Urban systems in the Roman Near East: historical and functional dimensions of urbanism in Roman Syria, Mesopotamia, Palestine and Arabia

Kloeg, P.

Chapter 3 Analysis: size, territory and carrying capacity

3.1 Introduction

We have discussed some of the more evident historical patterns in the past chapters. There was a strong continuation in site locations. Many of the cities that were inhabited, great and small, were built in, over or next to the sites of past settlements, with obvious examples being Damascus, Gaza, Ascalon and Jericho. They did not however, necessarily share in the prominence of those earlier cities and villages. In the Roman period the area of the Bronze Age city of Ebla was a backwater in the plain of Chalcis. The city of Mari, in the Jabbul plain, appears to have become even less important. Megiddo was reduced to a bare hill when the Romans set up a military base at a neighbouring village, which only over time grew into a moderate town. Ugarit was long gone, although Laodicea, just under 10 km to the south, did become one of the major cities of the Roman Levant. The once strong city of Qatna lay empty, and of two later nearby foundations, Emesa and Arethusa, only Emesa appears to have become a sizeable city.

Similarly, many of the once powerful centres of the Iron Age, whether the Phoenician cities, those of the Israelite Kingdom or the Neo-Assyrian empire, suffered in the tumultuous centuries of the first millennium B.C.E. Gath, Tel es-Safi and Zafit may have been the sites of later Roman villages. Beyond the Roman sphere of influence, at Nineveh it seems a small urban community existed, but nothing to reflect its former glory. In Judea, Jerusalem itself only slowly recovered from its sack during the Bar Kokhba war.

So while for the Roman period the settlement system is made up out of many of the same locations as the networks of earlier periods, how the settlements at these locations developed within the Roman period was very different. In other words, how a settlement system functions is determined by more than location alone. In this chapter, the urban system will be analysed as it had started to take shape in the Hellenistic period, and crystallized in the first centuries C.E. The preceding chapters have shown that our knowledge of this urban system has several large lacunae. There is little direct evidence for the economic, demographic and political status of the cities of the Syrian and Arabian provinces. What is available, however, is a reasonable overview of urban sizes and monumentality. By looking at patterns in the latter, combined with geographical analysis, an attempt will be made to reduce these gaps, and shed light on economic, demographic and political developments in the area in the second to third centuries C.E.

3.1.1 Size distributions

Out of the 98 settlements in the region that in this study are considered to have been self-governing cities, 69 have yielded sufficient evidence to allow a size estimate (Table 9). When including town-like settlements – places that are considered to have played a central role locally but lacked civic autonomy – this goes up to 111 places with a known size out of 219 total. It should be noted however that most of the published evidence relating to the lower-order settlements comes from the Decapolis, the Negev, Galilee and the Antiochene. Therefore, the resultant size distributions do not accurately portray that of the entire region. There must have been considerably more of these small towns and larger villages in the Roman Levant. Osrhoene and Mesopotamia stand out for their low number of known settlements in general, while it is clear that Arabia has the largest total of known non-urban central places lacking a size. In terms of size, the impact of the settlements for which we do have a size is evidently limited for the total built-up area in the region: they add 357 hectares to the far larger figure of 4697 hectares for the self-governing cities, only 7.6% of the combined total.

Province	**Urban area (ha)**	**% GT City Size**	**Total Places**	**Sized Places**
Syria-Coele	1683.9	35.96%	22	14
Syria-Palestina	976.1	20.85%	25	25
Syria-Phoenice	896.55	19.15%	20	13
Arabia	512.55	10.95%	20	13
Osrhoena	318	6.79%	6	3
Mesopotamia	295	6.30%	3	3
Grand Total	**4768.1**	**100.00%**	**98**	**71**

Table 9 Urban area of self-governing cities per province

This is of course even more true for villages lacking any indication of centrality, adding another 118 settlements for which 82 sizes were collected, only in the focus areas mentioned above. These villages will be discussed in the context of the Antiochene, in the following chapter.

The following figures show the size distribution for the self-governing cities, grouped by province. It is immediately clear that Coele Syria dominated the Levant in terms of urban scale. Antioch alone takes up 10,6% of the total size of all cities combined, and the province contains well over a third of the urban surface area of the entire study area. The differences between Syria Palaestina, Syria Phoenice and Arabia are not as pronounced, making up 23, 15 and 12 % of the whole respectively. The total urban areas of both Osrhoene and Mesopotamia are smaller, reflecting their rather different nature and development path compared to the other provinces. Of course, data limitations are especially visible here, when the presence or absence of a single measurement can double the total size for a province.

Province	Urban area (ha)	% GT City Size	Total Places	Sized Places
Syria-Coele	1817.6	35.31%	61	32
Syria-Palestina	1098.3	21.34%	55	37
Syria-Phoenice	904.25	19.24%	28	14
Arabia	612.05	11.89%	58	22
Osrhoena	334	6.49%	11	5
Mesopotamia	295	5.73%	6	3
Grand Total	**5147.2**	**100.00%**	**219**	**111**

Table 10 Urban area of central places in hectares, including those lacking civic autonomy

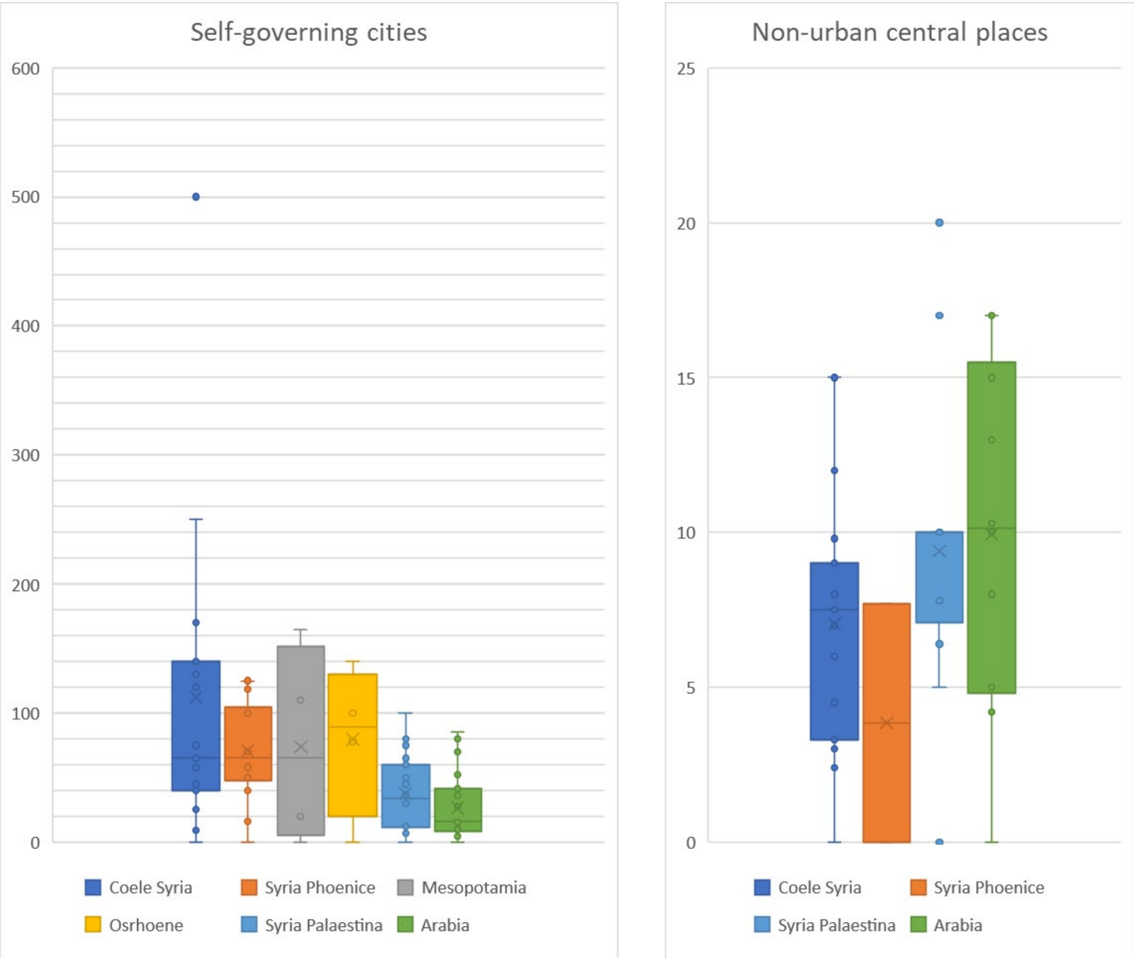

Figure 34 Size distributions per province

3.2 Explaining urban size

3.2.1 Correlating urban size and territory

There is a conceptually very simple approach to define how many people could live in a city: determine the resources produced in the city and the territory around the city, and determine the resources needed per person, and you will have what is called the carrying capacity of that area.

