also stated (pers comm) that what I am attempting is impossible.

known from all Lower Moesia, the majority were within Dobrogea.[422] Defining a *vicus* has long been problematic, and whether they were small towns or large villages is often open to question; in Lower Moesia the overall level of urbanization is so low as to normally suggest the latter. In many cases the exact location of a *vicus* is not known and its existence is attested through honorific inscriptions to the magistrates and members of the *ordo*: these institutions in themselves suggest a population running to hundreds maybe a few thousand to require such governance.[423] Similarly in 10 cases, Roman citizens and members of the Bessi and Lai tribes were *consistentes*, that is settled within these communities and this again points to a community in the hundreds.

Only a few rural *vici* have been positively located and fewer have been systematically surveyed. At Kamen near Nicopolis, isolated farmsteads were spread over a 16ha area, with evidence for cultivation in between the buildings; we might sensibly suppose cultivation for some distance outside the *vicus* area itself, but a population estimate is not forthcoming.[424] In Dobrogea at Fântânele, three settlement nuclei are known, and all together look to comprise a *vicus*.[425] The scattered buildings of the southern nucleus encompassed an area of 25ha, while the other two areas cover the same area between them, so overall settlement activity spreads to 50ha.[426] Housing density in the southern nucleus was very low, and only 16 certain dwellings have been identified, together with six other possibilities.[427] The most extensively excavated house - dwelling α - was a substantial building of

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[422] Dintchev & Sarnowski http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 31/10/11.
[423] Poulter 1980, pp.734-5; Schucany 2011, p.276 supposes 500-1500 inhabitants in Gallic rural *vici*.
[424] Kovalevska *et al* http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 31/10/11
[425] Suceveanu 1998, p.10; Bărbulescu 2001, pp.39-41.
[426] Suceveanu 1998, p.22.
[427] Suceveanu 1998, p.55.

rectangular plan covering $92m^2$, forming an open courtyard with two $7m^2$ living rooms in the 2nd century; later in the 3rd century it was greatly increased in size, to $353m^2$.[428] It is supposed by Suceveanu that Roman citizens, most commonly veterans, were the wealthier land-owners who had properties with resident labourers, and building α would fit this hypothesis.[429] The older parts comprising the owner's quarters, the newer extension being the *pars rustica*. Unfortunately, we possess too few excavations to be able to be sure that this sort of habitation was widespread. The small finds in this building point to mixed farming: pruning knives and bells for sheep or cattle are seen alongside a hoe, shovel and millstone fragments that point to cereal production.[430] As already suggested in Chapter Two, mixed farming was surely the norm, with self-sufficiency being a pre-requisite to producing a surplus. Dwelling α lacks a grain store, or cistern, and I would suggest those elements not seen in the house existed communally; indeed, a water tank fed from the main aqueduct to Histria is reported in the village.[431] For much of its existence dwelling α was clearly a residence of more than a single family, so that a staff of 10-20 would not be an unreasonable supposition. Now if all 16 certain dwellings were of the same size, and excavation has as not yet proven that this was the case, then 160-320 workers, assuming they worked 6ha each, could have worked 960-1920ha. For a single site this would still only represent radii of 1.74-2.47km, in no way a significant distance from the *vicus* centre. That is just one of three sites at Fântânele, so I might triple the number of workers and the size of potential land holdings. Suceveanu, with reference to an epigraphically reported donative to the members of the *vicus Celeris* of HS 300, assumed a single *sestertius*

[428] Suceveanu 1998, pp.26-30.
[429] Suceveanu 1991, p.74; 1998, p.54.
[430] Suceveanu 1998, p.58.
[431] Suceveanu 1998, p.55; Tomas 2011, p.63; *cf* Halstead 2014, pp.157-62 for alternatives to grain stores.

per head and thought this a reasonable figure for all *vici* in the region.[432] A voting, and so working, population of 300 men to a *vicus* does not seem unreasonable and, if they each worked 6ha, 1800ha of arable activity is possible. At the La Amza site near Teliţa, a 1st - 3rd century *vicus* type settlement extended over 14ha; the dwellings were predominantly of single family size, but more densely arranged than at Fântânele. Having sampled an area of 500m^2 and adjusted the density according to the chronology of the buildings, Baumann suggested a population for the whole *vicus* of 2240 in the mid-2nd century.[433] If each house held on average a family of four, of which 1.7 were workers, then of Baumann's total population 42.5% i.e. 952 would have been farm workers. This is a lot. If each man farmed 6ha they could till a massive 5712ha *pa*. Most of the pre-Roman indigenous Getic *dava* type settlements were subsumed within the rural or military *vici*, and only a few stood alone into the Roman period.[434] That at Satu Nou 'Valea lui Voici' is small, only 3ha in size, but the site 'La Moara' at Hârşova was of 10-12ha size, so that a working population running into the 100s can be imagined.[435] On balance, although I consider that the estimates for the *vicus Celeris* and Telița La Amza are quite possible, I would prefer to be pessimistic and take the lower figure of 160 workers suggested at the southern nucleus of Fântânele and so 960ha as an average landholding for the rural *vici*.

Beyond the rural *vici* there were only a few more urban centres; these communities generally grew up because of their proximity to the military and some significant part of their populations would have been those people not involved in

[432] *CIL* 3.7526 (*ISM* 1.352); Suceveanu 1977, p.47 fn181, 1998, p.120; Bărbulescu 2001, p.51; Baumann 2003, p.166 fn37.
[433] Baumann 2003, pp.164-6, pp.171-3.
[434] Irimia 2007, pp.141-2, p.221.
[435] http://cronica.cimec.ro/detaliu.asp?k=687 accessed 12/11/14; Bărbulescu 2001, p.102; Nicolae 2010, p.235.

agriculture who acted as the service providers to the military. When considering urban settlement in the wider empire it is common to take a recovered ground plan and multiply it by a standard population density of 100-400 persons per ha to arrive at a putative urban population, a method described by Wilson as the 'least bad'.[436] Wilson suggested that a lower figure of 40-60 persons per ha is quite possible in many of the less well developed parts of the empire, and Lower Moesia must surely be considered one of these; for Britannia and Iberia he suggested 100 persons per ha and for Asia Minor only 150 persons per ha.[437] Comparative literary and epigraphic evidence of donatives from elsewhere in the empire points to even the larger urban centres having populations of only 5000-20,000 inhabitants while smaller *poleis* might have had 1000-5000 inhabitants, close to the numbers that I associate with some rural *vici*.[438] I would venture that the nature of provincialism and the scale of the urban plans on the Lower Danube *limes* reflects urbanisation of no greater magnitude than that of Britannia. Even those settlements of the Black Sea *poleis* were similar to communities in Asia Minor. Therefore 100 and 150 persons per ha ought to be respective maxima.

Of the urban centres in the interior of the province, only Oescus, Novae, Durostorum, Troesmis, Tropaeum Traiani and Nicopolis have been surveyed sufficiently to yield ground plans. Oescus was small with two distinct phases: the first spread to 18ha with a 10ha later addition; the latter may have augmented or replaced the former, and the chronology of the archaeology is far from certain, but there were by the criteria above, at most 2800 inhabitants.[439] At Novae civil

[436] Wilson 2011, p.170.
[437] Storey 1997, p.973 comparative figures of 166/ha for Pompeii, 317/ha for Ostia; Wilson 2011, pp.172-4, 177, reports 164-415/ha for Sabratha in Tripolitania, but only 100/ha for Silchester.
[438] Brunt 1971, p.126, pp.259-62; Duncan-Jones 1980, pp.263-73; Morley 1996, p.182, 2011, p.144; Frier 2000, p.813.
[439] Poulter 1983, pp.76-7; Mulvin 2002, p.11.

habitation followed the normal double settlement pattern alongside legionary fortresses with *canabae* immediately adjacent and a *vicus* some 2.5km distant at Ostrite Mogili; but in this case the *canabae* was unusually larger, some 70-80ha in contrast to the 15-20ha *vicus*.[440] Nevertheless the combined size of *canabae* and *vicus* was 100ha, the greatest extent seen at any site on the Lower Moesian *limes*, which could be argued to have housed 10,000 inhabitants. It has been calculated that the main aqueduct would have provided 1,762,000 litres of water daily, sufficient for tens of thousands of residents.[441] However, it is not safe to postulate population sizes from aqueduct capacities, because baths complexes used huge quantities of water.[442] Novae is within the first survey region considered in Section Two of this Chapter and here Conrad has identified 32 small farmsteads within the immediate vicinity of the camp, *canabae* and *vicus*.[443] Taking a mid-range figure for his suggested land holdings, 695ha of agricultural potential is identified: not enough to feed the whole settlement and garrison, but indicative of the scale of landholding close to an urban centre and suggestive of some part of the urban population still being involved in agriculture. Durostorum had both a 25ha *canabae*, which is thought to have become the *municipium*, and a 24ha *vicus* type site at Ostrov nearby, the probable *vicus Gravidina*, in total space for potentially 5000 urbanites.[444] A recent survey at Troesmis suggests a *canabae* of 16ha area, to which could be added a similar area for the un-located *municipium*.[445] The remains of the town at Tropaeum Traiani are of Later Roman date and they are tiny, only 8-

[440] Tomas 2006, p.120; Conrad & Stancev 2002, p.674; Conrad 2006, p.321; Kovalevska *et al* http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 3/7/14.
[441] Tomas 2011, p.65.
[442] *cf* Duncan-Jones 1982, pp.261-2; Morley 2011, p.145; Wilson 2011, p.170; for the problems of this method.
[443] Conrad 2006, p.322.
[444] Boyonov 2010, pp.53-7.
[445] Alexandrescu & Gugl 2014, p.296, 2016, pp.13-18.

10ha in area; Later Roman sites did tend to be smaller than their predecessors but a small urban site in the 2nd and 3rd century is still likely.[446] Nicopolis was also small, only 22ha; the ground plan here is one of the best preserved and it was sparsely populated, several *insulae* seem to be the sites of individual farms.[447] Therefore we might expect at most a few thousand inhabitants because the town was an artificial construct set up under Trajan and was always linked to Novae; Poulter has suggested a Later Roman population of only a few hundred, something he also believes was the case in the 2nd-3rd centuries.[448]

If the few urban settlements have only revealed a few ground plans, the very existence of military *vici* alongside the auxiliary forts of the *limes* is not evident in every case. However, because civilian settlement alongside *limes* forts is so well documented elsewhere I have assumed that wherever I can position a garrison then a civilian settlement was also in attendance. I have followed the convention of only titling as *canabae* settlements close to the legionary sites and settlements adjacent to auxiliary forts as military *vici*, to distinguish them from the more commonplace rural *vici*. In the very west of the province, a settlement alongside the small 2.5ha fort of Augustae was 6.5ha in size, the enclosure walls are of late 3rd century date, but earlier settlement is accepted, so I might expect approximately 650 inhabitants.[449] At Halmyris on the Danube delta alongside the excavated fort a 10ha site suggesting a community of 1000, is associated with the epigraphically attested *vicus class(iciorum)*, one of the places where Roman citizens were *consistentes*.[450]

I must at this point consider the possible existence of *prata legionis* - legionary pastures, also known as *territoria legionis* - and their relationship with the

446 Bogdan Cătăniciu 1979, pp.53-4 Fig 33; Suceveanu 1991, pp.53-4.
447 Ivanov 2012d, p.111; Poulter 2007b, p.55.
448 Poulter, pers comm.
449 Gerov 1988, p.44.
450 *AE* 1988.986-90, 2003.1550; Suceveanu 1991, p.47; Zahariade & Phelps 2002, p.236.

military *vici*. Previously *prata/territoria legionis* have been thought to evidence direct military control of land potentially used as supply solutions to the garrison, but the paucity of evidence really leaves more questions than answers.[451] The original name *prata* implies that this was land used to feed cavalry mounts, or pack and draft animals moving supplies to a garrison.[452] It might also imply that meat moved on the hoof was fattened prior to slaughter, or even the existence of military herds and flocks; but this view is no longer prevalent.[453] There is only a single inscription from Lower Moesia, at Abritus where *prata publica* are recorded.[454] Gerov thought that the distance of the inscription to the camp, 7km, to be indicative of the size of Abritus' military territory; a circular territory to this distance would encompass a huge 15,400ha.[455] But these *prata publica* may well not have been military land at all, since elsewhere *ager publicus* was for the use of both Roman citizens and peregrines. Another inscription records a *territorium Abrittanorum* which just as credibly refers to a civil territory.[456] Seven other inscriptions from Lower Moesia refer to *territoria,* but all are more believable in a civil context.[457] Of these Poulter proposed that the *territorium* recorded at Capidava was under military control.[458] Yet the inscription records a civilian magistrate, again implying civilian land and Poulter does admit in his endnotes that this *territorium* may have been used by the civilian inhabitants of the military *vicus*. Mason also reports the

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451 Poulter 1983, p.85; Breeze 1984, p.277; Anderson 1992, p.77; Kehne 2011, p.329.
452 Ørsted 1985, p.343; Mason 1988, pp.164-5; Anderson 1992, p.77; Rathbone 2007, p.171.
453 This is the implication of Tacitus, *Ann* 13.54.
454 *CIL* 3.13726 . There are only eleven certain epigraphic records of *prata legionis* from the whole empire: eight from Spain, two from Croatia, one from Hungary, another three possible inscriptions come from Germany, Spain and the Abritus inscription itself; EDH search http://edh-www.adw.uni-heidelberg.de/inschrift/suche accessed 28/08/14.
455 Gerov 1988, pp.131-2.
456 *AE* 1985.765.
457 *AE* 1987.881, *CIL* 3.14437[2] (*AE* 1957.333), *AE* 1911.16, *CIL* 3.12491 (*AE* 1901.44, *ISM* 5.77), *AE* 2004.1281, *CIL* 3.7587 (*ISM* 3.241); *AE* 1980.818 (*ISM* 5.135) EDH search http://edh-www.adw.uni-heidelberg.de/inschrift/suche accessed 28/08/14.
458 *CIL* 3.12491; Poulter 1980, p.729, p.741 en5; 1983, p.85, p.110 en62; Bărbulescu 2001, pp.106-7.

territorium at Troesmis as military, but it was just as likely civilian.[459] Suceveanu suggests a three-fold landholding at Capidava and Aegyssus, the *territoria* reported for the use of the military *vici*, other land for the indigenous population, and thirdly military *prata*, although he gives no good evidence.[460] This sort of division of land between military and civic communities alongside the garrison was also favoured by Gerov.[461] Zahariade and Gudea's assessment of the rampart that exists to the north of the fort at modern Barboşi was that it included military *prata/territoria*.[462] This would have been another substantial area of approximately 17,000ha. That it would delimitate Roman authority seems sensible, but how land was used is more difficult to say. Piso studied the settlements around several legionary sites from the wider empire to conclude that in the case of legionary sites, although *canabae* sat close to the fortresses, the *coloniae* always fell outside of a radius of the ancient measure of one *leuga* [2.2km]. From this he suggested that land within such a radius was treated as *ager publicus* within the control of the camp prefect.[463] Ørsted also suggested *territoria* fell within the *imperium* of the camp prefects, administered by *primipili*, but still worked by private individuals; he suggested that the produce was exacted partly as tax, partly through purchase.[464] Because of the absence of any certain *prata*/*territoria legionis*, and the geographical set up of *canabae* and *coloniae* as defined by Piso, the most likely scenario to my mind was that some *ager publicus* was made available for the inhabitants of the *canabae* or, in the case of the more numerous auxiliary forts, the military *vici*. If this land were under the jurisdiction of the camp prefect it would have still been worked by

[459] *ISM* 5.135; Mason 1988, p.165 *cf* Suceveanu 1991, p.55.
[460] Suceveanu 1991, p.79, p.81.
[461] Gerov 1988, pp.19-20.
[462] Zahariade & Gudea 1997, p.81.
[463] Piso 1991, pp.131-69 cited by Tomas 2006, p.120.
[464] Ørsted 1985, p.343 fn682.

civilians, resident in the *canabae* or military *vici*, and this land would have been distinct from that belonging to any *municipia* or other settlement nearby.[465] This view is supported by an epigraphic reference to the *canabae* at Dimum between Oescus and Novae having its own territory.[466] I see no evidence for the military directing the agricultural activity. If Piso's interpretation of the size of these military *territoria* is correct, that would equate to 1520ha of land, not all of which would have been agricultural: some would be taken up by the forts and military *vici* themselves and in many cases part of these radii would extend over the *limes*, in this case across the unusable area of the Danube. Therefore a figure in the region of 750ha is plausible to be associated with the military *vici*. Clearly this would have been the land from which the army could most easily have drawn off the agricultural surplus whether by tax, rent or purchase; but the small size makes it unlikely to have provided all of the garrison's needs. Table T.1.1.2 details needs by unit type.

There are also the three Black Sea *poleis* Histria, Tomis and Callatis which are reported as being sizable urban centres with correspondingly larger populations. Suceveanu, although keen to stress he was dealing with hypothetical numbers, on the basis of aqueduct capacity, site area and epigraphic evidence, put forward purely urban populations of 10,000-15,000 for Histria and Callatis and 20,000-30,000 for Tomis; a total of 40,000-60,000 urbanites along the Black Sea shore.[467] These estimates seem to me overly high. Histria is the only one with a surviving ground plan: this is of only 30ha size, by the arguments used this far maybe enough to

[465] MacMullen 1963, p.9 followed by Breeze 1984, p.277.
[466] *ISM* 1.68; Gerov 1988, pp.19-20.
[467] Suceveanu 1977, pp.41-56; 1991, pp.40-2; above, p.128, fn442 for the problems of aqueduct capacities.

accommodate 4500 inhabitants.[468] Several boundary markers exist from Callatis suggesting centuriation.[469] The numbering ranges from the 20s into the 40s. If these stones are multiples of a standard 20 by 20 *actus* [710m x 710m] or 200 *iugera* [50ha] plots and if extending equally in both directions, then this would indicate a region of 1600 managed plots of 200 *iugera* each, and a very high total of 320,000 *iugera* [80,544ha], enough to feed 75,000 people if eating 0.5663kg of wheat daily and allowing for alternate fallowing. However, there is no evidence of centuriation through aerial survey, so that the boundary markers alone cannot prove such an organised landscape.[470] Neither is there evidence for centuriation at Histria and there is unlikely to be any from Tomis, the *chora* now having been covered by the modern city. In Chapter Four I will consider Tauric Chersonesus, not a particularly important community on the very edge of the Roman sphere of influence, as a long-distance supply solution to meet the deficits in the garrison's needs. Here, and at Panticapaeum the capital of the Bosporan Kingdom, there are areas of centuriation extending to 10,000ha.[471] With this in mind, it is tempting to posit similarly large landholdings to the Dobrogean *poleis*. 10,000ha of land cultivated around a *polis* would be sufficient land to feed 9313 civilians, something approaching Suceveanu's estimates of population numbers. However, this would encompass an arc of 8km and without any signs of centuriation in the landscape this seems too high a figure for a landholding. If the low end of Suceveanu's estimates were to hold good and each *poleis* had a population of 10,000, and if only 20% of urban adult males were employed in agriculture, then that could equate to 500 workers. If these worked 6ha each then a figure of 3000ha could be associated with

[468] Avram 2003, p.283.
[469] *CIL* 3.14214 [33] (*ISM* 3.51-5).
[470] Avram 2007, p.248.
[471] Carter 2006, pp.180-1; Nikolaenko 2006, pp.159-63; Smekalova & Smekalov 2006, pp.222-6; Chapter Four, pp.271-3.

the *poleis* itself, sufficient to feed 2,794 of the urban population, but requiring the *poleis* to be dependent upon their wider *chora* for arguably 72% of their needs.

Therefore, excluding the Black Sea *poleis* and Novae which did probably have populations towards 10,000, the other urban and semi-urban settlements were all small, with population estimates in the high hundreds or low thousands. Many of their inhabitants would have been the service providers to the military, while some were probably still involved in agriculture – this will be seen to have been the case at Novae, Nicopolis and Noviodunum at least. As such, in terms of agricultural labourers and agricultural output, the urban centres were not significantly different from the rural *vici* which maybe had slightly lower populations, but still in the hundreds. I will treat Novae differently in the first study area because of the level of detailed survey published, and I consider the agricultural potential of the *poleis* in the second study area as 3000ha in each case. Otherwise the generic figure that I will adopt for all these types of settlement, *vici*, *komai, coloniae, municipia, poleis, canabae* and military *vici* is 960ha of arable.

3.1.3 Small farm sites

There were significant problems classifying farm sites from the archaeological record. In many cases the literature uses the term *villa*. Traditionally the term *villa* is applied to a country dwelling designed to display status through Graeco-Roman features, but also having a working agricultural element.[472] Thus, finds such as good quality pottery spread over a wide area and mosaic *tessellae* would suggest a *villa*, whereas utilitarian pottery and roof tiles

[472] Mulvin 2002, pp.1-3; Dyson 2003, pp.13ff; Bâltâc 2010, p.437.

alone would not.[473] These distinctions are however, being increasingly challenged, there is no accepted definition of what was a *villa* and the term should be avoided where possible. In Lower Moesia, in keeping with the overall development of the province, the term small farm is more appropriate. This despite some studies tending to treat almost every rural site as a *villa* in the traditional sense.[474] Yet it is still necessary to arrive at an average land holding to apply to all those small farms which are reported. Because there is only limited evidence available from Lower Moesia itself, reference has also been made to a collection of recent studies from north-west Europe. Here in three different study regions, small farm density was observed of two or three per km^2; in one of the surveys, larger farms, of a more traditional *villa* style, were augmented by two-four smaller stone built farmsteads.[475] The potential arable activity was estimated at 50-200ha for each site.[476] This is quite reasonable if one considers the time required for travelling to the fields, it makes no sense to centralize all the farm buildings in an un-mechanised world and it accords with the evidence of the agronomists.[477] From these European studies Roymans and Derks have made a three-fold distinction between large monumental houses displaying Graeco-Roman features aligning with the traditional definition of a *villa*, secondary stone built homes inhabited by families farming the land that could still reasonably be considered small farms, and a third class of site, labourers' houses maybe doubling as smallholdings, but of insufficient size to be

[473] Dyson 2003, p.39.
[474] Baumann 1983 is worst for this.
[475] Schucany 2011, pp.276-9; Jenesen 2011, p.263, Gaitzsch 2011, pp.286-9; *cf* Kooistra 1996 for one of the same study areas.
[476] *cf* Junkelmann 1997, p.77 who suggests average *villa* landholdings of 100ha.
[477] Cato, *Agr* 10-11; Varro, *Rust* 1.18; Columella, *Rust* 2.12.7-9; Chapter One, pp.88-9.

considered a farm.[478] This is quite reasonable and accords with settlement activity the world over: there are, and always have been, degrees of wealth and success.

In Lower Moesia those stone built farms that are seen, although sometimes possessing Graeco-Roman features, were only occasionally grand enough for Roymans' and Derks' first category to be applied. Bâltâc identified 19 supposed *villae* that were attested by epigraphic references to *vilici* or other administrators, but some of her interpretations are tenuous.[479] Mulvin's survey of sites on the Lower Danube was only concerned with traditional *villae*; smaller native sites were automatically excluded, so that she only catalogues eight so called *villae* within the whole province.[480] Nevertheless the capacity of the grain stores where identified can be used to discuss the agricultural potential of some of these. To the south-west of Montana, Montana 1 is a farm of 2nd century date with both *pars urbana* and *rustica* covering a substantial 0.875ha.[481] The grain stores were some 624m^2 in plan, which if storing grain to a height of 1m allowing for a metre of walkway, would have held approximately 600m^3; such a capacity can be seen to house potentially 450,000kg of bread wheat, the annual product of 1169ha, a significant landholding.[482] Montana 2 is a rather more haphazard collection of seven buildings; the residential block has formal features suggesting a wealthy landowner and so agricultural staff, there is a 200m^2 grain store, sufficient for the annual product of 367ha.[483] There is evidence for sheep, pig and cattle all being kept at Montana 2, and as previously stated mixed farming ought to be considered normal.[484] Of the

[478] Roymans & Derks 2011, p.2.
[479] Bâltâc 2010, pp.438-9.
[480] Mulvin 2002, p.4, thereafter: Niculițel, Madara; Mogilets, Targoviste, Gorotsvet, Prisovo, Montana 1 and 2.
[481] Mulvin 2002, pp.95-6, Fig 45.
[482] Poulter 1983, p.89; *cf* Gentry 1976, p.26 and Bidwell & Speak 1994, p.29 who suggest sacks could be piled to 2.5m height.
[483] Mulvin 2002, pp.96-7, Fig 46.
[484] Poulter 1983, p.89.

other six supposed *villae* reported by Mulvin, store rooms and possible barns are visible, but no further certain granaries.

Around Novae Conrad has suggested land holdings for many of the sites that he identified as farms: these range from 50-380ha, which allows a calculation of the likely agricultural potential close to the fortress – the subject of Section Two of this Chapter.[485] In the territory of Nicopolis Poulter has mapped 253 sites; this sort of density is not seen elsewhere in Lower Moesia and, although this is partly due to prolonged survey in the region, it was also probably due to the market of both garrison and civilians at Novae.[486] Of 35 sites examined in detail, 33 sites were identified by Poulter as *villae*. One group of these – those sampled along the Rositsa valley – although they possessed traditional *villa* architecture with peristyle domestic quarters and one or two outbuildings, were also described as 'family estates' associated with veteran settlement and possibly only having a small staff.[487] This highlights the problems of defining farm types. These were not in Roymans' and Derks' first category, rather closer to their second category of small farms. They are typically 2-3km apart. A second group of sites more distant from the town appear to have been larger farms, according with Roymans' and Derks' first category, with outbuildings and in many cases clusters of smaller houses up to 0.5km distant with their own courtyard plots, these last buildings aligning with Roymans' and Derks' third category.[488] These larger farms have a separation of 5-6km. It is possible to speculate on the likely landholdings of farms from the quantity of land in between sites. In the first instance this presupposes a confidence that the bulk of the ancient settlement activity is still visible. Thereafter radii could

[485] Conrad 2006, pp.321-4.
[486] Poulter 2007b, pp.79-82.
[487] Poulter 2007b, pp.80-1.
[488] Poulter 2007b, pp.81-2.

be drawn about settlement foci to suggest areas of influence; later, when work was carried out in ArcGIS, Voronoi diagrams produced similar results. However, this only gives potential areas of influence. It is not credible that all the land between sites was actually farmed, and in the case of Poulter's 'family estates' with 2-3km separation, far too much land was evident than even an extended family could work. Only a couple of settlements within Poulter's survey region have been subject to excavation. One at Pavlikeni had a dominant main building in the traditional *villa* sense surrounded by lesser, domestic buildings, the whole forming a nucleated settlement of a hectare. The published reports dwell on the pottery production, and although a *horreum* and agricultural elements are reported, the sizes are not given.[489] At Prisovo a rectangular courtyard covers 0.24ha. The largest building is supposed as a barn because of agricultural implements found there, but there is no *horreum* or staff quarters from which to posit a landholding.[490]

In Dobrogea, the farm complex closest to a traditional *villa* definition is found at Horia, where hypocausts and a bath complex were built around a central atrium courtyard with a *pars rustica* attached as an annex.[491] The house extended beyond the excavated area of 900m^2, enough to house a staff; how many is open to conjecture, but surely running to double figures. A large room of 109m^2 is thought to have been a *horreum*, sufficient for *c* 75,000kg of bread wheat, the product of 193ha, and pieces of a ploughshare also point to arable farming. Another Roman farm site in the Capacilia valley near Niculiţel covered 0.32ha; again landholdings are not given.[492] Even larger was the 'Gurgoaia' site at Niculiţel, 0.459ha in area,

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489 Sultov 1985, pp.22-4; Dintchev & Kovalevska http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 31/10/11.
490 Mulvin 2002, p.101, Fig 56; Dintchev & Kovalevska http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 31/10/11.
491 Baumann 1973-5a, pp.61-75, 1983, pp.107-23; Bărbulescu 2001, pp.89-90; Bâltâc 2010, p.440.
492 Baumann 1983, p.74, pp.93-7; Bărbulescu 2001, p.78.

where a central courtyard was enclosed on three sides by large open aisled halls, within one of which were two cisterns for harvesting rainwater.[493] The size and shape of the rooms, the cisterns and plenty of cattle bones led Baumann to suggest that this site was a cattle ranch. A relatively small porticoed annex in one corner of the yard, with rooms of 105m^2 and 115m^2 where the majority of the small pottery finds were discovered, is suggested as quarters for a caretaker and herdsmen; Baumann believed the owner would have lived elsewhere, but posits a staff of 10-20.[494] The whole site is of a working nature and not in Roymans' and Derks' first category.[495] Baumann speculated on a pastoral regime, whereby cattle were brought within the compound at night, and reports Varro's recommendations for the optimum size of a herd being 100.[496] Yet a cow shed of comparable proportions to the covered areas would hold 269 animals according to modern welfare standards, assuming a live weight of 200kg, so this is actually an under-estimate.[497] 100 animals would have required 600ha to graze and 296 animals 1,776ha, but even in the latter case that would only be a radius of 2.38km, no great distance to move livestock.[498] Even if primarily a cattle farm, I do not rule out mixed farming, since agricultural implements were found on site and the benefits of mixed farming have been discussed. If this farm employed 10-20 labourers, that is far more than the few necessary to oversee a herd of 100 or even 296, so that they might have been expected to till 60-120ha as well.

Of all the farm sites evident through the province, Montana 1 and 2 and Horia would accord with Roymans' and Derks' first category, closest to that of the

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493 Baumann 1983, pp.98-107; Bărbulescu 2001, p.79.
494 Baumann, 1983, pp.104-5; Panaite 2004 and pers comm offers the alternative suggestion that this may be a *mansio*.
495 *cf* Mulvin 2002, p.97 who seems to miss this point.
496 Varro, *Rust* 2.5.18; *cf* Columella, *Rust* 6.22-24; Baumann 1983, p.105.
497 www.organicvet.co.uk/Cattleweb/health/hous.htm accessed 28/1/12
498 At 6ha per cow; Chapter Two, pp.82-3.

traditional *villa* definition. Although the landholding surmised from granary size was significant, in one case 1169ha, in the other two cases smaller landholdings were suggested of 367ha and 193ha. Elsewhere sites that accord with Roymans' and Derks' second category of stone built small farms are seen between Novae and Nicopolis, and at Niculiţel, which might more plausibly command landholdings in the 50-200ha range. Likely staffs of 10-20 would seem the most manageable figure and at 6ha a worker this implies moderate landholdings of 60-120ha. Thus the generic figure for that I shall use is 120ha. This would only represent an area of land radiating to 620m from the farm buildings.[499]

3.1.4 Individual settlements

The final category is that of individual sites where researchers note a Roman date for occupation, but often little else. Neither Conrad nor Poulter uses such a classification, but such sites surely existed in their landscape. In other areas such sites are rarely excavated and are only dated by the finds so that ground plans are very rare. One site Kurt Baiir – Slava Cercheza, has a ground plan which shows two individual houses existed side by side of $85m^2$ and $147m^2$; these are, if simple, still sizable properties.[500] The single-family properties in the *vicus* at Teliţa La Amza were smaller, $9\text{-}15m^2$ on average, but semi-urban dwellings were generally smaller than country ones which needed more space to accommodate tasks and equipment that might be carried out or held communally within a *vicus*. The rooms at Kurt Baiir would allow for larger families, with one or two labourers, yet despite their size the ground plan does still point to the abode of a single family living in an isolated location. I have suggested in Chapter Two that the average family had at

[499] *cf* Junkelmann 1997, p.77.
[500] Kovalevska *et al* hhttp://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 22/12/11; unfortunately a site that is not evident on cIMeC.

least one son, not maturing until 20 and replacing his father as the prime worker when the latter was 50, so that each family unit may have comprised 1.7 adult males working 10.2ha per family unit. In all certainty, other family members would have been pressed into service for the harvest, as is still the case today the world over. Furthermore, the more isolated a site, the more likely that further sons and other labourers might have also worked it. Nevertheless, where the reports record simply a site or settlement without any indication of size then I have been pessimistic and assumed single-family occupation so that 10.2ha of arable is the figure used.

Above I have tried to show the limitations of our knowledge of the Lower Moesian agricultural landscape. Because of these limitations I have proffered generic estimates to apply to broad categories of sites within the survey regions below. From these I aim to gauge the likely scale of agricultural activity available to the military.

Chapter Three, Section Two: The Novae to Nicopolis survey

Introduction

The first in-depth consideration of potential supply solutions to the garrison focuses on the area to the south of Novae including the region around Nicopolis ad Istrum, where two long-term archaeological investigations have examined the agricultural hinterland. One by a German-Bulgarian team considered the area from Novae to the east of the Yantra river, which produced results published by Conrad and Stanchev.[501] The other is at Nicopolis itself where there has been detailed research over the past 30 years in a joint Anglo-Bulgarian project led by Andrew Poulter.[502] The methodologies of both surveys and the manner in which their results are presented differ, nevertheless it was possible to splice the published material together to consider the area as a whole, covering some 4700 km^2. I will calculate the agricultural needs of the garrison, the agricultural workers who tilled the fields to feed that garrison, and the service providers to the military. Then, using the landholdings suggested by the published surveys where available, augmented by the generic figures for landholdings associated with the *vici* and small farms arrived at during the Preliminary Section of this Chapter, I will suggest an agricultural potential and consider how far the needs of the garrison and those dependent upon it might have been met.

3.2.1 The garrison's needs

Nominally, the legionary garrison at Novae comprised 6059 legionaries and servants and 144 horse. On the very north-eastern tip of Conrad's survey,

[501] Conrad & Stanchev 2002; Conrad 2006.
[502] Poulter 2007b, 2007c.

Sexaginta Prista was home to *cohors II Mattiacorum*, *vexillationes* of which are seen in Dobrogea so that half their needs are included in Section Three of this Chapter below.[503] Some part of the needs of this unit could have been drawn from Conrad's survey region, but only 10-15% of any radius drawn about the *polis* fell within Conrad's survey, therefore I add in the needs of another 15% of half of this unit's strength, a mere 41 auxiliaries. Three other forts: Scaidava, Trimammium and the cross-river fort of Pietrosani are known within the survey area.[504] No certain auxiliary units are known at these sites, but legionaries are in evidence at Trimammium so I shall assume that if garrisoned at this time, it was by legionary *vexillationes* and allocate no additional men to any site. The 6100 men posited would have required 9357ha of bread wheat allowing for alternate fallowing with a 385kg/ha yield, the cavalry would have required 665ha of barley, a total of 10,022ha of arable. Table T.3.2.1a refers. I have shown in Chapter Two that in absolute terms at the preferred yields, a soldier required the product of 0.767ha of land *pa* as arable, and any labourer working that arable would have required a similar amount of calories and so the same amount of land for himself. I will assume all land was subject to alternate fallowing so that the labourers' needs ought to be doubled to 1.534ha and the potential surplus would have therefore been 4.466ha, although he could have only produced half, 2233ha, in any given year. If I divide the 10,022ha arable required by this figure, I arrive at 2244 farm labourers to farm the land. They themselves would have needed an additional 3442ha of land to feed themselves, so in total 13,464ha of arable was required to feed Novae's garrison. These together represent 2.86% of the survey area. The cavalry who were few in number only required 665ha of feed-barley, and so only 149 of the

[503] Suceveanu 1991, p.66; Zahariade & Gudea 1997, p.74, pp.80-1; Spaul 2000, pp.243-4.
[504] Zahariade & Gudea 1999, pp.73-4 Scaidava is also termed Sacidava, not to be confused with Sacidava in Dobrogea.

farmworkers, who themselves would have required the product of 229ha of arable. Therefore, the cavalry's needs were significantly lower than in the wider province, because there, there were four cavalry units.

Beyond the estimated garrison strength and their farmers, there would have been the service providers who were not directly involved in agriculture, but working, managing or owning the businesses in support of the military, for instance the blacksmiths, carpenters, fullers, shop and inn-keepers.[505] Unlike the farmers actually feeding the soldiers, it is difficult to quantify the numbers of these civilians with certainty. There would also have been soldier's families, although we do not fully understand how many were in residence alongside the garrison at any time.[506] I would suggest that these dependants went some way to meeting their own needs by partaking in work either as a service provider, or as a farm labourer; I cannot believe that they formed so privileged a class that they did not need to work in some way. At Novae the combined *canabae* and *vicus* covered 100ha, as reported in the Preliminary Section of this Chapter, sufficient space for 10,000 inhabitants assuming an urban population density of 100 per ha.[507] There was also the population of Nicopolis, the ground plan of which points to the population being in the hundreds rather than thousands.[508] Neither is there any habitation evident within 5km of the town so that it appears that the fields about the town were worked by the inhabitants. Therefore, for the purpose of calculations the actual town of Nicopolis is taken to have been self-sufficient, but only that. The overall population density for the province has been suggested as 8 persons per km^2 and the area of Conrad and Poulter's survey region is 4700km^2 so that 37,600 inhabitants might be

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[505] *cf* Haynes 2016, p.156.
[506] *cf* Haynes 2016, p.159.
[507] Above, p.128.
[508] Above, p.129.

expected; I have excluded the garrison as supernumerary to any population estimate, because they were an artificial imposition on the landscape. It has already been reported that throughout antiquity *c* 80% of the population were farmers, so that 30,080 would have been farmers.[509] Yet by this reckoning, 7,520 would not have been employed in agriculture. This is of the same magnitude as the rough estimate of 10,000 urban inhabitants at Novae, and I imagine that the bulk of the suggested non-agricultural workers in the region were domiciled within *canabae* and *vicus* as service providers to the garrison. The needs of these nominal 7520 service providers ought to be considered in the argument because they would not have been present in such numbers were it not for the legionary fortress. Yet they may well not have eaten as well as the military or their agricultural workers: the former were a privileged class physically active with higher disposable income than most, while the latter were as active and enjoyed ready access to their calorific needs. Certainly, the half of the civilian population that was female would have needed fewer calories and so less agricultural produce than the men. Assuming that the service providers ate on average only 70% as well as the soldiers, i.e. 0.5663kg of bread-wheat a day, then they would have required the produce of 8,075ha with alternate fallowing. However, another 1,639 additional workers would have been required to feed these service providers and they would in turn have required a further 1,760ha to feed themselves, assuming that these workers only ate as well as the civilian service providers that they provided for.[510] This results in a total of 23,299ha need, 4.96% of the survey land area; these calculations are laid out in Table T.3.2.1a. Here also I lay out putative pasture needs for animals providing

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[509] Above, p.103 fn331.

[510] If the labourers required 207kg of bread wheat *pa*, the product of 1.074ha allowing for alternate fallowing, then each might have produced a surplus of 4.926ha, more than the labourers feeding the garrison but only because they ate less – this point could be disputed and figures adjusted accordingly.

meat to the garrison and service providers, another 11,384ha. The total calculated needs of the garrison are calculated as 34,946ha. The pasture need for meat represents *c* 33% of the total need for only 10% of the calories. Although the calculations are becoming increasingly speculative, what I would offer is that the service providers would not have been present were it not for the military, but they can be seen to have had a significant impact on the needs. They would have required 42% of both the arable needs and the total needs. This is worth carrying forward as an indicator of the additional needs that the army brought with it; looked at another way of course it was an additional stimulus to any local economy which the army brought with it.

To feed the garrison and service providers 3883 workers would have been required, but of a broad-brush population figure of 37,600 less 7520 service providers that still leaves some 26,197 civilians whose needs are unaccounted for. However, if I factor in dependants for the farm labourers the total number of people calculated is 29,577 approaching the same magnitude as the broad-brush figure of 37,600. The arable needs now increase to 33,084ha; the total calculated needs to 49,652ha. Table T.3.2.1b refers. These calculations did not allocate dependants for the service providers, because some of these would have also been service providers themselves and some may also have been agricultural workers, the extent to which this may have been so is impossible to say.

3.2.2 The published surveys

Conrad's published survey region ran 20-30km inland from the Danube and 50km east along the Danube *limes* towards Sexaginta Prista. In the immediate suburban area of Novae, an area of approximately 29km^2, a dense distribution of small farmsteads was observed with only 200-300m intervals, 26 sites had an associated land area of 5-30ha, and a further six had land areas of 30-50ha.[511] This is Area A on Fig 3.2.2.1 below, Conrad has suggested that these sites provided both small-scale agriculture and cottage industries. Further to the south Conrad identified small farm type settlements with an average interval of 2-3km between sites, 38 sites were investigated and a reconstruction of land use suggested that 10 were of 200-280ha size, 24 of 50-200ha size and four were less than 50ha in size.[512] Further afield to the south and east of the Yantra another 40 sites were identified as *villae*/small farms although how big a landholding these may have commanded is not provided and I treat as small farms, the interval here increases to 5-6km.[513] Five sites in this area are interpreted as *vici*, without information as to how they were so classified; this is rather worrying because *vici* weigh heavily on the supposed agricultural potential, but I will none the less persist with Conrad's interpretation. There are even nine sites recorded to the north of the Danube, which potentially supplied the garrison – Rome still had interests in the Wallachian plain. All of these sites, 83 small farms and five *vici* in total, are located within Area B of Fig 3.2.2.1 below. In total Conrad maps 120 sites excluding the fortress, the auxiliary forts and the *canabae* and *vicus*, 32 in area A, 88 in Area B.

The total quantity of apparent agricultural land surveyed by Conrad can be calculated if the mid-range figures of the settlement sizes that he suggested are multiplied by the number of each type of site. Where no suggested figures are given then I shall utilize those generic figures arrived at in the Preliminary Section of this Chapter. Thus, there were 26 seemingly individual sites within the suburban

[511] Conrad 2006, p.322.
[512] Conrad & Stanchev 2002, p.676; Conrad 2006, p.321.
[513] Conrad & Stanchev 2002, p.676; Conrad 2006, p316, p.319 Fig 8.

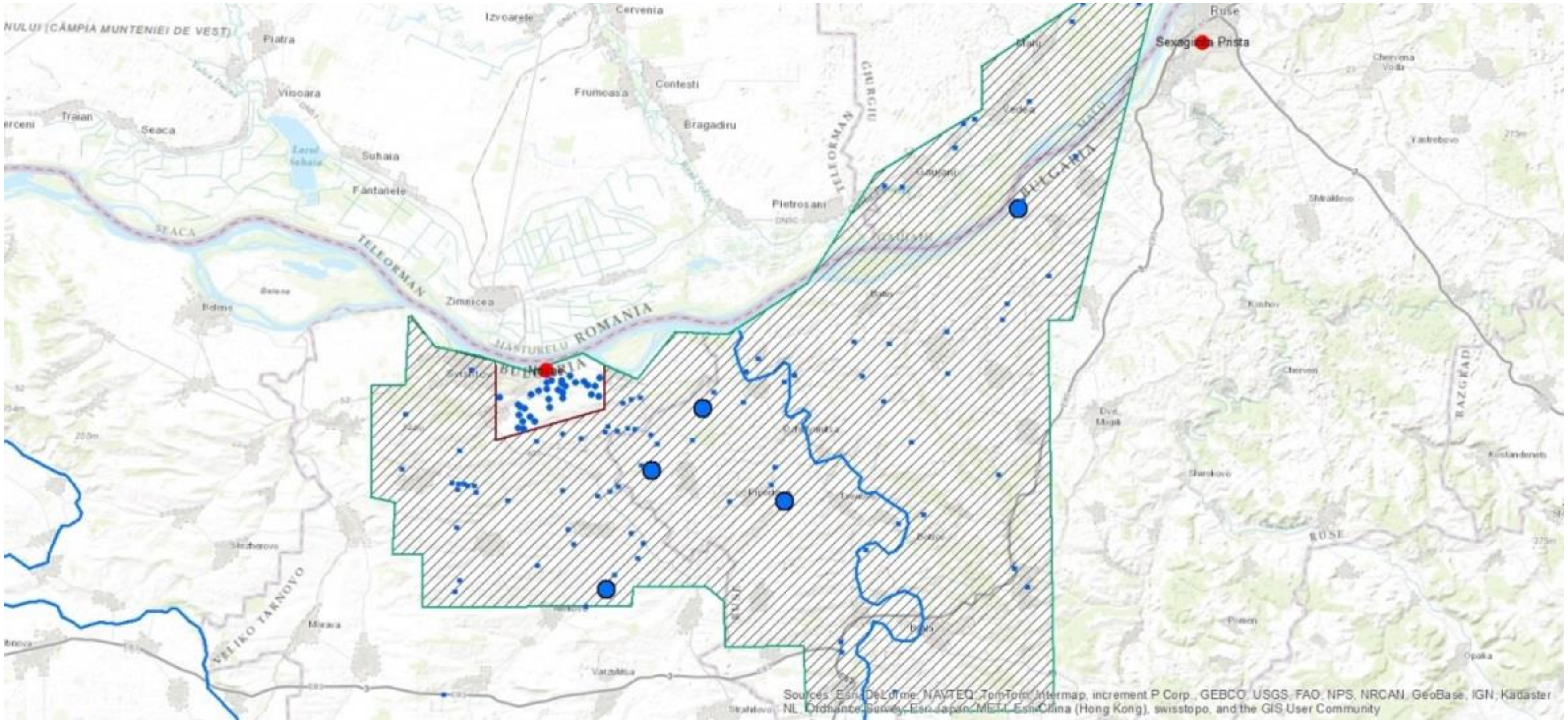

Fig 3.2.2.1: Conrad's sites Areas A, (open) and B (crosshatched)

Area A commanding a mid-range figure of 17.5ha. This is higher than the 10.2ha previously suggested for a single-family unit, but they were so close to the garrison that a market was assured and labourers could justifiably be employed, so that this remains a credible plot of land for an individual site. Six sites commanded a mid-range figure of 40ha; here several labourers would have been necessary, but that is still believable. The overall agricultural activity in Area A is estimated as 695ha. Although this is lower than the 960ha argued for in the Preliminary Section to this Chapter, because Conrad has intensively surveyed the area and specified figures for these sites, 695ha is preferred. Further to the south again, using mid-range figures, 10 sites of 240ha, 24 of 125ha and four of 40ha were identified. Further afield still to the south and east, 45 sites were identified as small farms of an unspecified size, together with the five identified as *vici*. For these sites I will use the generic figures of 120ha and 960ha arrived at in the Preliminary Section. This gives a total possible quantity of available land of 16,455ha, 70.63% of the arable need of both the garrison and the suggested civilian service providers. Although continuity of occupation is reported as being evident in the majority of cases and is reasonable, it cannot be certain what percentage of sites were in use at any given time.[514] Against this, we are unlikely to ever see the full agricultural landscape of the past, because of survivability factors. Therefore, the one was thought to mitigate the other and I continue with the figure derived from what is visible today. Although I make no claim to certainty with these numbers, what I believe they do illustrate is that within the immediate area of Novae the majority of the needs of the garrison and service providers could have been provided from those agricultural sites that are reported

[514] Conrad 2006, p.312, p.318.

by Conrad. Therefore the supply solution to the legionary garrison at Novae was surely a local one.

South of Novae by 45km lay Nicopolis, where by 2007, as a result of long-term survey led by Andrew Poulter, 253 sites were mapped in the area between the Haemus and the Danube.[515] Poulter's research, like this thesis, relied on the reports of others to pinpoint settlement, yet he excluded the smallest sites and it was accepted from the start that he was unlikely to see the full ancient landscape.[516] Of 253 sites identified, 35 were subsequently intensively surveyed to a radius of 1km of settlement centre. Several of these were chosen along the fertile Rositsa valley to the west of the town, where there had obviously been dense settlement activity, along with others from further afield where visibility was deemed good for pick-up survey.[517] Of the 35 sites sampled 33 were determined to have been *villa* sites. Those along the Rositsa valley were relatively modest comprising single main buildings with one or two outbuildings; with about 2.5km separation, although categorized as *villae*, Poulter also termed these 'family estates'.[518] Further afield, the sites sampled were irregularly spaced potentially commanding much more land; these were larger buildings at the centre of farm complexes with numerous outbuildings and most critically clusters of other houses implying labourers, according with Roymans' and Derks' first category.[519] Clearly Poulter has identified a micro-regional difference in settlement activity about the city. Previously Poulter had discussed the epigraphic material found around Nicopolis where Latin inscriptions associated with veteran settlement dominated the most fertile regions to north-west and south, while the less fertile area east of the Yantra

[515] Poulter 2007b, pp.79-80, Fig 12.
[516] Poulter 2007b, p.79, 2007c, p.583.
[517] Poulter 2007b, p.81; Tsurov 2007, p.581.
[518] Poulter 2007b, p.81.
[519] Poulter 2007b, pp.81-2.

he believed was the preserve of the indigenous population because of an absence of Latin inscriptions and the presence of Thracian names, although it must be said his sample was small.[520] It must be stressed, however, that although veterans clearly did settle between Novae and Nicopolis that does not, on its own, mean that there was a major *villa* economy: veterans were comparatively wealthy, enough to run a farm maybe, but only the officer class could reasonably be expected to manage large estates.

Unfortunately, the presentation of Poulter's survey comes down to a single map with all sites marked in the same manner, so that it is not possible to differentiate between the smaller 'family estate' type and the larger sites that he reports. Furthermore, without ground plans it is difficult to posit agricultural activity and indeed Poulter does not believe that this can safely be done with the current state of survey in the region.[521] Nevertheless, to progress my argument I needed to allocate some land areas or ignore his data completely. Because of the proximity, indeed overlap, with Conrad's survey it was felt best to attempt to incorporate the data. Most simply, if I take Poulter's own interpretation of these sites all as *villae*, and apply the generic figure for small farms of 120ha to all 253, noting that those 'family estates' were probably below this average and those further afield with additional houses were possibly above that figure, then the sites around Nicopolis might be suggested to be producing 30,360ha of arable *pa*. If this were added to the 16,455ha already suggested by Conrad, it would have provided twice the arable needs of the garrison and service providers at Novae. This was dismissed as overly optimistic pending ground plans of particularly the 'family estates'. Alternatively, the separation between sites could be used to suggest

[520] Poulter 1983, p.94 en95; 1992, pp.80-1.
[521] Poulter, pers comm.

potential areas of interest, although only a fraction of this can reasonably be assumed to have been in arable use. Taking a radius of the mid-distance between sites of *c* 2.5km separation, an area of influence of 491ha was arrived at. If this was divided by four, because only a fraction can have been arable, then a possible landholding of 123ha per settlement is found, very close to that figure of 120ha suggested in the Preliminary Section for a small farm with a staff 10-20. However, this is still far too much for a single family to have worked; even allowing for several sons and, or, one or two labourers, an agricultural potential of only 10-30ha might be more credible.

To accommodate the distinction between the 'family estates' and the larger farms further afield, I included those sites that appeared to be most closely distributed within a cordon of my own making that I imposed on Poulter's published map: there were 119 of them forming my Area C on Fig 3.2.2.2 below. This cordon was seen to encompass areas close to the Rositsa and Yantra river valleys, not unreasonably suggesting the importance of fresh water both for drinking and irrigation. If these were all single-family units of only 10.2ha output, then altogether they might have produced 1,214ha of arable; if all were genuinely small farms with 120ha, then 14,280ha would have been available. The artificiality of imposing a coarse distinction between individual sites and small farms is thus made clear; of course, the truth will have been somewhere between the two figures just suggested, 1214-14,280ha, yet I will stick with the worst case of 1214ha. Considering the sites further afield that Poulter identified, 21 fell within Conrad's survey, where, although Conrad identified considerably more sites, there was little alignment with Poulter's material. Therefore I excluded all 21 of Poulter's sites

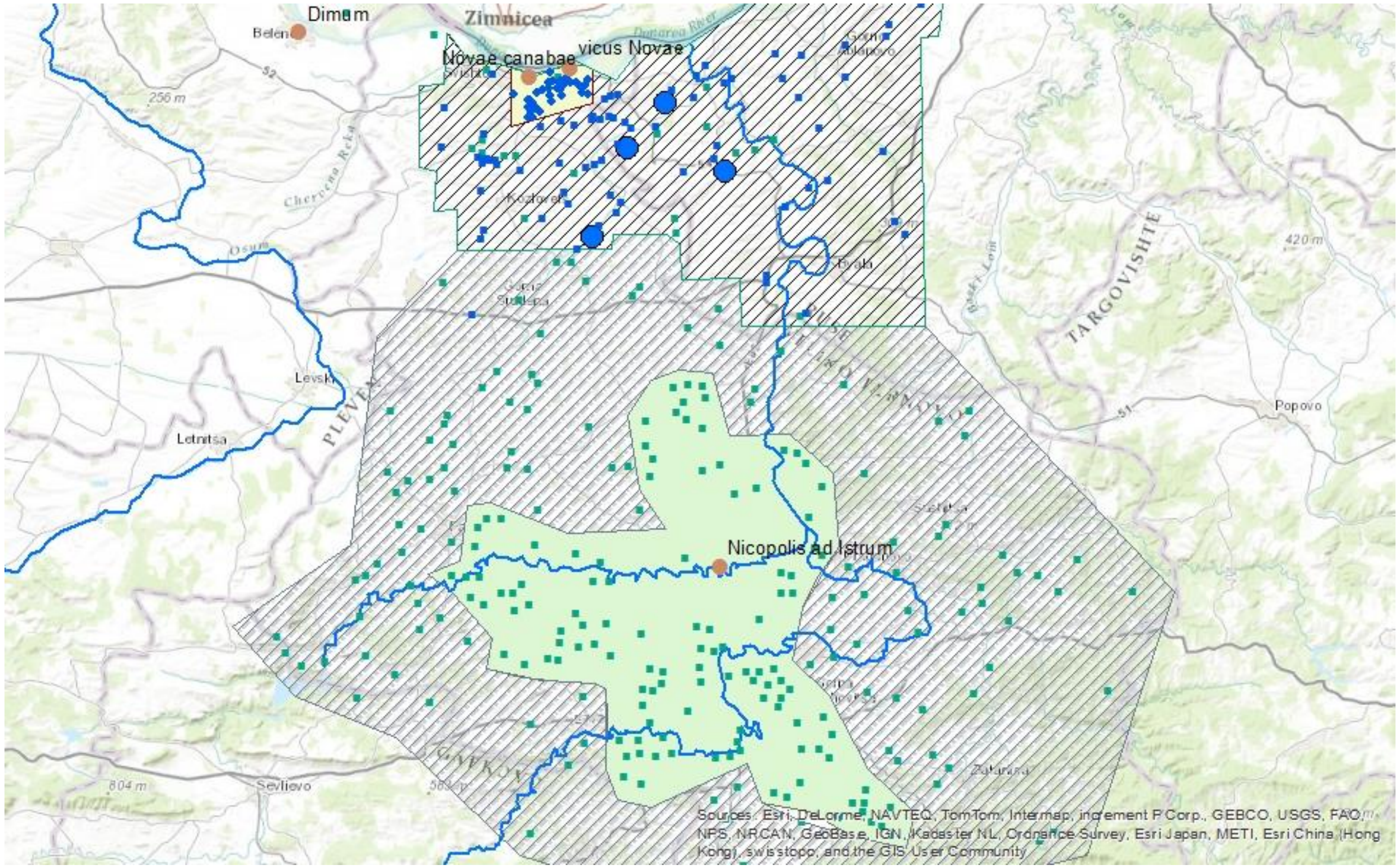

Fig 3.2.2.2: Conrad's and Poulter's sites, Areas A (open) B (cross hatched) C (green) D (cross hatched)

within Conrad's survey areas because the latter is more comprehensive and accessible. The remaining 113 sites identified by Poulter outside of my self-determined cordon Area C were spread more thinly over a wider area that I term Area D, and with these I am content to follow Poulter's identification as *villae* because some are reported as having extensive outbuildings and subsidiary housing. I still only allocate my generic figure for small farms of 120ha so that potentially there was 13,560ha in Area D. All together in areas C and D north of Nicopolis towards Novae I initially assessed an additional 14,774ha of arable activity.