As is immediately obvious, there are numerous complicating factors in getting to that point. To name but a few: what is the size of these urban territories? What type of resources are we talking about? How do we determine resource consumption per capita? What is the urbanisation rate: the percentage of people living in the city compared to those living in the countryside? And then, of course, there are underlying issues that may be just as critical, such as the question what happens when a population approaches or passes this ceiling. Are we talking about Malthusian doom scenarios, or stable equilibria forming around this ceiling? To frame it another way, is demographic growth logarithmic or logistic? And what happens on the ground? How do the inhabitants of a region deal with this limit? To return to the Antiochene hinterland, should we for instance consider the agricultural expansion into the marginal uplands of the Limestone Massifs the result of overpopulation? And, of course, how sustainable is the production of resources in a given region over time?

Not all of these questions can be answered fully, some not at all, depending on the limitations of the source material, and on what assumptions are considered acceptable. We will approach some of these issues in order of complexity. The first and simplest way is to look at the relationship between known urban sizes and the size of surrounding territories. The reason for doing so is that it takes away a number of uncertainties. As will become clear when these are introduced in section 3.2.2,variables such as population density, food consumption per capita and soil productivity have a relatively wide range of uncertainty, each compounding one another. Therefore, initially we will assume that there is a direct relationship between the physical size of a city and its population, leaving aside the specifics. Secondly, it will be assumed that cities were located in urban territories that met the necessary conditions in resource production, and therefore we ignore variation in production levels resulting from variations in soil fertility, looking only at variation in territory size.

The basic concept of site catchments is very straightforward.[650] Each site uses those resources around it that it can reach, and where there are multiple sites close to each other, the territory is

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[650] C. Vita-Finzi et al., ‘Prehistoric Economy in the Mount Carmel Area of Palestine: Site Catchment Analysis’, *Proceedings of the Prehistoric Society* 36 (December 1970): 1–37,

divided between them. The assumption is that sites with access to larger catchments or more resources will be able to sustain a larger population. This fits with the reality of Classical cities insofar as they acted as the administrative centres of their own territories. In the often-suggested Weberian parasitic models for these cities, these cities would then be largely sustained by the extraction of resources from their territory.[651] Furthermore, a larger number of cities with relatively equal status would make equal claims to their surrounding territory when dividing it between them. Looking at official status, in the Roman East there is little to suggest a more complex political hierarchy than that of provincial capitals above cities, with non-urban settlements below them. Even then, the exact nature and political position of capitals remains debated, with the actual impact of the presence of a governor and his staff probably being limited.[652]

Of course, evidence for the extent of territories is somewhat limited for the Near East. Figure 52 (page 243) shows the borders of the territory of Antioch, as determined by Georges Tchalenko and Henri Seyrig. In Antioch and the Antiochene a Caesarian era was adopted, dating from 49 B.C.E., while the surrounding cities of Seleucia, Rhosos, Cyrrhus, Chalcis and Apamea maintained a Seleucid era going back to 312 B.C.E. Laodicea switched to a Caesarian era as well, starting in 48 B.C.E. Based on the different dates used in inscriptions, the borders could be established with a relatively high level of precision in parts of the Limestone Massifs, where nearby villages used different eras, and by approximation towards the north. Only the border with Laodicea remains unclear.[653]

Another city that has offered reliable information is Gerasa, where in the 90s Jacques Seigne located ten rock markings to the east and southeast of the city reading ΠΟΓΕ, initials for the polis of Gerasa. According to Seigne these markers are dated before the third century C.E. and may very well indicate the borders of the polis of Gerasa. Note, however, according to Sartre these may have been property markers, resembling for instance those of the forest estates in the Lebanon mountains. A more typical border stone would have included on each side the name of a bordering polity. Even so, this would indicate that Gerasa's territory extended at least that far

https://doi.org/10.1017/S0079497X00013074; John Bintliff, 'Chapter 13: Settlement and Territory', ed. Graeme Barker, 1999, 505–45.
[651] Moses I. Finley, *The Ancient Economy*, A Chatto and Windus Paperpack 47 (London: Chatto and Windus, 1973), 123–49.
[652] Haensch, *Capita provinciarum*, 372–74, 377–89.
[653] Georges Tchalenko, *Villages antiques de la Syrie du Nord: le massif du Bélus à l'époque romaine*, vol. 3 (Paris: Geuthner, 1953), 11–14; 57 fig. 7.

(i.e. over the wadi Zerqa, instead of along it), but with the possibility that it reached further towards Bostra and Philadelphia (as suggested by Bietenhard).[654]

Unfortunately, only the territories of a handful of towns can be reconstructed on the basis of known archaeological or written evidence. For most cities it is necessary to recreate their territories by theoretical means.

3.2.1.1 Thiessen polygons

The simplest approach to artificially divide an area between a set of points (in this case our settlements), is to create Thiessen polygons. This method draws borders exactly halfway between each point and its neighbours, using Euclidean distance. This means that shapes are created where each originating point is the closest central point to any location within the surrounding shape.

The resulting images (Figure 36, Figure 37, Figure 38 and Figure 39, the red lines) highlight some of the issues inherent to this method. First, the figures are heavily influenced by the presence or absence of a starting point. In other words, if a city is unlocated, or a settlement not interpreted as a self-governing place, this means that a large area is allocated to its neighbours. Second, there clearly is a large divergence between the recreated territories and those for which we have actual information. A brief glance at the application of Thiessen polygons in various fields shows that results can vary: for instance Antrop and van Eetvelde mention a reasonable match between Thiessen polygons and municipal boundaries in 1960s France. Two other studies, one looking at territorial birds, another at farming villages in northeast Thailand, both found that regular Thiessen polygons overestimate the extent of territories.[655]

[654] Jacques Seigne, 'Les Limites Orientale et Méridionale Du Territoire de Gerasa', *Syria* 74 (1997): 121–40; David Kennedy, 'The Identity of Roman Gerasa: An Archaeological Approach', ed. Graeme Clarke and Derek Harrison, *Mediterranean Archeology*, Identities in the Eastern Mediterranean in antiquity : proceedings of a conference held at the Humanities Research Centre in Canberra, 10-12 November, 1997, 11 (1998): 39–69; Seigne, 'Les Limites Orientale et Méridionale Du Territoire de Gerasa', 138–40 appendix by M. Sartre.
[655] Lotte Schlicht, Mihai Valcu, and Bart Kempenaers, 'Thiessen Polygons as a Model for Animal Territory Estimation', *Ibis* 156, no. 1 (1 January 2014): 215–19, https://doi.org/10.1111/ibi.12105; Thomas W. Crawford, 'Spatial Modeling of Village Functional Territories to Support Population-Environment Linkages', in *Linking People, Place, and Policy* (Springer, 2002), 91–111.

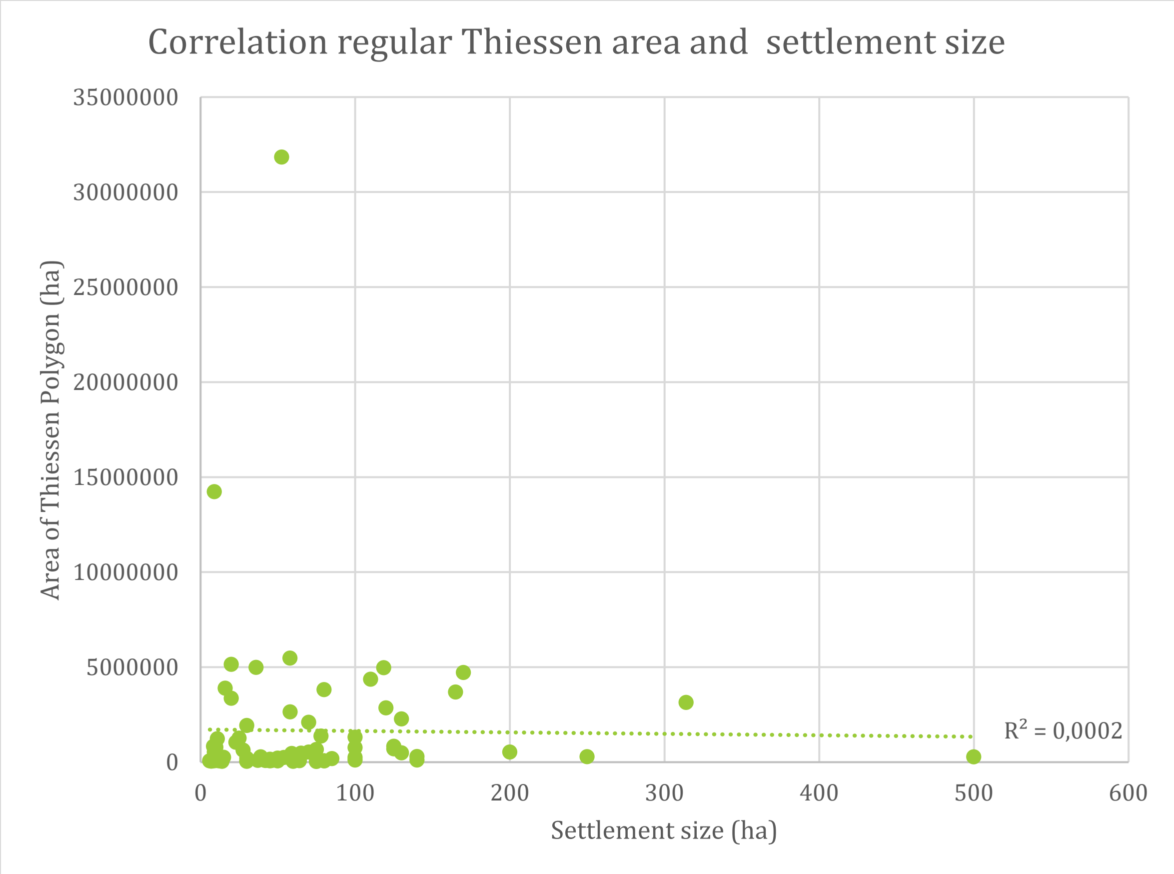

Figure 35 Correlation regular Thiessen area and settlement size

As was perhaps to be expected, in Figure 35 we find that there appears to be no correlation between settlement size and that of its surrounding Thiessen polygon. Naturally, this is exacerbated by the vast territories assigned to the settlements on the boundaries of the study area, or those bordering on the desert or the sea. But even if correcting for those, either by ignoring them, or by including boundary settlements from adjoining study areas and clipping away the sea and low rainfall zones, there is still no noticeable correlation.

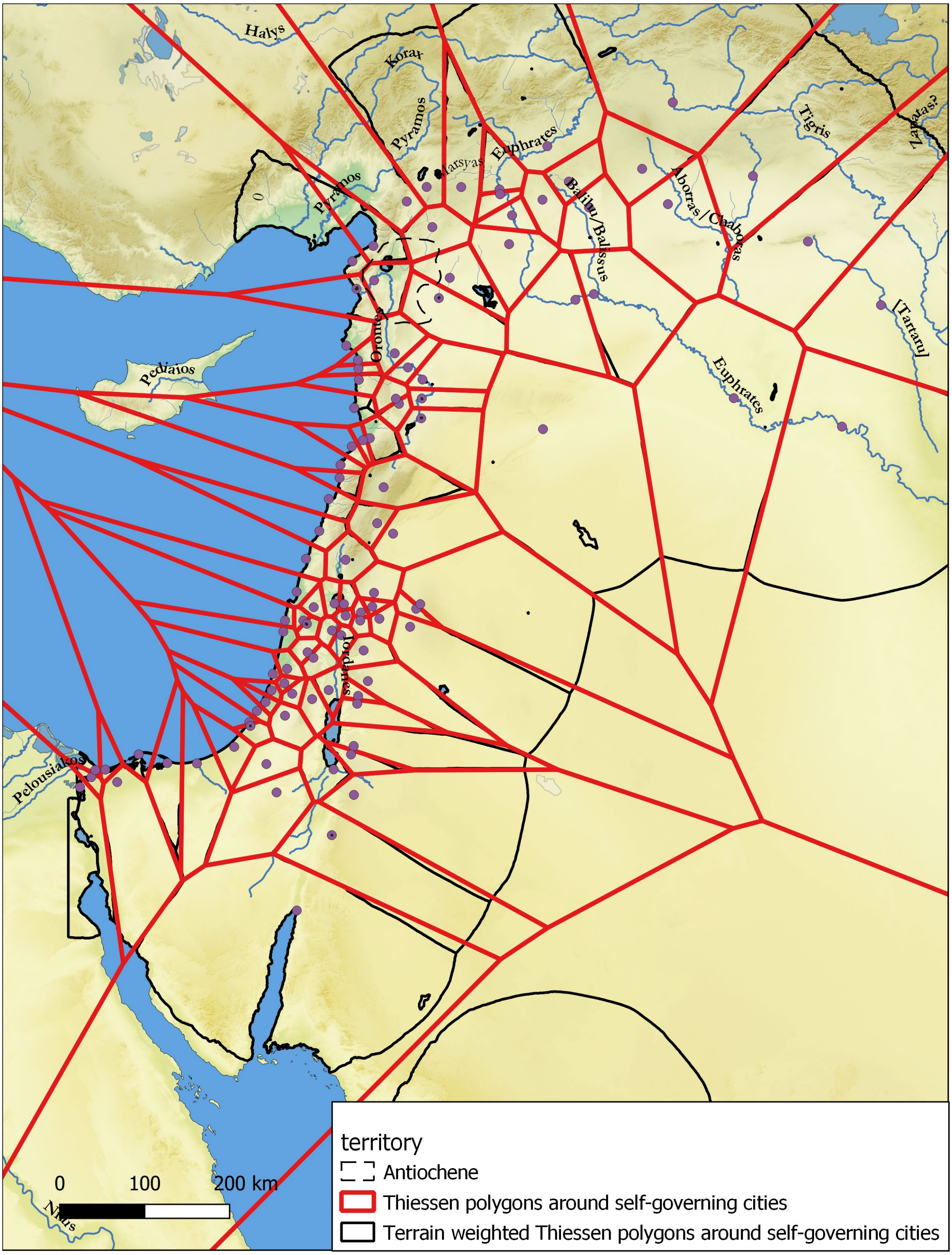

Figure 36 Euclidean and terrain weighted Thiessen polygons around self-governing cities

Figure 37 Thiessen polygons around self-governing cities, clipped by sea and 45 hour flat land travel equivalent