The above calculations were carried out using paper traces and overlays of the published maps prior to working within ArcGIS. When further analysis was carried out within ArcGIS, there was no effect on Conrad's sites close to the garrison in Area A because of the detail with which he presented his findings. Further afield, in Area B, Conrad gave some specific figures of land areas between 40-290ha, but for other sites he offered no figures at all. Voronoi analysis of the distribution of these latter sites gave a potential maximum area of influence for each site of 1447ha, but Voronoi analysis includes all land between sites and a look at the map makes it quite clear that there was space for many more sites to be found and many that may never be known. Therefore, this added little. With regard to Poulter's data, it was possible to discern the relative density of sites more clearly through ArcGIS than by paper methods alone. Yet the cordon that created Area C that I had originally delineated by eye was found to be mostly satisfactory; this was redrawn to only include those sites where relative density went three times beyond the average density for the whole of the region. There were now only 99 sites included within the cordon after this revision, and the proximity of sites to fresh

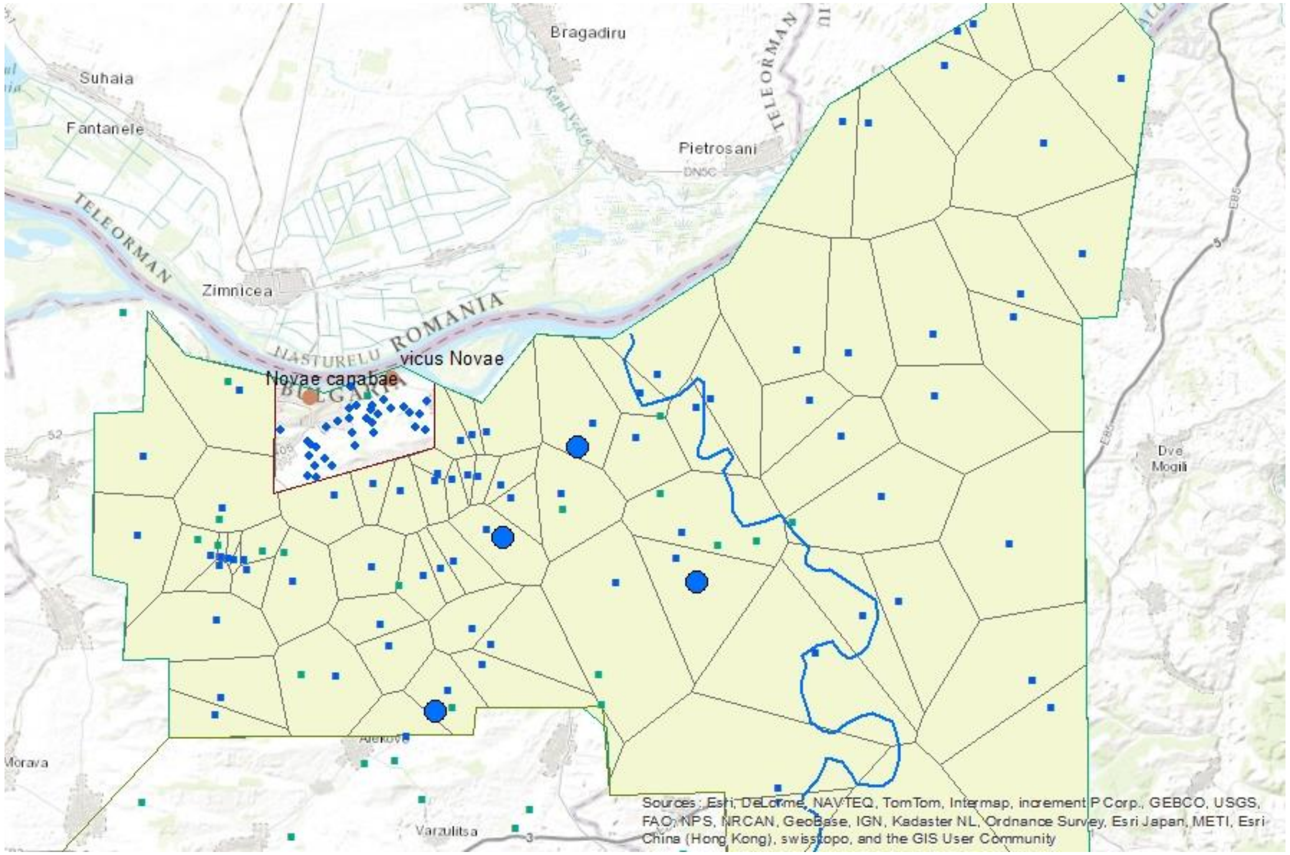

Fig 3.2.2.3: Voronoi analysis of land areas around Conrad's sites Area B

water was less marked. This modification had the effect of decreasing the number of sites that I applied the 10.2ha land area to and increasing the number that I applied 120ha to, so that the overall agricultural potential of Poulter's survey region went up. When Voronoi analysis was carried out to Poulter's sites within the revised Area C a potential land area of 597ha was arrived at, which is of the same magnitude as the figure of 491ha arrived at from the average radius of 1.25km about settlement centres. If this represented an area of influence, it could be divided by four to suggest an area of land farmed, and so 149ha is arrived at. Yet just as I had previously discounted the 123ha figure because the settlement activity shows insufficient farm buildings to staff such a landholding, I continued to do so. For the wider region surveyed by Poulter, Area D, the potential landholding derived from Voronoi analysis was 1505ha, but again it is obvious that there is space for many more agricultural sites that may never be discovered. What this Voronoi analysis does show is that the density of recovered sites in both Poulter's and Conrad's wider area is similar, and this may reflect an average distribution of larger sites in antiquity.

Poulter's survey was looking chiefly for *villae*/small farms so that he does not report any *vici*. One is known at Kamen, together with another five epigraphically attested, the *vici Saprisara, Zinesdina Maior, Dizerpera, Bri*… and *……tsitsi,* but unlocated.[522] These *vici* were within the area that I was looking at to provide for the military and so I added in their agricultural potential to the argument. It is acknowledged that some of these may represent some of the five reported by Conrad but not named, and that I may have therefore counted some

[522] Dintchev & Sarnowski http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 3/7/14; *AE* 1999.1354 (*RMD* 463) 1363 (*RMD* 311), 2000 740 (*RMD* 201), *AE* 2001.2165; *TIR* K35/2; above, p.124.

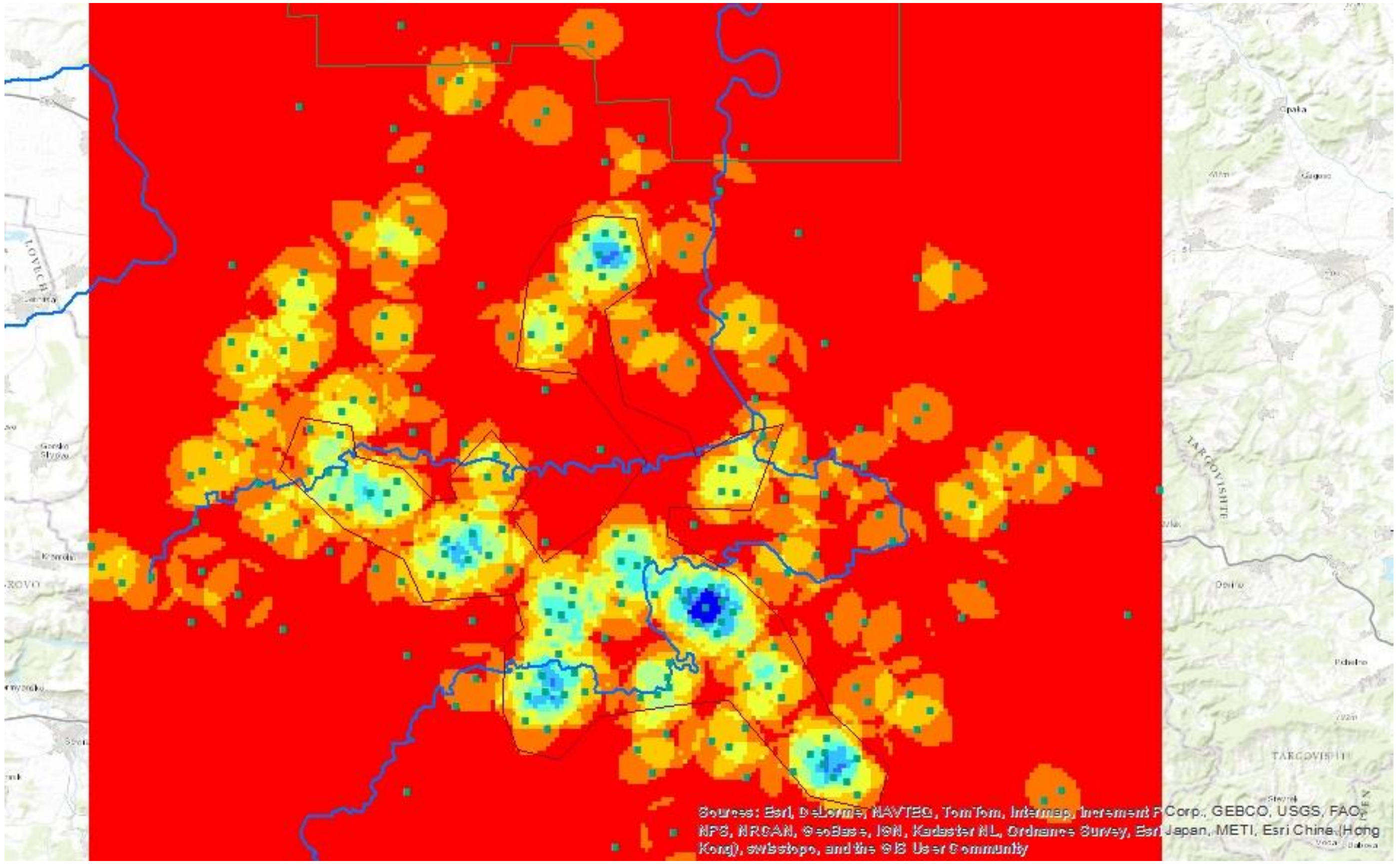

Fig 3.2.2.4: Relative density of Poulter's sites

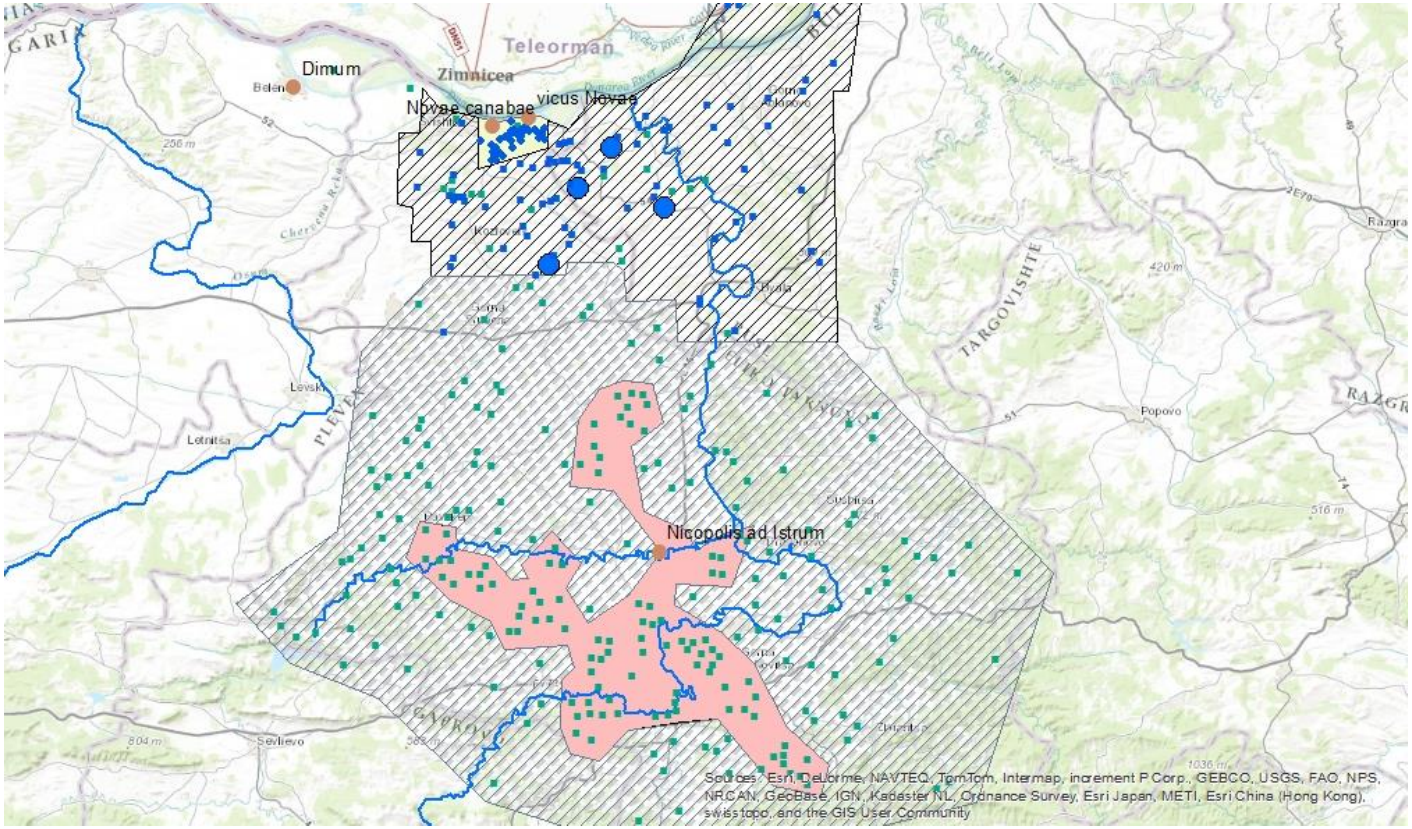

Fig 3.2.2.5: Areas A-D after adjusting Area C

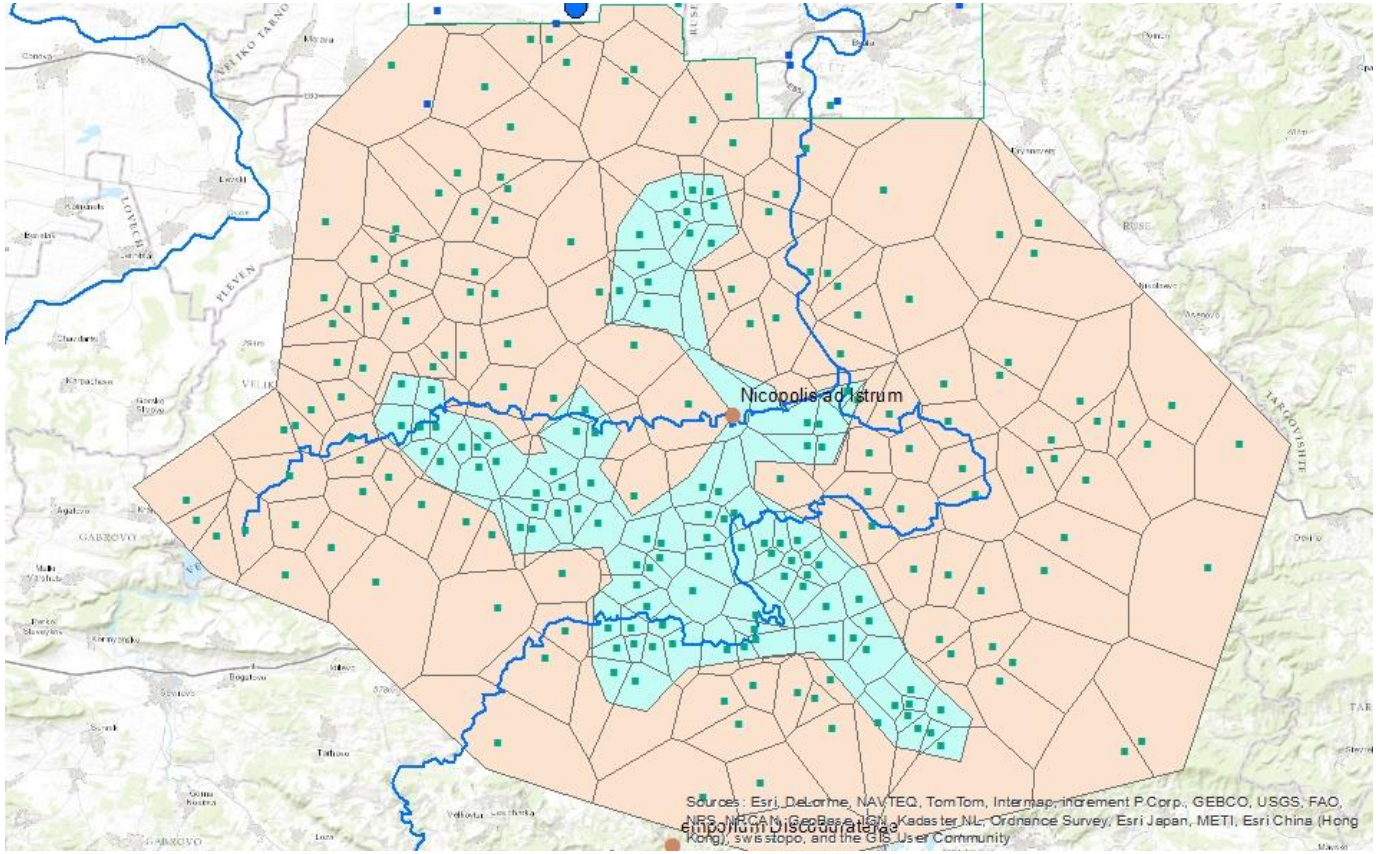

Fig 3.2.2.6: Voronoi analysis of land around Poulter’s sites

twice. Dintchev and Kovalevska reported a *vicus* type settlement surrounding the large farm at Prisovo, the editors of *TIR* acknowledge the opinion but do not follow it, so neither do I.[523] Other larger settlements include the *emporium Piretensium* close to the south-west at Gorsko Kosovo and the major pottery production centres to the south at Hotnica and north-west at Butovo and Pavlikeni.[524] These were all primarily industrial sites, so that although agriculture was surely practiced at least to be self-reliant, it is nowhere quantified.[525] As a result I will not add any additional arable potential from these sites into the argument. It has already been shown that much of the needs of the garrison may have been met from even closer to the fortress, if Poulter's estimate of the urban population of Nicopolis being only a few hundred is correct, then the town would have in no way required the output of the 232 sites that he identifies in Areas C and D whatever size they were, let alone the six *vici*. As a result, all these sites evident ought to be considered as potentially feeding the garrison at Novae.[526]

3.2.3 Are the garrison's needs met?

Using Poulter's own definition, his 253 *villae*/small-farms would have easily met the needs of garrison, farmers and service providers: 30,360ha was suggested. Modifying this with 21 sites excluded as being better surveyed by Conrad's survey, and after examining settlement density within ArcGIS so that 99 'family estates' and 133 small farms were counted, this resulted in 16,970ha of arable potential being represented. If the potential of six *vici* is added in, this becomes 22,730ha.

[523] Dintchev & Kovalevska http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 3/7/14; *TIR* K35/2; above, p.138.
[524] *TIR* K35/2.
[525] Sultov 1985, pp.18-30; www.museumpavlikenu.com accessed 3/7/14.
[526] Gerov 1988, p.117 fleetingly suggests that this was likely.

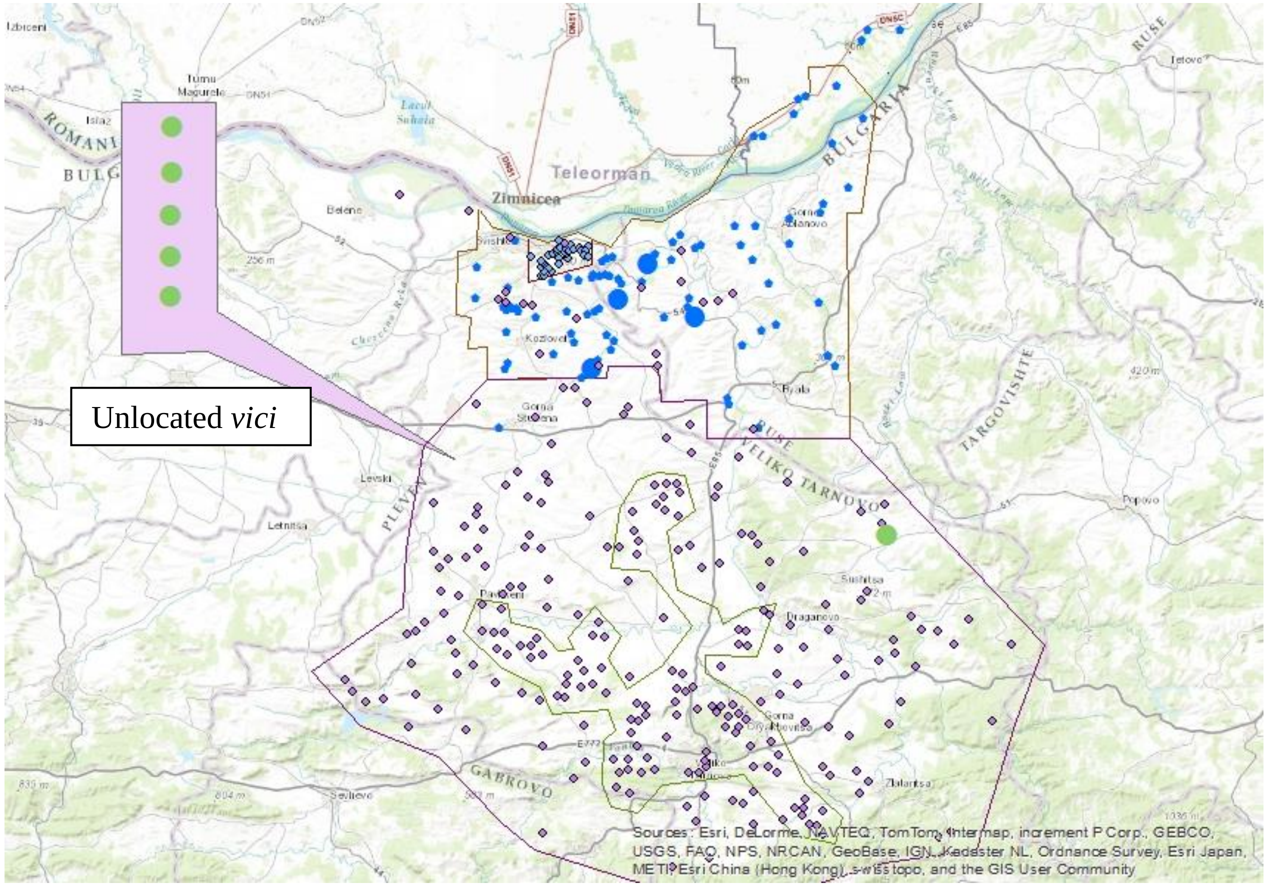

Fig 3.2.2.7: All sites

Adding this figure to the 16,455ha seen in Conrad's study region, 39,185ha of agricultural activity is evident. Therefore, the arable needs are met with a 68% surplus. If alternate fallowing were practised, the half of this land lying fallow in any given year would have also provided almost twice the 11,384ha of pastoral land required. Of course, there was plenty of other unattributed land in the survey region that could have done this also. If the suggested dependants of farm labourers feeding the army are considered there would have still been an 18% surplus. These calculations surely ignore very many of the smallest settlements where the inhabitants were simply self-sufficient and in the case of Poulter's survey at least isolated sites were deliberately excluded.[527] Nevertheless there appears to have been sufficient arable activity to meet the needs of the wider population.

Within this section I have assessed the needs of a single legionary garrison in relation to a particular landscape, parts of which have been subject to traditional extensive survey. Although the actual calculations may well be open to question, the overall picture is of an arable landscape comfortably providing for the needs of garrison and attendant civilians. Conrad's survey alone provided the majority of their perceived needs and when Poulter's survey is taken into account, even allowing for the lack of precision and the exact location of the unknown *vici*, then the scale of agricultural activity in the region goes beyond the needs of garrison service providers farm labourers and their dependants all. It is acknowledged that there are problems with Poulter's data, because it has all been gleaned from one published map of sites while the allocation of sites as either small 'family estates' of 10.2ha or small farms of 120ha production was an entirely arbitrary division that I made on the basis of relative site density. Also the inclusion of the *vici* greatly

[527] Poulter 2007b, p.79, 2007c, p.583.

increases the arable potential proposed across both surveys by 9,600ha, yet only one *vicus* is certainly located. Nevertheless, allowing for recovery factors, to be able to see this quantity of agricultural activity is remarkable.

Chapter Three, Section Three: The Dobrogea survey

Introduction

Modern Dobrogea, the area between the Danube and the Black Sea coast as the river turns first north from modern Silistra, then east at modern Galați, is an area where there is opportunity to expand the methods used above to assess the potential supply solutions from a wider landscape. The region has benefitted from more research than the rest of Lower Moesia so that there is a far greater visibility of settlement activity here than in the Danubian plain to the west. However, I would suggest that the greater visibility today is a reflection of widespread agricultural activity in antiquity. Recently the Romanian national database of archaeological sites maintained by the Institute of Cultural Memory, hereafter referred to as cIMeC, has offered the opportunity to consider a large number of reported sites all from one web-based resource. This only applied to that part of the region within Romania, the limit of the survey to the south was the national boundary. With this as a baseline, and comparing it with published archaeological surveys, often available in the journal Pontica, together with Baumann's and Suceveanu's work, and especially Bărbulescu's comprehensive monograph on rural activity in Dobrogea, I have attempted to gauge the scale of settlement activity over a far greater area than would have been possible by traditional survey, and from a remote distance rather than through fieldwork. Although there were sometimes more detailed archaeological reports pertaining to particular sites which offered building areas, landholdings were not suggested so that the generic landholdings suggested in the Preliminary Section were applied to the sites seen. Added to these, to the south of the modern Danube-Black Sea canal, there was another dataset derived from remote sensing which was provided by Dr Oltean. This showed a large number of tumuli identified from a combination of modern and Cold War satellite imagery, together with World War II aerial photographs.[528] Although constrained by the same geographical limits as the cIMeC material to the west, south and east: that is the Danube, the national frontier and the Black Sea; to the north this survey only extended as far north as 44.3 degrees of latitude, a line defined by a modern no-fly zone running from Cernovodă in the west to Năvodari in the east. With a starting assumption that each tumulus represents settlement activity, because somebody must have built the barrows, it was proposed to incorporate these data with the material from cIMeC to survey the agricultural landscape where possible. Although the tumuli could be used to build a better picture of settlement activity, the problems of dating them prevented their integration when it came to quantifying the potential arable output. The distribution of both the cIMeC sites and the tumuli was examined in terms of relative density, and against soil type, fresh-water courses, elevation and the known Roman road network. In the last case new evidence of roads was also provided by Dr Oltean from her aerial survey. From the tumuli data alone a new pattern of settlement activity in the interior of Dobrogea was discernable. From cIMeC the number of sites of all categories considered to represent distinct Roman period settlement, including the military sites, was 357. Those considered to have been potential suppliers to the military number 209, from which I will argue that some 76.35% of the agricultural needs of the army and their attendant agricultural workers are still evident in the archaeological record.

[528] Oltean 2013a, pp.207-9 describes the methodology by which they were collated; Oltean & Hanson 2007, pp.73ff report early findings from aerial survey.

3.3.1 Troop Disposition: Dobrogea

At Table 3.3.1.1 below are listed the military units of Dobrogea. I have considered the garrison in the mid-2nd century when *legio V Macedonica* was at Troesmis, before leaving for Potaissa *c* AD 167. At the same time *legio XI Claudia* was located at Durostorum, but in this case the site lies just outside the survey area in modern Bulgaria, so that much of its hinterland does not benefit from being catalogued on the cIMeC database. Based on the fraction of radii from Durostorum that fall within my study area, my first assumption is that nominally a quarter of Durostorum's garrison was fed by the sites visible on cIMeC. After *V Macedonica's* departure for Potaissa, legionaries of *I Italica* can be seen to have come to Dobrogea from Novae, so although my calculations are based on the mid-2nd century garrison, a similar legionary need can still be believed after that time also. Of the smaller forts, an auxiliary garrison is evident in nine cases, although sometimes the same unit is present at two forts. Yet I can only guess at the size of these particular detachments at any particular time, so that where a unit is split between two sites I simply halve the numbers. Many of the smaller forts along the *limes* also show a legionary presence at some period, with and without an auxiliary complement.[529] The practice of posting *vexillationes* away from their home base is well understood and evidenced within the province at the beginning of the 2nd century.[530] Furthermore there were nowhere near enough military units to garrison all the known forts. Therefore, where a garrison cannot be evidenced at a particular fort, I have not allocated any extra troops, assuming that those units evident in the region were responsible for occupying as many of the forts seen as they required at any given time. The location of auxiliary units has been discussed in Chapter

[529] Sucidava, Sacidava, Capidava, Dinogetia, [Barboşi] Halmyris, Suceveanu 1991, pp.70-1; Zahariade & Gudea 1997, pp.77-82.
[530] *P.Lond.* 2851.

Two.[531] Also as previously demonstrated, it is difficult to gauge the size of the fleet: the only universally agreed fleet station is their supposed headquarters

Table 3.3.1.1: Troop Distribution: Dobrogea

Unit	**Location**	**Men**	**Horse**
legiones			
Legio XI Claudia	Durostorum	6059/4 = 1515	144/4 = 36
Legio V Macedonica	Troesmis	6059	144
alae			
I Vespasiana Dardanorum	Arrubium	624	662
II Hispanorum Aravacorum	Carsium	624	662
cohortes			
II Mattiacorum	*vexillationes* at Dinogetia and [Barboşi]	546/2 = 273	
I Claudia Sugambrorum Vet eq	*vexillationes* at Sucidava	693/2 =347	156/2 = 78
I Cilicium sagittariorum	Tropaeum Traiani/Sacidava	546	
I Germanorum cR	Capidava	546	
I Lusitanorum Cyrenaica eq	Cius *vexillationes* at Tropaeum Traiani	693	156
classiarii			
classiarii	Noviodunum, Axiopolis	1600	
Total		**12,827**	**1738**

at Noviodunum, while most commentators also believe in a presence at Axiopolis.[532] Fleet activity elsewhere in Dobrogea is assumed to have been transient not permanent. A conjectural distribution is used of 1200 sailors at Noviodunum and 400 at Axiopolis, with the remainder on the upper reaches of the river. I did suggest another 400 might have been working from the Black Sea *poleis* and as far as the Crimea, but I do not include their needs in the argument because

[531] Chapter Two, pp.46-7; chiefly following Suceveanu 1991, pp.62-6; Zahariade & Gudea 1997, pp.76-82; Petculescu 2006, p.32.
[532] Chapter Two, p50.

both the *poleis* and the Crimea ought to have been able to absorb the needs of an additional 400 men easily. Overall, I suggest 7574 legionaries, 3653 auxiliaries and 1600 sailors, a total of 12,827 military men at work in Dobrogea. By way of comparison Suceveanu has suggested a not dissimilar 15,000, Petculescu an even closer figure of 12,000-13,000 men.[533] I also calculate 1738 horse. Of the whole Lower Moesian garrison *c* 41% was present in Dobrogea. This is not unreasonable because, following Batty's arguments, if the Lower Danube was subject to migratory crossings of the river, then the area in need of the greatest defence was where the Danube was most easily crossed, that is around Durostorum, and the approaches to the Black Sea coast where civil settlement was highest, that is Dobrogea as a whole.[534] If Dobrogea warranted the most intensive defence, it would also have necessitated the greatest agricultural activity leading to the now long-standing idea of Poulter's that the area was developed by the establishment of *vici* to support the military.[535]

3.3.2 The garrison's needs

A total of 12,827 men requiring 0.809kg of bread wheat a day would have required 3787 metric tonnes *pa*, the product of 9838ha, doubled to allow for alternate fallowing 19,676ha. The cavalry would have required the product of 8030ha as feed barley. Such a landholding would have required 6204 workers to till the fields. These workers themselves would have required another 9517ha. In total the garrison and its attendant workers would have required 37,222ha of arable, together with 3172ha of pasture for the cavalry mounts. These calculations are tabulated at Table T.3.3.1a.

[533] Suceveanu 1991, p.72; Petculescu 2006, p.32.
[534] Batty 2007, p.347ff.
[535] Poulter 1980, pp.729-44; Petculescu 2006, p.40.

In the Novae-Nicopolis survey, I took a 20% part of the estimated civilian population of the area to be the service providers to the military, who were not involved in agriculture. The dry land area of Dobrogea today measures 11,000km^2, while much of the Black Sea coast comprises salt-water lagoons, the delta shifts in area and to the west the Danube spreads to include inland lakes and marshland. The shape and size would have been different in antiquity, but how far is a matter of conjecture, so that pending any other figure I will use the modern one. Within the region I will make a division between *limes* facing and *poleis* facing zones according to the distribution of sites with reference the physical geography and to the size of the *chorai* of the *poleis*. I generally assume that those sites further than 15-20km west of the Black Sea littoral were available to supply the military despite sometimes possibly remaining administratively attached to a *polis*, as will be seen in the case of Histria below.[536] From this I estimate the *poleis* providing zone covered approximately 2300km^2 and the *limes* providing zone 8700km^2. The latter would result in a nominal 69,600 inhabitants at eight persons per km^2 and 20% of these would equate to 13,920 service providers living in support of 12,827 military men. If these nominal 13,920 urbanites ate 70% as well as the soldiers then 0.5663kg of grain daily would have required the product of 14,947ha of arable *pa*. To work this land 3034 additional farmers would have in turn required 3258ha to support themselves. The total arable need would have therefore increased to 55,427ha. The soldiers, service providers and their farm labourers would have also required 1128 tonnes of meat that would have in turn required a further 23,838ha of pasture working on the percentages arrived at in Chapter Two. The pasture need for meat was again seen to have been a considerable part of the whole; *c* 29% here

[536] Below, p.220.

similar to the *c* 26% calculated across the wider province (before service providers were considered) and *c* 33% at Novae. I will not pursue this further because the required arable needs only represent 6.37% of the *limes* facing land area and therefore a great deal of other land must have been available for pasture. This is all laid out at Table T.3.3.1a. The needs of the service providers once again can be seen to have presented a sizable drain on the whole: 33% of both the arable and overall needs, a lower percentage than the 42% calculated for Novae. This can be explained by the increased arable needs of a far greater number of cavalry in Dobrogea than those attendant on the single legion at Novae.

If dependants of farm workers are briefly reconsidered, 9450 agricultural workers would have been required, they themselves and their dependants needing another 28,992ha of arable land, the service providers would have required another 3880 workers, themselves needing 8332ha. Table T3.3.1b refers. The total arable need in this scenario is calculated as 79,977ha, with a civilian population estimate of 67,240. This is very close to the broad-brush estimate of 69,600 derived from eight persons per km^2, which adds security to the yield and fallow assumptions already made in Chapter Two.

3.3.3 Methodology: The Dobrogea survey

The cIMeC database aims to catalogue every archaeological site in Romania. It was therefore hoped that it could be used to carry out an extensive survey of Dobrogea. The database can be searched according to county, period and type of site among other criteria. However, there is considerable variability in the quality and quantity of information uploaded – it is relatively open access – so that it was found to be unsafe to simply search for the Roman period sites and take these at face value. It was found that particular care needed to be taken when distinguishing between the Roman and Later Roman periods because 3rd-6th century sites were regularly classified as being of either period. Differentiating between military sites and their adjacent civilian settlements proved sometimes difficult, so that military *vici* were often absent when they would be expected and forts were often listed as civil settlements because during the Later Roman period civilian occupation of deserted forts was commonplace. Occasionally it became obvious that the database was simply incorrect, reporting the same site twice in two different communes for instance.[537] Sites are at best described as being so many hundred metres north, south, east, or west of a modern village or landmark, so that it was rarely possible to locate precisely.

Tumuli proved particularly difficult to deal with: presumably and sensibly to reduce the numbers of entries on the database on cIMeC tumuli were often simply reported as being around a particular village. Only very rarely and recently were they located with any precision, and when this was done it had the tendency to clog up the database with entries.[538] Thus, it was tricky to decide if the tumuli reported ought to be associated with the other sites nearby that were imprecisely located or represented additional settlement activity in themselves. When Oltean's data was included because of the ubiquity of her findings it proved difficult to align her groups of tumuli with any tumuli recorded on cIMeC. The data provided had already been arranged according to Oltean's own interpretation of aggregation levels by creating radii or buffers of 100-200m distance from each tumulus and aggregating those that fell within the radius of each other, to form so-called tumuli

[537] e.g. cIMeC 62583.01 & 62075.03 are both Dervent Hill between Galiţa and Canlia.
[538] As is apparent around Valea Nucarilor, Iazurile and Agighiol; below, p.210.

buffers.[539] Thus 2244 buffers were produced from an original 8758 tumuli. Then the data had been divided into six classes according to the degree of aggregation. The idea being that the denser the distribution of buffers and higher the aggregation level the greater the level of settlement activity in antiquity. Of the 2244 total number of aggregated buffers, the largest group, 1013, were isolated tumuli and 914 were in clusters of fewer than six, 236 were in clusters between 6-15, 52 of clusters of 16-30, 19 in groups of between 32-51, and ten groups had greater than 60 tumuli. Therefore 86% were either isolated tumuli or in clusters of fewer than six and these were most likely to represent individual settlements.

It will be argued in Chapter Four that oxen could travel between 23 and 32km in a day, radii were produced at the upper figure of 32km from the *limes* forts including Tropaeum Traiani and from the *poleis*. Having done this the most immediate observation from the pictorial representation in ArcGIS was that almost all of Oltean's survey region was within 32km of either the forts or the *poleis*. Furthermore it was possible to easily count the 22 tumuli buffers that lay outside of these radii, i.e. less than 1% of the 2244 total and even then these were only a few km outside. Thus the settlements across the whole region could have potentially provided their agricultural surplus to one or other consumer within a theoretical day's travel. These radii provided a ready way of dividing the tumuli between a part which might have been directed towards the *limes* zone and a part to the *poleis*. This arbitrary division does not mean that I believe goods only travelled to the most immediate consumption centre, nor any further than 32km, but it did allow me to

[539] Oltean 2013a, pp.212-13.

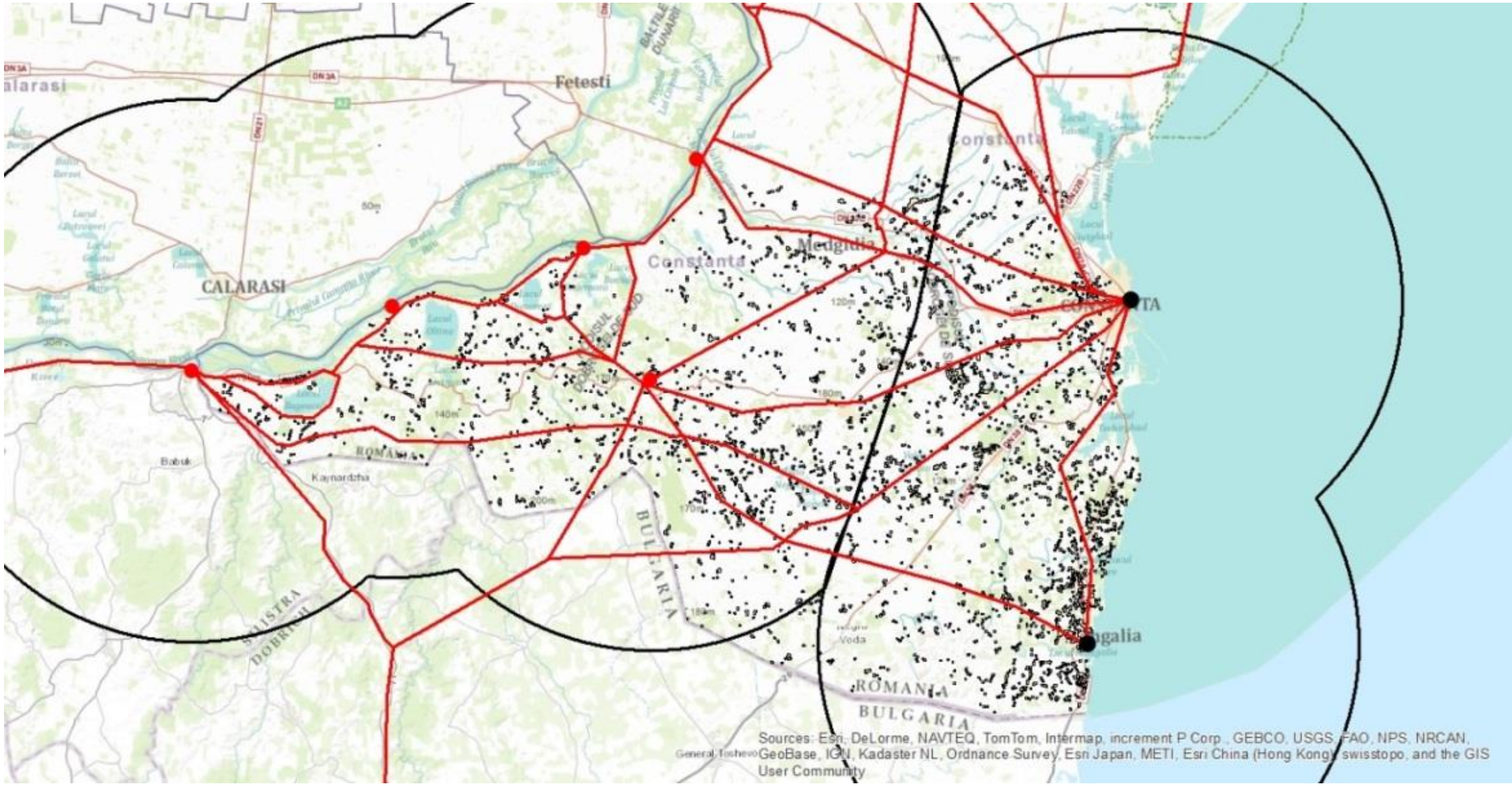

Fig 3.3.3.1: 32km radii about consumption centres

divide the tumuli into two groups – those facing the *limes* and those facing the *poleis*. When it came to integrating the tumuli evidence with cIMeC, because Oltean's data was derived from remote sensing, none of her tumuli were dated and to include undated tumuli without follow-up material felt cavalier. What I was able to do is consider the ratio of Roman to non-Roman tumuli on cIMeC and apply this to Oltean's data. Additionally it was possible to look at continuity of occupation of all sites as an indicator of which tumuli might have been of Roman date. Neither method was thought to be particularly safe. The overall effect is that I could have argued for more agricultural activity from the tumuli, but I was lacking the evidence to support my views.

The cIMeC database is a live document where new sites are regularly added but also existing sites are amended in line with on-going research. The positives of this are that some questions were answered as time went on, notably when picture files including detailed maps started to be added it became possible to locate sites with more precision. The negatives are that the total number of sites of all periods in the relevant counties increased sufficiently, from 700 to greater than 1000 over a three year period, so as to require a full re-assessment of the catalogue; there was no way to build on previous sifting already done and future work would require a similar fresh start. The catalogue of sites produced represents the data available in the summer of 2014. When considering the sites reported against published sources, especially Bărbulescu's, Baumann's and Suceveanu's work, there were obviously disagreements.[540] This was sometimes easily explained by the relative dates of publication. Also as researchers sometimes report sites on the basis of just isolated finds which do not always make it into cIMeC, I sought to take a

[540] Baumann 1983; Suceveanu 1991, 1998; Bărbulescu 2000.

pessimistic view and discounted such reports; for continuity I also discounted those few cIMeC reports of coin hoards or isolated finds on the same basis. Most critically, some archaeologists were in the past very optimistic about what is actually visible, so that Baumann in particular tends to posit *villae*, which I class as small farms, on less evidence than I might allow.[541]

Despite all these problems the cIMeC database provides a wonderful opportunity to examine the wider landscape from a distant perspective and any discrepancies with other commentators are more than compensated for by the sheer volume of data available in one place. In the first instance the status of every recorded site within Constanța, Tulcea and Galaţi Counties was considered to try and align with my three broad categories. Where cIMeC reports simply a settlement site – *aşezare*, in Romanian – without any indication of size I assumed single family occupation and allocated 10.2ha of arable activity as argued for above. Of the 25 small farms seen in Dobrogea there are no reports of potential landholdings on cIMeC or the secondary literature, so that I retained the figure of 120ha. Similarly, to the *vici* and *komai* I allotted the 960ha of arable potential argued for above. Because cIMeC is a database of sites it does not record the *vici* or *komai* epigraphically attested, but not certainly located, and indeed sometimes fails to make the link between particular sites and likely *vici*. Where the existence of a *vicus* is well acknowledged, I include it, but in a couple of cases the evidence is at best slight.[542] Similarly small farms are sometimes suggested as *villae* on the basis of an epigraphically attested *vilicus* or *actor*. These men almost certainly were employed supervising farms, but it is rather a leap of faith to posit substantial

[541] *cf* Panaite 2004, p.190 for the same criticism of Baumann.
[542] e.g. *vicus Rami*… *CIL* 3.14214[22] (*ISM* 5.117); un-named *vicus* at Neatârnarea *CIL* 3.12487 (*ISM* 1.368); Bărbulescu 2001, p.37, p.99; Panaite 2010, p.374.

landholdings on their basis alone.[543] Again the desire to show a *villa* economy seems to drive some researchers to do so, but where the body of scholarship supports these views I do at least allow a small farm of 120ha output.[544] Because it was impossible to date the tumuli within Oltean's dataset, it was not possible to allocate an arable potential to part of these, although the presence of tumuli will be remarked upon through the survey of sites and their distribution pattern will be commented upon further. In the case of the major urban centres, especially the Black Sea *poleis*, cIMeC tends to report multiple sites separately, but I have aggregated these, believing that even if some of the sites were separate farms in the immediate hinterland of the *polis*, they can be included in a total of 3000ha which I apportion to these *poleis*.

Beyond deciding which sites to list, and in what classification, the most arbitrary factor in my argument was to differentiate between those sites that might have supplied the *limes* zone and those which might have more credibly supplied the Black Sea *poleis*. This arbitrary division was carried out prior to having access to Oltean's dataset, but once the division of the tumuli arrived at from 32km radii of *limes* and *poleis* was considered the two demarcations were found to align sufficiently so that only three individual sites that I had previously assessed as *limes* facing now fell just outside the area of tumuli I considered to be *limes* facing. Therefore both divisions felt safe. Initially on cIMeC from a total of 1005 sites of all periods listed, after considering discrepancies between database and published sources on a case by case basis to decide which were truly of Roman Imperial date, only 326 civilian sites and 31 military sites were considered relevant. Of the 326 civilian sites 209 were considered to be *limes* facing, 117 *poleis* facing. At the

[543] e.g. *CIL* 3.12463: vicinity Adamclisi; *ISM* 5.72: Pantelimon; *CIL* 3.14214[21] (*ISM* 5.116) vicinity Gârliciu.
[544] Suceveanu 1991, p.83, 1988, p.139; Bărbulescu 2001, p.99, p.120, p.124; Bâltâc 2010, p.439.

same time in the south 1071 tumuli buffers were within 32km of the *limes* forts and 1151 were within 32km of the *poleis*.

3.3.4 Site Distribution *limes* zone

Throughout the following section I have listed the sites seen in a geographical pattern from the south-west travelling north, dealing with those sites in the west and centre of Dobrogea that I feel most probably directed their product to the *limes* zone. A catalogue of sites appears in Part Two of the thesis; each site is identified by a catalogue number. Map 1 also shows the site locations. I will later survey those sites along the Black Sea littoral which were more probably *poleis* facing. In contrast to the preceding narrative where I have used the ancient name of the well-known sites, throughout the following summary and in the catalogue, the modern name is used in the first instance. This is because in the majority of cases no ancient name survives, but where it does survive that will be provided in brackets. Exceptionally in the case of the *vici*, where only the ancient name is known, then of course that is the name used. Sometimes the same village name exists in both Constanța and Tulcea County, so where this is the case the county is bracketed.