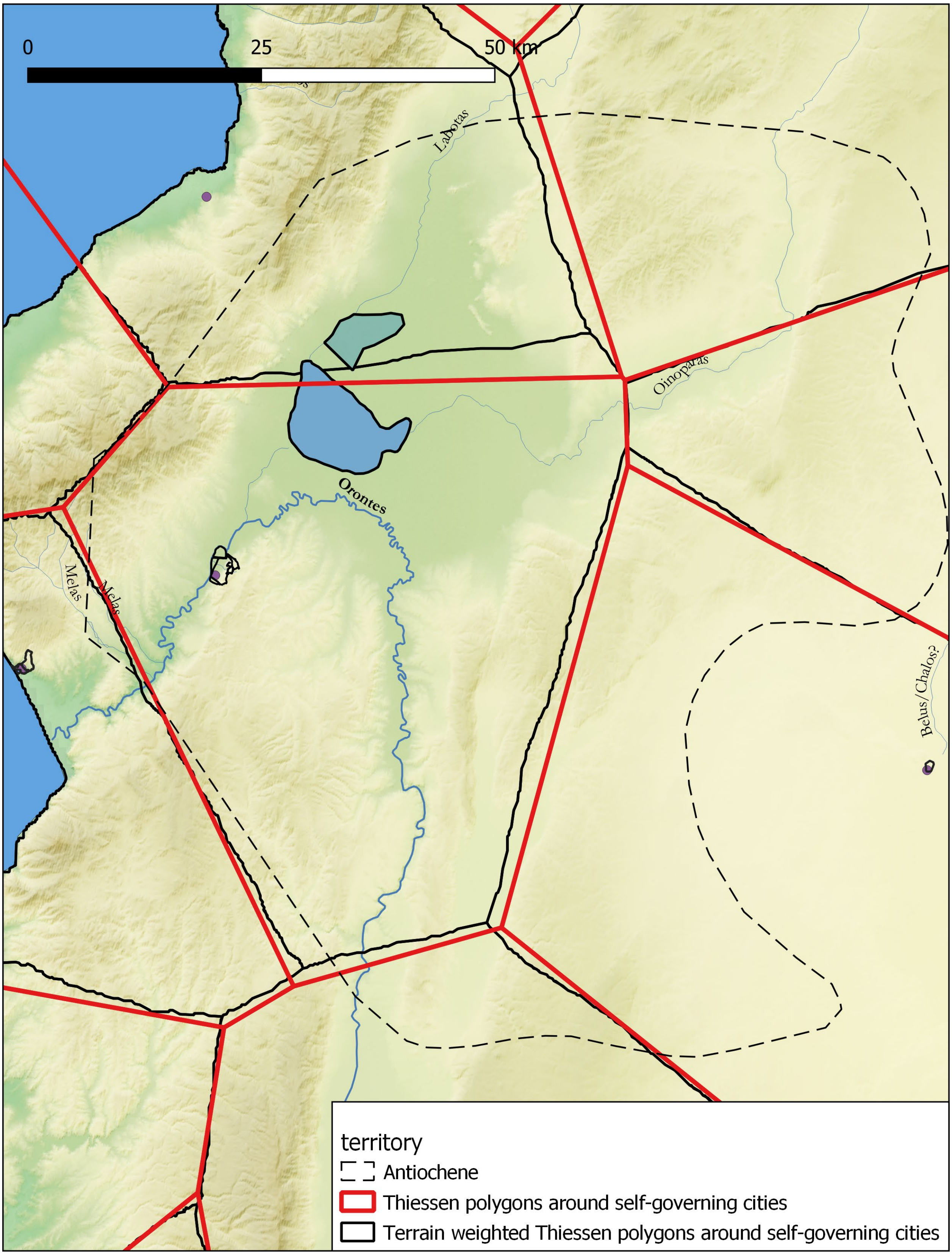

Figure 38 Thiessen polygons compared to reconstructed Antiochene territory

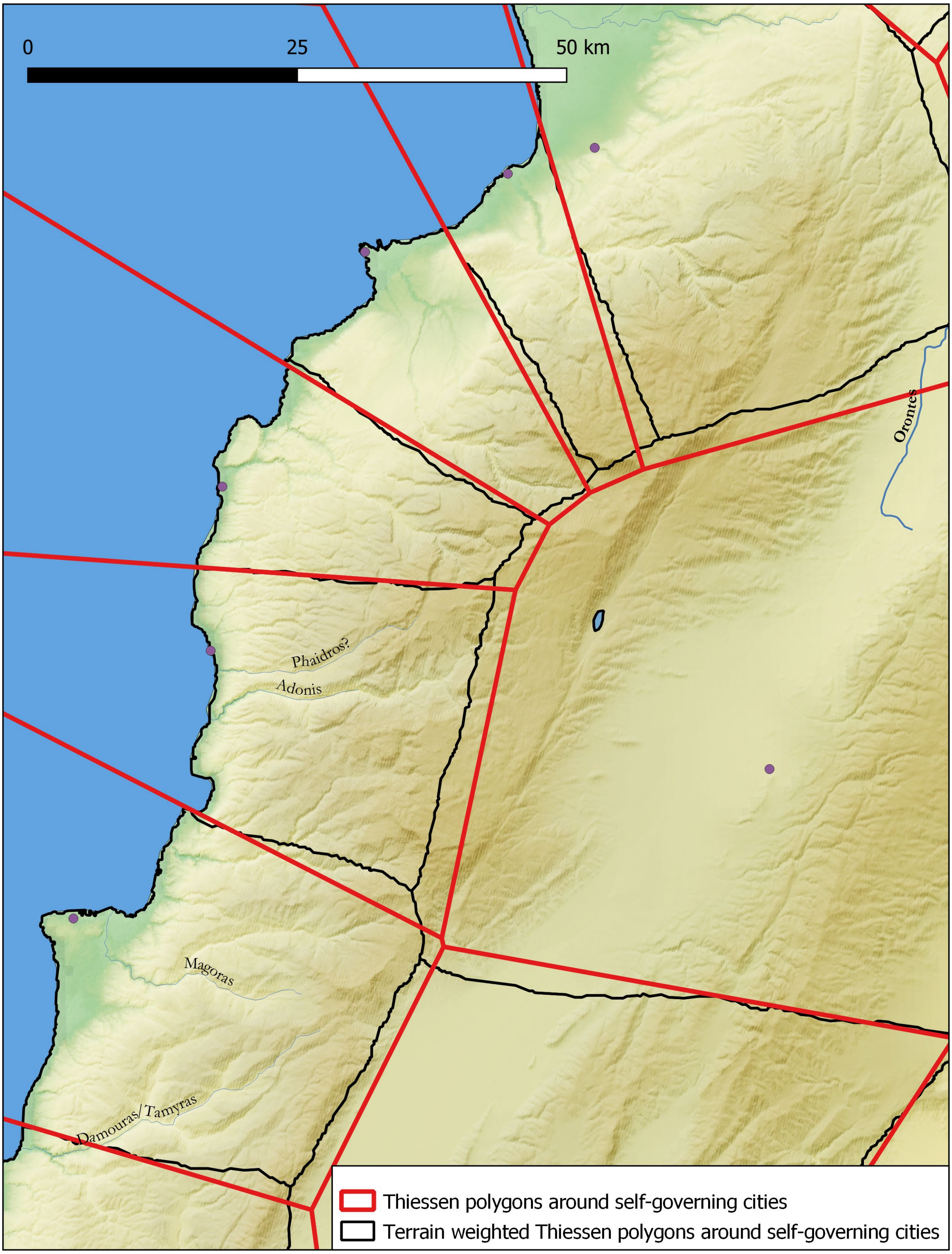

Figure 39 Detail of difference between Euclidean and terrain weighted Thiessen polygons

3.2.1.2 Terrain-weighted distance

Rather than using Euclidean distance, the same exercise could be performed using travel time. The core concept is that by taking obstacles such as elevation, rivers and vegetation into account, one gets a more reliable indication of the potential extent of a territory. The figures above show the reconstructed territories on the basis of Tobler's hiking function (in black, with a maximum travel time of 45 hours). This function, derived from empirical evidence from Imhof in 1950, gives an optimal walking speed of 6 km/hour at a downward slope of 2.86°, and just over 5 km/hour on flat land, quickly decreasing at steeper uphill or downhill inclines. See Figure 40 for expected walking speeds over different degrees of slope.

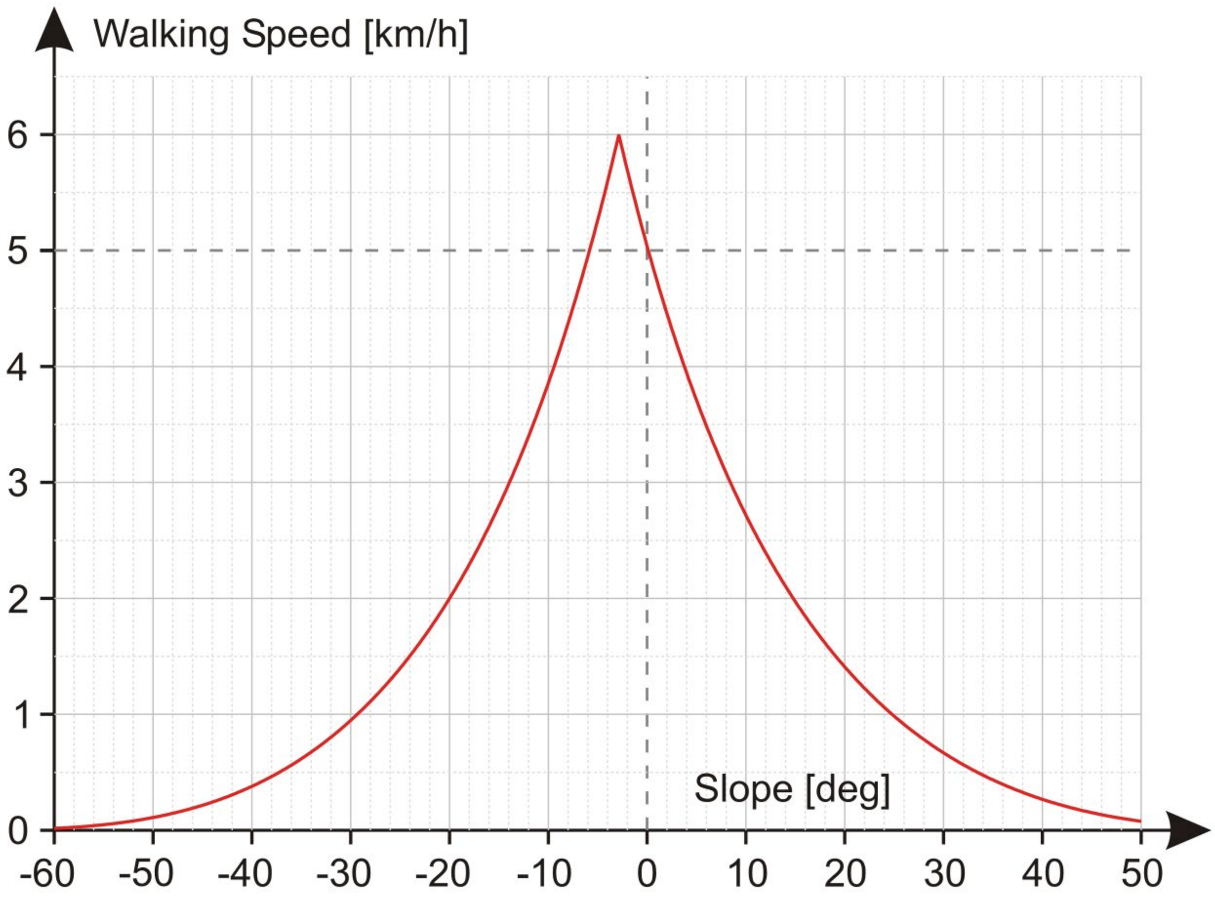

Figure 40 Toblers Hiking Function (credits: By Darekk2 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=55208352)

Several remarks should be made: the given walking speeds assume the presence of paths. Tobler suggests that off-road hiking speeds should be limited to 60% of the indicated times. In fact, different types of land cover, from agricultural fields with various crops to forest or marshes, will have vastly different effects on travel speed. Studies based on modern-day situations are naturally capable of taking this into account, using actual landcover data and empirical evidence for hiking speeds. In this case, however, neither detailed information on road systems (except a very limited number of major military roads) nor on landcover is available. Therefore, for these calculations only the effects of elevation differences have been taken into account.

As is clear, the differences from polygons made using Euclidean distances are minimal (except of course for the obvious difference that the territories now stop at the sea), with only specific cases such as the Amanos mountains and the Syrian coastal range causing considerable deviation. A detailed look shows that this result is not because of underestimation of terrain effects, but rather a logical effect of the distances involved. As the isochrone map in figure Figure

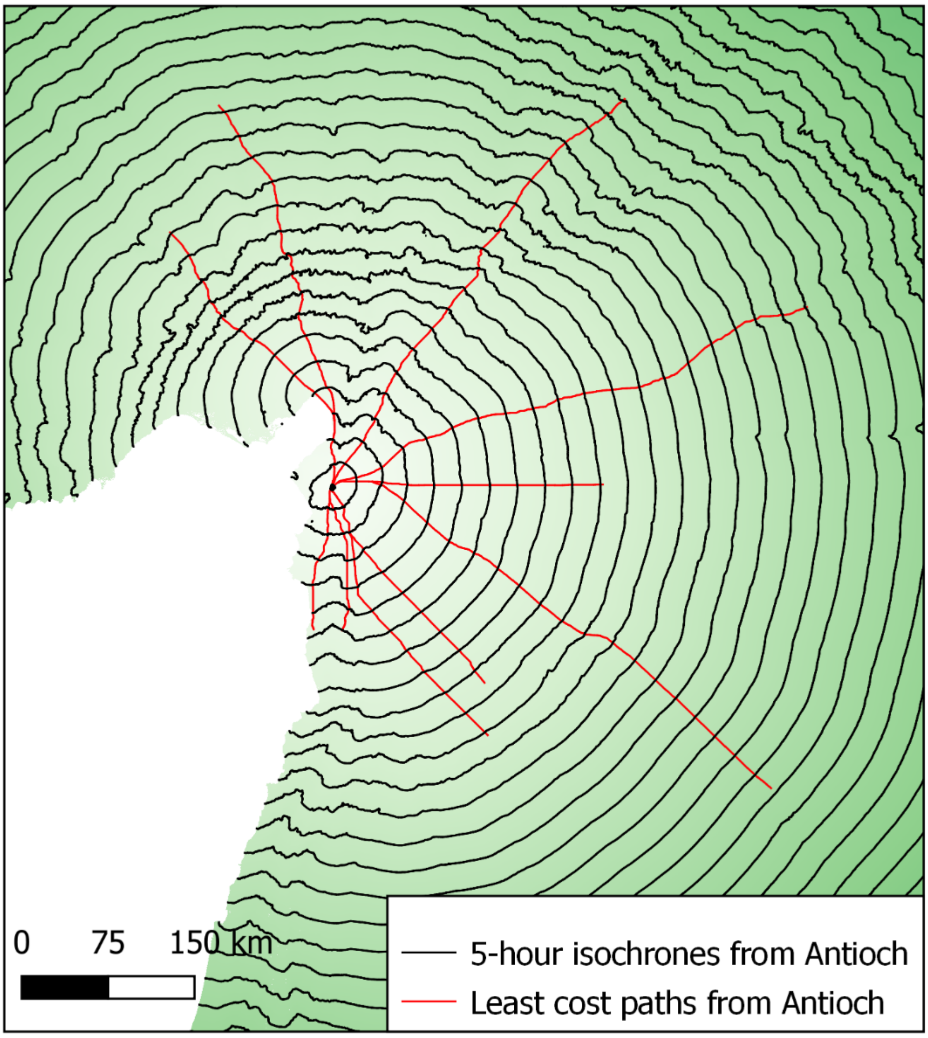

Figure 41 isochrones and least cost paths from Antioch

41 shows, at shorter distances the influence of mountains is very pronounced, while at long distances the isochrones approach a circular Euclidean distance. Over longer distances, the average speed to arrive at any point approaches that of walking over flat land. The explanation lies in the same figure: paths taken from the point of origin (in this case Antioch) to arrive at a random set of locations shows that efforts are made to circumvent high-slope areas. The further away, the more likely it is that there are alternative routes through passes or around mountains

that cost far less time than going straight through them. When more time is spent travelling, the percentage of time lost to detours around obstacles decreases.