The starting point of my survey is Silistra in Bulgaria, site of the legionary fortress of Durostorum, but being across the national frontier, neither fort, nor *canabae* are recorded on cIMeC. The camp lies 1km to the south of the river; the 25ha *canabae* was sited between camp and river.[545] There is another 24ha site, to the east across the national border at Ostrov [Constanța County] that is believed to

[545] Catalogue No 0, 1; Poulter 1983, p.78; Boyonov 2010, p.53; Ivanov 2012b, p.50.

have been the attendant *vicus*.[546] Although the *canabae* was titled *Aeliae* by AD 145, presumably following Hadrian's or Antoninus Pius' intervention, there has been continued disagreement as to which site received municipal status under M. Aurelius *c* AD 162.[547] This debate was resolved by the discovery of an inscription that records a *vicus Gavidina* which Boyonov identified with reference to the burial place of an early Christian martyr as the Ostrov site, so that now the *canabae* can be seen to have become the *municipium*.[548] Another *vicus Arnuntum Supperiore* is recorded on the same inscription and although un-located it is reasonably believed to have also been close to Durostorum.[549]

To the south-east of Durostorum a settlement existed at Almălău, and another nearby on the shores of Lake Bugeac at 'Ceairul lui Marinciu'; this was suggested as a *pagus* by the excavator, potentially bringing another new category of site to the argument, but the excavations were limited and a long time ago now so that I treat this as an individual site.[550] Roman period tumuli are also evident at Bugeac 4km away and so are treated as a separate site; other funeral monuments around the town are dated as pre-Roman and a small Roman period fort sits to the north.[551] Bărbulescu also reports Roman tumuli and tombs on the opposite shore of Lake Bugeac at Galiţa; cIMeC does not include them, but it does report a Medieval necropolis, which seems to be a more up to date assessment of the tombs so that I exclude them.[552] Two civil sites are recorded on cIMeC at Dervent Hill one to the north-east of Galiţa the other to the north-west of Canlia; this represents a problem

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[546] Catalogue No 2; cIMeC 62547.01, 62547.04, 62547.05.
[547] *CIL* 3.7474; *AE* 1924.318-20, 1925. 110; Poulter 1983, pp.78-82; Ivanov 2012b, p.50; Bărbulescu 200, pp.130-2.
[548] Boyonov 2010, pp.53-7 who also reports the previous arguments.
[549] Catalogue No 3; Boyonov 2010, pp.53.
[550] Catalogue No 4, 6; cIMeC 62556.01, 62565.05; Scorpan 1969, p.75.
[551] Catalogue No 5, 7; cIMeC 62565.04, 62565.08; Bărbulescu 2001, p.130.
[552] Bărbulescu 2001, p.130; http://cronica.cimec.ro/detaliu.asp?k=683 accessed 26/08/14.

within cIMeC in that it is sometimes not possible to differentiate between sites and occasionally a site is inputted more than once, which appears to be the case here.[553] Bărbulescu records a Later Roman site with plenty of Roman period finds on this hill.[554] But to confuse the matter further the now old *TIR* and Zahariade and Gudea, record this as a purely military site.[555] Weighing up the reports, I have treated it as an individual civilian site. On the stream running from Canlia to the Danube between the Uscat and Ghivizlicu hills there was continuous settlement from before Roman times until long after; this may have become the Later Roman military site of Cimbrianae.[556] Nearby within the Izvoarele commune [Constanţa County] is the Roman settlement 'Plantatie'.[557] The military site of Sucidava was located downstream of the modern village of Izvoarele at the mouth of the Pirjoaia valley; the garrison *cohors I Claudia Sugambrorum* is well attested here, while cIMeC lists a civil site 'Cale Gherghi' as the extra mural settlement or military *vicus*.[558] There are two well reported sites 500m apart on the Danube shore north of Satu Nou. One, 'Vadu Vacilor', was not in use in the Roman period. The other 'Valea lui Voicu' was established prior to the Roman period and continued into the 3rd century; this looks to have been more than an isolated site. Irimia collates the results of excavations and suggests that it was a Getic town – a *dava*, equivalent to a western *oppidum*.[559] The online reference material shows it to have been approximately 3ha in size, which although quite small I treat as a *vicus* type site

553 Catalogue No 8; cIMeC 62583.01, 62075.03.
554 Bărbulescu 2001, p.129.
555 *TIR* 1969, p.38; Zahariade & Gudea 1997, p.77.
556 Catalogue No 9; cIMeC 62075.01; *ND, Or* 40.27; Irimia 1981, pp.98-115; Matei 1991, p.147; Zahariade & Gudea 1997, p.77; Bărbulescu 2001, p.128.
557 Catalogue No 10; cIMeC 62128.02; Bărbulescu 2001, p.129.
558 Catalogue No 11-12; cIMeC 62128.01, 62128.07; Ptolemy, *Geog* 3.10.5; *IA* 224.01; Suceveanu 1991, p.61; Zahariade & Gudea 1997, p.77; Irimia 2007, pp.145-6.
559 Catalogue No 13; cIMeC 62510.02; Irimia 2007, pp.142-3, pp.221-2.

with 960ha agricultural potential.[560] A collection of undated tumuli in the vicinity evident in Oltean's data probably ought to be associated with the two sites. South at Lipniţa, significant numbers of tumuli are reported on cIMeC without adjacent buildings so as to suggest a habitation site, they are obvious in Oltean's data but not of the highest aggregation levels.[561] Bărbulescu puts two Roman sites between Oltina and Razoarele and another to the north-west of Viile, but cIMeC only lists the tumuli at Oltina.[562] At Băneasa cIMeC records two sites 1-1.5km apart, while Oltean identified tumuli to north and south of the village which do not appear to align with the cIMeC sites.[563] Between the Danube and Lake Dunăreni is the civil settlement 'La Bratca'.[564] Further down river, 5km north-east of Dunăreni, the military fort of Sacidava, home to *cohors I Cilicium sagittariorum*, is found on the Muzait hill to the north of Lake Vederoasa.[565] The civil site alongside was inhabited previously as a Getic settlement and is presumed to have continued as the military *vicus*.[566]

Around Aliman ten sites are evident from different periods. One with pre-Roman, Roman and Medieval habitation exists on the west bank of Lake Vederoasa. Tumuli are evident to the south-west. To the south-east at the abandoned village of Adâncata in the Poluci valley, the site Adâncata II is dated to the pre-Roman and Roman periods. All three sites are distinct and included separately.[567] To the south-west a settlement is known at Floriile.[568] An inscription from Urluia records a Greek magistrate which is taken to show a *kome* in the

[560] http://cronica.cimec.ro/detaliu.asp?k=687 accessed 12/11/14.
[561] Catalogue No 14; cIMeC 62066.01.
[562] Catalogue No 15; cIMeC 62495.02; Bărbulescu 2001, p.126.
[563] Catalogue No 16-17; cIMeC 61078.01, 61078.03; Bărbulescu 2001, p.121.
[564] Catalogue No 18; cIMeC 61032.01.
[565] Catalogue No 20; cIMeC 61032.06; Zahariade & Gudea 1997, p.78.
[566] Catalogue No 19; cIMeC 61032.02; Bărbulescu 2001, pp.117-18; Irimia 2007, pp.148-9.
[567] Catalogue No 21-3; cIMeC 61014.10, 61014.01, 61014.09.
[568] Catalogue No 24; cIMeC 61041.01.

region; only one site is recorded on cIMeC at Urluia, although the database does not make the connection, I count this as the *kome*.[569] To the east a settlement existed next to the canal between Hațeg and Lake Baciu.[570] Bărbulescu puts another site at Abrud on the basis of coin hoards and an aqueduct that probably served Tropaeum Traiani, but her cited material only records scattered material of Roman date so I discount it.[571] Inland to the west a settlement is evident at Raristea.[572] Bărbulescu suggests sites at Dobromir and on the basis of tumuli at Negureni, these tumuli are of the lower aggregation levels and are dated otherwise on cIMeC and so not included.[573] Neither is a Roman period aqueduct at Negureni included; it was also probably part of the system that fed Adamclisi. In the vicinity of Adamclisi a senatorial *latifundia* belonging to L. Aelius Marcianus is suggested on the basis of an inscription commemorating his *vilicus*.[574] Although this is rather flimsy evidence to posit a *villa*, let alone a *latifundia*, modern commentators do unanimously follow it.[575] I accord it only small-farm status and thus a 120ha landholding. Many of the *vici* are posited only on the basis of epigraphic material: generally, there is more than a single inscription, but not always, so that in this and other cases where several modern commentators are in favour of a settlement I do follow them. Adamclisi is the site of Trajan's victory monument and the ancient town of Tropaeum Traiani a kilometre to the west. The town grew in importance after the erection of the monument, becoming a *municipium c* AD 170; the town's remains are of Later Roman design but earlier occupation is well accepted.[576] The

[569] Catalogue No 27; cIMeC 60927.01; Bărbulescu 2001, pp.120-1, p.124.
[570] Catalogue No 25; cIMeC 60918.01.
[571] Barnea 1996, p.421; Bărbulescu 2001, p.124 fn 989.
[572] Catalogue No 26; cIMeC 62002.02.
[573] Bărbulescu 2001, p.123.
[574] Catalogue No 28; *CIL* 3.12463.
[575] Suceveanu 1991, p.83; Bărbulescu 2001, p.120, p.124; Bâltâc 2010, p.439.
[576] Catalogue No 29-30; cIMeC 60892.02 60892.08, 60892.10; *CIL* 3.7484, 3.12461, 3.12473; Poulter 1983, p.83; Suceveanu 1991, pp.53-4; Bărbulescu 2001, pp.119-20; Petculescu 2006, p.37.

garrison was formed by parts of *cohors I Cilicum sagittariorum* also seen at Sacidava, together with *vexillationes* of *cohors I Lusitanorum Cyrenaica* and legionary *vexillationes*, but an actual military site from the Roman period is un-located.[577] An outlying civil site is evident to the east, while tombs and tumuli of Roman and pre-Roman date are recorded around both town and monument.[578] I include all these as a single municipal centre, where the inhabitants could have provided a surplus to the value of 960ha. Remains of aqueducts are known immediately to the north of the town, to the north-west by 7km at Ispanaru and at Abrud, although the latter does not appear on cIMeC, and to the south and west at Zorile and Negureni; none is included in my count of sites.[579]

To the south-west of Adamclisi an isolated site is known within Pădureni village.[580] Close to the national border near Cetatea was the findspot of a marker stone that testifies to a peregrine community the *civitas Ausdecensium* possessing its own *territorium* distinct from a group of Dacians also resident in the area.[581] An isolated site is recorded on cIMeC at Şipotele with no further information, but there are significant numbers of undated tumuli including one cluster in excess of 16 buffers, the fourth aggregate class, to the south.[582] At Petroşani two Roman period sites are recorded, one within the village, the other to the north-west.[583] East of Adamclisi a small-farm is known at Pietreni and Roman period tumuli are reported around the commune these are reported by Oltean with a low level of aggregation, I associate the two with each other.[584]

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[577] Bărbulescu 2001, pp.119-20.
[578] cIMeC, 60892.04, 60892.03, 60892.11, 60892.22, 60892.24.
[579] cIMeC 60892.01, 60892.12, 60892.13; Barnea 1996, p.421.
[580] Catalogue No 31; cIMeC 61782.01; Bărbulescu 2001, p.123.
[581] Catalogue No 32; *CIL* 3.14437[2]; Bărbulescu 2001, p.125.
[582] Catalogue No 33; cIMeC 60728.04.
[583] Catalogue No 34-5; cIMeC 61693.04, 61693.01.
[584] Catalogue No 36; cIMeC 61700.01, 61700.02; Bărbulescu 2001, p.122.

To the south-east going towards the Black Sea there are Roman period tumuli at Fântâna Mare [Constanţa County].[585] Bărbulescu and Irimia also report tumuli with 3rd century remains at Independența.[586] This is an area where Oltean's data shows three clusters of tumuli with the highest or second highest level of aggregation, i.e. in excess of 30 buffers each. In addition another 54 tumuli buffers are evident within a 4km radius of a centre point between the two largest clusters. This was clearly an area with intense habitation at some point. Indeed this might be a better contender for the site of the *civitas Ausdecensium*; the marker stone found at Cetatea is only 15km distant and may quite sensibly delimitate the western extent of the territory. Other locations where tumuli buffers of higher aggregation levels, those greater than 16 tumuli together, exist south-west of Olteni and around Câscioarele, these are not evident on cIMeC. To the south a Roman site at Negru Vodă is thought to be far enough west to have directed a surplus to the *limes* zone.[587] I include settlements along the Urluia river valley around the Negreşti-Conacu lakes, although equidistant between *limes* and *poleis*, as directing their surplus to the military. Oltean's tumuli are here ubiquitous. One site is known at Negreşti, one at Conacu, and another at Credința, a treasure found at Casicea is not included, but a site to the north-east of General Scărişoreanu is; here two clusters of tumuli in the higher aggregation groups are known and may be associated with the cIMeC material.[588] The site at Credința was excavated in the 1980s and showed evidence of domestic and agricultural sections to a Roman period farm; I therefore classify it as a small farm.[589] To the north another site with necropolis is included

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[585] Catalogue No 37; cIMeC 61906.02.
[586] Catalogue No 38; Irimia 1987, pp.127-9; Bărbulescu 200, p.122.
[587] Catalogue No 43; cIMeC 62404.01.
[588] Catalogue No 39-42; cIMeC 61354.02, 61336.01, 61238.01, 61489.01.
[589] http://cronica.cimec.ro/detaliu.asp?k=681 accessed 26/08/14; Bărbulescu 2001, pp.68-9.

at Cobadin.[590] At Ciocârlia Roman period tumuli are recorded on cIMeC and two clusters of the higher aggregation levels appear in Oltean's data indicating settlement here.[591] Isolated Roman finds reported at Siminoc and Barganu are not included.[592]

Looking west in the centre of southern Dobrogea within the village of Izvoru Mare, a Roman period settlement is recorded on CIMeC while two clusters of tumuli in the higher aggregation levels evident in Oltean's data could be associated with it.[593] Remains of an aqueduct exist 800m to the north of Veteranu. The online reference material reports a basin within the village suggesting that this was the terminus of the aqueduct and such a construction implies considerable settlement; another site is recorded at the village on cIMeC, but there is no indication of size so I include both together but only count as an individual site.[594] At Peştera, Ivrinezu Mare and Cochirleni there are remains of a rampart dated to the Roman period by cIMeC. This is part of the system of recently re-investigated, but still incompletely understood, ramparts that cross southern Dobrogea. Current thinking is that the larger earthen wall was of Roman, possibly later 2nd century date but the smaller earthen wall is post-Roman.[595] Towards the Danube, 4km north-west of Ivrinezu Mare on the shore of Lake Cochirleni habitation is evident from before until well after the Roman period.[596] Back on the Danube, several sites and tumuli are known at Rasova: one 'Pescarie' lies 3km south-west on the banks of Lake Baciu and this has revealed a Roman *horreum* with legionary inscriptions in

[590] Catalogue No 44; cIMeC 61327.01.
[591] Catalogue No 45; cIMeC 61292.01.
[592] Irimia 1987, p.117.
[593] Catalogue No 46; cIMeC 62743.01.
[594] Catalogue No 47; cIMeC 62752.02; http://cronica.cimec.ro/detaliu.asp?k=1736 accessed 26/8/14; Bărbulescu 2001, pp.115-16.
[595] Hanson & Oltean 2012, pp.314-15; Rankov 2015, p.70.
[596] Catalogue No 48; cIMeC 62725.03.

the building works, suggesting a sometimes military presence although cIMeC lists it as a civilian settlement and pending more information so do I.[597] To the east of Rasova in the Caramancea Valley there was both a civilian site and 2nd-4th century fort.[598] Another site 'Malul Rosu' lies further to the north-east.[599] Tumuli are reported around the village also, but only a few appear in Oltean's dataset, I associate these with the other reported sites. In this region a *vicus Flaviana* is also attested but this is thought to have been of Later Roman date; the location is uncertain: the 'Pescarie' site near Rasova, or further west at Viile is suggested; but because Roman period occupation is uncertain I do not include it.[600]

The Hinog peninsula, south of modern Cernovoda, is the site of ancient Axiopolis which was originally a Greek settlement. It is unusual for a *polis* in being inland; cIMeC records only pre- and post-Roman occupation but its use in the Roman period is certain.[601] An inscription records *nautae universi danuvii* so implying port facilities, which corresponds with the conjectured fleet element.[602] Inland recent work along the A2 autostrada has revealed seven groups of as-yet undated tumuli; these appear in Oltean's dataset, but with a low level of aggregation. I feel sure that some of these will eventually be dated to the Roman period because two Roman period settlements have also been found among them, but do not include any additional settlements for consistency of argument.[603] Further along the A2 autostrada within Peştera commune near Remus Opreanu other tumuli are evident these are dated as pre-Roman on cIMeC, which I therefore

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[597] Catalogue No 50; cIMeC 62805.04; Bărbulescu 2001, p.116.
[598] Catalogue No 51-2; cIMeC 62805.07, 62805.02; Bărbulescu 2001, p.117.
[599] Catalogue No 49; cIMeC 62805.01; Irimia 1974: 75-7, 137; Bărbulescu 2001, p.116.
[600] *ND, Or* 39.20; Aricescu 1980, pp.62-3; Matei 1991, p.50.
[601] Catalogue No 53; cIMeC 60875.03; Ptolemy, *Geog* 3.10.5; *IA* 224.2; Suceveanu 1993, pp.172-3; Bărbulescu 2001, p.113; Petculescu 2006, pp.35-6.
[602] *CIL* 3.7485; Chapter Two, p.50, above, p.167.
[603] Catalogue No 54-5; cIMeC 60785.10, 60875.12.

exclude. A Graeco-Roman site also close to the autostrada on Aleca Hill is recorded on cIMeC as being near Ştefan cel Mare, across the canal in Mircea Vodă commune which is seemingly incorrect, highlighting some of the problems of recording within cIMeC.[604] Returning inland to the south of the canal, three significant clusters of tumuli buffers appear south of Medgidia near Valea Dacilor, close to, and inside of the small earthen wall of the Valu lui Traian. If this section of the rampart is post-Roman so may be the tumuli, but it is impossible to be sure. Medgidia was the probable site of *vicus I Urb….* where there were *c(ives) c(onsistentes)*.[605] Two Roman period sites appear on cIMeC to the north of the canal, one has attendant tumuli on cIMeC and a cluster of the highest aggregation level is evident in the tumuli data.[606] Neither site is associated with the *vicus* on the database, but I associate the one closer to the tumuli with the *vicus*, the other I record as an individual site.[607] The *vicus* would have been close to the intersection of two major road routes and the crossing of the Carasu river (now the canal); it is certainly close enough to the Danube to suggest that its product was directed to the *limes* zone. Another site and the remains of an aqueduct are evident at Cuza Vodă.[608] Here, alongside the Agicab valley is the largest aggregations of tumuli seen in the region, this is only 5km from Medgidia, maybe less from the not positively identified site of the *vicus I Urb….*; so that these tumuli may also be associated with the *vicus*. There are three Roman period settlements close together at Castelu and further associated tumuli up the Agicab valley.[609] A single settlement further up the Agicab valley 4km north of Nisipari is also included,

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[604] Catalogue No 56; cIMeC 62342.01.
[605] *CIL* 3.14441; Suceveanu 1991, p.50; Bărbulescu 2001, p.115.
[606] Irimia 1987, pp.1329-30.
[607] Catalogue No 57-58; cIMeC 60856.12, 60856.10.
[608] Catalogue No 63; cIMeC 61149.01, 61149.02.
[609] Catalogue No 59-61; cIMeC 61130.02, 61130.09, 61130.10; Bărbulescu 2001, p.56.

although only 23km from Tomis, its produce would most naturally travel downstream to the west and so to the *limes* zone.[610] Moving west once again, north of the Danube-Black Sea canal, Roman period tumuli indicate habitation at Mircea Vodă.[611] North-west of Stefan cel Mar towards Cernovodă a site of Graeco-Roman date is reported, but the reference material showed only pre-Roman amphorae, so I exclude it.[612]

To the north the tumuli data provided by Oltean cease. Up to this point I have commented where the national database and Oltean's material align and I have also commented when clusters of tumuli in the highest three aggregate levels existed; there are 24 of these in the *limes* facing zone, and 57 in the *poleis* providing zone. These numbers belie the very ubiquity of the tumuli in the region, they are indeed everywhere and some more sophisticated approach to their interpretation was required. Voronoi polygons were produced to illustrate the maximum space between tumuli centres, Fig 3.3.4.1. Voronoi analysis does not account for the size of the tumuli, but by aggregating the tumuli, there was an expectation that the largest aggregate groups might command a greater amount of land.[613] This was not seen. The average landholding by aggregate class was not significantly different, and neither did it show a trend away from the mean figure of 194ha for landholdings around all tumuli. This is in part explained because if a larger site attracted an aggregation of tumuli, this does not mean that its immediate hinterland would have been devoid of all other settlement activity evidenced by isolated tumuli. Clearly not all the land around a tumulus would have been in agricultural

[610] Catalogue No 62; cIMeC 61158.01.
[611] Catalogue No 64; cIMeC 62299.02.
[612] Irimia 1980, p.106; Sîrbu 1983, p.67; Bărbulescu 2001, p.114.
[613] *cf* Goodchild 2013, p.67.

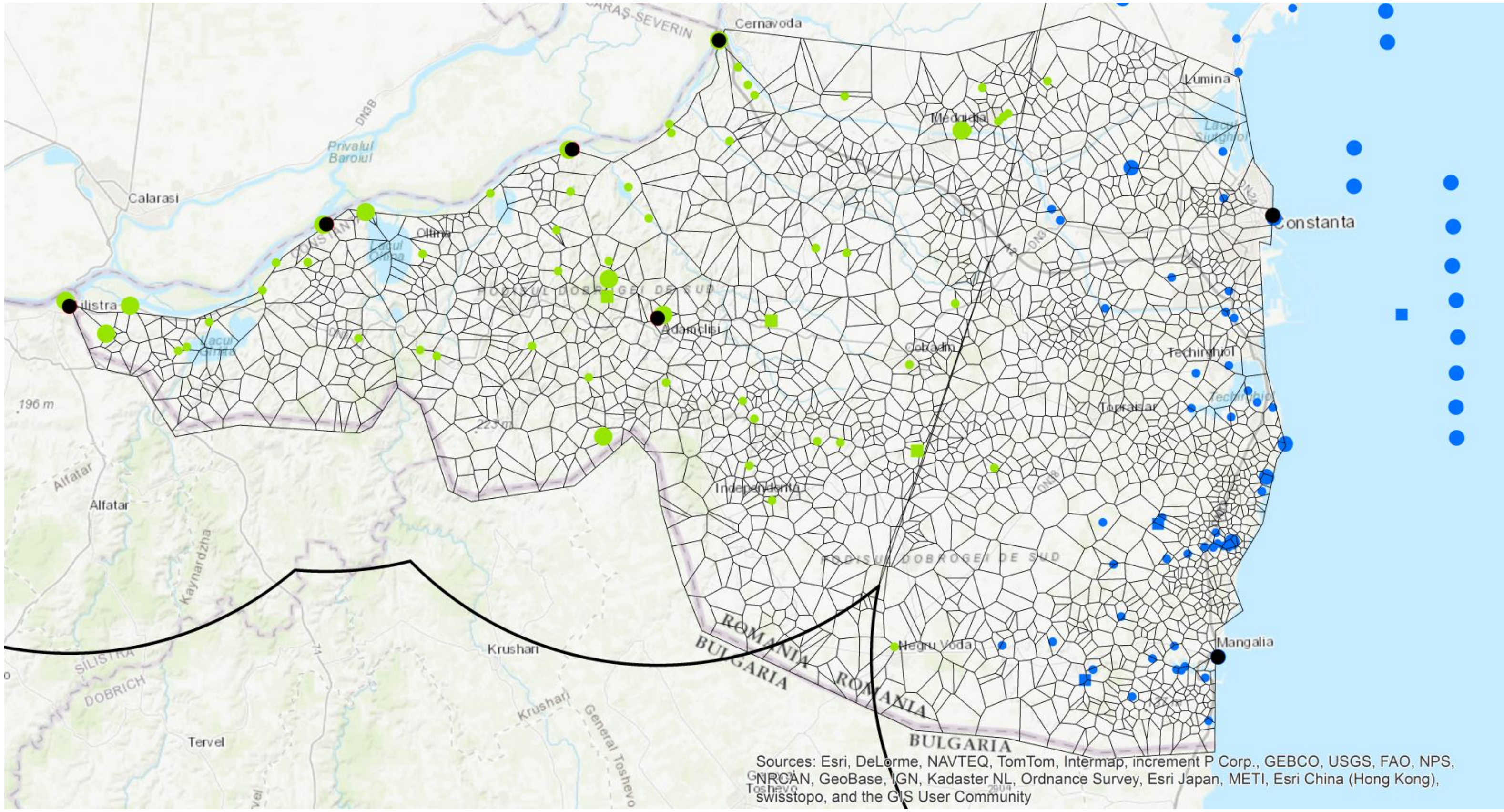

Fig 3.3.4.1 Voronoi polygons about tumuli

use, but this figure, or some fraction of it, might offer an alternative to those previously allotted for individual sites, small-farms and *vici* of 10.2ha 120ha, and 960ha respectively. Without excavation it is unclear if single barrows represent multiple burials over a protracted period or not, but what I would suggest is that some fractional part of this 194ha area of influence can reasonably be associated with the smaller sites represented by the lower aggregate classes of tumuli that dominate the dataset.

Table 3.3.4.1: Mean size of Voronoi polygons by aggregate class

Agg Class	0	1	2	3	4	5	All
Mean area	190ha	192ha	209ha	258ha	170ha	209ha	194ha

If only a fifth or a quarter of this average space between tumuli were farmed, that would equate to 38.8ha or 48.5ha of agricultural potential, which is a plausible landholding for an extended family. A full 194ha would have required slaves or labourers to work it, but this can be considered as an alternative to the 120ha previously applied to the small-farms category. This is still in the same region as the figures provided for satellite farms in north-west Europe of 50-200ha, as discussed in the Preliminary Section of this Chapter.[614] These alternative figures will be considered further below.

Point density analysis of the whole tumuli dataset without reference to aggregate class showed how settlement was spread across the southern survey area: there was an average density of 0.52 tumuli buffers and so habitation centres per km^2, see Fig 3.3.4.2. The densest distribution occurred in the *poleis*-providing

[614] Above, p.135

zone and will be considered further below. Other areas where density was about three times higher than the average at 1.45-1.74 tumuli buffers per km^2 were to the east of Fântâna Mare and Independența, and south of Medgidia, both of which have been commented upon. Of greater interest was a broad band of moderately increased density between 0.87-1.45 tumuli buffers per km^2 of 7-13km width north to south, but running east to west from the shore around Tuzla towards modern Independenţa before turning north-west towards Adamclisi [Tropaeum Traiani]. Thereafter to the west of Adamclisi the density decreases but there are still areas of slightly increased density interrupted by the physical geography of the Lakes Bugeac, Oltina and Dunăreni stretching to the Danube and Silistra [Durostorum]. Thus, the point density analysis shows an area, hereafter referred to as the 'broad central band of increased tumuli density' which is thought to represent higher levels of settlement activity.

When considered against the fresh water courses it was immediately obvious that this 'broad central band of increased tumuli buffer density' followed the course of the now seasonal Urluia river valleys including the Plopeni, Negreşti-Conacu lakes. In the west these river systems empty via the Vederoasa and Dunăreni lakes into the Danube beyond. When the number of tumuli-buffers was counted within 1, 2 and 4km of the river, there were higher percentages of sites against the percentage of total land area, most markedly within 2km of the water's edge. Wider Dobrogea is a dry region today and this was probably the case in antiquity, so that the draw of fresh water both for human consumption and irrigating crops was thought to be the cause of this increased settlement. If considered against the probable road network, that will be discussed in Chapter Four, there was further correlation, with a route

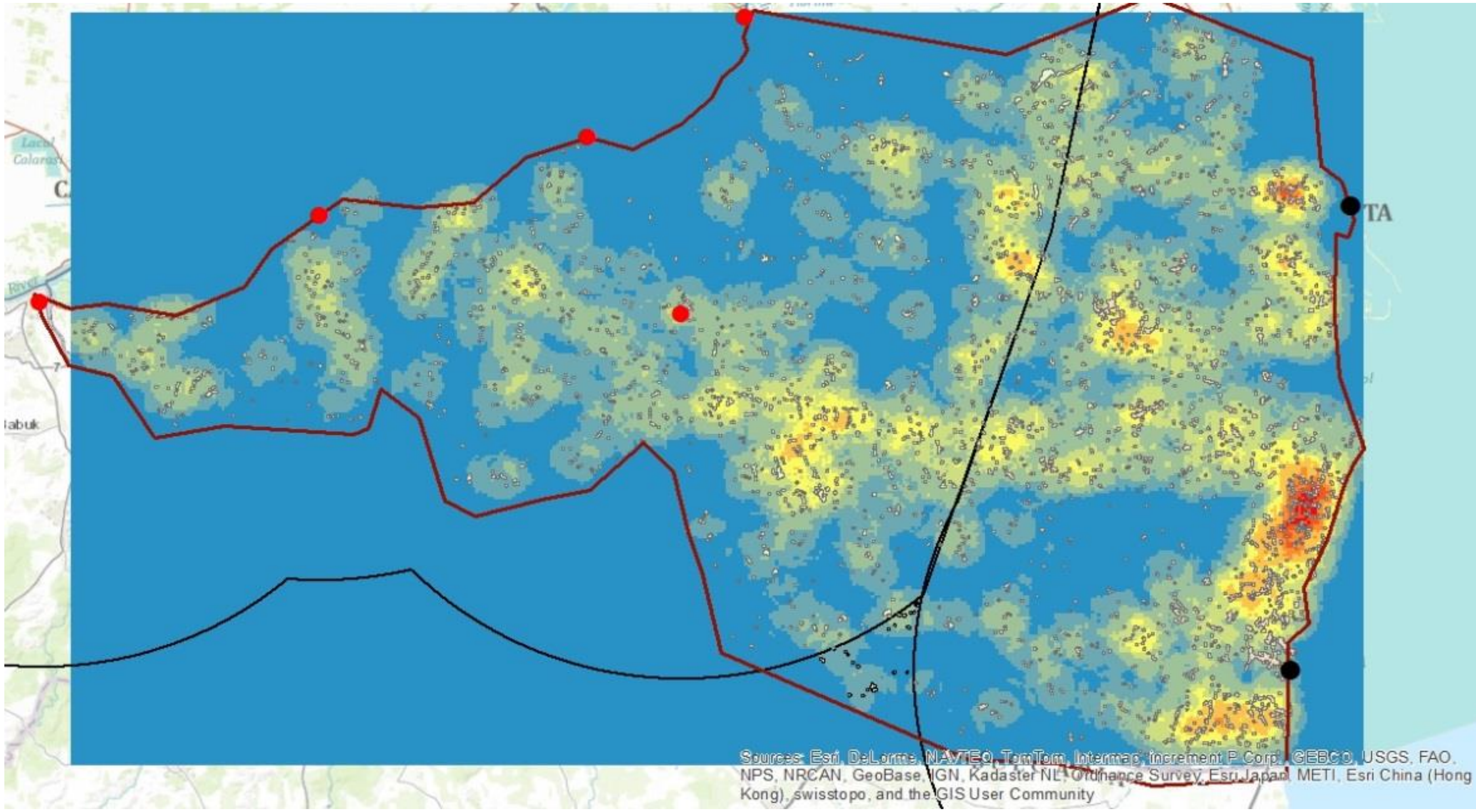

Fig 3.3.4.2: Point density analysis of tumuli buffers

running from south of Plopeni to Adamclisi [Tropaeum Traiani] though this area of increased tumuli density to the east of Fântâna Mare and Independența. Oltean also provided additional evidence for roads through remote sensing, which on the whole agreed with the published probable road network, but included a previously un-reported route running east to west from Petroşani towards Silistra [Durostorum] via Şipotele, skirting Adamclisi by 5km to the south, again running through this area of increased tumuli density. Notwithstanding these observations, it is very difficult to say what agricultural activity these tumuli buffers represent without knowing which were of Roman date. The whole dataset could only be safely used to augment the evidence of other settlement activity as has been done above, but not to argue for additional activity in the region without some further refinement which will be attempted below.[615]

To the north of modern Cernovodă, there was a fort but the garrison is unknown.[616] Roman period tumuli close to Seiminii Mici suggest habitation there, no additional information is forthcoming.[617] Nearby, Bărbulescu reports 11 sites in the Siliştea and Tibrinu valleys; however, her reference material is unavailable in the UK and cIMeC only records a single site here, so I do the same.[618] On the river at Dunărea, a settlement is dated from the Graeco-Roman period until the 3rd century AD.[619] A Roman period site is recorded at Tortoman on cIMeC, but the reference material points to Republican period coins only; Bărbulescu does not record this and I do not include it. Capidava – the ancient Capidava – was the home of *cohors I Germanorum cR*, where an early fort was destroyed in the mid-3rd

[615] Below, pp.215-17.
[616] Catalogue No 65; cIMeC 60785.09; Zahariade & Gudea 1997, p.78.
[617] Catalogue No 66; cIMeC 62930.02.
[618] Catalogue No 67; cIMeC 62912.01; Bărbulescu 2001, pp.113-14.
[619] Catalogue No 68; cIMeC 62921.01.

century and replaced by another in the 4th century that is still visible today.[620] Excavations are on-going, but the civil site does not appear extensive.[621] This is despite an inscription found at Pantelimon [*vicus Ulmetum*] to the east recording a magistrate of the *territorium Capidavensis*.[622] I believe that this should be associated with a military *vicus* and assume 960ha landholdings accordingly. A small farm is reported some 1.5km distant from Capidava at 'Vlah Canara'.[623] Nearby two inscriptions relate to either one or two small farms; the inscriptions relate to the landholdings of father and son, and I would suggest a single farm passed between generations.[624] I associate tumuli evident on the supporting online maps, but not listed separately on cIMeC, with the fort and the supposed military *vicus*. The epigraphically attested but un-located *vicus Scenopensis* is thought to have been in the vicinity.[625] Inland, cIMeC records sites at Băltăgeşti, Crucea and Gălbiori; the latter is considered to have been the site of an un-named *vicus* and I do the same; Roman period tumuli are also known.[626] The *vicus Hi…* was probably at Dorobanțu; although not specifically reported as a *vicus* on cIMeC I include it as such.[627] Further east a single site is evidenced at Târguşor.[628] The *vicus Casianus* can be positively aligned with two cIMeC entries near Casian, one for the settlement itself, the other an amphitheatre.[629] Four groups of cave dwellings are recorded close by in the river valleys to the south and east of Cheia; online material points to these having prolonged occupation and each cave supporting more than a

[620] Catalogue No 69; cIMeC 63063.01; Matei 1991, p.151; Suceveanu 1991, p.67; Zahariade & Gudea 1997, p.79; Bărbulescu 2001, p.105.
[621] Catalogue No 70; cIMeC 63063.06.
[622] *CIL* 3.12491 (*ISM* 5.77).
[623] Catalogue No 71; cIMeC 63063.05; Bărbulescu 2001, p.110.
[624] Catalogue No 72; *ISM* 5.29, 5.30; Bâltâc 2020, p.439.
[625] Catalogue No 73; *ISM* 5.21, 5.22; Bărbulescu 2001, p.111.
[626] Catalogue No 74-6; cIMeC 61577.01, 61568.01, 61595.01; *ISM* 5.56; Bărbulescu 2001, pp.111-12.
[627] Catalogue No 77; cIMeC 62468.03; Bărbulescu 2001, pp.111-12.
[628] Catalogue No 78; cIMeC 62994.03.
[629] Catalogue No 80; cIMeC 63009.01, 63009.06; Bărbulescu 2001, p.44.

single family. It is tempting to treat the whole as a village or *vicus* type community, but the lack of epigraphic evidence and close proximity to the *vicus Casianus* seems to suggest otherwise; what this may show is the close co-habitation of two different ethnic groups.[630] I also record individual sites in the area at Gura Dobrogei and Grădina.[631] The *vicus Ulmetum* is associated with the Later Roman site at Pantelimon by cIMeC and Bărbulescu.[632] I follow this majority view, although some fieldwork in the later 1990s pointed to an absence of Roman period settlement markers at the Later Roman site and suggested that the *vicus* ought to be situated in the nearby Casimcea valley.[633] The *vicus* is one of the sites where Roman citizens and members of the Thracian tribe the Bessi were *consistentes*, pointing to planned settlement activity.[634] Irrespective of its exact position, it is presumed to have been close to an important crossroads of routes to be discussed further in Chapter Four, and therefore well placed to have communicated with both *limes* and Black Sea *poleis*. Two other sites and tumuli recorded on cIMeC at Pantelimon are not possible to locate from the descriptions given: they look to be erroneous entries relating to settlement elsewhere, yet while Pantelimon is treated as a *vicus* the impact on the argument of this uncertainty is considered negligible and they are discounted.[635] In contrast, two potential small farms are recorded epigraphically: one inscription is the boundary marker of an individual's estate, the other refers to an *actor*; in the last case the evidence for a small farm is slight, but for consistency

[630] Catalogue No 81-4; cIMeC 63018.01, 63018.03, 63018.04, 63018.05; Bărbulescu 2001, pp.44-5, p.53.
[631] Catalogue No 79, 85; cIMeC 61416.02, 63027.01.
[632] Catalogue No 86; cIMeC 62618.01; Bărbulescu 2001, pp.107-9.
[633] Krebs 1998, pp.116-20.
[634] *CIL* 3.14214[26] (*ISM* 5.62); *ISM* 5.63.
[635] Erroneous entries not included cIMeC 62609.01, 62609.02, 62609.03.

of argument, as with other sites epigraphically recorded, it is included.[636] An individual site is also evident at Runca.[637]

Returning to the Danube a fort is recorded at Topalu by Zahariade & Gudea but this is reported as a civil site on cIMeC; the disagreement is unlikely to be resolved because the site has been destroyed by quarrying; I treat it as an individual site.[638] Moving along the Danube, a civil site is recorded 2km to the south of Ghindăreşti while another Roman period fort is recorded to the north-west of the village.[639] Downstream, Hârşova is the site of ancient Carsium, a site of long habitation and in the Roman period home to *ala II Hispanorum et Aravacorum*, while Later Roman and Medieval remains lie over the Roman period fort.[640] Two other Roman sites are recorded on cIMeC: one, the originally stone-age tell, shows continuity of occupation into the Roman period, this is located between the fort and the industrial complex to the east.[641] The other to the north and west of the fort is thought to have been the military *vicus*.[642] Additionally a 10-12ha civil site further to the south-east of the town at the place named 'La Moara', although of Getic origin, looks to have had continued habitation into the Roman period.[643] Despite an extensive bibliography the latter is not evident on cIMeC, possibly because it was destroyed in the 1980s and is now lying under the industrial complex.[644] Nevertheless I include two *vicus* type settlements here. Scattered Roman finds are also reported on another earlier Getic site further east at 'Celea Mică', as with other

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[636] Catalogue No 87-8; *ISM* 5.59, 5.72; Bâltâc 2010, p.439.
[637] Catalogue No 89; cIMeC 62654.01.
[638] Catalogue No 90; cIMeC 63054.01; Zahariade & Gudea 1997, p.88.
[639] Catalogue No 91-2; cIMeC 61853.01, 61853.02.
[640] Catalogue No 93; cIMeC 60810.01; Ptolemy *Geog* 3.10.5; Zahariade & Gudea 1997, p.79; Bărbulescu 2001, pp.100-3; Suceveanu 1991, p.60, p.67; Petculescu 2006, p.32; Nicolae 2010, p.224.
[641] Catalogue No 95; cIMeC 60810.02; Nicolae 2010, p.223.
[642] Catalogue No 94; cIMeC 60810.04; Nicolae 2010, p.232.
[643] Catalogue No 96.
[644] Nicolae 1993: 227-8, 2009:133-4, 2010: 235; Bărbulescu 2001, pp.102-3.

scattered finds I exclude these.[645] A rural *villa* is reported by Bărbulescu 1km to the north of the town; this is not evident on cIMeC and it together with another further afield are only reported as uncertain by Nicolae, thus they are excluded.[646]

Away from Hârşova [Carsium] another settlement existed at Ciobanu.[647] Alongside Lake Hasarlâc sat the military fort of Cius, home to *cohors I Lusitanorum Cyrenaica*; cIMeC lists this as a civil site but the fort is well accepted and a military *vicus* ought to be expected also, so I list both; tumuli are evident around about.[648] A *vicus Verg[ob]rittiani* is suggested close to the camp and a *vicus Rami*…. is also suggested by modern commentators.[649] The evidence for the latter is rather tenuous, merely that an ex-prefect of the *ala* posted to Carsium served close to his birthplace which was the *vicus*, yet it is not even certain that this was in Lower Moesia, let alone close to Carsium. A *villa* is also posited by Suceveanu and Bărbulescu in the region close to Gârliciu on the basis of a funeral monument that records a *vilicus*.[650] Once again this is not very much evidence upon which to include a *villa*/small farm but I have already used such an inscription to include the *latifundia* of L. Aelius Marcianus close to Adamclisi, so for consistency I do include this. Further east a settlement existed at Dulgheru.[651] Two settlements existed 1.5km and 200m north of Nistoreşti.[652]

Considering central Dobrogea to the east of Hârşova [Carsium], a collection of settlements are believed to have come within the *territorium* of Histria but

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645 Nicolae 2004-5, pp.389-90, p.404; 2010, pp.236.
646 Nicolae 1995-6: 139, 2010: 237-8; Bărbulescu 2001, p.103.
647 Catalogue No 97; cIMeC 61265.01.
648 Catalogue No 98-9; cIMeC 61817.01; Suceveanu 1991, p.67; Zahariade & Gudea 1997, p.79; Bărbulescu 2001, p.98; Petculescu 2006, p.32.
649 Catalogue No 100-1; *CIL* 3.12479 (*ISM* 5.115), *CIL* 3.14214[22] (*ISM* 5.117); Bărbulescu 2001, pp.98-9; Panaite 2010, p.374.
650 Catalogue No 102; *CIL* 3.14214[21] (*ISM* 5.116); Suceveanu 1998, p.139; Bărbulescu 2001, p.99.
651 Catalogue No 103; cIMeC 62850.01.
652 Catalogue No 104-5; cIMeC 62636.02, 62636.01; Bărbulescu 2001, p.43; *cf* Bâltâc 2010, p.439 who suggests a *villa* here on the basis of a funerary inscription of a libertus *CIL* 3.12489 (*ISM* 1.373) but the connection is too tenuous.

outside of its *chora*; that there was a distinction between the two will be discussed below when considering the size of the *poleis* facing zone.[653] However, I will state at this point that I see no issue with *vici* and other settlements in the west of Histria's *territorium* providing their surplus to the *limes* zone. A *vicus V….* mentioned on an inscription found at Râmiciu de Jos, although not positively located, is thought to have been on the road connecting Carsium and Histria.[654] Also in the same area was the unlocated *vicus Secundini* where there were *c(ives) R(omani) et Lai consistentes*, as was also the *vicus …..stro* where again there were *vet[erani et c(ives)] R(omani) [consist]ente[s]*.[655] While at Neatârnarea an inscription recording a *magister* of an un-named *vicus* was found, in this last case he may have been *magister* of one of the three *vici* already recorded, but modern commentators assume a separate *vicus* here and I follow them.[656] The exact location of these four *vici* is uncertain but all were close to the main north-south highway through Dobrogea to be discussed in Chapter Four. A small farm is known at Sarighiol de Deal and an individual settlement at Beidaud with associated cistern.[657] At Casimcea cIMeC records two sites: one a small farm to the north, the other an individual site to the south-east of the village; Bărbulescu and Baumann both report these sites but both explicitly add a third site 'La Vie' on the basis of funeral architecture, and here I follow them.[658] Moving north, an individual settlement existed between Stejaru [Tulcea County] and Vasile Alecsandri.[659] To the north-east Camena is the probable site of the *vicus Petra*.[660] Further north

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[653] Below, p.220.
[654] Catalogue No 106; *CIL* 3.14442.
[655] Catalogue No 107, 108; *ISM* 1.138, 1.343-7, 1.349.
[656] Catalogue No 109: *CIL* 3.12487 (*ISM* 1.368); Bărbulescu 2001, p.37; Panaite 2010, p.374.
[657] Catalogue No 110-11; cIMeC 159874.01, 159856.04.
[658] Catalogue No 112-14; cIMeC 159972.01, 159972.02; Baumann 1983, pp.77-9; Bărbulescu 2001, p.39.
[659] Catalogue No 115; cIMeC 161357.01.
[660] Catalogue No 116; cIMeC 159801; Bărbulescu 2001, p.96.

again, Slava Rusă is the site of the ancient Ibida, a *vicus* that sat on the crossroads of the north-south highway with a route travelling west to Hârşova [Carsium].[661] Further north a settlement is reported at Slava Cercheză.[662] Another is evident at Ciucurova.[663] Around Topolog two small farms are known.[664] Other sites existed to the south-east of Sâmbăta Nouă, to the south of Luminița [Tulcea County] and within Făgăraşu Nou; Baumann identified these latter three as *villae* also, but he tended to overestimate agricultural activity and I stick with the identification as *aşezare* on cIMeC.[665]

Returning towards the Danube, at Rahman three sites are evident.[666] On the river itself north of Hârşova, opposite modern Frecăței [Brăila County], sat the Byzantine fort of Beroe where small finds point to a Roman period military presence.[667] The online material for the civil settlement shows an extensive fortified position, but it is impossible to differentiate between the Later Roman fort and earlier settlement; I class it as an individual site.[668] Another tell lies 5km to the north of Ostrov where Roman occupation is reported but without detail.[669] Otherwise between the latitudes of Gârliciu [Cius] and Turcoaia [Troesmis], there is very little settlement activity apparent on cIMeC. At Peceneaga cIMeC reports two sites, a small military fort and a civil settlement; yet the fort does not appear in Zahariade and Gudea, therefore I do not believe it to have been significant; I list it

[661] Catalogue No 117; cIMeC 161277.01; Suceveanu 1977, pp.71-2; Bărbulescu 2001, pp.91-3.
[662] Catalogue No 118; cIMeC 161268.02; Bărbulescu 2001, p.95.
[663] Catalogue No 119; cIMeC 160234.02.
[664] Catalogue No 120-1; cIMeC 161393.01, 161393.02.
[665] Catalogue No 122-4; cIMeC, 161455.01, 161437.01, 161428.01; Baumann 1983, pp.79-81, p.86; Bărbulescu 2001, p.97.
[666] Catalogue No 125-7; cIMeC 160010.01, 160010.03 160010.04.
[667] Catalogue No 128; the code cIMeC 160396.01 associates Beroe with the Frecăței in the north of Tulcea County, but this is clearly a mistake; Zahariade & Gudea 1997, p.80.
[668] Catalogue No 129; cIMeC 161115.01.
[669] Catalogue No 130; cIMeC 161115.02.

and class the civil site as an *aşezare* only.[670] A single settlement is reported at Traian [Tulcea County].[671] Further inland at Horia excavations in the 1970s revealed the best example of a traditional *villa* found in Dobrogea, which has already been described above.[672] Baumann associated a *vicus* with this site on the basis of surface finds, but cIMeC dates these as Geto-Dacian and as already stated Baumann tended to be overly optimistic, so I do not include it as such. Inland there was also a military fort at Izvoarele [Tulcea County], probably close to the junction where a road departed the north-south highway for Troesmis.[673] Another settlement is reported to the north of Capioara.[674] Bărbulescu also puts settlements at Greci, Cerna and Cloşca, where cIMeC only reports isolated finds, so that I do not include them.[675] Although I cannot compete with Bărbulescu's local knowledge, to keep the argument as solid as possible, if I cannot find corroboration of Bărbulescu's reports, I favour cIMeC.

North of Turcoaia by 4km on a bend in the Danube lies the site of Troesmis where a Getic *oppidum* was worthy of Roman military protection as early as Ovid's day.[676] A permanent Roman military presence is evident from the later 1st century; it was home to *legio V Macedonica* AD 106-167.[677] When the legion transferred to Dacia *c* AD 167 authority for the site passed to *legio I Italica* based at Novae who provided *vexillationes* as a garrison.[678] This seems a rather strange arrangement considering that *legio XI Claudia* was stationed much closer at Durostorum, yet because legionary *vexillationes* are evident at so many forts throughout the

670 Catalogue No 131-2; cIMeC 161160.01, 161160.02.
671 Catalogue No 133; cIMeC 160163.01.
672 Catalogue No 134; cIMeC 160537.02; above p.138.
673 Catalogue No 135; cIMeC 160573.02.
674 Catalogue No 136; cIMeC 160500.01.
675 Bărbulescu 2001, pp.88-90.
676 Ovid, *Pont* 4.9.75-80.
677 Ptolemy, *Geog* 3.10; Zahariade & Gudea 1997, p.80.
678 *ISM* 5.146, 5.176, 5.202, 5.216; Suceveanu 1998, p.138.

province, it may well have been that after *legio V's* departure *legio XI* could not cope alone. Fleet elements are evidenced, but as previously discussed these are more likely to have been a transient force rather than a permanent squadron.[679] On two adjacent hills, unexcavated Later Roman fortifications are easily observed from the air. The legionary camp lay between the two hills, with the *canabae* spreading north and east, over an area of approximately 16ha.[680] Here are recorded *vet(erani) et c(ives) R(omani) cons(istentes) ad canab(as) leg(ionis) V Ma(cedonica)*.[681] The western hill was for a long time believed to have been the site of a *vicus* where Roman citizens were also *consistentes*. The *vicus* was probably promoted to municipal status under Marcus Aurelius and was also probably responsible for the *territorium Troesmis*, although as already discussed the nature of such *territoria* is far from clear.[682] That these two civilian sites were distinct is evidenced by a magistrate who was *q(uin)q(uennalis) [….c]anab(ensium) et dec(urio) Troesm(ensium)*.[683] However, the most recent opinion is that the legionary fort became the site of the *municipium* after the legion moved on and the *vicus* may have been co-located with the *canabae* prior to that.[684] As a legionary site Troesmis' area of influence might reasonably be expected to have spread wide, yet within this north-west sector of Dobrogea there are very few recorded Roman sites, so that the area with probably the highest military needs appears least well equipped to meet those needs.

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[679] *ISM* 5.217; Bounegru & Zahariade 1996, p.11; Bărbulescu 2001, p.86; Chapter Two, p.50, above, p.167.
[680] Catalogue No 137-8; cIMeC 161473.01; Alexandrescu & Gugl 2014, p.296, Fig 5, 2016, pp.13-18.
[681] *ISM* 5.141, 5.154; Bărbulescu 2001, p.85.
[682] Catalogue No 139; *ISM* 5.135, 5.143-4, 5.150, 5.152, 5.153; Poulter 1983, p.83; Suceveanu 1998, pp.137-8; Bărbulescu 2001, p.86; Petculescu 2006, pp.34-5, above, pp.129-32.
[683] *ISM* 5.158.
[684] Alexandrescu & Gugl 2016, p.189 (the same researchers were still looking for a second settlement site for the *vicus* as late as 2012 Alexandrescu & Gugl 2012, p.253).

Further north, three forts existed at Măcin [Arrubium], Garvăn [Dinogetia] and one at modern Barboşi on the Tirighina promontory of south-west Galați. At Măcin the 2nd century fort, Arrubium, is believed to underlie a Later Romano-Byzantine fort on the basis of earlier finds, it was home to the *ala I Vespasiana Dardanorum*.[685] On cIMeC there are two civil sites in the town which are so close together that they and funeral monuments also evident all ought to be considered a military *vicus*.[686] North-west of Garvăn on the Bisericuta hill lay the Later Roman fort of Dinogetia.[687] The existence of a 2nd-3rd century fort is thought likely on the basis of epigraphic material referring to military units and civilian buildings of the Antonine period, so that I assume a military *vicus* also.[688] The 2nd-3rd century garrison of both the fort at Barboşi across the river and Dinogetia is thought to have comprised of elements of the *cohors II Mattiacorum* together with legionary *vexillationes*, possibly supported by fleet elements on the basis of brick stamps.[689] The location of the fort at Barboşi certainly demanded some riverine access so that fleet elements are understandable, but for the reasons already discussed I do not allocate a permanent squadron. The fort was established under Trajan and commanded the Danube junction with the River Siret. Excavations point to a military *vicus* to the south of the fort and a large funeral site to the north.[690] To the east by 1.5km is a small fortlet in the Dunărea district of Galaţi.[691] Aerial survey by Hanson and Oltean has shown the remains of one possible, and two certain further fortlets, eight possible towers and five discernable sections of Roman period

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685 Catalogue No 140; cIMeC 159749.03; *ISM* 5.251; Zahariade & Gudea 1997, p.80; Suceveanu 1991, p.59, p.66; Petculescu 2006, p.32.
686 Catalogue No 141; cIMeC 159749.01, 159749.05.
687 Catalogue No 142; cIMeC 160635.03.
688 Catalogue No 143; Ptolemy, *Geog* 3.10; Zahariade & Gudea 1997, p.80; Bărbulescu 2001, p.82.
689 *ISM* 5.297, 5.305-5.307; Matei 1991, p.154; Suceveanu 1991, pp.59-60, p.66; Bounegru & Zahariade 1996, p.11; Bărbulescu 2001, p.82.
690 Catalogue No 144-5; cIMeC 75105.04; Zahariade & Gudea 1997, p.81.
691 Catalogue No 146; cIMeC 75105.02.

rampart, describing an arc from Tuluceşti to Traian [Galaţi County], some 8-12km distant from the Barboşi site.[692] The whole appears to have delimitated a military zone on this corner of the western bank of the Danube. However, the relationship between the rampart and the towers is perplexing, because although Ţentea and Oltean suggest the towers were spaced to control the territory, they are still up to 7km inside the rampart. If this were a sterile zone to answer a tactical imperative, I would suggest it were short-lived because otherwise the probable military *vicus* would have been unsafe, as would have been other Roman settlements known at Vanatori and at Sendreni, both within the rampart but beyond the towers.[693] Zahariade's and Gudea's assessment is that the rampart described *prata/territoria* for the inhabitants of the military *vicus*, and this, despite the uncertainties about military *territoria* is a more attractive proposal.[694] On balance I include an agricultural potential for a military *vicus* using my generic figure of 960ha, not some fraction of the 17,000ha delimitated by the rampart.

Of the 14 Roman period sites of any type within Galaţi County, all but two lie within this rampart; these two are far away to the north-west, 70km and 90km distant at Tecuci and Poiana respectively. Poiana upstream on the River Siret was the site of long habitation, in the Roman period it is identified as Piroboridava.[695] This was garrisoned by a detachment of troops from *cohors I Hispanorum*, at the start of the 1st century.[696] The older view was that military occupation continued into the 3rd century, but this is now thought unlikely and the fort may have been

[692] cIMeC 75187.01, 77340.01, 75748.01, 75141.01, 77242.01; Ţentea & Oltean 2009, pp.1515-22 Fig 4.
[693] Catalogue No 148-50; cIMeC 75105.01, 75169.01, 75169.02, 75123.01.
[694] Zahariade & Gudea 1997, p.81.
[695] Ptolemy, *Geog* 3.10.8; cIMeC 76905.01.
[696] *PLond.* 2851.

abandoned as early as Hadrian.[697] Tecuci is simply listed as a civil site on cIMeC, its purpose is not clear.[698] As an aside, the other Romanian counties across the Danube from Dobrogea: Brăila, Ialomita and Calarasi, contained only eleven Roman period sites in total according to cIMeC. Now, the nature of Roman frontiers has been suggested most influentially by Whittaker as being porous zones of interaction and areas of waning Roman influence.[699] Yet in the case of the Lower Danube the archaeological evidence as reported on cIMeC points to the river presenting a very clear demarcation of influence with no significant settlement activity beyond it that might have been directed towards the *limes* zone.[700] These few sites across the river are not included in the catalogue, although while Piroboridava had a garrison it would have required a supply solution; its distance from anywhere else most probably meant a local source.

Returning to Dobrogea, two civil settlements are found north-west of Garvan, and single sites at Jijila and Văcăreni.[701] Moving east at Luncaviţa another settlement is reported 4km south of the village.[702] Zahariade and Gudea report a rectangular fort on the Milan hills to the north of Luncaviţa; cIMeC does not report the fort but does report Later Roman activity on these hills; these two reports probably ought to be associated with each other.[703] cIMeC also reports a Roman fort north of Rachelu, which is not in Zahariade and Gudea's catalogue, although Zahariade does acknowledge it elsewhere; *TIR* and Suceveanu both acknowledge it

[697] Vulpe 1931, pp.254-259; Birley 1997, p.86; http://cronica.cimec.ro/detaliu.asp?k=715.
[698] cIMeC 75212.01.
[699] Whittaker 1994, pp.72-3, pp.85-7; 2002: p.206, p.226; Batty 2007, p.459.
[700] *cf* Rankov 2005a, pp.175-81.
[701] Catalogue No 151-4; cIMeC 160635.01, 160635.06, 160626.01 160715.03; Bărbulescu 2001, p.84.
[702] Catalogue No 156; cIMeC 160699.02.
[703] Catalogue No 155; cIMeC 160699.03; Zahariade & Gudea 1997, p81.

so I include it.[704] Travelling east along the Danube, north-east of modern Isaccea is the fort of Noviodunum, the location of the fleet headquarters and so possessing harbour facilities, it was also home to legionary *vexillationes*.[705] Civilian settlement 0.25-0.5km distant from the fort is thought to be part of the military *vicus*, this gained municipal status *c* AD 200.[706] The whole *vicus* covers an area of 13ha; preliminary findings suggest, just as was seen at Novae, that small-scale agriculture was practised between dwellings close to the fort.[707] Another settlement is known to the north-west of Isaccea at Suhat.[708] Across the Danube from Isaccea at Orlovka in the modern Ukraine the bridgehead fort of Aliobrix is assumed on the basis of military brick-stamps and a reference in Ptolemy.[709]

Noviodunum's *territorium* is thought to have spread from Luncavița already mentioned in the west, to Parcheş and Somova in the east; civil sites are recorded at both the latter.[710] To the south-east there is a relatively dense distribution of sites from Niculiţel, along the Teliţa river valley to Cataloi and to the south at Trestenic. With regards to the well-known sites around Niculiţel there are significant differences between the narrative reports of Baumann, now 30 years old, and cIMeC. Bărbulescu follows Baumann but adds additional reference material, and these do bring into question the utility of cIMeC because some of Baumann's sites are very well attested, but they do also point to Baumann being overly optimistic in what might constitute a *villa*, particularly on the basis of surface finds.[711] From

[704] Catalogue No 157; cIMeC 160706.01; Zahariade 1999, p.202; *TIR* 1969, p.60; Suceveanu 1991, p.66.
[705] Catalogue No 158; cIMeC 159696.05; Suceveanu 1991, p.48; Zahariade & Gudea 1997, p.81; Bărbulescu 2001, p.76.
[706] Catalogue No 159; Bărbulescu 2001, p.76; Petculescu 2006, p.35.
[707] Lockyear *et al* 2005-6, p.123, pp.126-7, pp.149-50.
[708] Catalogue No 160; cIMeC 159696.04.
[709] Catalogue No 161; Ptolemy, *Geog* 3.10; Bounegru & Zahariade 1996, p.11; Zahariade & Gudea 1997, p.81.
[710] Catalogue No 162-3; cIMeC 161339.01, 161311.01.
[711] Baumann 1983, pp.71-5; Bărbulescu 2001, pp.78-9.

cIMeC, five settlements were considered together with others reported by Baumann and Bărbulescu. The first is 5km north-east of the village near the Saon monastery.[712] The second 3km north-east of the village at ‘Ceairul lui Iancu’ in the Iancu valley was an indigenous site with continued habitation into the Roman period.[713] Bărbulescu includes another site to the north-east of the village at Gorgonel; this is not evident on cIMeC or in Baumann and thus not included.[714] The third, a *villa*/small farm is found north-west of the village in the Capacilia valley, here Baumann reported farm buildings of 3,200m^2 area with a clear distinction between *pars urbana* and *pars rustica* and a necropolis 200m distant.[715] Baumann followed by Bărbulescu lists another five sites to the north of the village, one at Pasoiaei knoll midway between the Capacilia and Iancu valleys, two 1,500m and 2,000m to the north-west of the Capacilia valley small farm, another close to the Cocos monastery, and finally one on the western bank of the Iancu valley, 1km north of the village and distinct from the indigenous site already reported at ‘Ceairul lui Iancu’.[716] None is evident on cIMeC, but I feel compelled to include them as, at least, individual sites, because of the certainty with which they are reported. Returning to those sites actually on cIMeC, on the northern limits of the village itself is the ‘Gurgoaia’ site extensively excavated in the 1970s, which looks to have possibly been a cattle ranch as reported in the Preliminary Section to this Chapter.[717] Scattered finds to the west of the village still within the Gurgoaia suburb, including the find-spot of a treasure reported on cIMeC, led Baumann to

[712] Catalogue No 164; cIMeC 161044. 03; Bărbulescu 2001, p.78.
[713] Catalogue No 165; cIMeC 161044.04; Bărbulescu 2001, p.77.
[714] Bărbulescu 2001, p.78.
[715] Catalogue No 166; cIMeC 161044.02; Baumann 1973-5b, pp.110-11, 1983, p.74, pp.93-7; Bărbulescu 2001, p.78.
[716] Catalogue No 167-71; Baumann 1983, pp.74-5; Bărbulescu 2001, p.78.
[717] Catalogue No 172; cIMeC 161044.06; above, pp.138-9.

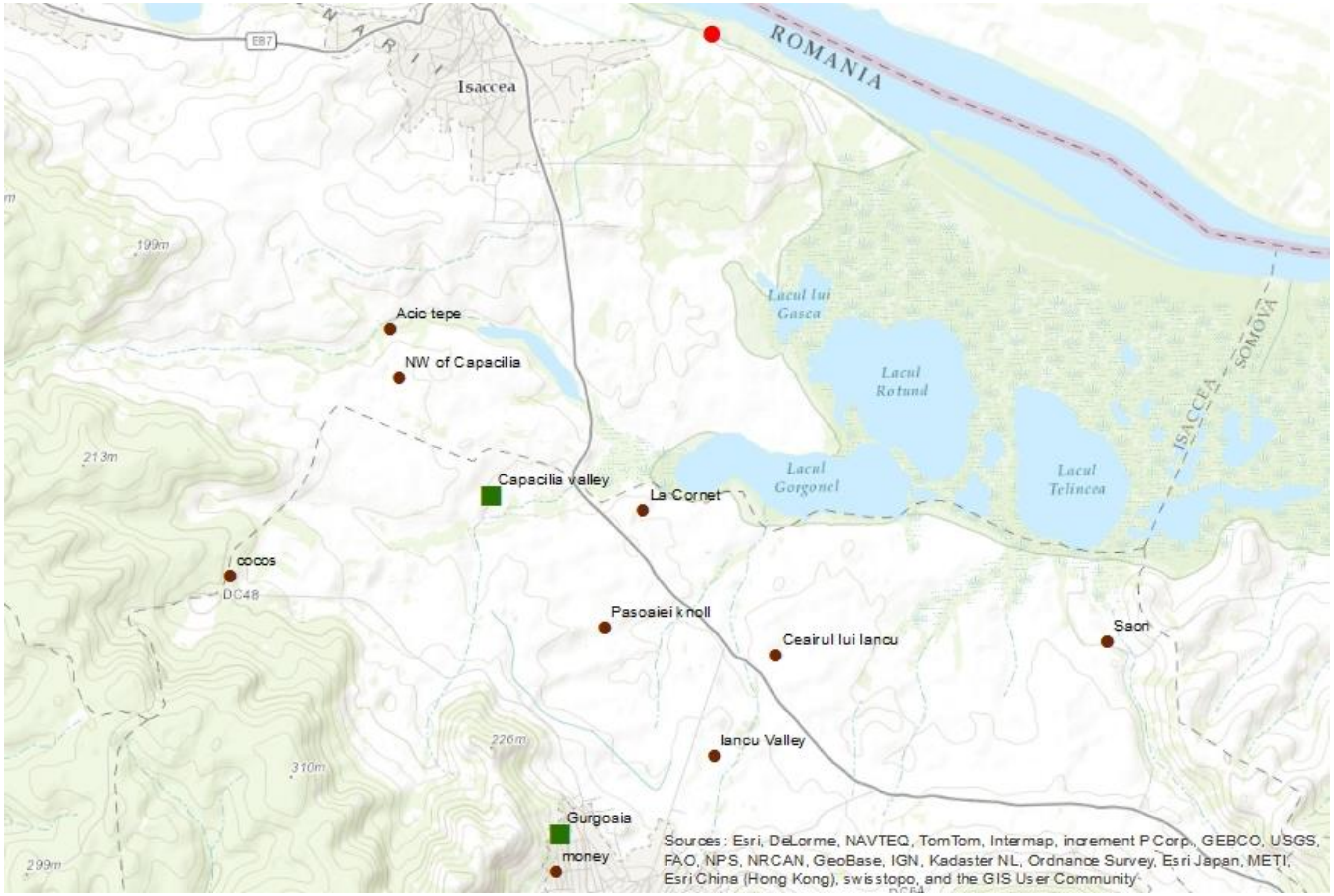

Fig 3.3.4.3 Niculițel sites and certain small farms

posit a farmstead here, but the proximity to the 'Gurgoaia' site incline me to include it with that.[718] Baumann also suggested a handicraft site to the south of the village and another site to the east.[719] Bărbulescu does not follow him on these, nor are they on cIMeC, so I do not include them. A fifth site on cIMeC not reported by Baumann is titled 'Cornet' at the head of the Capacilia valley; it is distinct from Baumann's sites because it was not discovered until 1993.[720] The overall effect of all these sites around Niculiţel is to suggest an area of intensive farming activity and although the six *villae* suggested by Baumann might not all have been *villae*/small farms, ten sites are known of which at least two ought to be considered small farms. The degree of agricultural activity might warrant considering the whole as a *vicus*; Bărbulescu following Baumann did suggest this much, as did Suceveanu, although his cited inscription, a milestone, proves little.[721] Therefore without epigraphic evidence of civic administration I am not inclined to do so.

At Telița there was a *vicus* type settlement now titled 'La Amza' which has been subject to excavation.[722] Continuous habitation is evident from the Hallstatt until the Later Roman period, and in the 1st-3rd centuries sunken huts existed, both oval, and rectangular in shape with wooden superstructures, together with a more substantial building which is thought to have been an assembly hall.[723] The whole Roman-period site extended to approximately 14ha, with dwellings of between 9 and 20m^2 in size, sufficient for a single family unit; the density of the housing led Baumann to suggest a 2nd century population of 2240 as discussed above.[724]

718 Baumann 1973-5b, pp.113-14, 1983, p.73.
719 Baumann 1973-5b, pp.113-14, 1983, pp.71-3.
720 Catalogue No 173; cIMeC 161044.08.
721 Suceveanu 1991, p.80 citing *ISM* 5.250; Bărbulescu 2001, p.79.
722 Catalogue No 174; cIMeC 160421.01.
723 Baumann 2003, pp.164-5, pp.171-3; Kovalevska & Sarnowski http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 30 Oct 2012.
724 Above, p.126.

Undated tumuli are clearly related. Two further sites, one south-west of the village and another further south at the Celic Dere monastery, were suggested as *villae* by Baumann, but without excavation I stick to cIMeC's description of simply *aşezare*.[725] A collection of ovens to the north of the village at Izvorul Maicilor and another to the south-west at 'La Hogea' both imply industrial sites that I exclude. Four more sites are recorded on cIMeC at Poşta, two of which were small farms.[726] At one of the individual sites a military *horreum* with tile stamps of *legio V Macedonica* was found, leading the excavators to suggest that this was a storage depot for long-distance supplies destined for Troesmis.[727] However, only a single part-excavated granary is reported. Furthermore the site is 15km east of Noviodunum and 40km east of Troesmis, so the tile stamps may simply be indicative of legionary *vexillationes* being posted there. Such detachments are known at nearby Halmyris. Therefore to posit a supply station is tenuous, despite Troesmis, Arrubium and Dinogetia being in the area with least agricultural activity and most in need of overseas supplies being landed somewhere nearby. Five settlements are recorded and easily positioned at Trestenic, and two each at Nalbant and Frecăţai; in this last case a Roman necropolis is also present but I associate it with the sites and do not count it separately.[728] Five sites, two of them small farms and undated tumuli, are known at Cataloi.[729] Thus this area of northern Dobrogea 10-15km south of the Danube was more highly populated than any other part; yet other than that for Niculițel and Telița La Amza, there is little supporting literature.

[725] Catalogue No 175-6; cIMeC 160421.03, 160421.05; Baumann 1983, pp.87-9.
[726] Catalogue No 177-80; cIMeC 160412.05, 160412.07, 160412.03, 160412.08.
[727] Catalogue No 180; Cronica.cimec.ro/detaliu.asp?k=3953; Lockyear *et al* 2007, pp.46-7.
[728] Catalogue No 181-9; cIMeC 161026.05, 161026.02, 161026.09, 161026.04, 161026.06, 161008.02, 161008.01, 160396.07, 160396.03, Bărbulescu 2001, pp.74-5.
[729] Catalogue No 190-4; cIMeC 160403.05, 160403.04, 160403.03, 160403.01, 160403.02.

To the north-east of modern Tulcea was the native town of Aegyssus, another place warranting Roman interest by the time of Ovid.[730] A fort is assumed on the basis of later 3rd century tile stamps but it is not located.[731] Three cIMeC sites and a necropolis lie beneath the modern town; the full extent of ancient habitation is unlikely to ever be understood, but I class all as a single *vicus* type site; other independent sites lie to the north-west and east of the town.[732] A *vicus Urbiin….* was located nearby.[733] Across the Danube in the modern Ukraine a Roman fort is supposed at Ismail on the Chilia bank of the Danube.[734] Further settlements existed at Malocci, two at Nufăru, and four in the region of Beştepe.[735] Across the St George channel another site is known at Băltenii de Jos.[736] To the north-west of Mahmudia lay Salsovia, where a Later Roman fort is supposed to overlie an earlier one; the small finds suggest a military presence from the 1st century, but no Roman period settlement is recorded on cIMeC so that I simply record it as military site and do not allocate any civilian activity.[737] To the east, a Roman period site lies to the north of the Filip Rosu canal.[738] A further site on the road travelling east is recorded as Roman but also as 4th century; no follow up material is cited and I discount this.

On the promontory extending east of Tulcea bounded by the St George branch of the Danube to the north and Lake Razim to the south sits Murighiol the

[730] Ovid, *Pont* 4.7.21, 4.7.53.
[731] Catalogue No 195; *IA* 226.02; Matei 1991, p.155; Zahariade & Gudea 1997, p.81; Suceveanu 1993, p.164; Bărbulescu 2001, pp.73-4.
[732] Catalogue No 196-8; cIMeC 159623.01, 159623.07 tumuli, 159623.08, 159623.10, 159623.04, 159623.03; Suceveanu 1991, p.48; Bărbulescu 2001, p.74; Petculescu 2006, p.35.
[733] Catalogue No 199; Bărbulescu 2001, p.74.
[734] Catalogue No 200; Zahariade & Gudea 1997, p.82.
[735] Catalogue No 201-7; cIMeC 161080.02, 161062.03, 161062.01, 160760.06, 160760.03, 160760.04, 160760.07.
[736] Catalogue No 208; cIMeC 160742.01.
[737] Catalogue No 209; cIMeC 160733.12; *IA* 226.3; Matei 1991, p.156; Zahariade & Gudea 1997, p.82; Bărbulescu 2001, p.70.
[738] Catalogue No 210; cIMeC 160733.04.

site of ancient Halmyris, also called Salmorus, where a native town and Roman period fort both lie beneath a Later Roman fort. Halmyris was home to legionary *vexillationes* through the 2nd and 3rd centuries.[739] Close by *c(ives) R(omani) consist(entes) vico class(iciorum)* are recorded by a series of votive altars implying a fleet presence and probable harbour; this *vicus* ought to be associated with an unexcavated 10ha site to the west of the fort.[740] Such a community on the very edge of the province, indeed of the empire, can only have been established in direct support of the military as the name implies.[741] Two other settlements are known within a kilometre of Murighiol.[742]

To the south of the promontory on the northern shore of Lake Razim indigenous habitation was well established and many sites continued their existence into the Roman period. A solitary rural site is recorded north of Sarinasuf.[743] While around Valea Nucarilor, Iazurile, and Agighiol there are five sites, one of which in the Tulcea Valley to the north of Agighiol was a small farm.[744] There are also a great many undated tumuli around all three villages. Unusually these tumuli are more specifically located on cIMeC than in other parts of the survey region. The pitfalls of such precision are that these make up 12 entries on cIMeC; if this degree of precision were applied across the whole database it would soon become unwieldy. Although undated, it stands to reason that some of these ought to be associated with the Roman period settlements. Travelling around the shore of Lake Razim, a settlement existed to the north of Sabangia and a funeral site is known

[739] Catalogue No 211; cIMeC 160920.01; Suceveanu 1991, p.47; Zahariade & Gudea 1997, p.82; Zahariade & Phelps 2002, p.231, p.236.
[740] Catalogue No 212; *AE* 1988.986-90, 2003.1550, 2011.1140; Suceveanu 1991, p.47; Zahariade & Phelps 2002, p.236.
[741] Suceveanu & Zahariade 1986, pp.109-20; Bărbulescu 2001, p.70.
[742] Catalogue No 213-14; cIMeC 160920.01, 160920.03.
[743] Catalogue No 215; cIMeC 160975.01.
[744] Catalogue No 216-20; cIMeC 161516.01, 161491.01, 161507.03, 161507.08, 161507.04.

within the same village; the two are 2km apart and probably evidence separate habitation, I count these separately.[745] At Sarichioi settlements existed in the north of the village on the edge of the lake and 1.5km to the south; again four groups of undated tumuli are located to north and south.[746] Although this is part of the Black Sea littoral, these sites are all close enough to the *limes* zone to be associated with it, but how far arable farming was actually practised here is uncertain; their position suggests fishing communities yet for the purposes of argument they will be considered as producing an arable surplus as well. A military site, *vallis Domitiana*, is recorded in the area by the Antonine Itinerary and it was probably positioned near Agighiol or Sarichioi.[747] Enisala was also a place of long habitation from before, until well after, the Roman period; three Roman sites exist, one in the north-east, another in the centre of the village, and one just to the west; a Roman coin hoard was also found in the Later Roman fortified site, but this last I do not include.[748] A site with necropolis is known at Visterna.[749] Moving inland Babadag was the site of the *vicus Novus* to the south-west of the modern village; another settlement is reported within the village and a third to the north-east on the shore of Lake Babadag was established before the Roman period and remained so until Medieval times.[750] To the west of Mihai Bravu, the *vicus Bad*….was positioned where again *v(eterani) et c(ives) R(omani) consist(entes)* are known; another site is evident a kilometre to the north.[751] A single settlement is also evident within the village of Turda.[752]

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[745] Catalogue No 221-2; cIMeC 161204.01, 161204.03.
[746] Catalogue No 223-4; cIMeC 161188.01, 161188.10, 161188.04.
[747] Catalogue No 226; *IA* 226.5; Zahariade & Gudea 1997, p.85.
[748] Catalogue No 227-9; cIMeC 161197.01, 161197.03, 161197.05.
[749] Catalogue No 230; cIMeC 161213.01.
[750] Catalogue No 231-3; cIMeC 159669.02, 159669.03, 159669.01; *CIL* 3.14448; Bărbulescu 2001, p.94.
[751] Catalogue No 234-5; 160840.03; 160840.07; Bărbulescu 2001, p.94.
[752] Catalogue No 236; cIMeC 160868.02.

3.3.5 Are the garrison's needs met?

In total I have counted 28 military sites, and 209 civilian sites on cIMeC which, according to their geographical position were, by my own assessment, considered best placed to serve the *limes* zone. I will consider separately those sites that were best placed to serve the *poleis*. Of the *limes*-facing sites, 40 are supposed to have been settlements like the rural *vici* with a nominal agricultural potential to the value of 960ha; they include not only the rural *vici* and *komai* but the military *vici* adjacent to the camps, the *municipia* and some Getic *dava*. In many cases continuity of occupation from before the Getic period into the Roman occupation is evident. Of those sites on the cIMeC database only, excluding those sites that I have included on epigraphic evidence, it was seen that 55% showed continuity of occupation from before or after the Roman period, and this may well be an underestimate because in many cases an earlier or later site is within a few hundred metres of a Roman site. Irimia's research has repeatedly shown an indigenous Getic culture possessing small semi-urban centres that pre-dated the Roman arrival.[753] Yet in contrast Poulter argued that the *vici* were established specifically to provide for the military.[754] Suceveanu, looking towards the indigenous habitation, denied these settlements were a Roman innovation.[755] Yet it has repeatedly been stated that within these *vici* often *cives Romani* are specifically reported as being *consistentes*, that is settled. It will be seen when considering the *poleis* providing zone that this was often done together with members of two particular Thracian tribes, the Bessi and the Lai.[756] In addition there is evidence for

[753] Irimia 1980, 1981, 2007.
[754] Poulter 1980, pp.729-44; 1983, p.86.
[755] Suceveanu 1991, p.36.
[756] *ISM* 1.324, 1.326-328, 1.330-332; 1.343-349; *CIL* 3.7533 (*ISM* 2.141), *CIL* 3.14214[26] (*ISM* 5.62) *ISM* 5.63, 5.141, 5.154; *CIL* 3.14441; Batty 2007, pp.522-3 suggests that these were residual tribal enclaves.

large scale migrations into the province, firstly 50,000 Getae under Aelius Catus *c* AD 2-3 and another 100,000 probably Bastarnae and Peucini settled by T. Plautius Silvanus Aelianus *c* AD 60-67, together with the Dacian community reported near to Tropaeum Traiani.[757] These peoples may well have been attracted, or directed, to settling on and farming land to feed the army. Therefore, a middle way between the views of Poulter and Suceveanu is most credible, the native agricultural scene may have been well-established, but the *vici* do have Roman names and Roman citizens are present together with other migrants. It appears that Rome organized, according to its own terms, an agricultural landscape that was already present in Dobrogea, increasing settlement activity and so agricultural productivity especially in the *vici*. It should be noted that such migrations and increases in productivity are often thought to have also necessitated a specialization of production and reduction in crop diversity, to accommodate the population growth.[758] I cannot say if that was the case in Dobrogea. Within the military *vici* there would have certainly have been some of the service providers whose needs I have enumerated above. Yet I still believe that these settlements would have produced a surplus, as the surveys at Novae and Noviodunum suggest, and as my preferred interpretation of the function of *territoria legionis* would imply. I have also recorded 20 small farm sites to which I allocate 120ha each; although some commentators might report more of these, I prefer to be pessimistic and only use this term when a farm requiring a staff is evident. All the other 149 settlement sites have been assumed as belonging to single-family units farming only 10.2ha each. These therefore equate to 38,400ha, 2400ha and 1520ha for the *vici*, small farms and individual sites respectively, a total of 42,320ha of arable potential. So, the *vici* are seen to have provided the majority

[757] *CIL* 14.3608; *CIL* 3.14437[2]; Strabo 7.3.10; Mócsy 1974, p.37; Gerov 1988, p.18, p.23; Bărbulescu 2001, p.125; Batty 2007, p.404; above, p.182.
[758] Kooistra 1996, p.126.

of the agricultural potential; indeed I could ignore the lesser settlements and still arrive at similar results.

I have also in the south of the region considered the 1071 tumuli buffers recorded by Oltean. However, the identification of such features can in no way offer a suggested date of construction and so date of settlement. These tumuli would have often been the product of several generations, even in the case of isolated sites they can be up to 100m in diameter. In the more aggregated clusters they may represent habitation over many centuries. Away from the *poleis* of the east, within cIMeC only 15 Roman-period tumuli and two other funeral sites were reported in the wider countryside. There were a further 13 tumuli and 39 other funeral monuments from other periods. Therefore there is a huge discrepancy between the total reported tumuli, or even funeral sites in general, of any period on the national database and Oltean's dataset. This is because tumuli are normally reported *en bloc* on cIMeC as being in the perimeter of a particular village or commune without specific locations, and has previously been observed around the villages of Valea Nucarilor, Iazurile, and Agighiol, to do otherwise would clog cIMeC up with many similar entries.[759] What can be done is to take the ratio of Roman to non-Roman funeral sites recorded on cIMeC of 17:52 and apply that to the larger dataset provided by Oltean as a means of compensation for not being able to date her tumuli. In this way one could argue that only 24.6% of Oltean's tumuli were of Roman date and 75.4% were of other periods. Alternatively because of the 55% continuity of occupation seen with all of the cIMeC sites one could argue that 55% of the tumuli also may have been in use in the Roman period.

[759] Above, p.210.

Taking the total number of tumuli buffers present in my *limes* zone and multiplying by the low figure used throughout this Chapter of 10.2ha for an individual settlement, that equates to 10,924ha. If this adjusted down by my dating factor of 24.6%, then only 2640ha may have been available, or adjusting by 55%, 6008ha. Yet at least in the case of the buffers around Fântâna Mare and Independența together with those at Medgidia and Cuza Vodă these are possibly to be associated with the *civitas Ausdecensium* and the *vicus I Urb…*, another fifteen groups of tumuli have been linked to individual sites, and the potential of all of these has already been accounted for. As a result one cannot simply add in the potential arrived at from the tumuli to that argued for from the cIMeC material. An alternative might be to discount the evidence of cIMeC and use just the tumuli data for the southern section. This would allow one to use the aggregate classes as proxies of different settlement types. To test this it was decided to allocate a set of nominal figures to each aggregate class and date-adjust total landholdings down to arrive at a putative total land holding for the Roman period. The figures used were those already derived at in the Preliminary Section to this Chapter and a fifth and a quarter of the average land area derived from the Voronoi analysis above, i.e. 38.8ha or 48.5ha, together with the whole 194ha.[760] A new lesser figure of half 10.2ha, i.e. 5.1ha and a new higher figure of twice 960ha, 1920ha were also used. These figures were applied to the different aggregate classes in three possible and purely speculative combinations. The results are a range of putative landholdings. This approach is purely theoretical.

[760] Above, p.189.

Accepting that aggregation is an indicator of the scale of settlement activity, then these calculations do allow the higher number of small settlements, to have a greater impact upon the argument than the *vici* have hitherto done. In all the

Table 3.3.5.1: Suggested landholdings by aggregate class in *limes* zone

Agg Class	No of tumuli	1st scenario		2nd scenario		3rd scenario	
0	491	5.1	2504.1	10.2	5008.2	10.2	5018.4
1	462	10.2	4712.4	38.8	17925.6	48.5	22407
2	98	38.8	3773	48.5	4753	120	11760
3	11	48.5	533.5	120	1320	194	2134
4	4	120	480	194	776	960	3840
5	5	960	4,800	960	4800	1920	9600
	1071						
Total land-holding			16,803		34,583		54,759
Adjusted by 24.6% date correction			4134		8507		13471
Adjusted by 55% date correction			9242		19,021		30,118

suggested scenarios, the potential of the two classes of lowest aggregation surpasses that of the highest aggregation class. Of the 42,320ha argued to have been present in the *limes* providing zone from cIMeC, 11,379ha was evident in the southern part of the survey area. If the arable potential from the second scenario, using the mid-range figures of 8507ha or 19,021ha replaces this 11,379ha, then across the wider Dobrogea either 39,448ha at the lower dating adjustment and 49,962ha at the higher dating correction would have been available to the garrison across the whole *limes* zone. Now the problems of this approach become evident: there is no good argument for preferring a 55% occupation rate of the tumuli over the 24.6% or vice versa and so it is difficult to argue for either figure. Neither is the second scenario any more plausible than the first or third. If the low and high figures derived from all three suggested scenarios in Table 3.3.5.1 are used in lieu of the cIMeC material in the south, a range of 35,075-61,059ha is arrived at across the whole region, 63-110% of the garrison's needs. Therefore because of these uncertainties and while the tumuli dataset can only be applied to part of Dobrogea it was thought better to utilize only the cIMeC material, while acknowledging the potential of the tumuli data to identify sites more precisely and point to trends in settlement activity.

I have in Table T.3.3.1a calculated that the estimated arable need of the Dobrogean garrison, service providers and their attendant farmers would have totaled 55,427ha. As previously stated, I will no longer pursue the pasture needs when so small a percentage of the whole landscape is required for arable. The 42,320ha of arable potential suggested from cIMeC represents 76% of the arable needs of garrison, service providers and the farm workers serving both. If the arable potential seen is measured against the overall needs once dependants are included, and it is to be remembered that the total population estimate here of 67,240 is very close to the rough estimate derived from eight persons per km^2, then still, 53% is visible, Table T.3.3.1b refers. It can therefore be said that the Roman army had a ready supply of food for its immediate needs. The availability of arable is part of Whittaker's argument for the frontiers only extending as far as the empire could support them.[761] A basic premise of Kooistra's study of Germania Inferior was also that the province should support all of its inhabitants, the army included.[762] Yet, it is sensible to not be completely dependent on a single supply source, so that I would expect a majority two-thirds to three-quarters of a garrison's needs to be available locally, but some part to be shipped from further afield.

[761] Whittaker 1989, pp.66-9, 1994, pp.86-7; a view also espoused by Hanson 2003, p.202; but note Kehne 2011, p.326 suggests some frontiers were incapable of supporting the army.
[762] Kooistra 1996, p.117, p.125.

Now one could contest the assumptions made to arrive at these figures, such as the arable potential of the sites, which of the sites catalogued actually did provide a surplus to the military, and how many sites were in use concurrently.[763] Against these unknowns, there were surely many, many, more especially single-family sites in the region than those that survive archaeologically; this is what the tumuli data shows, but without secure dating. Additionally it is probable that many of the smaller farms were of a greater size than I suggest. Therefore the percentage part of the needs seen should only increase. Because of such factors it is common to assume, quite correctly, that what is seen in the archaeological record is only part of what was present in antiquity and thus to multiply what is seen by a survivability factor. Yet, because of the unknowns, I prefer to err on the side of caution and not use a survivability factor; rather I will stick with the sites evident today to make my calculations. From this one can say that both the garrison and service providers could have been fed in a significant 76% part from the agricultural activity still visible today.

3.3.6 Site distribution: Black Sea *poleis* zone

I shall now consider those sites closer to the Black Sea littoral that I believe to have provided for the Black Sea *poleis* which must have had well-established food supplies prior to the arrival of the Romans. I have already reported Suceveanu's suggested population figures of 40,000-60,000 urbanites.[764] Properly the populations of all Greek *poleis* included those resident in the *chorai*.[765] Because of this Suceveanu added another 40,000-70,000 citizens resident in the *chorai*; in

[763] *cf* Matthews 2015b, where I did not include service providers, which decreased the arable need, but then I halved the quantity of sites seen to allow for those sites that may not have produced a surplus, yet I still arrived at 66% of the garrison's needs being available.
[764] Chapter One, p.21.
[765] Finley 1992, p.123.

broad terms suggesting 100,000 people in the area. However, the ground plan at Histria has already been shown to be far from capable of housing even Suceveanu's lower estimate.[766] I therefore arrived at an average figure of 10,000 urbanites in each *polis*. Most of those people within the *chorai* will have been farmers, in part self-sufficient, in part supplying their *polis*, and many will have lived in the *vici* and *komai* that will be seen within the *chorai*, so that for the calculations they will not be counted among the urban population. The parasitic nature of these *poleis* should not be over-emphasized, since beyond Imperial Rome, Alexandria and Classical Athens the consumer city was an abstract; in reality all urban centres reacted with their hinterland to a greater or lesser degree, so that many of the inhabitants were probably involved in agriculture walking to the fields daily to work and produce food for the city.[767] It is for that reason that I suggested at least 500 farm workers and so a 3000ha output from the *poleis* themselves.

The potential size of the *chorai* has been chiefly responsible for my division between sites providing to the military and those not doing so, although I did make some reference to the physical geography, particularly the lie of river valleys and the location of the *limes* forts themselves. In the first instance the needs of the *poleis* ought to have been met from their own *chorai*; it was not in the Romans' interest to denude a *polis* of its agricultural hinterland by diverting too much agricultural product to the *limes* zone so that the *poleis* would cease to function economically. Both Histria and Callatis are estimated to have commanded *chorai* of up to 500km^2 by Hansen and Neilsen in their gazetteer of Greek *poleis*; Tomis' *chora* is estimated to have been smaller at between 200 and 500km^2.[768] These would equate to radii of 18km in the case of Histria and Callatis and somewhere

[766] Above, pp.132-3.
[767] Finley 1992, p.125; Ørsted 1985, p.55; Morley 2004, p.10, p.13, p.23.
[768] Hansen and Nielsen 2004, pp.932-3, pp.940-1.

between 11-18km in the case of Tomis.[769] In the case of Histria, the limits of its *territorium* were set by and preserved in the Horothesia of Ti Laberius Maximus.[770] Although interpretations of this text have been subject to continued debate, the two most influential older arguments were combined and modified by Avram and his interpretation is generally followed today, with boundaries for a *regio* lying on an arc of at least 30km from the *polis*.[771] However, other inscriptions make it quite clear that there were two distinct administrative organizations centred on Histria, each with separate magistrates: the *regio* and the *civitas*.[772] This leads to the belief that there was another demarcation approximately 12-15km from the *polis* that separated the *chora* from the larger *regio* or *territorium*.[773] Fig 3.3.6.1 below illustrates. By these interpretations the *chora* was of 350km^2 area, and this is probably more accurate than Hansen's and Neilsen's estimate. The distinction between *chora* and *territorium* further allows me to propose that that some communities known to be associated with Histria might none the less have provided for the *limes* zone without legal impediment, as I have done above. For my own suggested demarcation between *limes*- and *poleis*-providing sites, rather than reducing the *chorai* as the arcs return to the shore I have kept to their western limit, to suggest a zone running approximately 15-20km inland but parallel to the shore. I therefore arrive at a suggested area of land best placed to serve the *poleis* as 2300km^2. The nominal 30,000 urbanites would have required the agricultural product of 322km^2, so plenty of land ought to have been available. It was not my purpose to solve the supply solution to the *poleis*, but I have to acknowledge its

[769] These distances pertain to radii only facing inland of course.
[770] *ISM* 1.68.
[771] Bărbulescu 2001, pp.32-3 lays out the earlier arguments and cites Avram 1988-1989 as does Panaite 2010; good maps are available in the commentary to *ISM* 1.68 and Irimia 2007, p.217.
[772] *ISM* 1.329, 5.123; Suceveanu 1977, p.38 fn78; Bărbulescu 2001, pp.34-5; Panaite 2010, p.373.
[773] Suceveanu 1977, p.43, 1988, p.161; Suceveanu 1991, p.48; Bărbulescu 2001, p.39; Panaite 2010, pp.374-5.

drain upon potential military resources and at least recognise that the *chorai* ought to have provided to the *poleis*.

Starting where I left off, in the north-east of Dobrogea at Cape Doloşman within the modern commune of Jurilovca a small Greek settlement Argamum existed from the 7th century BC.[774] This is a case of a site that does not easily fit within the categories used: it was urban, but not necessarily an independent *polis* in its own right – coming within the *regio* of Histria, so that I treat it as a *kome* type site. Two other Roman-period sites and undated tumuli are known at Jurilovca itself, and a Later Roman fort offshore at Insula Bisericuta on Lake Razim shows signs of earlier civil habitation.[775] Two settlements are reported at Sălcioara and Vişina each.[776] Two further settlements and tumuli are known at Lunca and another between Lunca and Ceamurlia de Jos.[777] To the north-west of Ceamurlia de Jos, another site appears on cIMeC together with three groups of undated tumuli. Baumann reports two *villae* here and Bărbulescu follows him, although she notes that the second is smaller, possibly the farm of an individual; I list both, the first as a small farm the second as an individual site.[778] Four sites: two dwellings, two funeral, are evident at Baia, all are sufficiently far apart to suggest separate habitation.[779] The position of all these on the lake suggests that they looked to the Black Sea *poleis*. However, there was also a Roman fort named *ad Salices* not accurately located but thought to have been nearby; it is fair to assume that the

[774] Catalogue No 237; cIMeC 160653.02; Mănucu-Adameşteanu 1992, pp.55-7; Bărbulescu 2001, p.72; Avram 2003, p.286; Petculescu 2006, p.36.
[775] Catalogue No 238-40; cIMeC 160653.01, 160653.05, 160653.03; Bărbulescu 2001, p.73.
[776] Catalogue No 241-4; cIMeC 160671.05, 160671.06, 160622.02, 160622.01.
[777] Catalogue No 245-7; cIMeC 160118.02, 97287.01, 160109.02; Bărbulescu 2001, p.73.
[778] Catalogue No 248-9; cIMeC 160109.01; Baumann 1983, pp.84-85; Bărbulescu 2001, p.73.
[779] Catalogue No 251-4; cIMeC 159794.06, 159794.02, 159794.08, 159794.04.

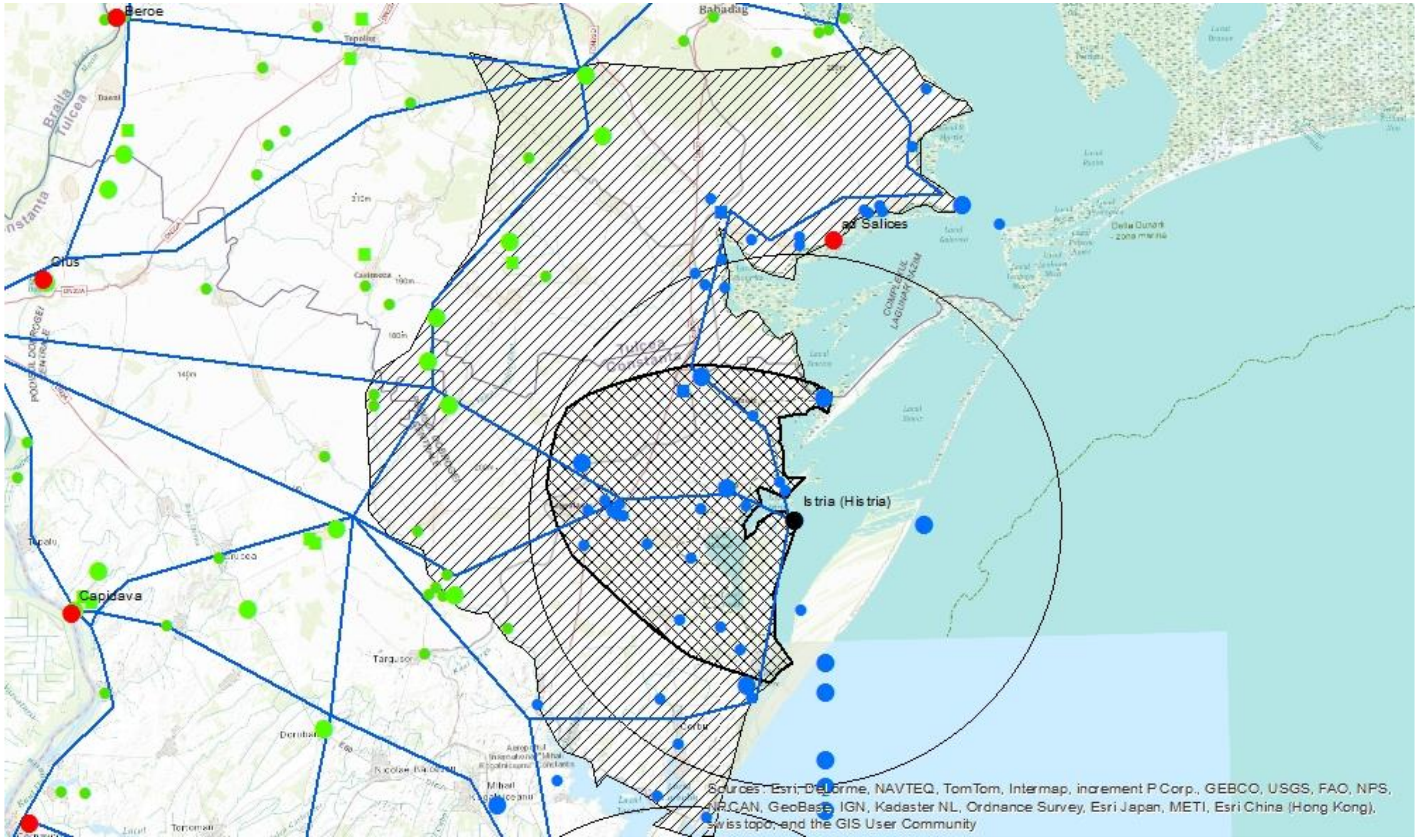

Fig 3.3.6.1 Histria *regio* (cross hatched) and *chora* (double cross hatched)

After Avram 1988-9, Bărbulescu 2002, Irimia 2007 and Panaite 2010 all interpreting: Pârvan 1916, see also *ISM* 1.68. Green dots *limes* providing, blue dots *poleis* providing sites, 20km radius drawn.

garrison's needs were met from this area, but without a known garrison and so troop numbers I do not pursue this further.[780] Following the preferred interpretations of the aforementioned Horothesia of Laberius Maximus, Histria's *territorium* stretched from the shore of Lake Razim, north of Argamum and then along the hills between Enisala to Slava Rusă [ancient Ibida], past the confluence of the Slava Rusă and Slava Cercheză streams, west and then south to Biedaud, and then further south along the Casimcea river valley until it discharged into Lake Taşaul, to include the northern shore of this lake as far as the Black Sea at Cape Midia, see Fig 3.3.6.1 below.[781] This is a considerable arc, but the *chora* is thought to have been closer to the *polis*, describing an arc from Sinoe [*vicus Quintionis*], Fânâtele and Cogealac to arrive back at the shore at Vadu.[782]

Considering those sites in the *chora* that probably provided to Histria, 6km east of modern Sinoe is the site of the *vicus Quintionis* which has yielded a considerable quantity of epigraphic evidence of administrative activity tied to Histria and many references to veterans and members of the Bessi and Lai being *consistentes*.[783] That Roman citizens and members of the Bessi and Lai were present so close to the *polis* implies that Rome asserted its authority in the region by imposing these communities upon them. Another settlement is evident within Sinoe itself.[784] The *vicus Buteridavensis* and a *latifundia* are thought to have been close to modern Mihai Viteazu on the basis of boundary stones between the two, I include the latter as a small farm. Roman period tumuli also indicate habitation in the

[780] Catalogue No 250; *IA* 227; Zahariade & Gudea 1997, p.85.
[781] Bărbulescu 2001, pp.32-3; Panaite 2010, pp.373-4.
[782] Suceveanu 1977, p.43, 1988, p.161; Suceveanu 1991, p.48; Bărbulescu 2001, p.39; Panaite 2010, p.375 has it extending further south to include sites near the modern villages of Gura Dobrogei, Palazu-Mic, Piatra and Corbu.
[783] Catalogue No 255; cIMeC 62271.01; *ISM* 1.324, 1.326-328, 330-332; Suceveanu 1991, p.48; Bărbulescu 2001, pp.34-5.
[784] Catalogue No 256; cIMeC 62271.02.

area.[785] cIMeC records a single site at Fântânele, the existence of three settlement nuclei has already been discussed, and Suceveanu's work on the site is so well received that I record all together as a *vicus*.[786] Five separate settlements are recorded at Tariverde.[787] Two further sites are located at Cogealac, together with tumuli; these are not specifically located so that I associate them with the other two sites.[788] Another two settlements are reported at Nuntaşi.[789] Single settlements are reported at Săcele and Traian [Constanța County]; in this last case Roman-period tumuli are again reported but un-located so, for consistency I have no option but to associate them with the settlement.[790] The *polis* of Histria itself lay to the east of modern Istria; I have already commented on the likelihood that some of the inhabitants worked the land and I allocate the standard figure of 3000ha of arable to it.[791] Another *kome* is suggested at Caranasauf, a suburb of the modern village that does not appear on cIMeC, presumably because the site is uncertain, but the secondary opinion is secure; two other sites are included, one to the south-west on Istria hill and one 1.5km south-east conventionally called Histria β, while to the north-west of the ancient *polis* are two sites, Histria α and γ.[792] In the vicinity of Vadu four sites are recorded on cIMeC, one of which is explicitly linked with the *vicus Celeris*.[793] Epigraphic evidence points to a further three *vici* nearby, the *vicus Parsul*, and the *vicus C….cos* are recorded on a single boundary stone, while the *vicus Arcidava* is recorded on another stone found at Histria; I include all three,

785 Catalogue No 257-8; *CIL* 3.14447 (*ISM* 1.359), *ISM* 1.360; Suceveanu 1991, p.48; Bărbulescu 2001, pp.37-8; Panaite 2010, p.374, Bâltâc 2010, p.439.
786 Catalogue No 259; cIMeC 61407.01; Suceveanu 1998; above, pp.124-5.
787 Catalogue No 260-4; cIMeC 61443.05, 61443.04, 61443.07, 61443.01, 61443.03.
788 Catalogue No 265-6; cIMeC 61381.01, 61381.04.
789 Catalogue No 267-8; cIMeC 62048.02, 62048.04.
790 Catalogue No 276-7; cIMeC 62887.02, 62896.02; Bărbulescu 2001, p.43.
791 Catalogue No 269; cIMeC 62039.01.
792 Catalogue No 270-4; cIMeC 62039.10, 62039.05, 62039.06; Bărbulescu 2001, p.42; Panaite 2010, pp.374-5.
793 Catalogue No 277-80; cIMeC 61540.03, 61540.04, 61540.06, 61540.05; *ISM* 1.351, *CIL* 3.7526 (*ISM* 1.352); Bărbulescu 2001, p.46 offers alternative locations for the *vicus Celeris*.

although not actually located.[794] Thus there was extensive village type settlement very close to the *polis* presumably to farm the immediate hinterland.

Travelling down the shore, there are sites to the north and within Corbu, together with Roman period tumuli that I include with these.[795] There are also two sites to the south-west at Luminiţa [Constanţa County] and south-east at Cape Midia.[796] Bărbulescu and Panaite position the village of *Tres Protomae* around Corbu also; this village is only known from a milestone found at Constanţa [Tomis] giving the distance 27 Roman miles (40km), from the village; Suceveanu has alternatively suggested it was in the territory of Axiopolis away to the west.[797] Following the road network, both are possible, but I take the majority and more modern view and position it at Corbu. Of uncertain location, but to the south of Histria's *regio*, an inscription reports the sites of *Chora Dagei* and *Laigos Pyrgos*, the latter taking its name from the tribe of the Lai already discussed.[798] Also at this latitude but further inland are sites at Palazu Mic and Sibioara on the banks of Lake Taşaul with associated Roman period tumuli.[799] Mihail Kogălniceanu is associated with the *vicus Clementiani*.[800] Although I include it with those sites providing to the *poleis*, its position with relation to the road network means that any surplus might as easily have gone either way to *limes* or *poleis*.

Suceveanu suggested that certain magistrates within the *regio Histriae* were specifically charged with raising the *annona militaris* from the second half of the

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[794] Catalogue No 281-3; *CIL* 3.12488 (*ISM* 1.350), ISM 1.358; Suceveanu 1991, p.46; Bărbulescu 2001, p.46; Panaite 2010, p.374.
[795] Catalogue No 284-5; cIMeC 61522.02, 61522.03.
[796] Catalogue No 286-7; cIMeC 61531.01, 61522.04.
[797] Catalogue No 288; *CIL* 3.7613 (*ISM* 2.53); Suceveanu 1991, p.52; Bărbulescu 2001, p.46; Panaite 2010, p.375.
[798] Catalogue No 289-90; *ISM* 1.378; Poulter 1980, p.737; Bărbulescu 2001, p.47; Petculescu 2006, p.39.
[799] Catalogue No 291-2; cIMeC 62226.01, 62244.01; Bărbulescu 2001, p.51.
[800] Catalogue No 293; cIMeC 62208.02; *ISM* 2.134; *CIL* 3.7565 (*ISM* 2.191); Bărbulescu 2001, pp.51-2.

2nd century.[801] Suceveanu followed van Berchem for the *annona* being a Severan invention arising out of even earlier practice.[802] As I have already stated, I believe the *annona militaris* to have been a product of the Tetrarchy, but that communities within the region were required to supply the garrison by way of taxation and forced purchase is still quite credible.[803] The responsibility would have probably been devolved on to civic officials as is seen in Egypt.[804] The *annona militaris* did not come about all of a sudden and surely drew on earlier precedents. A similar precedent may be the inscription that reports the sites of *Chora Dagei* and *Laigos Pyrgos* which carries a complaint by the inhabitants of the former village about the *munera* that they have to perform for the *cursus publicus*, dated to AD 159, and those that the latter village had performed *c* AD 139.[805] Although in my argument the arable from these communities is directed to the *poleis*, this is an example of corvée labour where the military are the most obvious recipient. In Chapter Four I will consider the shipment of supplies from overseas and it may be that this inscription witnesses the movement of these towards the *limes* zone.

South of Histria's *regio* lay Tomis', modern Constanţa's, *chora*. Within this two settlements are reported at Navodari to the north of Lake Stiughiol.[806] On the lake at modern Ovidiu and Mamia-sat, Bărbulescu posits several other sites; there is certainly evidence of habitation from the stone-age here, yet cIMeC does not report Roman settlement here and Bărbulescu's reference material is unavailable so I exclude these.[807] Oltean's tumuli are again usable from this point south a significant cluster of the highest aggregation class is evident at Lumina, but the only

801 Suceveanu 1998, p.108, p.160.
802 van Berchem 1937.
803 Chapter Two, pp.115-16.
804 Chapter Two, p.109.
805 *ISM* 1.378; Stoian 1959, pp.369-90.
806 Catalogue No 294-5; cIMeC 60516.06, 60516.01.
807 Bărbulescu 2001, pp.49-50.

material on cIMeC is a Stone Age site so that these tumuli are not included. Other significant clusters exist in the Carotul and Ovidiu valleys, either side if the northern branch of the Black Sea canal. These may well be associated with the supposed *vicus Narcissiani* which is thought to be in the area of the nearby modern village of Poiana.[808] A Later Roman *quadriburgium* at Ovidiu, together with a water settling basin connected to an aqueduct feeding Tomis, are both excluded.[809] Another settlement with necropolis appears on cIMeC at Palazu Mare on the lake's southern shore.[810] Today this is a suburb of Constanţa but it is 7.5km from the site of the ancient *polis* of Tomis so that I treat it separately. Also in this area between Palazu Mare and the modern suburb of Constanţa-Anadalchioi, inscriptions were found that record a *vicus Sc[ap]ia* and the *vicus Turris Muca[poreos* or *traleos]* where there were *cives Romani et Lai consistentes*.[811] Here and elsewhere along the coast it would appear that settlement was encouraged maybe to support the *poleis*, maybe to provide additional support to the *limes*. Some 17 Roman period sites are recorded on cIMeC for Constanța; most of these I aggregate and allocate a single agricultural potential of 3000ha.[812] This is may be an under-estimate, but the subsequent urban development of Constanța makes it impossible to see the immediate agricultural hinterland. A site with necropolis to the north-west of the modern city at the Real 2 shopping centre is 5km distant from the ancient *polis*, significant numbers of tumuli are also evident in Oltean's data.[813] Although this might have been the site of one of the above mentioned *vici*, I cannot make a certain connection. The un-located *kome Apollonion* shows that there was still a continuity

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[808] Catalogue No 303; *ISM* 2.133; Suceveanu 1991, p.42; Bărbulescu 2001, pp.55-6.
[809] Tomas 2011, p.63.
[810] Catalogue No 296; cIMeC 60446.01.
[811] Catalogue No 297-8; *ISM* 2.137; *CIL* 3.7533 (*ISM* 2.141); Suceveanu 1991, p.42, 1998, p.124; Bărbulescu 2001, pp.48-9.
[812] Catalogue No 300.
[813] Catalogue No 299; cIMeC 60428.33, 60428.34.

of Greek culture close to the *polis* and is included.[814] Once outside of the urban sprawl of the modern city there is a regular spread of tumuli in a radial pattern up to 10km from the ancient city in large part concentrating along the known roads. These should probably be associated with the *polis* itself and the unlocated *vici* and *kome*. Bâltâc posits three *villae* close to Tomis on the basis of inscriptions: one refers to a veteran's *praedium*, the other two point to slaves and property but not necessarily an estate or even small farm; therefore I include the former as a small farm but not the latter two.[815] To the south of the *polis* other settlements are evident at Lazu and Agigea.[816] Significant clusters of tumuli exist between the two villages, these are undated on cIMeC. The exact location of a site at Cumpăna is not given, but aerial observation has identified field systems surrounding a fortlet attached to the stone rampart.[817] Isolated monetary finds at Bărăganu are not included.

To the west of the *polis* Roman period forts existed at Murfatlar [formerly Basarabi] and Porta Albă, which are associated with the Valu lui Traian.[818] The ramparts are reported in several sections around Murfatlar and the village of Valu lui Traian, but both the large earthen wall and the stone wall are given a Medieval date on cIMeC, that is no longer thought correct.[819] Civilian settlements are also evident at Murfatlar and Straja, probably associated with these ramparts.[820] A high density of tumuli exists around Lanurile with no obvious settlement site to associate this with on cIMeC.

Lake Techirghiol probably formed the boundary between the *chorai* of Tomis, modern Constanța, and Callatis, modern Mangalia; there are seven

[814] Catalogue No 302; Bărbulescu & Radulescu 1994, pp.168-9; Bărbulescu 2001, p.58.
[815] Catalogue No 301; *ISM* 2.180, 2.289, 2.292; Bâltâc 2010, p.439.
[816] Catalogue No 308-10; cIMeC 60589.01, 63269.01, 63269.03; Bărbulescu 2001, p.59.
[817] Catalogue No 311; cIMeC 61639.01; Bărbulescu 2001, p.58; Hanson & Oltean 2012, p.312.
[818] Catalogue No 304, 307; cIMeC 62770.02 62379.02.
[819] cIMeC 62379.06, 63134.02, 63134.05; Hanson & Oltean 2012, pp.297ff; Rankov 2015, pp.70-3.
[820] Catalogue No 305-6, 312; cIMeC 62379.05, 62379.04 61666.01; Bărbulescu 2001, pp.54-5.

settlements close to the lake, three to the north around Techirghiol, three more to the west of Tuzla on the southern shore of the lake, and one south of Eforie Sud; none is easily located.[821] Significant clusters of tumuli are evident around the lake and also exist moving inland at Biruința and Topraiser, the former do not appear on cIMeC, the latter are suggested as Iron Age, but some should surely be associated with Roman period settlement. The immediate vicinity of modern Mangalia is particularly rich in ancient sites, many of them showing continuity of occupation from before the Roman period well into Byzantine times. As reported in the Preliminary Section, several boundary markers point to the *chora* having been subject to extensive centuriation.[822] To the north of the *chora* a site at Cape Tuzla is associated with the *vicus Strationis*.[823] Costineşti is the site of the small Greek town of Parthenopolis; despite its name to accord it *polis* status is too much, and it looks to have been a Greek entrepôt and *emporion*; another distinct site lies to the south.[824] There are five sites on Lake Tătlăgeac at 23 August; the exact location of these is not always clear on cIMeC; additionally the *vicus Amlaidina* was probably also in the vicinity, although no single site can be linked to it.[825] Within a band of 6-7km width inland from the coast isolated and low aggregated groups of tumuli are widespread. To the west of Lake Tătlăgeac, there is an individual settlement south of Dulceşti; another two at Moşneni – one of which was a small farm – three more around Pecineaga one with attendant tumulus, and one at Arsa; two significant

[821] Catalogue No 313-9; cIMeC 60543.03, 60543.02, 60543.04, 60730.02, 60730.04, 60730.03, 60464.01; Hansen & Nielsen 2004, p.940; Bărbulescu 2001, pp.59-60.
[822] *CIL* 3.14214[33] (*ISM* 3.51-55); Suceveanu 1991, p.40; Bărbulescu 2001, pp.61-2; above, p.133.
[823] Catalogue No 320; Suceveanu 1991, p.42; Bărbulescu 2001, pp. 63-4.
[824] Catalogue No 321-2; cIMeC 60749.01, 60749.03; Suceveanu 1991, p.42; Bărbulescu 2001, p.64.
[825] Catalogue No 323-9; cIMeC 60605.06, 60605.05, 60605.04, 60605.01, 60605.03, 60605.02; Suceveanu 1977, p.94.

clusters of tumuli are evident between the latter two villages.[826] The *polis* of Callatis itself was initially in the 1st century BC a *civitas foederata* but it appears to have lost this status by the 2nd century when Roman troops were stationed there.[827] Despite this, the epigraphic record is predominantly Greek and the town looks to have still retained its *polis* ‘feel’ throughout.[828] Outside of the modern urban area a dense distribution of tumuli exist extending in a radial pattern; Oltean has previously observed how the tumuli align with the roads radiating from the *polis*.[829] Again I aggregate all the sites recorded here that appear to be close to the town centre and so are associated with the ancient *polis*.[830] Only one site recorded at Mangalia is 3.2km inland so that I record this separately.[831] To the south a site is reported at 2 Mai.[832] At Limanu, four settlements are reported to the north of the town; although exact locations are not given, they all seem to have been close to the estuary; another is reported at Hagieni.[833] Albeşti is a village with a great deal of settlement activity from the La Tene and Hellenistic periods: two Roman sites, one of them a small farm to the south of the village, are reported.[834] Roman period tumuli are reported on cIMeC at Vârtop independent of any other settlement, but only a few isolated barrows appear from remote sensing.[835] Further west a site is

[826] Catalogue No 330-6; cIMeC 60614.02, 60623.02, 60623.01, 62681.03, 62681.04, 62681.01, 60963.02; Suceveanu 1977, p.56, p.94; Irimia 1987, p.109, p.135; Suceveanu 1991, p.41; Bărbulescu 2001, pp.65-6.