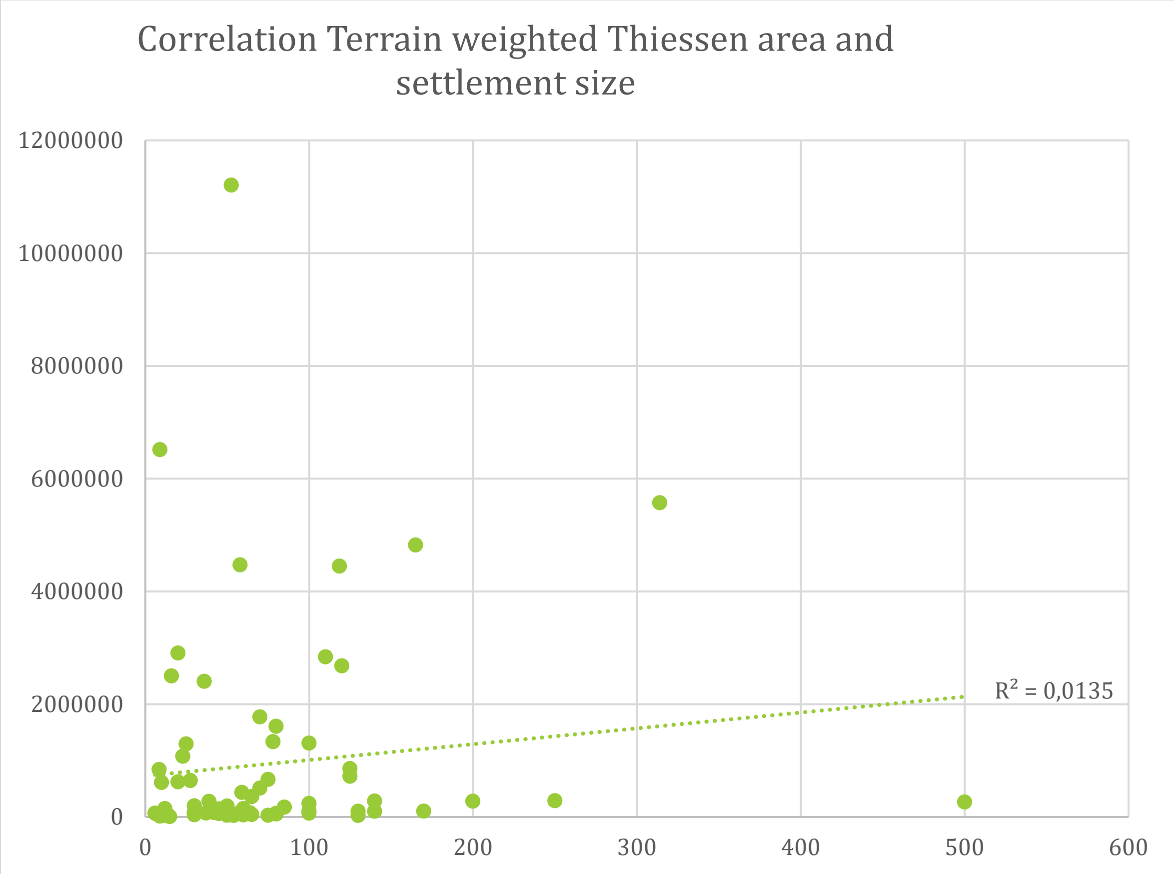

Figure 42 Correlation Terrain weighted Thiessen area and settlement size

As the resulting areas approach those of regular Thiessen polygons, the same conclusions can be drawn as regards the relationship between territory size and urban area: there is none.

3.2.1.3 Market distance

Using isochrones creates the opportunity to look at only those areas reachable within a certain time limit. This links back to the concept of market distance and willingness to travel from a village to farmland. In most circumstances most farmland is located within a 15- to 30-minute radius of a settlement nucleus.[656] Within a hierarchical system, it can be assumed that a central settlement depended for its food provision not only on its direct surroundings, but also on surplus generated by lower-order settlements in its surroundings, in this case the villages within its territory. For the following section, 3.2.2, it is furthermore assumed that only those villages playing a role in primary production for the settlement that lay within such a distance that

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[656] Wilkinson et al., 'Structure and Dynamics of Dry-Farming States', 496; John Bintliff, 'Emergent Complexity in Settlement Systems and Urban Transformations', in *Historische Geographie Der Alten Welt, Grundlagen, Erträge, Perspektiven, Festgabe Für Eckart Olshausen.*, ed. U. Fellmeth, P. Guyot, and Holger Sonnabend (Hildesheim, 2007), 57.

allowed travel to the city, the sale of goods and a return trip within a single day. This has been argued for instance by Tony Wilkinson.[657] The commonly accepted maximum figure for such a single-day return trip would be three hours each way, or some 15km radius. As such, the resulting areas could be interpreted as an ideal model for what could have functioned as practical territories.[658] In the following we will describe this area as the 'market zone' of the city. In reality of course, in larger political territories one should also expect surplus extraction, albeit perhaps less efficiently, from rural populations further away as well, while it is also clear that people could also be expected to be willing to travel further to sell their goods if necessary.

3.2.2 Soil productivity and food consumption

Territory size or market area alone does not give an explanation for urban size. It has, however, given us the basis for further evaluation of the potential carrying capacity of those territories: even if a direct correlation cannot be found between territory size and population, at least the likely natural upper limits can be defined for an urban population sustained by production in its direct hinterland.

Similar calculations of the upper limit of a population have been made often enough in any field that concerns itself with population levels, originating in range management (ignoring 19th-century use of the term 'carrying capacity' simply meaning payload), and adopted in the 50s and 60s of the past century in the fields of anthropology, as well as archaeology and history.[659] It is perhaps, as Sayre puts it, a "very dull tool for understanding the complex interrelations of humans with the face of the earth"[660], but in demography for ancient history one has to resort to simple methods that get the job done.[661]

While in history and anthropology carrying capacity is defined as a property of a specific territory (how many people can be supported by that territory), in ecology it is a property of population (at what population density does population growth equal mortality).[662] Leaving the specifics of the latter aside, the implicit assumption is exactly the same: at the maximum population for a given territory (which is a density), no further growth is possible. At a higher density, mortality would increase until the population returns to the maximum. Perhaps more

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657 Wilkinson et al., 'Structure and Dynamics of Dry-Farming States'.
658 Bintliff, 'Going to Market in Antiquity'.
659 Stephen B. Brush, 'The Concept of Carrying Capacity for Systems of Shifting Cultivation1', *American Anthropologist* 77, no. 4 (1 December 1975): 799–811, https://doi.org/10.1525/aa.1975.77.4.02a00040; Nathan F. Sayre, 'The Genesis, History, and Limits of Carrying Capacity', *Annals of the Association of American Geographers* 98, no. 1 (5 February 2008): 120–28, https://doi.org/10.1080/00045600701734356.
660 Sayre, 'The Genesis, History, and Limits of Carrying Capacity', 132.
661 Mogens Herman Hansen, *The Shotgun Method the Demography of the Ancient Greek City-State Culture*, Fordyce W. Mitchel Memorial Lecture Series (Columbia: University of Missouri Press, 2006), 2.
662 Robert Sallares, *The Ecology of the Ancient Greek World* (Cornell University Press, 1991), 74–79.

interesting is that Sallares' calculations for 4th-century B.C.E. Attica with the former method result in population densities that match those known from late 19th-century Greece, a point at which population growth in the recently formed country resulted in overpopulation, and subsequently, food imports and emigration.[663]

Elio Lo Cascio and Paolo Malanima give a clear expression of carrying capacity as area per person.[664] In the following formula it has been rewritten to give the maximum total population to be supported by a known area:

$$p_{tot} = \frac{g \cdot c \cdot A}{f}$$

This gives us, as mentioned earlier, the following variables that need to be determined, which will be explained in the following paragraphs. Firstly, A, the size of the productive territory. As discussed above, a 3-hour walking distance around each settlement will be used to create an equal basis for comparison. Secondly, the potential grain yield (g) will be determined within that territory, minus the amount of seed needed for reseeding.. There are a considerable number of resources that play a vital role for ancient society, if we consider for instance Malanima's views on energy consumption in the ancient world in general, or a recent article by Jansen et al., reminding us of the importance of fuel for heating.[665] In general, for this region, the presence of water and food is the most limiting condition for survival. Calculations on the basis of water supply tend to be dramatically inaccurate, but in combination with food resources it is possible to create plausible ranges. Thirdly, we need to know the amount of land under fallow (c). As Lo Cascio and Malanima state, for a two-field system, with half the land under cultivation, c would be 0.5; for a three-field system, with one third of the land under fallow, this would be 0.66.[666] Fourthly, we need a figure for food consumed per capita (f) (see 3.2.2.2 below). Finally, as the combination of production and consumptionarrives at the total population for the whole territory (p_{tot}), it is necessary to look at the ratio between people living within the city and outside of it, to propose the maximum sustainable urban population.

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[663] Sallares, 79.

[664] Elio Lo Cascio and Paolo Malanima, 'Cycles and Stability. Italian Population before the Demographic Transition (225 B.C. - A.D. 1900)', *SE*, 2005, 20, https://doi.org/10.1410/20933; Ellen Janssen et al., 'Fuel for Debating Ancient Economies. Calculating Wood Consumption at Urban Scale in Roman Imperial Times', *Journal of Archaeological Science: Reports* 11 (February 2017): 592–99, https://doi.org/10.1016/j.jasrep.2016.12.029.