[827] *ISM* 3.1, pages 215-23; Suceveanu 1991, pp.39-40; Bărbulescu 2001, p.61; Petculescu 2006, pp.36-7

[828] *cf ISM* Vol 3.

[829] Oltean 2013a, pp.214-15.

[830] Catalogue No 337; cIMeC 60491.03, 60491.05, 60491.10, 60491.13, 60491.16, 60491.20, 60491.27, 60491.30.

[831] Catalogue No 338; cIMeC 60491.32.

[832] Catalogue No 339; cIMeC 60699.01; Suceveanu 1977, p.56; Bărbulescu 2001, p.65.

[833] Catalogue No 340-4; cIMeC 60641.07, 60641.05, 60641.04, 60641.06, 60650.04; Suceveanu 1977, p.56; Bărbulescu 2001, p.66; it is not clear if that at Hagieni is the large site reported by Oltean & Hanson 2007, pp.84-5.

[834] Catalogue No 345-6; cIMeC 60954.04, 60954.07; Suceveanu 1977, p.56; Bărbulescu 2001, p.66.

[835] Catalogue No 347; cIMeC 60990.01.

known at Cotu Văii.[836] This is as far west as I go to include sites as *polis* facing. Back on the Black Sea shore the most southerly site that benefits from being recorded on cIMeC is at Vama Veche significant clusters of tumuli are seen here; further south one crosses out of the study area into modern Bulgaria.[837] Of course, agricultural activity would have gone on beyond the modern frontier, and this is evidenced by a territorial marker found 25km to the south at Tvarditsa.[838] A brief inspection of the new publication of *TIR* for Bulgaria suggested a further 30 *vici* type sites within 32km of Mangalia. However, the criteria by which the term *vicus* is applied has not been followed up, nor are any lesser sites reported, so that no sites outside of Romania are included. However, there are also another seven *komai* epigraphically attested on the southern part of the Black Sea littoral: none has been positively located and some may align with those sites that I have already included from cIMeC, although others may have been across the modern national frontier. Nevertheless I include the *komai Ke…., Val……, Asbolodina, Sardes, …..myle, P……, and pyrgos ……*, within the Catalogue.[839] Certainly the areas where high tumuli density and especially high aggregation levels have been seen around Lanurile, Topraiser and Biruința, must surely be contenders for the sites of these ancient villages, as well as the immediate environs of Tomis and Callatis.

3.3.7 Are the Black Sea *poleis'* needs met?

Within that region that I have suggested as supplying the *poleis*, beyond the three *poleis* commanding nominally 3000ha each, there were 27 *vici* or *komai*, five small farms and 82 individual sites reported, and this would result in a total

[836] Catalogue No 348; cIMeC 60981.01.
[837] Catalogue No 349; cIMeC 60678.01.
[838] *CIL* 3.7587 (*ISM* 3.241); Suceveanu 1977, p.56; Bărbulescu 2001, p.63.
[839] Catalogue No 350-6; *ISM* 3.51-53, 3.55; Suceveanu 1991, p.41; c & Sarnowski http://www2.rgzm.de/Transformation/Bulgaria/Vici/VICI_BG2.html accessed 03/12/2011.

agricultural potential of 36,356ha. Again the tumuli data was considered as an alternative for the cIMeC data in the south. At the mid-range set of values for each aggregation level, two figures for arable potential were arrived at: one with the lower dating correction that was only two thirds as much as was available from the cIMeC sites, the other at the higher dating correction, produced a very similar figure to that achieved with the cIMeC material. With no real preference for one dating correction over the other it was thought better to continue to quantify with just the cIMeC data. The suggested 30,000 inhabitants would have required 32,213ha for themselves, assuming 500 of the inhabitants at each *polis* were farmers, so that their needs are already included; still another 5411ha would have been required for another 5039 farmers in the countryside, thus a total need of 37,624ha is arrived at. If dependants of the farm workers are brought into the calculations, and here many may have been domiciled within the *poleis* themselves, then the needs are calculated as only marginally higher at 39,581ha Tables T.3.3.2a-b refer. Therefore 92-97% of the needs of the *poleis* can be argued to have been met. However, one should not read too much into this because these figures were arrived at with two significant unknowns, namely the actual population, and so real needs of the *poleis* communities, and also the number of agricultural workers resident within the town. The estimates used 10,000 and 500 respectively, are quite plausible, but unsubstantiated. Were the populations higher, for instance the 50,000 that Suceveanu suggested, and still with 500 farm labourers domiciled within the town, then only 54-57% of the needs would have been met. This highlights the problems of this sort of calculation: one really needs some certain producer or consumer numbers such as the diplomas for the garrison strength to step off from. If I were seeking to solve the needs of the *poleis* not the *limes* this would be an insurmountable problem. However, it still does bring into question my *limes* solutions because were the populations higher, and so a deficit present, then the solution ought to have come in the first instance from Dobrogea. It certainly would not have been in the Romans' interests to denude the supply to the *poleis* to advantage the *limes*, since this would have only fostered resentment, of which nothing is heard. By the same token, were there 10,000ha available, as will be seen at Chersonesus and Panticapaeum, then that would provide sufficient land for 9313 inhabitants, potentially the whole population of a *polis*.[840] I must however, contest the suggestion made by Suceveanu that each *polis* controlled 30-50,000ha in their *chora* and this resulted in an export market, because there is no evidence to suggest this quantity of arable activity or export market.[841]

3.3.8 Site distribution in Dobrogea

Although the sample set is small, 326 producer sites over an area of 11,000km^2, point density analysis was carried out that chiefly corroborated what was seen by eye. The highest density of settlement was seen in northern Dobrogea, south east of Isaccea [Noviodunum] from Niculițel along the Telița river valley; how much this is due to survey is questionable, and certainly Niculițel added greatly to the count. Other areas of significantly higher settlement density were to the west of Istria [Histria] around Tariverde and to the north of Mangalia [Callatis] around Lake Tătlăgeac. In the southern part of Dobrogea, the distribution of the tumuli was densest along the Black Sea coast north of Mangalia [Callatis] towards Tuzla, and also around the village of Lanurile. These latter areas were within the *chorai* of well-established *poleis*, so we might expect a similar density close to Constanța

[840] Chapter Four, pp.271-3.
[841] Suceveanu 1977, p.87, p.95.

[Tomis] were it not for the modern urbanization in the immediate vicinity. The most consistent area of slightly increased density ran all along the Black Sea shore, so proximity to the sea was certainly an attraction to settlement, although the continuity of occupation from previous periods in this area was no different from the wider Dobrogea. I would have expected it to be higher.

To the west of the *poleis*, settlement is generally close to the road network, which will be discussed further in Chapter Four. The rural *vici* in particular seem to concentrate on the north-south highway, supporting Poulter's long-standing idea that the *vici* came into existence in support of the *limes*.[842] More striking are the areas of lowest settlement activity in the centre-west and the north-west between the *limes* themselves and the north-south highway. It has already been observed that the presence of a legionary garrison and auxiliary units at Turcoaia [Troesmis], Măcin [Arrubium] and Garvăn [Dinogetia] are seemingly without an agricultural hinterland. Similarly, in the 20km east of the *limes* between Cernovodă [Axiopolis] and Capidava [Capidava] and also east of Hârşova [Carsium] there is little agricultural activity reported; this observation would be improved by the reports of 11 sites in the Siliştea valley that Bărbulescu cites but cIMeC does not report.[843] Following the cIMeC material in the south-east there is little settlement activity in a 20km band between Adamclisi [Tropaeum Traiani] and the *chorai* of the Black Sea *poleis*. Indeed, this absence of settlement made my division between *limes* and *poleis* facing zones more easily decided upon in this region but this absence of settlement is not obvious once the tumuli are considered. I have already reported a 'broad central band of increased tumuli buffer density' of 7-13km width north to south, running north-west towards Adamclisi [Tropaeum Traiani] and beyond to the

[842] Poulter 1980, pp.729-44.
[843] Above, p.192.

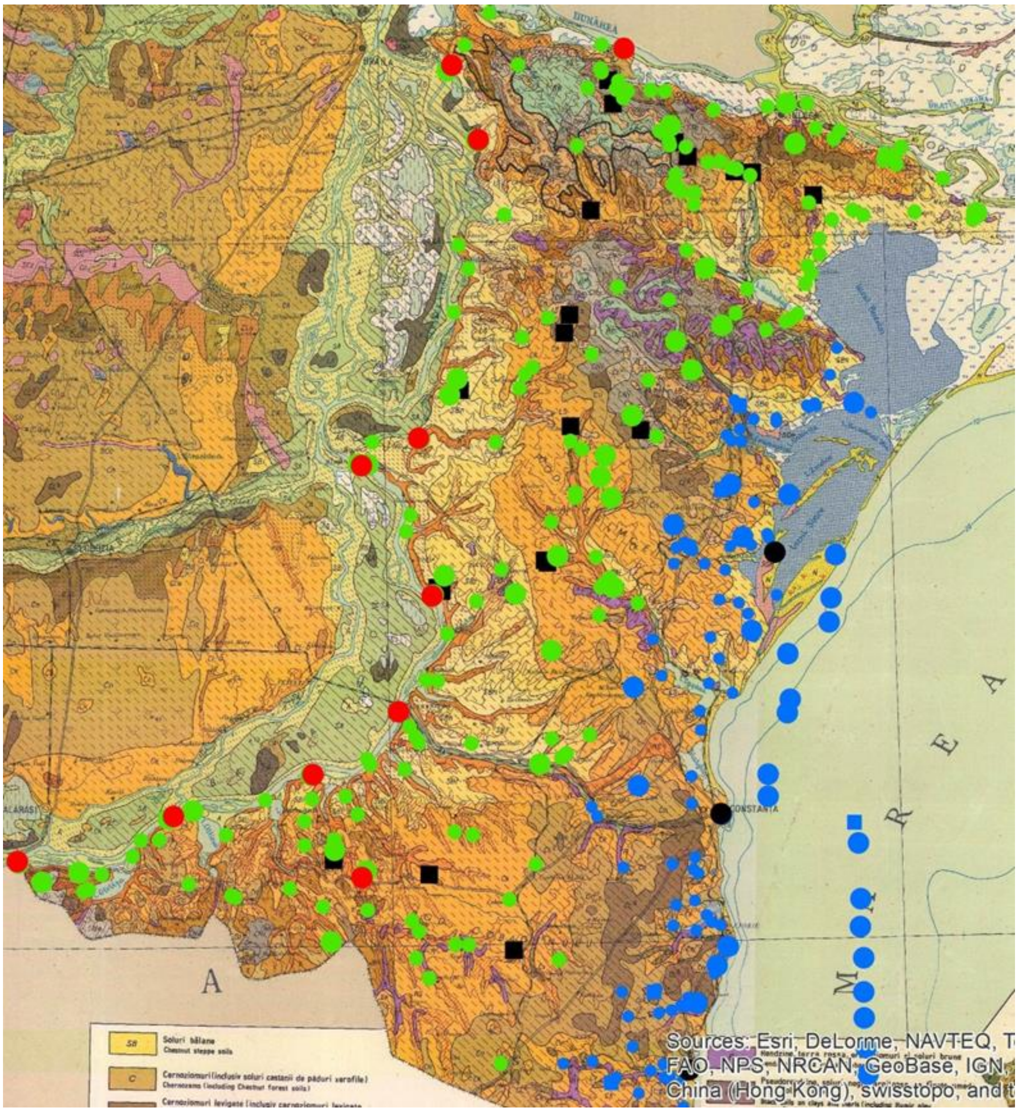
Lakes Bugeac, Oltina and Dunăreni as far the Danube and Silistra [Durostorum]. This band of increased tumuli buffer density can be seen to have originated from the Black Sea shore around Tuzla running inland, to Topraiser and through the area devoid of settlement according to cIMeC towards modern Independenţa and Fântâna Mare before turning to Adamclissi.

When the soil map is considered, chernozems – black soils with a high percentage of humus and so both phosphorous and ammonia making them good for agriculture - cover 51% of Dobrogea.[844] The remainder includes, unsurprisingly, alluvial soils along the Danube, and rhegosols, another alluvial soil type that follow the lesser river tracts; these latter are often young soils and may not have been present in antiquity. There are also pockets of rendzinas which are shallow soils formed over calcareous rocks along the river valleys; these are not normally associated with high agricultural output. Chestnut soils, which are normally associated with arid regions and do not attract high agricultural yields, cover another 22% of the region, especially in the west.[845] In the south-west of the study region there are pockets of forest chestnut soils, as their name implies a product of woodland. Because of the uncertainty with which many sites are positioned, only 242 of the 357 sites could be allocated to a particular soil type, and Chi-squared testing confirmed what is readily apparent, in that the distribution of sites was not normal against soil type; Table T.3.3.3 gives the results. I would have expected a higher number of sites on both the calcareous chernozem and chernozem soils than was seen. A higher distribution was seen on the alluvial soils along the Danube and, although statistically unexpected, this is quite understandable: the count

[844] Mayhew 2009, p.75.
[845] Mayhew 2009, p.75.

includes the 31 military sites located on the *limes* zone itself, and these together with their military *vici* were positioned according to the military imperative rather

Fig 3.3.8.1 Soil map of Dobrogea[846]



Green dots *limes* providing, blue dots *poleis* providing sites

than the fecundity of the soil. The other soil types demonstrating statistically higher than expected settlement activity are the typical chestnut soils and the rhegosols.

[846] Florea *et al* 1971.

Chestnut soils are not good soils for agricultural activity, but the highest number of sites on this soil type is in the north-east of Dobrogea alongside Lake Razim, where settlement is thought to have been as much encouraged by the natural maritime benefits of sheltered sea water, and so trade and fishing, as by any other factor. The higher proportion of sites on rhegosols presents the most interesting deviation from the statistical expectation, in that these are generally weak soils, so that settlement activity here is probably as a result of some other factor than the soil type, the most obvious being the presence of fresh water to irrigate the fields.

The area of densest settlement activity from the point density analysis was seen to be along the Teliţa river valley from Niculițel to Cataloi; here both good chernozems and less fertile forest chestnut soils are present, so that soil does not seem to have been a deciding factor. The area of lowest settlement activity in the north-west is marked by a large mass of brown lessive soil, often associated with woodland which does cover the region today, and this, together with marshland, may have been the case in antiquity also. The absence of settlement to the east and south-east of Turcoaia [Troesmis], and to the east of Hârşova [Carsium], Capidava [Capidava] and Cernovodă [Axiopolis] is not explained by the soil type: here chernozems and chestnut soils abound, and the first is good for arable while the second at least managed to support agricultural activity in other parts of ancient Dobrogea. The *vici* which are known from the centre of the region around Pantelimon, Râmiciu de Jos, Casimcea, Sarighiol de Deal and Neatârnarea, were all on good chernozem soils, so this might have impacted on the choice of these as settlements, especially if agricultural settlement predated the Roman arrival. The presence of the north-south highway running through Dobrogea was also surely a factor, but whether this came before or after the *vici* is probably a question that cannot be resolved.

The distribution of tumuli was also considered against a soil map, although it is known that not all soils show crop marks equally.[847] Chernozems dominate southern Dobrogea to a far greater degree than the wider region; 72% is covered in a variant good-quality chernozem. A Chi-Squared test of just the tumuli data again showed that the distribution was not normal: the results are at Table T.3.3.4. Examining those soil types where the density of tumuli was higher or lower than statistically expected, again factors other than soil could also be suggested for the distribution. Firstly, slightly leached chernozems attract a higher than average density over a sizable 7% of the south, which seems to indicate a preference for this soil type in antiquity. Secondly, compacted and leached chernozems, although not good soils for agriculture, also showed higher than statistically expected tumuli distribution. In both cases these soils are in the east, rarely more than 20km from the coast and the *poleis*, so that access to the coast for seafaring or commercial activity must have also been factors. With regard to those areas of lower than statistically expected tumuli buffer density, typical chestnuts, forest chestnuts, rhegosols and alluvial soils are all poor agricultural soils and so low settlement activity here in the south would be expected. Similarly forest chestnut soils, as their name implies, normally underlie woodland and so do not lend themselves to agriculture. When the soil map was compared to a Corine land cover map of modern woodland there was broad correlation, also visible on Google Earth.[848] Thus in general terms a similar amount of land is forested today as was forested in the past, approximately 5% of the south of the region. However, the presence of

[847] Oltean & Hanson 2007, pp.73ff.
[848] Corine Land Cover 2006 accessed via ArcGIS.

many tumuli buffers within the areas of forest chestnut soils precluded removing this percentage from the total available land in antiquity. Unsurprisingly, tumuli rarely appear in those areas that are actually still wooded today. The 'broad central band of increased tumuli density' was seemingly indifferent to soil type, crossing moderately leached and calcareous chernozems but also rendzinas and rhegosols, in no apparent pattern, so that a factor other than soil type was thought more likely to have attracted settlement in this area.

The higher than expected density on rhegosols drew attention to the presence of fresh water as a factor to settlement. Although it is obvious that the presence of water would have been a pre-requisite to settlement, when a 1km buffer was produced around the more significant water tracts of Dobrogea, then 45% of sites were within 1km of an inland river, and a further 13% lay within 1km of the Danube itself. This is not only reasonable but has been observed previously with settlement activity between Novae and Nicopolis.[849] It has already been reported that the 'broad central band of increased tumuli buffer density' followed the course of the now seasonal Urluia river valley including the Plopeni, Negreşti-Conacu lakes. When the number of tumuli-buffers was counted within 1, 2 and 4km of the valley, there were higher percentages of sites against the percentage of total land area, most markedly within 2km of the water's edge. The attraction of fresh water is more obvious with the tumuli than across wider Dobrogea. Much of this river valley system is flanked by the rhegosol soils that I have already reported as not attracting high tumuli buffer density so that these observations appear at first contradictory. This is explained by the rhegosols not penetrating far beyond 500m of the water's edge, while many of the tumuli buffers are within the area between

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[849] Above, p.152; Tomas 2011, p.61 reports how this was normal in rural Moesia.

500m and 2km of the river bank. Therefore, although close to this river system, settlement activity was generally not so close as to be on the poorest soils or possibly to be the subject of seasonal flooding. It is notable today that there is evidence of previous irrigation, with covered watercourses obvious from Google earth to the north of Urluia river valley and irrigation canals, alongside the Black Sea canal that follows the Carasu valley. Yet much of the irrigation evident was only a product of the Communist era, when *c* 572,000ha, 52% of the dry land area of Dobrogea, was subject to irrigation schemes.[850] In many of these systems, including those in the Carusu valley, the water transport canals were not lined and losses were significant, the operating costs both in initial outlay and power to pump the water were also huge.[851] Most of the systems subsequently fell out of use in the 1990s.[852] There is no clear evidence of Roman irrigation systems, the earliest recorded system in Romania is Medieval; although proximity to water must have been attractive for farming, whether or how the fields were systemically irrigated is uncertain.[853] Nonetheless, the availability of fresh water seems to have overridden soil type and looks to have been the most significant factor in settlement activity.

Dobrogea is low lying and without great variation, most is below 200m. Using a Digital Elevation Model, the average altitude of all those sites that could be located was 54m; the highest point was at 274m. Therefore, altitude was unlikely to impact on agricultural activity. There was not however a digital map of the slope available so that it was not possible to consider whether either slope or aspect had an effect on settlement activity.

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[850] Anyoji *et al* 1996, p.126-7, p.128; Sima 2012, p.87-8 Fig 1 shows the extent of irrigated land ; Lup & Miron 2013 Table 2, 2015, p.203-4.
[851] Lup & Miron 2013, 2015, p.205.
[852] Anyoji *et al* 1996, p.128; Lup & Miron 2013.
[853] Sima 2012, p.86.

Conclusions to Chapter Three

Certain assumptions have had to be made to simplify the calculations above. Firstly, all settlement activity seen was assumed to have produced a surplus. This viewpoint can be defended because the upper levels of settlement activity survive best in the archaeological record. The evidence of the tumuli has made it clear that I am seeing only a fraction of the agricultural landscape of antiquity. I could therefore have multiplied what is seen by a survival factor to arrive at a higher figure for agricultural activity. Without dating evidence for the tumuli, I could not be sure how many ought to be dated to the mid-2nd century, but neither could I decide by what factor they could justifiably be corrected. The application of landholdings by aggregate class offered an alternative means to assess arable potential, but too wide a range of possibilities was arrived at to take the results far. I preferred to stick with what was actually recorded. Yet even then, although there would have been a wide range in the size of farm-holdings, depending on the wealth of the owners and the number of productive workers, the categories of sites and the figures attached to them which I did use are artificial, being derived from an assessment of the few excavated sites in the study regions. Variability in previous survey also impacted on the security of the argument. Conrad's level of detail allowed for the most accurate assessment of potential. Beyond his material, it became obvious from cataloguing the sites in Dobrogea how little information there is pertaining to rural settlement size. The inconsistencies with which material is added to cIMeC also question the accuracy which I can claim for the argument; the resource provided a wonderful opportunity to survey the wider landscape, but its changing nature and lack of controls may limit how much further it can be used.

Nevertheless, despite all these limitations in several scenarios, a sizable part of the garrison's needs were seen to be met. In the first instance at Novae a successful supposition was proffered: when Conrad's settlement activity was added to Poulter's survey material, even adjusting the latter so that approximately half of his reported *villae*/small farms were only counted as individual sites, it was still possible to solve the total arable needs of garrison, the service providers and their farmers, with a 68% surplus. Even after dependants of farm labourers are factored into the calculations an 18% surplus is seen. In Dobrogea it is possible to see 76% of the arable needs of the garrison, the service providers and their necessary farm workers, and 53% when the farm workers' dependants are included. The resulting net shortfall in needs will be addressed through the possibility of long-distance supply in Chapter Four. Additionally the calculations at Tables T.3.2.1b and T.3.3.1b which consider dependants result in overall population estimates of the correct magnitude. In the case of Dobrogea they are very close to the rough estimate derived from eight persons per km^2.

In Dobrogea despite all of the food needs of the garrison not being met, it is still felt that the division between *limes* providing and *poleis* providing zones, although very probably not working in such a simple manner in antiquity, does provide a model of how garrison and *poleis* might have been fed. It was also possible to find 92-97% of the *poleis* needs. This last finding was done with rather shaky data and ought not to be considered secure. Although it was never the intention to solve the needs of the civilian population in the wider countryside, it was necessary to consider at least the needs of the *poleis* because the supply of the garrison cannot have happened in isolation. If my assessment of meeting the *poleis* needs is overly optimistic, that would impact on the quantity of land available to the *limes* and so increase the deficit and so the size of the overseas solution that would have been required. When one considers the location of Novae especially, and the problems of transport it becomes clear that local supply sources ought to have been preferred. And indeed this is what is seen in the levels of settlement activity which suggest a predominantly local solution, very definitely at Novae and mostly in Dobrogea,

Although the inability to securely date the tumuli meant that any arable potential allocated to them was purely speculative, nevertheless settlement activity could be deduced from them. The levels of aggregation seen should be considered as a tool for identifying larger settlement sites. Certainly the highest clusters of tumuli ought to be contenders for the un-located but epigraphically attested *vici* and *komai*: in particular in the east around Lanurile, Topraiser and Biruința. The tumuli buffers in the vicinity of the *civitas Ausdecensium* might be indicative of the *civitas* centre being further east that the findspot of the boundary marker that proves its existence. While point density analysis of the tumuli offered alternative settlement patterns to those seen on cIMeC, in particular the 'broad central band of increased tumuli density' running through the Urluia river valleys. Here and across wider Dobrogea and along the Rositsa river valley west of Nicopolis the presence of fresh water can be seen to have been a significant factor to attracting settlement for both human consumption and maybe for irrigation. Soil type was seen not to be a dominant factor for settlement.

The different opinions of Poulter and Suceveanu as to agricultural activity in the region ought not to be contradictory. Certainly, the arrival of a Roman garrison in a strategic edge of the empire looks to have significantly altered the lifestyle of the native population. Yet there was an arable agricultural culture existing prior to

Rome's arrival, evidenced both by cIMeC and surely suggested by the tumuli, which may have failed to reach its full potential because of the threat from beyond the Danube. The arrival of the Romans secured the frontier and seemingly allowed the native culture to expand, to truly flourish. Within this the Romans appear to have established *vici* communities, sometimes using the indigenous populations, at other times Roman veterans and even some forced, or at least encouraged, migrations in the persons of the Bessi and Lai, all of which resulted in a compact agricultural hinterland that could have met the needs of the military.

Admittedly, this Chapter has piled supposition upon supposition, but it is only supposed to be a possible solution; it is a model and any model can be adjusted, in particular, the relationship between garrison and *poleis*; it would be relatively straightforward to take those sites catalogued and shift them east or west so as to be included within the supply zones of either *limes* or *poleis*. The model suggested so far is best described as interim; it is unsatisfactory, but a long-distance solution to some of the garrison's needs may have gone a long way to mitigating the shortfall. The movement of both local and long-distance supplies will be investigated further in Chapter Four.

Chapter Four Transport Requirements

Introduction

I have proposed thus far that the Lower Moesian garrison was mostly supplied with food from the province itself. I have demonstrated that only a small part of the overall land area of the province would have been required to feed the garrison, and in two areas I have offered arable solutions to meet the logistical need. In this Chapter I will consider how food was moved to the garrison, and carry out a quantification of the logistical burden that the garrison brought with it. By adapting von Thünen's central place theory to the *limes*, which can be thought of as a linear central place, I would expect there to have been areas of different agricultural activity at intervals from the *limes* itself. The paucity of archaeological evidence does not allow me to posit the extent of such areas, and even my self-imposed *limes*- and *poleis*-providing zones within Dobrogea are speculative. However, I am able to see arable activity decreasing with distance from the garrison forts, which accords with the general idea of von Thünen. To calculate the logistical burden, a consideration of the capacity and speeds of ancient wagons and pack-animals is first necessary in the Preliminary Section of this Chapter. Then, in Section Two, radii about consumption centres are considered but these assume straight line travel and do not take the road network into account. Therefore, the concept of Service Areas, a term used in the modern logistics and delivery world that looks for travelling distances from distribution centres according to the layout of a network, is applied to the ancient road network as far as it is understood. This is done within ArcGIS to produce visual representations of travelling times which could be interrogated to count how many ancient sites were within one, two, or more days of a consumption centre, in my case the *limes* forts. Then it is possible to apportion the arable activity seen to the garrisons that it would have been best placed to feed. These calculations will also measure the impact of providing animal feed on the availability of arable. Because I have not identified all of the arable necessary to feed the garrison in Dobrogea the effect of providing long-distance supplies to meet this deficit will be considered. Such provisioning came with a need to provide further feed-barley to move it and this will be seen to have had an increasingly significant impact on the availability of local arable. I also briefly consider the scale of ancient shipping required to provide the deficit, including a preliminary assessment of the size of ancient ships. The suggestions made are only one set of possibilities, but the models proposed ought to show efficient methods which, although calculated with a computer tool, ought to reflect a plausible reality. From these I calculate probable numbers of wagons or mules that would have been required *pa*. In all the suggested solutions this is a surprisingly low number. For the single garrison at Novae only *c* 109-133 oxen-drawn wagons, 101 mule-drawn wagons, and as few as 58 mule-trains might have supplied the fortress. For nominally 12,827 troops in Dobrogea, a range of 191-233 oxen-drawn wagons, 148 mule-drawn wagons and only 94 mule-trains are suggested as having been necessary for the local part of the solution. Even when an overseas component was considered the overall requirements in terms of vehicles are still thought low: 260-537 oxen-drawn wagons, 221-380 mule-drawn wagons, and 133-199 mule-trains would have sufficed.

Chapter Four, Section One: Preliminaries, transport methods

4.1.1 Road network

With regard to the ancient road network away from Dobrogea, only the major highways are well accepted, yet if my basic premise of the supply solution being local is correct, then these will only be relevant to long-distance supply. It is to be noted that some of the milestone evidence is from the period of the Tetrarchy or later; such evidence is however admissible with caution, because road building in the Later Roman period would have been best served by repairing the existing network rather than building from scratch. Dr Panaite is the chief researcher into Roman roads in the region and hers is the preferred modern work.[854] As far as describing the routes, where an ancient name is known this is used below with the modern name in brackets; this is in contrast to the survey of Chapter Three, because I am dealing with ancient destinations.

The major Balkan highway ran from Singidunum [Belgrade] in Upper Moesia to Serdica [Sofia] in Thrace, and then followed the modern Maritsa river valley to the south-east, through Philippopolis [Plodiv] to Hadrianopolis [Edirne], continuing to the Aegean coast at Traianopolis [Alexandroupoli]. Northwest from Serdica, Montana was connected by a road through the Petrohan pass.[855] Tentative routes from Montana to the Danube at Augustae [Harlets], Almus [Lom] and Ratiaria [Archar] are suggested. Also running north from Serdica across the Haemus another route followed the course of the Oescus [Iskar] river to Oescus.[856] Away from the *limes* zone, Serdica was connected to the Aegean via the Struma and

[854] Panaite 2006, 2010, 2011, 2012, 2015.
[855] Gerov 1988, p.102 fn92; Wilkes 2005, p.148 writes that there is no proof of a road between Serdica and Montana, but draws one in Talbert's Atlas 2000 none the less.
[856] Wilkes 2005, p.148; Panaite 2015, p.596.

Strymon valleys to Amphipolis [Amphipolis] and via the Axiois river valley to Thessalonica [Thessalonica].[857] As well as those routes leaving Serdica, three other roads crossed the Haemus from the major Balkan highway. One ran from Philippopolis [Plodiv] through the Traian pass to Melta [Lovech] and on to Oescus via a road station-cum-*vicus* at Ad Putea [Pleven].[858] Another route ran from Augusta Traiani by the Shipkla pass and the *emporium Discoduraterae*, another still from Hadrianopolis, Cybele and by the Vratnik pass, both arriving at Nicopolis; thereafter two significant routes ran on to Novae.[859]

Once the garrison was established on the *limes*, a road was also put in place alongside the Danube.[860] Another major route ran east to west across the plain to the south of the Danube from Odessus [Varna], west by Marcianopolis [Devnya], close to modern Shumen, Nicopolis, Melta and finally onto Montana, intersecting with those routes crossing the Haemus already reported.[861] A branch ran north-west from Shumen to Sexaginta Prista [Ruse] via Abritus [Razgrad].[862] From Marcianopolis a road ran to Durostorum; the only reported station upon it was Palmatis recently associated with an unexcavated site near the modern village of Onogur close to modern Tervel in Dobrich province.[863] Fig 4.1.1.1 below illustrates.

Focusing on those routes around my first study region between Nicopolis and Novae, see Fig 4.1.1.2 below, there was seemingly no direct route between the

[857] Wilkes 2005, p.148, pp.191-2.
[858] Gerov 1988, p.100; Wilkes 2005, p.148, p.192; Panaite 2006, p.60, 2015, p.596.
[859] Wilkes 2005, p.148, p.192; Panaite 2015, p.596.
[860] *IA* 220-226; Panaite 2006, p.59; 2012, pp.132-4; 2015, p.593.
[861] Ivanov 2012e, p.163; Panaite 2012, p.135, 2015, p.596.
[862] Panaite 2015, p.596; n.b. Abritus [Razgrad] is not to be confused with Zaldapa [Abrit] further east.
[863] Torbatov 2000, p.69; Ivanov 2012b, p.52; Panaite 2015, p.598.

Fig 4.1.1.1: Road Network: The wider region

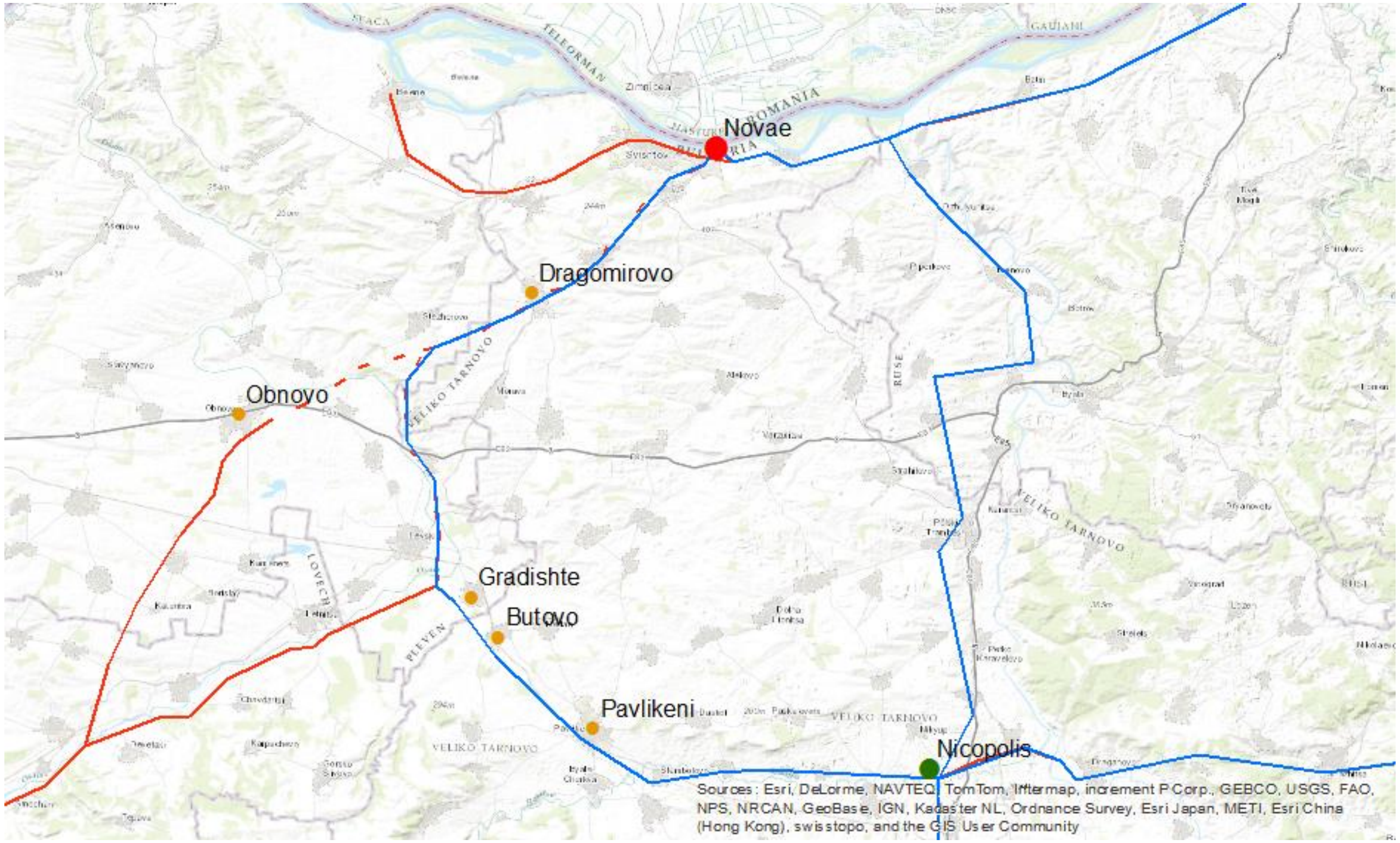

Fig 4.1.1.2: Roads: Novae-Nicopolis

two according to Panaite's research; although Wilkes does draw one in Talbert's atlas, I follow Panaite.[864] One significant, albeit circuitous route, travelled north from Nicopolis following the Yantra river valley to the *limes* road and then west to Novae, an approximately 70km journey.[865] Another road departed Nicopolis west along the Rositsa river moving north-west around Pavlikeni and past Butovo and Gradishte, before turning south-west towards Melta [Lovech] along the Osam river valley.[866] This was joined at some point by a road travelling from Novae via the villages of Dragomirovo and Obnova towards Melta, although the exact route is unclear. Gradishte and Obnova are 17km apart, and it is sensible to infer a route along the Osam river valley north to connect these two roads. However, that still presents only two routes between the two towns, neither of which was very direct, and this requires some explanation. Most plausibly, roads were maybe not always necessary across the dry, at least in summer, flat landscape, the farmers being able to travel according to the natural topography by the most direct route. If this were the case, well-worn pathways would be evident through aerial survey; indeed where such survey has been carried out in southern Dobrogea, very many linear features are obvious.[867] Thus, it is probably the absence of aerial survey that limits our knowledge of the road network here above all else.

Increased excavation and publication of sites in Dobrogea leads to far more information but inevitably some differences of opinion as to the lie of the road network. Here the *limes* road already mentioned continued into Dobrogea and a rich collection of milestones proves the road ran past Rasova, Axiopolis, Capidava,

[864] Talbert 2000; Panaite, pers comm.
[865] Ivanov 2012d, p.113; Panaite 2015, p.598.
[866] Panaite 2015, p.596.
[867] Oltean 2013a, p.210.

Carsium, Arrubium and Dinogetia.[868] A coastal road is attested epigraphically and evident in part through aerial photography from the Danube estuary, all the way from Halmyris via Vallis Domitiana, Enisala, ad Salices, Argamum, past Mihai Viteazu and Sinoe – the *vici Buteridavensis* and *Quintiones*, Histria, Vadu – the *vicus Celeris*, Corbu – the probable *Tres Protomae*; after which the road turned inland towards Mihail Kogălniceanu – the site of the *vicus Clementiani*, before turning south again thus skirting the modern Lake Tasual, Constanța-Anadalchioi the site of the *vici Scapia* and *Turris Muca*…. and then on to Tomis, Callatis and beyond to Odessus, Mesambria and Deultum.[869] Another major route, hereafter termed the north-south highway, ran through the centre of the region. This probably originated close to Palmatis on the Marcianopolis-Durostorum road.[870] It passed through Zaldapa [modern Abrit] on the grounds of a Hadrianic milestone, Cetatea within the territory of the *civitas Ausdecensium*, and modern Zorile before it arrived at Tropaeum Traiani.[871] North of here it ran via the *vici Urb*… [Medgidia], *H*…. [Dorobantu], *Ulmetum* [Pantelimon] and Ibida [Slava Rusa] to Noviodunum.[872] I have followed Bărbulescu & Câteia who put the *vicus Urb…* at Medgidia rather than Ramniciu de Jos as Wilkes suggested.[873] When the locations of the *vici* discussed in Chapter Three are remembered, the unnamed *vicus* at Galbiori, the *vici V…., Secundini* and *….stro* which are assumed in the area between

[868] Rasova *CIL* 3.13755 (*IGLR* 190); Axiopolis *CIL* 3.7602; Capidava: *ISM* 5.9; Carsium: *CIL* 3.7603-8 (*ISM* 5.95-100, *CIL* 7609 (*IGLR* 232); Arrubium: *CIL* 3.7610; Bărbulescu & Câteia 1997, p.193, 1998, p.119, p.122; Bărbulescu *et al* 2008, pp.173-7; Panaite 2011, p.147; 2012, pp.132-4.
[869] Mihai Viteazu: *CIL* 3.14463; Sinoe: *CIL* 3.12515 (*ISM* 1.322); Histria *CIL* 3.12513-12514, (*ISM* 317-318); Corbu: *CIL* 3.7614 (*IGLR* 82), *CIL* 3.14462 (*ISM* 1.321); Tomis *CIL* 3.7613 (*ISM* 2.53) *CIL* 3.12517 (*ISM* 2.109); Callatis *CIL* 3.7616 (*ISM* 3.195); *ISM* 3.195-9; Bărbulescu & Câteia 1997, pp.193-6; 1998, pp.121-6 fn57; Bărbulescu 2001, p.36, pp.64-5 fn360-2; Bărbulescu *et al* 2008, pp.169-70; Wilkes 2005, p.127 p.193; Panaite 2010, p.376, 2011, p.147, 2012, pp.132-5.
[870] Torbatov 2000, p.70.
[871] Abrit: *CIL* 3.14464; Bărbulescu & Câteia 1997, p.195; Panaite 2006, p.59, p.65, pp.68-9; 2011, p.147; 2012, pp.132-4, 2015, p.596.
[872] Dorobantu *CIL* 3.12516 (*ISM* 5.5); Ibida: *CIL* 3.7612 (*ISM* 5.223); Suceveanu 1991, p.291; Bărbulescu & Câteia 1997, p.195, 1998, p.121; Panaite 2011, p.147.
[873] Bărbulescu & Câteia 1997, p.196 *contra* Wilkes 2005, p.194.

Ramnicu de Jos and Casimacea, another unnamed *vicus* close to Neatârnarea, and the *vicus Petra* at Camena all look to have been close to this road.[874]

Oltean's aerial survey of Southern Dobrogea added a great number of possible routes to the previously published opinions, the more significant of which I shall include.[875] A road ran from Callatis [Mangalia], via modern Arsa, Plopeni, close to Petrosani, to Tropaeum Traiani [Adamclisi].[876] At Plopeni this intersected with a road running from Tomis via modern Miristea to Zaldapa [modern Abrit]; the intersection is clearly visible in Oltean's images 4km to the south-west of Plopeni. Two routes are visible in this area on Oltean's images that are not reported by others: one runs north of Petrosani skirting Tropaeum Traiani by 5km to the south near Şipotele and continues west towards Durostorum [Silistra]. The second ran for 10km between Tropaeum Traiani [Adamclisi] and modern Cobadin; to the east of here it can plausibly be associated with a route radiating from Tomis. Oltean also identified two forts on this route; these do not appear in my catalogue, not being on cIMeC, but they and other inland forts on the road network suggests way-stations between the Black Sea ports and the *limes*. To the west of Tropaeum Traiani, as well as the route just mentioned that skirts south of the town, another is thought to have travelled via modern Urluia, the site of an unnamed *kome* and modern Ion Corvin, before moving west; Oltean's images show 20km of a route south of Lake Oltina, dividing around Lake Bugeac, and on to Durostorum.[877] It is possible to discern routes from Oltean's analysis from modern Urluia to Sucidava and Sacidava, the routes splitting south of Lake Dunareni; it is also sensible to infer a route from Tropaeum Traiani to Rasova although this cannot be seen in the aerial

[874] Chapter Three, p.197.
[875] Oltean 2013a, p.210; Dr Oltean kindly provided shapefiles of the roads she had identified.
[876] Panaite 2006, p.65, 2015, p.598.
[877] Panaite 2006, pp.68-9.

survey.[878] Another road ran from Tomis to Axiopolis [Constanţa to Cernovoda] to the north of the Carasu river valley, crossing the north-south highway in the vicinity of *vicus Urb* [Medgidia].[879] Oltean's survey now suggests two routes, one to the north and one to south of the Carasu valley. The latter might be best associated with the Valu lui Traian ramparts between Medgidia and Basarabi which are still being interpreted. Several sections of roads at right angles to the ramparts have also been reported.[880]

From the coast road already mentioned north of Tomis two branches continued inland to intersect the Dobrogean north-south highway, one at *vicus H*…. [Dorobantu] and then travelling onto Capidava [Capidava], the other travelling further north to the *vicus Ulmetum* [Pantelimon].[881] A road ran west from Histria, probably splitting into two routes near to modern Tariverde; thereafter a more southerly route ran close to the *vicus Casianus* [modern Cheia] met the north south highway at *vicus Ulmetum*, from where two roads continued west onto Capidava [Capidava] and Carsium [Hârşova].[882] The more northern route ran from Tariverde directly onto Carsium via the *vicus V…* [Ramnicu de Jos].[883] Panaite is alone in suggesting two routes from Ibida [Slava Rusa] to Cius and Beroe, but hers is the preferred work.[884] Also from Ibida a road moved east to the *vicus Novus* [Babadag] and on to the coastal road in the vicinity of Enisala. North of Ibida a route is

[878] Panaite 2006, p.65, pp.68-9.
[879] Bărbulescu & Câteia 1998, p.121; Panaite 2006, p.59.
[880] Hanson & Oltean 2012, p.312.
[881] Bărbulescu & Câteia 1997, p.195; Panaite 2006, p.59, 2015, p.598.
[882] Bărbulescu 2008, pp.170-1, p.177; Panaite 2010, p.376, 2015, p.598.
[883] Panaite 2010, p.376.
[884] Panaite 2015, p.598.

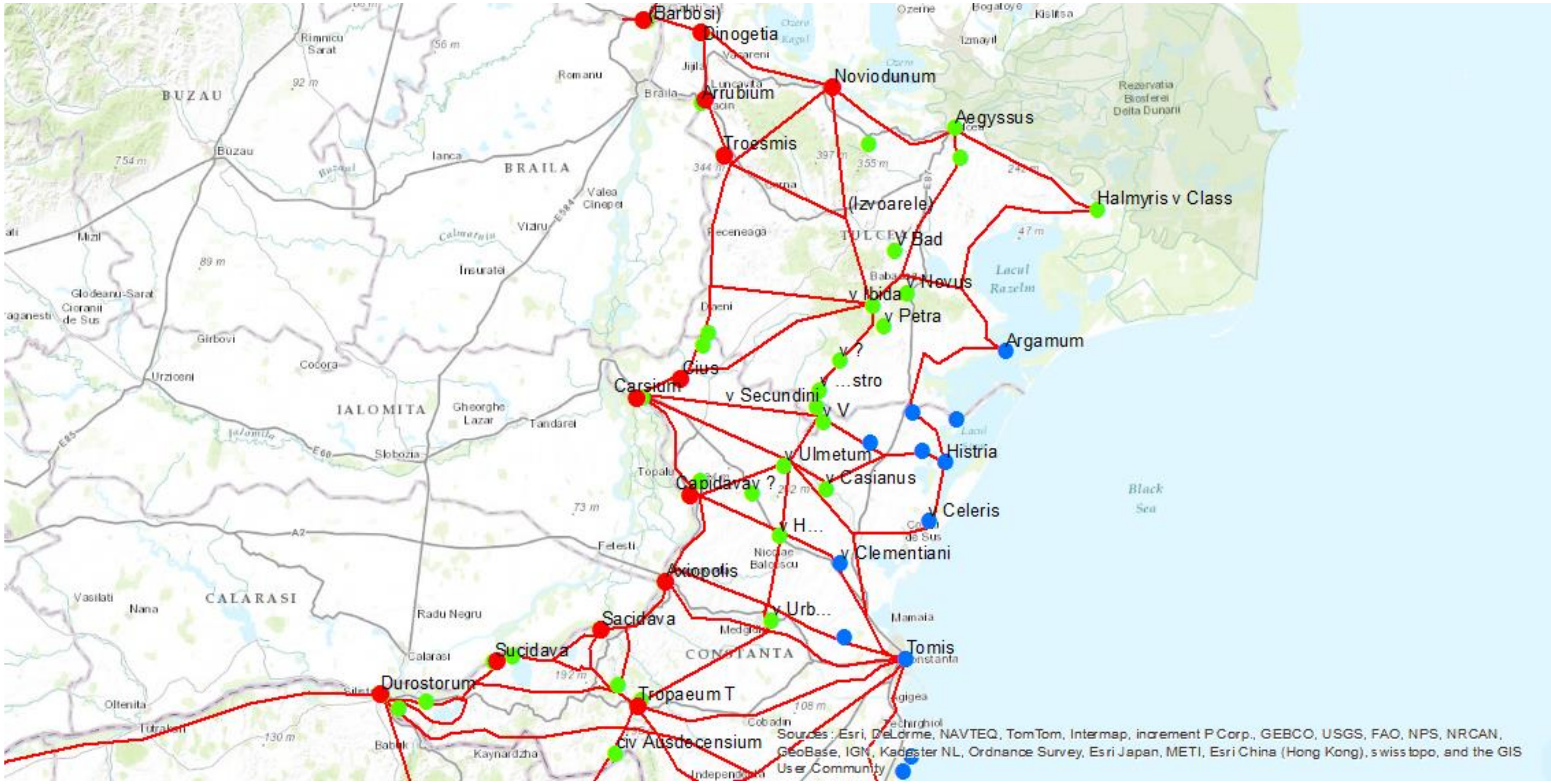

Fig 4.1.1.3: Road network: Dobrogea

supposed to Aegyssus; I have drawn this from *vicus Novus* [Babadag].[885] In the very north-west, the *limes* road is believed to have travelled as far north as Dinogetia before a spur moved to the shore opposite the fort at modern Barboşi while the main route turned east to Noviodunum. I have shown in Chapter Three how Troesmis and neighbouring Arrubium most needed supply lines, having no agricultural hinterland of their own. A route from the north-south highway to Troesmis is thought likely but is as yet un-proven; Panaite is certain such a route existed, believing it moved via Horia, and I follow her in this.[886] Where it departed from the north-south highway is purely conjecture, but somewhere near the fort at Izvoarele would be sensible. Recent survey at Troesmis has shown a route departing the fort travelling north-east towards Noviodunum. Thereafter its course is uncertain, but it would make sense to connect Troesmis to the ports at Noviodunum and beyond to Halmyris.[887]

4.1.2 Agricultural zones

Any product has a cost-distance function, so that profitability varies according to the distance from market and impacts on how far a particular product can be moved. Central place theory as described by von Thünen's model, reproduced for a Classical audience by Morley, envisaged a series of concentric circles of agricultural activities surrounding market centres.[888] In this model luxury goods come from afar, animals are driven to market from further afield than grain, and grain from further afield than dairy, which together with horticulture is practised closest to the consumption centre. Away from major urban centres such

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[885] Wilkes 2005, p.127 does not include in his itinerary, but draws it in Talbert's Atlas; Panaite 2006, p.59.
[886] Panaite, pers comm.
[887] Alexandrescu & Gugl 2014, p.296 Fig 4, 2016, Fig 6.
[888] Morley 1996, pp.59-63.

as Rome and possibly Alexandria and Antioch, this can only ever be a model; even Athens does not fit because olives were farmed as a cash crop in Attica. Yet I believe that the *limes* can fit this model and should be seen as a linear central place, with zones of differing agricultural activity spreading away from it. It is obvious that some luxury goods did come from afar: Istrian and Aegean wine can only have travelled from Istria or the Aegean. The agronomists describe the droving of livestock to market in Italy; and there is some evidence for this at Nicopolis, but not in Dobrogea.[889] I have already made the case for much of the grain need being available locally. Yet, dairy does not survive in the archaeological record at all, and horticulture is difficult to discern. Unfortunately, the survey of Chapter Three rarely indicates the nature of farm activity, with the exception of the still-disputed cattle farm at Niculiţel - 'Gurgoaia'.[890] Generally where agricultural implements are evident they point to poly-culture which has been seen to be preferable. Therefore, adhering to the spirit, rather than the details, of this theory, increased agricultural activity evidenced by increased settlement intensity should be evident closer to military installations than distant from them. How far this theory could be applied is further limited by the topography of my study regions and Lower Moesia as a whole. The Haemus mountain range provides a barrier that would have made moving bulky agricultural products from Thrace uneconomical. This also explains why Nicopolis and Marcianopolis were included within Lower Moesia *c* AD 193, so that the provincial boundaries aligned with the natural one.[891] Similarly in Dobrogea the Black Sea limited the extent to which zones of decreasing arable activity can be seen travelling away from the *limes*; the region is only 50-70km wide in parts. Yet what I will show below is that, where the shortfall is not too

[889] Beech 2007, pp.164-5, p.190.
[890] Baumann 1983, p.105; Chapter Three, pp.138-9, p.205.
[891] Klenina 2005, p.403.

significant, then the percentage of the available arable potential diminishes the further one travels from the consumption centres. It must also be said that von Thünen's theory is not applicable when an arable shortfall existed, because the state in the form of the *fiscus* will be seen to have been required to absorb the unnaturally high cost of importing staples for the army and to go outside of the model.

4.1.3 Overland transport wagons and mule trains

The existence of so many roads in Dobrogea suggests that overland transport was commonplace and further enforces the idea of a local supply solution to the garrison. Modern commentators often diminish the importance of overland transport in favour of moving bulk cargoes by water. Diocletian's price edict and the famine at Antioch that required Imperial intervention to move grain only 80 and 160km distances are often cited as evidence against overland transport.[892] Yet the road system surveyed above makes it clear that the garrison of Dobrogea was as equally well served by road as it was by water.

The capacity of the wagons used would have clearly impacted on the logistical task. Because carts and wagons were mostly made of wood they rarely survive in the archaeological record. To the west of my region the practice of wagon burials among the indigenous population is known from the late Iron Age increasing into the Roman period. These burials were for the nobility and so the wagons were finely decorated, but the basic design would nonetheless sometimes accord with a utilitarian vehicle.[893] Close to Montana a 4th century BC Iron Age burial has revealed a four-wheeled wagon of proportions appropriate to a working

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[892] Julian Misopogon, 368c-369d; Libanius, *Or* 18.195; Duncan-Jones 1980, pp.366-9; Finley 1992, pp.33-4; Garnsey 1988, p.23 fn5 makes the case for the Antioch famine being brought about by grain speculators not transport deficiencies; Tilburg 2007, p.72 en590.
[893] Venedikov 1960, pp.245-9; Mócsy 1974, pp.147-8.

wagon; other similar burials are known at Peretu in Romania and Skopje in Macedonia, but cargo capacity is not forthcoming.[894] In Dobrogea itself the only wagon burial known was definitely a light battle wagon.[895] From remains found in Italy a four-wheeled wagon has been reconstructed that had a platform of 1.6 x 0.77mts.[896] Although the published reports do not offer a suggestion of the cargo capacity, if grain were piled in sacks to a height of half a metre, I would venture that the platform could have carried a 462kg load.