[665] Paolo Malanima, 'Energy Consumption and Energy Crisis in Roman World', *The Ancient Mediterranean Environment between Science and History*, 2011, 13–36; Janssen et al., 'Fuel for Debating Ancient Economies. Calculating Wood Consumption at Urban Scale in Roman Imperial Times'.

[666] Lo Cascio and Malanima, 'Cycles and Stability. Italian Population before the Demographic Transition (225 B.C. - A.D. 1900)', 20.

3.2.2.1 Agricultural yield

For all the following calculations of agricultural yield, the focus will lie on wheat cultivation. In reality, as also discussed below when looking at food consumption, it is quite possible that barley was the preferred crop, being more suited to cultivation in a drier, warmer climate. Additionally, part of the land will have been used for animal husbandry, olives and viticulture. It is likely that transhumance was practiced allowing the use of more marginal steppe or upland areas.[667] On the other hand, Paul Halstead makes the interesting point that with denucleated settlement it would be just as viable to keep animals locally. This would make manure from the animals easily available and intensive agriculture possible. It would, however, necessitate the growth of fodder crops, although rotating food crops for fodder rather than bare fallowing would reduce the amount of land required for this purpose.[668] Of course, there is also the question to what degree fertilisation was necessary: for instance for Upper Mesopotamian and other semi-arid soils, water resources and soil workability were larger constraining factors than nitrogen or phosphorus levels.[669] As it cannot be clearly defined to what degree animals competed for space and food with humans, and to which degree this was offset by the labour and food they provided, only wheat yields will be considered.

Araus et al. clearly illustrate that there is a range of methods to estimate agricultural yields for ancient agriculture, where there is an inverse relationship between the uncertainties around the underlying assumptions and the complexity of the biology needed to make the estimate. Besides using information available in historical written sources, methods range from entirely made-up, speculative estimates that completely disregard the crops used, through using modern yields and experimental archaeology, to calculations based either on grain size or chemical properties, such as carbon isotope composition.[670] The most reliable estimates come from the latter method, but of course, this is only applicable in a handful of case studies where the carbon composition of recovered grains has been analysed.[671] This method can also be used to check the potential validity of estimates made using simpler methods. So, in tables 4 of both Ferrio et al. 2012 and Araus et al. 2007, there are yield estimates based on carbon isotope discrimination in several Neolithic periods at Tell Halula and Akarçay Tepe, compared with modern yields in Raqqa and Aleppo. Here, we get ranges for naked wheat from 700 to 1800 kg per hectare, with most likely results around 1000 to 1200 kg per hectare, compared to 1500 kg per hectare for modern yields

[667] Tony J. Wilkinson, *Archaeological Landscapes of the Near East* (University of Arizona Press, 2003), 218.
[668] Wilkinson et al., 'Structure and Dynamics of Dry-Farming States', 64–65.
[669] José Luis Araus et al., 'Productivity in Prehistoric Agriculture: Physiological Models for the Quantification of Cereal Yields as an Alternative to Traditional Approaches', *Journal of Archaeological Science* 30, no. 6 (1 June 2003): 691, https://doi.org/10.1016/S0305-4403(02)00240-6.
[670] Araus et al., 690.
[671] Araus et al., 689.

in that region (this is a lowered estimation from that given in 2007, based on potential grain size).[672]

Eva Kaptijn compared data on 19th- and early 20th-century crop yields in parts of Israel and the Jordan Valley. She mentions yields of 600 to 780 kg per hectare for a single 20-hectare farm in the Jezreel valley in the 1930s, and around 1000 kg per hectare in the Zerqa triangle in the Jordan Valley, under irrigated conditions, in the same period. In comparison, in 1965 irrigated yields in the Jordan valley lay around 1000 to 1200 kg/ha, while non-irrigated yields in the upper Jordan Valley were as low as 350 kg/ha.[673] It is important to note that in a low-rainfall zone such as the Jordan Valley, better yields could clearly be obtained through irrigation than in wetter zones using rainfed agriculture.

To avoid soil depletion and maintain long-term crop health, each year part of the agricultural land had to lie fallow. While in wetter climates fallow is mainly important for restoration of nutrient levels in the soil, such as nitrogen, at lower precipitation levels (below 300 mm per annum), it is also necessary to increase or maintain soil wetness. While manuring and alternate cropping with nitrogen-fixing plants may reduce time under fallow, in the drier parts of the study region biennial fallowing would still be necessary under rainfed conditions.[674]

Lo Cascio and Malanima argue that more complex regimes such as a three-field system were already being used in Italy in Roman times, meaning that only a third, rather than half of the land lay fallow.[675] It is not unthinkable that such techniques were also practiced in the east. Note that such a reduction would imply a 32% increase in annual production. In this context we should also consider Halstead's argument, that simple bare fallowing pays off for extensive cultivation of more distant fields, which makes sense in nucleated settlement systems of the more recent past. But as will be discussed in the following chapter for instance for the Antiochene, or Roman Syria in general, from the late Iron Age onwards the countryside was characterised by denucleated settlement. As such, with shorter distances to fields, more intensive agricultural practices, including manuring and weeding and more labour-intensive cultivation of legumes as

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[672] José Luis Araus et al., 'The Historical Perspective of Dryland Agriculture: Lessons Learned from 10 000 Years of Wheat Cultivation', *Journal of Experimental Botany* 58, no. 2 (1 January 2007): 137 table 4, https://doi.org/10.1093/jxb/erl133; J. P. Ferrio et al., 'Agricultural Expansion and Settlement Economy in Tell Halula (Mid-Euphrates Valley): A Diachronic Study from Early Neolithic to Present', *Journal of Arid Environments*, Ancient Agriculture in the Middle East, 86 (1 November 2012): 109 table 4, https://doi.org/10.1016/j.jaridenv.2011.09.011.
[673] E. Kaptijn, *Life on the Watershed. Reconstructing Subsistence in a Steppe Region Using Archaeological Survey a Diachronic Perspective on Habitation in the Jordan Valley* (Leiden: Sidestone Press, 2009), 346, 353.
[674] Sallares, *The Ecology of the Ancient Greek World*.
[675] Lo Cascio and Malanima, 'Cycles and Stability. Italian Population before the Demographic Transition (225 B.C. - A.D. 1900)', 21.

a rotation for cereals was possible, even likely.[676] Even so, we will for now maintain the more commonly accepted view that a simple two-field system was used in the East, where half of the cultivable land lay fallow.

Before looking at consumption, it is important to subtract the amount of seed saved for reseeding. Both Sallares and Lo Cascio and Malanima give figures between 100 and 150 kg of seed needed per hectare of land. As Sallares indicates, while 100 kg per hectare is suggested in a modern context, a higher sowing rate of 126 kg/ha (based on 5 modii per iugerum as suggested by Columella) would be sensible, considering lower seed quality. But note as well that in drier regions we often find lower seed rates being used.[677]

Looking at total yield, Sallares expects "that cereal yields in the Mediterranean in the past could have exceeded 650 kg/ha only rarely, except on very good soils."[678] Overall, Sallares' estimates appear to lie on the lower end of the spectrum, with potential rainfed yields as high as 1800 kg/ha based on grain characteristics. Considering, however, that earlier 20th-century irrigated yields were considerably lower than that, a yield of 1000 kg per hectare seems a reasonable upper boundary for rainfed cereal yields. Another method to estimate crop yields is to derive them from satellite-based vegetation indices, which have the advantage of giving estimates for a wider geographical area, but naturally only give current information for the date the image was made. By looking at parts of the light spectrum reflected by vegetation, it is possible to determine such things as area under cultivation, crop health and the like. Numerous studies show the possibility to translate this to crop yield in a modern context.[679] In this section, a dataset provided by the United Nations Food and Agricultural Organisation (FAO) has been used, called the Global Agro-Ecological Zones Data Portal (GAEZ). The FAO created this database to calculate actual agricultural yields on a global level based on satellite data, and from that (together with additional data such as soil composition) calculate potential yields under different conditions. The model is additionally based on a number of variables for which the FAO