Pictorial representations of wagons are found on Trajan's Column, albeit in a campaign context, where two-wheeled carts are drawn by both mules and oxen, yet these are small and do not seem to warrant the use of oxen.[897] Four-wheeled wagons only appear un-yoked.[898] Marcus Aurelius' Column shows mules, horses and oxen pulling both two- and more substantial four-wheeled carts.[899] The loads depicted on both Columns are the soldiers' day-to-day kit, plunder and wooden barrels. As such only the latter might have relevance to garrison re-supply. Further pictorial representation is available on metope number nine of the Tropaeum Traiani monument, where a four-wheeled wagon is clearly represented being pulled by an ox, carrying passengers who are interpreted as local Sarmatian refuges.[900] Metopes 35 and 37 show wagons without draft animals, and in all three cases the wagons are of a significant size.[901] Pictorial representations of wagons are also commonplace on Roman period gravestones from the Pannonias, but I know of none from Lower Moesia itself.[902] Overall the pictorial record confirms the use of

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[894] Torbav 2007, pp.45-52.
[895] Hartuche 1967, pp.231-57.
[896] Miniero 1987, p.194 repeated by Raepsaet 2002, pp.228-9.
[897] Lepper & Frere 1988, Scenes xlix, lxi-xii, cvi-vii; I exclude carts carrying simply *carroballista.*
[898] Scene xxxviii.
[899] Coarelli 2008, Scenes xxv, xxvi, xxviii, xxxviii, xxxix, lxxxv, xcii, cxi.
[900] Tocilescu 1895, p.48; Florescu 1962, p.469.
[901] Tocilescu 1895, pp.61-62; Florescu 1962, pp.476-7.
[902] *cf* Sági 1944-45, pp.232-48; Visy 1997.

two-wheeled carts and four-wheeled wagons pulled by both mules and oxen, but it is rather too open to interpretation to provide cargo capacities. Neither are the agronomists very helpful; Varro reports the ubiquity of mule-drawn wagons in Italy, but not capacity.[903]

One accurate ancient figure for the size of wagons used to supply the military comes from a Vindolanda text that records wagons carrying 53-63 *modii*, 343-407kg, of grain to the garrison.[904] Other tablets show that Vindolanda was routinely supplied by wagon.[905] The Theodosian Code set maximum loads of 200 Roman lbs, 65kg for a two-wheeled vehicle, a *plaustrum*, 600 Roman lbs, 194kg for a cart, a *carrus*, 1000 Roman lbs, 323kg for a wagon, a *rheda*, and 1500 Roman lbs, 485kg for heavy wagons, *angariae* sometimes translated as post wagons.[906] Diocletian's price edict gives a figure for a 1200 Roman lb, 388kg, load.[907] Although the legal texts date from the 4th century, the nature of wagon technology in antiquity, and until the modern epoch, was such that designs would have remained standard for long periods. Therefore, although the *annona militaris* that is described within the Theodosian Code is not applicable in my own models, the wagons reported at work within it are still thought relevant, although the loads may have been set to protect both the animals and the roads. Oxen-drawn wagons are commonplace in India and Africa today and oxen were regarded as excellent draft animals by a late 19th century military manual.[908] With regards to speed, the agronomists are unhelpful: Cato only reports an oversize load of a mill-stone taking

[903] Varro, *Rust* 2.8.5; White 1970, pp.300-1.
[904] *TV* 3.649.
[905] *TV* 3.583-584.
[906] *CTh* 8.5.8, 8.5.17, 8.5.28, 8.5.30, 8.5.47 (which allows only 1000lbs on a heavy wagon); Vigneron 1968, p.152; Chevalier 1976, pp.178-9; Hyland 1990, pp.256-7; Anderson 1992, pp.12-13; Roth 1999, p.211; Tilburg 2007, p.54, p.60; Kehne 2011, p.328.
[907] Diocletian, *EP* 14.8; Jones 1986, p.841.
[908] Wolseley 1871, p.37; Goldsworthy 1998, p.293; Raepsaet 2002, *passim*.

six days to move 50km by oxen-drawn wagon.[909] The near-modern military manuals suggested that oxen should work for 7-8 hours a day at 3.2-4km/ph, equating to 23-32km a day and this allowed them 6-7 hours to graze before and after working.[910] It is to be noted that the *limes* forts are typically 12-30km distant within Dobrogea, so never more than a day apart. Speeds for mule-drawn wagons are not as easily defined because the effectiveness of the Roman harness is debated, but they were faster: 5-6km/ph is expected.[911] Ovid reports the journey from Brundisium to Rome of 580km by mule-drawn wagon taking 10 days, so 58km a day.[912] The Theodosian Code again gives the number of mules required to move cargoes, but not speeds, so eight were required to move 1000 Roman lbs, 323kg, a large number in comparison to the two oxen required to move the same sort of load; but only three to move a two-wheeled cart carrying 200 Roman lbs, 65kg.[913]

Because the figures from Vindolanda, that for the *rheda* in the Theodosian code and the 19th century military manuals all generally agree, I shall assume oxen-drawn wagons moved an average load of 350kg at speeds of 23-32km a day. A team of mules would have moved faster than oxen and did not require as long to graze because a higher percentage of their food was feed-barley, so that I will assume the same load 350kg, pulled by eight mules, moved 50km a day. The need for feed-barley would have had a significant impact on the capacity of the wagons: for eight mules requiring 2kg each a day 16kg of the cargo would have been turned over to feed-barley daily, 32kg for a return journey. This reduces the effective load,

909 Cato, *Agr* 22.3; Anderson 1992, p. 11; Laurence 1998, pp.132-3.
910 Wolseley 1871, p.37; War Office Veterinary Department 1908 cited by Kendal 1996, p.143 & Goldsworthy 1998, p.293; Engels 1980, p.15; Jones 1986, p.842; Anderson 1992, p.11; Junkelmann 1997, p.62.
911 Engels 1980, p.16; Hyland 1990, p.261; Kendal 1996, p.143; Goldsworthy 1998, p.294; Adams 2012, p.220.
912 Ovid, *Pont* 4.5.8; Laurence 1998, p.133.
913 *CTh* 8.5.8.

so that after eleven days the feed-barley exceeds the cargo.[914] In contrast, oxen could graze most of their needs after every day's work and although they benefit from some feed-barley this is not essential every day, especially when not actively being worked.[915] As a planning assumption, for oxen I have used 2.25kg feed-barley for each day, so 9kg for a yoke on a return journey. Therefore, I would favour oxen as the main traction animal in a garrison context because fewer animals could haul larger loads, they were sturdier than mules as well as horses and, most importantly, they did not require anything like as much hard fodder.[916] I will not model for wagons carrying their own hay, assuming all animals grazed green fodder by the road side, but in other contexts, such as desert conditions, this and also water would have reduced the cargo capacity more quickly.[917]

While a local supply solution is preferred, for many of the supposed farmers it may have been much cheaper and easier to use a single mule than employ carters. There are several depictions of pack-animals, both mules and horses, on Trajan's Column; in one the rig is clearly visible extending out to the sides of the animal.[918] Pack-animals are not evident on the Tropaeum Traiani monument. Diocletian's price edict gives prices for a 200 Roman lb, 65kg, load on a donkey and 300 Roman lb, 97kg, load on a mule.[919] Another Later Roman reference from Cassiodorus suggests only 100 Roman lbs, 32.6kg, for a pack-horse.[920] The last seems very low, but mules are more sure footed than horses and sturdier, so that White followed by Tilburg suggests figures for mules of 90-136kg; Engels suggested 91kg; Anderson

[914] Engels 1980, p.22, p.121; Junkelmann 1997, p.64; Roth 1999, p.198.
[915] Wolseley 1871, p.47; Goldsworthy 1998, p.293; Halstead 2014, p.20, p.291.
[916] Tilburg 2007, p.52.
[917] Engels 1980, pp.21-2.
[918] Lepper & Frere 1988, p.174, Scenes xv, xlix, cv, cvi, cx, cxxxviii;
[919] Diocletian, *EP* 14.10-11; Roth 1999, pp.205-6.
[920] Cassiodorus, *Variae* 4.47; Tilburg 2007, p.60.

100kg; Adams 80-150kg.[921] Mules in the early 20th century British army carried 69kg at a speed of 5km/ph, and comparative modern evidence is collated by Raepsaet.[922] Having considered these various reports, for modelling I have opted for a mid-range figure of 70kg, travelling at 5km/ph for 10 hours a day and so 50km distance daily.[923] I assume mule-trains of eight animals carrying a 560kg load, greater than the same number of animals pulling a wagon.[924] Although a single wagon would have required only one driver, every five to eight mules would have required a handler.[925]

4.1.4 Seaborne and riverine transport

It will be suggested that the deficit in Dobrogea was met by grain that travelled across the Black Sea by ship. Casson collated the literary evidence for sea-going vessels to conclude that they travelled at 4-6knots with a favourable wind, and 2-2.5knots against the wind, that is 3.7-11km/ph.[926] From the Black Sea specifically, Thucydides reports that cargo vessels took four days and four nights sailing to travel 450km from the Hellespont to the mouth of the Danube, so 4.7km/ph.[927] I will use an average figure of 4knots, *c* 7.5km/ph, for sea-going vessels, assuming that if a vessel had a favourable wind in one direction, it would be less so in the other. Despite Thucydides' mention of night sailing I will deal in terms of only 12-hour day sailings below, because sea-going was fraught with danger especially at night time, so that the ancients generally preferred to employ

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921 White 1962, p.129 repeated by Tilburg 2007, p.72; White 1970, p.300; Engels 1980, p.14; Anderson 1992, p.15; Adams 2012, p.230.
922 Goldsworthy 1998, p.293; Roth 1999, pp.77-78; Raepsaet 2002, p.69.
923 Anderson 1992, p.12 suggested 80km a day; Roth 1999, p. 207; Adams 2012, p. 230, 40km a day.
924 *cf* Roth 1999, p.202 who believes pack animals to be less effective than wagons.
925 Roth 1999, pp.113-14.
926 Casson 1971, pp.282-96; Roth 1999, p.195.
927 Thucydides, 2.97.

cabotage along a shore-line, and to do this safely would have necessitated daylight sailings.

The Danube's primary function was defensive, additionally it delimitated the extent of Roman authority, but not necessarily its influence.[928] This was borne out in Chapter Three with only a little settlement activity being seen to the north of Novae and very little to the west of Dobrogea. A secondary advantage of river boundaries was that they acted as a means of communication. It was Richmond who first pointed out that almost every legionary garrison was served by a river and suggested this was for resupply, a view that has become canonical.[929] Today the Danube travels at 7-9km/ph on the upper reaches, but slows downstream of the Iron Gates, so that at Galați 2.3km/ph is reported.[930] In antiquity when the river was unmanaged slower speeds are evidenced as Ovid and Pliny both record that the river froze in winter.[931] However, even with a weak current of 2-3km/ph, I think it unlikely that bulk supplies travelled far upstream, because this implies some form of motive power, a sail when the winds were favourable, oars otherwise. There is no evidence of towpaths away from the Iron Gates, while on the lower reaches there are extensive marshes today, and surely there were in antiquity also, that would have excluded towing.[932] So maybe luxury goods were moved upriver, which will be considered below, but not staples. For the purposes of modelling I shall assume that the current was 2.5km/ph, which if I apply to a mid-range speed of seagoing

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[928] Rankov 2005a, pp.175-81.

[929] Richmond 1982 (originally 1935), pp.33-4; Rickman 1971, pp.235-6; Jones 1986, p.844 (for the Later Roman period); Roth 1999, p.174; Batty 2007, p.461; Lemke 2015, pp.845-52.

[930] http://www.icpdr.org accessed 10/02/12; http://www.aries-shipping.ro/port-directory/port-information/galati-port.php accessed 06/05/15.

[931] Ovid *Tr* 3.10.39; 5.10.2; Pliny *Pan* 12.3; Oltean, pers comm: when frozen, the river may have been traversed with sledges.

[932] Šašel 1973, pp.80-5; Anderson 1992, pp.93-4.

vessels of 7.5km/ph, would result in a mean with-the-current speed of *c* 10km/ph, and an against-the-current speed of *c* 5km/ph for river craft.

Trajan's Column offers several representations of ships and boats on the Danube. Bounegru and Zahariade suggest that outside of a campaign context *liburnae*, a term which came to mean any small military vessel, were most likely used on the Danube.[933] Cargo ships, troop-carriers and horse-transports are all also represented on Trajan's Column.[934] However, the images are stylised so that it is impossible to discern capacity from them as such. Marcus Aurelius' Column has fewer images and these are similarly un-informative, showing simply rounded barges.[935] From Rome there is some pictorial evidence of river-going lighters, *lenunculi* and *caudicariae*, that were either rowed or more commonly towed upriver.[936]

Archaeological evidence is lacking from the Lower Danube itself, but a great many types of river, or river/sea-going ships, have come to light in recent years through the excavation of harbour facilities elsewhere. Several of the Fiumicino wrecks are working harbour craft, *caudicariae*; harbour ships were also found at Naples, Marseilles and Toulon.[937] River/sea-going craft are exemplified by the 20-tonne Comacchio wreck and the ships found at Pisa.[938] A group of small, light, rowed military boats, *lusoriae*, have been discovered on the upper Danube at Oberstimm and on the Rhine at Mainz.[939] These might be indicative of the way the Roman fleet navigated the Lower Danube, but they are not freight carriers. From

[933] Bounegru & Zahariade 1996, pp.49-52, pp.55-7.
[934] Lepper & Frere 1988, Scenes ii-iii, xxxiii-v, xlvi-vii.
[935] Coarelli 2008, Scenes ii lix, lxxxi.
[936] Casson 1965, pp.32-3, p.36.
[937] Parker 1992, pp.178-9; Pomey 2009, pp.268-9; Boetto 2009, pp.290-5 http://www2.rgzm.de/navis/home/frames.htm# accessed 27/12/16.
[938] Pomey 2009, pp.273-4; http://www2.rgzm.de/navis/Ships/Ship050/TheComacchioWreck.htm accessed 27/12/16.
[939] Parker 1992, p.253, p.291; http://www2.rgzm.de/navis/home/frames.htm# accessed 25/03/15.

the lower reaches of the Rhine and its tributaries at Zwammerdam and subsequently Woerden, barges known as the Zwammerdam type have been discovered occasionally since the early 1970s.[940] These boats are flat bottomed but of 15-35m length and 3-5m breadth, and some show evidence for being able to have been rowed back upstream; depending on the draft, a capacity of 22.5-25 tonnes is plausible.[941] Similar barges were found in 2004 on the Rhône at Arles and are also known from Lyon and Chalon-sur-Saône.[942] Three river/sea-going ships were found at the port of London: a 26 tonne cargo capacity is suggested for the Blackfriars boat.[943] Two other ships, the New Guy's House and the County Hall ship were smaller than the Blackfriars boat but cargo capacity is not offered.[944] So in all cases river and river/sea-going craft were small and, where a freight capacity is offered, of *c* 20-25 tonnes burden; I will assume 20 tonnes for modelling.

For ancient sea-going ships there are plenty of literary references. Casson influentially suggested that in the Aegean, at the time of Athenian empire, vessels of 100-150 tonnes were commonplace. He did so with reference to the port regulations of Thasos where 80 tonnes was considered a minimum worthy burden, while 120 tonnes is the most commonly reported capacity from the Aegean.[945] He also considered legal privileges for sea-going, grain-carrying vessels that supplied Rome, of initially more than 70 tonnes burden and later as much as 340 tonnes capacity.[946] Casson was robustly challenged by Houston, who pointed out that the evidence cited only points to the desirability of such vessels in the eyes of authority,

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[940] De Weerd 1977, p.15; Parker 1992, p. 459; http://www2.rgzm.de/navis/home/frames.htm# accessed 25/03/15.
[941] De Weerd 1977, pp.16-17; http://www2.rgzm.de/navis/home/frames.htm# accessed 25/03/15; Kehne 2011, p.328 suggests higher cargo capacities.
[942] Long *et al* 2009, pp.303-10; Pomey 2009, pp.268-9.
[943] Marsden 1994, p.76, p.83.
[944] Marsden 1994, p.103.
[945] Casson 1971, pp.171-3, pp.183-4 citing SEG 21.298.14.
[946] Gaius, *Inst* 1.32c; Digest, 50.5.3; Casson 1971, pp.171-2; Hopkins 1980, p.105 fn16 also favoured 400 tonne burdens being commonplace; Adams 2012, p.227 still follows this view.

not to the reality that existed.[947] There was a century and half between the first and second Roman decrees, implying that the first had been ineffectual, while the second decree had a caveat allowing several 68 tonne vessels in lieu of a single 340 tonne ship. Houston went on with reference to literary evidence, comparative data on Medieval and early modern ships sizes, and the absence of port facilities throughout the ancient and early modern world to make the case for most ships being well below 100 tonnes burden.[948] Underwater archaeology does show a wide variation in size, so that despite the largest ship found to date being of 500 tonnes burden, modern thought does tend towards Houston's low end view as being more normal, *c* 75-100 tonnes.[949] As a result it is not possible to model the sea-borne component with any precision and only provisional numbers of sailings for different burdens will be offered below.

It has been noted that the area around Troesmis is the most lightly populated of all Dobrogea so that if ever a garrison had need for long-distance food supply it was at Troesmis and to do so by boat is at first most obvious. That ships could travel up river is evidenced by ports at Halmyris and Noviodunum together with a possible resupply base at Poşta.[950] The question is how far they might have travelled against a significant current in marshy meandering water, which would have depended on the draft of the ship. The difficulties of navigating up the Tyne estuary was one of the reasons Anderson dismissed the Piercebridge Formula.[951] Casson loosely reports that many sea-going wrecks were shallow bottomed, but it is

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[947] Houston 1988, pp.558-9.
[948] Hero, *Sterometrica* 1.53; Livy 21.63, & Plutarch *Merc* 75-76 on a *lex Claudia*; Cicero *Fam* 12.15.2; Houston 1988, pp.553-61; *cf* Novellae Theodosianae, VIII ships as low as 13 tonnes were permitted to supply the *annona* to Constantinople: Jones 1986, p.843.
[949] Parker 1992, p.26; Roth 1999, p.192; http://oxrep.classics.ox.ac.uk/databases/shipwrecks_database/ .
[950] Chapter Three, p.204, p.208, pp.209-10.
[951] Anderson 1992, p.84, p.87.

difficult to say what that means in terms of burden.[952] This problem has been previously addressed by a former Chief Naval Architect to the Royal Navy to arrive at a putative draft of 2.25m for a vessel of 80-tonne burden and 2.5m for a 120-tonne burden.[953] Today the river is reported as being 7.6m deep at Galaţi, and sea going ships could reach this far in the 19th century, but this was surely due to dredging.[954] When a map is consulted it is clear that from Noviodunum to Troesmis was only 30km by land, but 100km by river, so it would have been much quicker to move overland although the cargo would have been far smaller. This together with the possible supply depot at Poşta points towards supplies being landed at Noviodunum. This does go against the conventional wisdom of waterborne transport being preferred for bulk cargoes.[955] But in the case of Dobrogea, with a well-developed road network I believe it more credible that overland transport from the most convenient ports should warn against believing that boats travelled very far up river for re-supply purposes. I will make the division at 80 tonne burden, modelling ships up to this figure travelling to Noviodunum, which is known to have had a port, with larger vessels berthing at the Black Sea ports.

4.1.5 Storage solutions

There is only limited evidence of storage facilities from the study areas. A granary of approximately 570m^2 is evident at Capidava, another of 442m^2 at Novae; these could hold in the region of 428 and 332 tonnes of grain respectively if stored to 1m height, plenty for the garrison of 546 men at Capidava but only two months'

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[952] Casson 1971, p.175.
[953] I am grateful to Mr Doug Pattison VPRINA who carried out the calculations based on a scaling up of the Kyrenia wreck of the 4th century BC, and to Professor Boris Rankov who supplied the figures.
[954] Oltean 2013b, p.148; http://www.afdj.ro/cote/cote_en.htm accessed 06_05_2015.
[955] *cf* Duncan-Jones 1982, pp.366-9; Adams 2012, p.222, p.224.

supply for *legio I Italica* at Novae.[956] However they are both of 4th century date, when troop numbers in the case of Novae were much lower, so that little can be deduced from these. One granary has also been found to the south west of Rasova, with legionary inscriptions in the building works, but this is four kilometres from the supposed site of the fort which is perplexing.[957] Another is that just mentioned to the east of Noviodunum at Poşta: a capacity is not reported, and only approximately 15m^2, has been unearthed.[958] There is no evidence of storage sheds at the nodal points of the road network, as are sometimes posited in the north-western provinces, but the compact nature of Dobrogea may have made them unnecessary. Oltean has suggested that some forts identified through aerial survey in the interior of Dobrogea had a logistical function as way-stations.[959] Panaite also suggests that Niculiţel 'Gurgoaia' where Baumann had previously suggested a cattle farm, was a possible *mansio* connected to the Imperial messenger service.[960] *Mansiones* are sometimes linked to Roman military supply, and the buildings here were substantial of half-hectare area so there would have been ample storage space, but there is no explicit link to the military.

4.1.6 Long-distance supply solutions

Long distance supply to the Pannonias and the Upper Moesian province via well-established trade routes from the Adriatic down the Drava and Sava rivers is evident through the record of amphorae. Yet the Iron Gates were surely a significant impediment to moving into the lower province. Trajan's canal and

[956] *cf* Gentry 1976, pp.25-6 and Bidwell & Speak 1994, p.29 who suggest grain could be stored in sacks to 2.5m height; Roth 1999, p.186; Klenina 2005, pp.403-4 estimates a 725 tonne capacity; Rizos 2013, pp.660-1.
[957] Catalogue No 50, 52; Bărbulescu 2001, pp.116-17; Chapter Three, pp.184-5.
[958] Lockyear *et al* 2007, p.47.
[959] Oltean, pers comm.
[960] Panaite 2004 & pers comm *contra* Baumann 1983, pp.100-5.

towpath indicate that movement around the cataracts was possible, although this is best associated with the Dacian wars and thereafter the regularity of trade through the Iron Gates is uncertain.[961] Dyczek's comprehensive study of the amphorae distribution in the lower province coupled to Bjelajac's study of amphorae in the upper province negates the need for detailed repetition of the origin of amphorae. Unfortunately, Dyczek does not quantify the scale of the finds, using terms such as 'a few fragments' 'quite numerous' or 'large numbers'. Only Novae and Histria show a wide selection of types. Histria's location would allow access from all over the empire and it is tenuous to infer trade routes from the amphorae found there alone. What these studies do show is that western amphorae, both Baetican and Istrian, are evident at Oescus, Novae, Troesmis and [Barboşi] dating from the 1st until early 3rd century.[962] Generally, in the 1st century more imports came from the west, especially Italy, whereas from the 2nd century onwards local and Bosporan goods dominate.[963] The same pattern is seen with amphorae in the upper province.[964] A similar temporal shift is seen with table-wares examined at Diana in the upper province.[965] This is all reasonable, since in the 1st century the army on the Lower Danube was expeditionary; whereas after the Dacian wars it was established and would remain so until the 5th century. After the 1st century substantial numbers of locally produced amphorae from Hotnica, Butova and Pavlikeni suggest that the region around Nicopolis supplied at least ordinary wine to the garrison.[966] Aegean amphorae, in particular Kapitän II, are found along the *limes* zone suggesting some transport was made either against the current or overland from Traianopolis

[961] *ILS* 5863; *ILJug* 63, 468 *AE* 1973.475; Šašel 1973, pp.80-5.
[962] Dyczek 2001, *passim*.
[963] Dyczek 1997, pp.84-6.
[964] Bjelajac 1992, pp.122-4.
[965] Cvjeticanin 1996, pp.95-7.
[966] Dyczek 2001, pp.83-4, pp.225-8, pp.242-50; Klenina 2005, p.405; Swan 2007, pp.253-4.

[Alexandroupoli], Amphipolis [Amphipolis] and Thessalonica [Thessalonica].[967] Rhodian wine also was carried in a series of similar types: Zeest 64, 94, 104 and 105 from the 2nd century onwards.[968] Zeest 91-93 are also commonplace although their origin is unclear.[969] The most common amphorae type in both Upper and Lower Moesia is Zeest 90; this type was produced in both the eastern Mediterranean, notably Cos and Erythriae, and the Black Sea; they carried wine.[970] Several Zeest 90 carry stamps LVM, LE V and LEG I indicating that they were specifically destined for *legio I Italica* and *V Macedonica*. Pontic olive oil was moved in Zeest 75 and 84 type amphorae.[971] Despite the preference for local supplies, Spanish oil and fish products are also evidenced in Dressel 20, 25 and Beltrán 51 from both 2nd and 3rd centuries.[972]

The amphorae only really evidence high-value commodities travelling long distances, but for the significant deficit in grain to the garrison of Dobrogea an overseas solution is also thought likely. The Crimea is the most obvious long-distance supply solution to Lower Moesia because of the well-established practice of exporting grain from there to the wider ancient world. Anatolia has also been suggested as a supply solution, but with no certain evidence.[973] Additionally Hunt's *pridianum* does report soldiers of the Lower Moesian garrison being absent in Gaul collecting both clothing and grain. This is quite perplexing, to bring clothing such distances would have been problematic, to move grain much more so.[974] In the Crimea the centuriation of the 'nearer *chora'* at Chersonesus [Sevastopol] covers

[967] Dyczek 2001, p.137-41.
[968] Dyczek 2001. p.202-20.
[969] Dyczek 2001, pp.221-5.
[970] Dyczek 2001, pp.173-96; Ciauşescu & Symonds 2005-2006, p.132.
[971] Dyczek 2001, pp.233-6, 250-2.
[972] Dyczek 2001, pp.93-9, pp.124-7.
[973] Mitchell 1993, pp.250-1; Levick 2004, pp.187-8 is followed by Batty 2007, p.468 in keeping with his view of limited agriculture in the region.
[974] *P.Lond*. 2851; Lepper & Frere 1988, p.247.

10,000ha with approximately 400 plots of 17-26ha size, about a third of which had small farms upon them.[975] Wine had been an important crop here in Hellenistic times, but by the Roman period, it was replaced by widespread arable production.[976] This immediate *chora* would have been sufficient to provide for 9313 civilians according to my earlier assumption of 0.5663kg grain a day and alternate fallowing. The *polis* population has been estimated at 20,000-25,000 by Zubar.[977] This is rather an ambitious figure; Chersonesus was far from a major urban centre, the ground plan stretches to 20ha, so that by the criteria I have used hitherto I would expect something closer to 2,000 inhabitants, plus maybe another 600 within the nearer *chora* living in the small farms so that I might suggest a tenth of the population offered by Zubar.[978] The farther *chora* is suggested as extending between 44,000-48,000ha, sufficient to feed another 40,977-44,703 civilians.[979] This includes land on the Tarchankut peninsular 90-110km distant from the *polis* with no urban settlement evident close at hand, so that this area looks to have provided for an export market.[980] Certainly the organised landscape is greater than anything seen in Dobrogea. There was also a small Roman military garrison at Chersonesus: its function seems to have been political, bolstering friendly relations with Rome, rather than directly logistical; its presence does however suggest trade links.[981] Further to the east in the Crimea, the Bosporan kingdom centred at Panticapaeum [Kerch] supplied classical Athens from the rule of the Spartocid dynasty onwards.[982] There are literary references to large quantities of grain being

[975] Carter 2003, p.121, 2006, pp.180-1; Nikolaenko 2006, pp.159-63.
[976] Strabo, 7.4.6; Carter 2003, pp.122-9; 2006, p.198; Nikolaenko 2006, p.156.
[977] Zubar 2007, p.758.
[978] *cf* Storey 1997, pp.969-73 who argues for only 22,000 at Ostia, a site of *c* 70ha.
[979] Nikolaenko 2006, p.163.
[980] Klenina 2005, p.404.
[981] Bounegru & Zahariade 1996, p.12; Klenina 2005, p.404.
[982] Isocrates, 17.57; Syll^3, 206; Demosthenes, 20.31-32 reports an annual export of 400,000 *medimnoi* 15,750 tonnes; Strabo, 7.4.6 reports 2,100,000 *medimnoi* over an eight year period, in the

shipped from here, sufficient to support 250,000 of Mithridates' troops annually, during the third war with Rome.[983] By the start of the Imperial period it was a vassal state, recorded by Strabo as being extremely productive in grain.[984] To the north of Panticapaeum itself, an area of potentially 10,000ha of cultivation is evident, although the field system is not as detailed as at Chersonesus; to the west another 16,000ha is suggested.[985] At the site of Nymphaion to the south, 1,350ha of ancient plots are still discernable, but the *chora* has been estimated to have covered 5000ha in antiquity.[986] Finally 90km to the west lay the ancient *polis* of Theodosia [Feodosia] where 1,765ha of centuriation are evident and another 35,000ha hypothesised; again the *polis* itself was small at only 40ha.[987] To have utilised a grain source external to the empire does not undermine my faith in Hopkins' model, because there would have been reciprocity in trade. Indeed a triangular trade route is apparent from the Greek period; although the nature of the treaty agreements with Rome are not understood.[988] So, from Panticapaeum's kingdom in excess of 50,000ha of possible arable are evident, together with as much as 58,000ha associated with Chersonesus. Thus, the Crimea could very easily have answered my shortfall.

That four minor ancient *poleis* had this degree of organised landholdings within their *chora* would suggest that many other Greek *poleis* might also have had considerable landholdings. It is because of this, that I have happily suggested

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4th century BC or 10,336 tonnes *pa*; Theopompus, *FGrH* 115 F292 and Philochoris, *FGrH* 328 F162 report a flotilla of 180 or 230 ships bound for Athens in 340; Osborne 1987, p.99; Whitby 1998, pp.122-3; Saprykin 2006, pp.277-8; Garnsey 1988, p.124; Moreno 2007, pp.178-89, pp.207-8.

983 Strabo, 7.4.6 & Memnon, *FGrH* 434 F37.6 reports 180,000 *medimnoi*, 7,088 tonnes of annual tribute; Saprykin 2006, p.281.

984 Strabo, 7.4.4.

985 Smekalova & Smelalov 2006, pp.222-6.

986 Smekalova & Smelalov 2006, pp.218-22; Zin'ko 2006, p.295.

987 Gavrilov 2006, pp.252-3; Smekalova & Smelalov 2006, p.211-15.

988 Demosthenes, 35.10-13; Whitby 1998, p.122; Davies 1998, p.229 fn6.

figures for landholdings of the *poleis* in Dobrogea as being at least 3000ha in Chapter Three.

<u>Chapter Four, Section Two: Transport modelling</u>

4.2.1 Methodology Service Areas

Returning to the results of the surveys carried out in Chapter Three, I have made the case for 168% of the agricultural need of the garrison and their service providers at Novae being available locally. I have also made a case for 76% of the agricultural need of the garrison in Dobrogea being available locally. Here where I listed 209 *limes* facing sites, attempting to allocate arable potential to consumers required a great many assessments of travelling distances from each particular producer site to each consumer fort, and then arbitrary divisions of arable potential among the forts. There were endless permutations of how to do this and it was difficult to put into a coherent scheme. However, the Service Area function of ArcGIS allowed for more rapid assessment of which arable potential might have been moved to which garrison. This operation takes account of the travelling distance along the supposed road network to produce irregular polygons of the area that lay within any given distance of a consumption centre. Where several *limes* forts were located close together, the program can measure the half-distance between two or more forts in a similar manner to Voronoi analysis, and therefore the polygons produced show the area best placed to serve each particular fort. Once a pictorial representation of each day's travelling distances from potential consumers was produced, the potential suppliers within these areas were counted. Where the needs of an individual garrison was theoretically met, its surplus was made available to other garrisons within the model, then subsequent Service Areas were produced at two to five-day intervals from those forts with a deficit. The overall effect was to build tabular models found at Appendix B for Novae-Nicopolis and Appendix C for Dobrogea, of how the garrison might have been supplied using both 23km and 32km travelling days for oxen-drawn wagons and 50km travelling days for mule-drawn wagons and mule-trains. From these tabular models it was possible to calculate the number of wagon days, and so wagons or mule-trains required annually. The numbers of vehicles arrived at also reflects a corresponding number of drivers, although it would be fair to say that in many cases these could have been the same agricultural workers who tilled the fields. These calculations only arrive at four possibilities; there are endless permutations using wagons and mules together of how the agricultural potential might have been moved to the consumer, but the suggested models are thought plausible.

The number of sites within each Service Area was enumerated in hectares of potential, equating to kilograms and then wagon loads; it was found necessary to take calculations to several decimal places to avoid rounding errors between kilograms and hectares. This leads to a deceptive impression of accuracy, but the final figures for wagon loads of 350kg were rounded to whole or half numbers, multiplied by the number of travelling days and then divided by a working year of 300 days, to arrive at round figures.[989] These calculations became more complicated because some land would have had to be given over to producing the feed-barley for the animals. If the needs of a particular garrison could be solved by the arable potential within a particular day's travel, it was a simple matter of deducting the feed-barley requirement from the load-carrying capacity of the wagon to arrive at the cargo. However, where there was insufficient potential to supply the fort in full, and this was more frequently the case in Dobrogea where there was a net deficit, then there was an inherent error in those calculations because of the

[989] This is the same number of working days as that assumed for farm labourers in Chapter Two, p.89.

differing suggested yields of feed-barley and wheat. So, the arable potential could be seen as a weight of wheat and that weight divided by wagon capacity to arrive at an estimated number of wagons required. When the necessary land to produce feed-barley for this estimated number of wagons was deducted from the arable potential seen, then because less land was required for a given weight of barley than wheat, a greater weight of grain would have been produced from the land and so a higher overall load, which in turn required more wagon space, but this would also require slightly more feed than initially estimated. These were constant positive errors in overall load, that were resolved by repetitive calculations termed 'error loops', where revised estimates of wagons with increased feed requirement were carried out that in turn reduced the available wheat to the garrison. These errors diminished so that after two or three such calculations they became negligible. Such errors were not induced by the barley part of any cargo. In the example below beginning with 1000ha of arable potential, the difference in wheat available between the original estimate and the first error loop was a 79kg decrease; by the inclusion of the second error loop this change became a mere 184g and less than a gram change after three such error loops. Although this is a hypothetical model, such accuracy was necessary to check the completeness of any given calculation. The figures derived from these calculations are only indicative of scale.

Further repetitive calculations were required when long-distance modelling was carried out because, if the long-distance component used feed-barley produced within Dobrogea to feed the animals moving it overland, then the quantity of local hectares available for grain decreased, so that the deficit increased further. At the same time, because the quantity of local grain moving to the garrison was diminished, the barley feed to move that local component decreased. As a result, the calculations for the long-distance supply solutions had to be repeated many times before an equilibrium was reached. I am indebted to a geographer, Professor Paul Bates, who pointed me towards the benefit of carrying out these calculations within Excel; using basic logic equations the calculations became in effect simple algorithms that could be fairly rapidly reproduced.

The conclusions reached from all these calculations assume a steady flow of supplies to the garrison, although the harvest was of course seasonal; in the absence of evidence for depots, I am assuming that locally produced grain was stored at source until shipment could happen. I will also briefly consider different vehicle capacities, which will obviously change the number of vehicles required. Finally I will consider the likelihood that transport was restricted for a protracted period of the year. In this last case the total number of loads and vehicle days would have remained the same but the vehicles at work at any given time would have increased and so the number required *pa*.

Table 4.2.1.1: Error Loop example

1000ha Potential
x 385kg/ha
385,000kg wheat
/350 = 1100 wagon loads but these would require feed-barley and this can only be estimated in the first instance because the area of barley required depends on the weight of wheat carried

Feed = 1100 wagon loads x 32kg = 35,200kg
Feed = 1100 wagon loads x 0.081012658ha = 89.11392405ha
Cargo = Potential – Feed b
Cargo = 1000ha - 89.11392405ha Feed b
Load = Cargo + Feed b
= 910.8860759ha wheat + 89.11392405ha Feed b
x 385kg/ha x 395kg/ha
350,691.1392kg w + 35,200kg b = 385,891.1392kg Load
/350 = 1102.546112 wagon loads, = plus 2.5461121 wagon loads = positive 0.2314647% error

Error Loop
Feed = 1102.546112 wagon loads x 32kg = 35,281.47559kg Feed b
Feed = 1102.546112 wagon loads x 0.081012658ha = 89.32019136ha Feed b
Cargo = Potential – Feed b
Cargo = 1000ha - 89.32019136ha Feed b
Load = Cargo + Feed b
= 910.6798086ha wheat + 89.32019136ha Feed b
x 385kg/ha x 395kg/ha
= 350,611.7263g w + 35,281.47559 b = 385,893.2019kg Load
/350 = 1102.552005 wagon loads = only 0.00589 increase in wagons from 2.0627kg increase in total load; but 79.4129kg decrease in wheat carried from a reduction of 0.20626726ha

This can be continued but the changes are negligible after the second or third error loop
e.g.
Error Loop Two
Feed = 1102.552005 wagon loads x 32kg = 35281.66417kg
Feed = 1102.552005 wagon loads x 0.081012658ha = 89.3206688ha b feed
Cargo = Potential – Feed b
Cargo = 1000ha - 89.3206688ha Feed b
Load = Cargo + Feed b
= 910.6793312ha wheat + 89.3206688ha Feed b
x 385kg/ha x 395kg/ha
= 350,611.5425kg w + 35,281.66417kg b = 385,893.2067kg Load
/350 = 1102.552019 wagon loads = only 0.000014108 increase in wagons from a minuscule 5g increase in total load; now only 184g decrease in wheat from a reduction of 4.77m^2

Error Loop Three
Feed = 1102.552019 wagon loads x 32kg = 35,281.66461kg
Feed = 1102.552019 wagon loads x 0.081012658ha = 89.3206699ha Feed b
Cargo = Potential – Feed b
Cargo = 1000ha - 89.3206699ha Feed b
= 910.6793301ha + 89.3206699ha Feed b
x 385kg/ha x 395kg/ha
= 350,611.5421kg + 35,281.66461kg = 385,893.2067kg Load
/350 = 1102.552019 wagon loads = negligible change in overall weight with 0.4g decrease in wheat from a reduction of 0.01m^2

4.2.2 Transport modelling: The Novae-Nicopolis survey

I have shown in Chapter Three how the legionary garrison at Novae together with part of the *cohors II Mattiacorum*, and a nominal 7520 service providers together with their attendant farm workers, would have required the arable product of 23,299ha. Table T.3.2.1a refers. It is assumed that the farmers who worked this land consumed their food at source so that only 18,097ha of the calculated requirement, i.e. 77.673%, was required to be moved to garrison.

Conrad's and Poulter's surveys together showed a combined potential of 39,185ha.[990] Because only 18,097ha 77.673% of the total needs would have been required to have been moved to garrison, it is also suggested that only 77.673% of the total potential seen, 30,436ha would have been available to either the garrison or as a surplus, the remainder being available in the first instance to their farm workers but thereafter to the indigenous population, the majority of whose arable activity has gone un-reported. The potential allocated to sites previously in Chapter Three assumed alternate fallowing, yet when dealing with transportation it is the annual need which would have had to be moved, and therefore I halved both the garrison's transport needs to 9049ha and the arable potential to 15,218ha.

The survey of roads above has shown an absence of visible routes from the agricultural hinterland of Novae and Nicopolis to the fortress itself. Because of this and the nature of the terrain, pack and draft animals may have moved goods directly overland. Therefore, producing radii about Novae looked to present the easiest way of assessing the travelling costs in the first instance. Firstly, it was observed that the small 61ha need associated with Sexaginta Prista could be easily met within a

[990] Chapter Three, p.162.

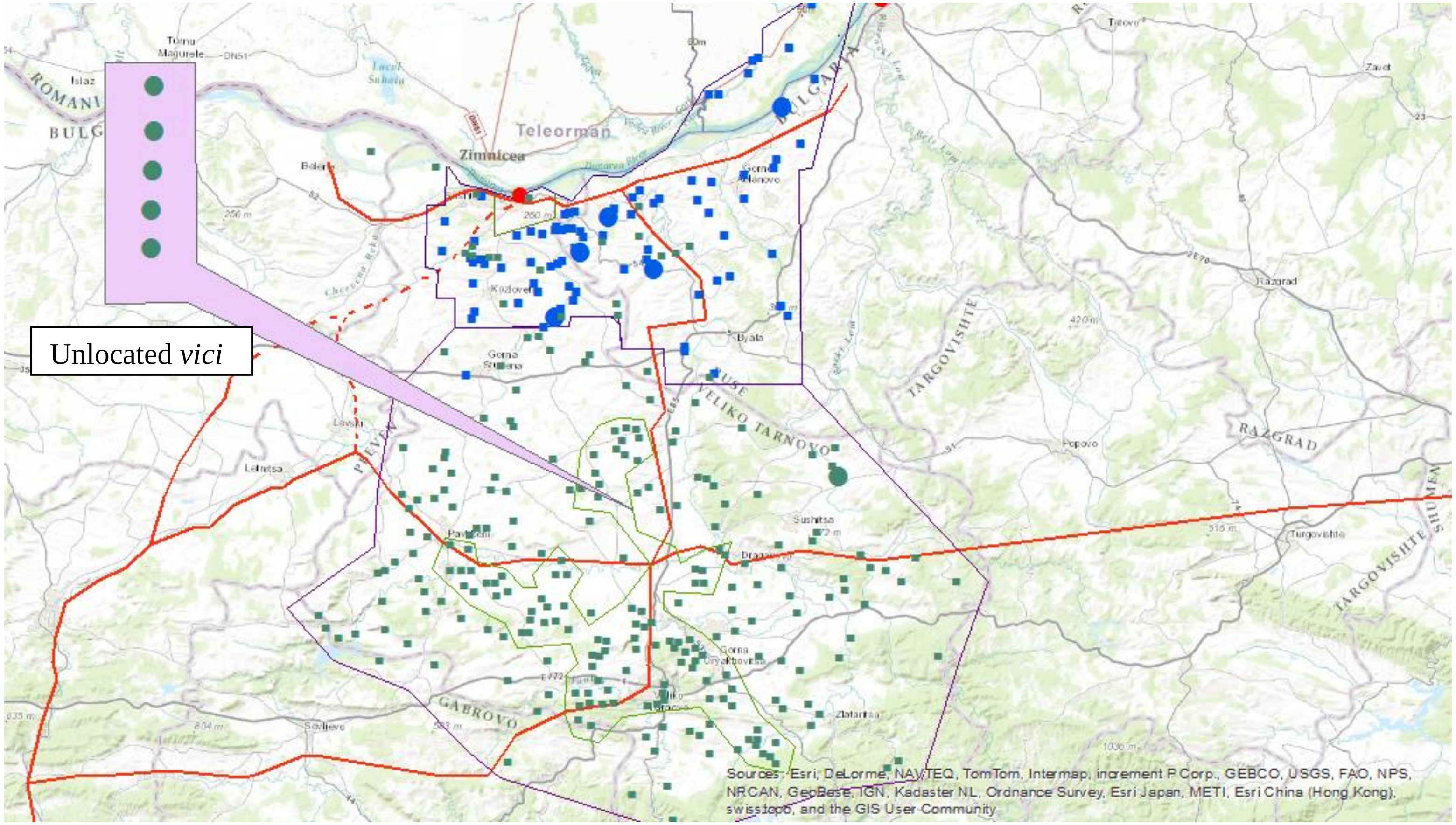

Fig 4.2.2.1 Conrad's and Poulter's surveys

single travelling day by any model, see Fig 4.2.2.2 below. Thereafter, radii at 23km intervals were produced and the number of sites falling within each radius counted. The full calculations are at Appendix B.1-4. Problems were encountered in that Conrad had allocated specific arable areas to some but not all of his sites.[991] It was therefore necessary to apply percentages of his total suggested landholdings to groups of his sites. The unknown location of five epigraphically attested *vici* in Poulter's study area required that these were arbitrarily located in the middle distance of each model. See Fig 4.2.2.1. The calculations arrived at a need for 102 or 91 wagons at work *pa* in the 23km and 32km oxen-drawn wagon models, with a 5822-5860ha surplus remaining. In the case of mule-drawn wagons, because of the greater distances that could be covered, sufficient potential to feed the full garrison was available within a single day's travelling. The available surplus was reduced to 5281ha because of the need for more feed-barley, but the number of wagons would have been reduced to 73. Mule-trains consisting of eight mules carrying a 560kg load, less feed-barley, were more efficient, as a result the surplus of 5634ha was closer to that of the oxen-drawn vehicles than the mule-drawn carts, but with fewer vehicles required, a mere 44 mule-trains.

Beyond simple cross-country travel, there were the two possible roads between Novae and Nicopolis: the western route proposed from the Novae-Melta road south along the Osam river and then east along the Rositsa river, a distance of 85km, and the eastern route by the Yantra river of 70km. Using these routes, Service Areas of 23km, 32km and 50km were produced, Figs 4.2.2.3-5 and Appendix B.5-8 refer. In all cases because the travelling distances were greater, the

[991] Chapter Three, p.147

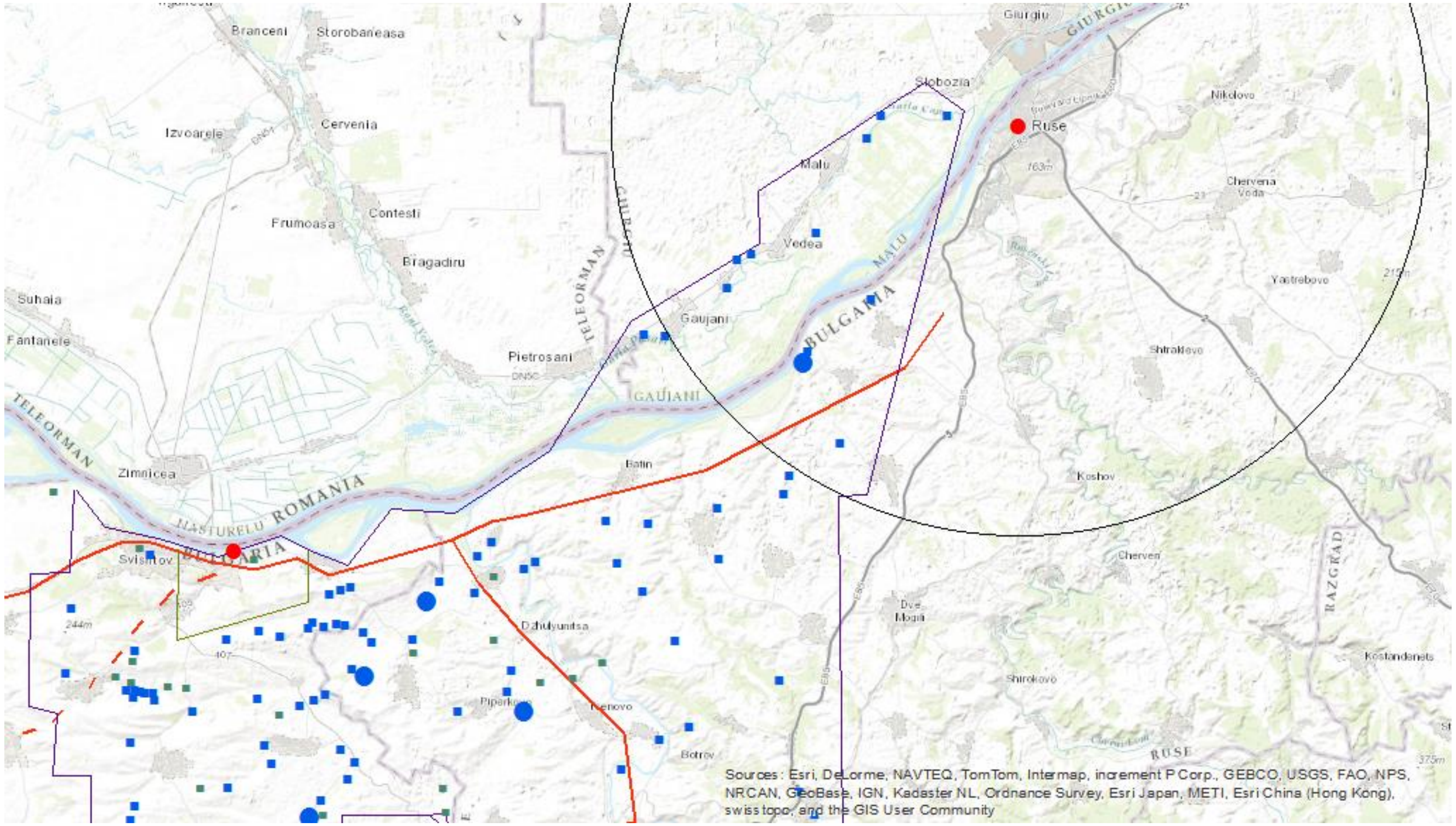

Fig 4.2.2.2: Sites within 23km of Sexaginta Prista

surplus after feed-barley was smaller and the number of vehicles greater. 133 and 109 wagons would have been required respectively in the 23km and 32km models. There would have been a need for 101 mule-drawn wagons and 58 mule-trains. Table 4.2.2.1 below refers.

Table 4.2.2.1: % Surplus available and vehicles required, Novae-Nicopolis

Model	% surplus	Vehicles required
Direct routes across country calculated using radii		
23km Oxen-drawn wagon	+ 64.35%	102
32km Oxen-drawn wagon	+ 64.76%	91
50km Mule-drawn wagon	+ 58.36%	73
50km Mule-trains	+ 62.27%	44
According to road network calculated using Service Areas		
23km Oxen-drawn wagon	+ 63.17%	133
32km Oxen-drawn wagon	+ 64.07%	109
50km Mule-drawn wagon	+ 54.64%	101
50km Mule-trains	+ 60.37%	58

The summary table illustrates how the faster moving oxen-drawn wagons required fewer wagons at work and allowed a greater surplus than the slower 23km oxen-drawn wagons. The use of mule-trains decreased the surplus available and the use of mule-drawn wagons decreased it further, so that these were more burdensome on the local arable potential. This was most marked in the case of the mule-drawn wagons travelling according to the Service Areas, where the need to accommodate a second day's feed significantly reduced the effective cargo and so increased the overall number of wagons required as well.

These calculations indicate the scale of the logistical task that a single legion brought with it, assuming sufficient arable was available within a few travelling days. Roughly 100-130 oxen-drawn wagons or about 50 mule-trains could have

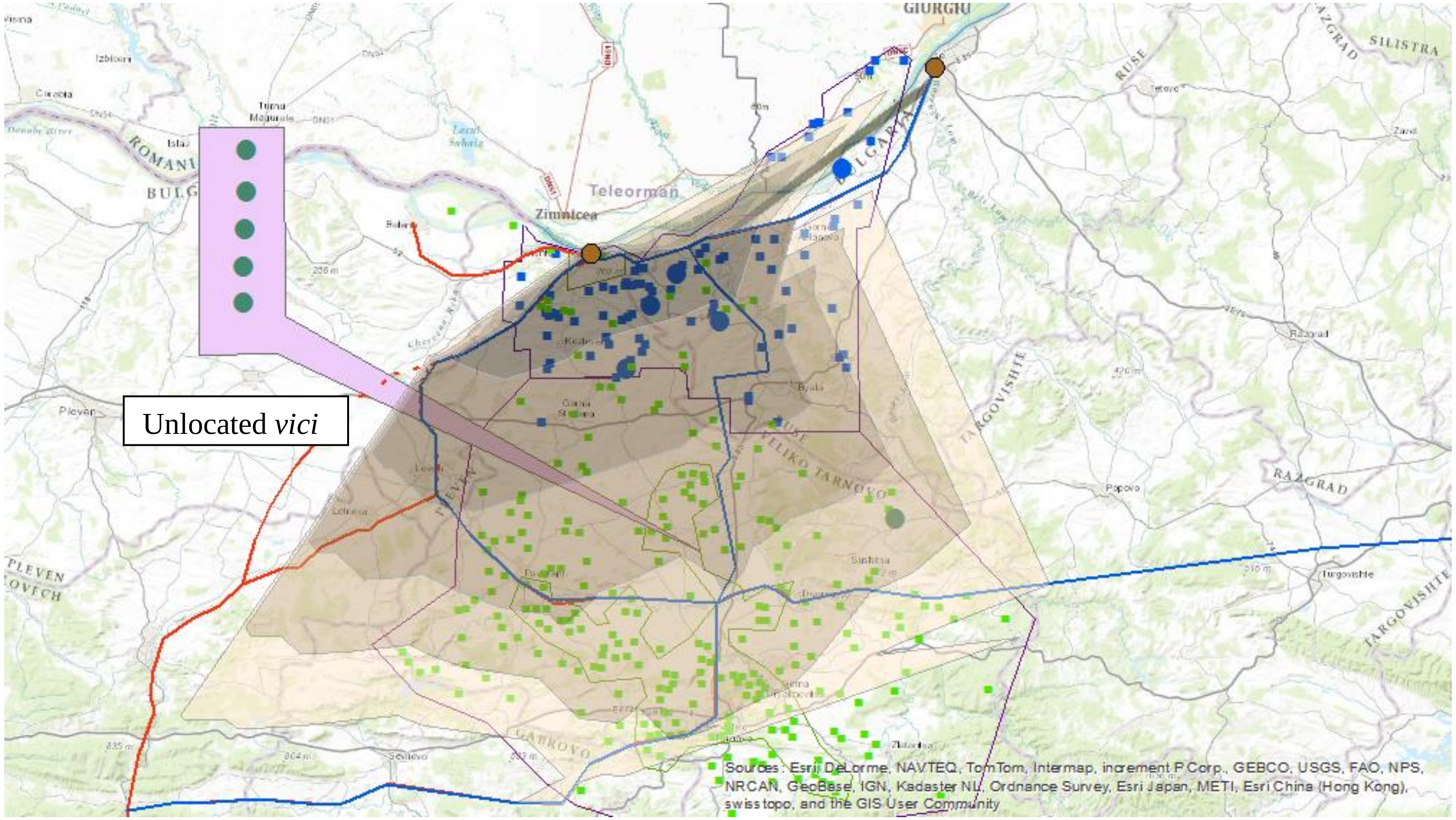

Fig 4.2.2.3: 23km Service Areas, Novae-Nicopolis

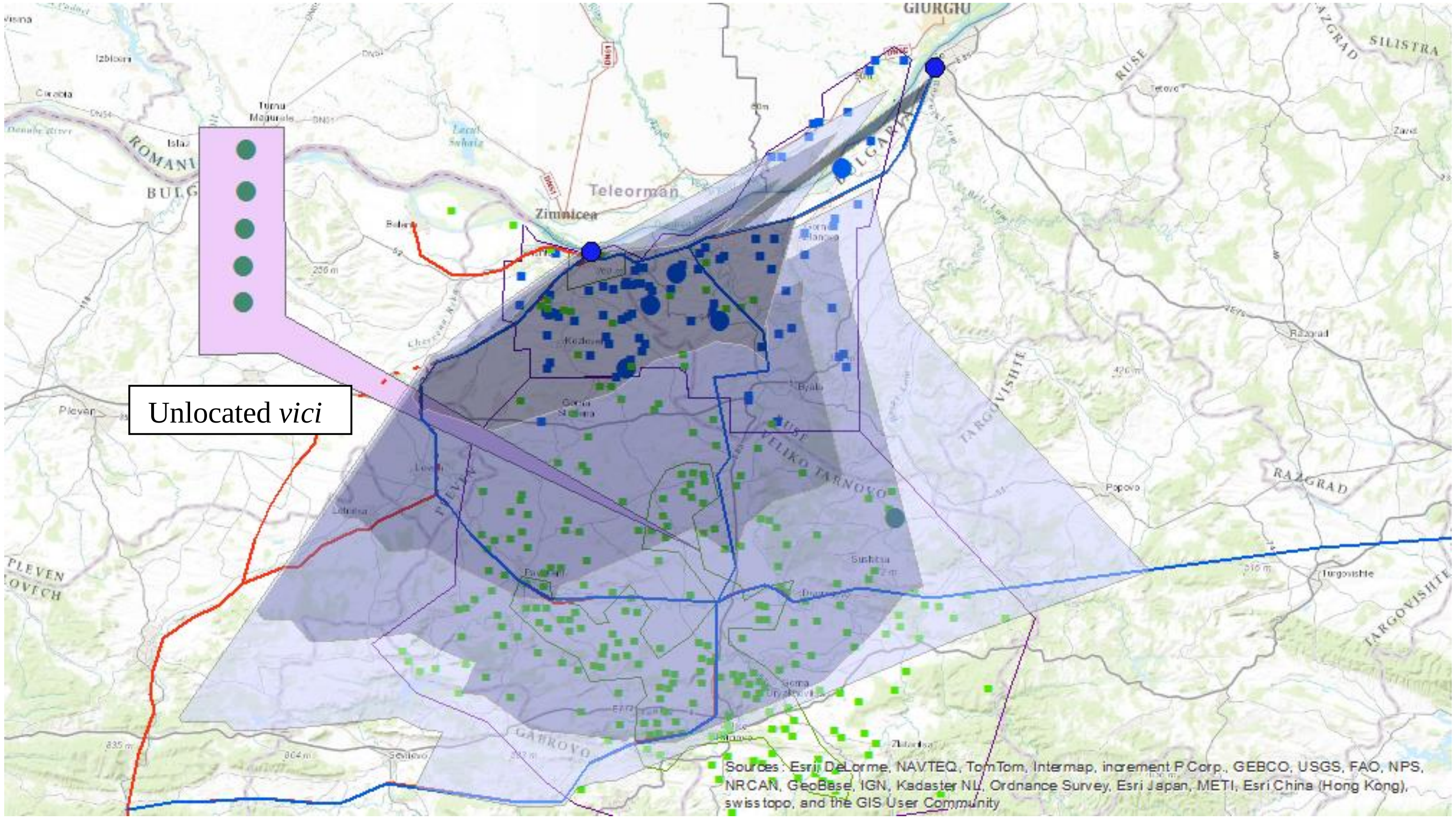

Fig 4.2.2.4: 32km Service Areas, Novae-Nicopolis

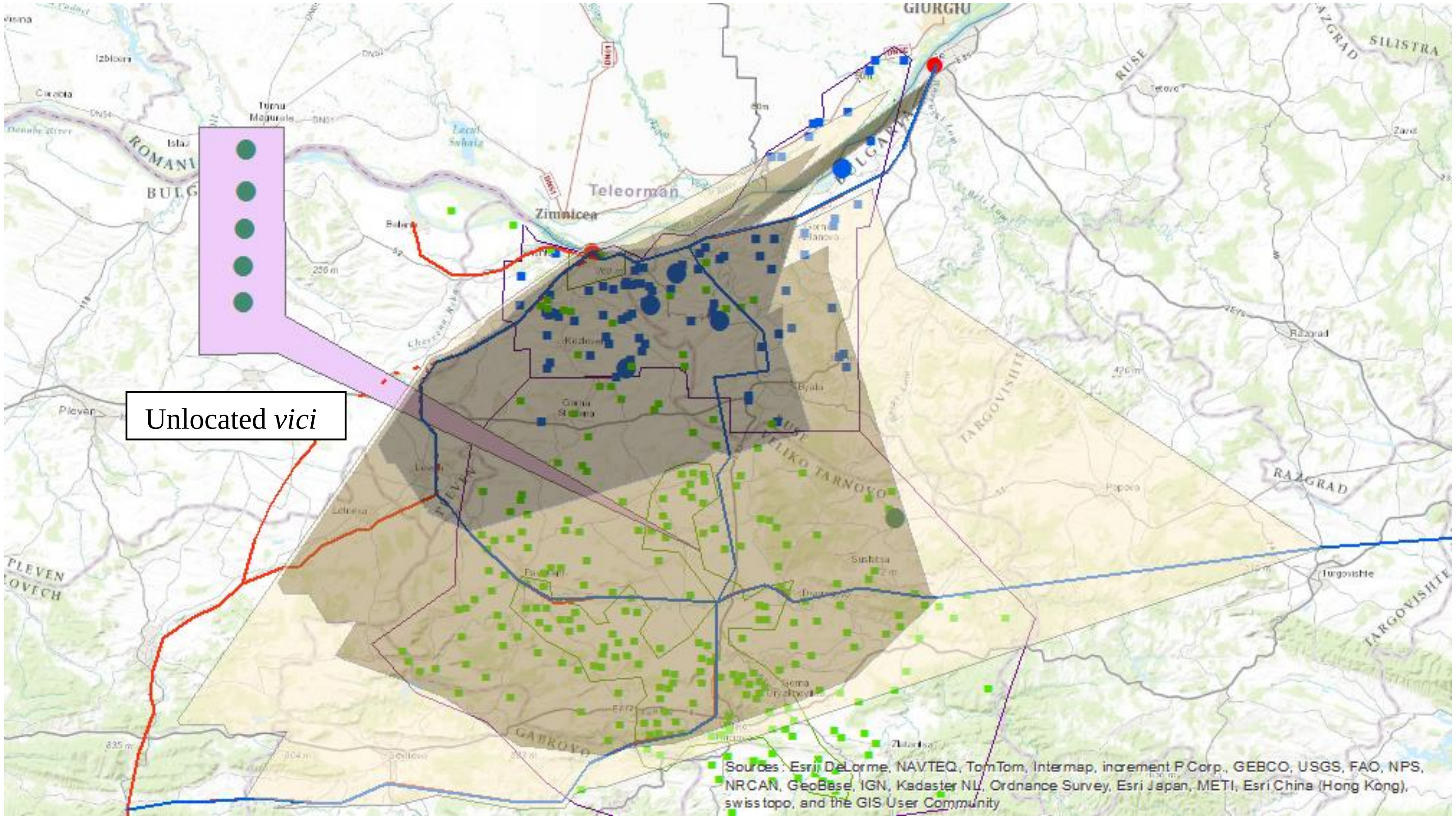

Fig 4.2.2.5: 50km Service Areas, Novae-Nicopolis

supported a legion for a year. This does not seem to be a high logistical burden, especially in comparison with calculations by modern scholars of the number of vehicles required by a campaigning army, which run to thousands of animals per legion.[992] As far as the surpluses seen, these may have been directed elsewhere, for instance Dobrogea, where a shortfall is evident. This is speculative, but Hunt's *pridianum* does make reference to soldiers being absent from home-base dealing with the grain ships, *naves frumentarias*.[993] The text says that they were still in the province, but whether this was on the Danube or the Black Sea coast is unclear.[994]

4.2.3 Transport modelling: The Dobrogea survey

In Dobrogea, prior to using the Service Area function within ArcGIS, simple radii were produced to see which of the *vici* that were shown in Chapter Three to have been the chief producers of a surplus were within 23km and 32km of the *limes*. Excluding those *vici*, *canabae* and *municipia* actually adjacent to the forts, of 13 forts, Axiopolis, Troesmis, Arrubium, Dinogetia and [Barboşi] had no other *vici* within 23km radii; when it came to 32km radii only the latter three had no additional *vici*. This seems to affirm Poulter's long-standing idea of the *vici* having been established to feed the garrison.[995] However, simple radii did not allow for the density of the inland *vici,* or the other sites, against the differing garrison sizes and numbers of service providers at particular forts, neither did it take into account the

[992] On campaign, Peddie 1997a, p.50 suggests 1250 mules per legion; 1997b, pp.28-9, p.36, p.46 suggests 5000-6000 for the invasion of Britannia; Roth 1999, pp.82-3; considers others' estimates and suggests 1400 per legion; Kehne 2011, p.325 suggest 60,000 mules at work for the whole army *pa* – which appears to assume that all units had their campaign complement.
[993] *P.Lond*. 2851; Lepper & Frere 1988, p.244.
[994] Bounegru & Zahariade 1996, p.59 suggest they were on the Danube.
[995] Poulter 1980, pp.729-44.

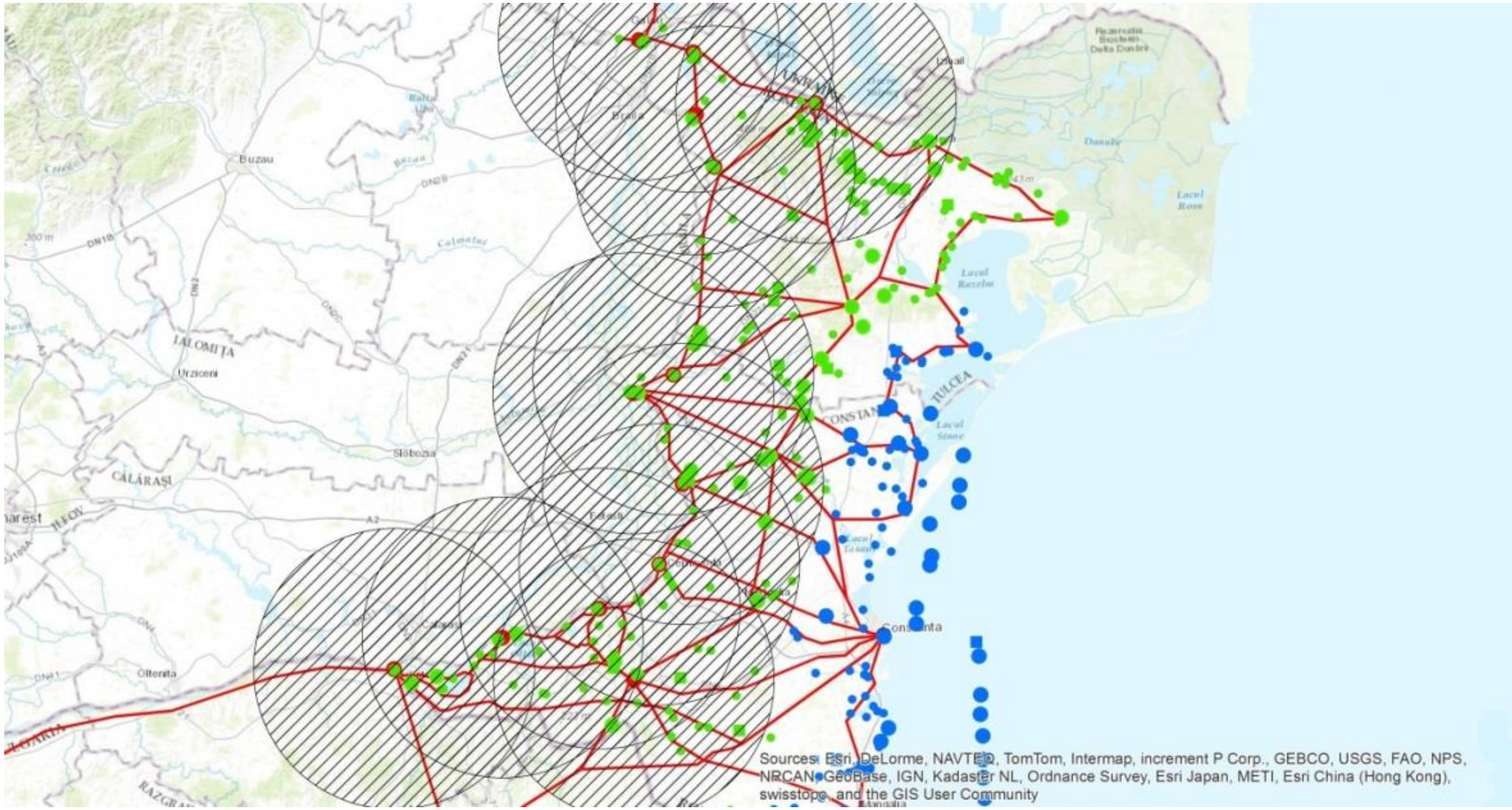

Fig 4.2.3.1: *vici* within 32km of *limes* forts, in Dobrogea

lie of the road network, and so begged the more sophisticated approach of Service Areas.

I have in Chapter Three estimated that the arable need of the Dobrogean garrison, their service providers and their attendant agricultural workers would have totaled 55,427ha of arable, Table T.3.3.1a refers. As with Novae-Nicopolis, I will reduce the figures to deal with only that part produced each year after alternate fallowing, and I will assume that the farmers consumed their food from the fields that they worked, so that their food did not require transportation. Therefore a revised figure for food to have been transported to the garrison and their service providers only is 21,326ha, 76.95% of the total annual need. In line with these reductions, it was necessary to reduce the arable potential that I have argued as being visible in Chapter Three by the same factors. It is stressed at this point that I have in Chapter Three argued for 76.35% of the total garrison's needs being visible in the archaeological record and that this figure is in no way related to the 76.95% part of the visible potential that I now argue would been required to have been moved. Thus, of the 76.35% of the 55,427ha needs of the garrison, service providers and farm labourers for both, that is 42,320ha argued to have been present in Dobrogea, half, 21,160ha, would have been productive in every year, and only 76.95% of this, the product of 16,283ha, is the part that I imagine to have been moved to the garrison and service providers whose needs without the agricultural workers were calculated at 21,326ha. The service providers were divided among the consumer sites according to the size of the known urban areas. Only Durostorum and Tropaeum Traiani have been excavated sufficiently to suggest populations, on the basis of the ground plans, of 5000 and a mere 800 individuals respectively.[996] In the former case, because Durostorum was on the edge of my survey area I only model a quarter of that town's population as being provided from my study area, so 1,250 civilians are allocated to Durostorum. Troesmis' urban area is not clearly defined, but the most recent survey suggests a 16ha *canabae* area; although this work does not identify the *municipium*, this figure is doubled to a best guess of 3,200 urbanites.[997] Thereafter the remainder was divided equally between the *canabae* of the other forts.

In the first instance, 23km Service Areas were produced, which were interrogated to count the number of sites within one day's travelling distance of the garrison, Fig 4.2.3.2 and Appendix C.1 refers. It was found that 68.69% of the needs of the southern garrison were available within a single day pointing to a rich arable zone close to the *limes,* which does accord with von-Thünen's theory. There was, none-the-less, a shortfall for all the forts except for Tropaeum-Traiani, so that 46km Service Areas were produced. This solved most of the need for Axiopolis by the inclusion of the product of the inland *vicus I Urb….* near Medgidia, with a very small quantity from the surplus evident at Tropaeum Traiani. Yet there was still an 1101ha shortfall across the remaining forts. This may have been met by the surplus seen in the first study area around Novae-Nicopolis, from further north in Dobrogea, or from overseas via the Black Sea ports, see Figs 4.2.3.3-4.

In the centre of Dobrogea, Fig 4.2.3.5, the considerable agricultural potential close to Capidava solved that garrison's need with a surplus that could have been directed to north or south. Fourteen *vici* were within 46km, that is two days' travel, of all three forts so that all their needs would have been met, including the sizable barley requirement for the *ala II Hispanorum Aravacorum* at Carsium.

[996] Chapter Three, pp.128-9.
[997] Alexandrescu & Gugl 2014: 296, 2016: 13-18.

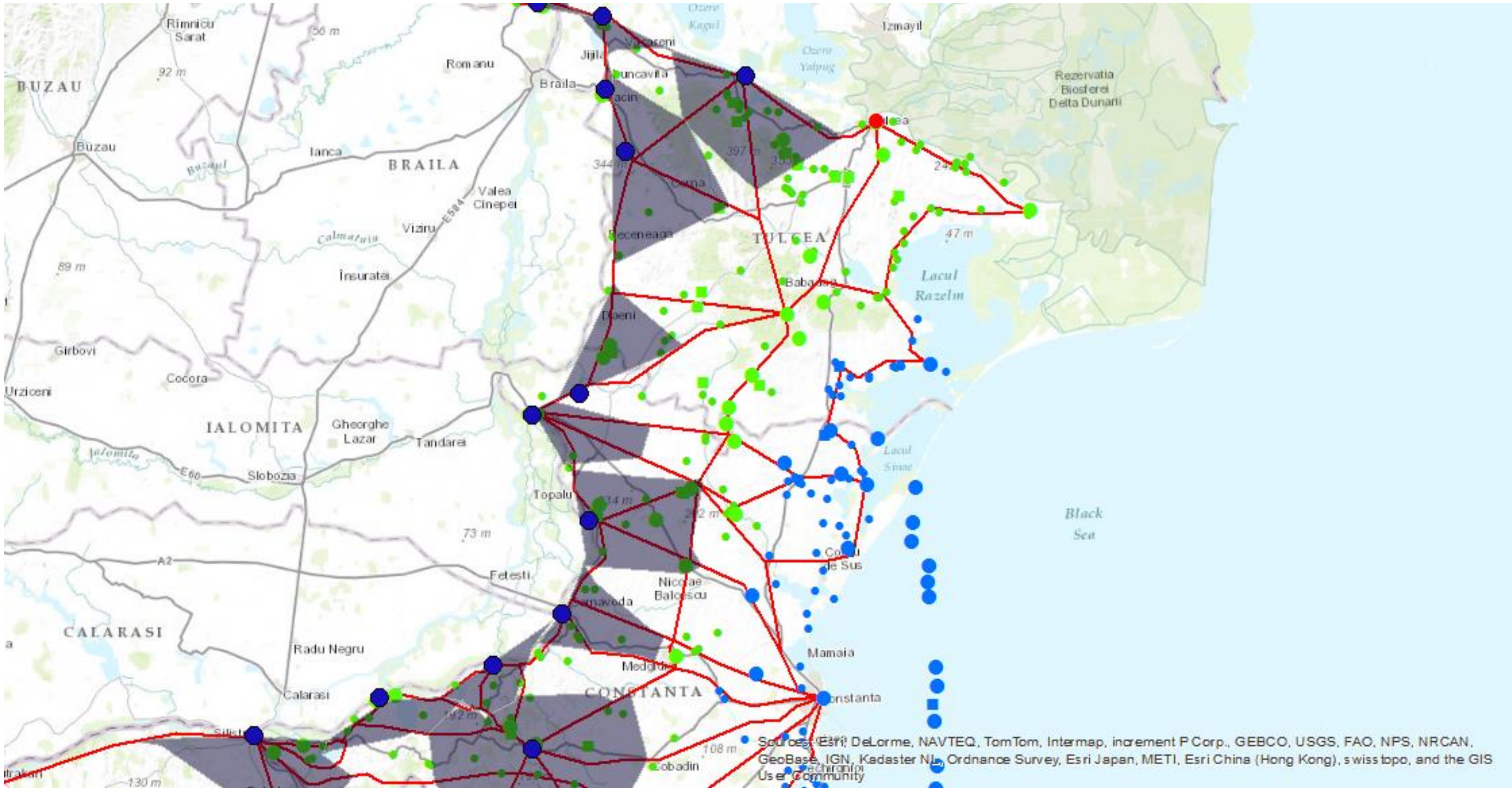

Fig 4.2.3.2: 23km Service Areas Dobrogea

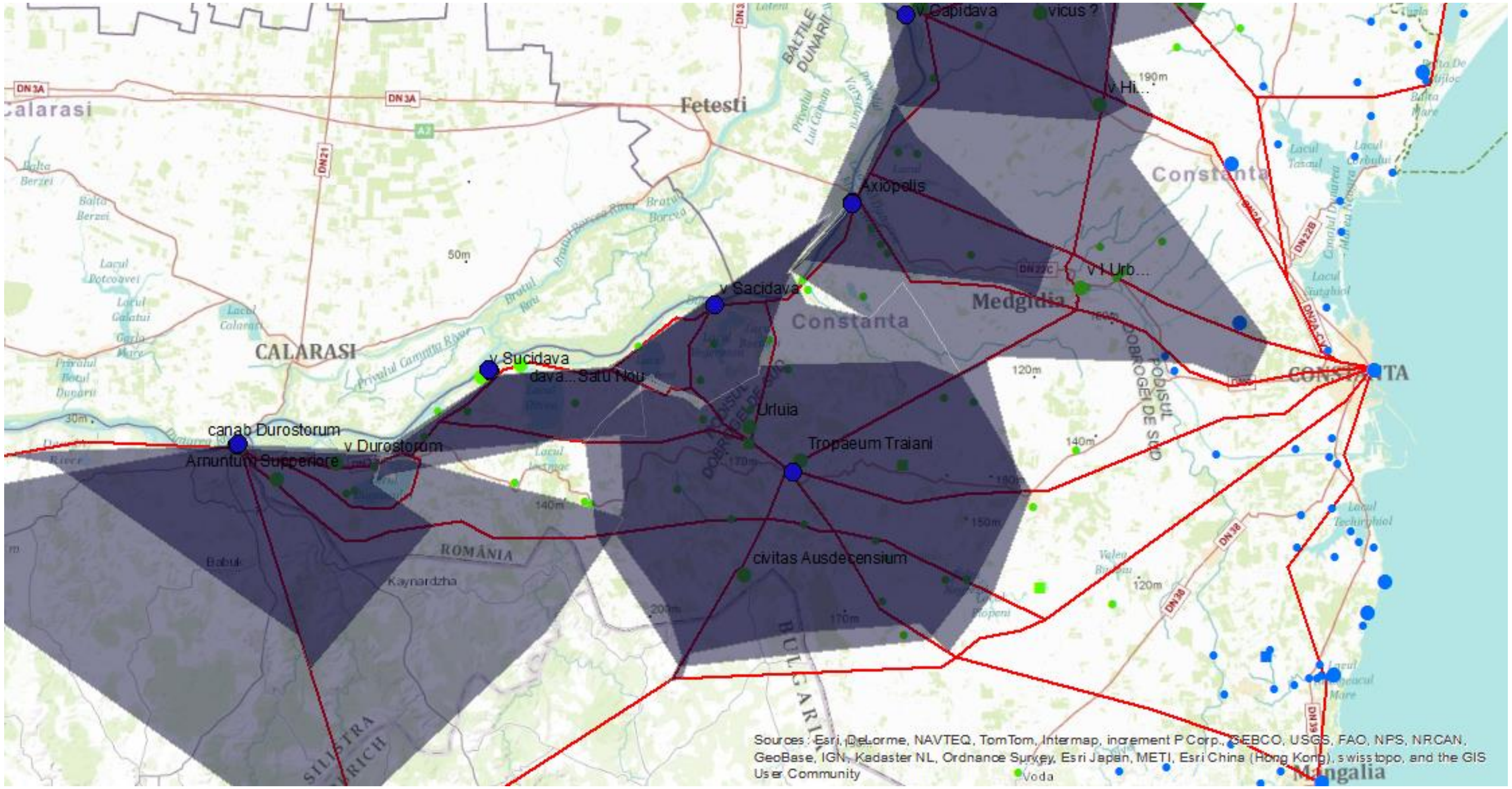

Fig 4.2.3.3: 23-46k Service Areas, Southern Dobrogea

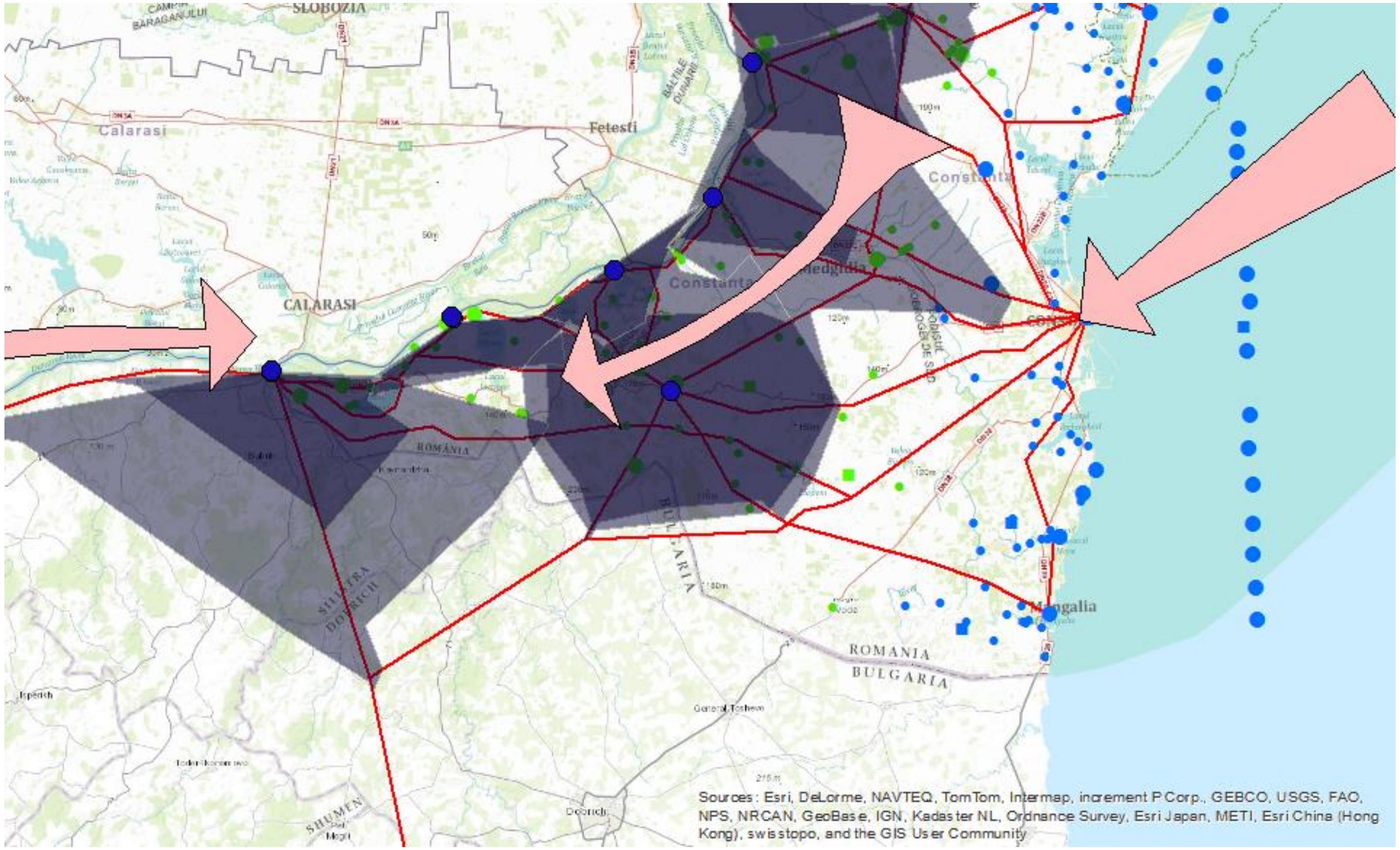

Fig 4.2.3.4: Possible Long-distance Solutions, Southern Dobrogea

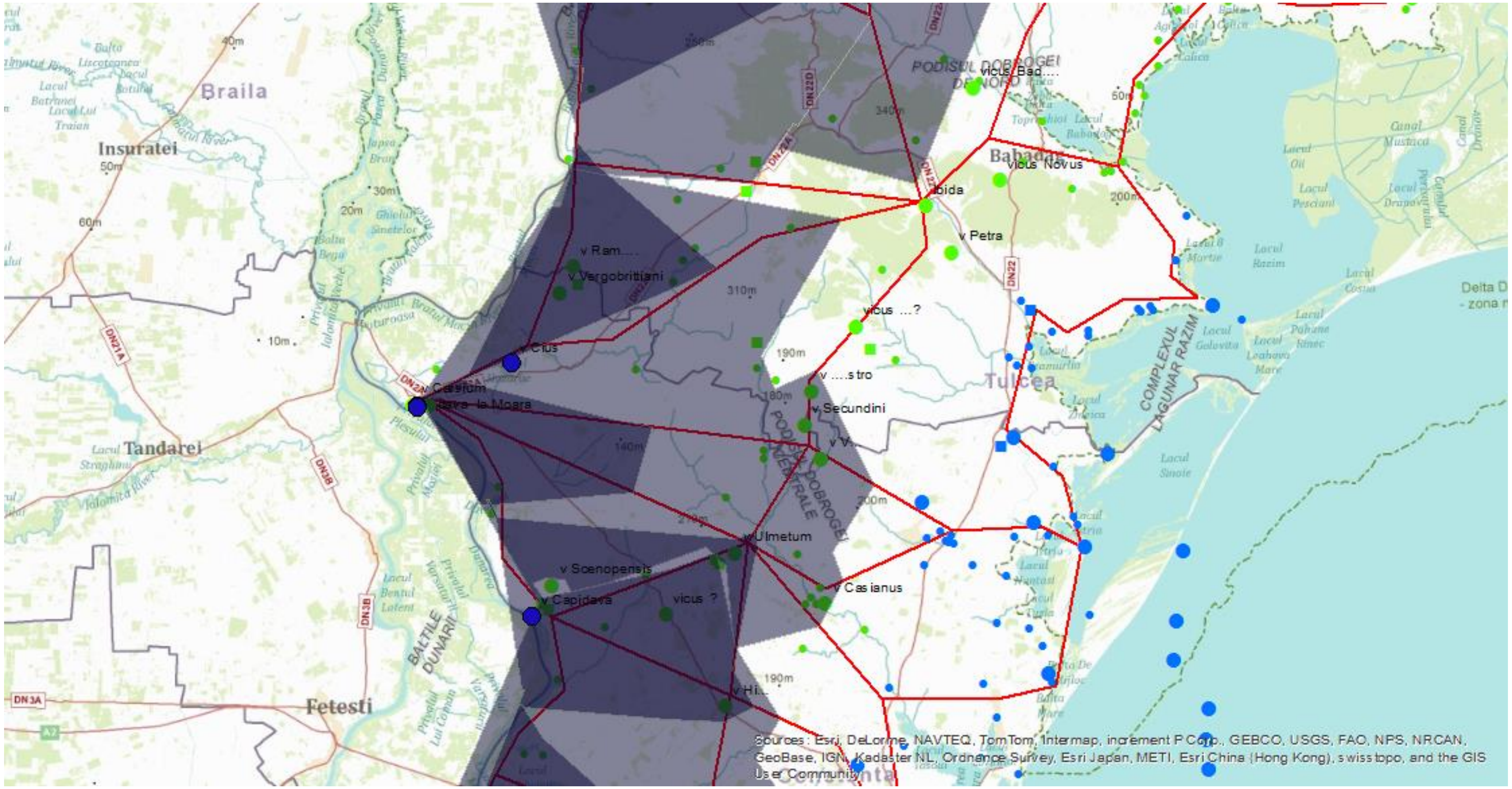

Fig 4.2.3.5: 23km Service Areas, Central Dobrogea

It was in the north, Fig 4.2.3.6, that the greatest shortfall in agricultural potential has already been identified in Chapter Three. Because of Troesmis' position on the road network, it lay between many of the producer sites and the forts at Arrubium, Dinogetia and [Barboşi] so that the needs of these latter forts could not be met in the first iteration of the model while Troesmis took precedence. ArcGIS was manipulated so that overlapping service areas were produced. It was possible to solve the needs of the fleet at Noviodunum within two days, in large part because of the high density of settlement along the Teliţa river valley, so that some sites, although closer to Noviodunum, could still have been supplying Troesmis within two travelling days. Then the surplus seen after two days at Noviodunum was directed to Dinogetia where the needs were met in total, together with part of [Barboşi's] and Arrubium's needs. It is acknowledged that the suggested solutions are here the most questionable for several reasons: the fleet element is estimated as 1,200 men at Noviodunum, but the fleet by its nature was mobile so that many of the sailors can be expected to have been absent with their needs being met from elsewhere. Similarly, the large barley need of the *ala I Vespasiana Dardanorum* at Arrubium would have been met by the cavalry moving to collect their food from distribution centres. Since a horse can comfortably travel 50km in a day, they could have easily collected their own food from Noviodunum or elsewhere. There is good evidence of cavalry units collecting supplies directly from villages in Egypt.[998] Finally [Barboşi] would, on account of its location on the far bank of the Danube, have required some cross-river supply, and its provisioning may have been linked to that of the fleet. However, the calculated need at [Barboşi] is only just not met,

[998] *P.Amh* II.107; Adams 1999, p.120.

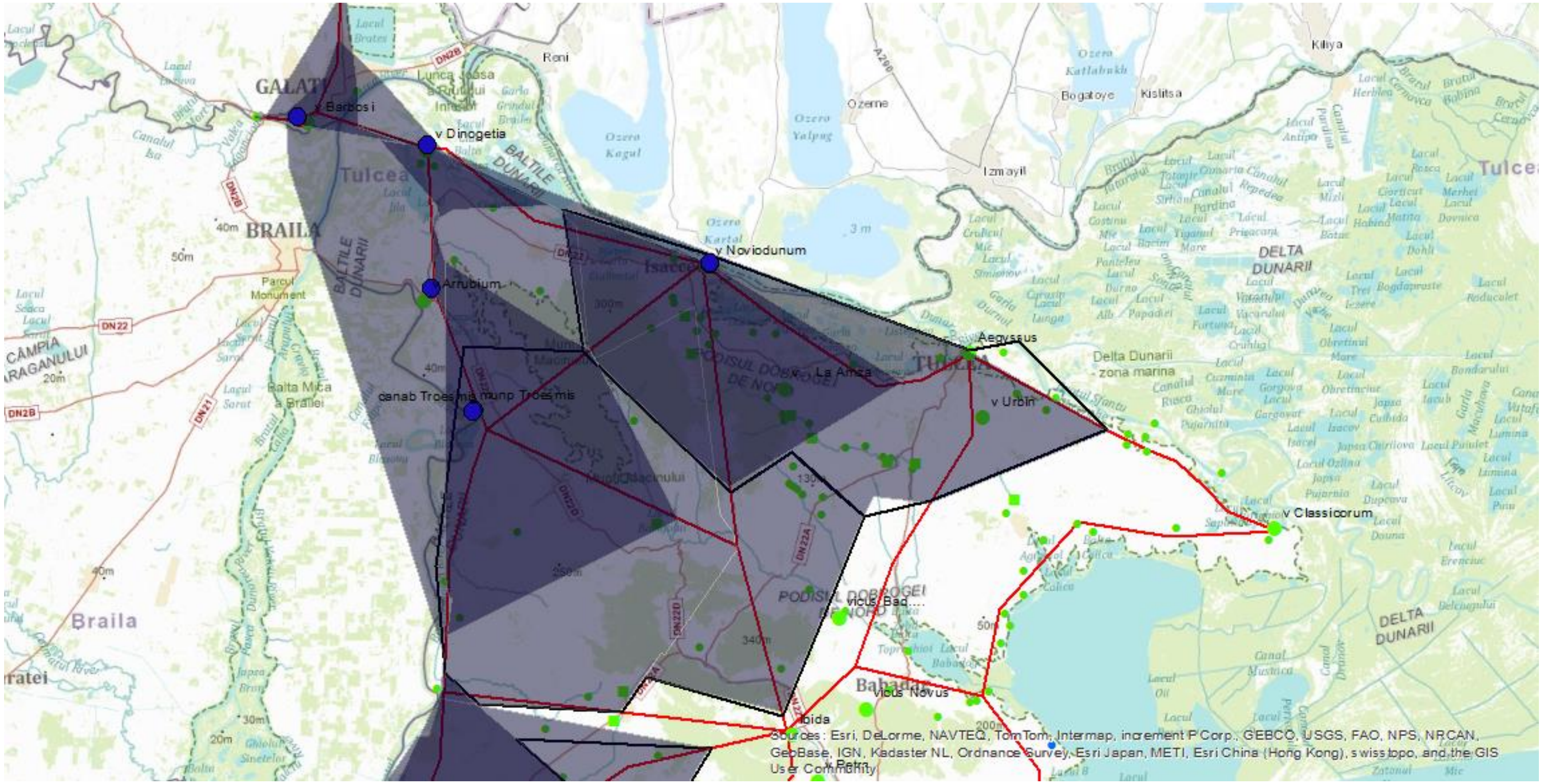

Fig 4.2.3.6: 23km Service Areas, Northern Dobrogea

Black lines show suggested 46km demarcation between Troesmis and Noviodunum chiefly because of the arbitrary and high figure of 867 service providers allocated to the fort that is in stark contrast to the small suggested garrison of 136 men. Were the number of service providers lower or the *vicus* at [Barboşi] more productive than the average figure of 960ha I have used throughout, then the troops here could potentially have been fed from the area within the demarcated ramparts. After three travelling days it was impossible to discern which of Arrubium or Troesmis were closer to particular production sites, so that arable was arbitrarily divided between the pair. Similarly, the surplus from Capidava and Carsium was divided between the two northern consumers but with differing travelling days. For the needs of the northern element of the garrison only 23.97% was within a single day, with no regular pattern thereafter, and 40.23% equating to 4706ha would have required a long-distance solution. Table 4.2.3.1 refers. What is also evident from the pictorial representation, Fig 4.2.3.7, is that many of the sites that I have allocated to the *poleis* zone, most obviously those close to Histria, also fell within 69km and especially 92km of Troesmis and could therefore have provided food to the garrison after three or four days, depending on the needs of the *poleis* which have been discussed in Chapter Three.

When the same calculations were run with 32km Service Areas, Appendix C.2, obviously more sites fell within a single day's travelling distance of the forts. In the south, all but three individual sites were within 32km of a garrison, while Tropaeum Traiani had a surplus after a single day. Therefore, 75.84% of the needs could have been met within a single day, and little more thereafter; the deficit was very similar to the 23km model because a similar quantity of feed-barley would

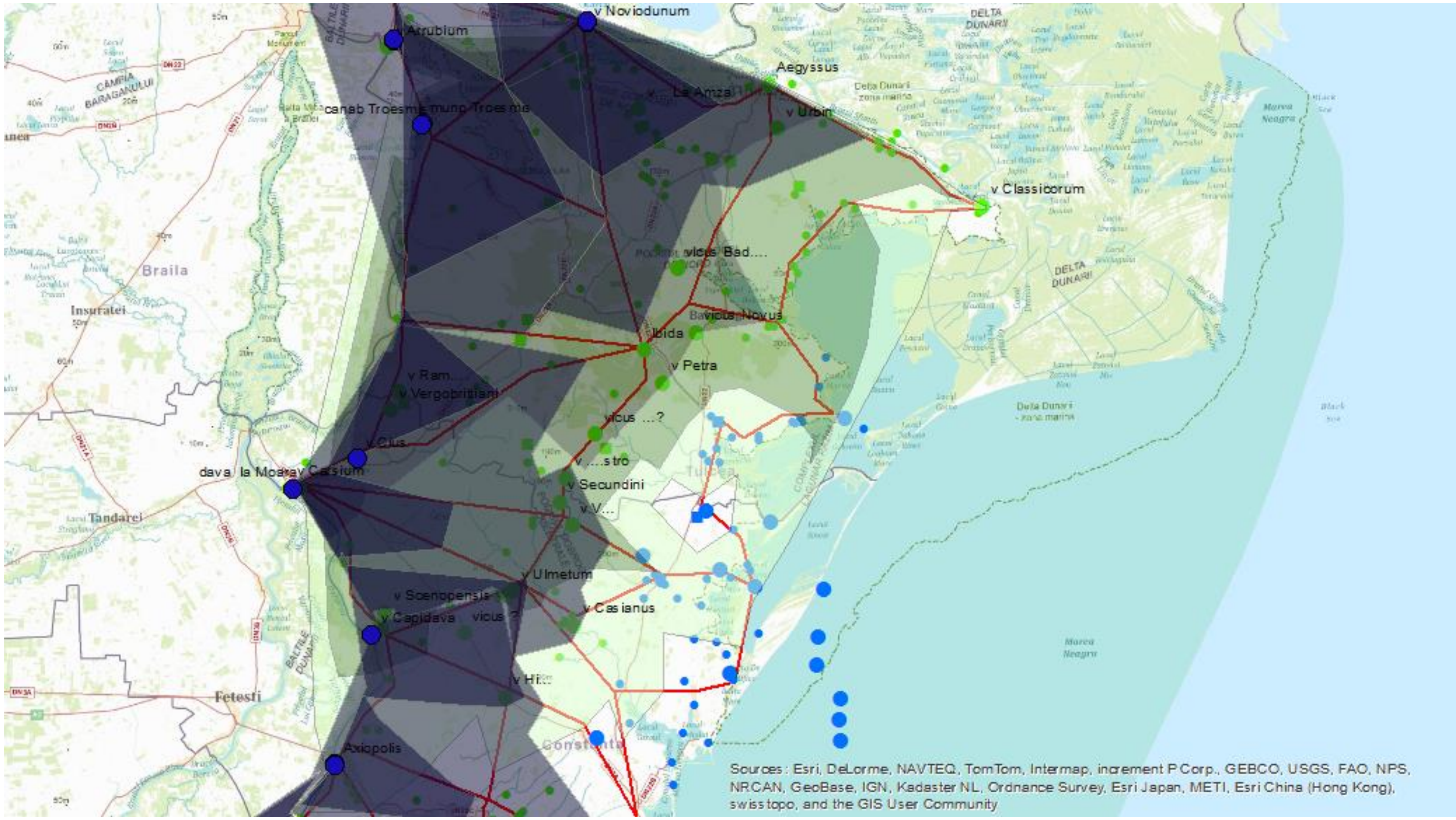

Fig 4.2.3.7: 23-46-69-92-115km Service Areas, North and Central

have been required. Once again, in the centre of Dobrogea the *vici* would have met the needs of the garrison there and provided a surplus. In the model I direct this north again where, as before, there was a shortfall, but the greater daily travelling distance resulted in the needs of Noviodunum being almost met within a single day. Many of the sites within two days of Noviodunum were within the same distance of Troesmis and Arrubium, so that it was necessary to overlay the service areas and to offer a demarcation between sites providing each site. A surplus from Noviodunum was within 96km, three days, of Dinogetia and [Barboşi] and in the model directed there. Again, the surpluses from Carsium and Capidava were divided between Troesmis and Arrubium equally, although in the latter case there was an additional travelling day. Still, a 39.39% deficit was evident in the north equating to 4608ha; the difference between this and the figure arrived at in the 23km model is explained by fewer wagon loads and so less feed-barley being required. All of this is speculative, but it offers an economic solution that results in the overall deficit being felt at Troesmis and Arrubium, which were better placed to be supplied from overseas than Dinogetia and [Barboşi]. Figs 4.2.3.8-10 refer.

When the whole of Dobrogea is considered in both the 23km and 32km models, in the south and centre the majority of the need was moved within a single day, while in the north significant quantities of the potential available were still travelling on the latter days; Table 4.2.3.1 below refers. The total number of wagon days was divided by 300 working days to arrive at only 191-223 oxen-drawn wagons at work *pa*. This is really a very low figure considering that 12,827 men were in garrison across 10 military sites; in very broad terms a wagon was at work

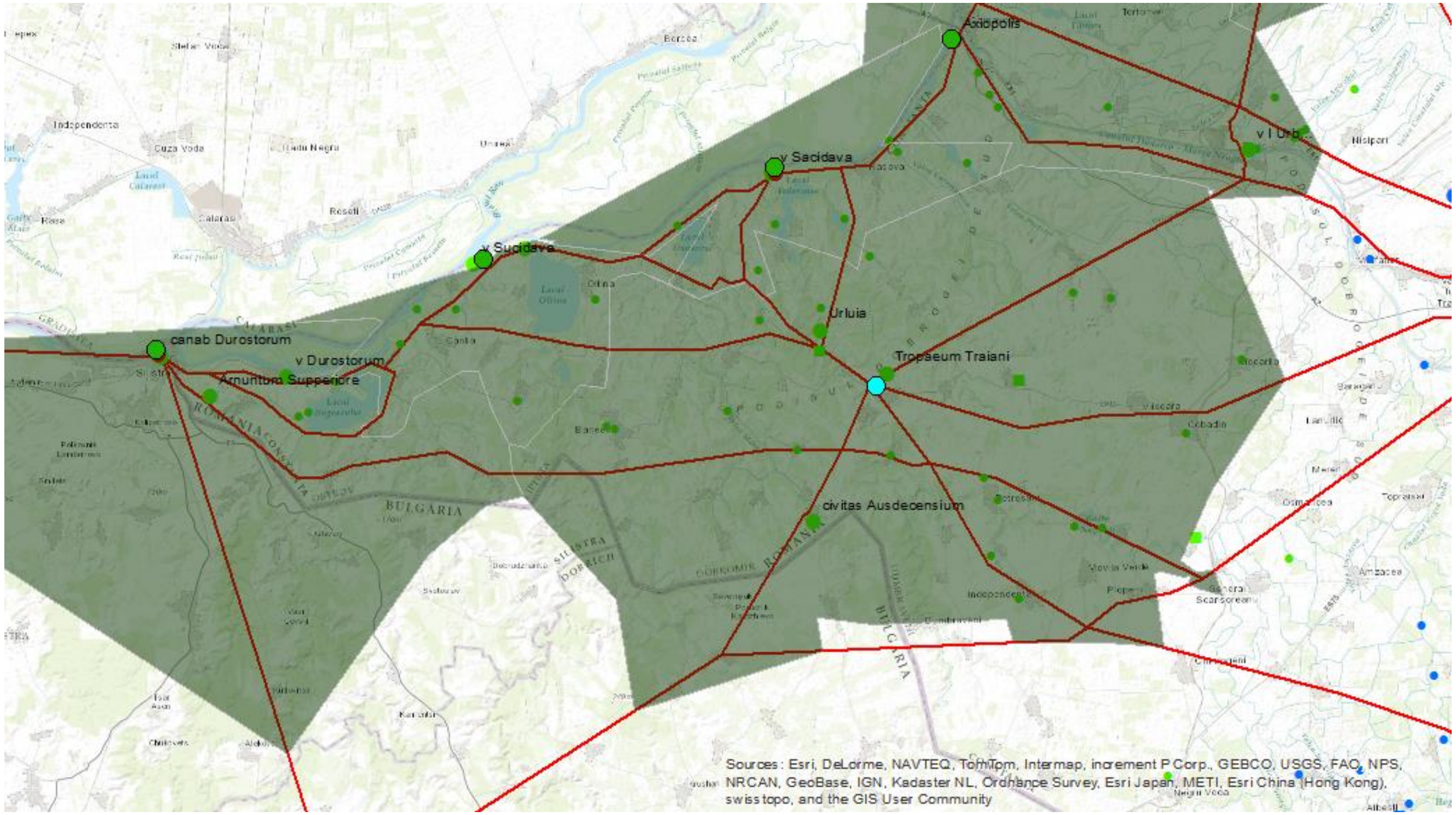

Fig 4.2.3.8: 32km Service Areas, Southern Dobrogea

throughout the year for every 57-67 soldiers. It also accords with the calculations for a single legion carried out at Novae-Nicopolis, where roughly 100-130 wagons were required to move the full requirements. The feed required for oxen increased the overall needs and so the deficit by 654-763ha or 3.07-3.58%, decreasing the quantity available to the garrison correspondingly. Table 4.2.3.2 below refers.

When the use of mules was considered, Fig 4.2.3.11, the 50km travelling distance for both wagons drawn by a team of eight mules and a train of eight pack-animals would have resulted in all of my suggested *limes* providing sites being within two days' distance of the garrison. The location of Troesmis would again have impacted on the availability of those sites to the north-west, so that the program was manipulated and some part of the surplus seen at Noviodunum was directed to Dinogetia and [Barboşi] on the second travelling day. Again, the potential from Cius and Capidava was divided between Troesmis and Arrubium, that from Capidava going to Troesmis, that from Cius going to Arrubium, so that each travelled the shorter distance. Of course there are countless permutations of which sites might have supplied which garrison in antiquity, and each would change the travelling days slightly. However, it was found through various iterations of the models pursued that such changes would not significantly alter the overall deficit or number of wagons required *pa*. Thus the models produced are thought to represent as efficient cases as can be discerned today. The feed-barley for the mules would have denuded the available arable to the garrison to a greater extent than that

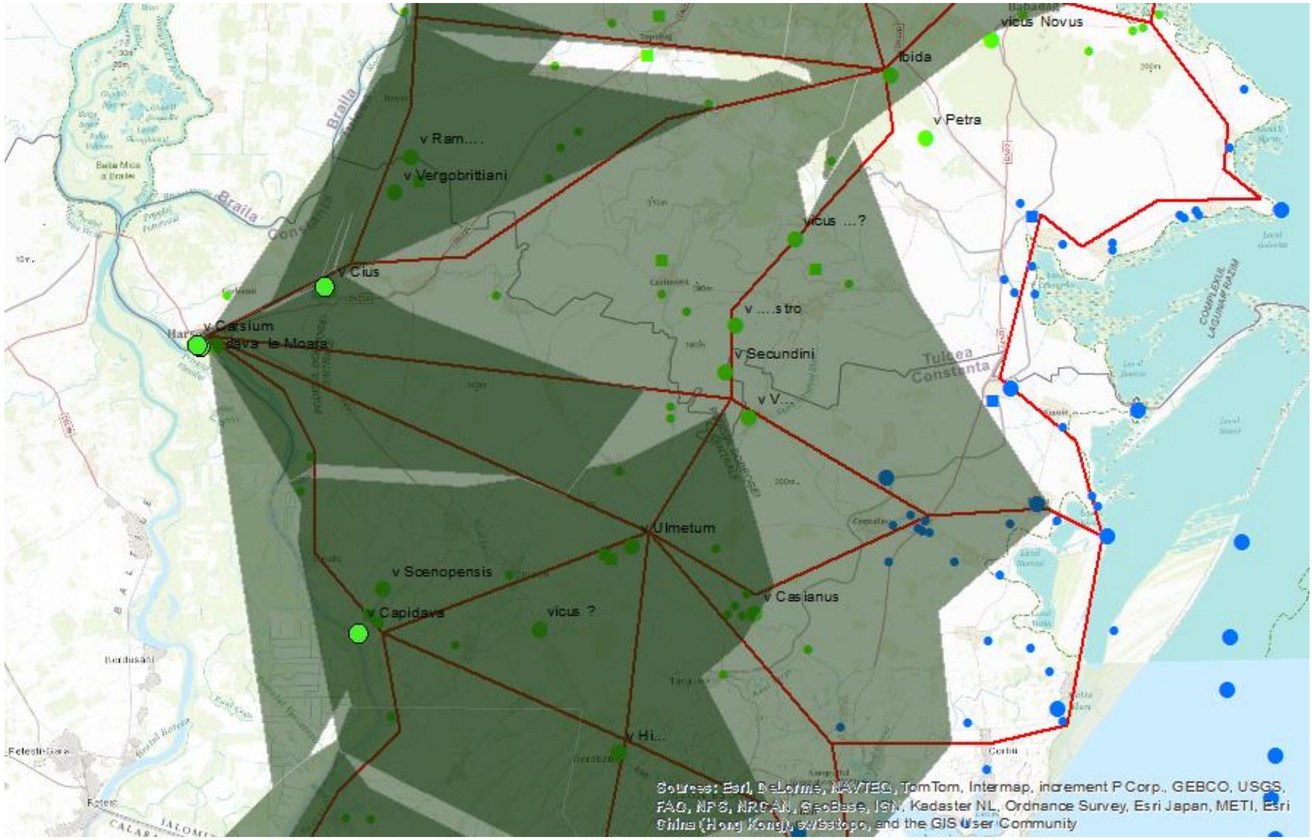

Fig 4.2.3.9: 32-64km Service Areas, Central Dobrogea

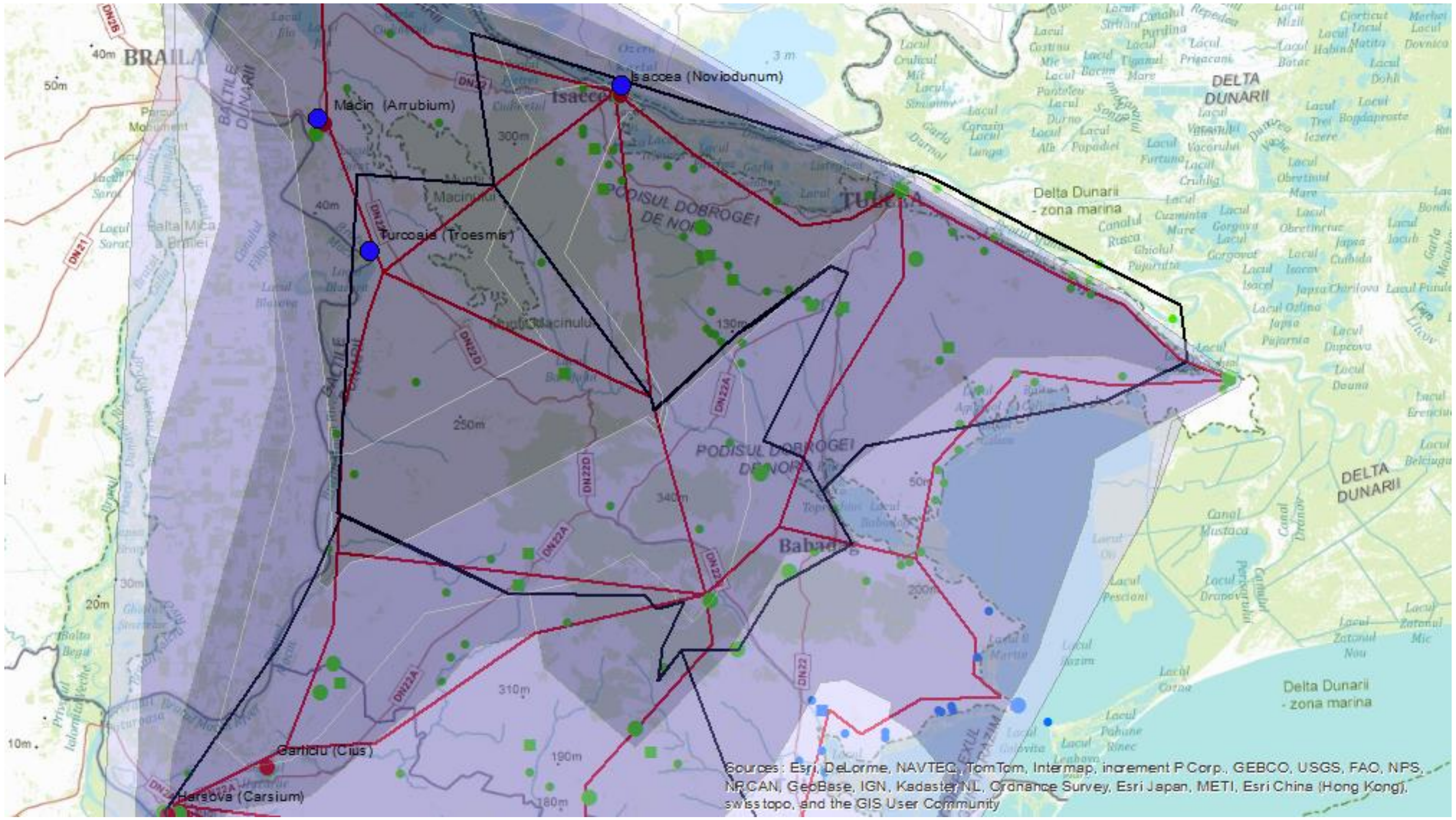

Fig 4.2.3.10: 32-64-96km Service Areas, Northern Dobrogea

Black lines indicate suggested division between Noviodunum and Troesmis with Arrubium calculated for oxen; the carrying capacity of the wagons was reduced by 32kg for each return travelling day. A starting assumption was that the feed-barley came from Dobrogea, rather than import barley to feed animals moving the food. This is a problem of modern logistics, where the fuel, the modern equivalent of feed, also has to be moved into an operating area. Yet, when the long-distance component is considered below, it will be shown to have been preferable to ship in additional feed-barley to move at least the long-distance component of the necessary supplies. It was found in the scenario tested with mule-drawn wagons that in the north especially the deficit now became significant, 46.82% of the original needs, because of the much greater requirement for feed-barley. For the whole of Dobrogea the feed-barley needs of the mules pulling wagons amounted to 1800ha, adding another 8.44% to the arable needs of the garrison and their service providers, so that the deficit for the whole of Dobrogea was 32.09% of the original needs. Because of the increased daily distance travelled, the total number of mule-drawn wagons required was lower than oxen-drawn wagons, 148 as opposed to the 191-223 calculated for oxen. Appendix C.3 refers.

Mule-trains could carry more cargo 560kg, less feed, rather than 350kg load, less the feed, for a wagon, so that that they were obviously more efficient. Calculations at Appendix C.4 run a possible scenario, using the same divisions of potential as those used for mule-drawn wagons. Now, for the whole of Dobrogea only 1136ha would have been required for feed-barley, a 5.33% increase in the needs, still increasing the size of the deficit but only to 28.98% of the original

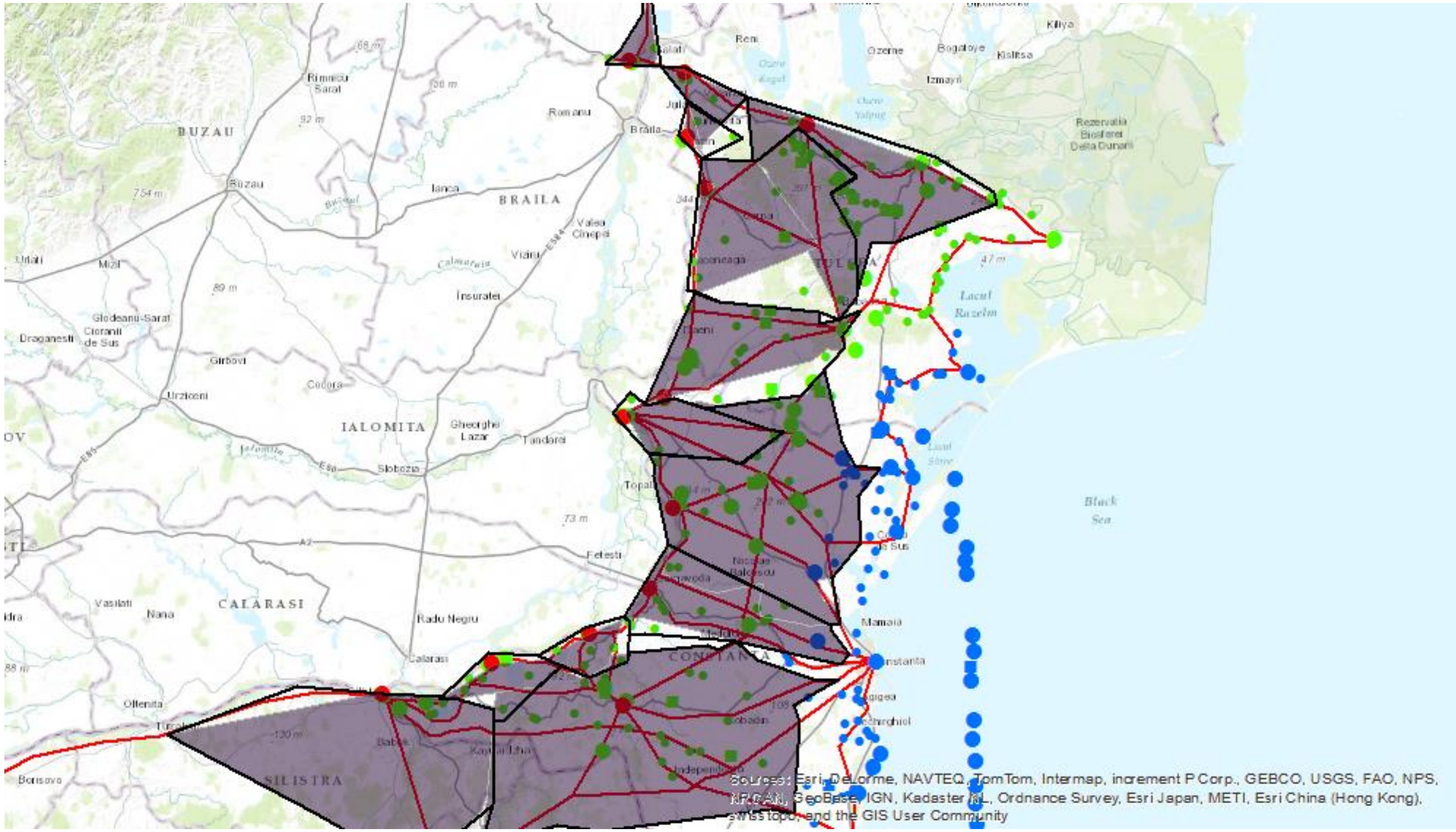

Fig 4.2.3.11: 50km Service Areas, Dobrogea

Black lines show suggested 50km demarcation between sites requirement. The total number of mule-trains required would have been 94, half the number of oxen-drawn wagons. So, in both cases the increase in the logistical footprint in terms of feed-barley would have been offset by the increased speed and lower number of vehicles and also drivers required.

The four suggested models are compared in Table 4.2.3.2 below. It is clear that the smallest increase in needs, and so the smallest deficit, would be arrived at by the use of oxen-drawn wagons, travelling at the faster speed of 32km a day, whereas mule-trains only used 1.74 times as much feed and so produced a slightly larger deficit, 28.98%, for half as many vehicles at work. Therefore, mule-trains ought to have been preferred, especially because wagons were an expensive piece of technical equipment that would have required upkeep whereas single mules might more easily have come within the financial reach of small farmers. Although modelling has been done with teams of eight mules for comparative purposes, for an individual producer one or two mules might have met his needs in total, without needing to employ carters and so reduce costs.[999] However, one ought to also consider that oxen might have been preferred as plough animals and then doubled as draught animals, despite needing a greater green-fodder crop. So, without a greater understanding of farm practices in the region it is difficult to say which would have been preferred. Mule-drawn wagons were the least economical in terms of the increase in deficit against the number of vehicles required.

I have assumed that any green-fodder crop was grown on arable land lying fallow. I have calculated that 382-446 oxen, 1184 mules drawing wagons, and 752 mules acting as pack animals would have been required. If my assumptions of 2000kg of vetch and a tonne of hay per hectare are correct, then 767-895ha for oxen

[999] Adams 2012, p.224.

consuming 11kg of vetch a day and 1372-2161ha for the mules consuming 5kg of hay would have sufficed.[1000] Therefore a small part of the land lying fallow in any given year could have easily provided these crops in both my study areas.

Table 4.2.3.1 below, shows that, in the south and centre of Dobrogea at least, the percentage of goods moving to the forts decreased with distance from the *limes*, this broadly agrees with von Thünen's theory. Yet, because of the lack of settlement in the north-west this pattern is not evident there, so that the army looks to have required a long-distance supply solution. When it comes to modelling long-distance supplies, there would have been an additional feed-barley requirement to move the overseas component once it arrived in Dobrogea. This would have increased the total quantity of grain that would have been required whether it was supplied from overseas or extracted from Dobrogea itself, and therefore the overall deficit will be seen to have increased further.

[1000] Chapter Two, p.76.

Table 4.2.3.1: % Arable available by travelling day

	One day	Two days	Three days	Four days	Five days	Long distance solution
23km oxen-drawn wagon						
South	68.69%	9.77%	0.93%	0.07%		20.54%
Centre	59.2%	40.8%				0%
North	23.97%	4.8%	16.78%	7.15%	7.07%	40.23%
Total	42.27%	13.26%	9.44%	3.94%	3.88%	27.23%
32km oxen-drawn wagon						
South	75.84%	3.77%	0.07%			20.32%
Centre	59.2%	40.8%				0%
North	27.73%	13.79%	11.71%	7.38%		39.39%
Total	46.12%	16.68%	6.44%	4.05%		26.71%
50km mule-drawn wagon						
South	74.44%	0.06%				25.5%
Centre	100%					0%
North	27%	26.17%				46.82%
Total	53.54%	14.37%				32.09%
50km mule-train						
South	77.19%	0.07%				22.75%
Centre	100%					
North	27.565%	30.025%				42.41%
Total	54.54%	16.49%				28.98%

Table 4.2.3.2: Comparison of transport methods

Model	% Deficit of original needs	% Increase in overall needs for feed-barley	Vehicles required
23km oxen-drawn wagon	- 27.23%	+ 3.58%	223
32km oxen-drawn wagon	- 26.71%	+ 3.07%	191
50k mule-drawn wagon	- 32.09%	+ 8.44%	148
50k mule-train	- 28.98%	+ 5.33%	94

Chapter Four, Section Three: Long-distance Modelling

4.3.1 Long-distance modelling: The Novae-Nicopolis survey

Although there was no arable shortfall in the first survey area around Novae and Nicopolis, long-distance supply of wine amphorae to Novae was evident. Therefore, it was decided to compare the relative merits of overland versus riverine transportation to this garrison, notwithstanding the sea-borne shipping costs which would have varied according to the origins of the amphorae. From a sample set of 86 amphorae at Novae, Klenina reports that 20% were of Aegean origin, 11% were Pontic, 2% Italian and 67% local.[1001] For 6100 men consuming half a litre of wine a day, the garrison would have required 1,113,250l *pa*, and if 20% of this were Aegean that is 222,650l, while if 11% were Pontic, 122,458l. I have only modelled the needs of the garrison; they will be seen to be considerable, so much so that it is difficult to imagine that the service providers commanded such resources to be shipped en-masse. Fermented wine weighs about 1kg per litre, depending on alcohol content. The most common Aegean type amphorae Kapitän II had a capacity of no more than 15l; of the Pontic types, many were of only 5l capacity, but Zeest 90 from both the Aegean and Pontus were of 40-59l capacity.[1002] This variation in capacity is problematic, because there are few references to the dry weight of amphorae. Some thinking is that in the case of the larger amphorae, the empty weight equaled half the full weight, which allowed for easy balancing of ship cargoes.[1003] Yet with smaller amphorae the weight looks to have dropped to only 35% of the whole.[1004] Therefore the calculations that follow start from an uncertain

[1001] Klenina 2005, p.410.
[1002] Dyczek 2001, p.140, p.182, p.214.
[1003] http://www.anticopedie.fr/dossiers/dossiers-gb/amphora.html accessed 18/11/15.
[1004] Peacock & Williams 1991, pp.51-2; Rathbone 1991, p.470.

position but I will assume for ease of calculations that the total load can be calculated as 1.5 times the liquid need, i.e. 333,975kg for the Aegean component and 183,686kg for the Pontic component.

It was approximately 240km from Odessus [Varna], 400km from Traianopolis [Alexandroupoli], and 560km from Amphipolis to Novae. The effective loads would have been reduced by a quantity of feed-barley, for each journey. Both the Aegean and Pontic component were divided by the effective load after feed-barley to arrive at a number of loads required and so a number of vehicles required *pa*. This is all laid out at Table T.4.3.1. The benefits of moving via Odessus are obvious: the number of vehicles required was lowest and also the least feed-barley was needed. In contrast, the number of vehicles required to move from Amphipolis especially seemed to tell against doing so. In the case of mule-drawn wagons via Amphipolis, the whole cargo capacity would have needed to be turned over to feed. The only option would have been to supply feed-barley en-route, but we have no evidence for this in the region. Long-distance pack trains are evidenced for the length of Gaul, so I am not suggesting that it was impossible to do so, simply costly.[1005] Furthermore the Haemus may have presented so significant a barrier that mules were slowed down by the climbs and travelling days increased even further. Because of these problems, although the sea-borne sailing time would have been longer, it was thought plausible that both Pontic and Aegean amphorae were shipped via Odessus. Equally, there would have been no merit to shipping Pontic wine via the Aegean ports and the vehicular requirements were not calculated in these cases. Even if all the wine travelled via Odessus, although the numbers of vehicles required to move the foreign wine are not high in absolute terms, if

[1005] Diodorus Siculus, 5.22.1.

compared with Table 4.2.2.1 they add a significant 74-106% increase to the number of vehicles required to supply the garrison at Novae. To do so via Traianopolis or Amphipolis resulted in increases of two to three times as many vehicles. This would have certainly made a local supply solution of wine preferable, except for the very best vintages, and this is borne out by the presence of locally produced amphorae from Butovo and Pavlikeni.[1006]

Were the Aegean component to have been shipped up-river, by a 20-tonne boat, then 17 sailings would have been required, over a distance from the delta of 560km, taking 14 days' return sailing, equalling 238 sailing days for a single vessel. It must be stressed that the difficulty of navigating up river may well have made this journey much longer. As already stated, the presence of a legionary granary at Poşta implies that travelling around just the north-western bend of the Danube was time-consuming. For the Pontic component, the riverine journey would have required fewer sailings, only nine, so a boat would have only needed work for 126 days – a third of the year.

4.3.2 Long-distance modelling: The Dobrogea survey

In Chapter Three, prior to taking into account the scale of the transport feed requirements, I argued for 76.35% of the needs being present with a deficit of 23.65%. This deficit increased with the need for transport feed to 26.71-32.09% of the original needs depending on the mode of transport used, Table 4.2.3.2 refers. When it comes to modelling the transport requirements to move both the arable available locally and the deficit from particular ports, both the absolute needs and

[1006] Dyczek 2001, pp.225-8, pp.242-50.

the size of the deficit of the original needs will increase further because of the need for feed-barley.

In the south, Durostorum was *c* 120km distant from both Tomis and Callatis, quite possible within five days.[1007] The other forts were a similar distance from either port: Sucidava 94km, Tropaeum 60km, and Sacidava 76km distant. Only Axiopolis was closer to Tomis, at 57km, than it was to Callatis, 87km away. All could have been reached within two to five days using oxen, fewer using mules. For the more significant deficit in northern Dobrogea, the existence of ports at Noviodunum, Halmyris and the granary at Poşta imply that some supplies were landed on the river. I have assumed that ships of as much as 80 tonnes burden did travel as far Noviodunum, but I favour the idea of a 30km overland journey from there, to the 100km by meandering river journey, to Troesmis. Although the road from Troesmis to Noviodunum is not positively identified beyond the immediate environs of Troesmis, the fact that the garrison here had the most severe shortage of arable makes such a road more credible. By the attested *limes* road, Dinogetia was 30km from Noviodunum and [Barboşi] 45km. I have in Chapter Two favoured the idea that civilians carried out such work, but whoever did so would probably be working repeatedly and the operation was initially assumed to be continuous throughout a 300 day working year.[1008]

Modelling was carried out supplying each deficit from the nearest port. In the first iteration the feed-barley to move this overseas component was assumed to have been provided from overseas also, so increasing the overall need. Alternatively, if this feed-barley were provided from Dobrogea itself, then the arable available to feed the garrison would have been reduced, so increasing the

[1007] Above, p.261.
[1008] Chapter Two, pp.113-14.

deficit and thus again the overall need. This would result in more wagons at work and more feed-barley being required for the overseas component, but at the same time the number of vehicles and feed-barley to move the reduced local arable component would have decreased. To calculate this, repetitive calculations with ever-diminishing increases in the deficit and feed-barley requirements were carried out using the algorithms within Excel. These had to be repeated up to a dozen times because once each calculation of arable required to move the overseas component was removed from the local potential the amount available locally would reduce and so the deficit would increase further. Calculations were continued until there was negligible change. In the tables that follow, the deficit is measured as a percentage of the original needs to allow comparison.

As was seen when calculating the local solution, the lowest increase in overall needs would have been achieved using the faster oxen-drawn wagons because these required least feed; the greatest increase by using mule-drawn wagons. The lowest number of vehicles would have been arrived at using mule-trains. In all cases, if the feed for the overseas component were provided from within Dobrogea, then because this would have reduced the arable available to the garrison locally, the deficit was greater and more of the overall needs would have had to come from overseas. This would have also required more wagons and more feed-barley, so the overall requirement would have been slightly higher. This would suggest that if supplies were shipped from the Black Sea ports, then the barley feed to move them ought to have come from overseas also. For all Dobrogea the increase in the size of the deficit was not too onerous, but if the deficit in the north only were examined this was seen to be significant, ranging from 40-51% of the needs of the garrison, the worst case being mule-drawn wagons where the feed-barley were supplied locally. There was only a small increase in the number of wagons required, even though in the south the overseas component was being moved a significant number of wagon days. This was because in the north the distance travelled from the port at Noviodunum to the garrison where the deficit was felt was achievable within a single day for the faster oxen and the mules, and was no farther, indeed closer, than some of the local arable potential seen.

Table 4.3.2.1: Dobrogea Long-distance supply (via Noviodunum to north)

Model & source of feed	% Deficit of original needs felt in Dobrogea	% Increase in needs due to transport feed	Local vehicles	Long-distance vehicles	Total vehicles
23km overseas	27.23%	+ 5.18%	223	100	323
23km local	28.93%	+ 5.28%	221	109	330
32km overseas	26.71%	+ 4.17%	191	69	260
32km local	27.85%	+ 4.21%	189	73	262
50km overseas	32.09%	+ 12.59%	148	73	221
50km local	36.62%	+ 12.97%	140	87	227
50km overseas	28.98%	+ 7.55%	94	39	133
50km local	31.29%	+ 7.64%	91	43	134

Although I favour unloading bulk supplies at Noviodunum or further east for Troemis and Arrubium, it is not impossible that some overseas supplies may have been shipped from the mouth of the Danube up-river. Durostorum, Sucidava and Sacidava were 380-430km distant, a seven-day journey against the current depending on the navigability of the river. Alternatively, these forts were 170-221km from Novae where a surplus has been suggested; similarly Arrubium and Troesmis were 375km and 390km distant from Novae. Journeys to the forts in the south of Dobrogea from Novae would have required two days' travel with the current and a return of double that; to the northern forts the journey may have been done in three days, but the return would have been six or seven days.

I have previously made an assumption that the depth of the channel limited the size of ship that might have travelled as far as Noviodunum to approximately 80 tonnes.[1009] Alternative solutions whereby vessels, maybe as large as 200-340 tonnes burden, landed at Histria or Tomis were also considered to supply the northern deficit. I must caution that Avram has suggested that Histria was already shut off from the sea *c* AD 100 because Lake Halmyris is reported as a *lacus* in Laberius Maximus' Horothesia.[1010] However, Lake Halmyris has also been identified in one study that followed the elder Pliny as Lake Razim further north, and ancient authors pre- and post-AD 100 imply it was possible to sail to Histria.[1011] Scholars also continue to pursue the location of an ancient harbour.[1012] Modelling via Histria, Troesmis and Arrubium were 107 and 119km distant, [Barboşi] 146km, Dinogetia 133km and Noviodunum 106km distant. In contrast to the modelling carried out via Noviodunum, where the local arable to provide long-distance feed for the overseas component was taken from the area within a single day of Troesmis, this could not have happened if travelling from Histria because it would have taken oxen three to four days to get that close to the garrison. Therefore, the local arable required for long-distance feed was removed from the surplus to the central region, at four and five days distance from the northern garrisons, which put it within the first travelling day of the port of Histria. Because the ports were further away, obviously more vehicles would have been required *pa*, but not

[1009] Above, p.268.
[1010] Avram 2003, p.281.
[1011] *ISM* 1.68; Strabo, 7.6.1; Pliny, *HN* 4.12.79; Arrian, 24.1; Ptolemy, *Geog* 3.10.3; all reproduced Panin 1983, pp.180-1.
[1012] Dabica 2010, pp.381-2.

massively so. The increased requirement for feed-barley now started to increase the overall needs noticeably. In the case of oxen, travelling at the faster speed, an increase of 5.68-5.73% on the original needs was seen, and at the slower speed this became 7.15-7.26%. For mule-trains the needs were now increased by 9.19-9.34%, but mule-drawn wagons increased the needs by as much as 16.55%, which points to this being an uneconomical method of transportation. In these latter cases it is to be remembered that the requirement for feed-barley had increased the overall needs by

Table 4.3.2.2: Dobrogea Long-distance supply (via Histria to north)

Model & source of feed	% Deficit of original needs	% Increase in needs due to transport feed	Local vehicles	Long-distance vehicles	Total vehicles
23km overseas	27.23%	+ 7.15%	223	223	446
23km local	30.91%	+ 7.26%	199	254	453
32km overseas	26.71%	+ 5.68%	191	163	354
32km local	29.38%	+ 5.73%	178	180	358
50km overseas	32.09%	+ 15.95%	148	132	280
50km local	40.2%	+ 16.55%	121	169	290
50km overseas	28.98%	+ 9.19%	94	68	162
50km local	32.99%	+ 9.34%	86	78	164

5.33% and 8.44% to move just the local component, so that, broadly speaking, the increase in overall needs was close to doubled to move the overseas component via Histria. What is more marked is the difference in the size of the deficit between providing the feed-barley for the overseas component from Dobrogea or from overseas. In the worst case of mule-drawn wagons, the deficit was 8% greater, if supplying the feed-barley to move the overseas component locally, than doing so from overseas. This does not make military sense, to prioritise feed-barley to move supplies and so be more dependent on a distant source of bread wheat to feed soldiers, when significant arable potential was available locally.

Modelling from Tomis to the north, Troesmis, Arrubium [Barboşi] and Dinogetia were 140, 152, 179 and 166km distant. The number of wagons

Table 4.3.2.3: Dobrogea Long-distance supply (via Tomis to the north)

Model & source of feed	% Deficit of original needs	% Increase in needs due to transport feed	Local vehicles	Long-distance vehicles	Total vehicles
23km overseas	27.23%	+8.26%	223	292	515
23km local	32.25%	+8.61%	188	349	537
32km overseas	26.71%	+6.36%	191	205	396
32km local	30.15%	+6.5%	173	233	406
50km overseas	32.09%	+19.59%	148	195	343
50km local	45.31%	+21.67%	101	279	380
50km overseas	28.98%	+10.87%	94	97	191
50km local	35.01%	+11.36%	81	118	199

required was greater again than via Histria. In each model, a higher increase in needs and so greater deficit is apparent were the feed-barley to move the overseas component to be supplied from within Dobrogea. Critically again, it is the make-up of these needs that is important. Over the whole of Dobrogea, in the case of mule-drawn wagons, if the feed-barley were supplied locally then the deficit became 45% of the original food needs, so that only 55% would have been provided locally. Originally, when just the movement of the local component were considered, the deficit was 32%, see Table 4.2.3.2, so this is a significant increase in the logistical cost. In the case of mule-trains, the deficit became 35%, up from 29% originally. At the northern forts the size of the deficit was even more pronounced, being as high as 67% for mule-drawn wagons and 52% for mule-trains. Now the military risk is far too great, and I can see no reason to have been so dependent on overseas supplies. Therefore, it becomes certain that if supplies were moved from the Black Sea ports to the *limes*, the transport feed to move them ought to have been provided from overseas also. Using local arable as feed-barley for overseas grain would also have had a financial impact because, although I cannot be sure how the Romans paid for the local component, I cannot imagine that they did not have to pay for the overseas component, so that the overall cost would have been higher if local arable was used for feed-barley.[1013] Additionally there must have been a shipping cost to that overseas component that ought to have been kept to a minimum. It is acknowledged that tax coin could have paid for an overseas component, and this represents leakage if following Hopkins' model, but reciprocal trade would have returned coin eventually. Furthermore, in this last model the number of mule-drawn wagons required, 343-380, was of a similar magnitude to the number of faster oxen-drawn vehicles required, 396-406, yet oxen required only a third as much feed-barley, so that this also points away from the use of mule-drawn wagons in favour of oxen-drawn wagons. These calculations also show that shipping grain through Histria or Tomis would have been unlikely, while landing supplies at Noviodunum required significantly less arable overall and far fewer vehicles.

Comparing the quantities of vehicles required throughout when shipped from each port, roughly half as many mule-trains would have been required than the faster 32km-a-day oxen-drawn wagons, for an approximately 60-80% increase in arable required for feed-barley. Therefore, although in theory mule-trains ought to have been more economical, it is difficult to say which would have been the

[1013] Demosthenes, 35.10-13 clearly shows that Athens paid in the 4th century, albeit with a cargo; above, p.273.

preferable mode of transportation, because of uncertainty as to the availability of arable. If there was in reality plenty of arable, then mule-trains would have made more sense, but if long-distance supplies were required then oxen may have been more economical. Additionally, the other farming benefits of oxen over mules are not quantifiable.

As far as providing wine to the Dobrogean garrison, there is no explicit evidence for local wine production, although some of the amphorae produced at Butovo, Hotnica and Pavlikeni are known in the region.[1014] There is also some, albeit earlier, evidence for wine production at Tauric Chersonesus, and overall an overseas solution seems more likely.[1015] 12,827 men would have required 2,340,928l *pa*; if carried in containers of half the weight, this would have resulted in an annual cargo of 3,511,391kg. Again, I did not model a wine solution for the service providers, or for the farmers working to provide food for both these groups, because it is thought unlikely that these would have commanded the supply of overseas wine in significant quantities. These needs were broken down according to individual forts, and travelling times from the nearest ports were considered at Table T.4.3.2. The transport feed was assumed to have come from overseas also because this has been shown to be preferable. The requirements for just the soldiers were calculated as 157 wagons in the 23km model, 112 in the 32km model, 92 mule-drawn wagons or 55 mule-trains. If compared with Table 4.3.2.1, where the nearest ports were also used, these figures increase the number of wagons required by 41-49% from those calculated to just move the arable deficit using the nearest port. So, just as with Novae, this may suggest that either local wine, the production of which I am unaware of, was provided or alternatives to wine were consumed.

[1014] Dyczek 2001, pp.225-8.
[1015] Carter 2003, pp.123-6; 2006, p.197.

4.3.3 Vehicle capacity variations and seasonality

Although I have made the case for wagons having an average cargo capacity of 350kg, higher capacities are possible.[1016] The use of smaller or larger wagons would clearly impact on the numbers of vehicles required and so because of the feed requirements the size of the surplus or deficit. In terms of the number of animals required to pull a 350kg load, the recommendation of the Theodosian Code of eight mules might seem excessive.[1017] The same law also limits a two-wheeled wagon to 65kg capacity, in both cases seemingly looking to protect the animals at work. Varro reported smaller wagons being commonly drawn by pairs of mules.[1018] There are also several images on Trajan's Column of two-wheeled wagons, which surely were also used by farmers in the region.[1019] A small wagon using two draught mules to carry only 65kg would be less effective than eight pulling a 350kg load. However, if two mules could have pulled more, maybe 150kg, then they would have been more efficient than the eight mules pulling a wagon or indeed a team of eight pack animals. Additional modelling was therefore carried out with wagons carrying loads of 500kg, but pulled by the same number of animals and wagons carrying a 150kg load pulled by two mules. The 70kg capacity of pack animals used previously was also adjusted up to 90kg, and so with eight pack animals a 720kg total load was considered.

What is obvious is that with a greater cargo capacity for the same feed requirements fewer vehicles would have been necessary. Around Novae, the surplus was greater than previously, in Dobrogea modelling via the nearest port, that is Noviodunum in the north, the deficit was smaller, but not massively so; in

[1016] Above, pp.260-1.
[1017] *CTh* 8.5.8.
[1018] Varro, *Rust* 2.8.5; White 1970, p.301.
[1019] Lepper & Frere 1988, Scenes xlix, lxi-xii, cvi-vii.

any model only a matter of a few per-cent. With the increased cargo capacity of the mule-trains, the results were as expected: fewer vehicles would have been required and the deficit was smaller. If two mules pulled a 150kg load on a two-wheeled wagon, which would have required a quarter of the feed for 43% of the load previously modelled and would therefore be more economical. The surplus at Novae-Nicopolis was now 6% higher, and the deficit in Dobrogea was 3.5% smaller than that produced by the 350kg wagons, compare Table 4.3.3.1-2 with Tables 4.2.2.1 and 4.3.2.1. At the same time with these smaller vehicles many more would have been required. One is however, comparing apples and pears, so that the comparison is unfair because smaller vehicles may well have been cheaper and easier to maintain. What this does show is that changes in vehicle size do not massively impact upon the surplus or deficit in either study area.

Table 4.3.3.1 Transport variations, Novae-Nicopolis

Model	% deficit/surplus of garrison 9049ha needs	Local wagons
23km oxen-wagon	+ 64.79%	90
32km oxen-wagon	+ 65.37%	74
50km mule-wagon	+ 59.29%	66
50km mule-train	+ 62.27%	44
New model		
50km wagon 150kg load two mules	+ 60.95	215

Table 4.3.3.2: Transport variations, Dobrogea

Model	% deficit/surplus of 21,326ha garrison need	Local vehicles	Long distance wags	Total wagons
23km oxen-wagon	- 26.17%	157	66	223
32km oxen-wagon	- 25.80%	134	46	180
50km mule-wagon	- 29.60%	105	45	150
50km mule-train	- 27.81%	73	28	101
New model				
50km wagon 150kg load two mules	- 28.63%	349	143	492

Throughout I have assumed a steady-stream flow of supplies to the garrisons, because of the limited evidence for storage facilities. My assumption of a 300 day working year was based on farming practices in the Mediterranean. One could reduce that further to 240 days because of the cold winters of the region which may have made transport difficult for four months of the year. The deficit, the number of loads and wagon days would remain unaffected, but there would have been an increased need for vehicles, although they would have been used for a smaller part of the year. If one assumes four idle months, there is a *c* 25% increase in the number of vehicles required.

Table 4.3.3.3: Seasonal variation, Novae-Nicopolis

Model	Vehicles required at 300 days *pa*	Vehicles required at 240 days *pa*
23km oxen	133	166
32km oxen	109	136
50km mule wagon	101	126
50km mule trains	58	73

Table 4.3.3.4: Seasonal variation, Dobrogea

Model	Vehicles required at 300 days *pa*	Vehicles required at 240 days *pa*
23km oxen	323	404
32km oxen	260	325
50km mule wagon	221	276
50km mule trains	133	166

4.3.4 Shipping requirements to the Dobrogea survey

Three possible long-distance supply solutions from the Crimea were considered: the further *chora* of Chersonesus on the Tarchankut peninsular, Chersonesus itself, and the Bosporan kingdom centred at Panticapaeum, respectively 510, 615 and 950 km from the mouth of the Danube.[1020] The distances assume that the ships kept close to the shore and did not sail in open water because of the danger of storms and problems of navigation, I also assume overnight stops. From the mouth of the Danube along the course of the modern St George channel to Noviodunum is approximately 150km. This route may have changed since antiquity, although one study of the river courses shows only increased flow in the last 2000 years, while the presence of the ancient sites of Aegyssus, Salsovia and Halmyris all imply that the ancient channel ran close to the present one.[1021] With open-water speed dependent on the wind, but with an average figure of 7.5km/ph, these distances equate to 15, 18 and 25-day return journeys to Noviodunum, 13, 16, 23 to Histria, and 13.5, 16.5 or 23.5 to Tomis. These broadly agree with an ancient report

[1020] These distances were calculated independently of, but do broadly agree with, those given on the ORBIS Geospatial model of the Roman world. www.orbis.stanford.edu. accessed 18/09/16.
[1021] Panin 1983, p.177.

Table 4.3.4.1: Number of sailings against arable deficit

Model & Deficit	Size of ships' cargo					
	20t	**50t**	**80t**	**120t**	**200t**	**340t**
23km oxen						
Southern deficit	**via Tomis or Callatis**					
423.766kg	21	8.5	5.3	3.5	2	1.25
Northern	**via Noviodunum**			**via Histria or Tomis**		
1,816,911kg	91	36	22.7	15	9	5.35
Total	112	44.5	28	18.5	11	6.5
32km oxen						
Southern	**via Tomis or Callatis**					
419,406g	21	8.4	5.3	3.5	2	1.24
Northern	**via Noviodunum**			**via Histria or Tomis**		
1,780,045kg	89	36	22.25	15	9	5.23
Total	110	44	27.5	18.5	11	6.5
50km mule-drawn wagon						
Southern deficit	**via Tomis or Callatis**					
526,175kg	26	10.5	6.6	3.5	2.6	1.55
Northern deficit	**via Noviodunum**			**via Histria or Tomis**		
2,112,722kg	105.6	42.25	26.4	17.6	10.6	6.21
Total	132	53	33	21	13	8
50k mule-train						
Southern deficit	**via Tomis or Callatis**					
469,332kg	23	9.4	5.9	3.9	2.3	1.4
Northern deficit	**via Noviodunum**			**via Histria or Tomis**		
1,913,737kg	95.7	38.3	23.9	15.9	9.6	5.6
Total	119	48	30	20	12	7

of an open water, one-way crossing of three 24 hour days, between Histria and Chersonesus.[1022] Clearly fewer, larger, ships could have landed at the Black Sea ports, but I have already commented on how modern thought favours smaller ships as being more common in antiquity.[1023] Table 4.3.4.1 above is illustrative of the number of sailings of different burdens only. There is nothing to indicate any great

[1022] Ps-Scylax 68 cited by Zubar 2007, p.735.
[1023] Above, p.267.

advantage in sailing to Histria or Tomis, when the overland advantages of Noviodunum have been made clear above. In all cases the numbers of voyages required are low: 132 is the highest figure, and that is for very small vessels of only 20 tonnes. It is difficult to imagine that it was worth braving the sea that many times purely to supply the Roman army, so that any overseas supply solution is best thought of as a part of a greater export market from the Crimea operating throughout antiquity as discussed above.

Conclusions to Chapter Four

This Chapter has sought to quantify the logistical burden in terms of wagon or mule-train days in two distinct study zones, with four modes of transportation. Although the calculations within the algorithms have been to several decimal places, the answers throughout ought to be seen only as indications of scale rather than as precise.

The first conclusion is that the army brought only a small logistical cost with it in terms of wagon or mule-train journeys required and so wagons at work *pa*. The results from Novae show in broad terms the logistical impact of a single legion; the additional troops at Sexaginta Prista were added for completeness of argument. Here, it was seen that a single legion required about 109-133 oxen-drawn wagons, 101 mule-drawn wagons and 58 mule-trains using the road network as it is understood. This is thought to have been a low annual logistical cost. In Dobrogea, to move just that part of the supply solution available locally, 191-223 oxen-drawn wagons, 148 mule-drawn wagons and 94 mule-trains would have been required; when the long distance calculations were carried out, still only 260-537 oxen-drawn wagons, 221-380 mule-drawn wagons and 133-199 mule-trains were necessary. These are all thought to be very low figures, especially when compared with the number of animals required by a campaigning army.

In Dobrogea, the 23.65% overall deficit seen in Chapter Three was unevenly distributed, with a smaller 18% deficit present in the south and a surplus in the centre as a result of the many *vici* observed here, but a large initial deficit of 35% in the north. In the south and centre a dense settlement pattern close to the *limes* zone broadly agreed with von Thünen's central place theory, but thereafter the percentage of arable available diminished with distance from the *limes*. This pattern was not evident in the north-west of Dobrogea because of the absence of settlement activity reported in Chapter Three. After the arable required for transport purposes of just the local component was considered, the overall needs, and so the deficits, increased. This increase was quite small, only 3.07-3.58% in the case of oxen-drawn wagons; but a more significant 8.44% for mule-drawn wagons and 5.33% for mule-trains.

With regards to overseas supply the ports of Halmyris and Noviodunum imply that some ships travelled that far up the Danube. If the granary at Poşta truly does indicate a supply depot that would suggest that it was deemed beneficial to move supplies 30km overland from Noviodunum rather than 100km up-river, despite ships carrying many times larger cargoes than wagons. Modelling from Noviodunum and the Black Sea ports of Histria and Tomis showed the advantages of Noviodunum as a port in terms of arable required for feed-barley purposes and the lowest number of travelling days, and so vehicles required. Irrespective of which port was used, there would have been an increase in wagons or mule-trains to move the overseas component. The numbers varied according to the port used, the mode of transport and the origin of the transport feed, which could have either been supplied locally or from overseas. In the former case the local arable previously available to provide bread wheat would have been reduced and the deficit increased, so that more of the garrison's food would have had cause to travel from the ports to the garrison. The overall deficit increased to as much 45% of the original needs in the worst case scenario using mule-drawn wagons travelling from Tomis for the northern component and with local arable supplying the transport feed. This scenario would have left the Roman army far too heavily dependent on an overseas source for its bread wheat and thus makes no military sense: men very definitely ought to have been fed in preference to horses and mules. Therefore, the movement of overseas grain using mule-drawn wagons from the coastal ports can only have been acceptable if the feed-barley for the overseas component were also coming from overseas. Because the deficit and the numbers of vehicles would be lowest if Noviodunum were used, the only apparent benefit to landing supplies on the coast would have been the reduced number of sailings required by larger ships. Yet it is thought that large ships were less common than smaller ships and I argue that ships up to 80 tonnes burden, could have made it as far up river as Noviodunum. Furthermore, the numbers of sailings required in any model were so small as to suggest that any overseas supply to the army in Dobrogea was part of a larger commercial operation to the Black Sea *poleis* and beyond. I have supposed the Crimea to be the most likely source, but my point holds for any overseas source.

The quantification of the supply of amphorae to Novae makes it quite clear that this would have represented a considerable logistical burden. Potentially, to move only the 31% of the necessary wine that is suggested to have originated in the Aegean or Black Sea, the distances involved seem to exclude the possibility of using mule-drawn wagons with their high feed-barley requirements from the Aegean ports. To move wine even by Odessus was seen to increase the number of vehicles needed to supply the Novae garrison by 74-106%. This seems to suggest that long-distance supply of wine was unlikely except for the highest quality, and so points to a local supply solution, which is evidenced by amphorae production at Butovo, Hotnica and Pavlikeni. To move wine in Dobrogea on the other hand may have been possible, but again with a 41-49% increase in vehicles required.

In sum, after calculating the increase in arable needs for feed, the faster 32km a day oxen-drawn wagons were the most economical mode of transport in terms of feed. The increased feed-barley requirements of mule-drawn wagons do not seem to have warranted their use against only about a third saving in vehicles at work in the case of the slower 23km oxen, and less for the faster moving oxen. So, mule-drawn wagons should have been the least preferred mode of transportation. On the other hand, fewer mule-trains would have been required than oxen-drawn wagons, less than half the number of even the faster oxen type, for only 1.74 times as much feed. This, together with the increased speed of mules and the belief that individual pack-animals would have been easier for farmers to keep and use without resorting to carters, should to my mind have made pack-animals preferable as a mode of transport. Yet the overall preferability of mules depends on the other farming uses to which both animal types were put.

Chapter Five Conclusions

This thesis has sought to offer a method of solving the supply problems to the *limes* garrison in two specific areas of Lower Moesia. It has also investigated the transport penalties in these areas. In so doing I have had to make many suppositions. The troop numbers including their servants are paper figures for the mid-2nd century garrison. If these are paper figures, the size of the civilian population and numbers of service providers are educated guesses, demographics being an imprecise science. The uncertainty over the size of the civilian population resulted in the estimated arable needs of the Black Sea *poleis* in particular being tenuous. The 0.809kg daily allowance assumed for a soldier is derived from Polybius, while the 0.5663kg figure for the service providers is simply 70% of the soldiers' allowance. Yields of 385kg/ha for wheat, 395kg/ha for barley are thought realistic, as is the use of alternate fallow regimes, considering the ancient and Medieval evidence assessed in Chapter Two. The viability of these figures was strengthened by modelling the scale of the garrison's needs with alternative low and high yields. Here at low yields in several scenarios the arable needs and the numbers of workers became staggeringly high so that famine ought to have been commonplace; whereas at higher yields although the garrison's requirements were attractively low, the number of farm workers needed to farm the land was thought to be unrealistically low. Additionally in these high yield models the arable potential of the region would have been so high as to result in famous export markets. Although an argument from silence, that nothing is heard of such surpluses is persuasive. Of course there were variations in good and bad years, but as an average figure 385kg/ha is thought safe. Similarly, the 6ha allocated to each labourer, of which half was worked in any given year, is argued from ancient and near modern pre-mechanised evidence. Furthermore once dependants are considered, the overall population estimates derived from the number of workers required to feed the garrison is of the same magnitude as, and in the case of Dobrogea very close to, the population estimates derived from the broad-brush estimate of eight persons per km^2. This makes the assumptions made about yields and worker productivity seem even safer. Although I did quantify a pastoral need, I was unable to evidence where this was practised, or to pursue this beyond the rather obvious observation that there was no shortage of potential pastureland. I made it clear that I at no point believed that what was seen in the archaeological record represented anything like the full scale of agricultural activity, yet I have resisted the urge to multiply what is seen by some survivability factor, preferring to deal with what is actually seen. In part this is justified because I doubt many more *vici* are left to be discovered and these are seen to have been the chief agricultural producers of the region in antiquity. The cargo capacity and feed-barley requirements of wagons and pack animals were again considered reasonable but a plurality of transport methods and possible routes were evident, so that I have had to simplify to just four possible modes of transport for modelling. The permutations of possible routes taken by grain from producer to consumer necessitated that the modelling was carried out within ArcGIS using the Service Area function, and this again only takes a single possible travelling distance for a particular cargo. However, it can be said to rapidly assess the most effective route for a particular parcel of arable produce. In effect I used a computer program to assess what the Romans should have done through experience.

The overall requirement in terms of land as laid out at Table T.2.1.1 gives the scale of a particular province's needs, which will be similar in scale to other provinces, while those at T.3.2.1a effectively give the needs of an individual legion. The absolute figures in terms of land required to feed the provincial garrison were not considered significant, only 2.88% of the total land area of Lower Moesia. It is thought that through taxation and compulsory purchase this need would have stimulated economic growth in the region. The relative proportions of land that are required by different components of the army are of note. Most strikingly, the cavalry required a significant *c* 28% of the calculated needs of the provincial garrison. This would appear justifiable in the open plains of the Danube, but may not have been so always. Because *equitata* units were so common across the empire it may be that this represented a halfway house where the flexibility of cavalry was available without the logistical penalties becoming too great. Meat was seen to be an inefficient source of food requiring *c* 26% of the calculated land for the garrison across the wider province. Once service providers were considered in individual study areas, meat made up *c* 33% of the needs at Novae and 29% of the needs in Dobrogea – all for only 10% of the calories, although of course it also provided essential protein. Additionally the benefits of especially cattle to farmers as traction animals and of all animals for manure and as a walking food reserve are difficult to quantify. The number of farm workers that the garrison required, in the preferred scenario with regards to yield and landholdings, was argued to have been in the region of half as many men as were in the garrison itself. Once specific study areas were considered in Chapter Three the needs of service providers were also included and these were seen to require a sizable percentage of both the arable and overall needs, *c* 43% at Novae, 33% in Dobrogea. The difference here is a result of a larger cavalry contingent in Dobrogea that required a greater part of the total requirements. Nevertheless, the needs of the service providers are indicative of the additional burdens that the army brought with it, although one could argue that this represented an even greater stimulus to the economy.

As the work progressed I have made claims as to the quantity of the arable needs that is still visible in the archaeological record. In the Novae-Nicopolis area, the needs of garrison, their agricultural workers and the service providers are met with a 68% surplus. In Dobrogea *c* 76% of the needs were seen, i.e. there was a *c* 24% deficit present. When I doubled the needs of the farm workers to allow for their dependants, assuming that both wives and children would have gone a long way to providing for themselves, there was still an 18% surplus around Novae-Nicopolis and *c* 53% of the needs were argued to have been met in Dobrogea. The conclusion that 93-97% of the Black Sea *poleis*' needs were available is acknowledged as the least secure of all the assertions made, because the population sizes and arable holdings for the *poleis* are so unclear. The quantity of arable perceived to have been available to the military was reduced further by the need to provide feed-barley to move grain from producer to consumer. To move the requirements of Novae by the road network reduced the surplus by 4-14% of the original. To move just the local arable component in Dobrogea increased the needs and so increased the size of the deficit by 3-8%. It was only in Dobrogea that a deficit was seen. To provide this deficit from afar and then move within Dobrogea increased the feed-barley need further. By how much differed according to the port used, ranging from an increase of 4-13%, if moved by the nearest port, in the north this was Noviodunum; but considerably higher increases of 6-17% and 6-22% if the northern component was moved via Histria or Tomis. That it required significantly more land turned to feed-barley seemed to exclude using the more distant ports, especially because small ships in the region of 80 tonnes burden, which are argued to have been able to travel up river to Noviodunum, are considered more normal. Therefore, Noviodunum ought to have been the preferred port for the garrison of Dobrogea.

Furthermore, when the size of the deficit – that part of the needs not available locally – was considered, it was seen that the size differed according to the source of the feed-barley required to move that deficit. Travelling by the most economical route from Noviodunum, the deficit ranged between 27-32% depending on transport method, if the feed-barley was supplied externally, but if supplied internally then the arable available to the garrison would have been reduced further, so that the deficit would have increased to 28-37%. In this case the difference between locally procured and overseas feed-barley is not too marked. The range in figures was brought about by the different feed requirements of each transport method and their speeds. Were the supplies to the north shipped by Histria, then the deficit was unchanged if the feed-barley was also shipped in from overseas, but increased to 29-40% if the barley-feed was provided locally. Similarly, if supplies were moved via Tomis, and the feed-barley was provided from within Dobrogea, the size of the deficit ranged between 30 and 45%. Although the absolute quantity of both food and feed-barley was only marginally greater if the feed-barley was provided locally rather than from overseas, it is the size of the deficit relative to the original needs that would have been most critical, because this represented that part of the garrison's food not available locally. To use local arable to provide feed-barley in order to move the overseas component would have been militarily nonsensical, effectively prioritising the beast of burden over the troops themselves, and so it is argued that if overseas grain was moved within Dobrogea it was done by animals fed on overseas feed-barley. Additionally, although we do not know how Rome paid for its overseas grain, there would have also been a shipping cost that ought to have been mitigated by only shipping the minimum amount required.

Oxen-drawn wagons required less arable to be turned to feed-barley than mules, but more vehicles, and even here this assumed that they were fed barley every day, which is not essential. Therefore in terms of arable they would have been most economical. Yet it was universally seen that mule-trains required the lowest number of vehicles to be at work. Were land for feed-barley plentiful, then mules should have been preferred; were land for feed-barley in short supply, then oxen should have been preferred. Although it is noted that mules may have been easier and cheaper for farmers to keep, by the same token oxen could have also been more effective plough animals. Without a fuller understanding of farming practices it is difficult to say which animal individual farmers or hauliers would have favoured. Mule-drawn wagons on the other hand were least economical, generating the greatest need for arable without significant reductions in vehicle numbers over oxen-drawn wagons. The absolute numbers of vehicles required in every case is thought to be low, especially in comparison with the number of animals required in a campaign context. The calculations at Novae make a case for a legion requiring only 109-133 oxen-drawn wagons, 101 mule-drawn wagons and 58 mule-trains to move their annual needs. Those in Dobrogea suggest a range of 191-233 oxen-drawn wagons, 148 mule-drawn wagons and only 94 mule-trains to move just the local component. I make no claim to the precision of such figures simply the scale, which is very low, 100-130 wagons to supply a legion year-on-year. Once long-distance supplies are considered for Dobrogea by the most economical route, using

Noviodunum in the north, between 260-323 oxen-drawn wagons, 221 mule-drawn wagons and 133 mule trains could have supplied the garrison annually – these are all very low figures. In contrast, the long-distance supply of only 31% of the wine needs from the Aegean to Novae has been shown to have been prohibitively costly in terms of vehicles. In the best case, if moved via Odessus there would have still been a 74-106% increase in the number of vehicles required over those moving local arable produce. In Dobrogea, to move all of the garrison's wine, albeit a much shorter distance would have added 41-49% to the numbers of vehicles used. Therefore, the supply of foreign wine and even olive oil, which are both evidenced at Novae and in Dobrogea, is not considered normal for all but the most senior men.

Beyond the basic question of quantifying the needs and the transport penalties of moving that need, I have presented a survey of the archaeological landscape of Lower Moesia. This has been done from previously published data, but in the case of Novae-Nicopolis I spliced together the work in two adjacent areas to provide a fuller picture than that which has gone before. In the case of Dobrogea, I took the contents of the national database and augmented it with the work of more traditional scholarship to produce a relatively large dataset of settlement activity. No patterns emerged when this activity was mapped against soil type. However, the proximity to fresh water was seen to be a significant factor in attracting settlement in both study areas. Additionally the tumuli data provided by Oltean showed a broad swath of settlement activity across the centre of southern Dobrogea that aligned with the now seasonal Urluia river valley and so drew attention to the importance of fresh water for consumption and irrigation. The importance of communications within Dobrogea was made clear, and there was a close proximity of settlement activity to the roads evident; the additional data provided by Oltean made this more obvious in southern Dobrogea. Here two routes in particular look to have followed the broad central swath of settlement activity along the Urluia river valley. In the south of Dobrogea alternative landholdings derived from Voronoi analysis about the tumuli foci were proposed. This diminished the importance of the larger *vici* which dominated the calculations done using the cIMeC data. Unfortunately, without dating information for any of these tumuli it was thought unwise to press the point too far. Once the distribution of sites within Dobrogea is considered in relation to the road network it is possible to argue that settlement activity aligned broadly with von Thünens' central place theory. There was a markedly denser distribution of sites closer to the *limes* than away from them; at least in the south of the region, although the compact nature of the region resulted in increased density again as one approached the Black Sea *poleis*.

The calculations for Dobrogea indicated that the majority of arable activity was supplied by the *vici*. Therefore, the view of Poulter that the *vici* were established to support the garrison still seems to hold good. Indeed future work might concentrate on these alone and dismiss the individual settlements as simply self-supporting. The positioning of the *vici* with regards to the roads and the very developed nature of the roads network itself appears to have been by design and reinforces their importance. Through the consideration of the transport requirements I have brought into question the belief that supplies travelled very far up-river, something that has been almost canonical since Richmond. That supplies could have travelled some way up river is not in doubt. However, the presence of a port and a possible supply depot near Noviodunum some 100km distant by a meandering and arguably shallow river from Troesmis, but 30km away by land, seems to indicate that land haulage was more beneficial. Similarly, for central and southern Dobrogea overseas supply solutions would have been better moved from the Black Sea ports by the extensive road network rather than by long river voyages. If the models are close to what was actually carried out in the Roman period, then the relatively small requirement for ship-borne supplies from overseas surely points to this being part of a larger commercial shipping enterprise, since the army was not so important a market as to warrant trade or supply from outside the empire all of itself. This would align with the reputation of the Crimea as a bread basket.

This work has dealt with a particular place and time, yet its value lies with its perceived applicability elsewhere. Although it is difficult to claim any homogeneity of administration and finance across the wider Roman empire, the systems that have been proposed for Lower Moesia, ought, if credible, to be applicable to other *limites*. Certainly, the methodology would be usable elsewhere, especially the transport modelling, and the use of Service Areas within ArcGIS could become a normal way of investigating ancient trade and supply networks. The choice of Dobrogea as a study area came from the existence of a publicly available database of archaeological sites. The same methodology could be applied to other datasets of settlement activity. In particular for the United Kingdom and the garrison on Hadrian's Wall, 'The Rural Settlement of Roman Britain' project would allow one to start with a searchable database and map where sites can be filtered according to type. Then the follow up material can be further investigated through the published reports acknowledged within the project webpages, or elsewhere, to consider the agricultural potential of the sites.[1024] The transport penalties of moving arable produce from the sites seen to Hadrian's Wall could be

[1024] The project is hosted by the archaeology data service at: http://archaeologydataservice.ac.uk/archives/view/romangl/index.cfm.

modelled as I have done above for Dobrogea. Although, having come to the end, I believe that it would be potentially as profitable to carry out transport modelling for the supply to Hadrian's Wall from broad regions of Britannia without identifying specific parcels of available arable, simply probable production areas. Overall that the Roman army did feed itself in Lower Moesia is axiomatic, how they did so is hopefully now clearer.