[676] Halstead, 'Traditional and Ancient Rural Economy in Mediterranean Europe: Plus Ça Change?', 61–66.
[677] Lo Cascio and Malanima, 'Cycles and Stability. Italian Population before the Demographic Transition (225 B.C. - A.D. 1900)', 20; Sallares, *The Ecology of the Ancient Greek World*, 374; Richard Duncan-Jones, *The Economy of the Roman Empire: Quantitative Studies* (Cambridge: University Press, 1982), 49, 371; Columella, *RR*, trans. Harrison Boyd Ash, Loeb Classical Library 361, 1941, II.9, II.12.1, III.3.4.
[678] Sallares, *The Ecology of the Ancient Greek World*, 389.
[679] See for instance: M. S. Rasmussen, 'Developing Simple, Operational, Consistent NDVI-Vegetation Models by Applying Environmental and Climatic Information. Part II: Crop Yield Assessment', *International Journal of Remote Sensing* 19, no. 1 (1 January 1998): 119–39, https://doi.org/10.1080/014311698216468; M. P. Labus et al., 'Wheat Yield Estimates Using Multi-Temporal NDVI Satellite Imagery', *International Journal of Remote Sensing* 23, no. 20 (1 January 2002): 4169–80, https://doi.org/10.1080/01431160110107653; Paul C. Doraiswamy et al., 'Application of MODIS Derived Parameters for Regional Crop Yield Assessment', *Remote Sensing of Environment* 97, no. 2 (30 July 2005): 192–202, https://doi.org/10.1016/j.rse.2005.03.015; M. S. Mkhabela et al., 'Crop Yield Forecasting on the Canadian Prairies Using MODIS NDVI Data', *Agricultural and Forest Meteorology* 151, no. 3 (15 March 2011): 385–93, https://doi.org/10.1016/j.agrformet.2010.11.012.

provides three different scenarios describing cultivar types and farming methods, ranging from ‘low-level inputs/traditional management’ to ‘high-level inputs/advanced managment’. The scenario which the FAO calls ‘low input’ most closely approaches Classical agriculture, working without mechanical means and using older cultivars. Additionally, the applied fallow rate is in fact higher than suggested above, with 60% land under fallow for most soil types in the region, and even higher at 75% required fallow on for instance xerosols (desert soil) and lithosols.[680] The data provided is of a far lower spatial resolution than could be achieved by calculating cereal yields directly from vegetation index data, but because of the large scale of the study area a higher resolution would be redundant. Compared datasets were a: modern (year 2000) wheat production, both rain-fed, irrigated, and combined, and b: potential rain-fed wheat production at low input, both in general and within the bounds of currently used agricultural land. The year 2000 production estimates were based on remote sensing data, corrected to correspond to national and regional production statistics.[681]

Within the study region, for low input, potential rain-fed wheat the yield range lies between 0 up to 1975 kg/ha (Figure 43). The mean lies around 308 kg/ha with a standard deviation of 459 kg/ha (Table 11). Within the direct market zones of cities, the distribution is naturally different, as most cities do not lie within the vast deserts that are part of this region (once again highlighting the gravitation of human settlement to ecologically preferable areas). So, only desert cities such as Aila, Timna, Hegra and Zoara have an average cereal production of 0, while the highest city has a potential territorial production of 1752 kg/ha (Antoninopolis, in upper Mesopotamia), and the runners-up in quite diverse locations (Gerar, Ioppe, Chalcis ad Belum and Caesarea Maritima) have values around 1450 kg/ha. The mean for market zone production lies at 605 kg/ha, with a standard deviation of 405 kg/ha (the median lies at 521 kg/ha). About 65% of the settlements lie within one standard deviation, in other words, have a yield figure

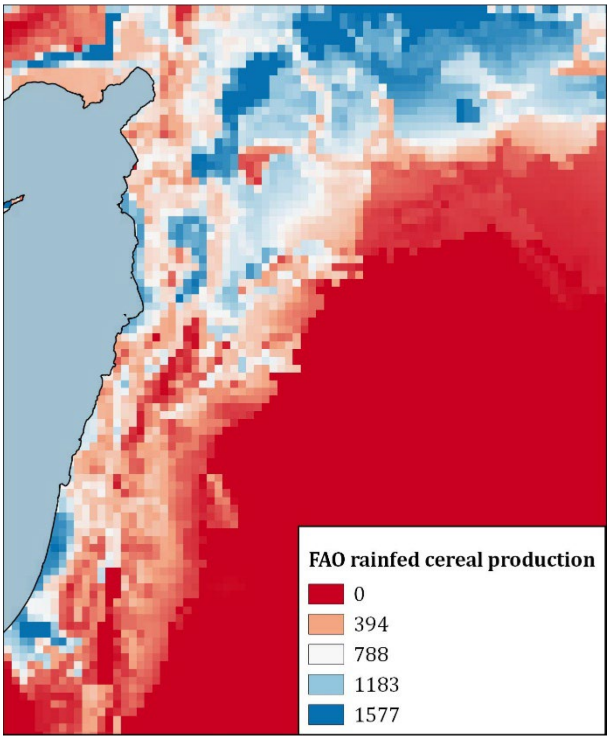

Figure 43 FAO low input rainfed cereal production (kg/ha)

[680] G. Fischer et al., ‘Global Agro-Ecological Zones (GAEZ v3.0)- Model Documentation’, 2012, 56, 83–84, appendix 6-4, http://www.fao.org/fileadmin/user_upload/gaez/docs/GAEZ_Model_Documentation.pdf.
[681] Fischer et al., 49–53, 56, 89–93.

between 200 and 1010 kg/ha. Considering this, these yields lie on the higher end of the likely spectrum given above, but well within the potential suggested by Ferrio and Araus et al.

For the sake of illustration, year 2000 yields show the vast improvements attained by modern agriculture, with a combination of better cultivars, irrigation, artificial fertilizers, crop rotation, and mechanisation. With modern techniques, the regional maximum lies over four times as high, at 8090 kg/ha, which appears to be an outlier in Lebanon. Even so, the mean of 537 kg/ha and a standard deviation of 975 kg/ha show that production potential has improved considerably with modern agriculture. Within our urban territories, the range lies between 0 and 3980 kg/ha, with an average at 1250 kg/ha, and a standard deviation of 880 kg/ha.

	Minimum	Maximum	Mean	St. Dev.
Low input – regional yields	0	1,975	308	459
Low input – city yields	0	1,752	605	405
Year 2000 – regional yields	0	8,090	537	975
Year 2000 – city yields	0	3980	1250	880

Table 11 FAO yield data within the study area

3.2.2.2 Food consumption and population density

This brings us to the final coefficient needed to establish carrying capacity: food consumption. This is, as Lo Cascio and Malanima write, probably the least doubtful variable. It is, firstly, based on the required caloric intake per person, which on average for adults lies between 2000 and 3000 kilocalories. Jongman considered average caloric needs per gender and age group in more detail, to arrive at an average of 2000 kcal, assuming a high number of young people for the Roman population (based on UN life tables, model south, with a life expectancy at birth of 25 years).[682] This is essentially the minimum subsistence level. If the caloric intake is lower than expenditure, vulnerability to disease increases. Eventually, starvation sets in.[683]

In literature, the required caloric intake is usually translated into an amount of cereals consumed per person. The actual diet of the inhabitants of the Roman empire will likely have been far more diverse, not in the least because a purely cereal-based diet would lead to significant deficiencies. As Jongman summarises, perhaps as much as half the calories of the basic diet came from wine (apparently, about a modern bottle a day per person) and olive oil. This seems an unlikely high amount, but at least it illustrates the potential of other nutritional

[682] Willem M. Jongman, 'The Early Roman Empire: Consumption', in *The Cambridge Economic History of the Greco-Roman World*, ed. Walter Scheidel et al. (Cambridge: Cambridge University Press, 2008), 599.
[683] Jongman, 598–99.

sources. Furthermore, at least in Italy, there was a large increase in the consumption of meat from the Late Republic onwards.[684] It is also clear that fish (and fish sauce) likely played a large role in Roman Levantine diets, with plenty of written and pictorial evidence for fishing-related activities. As also suggested by Justin Lev-Tov, sheep and goat meat played a large role in Palestine, and with Roman influence the consumption of fish also increased in prominence, with marine fish consumed in communities well away from the sea.[685] Kevin Butcher also highlights a taste for imported fish-related goods in some of the coastal cities of Syria, based on fish or fish-sauce amphorae.[686]

Even so, in the following we assume a purely cereal-based diet as a baseline. To arrive at an equal number of calories from wine and olive oil for the part of the diet covered by those foodstuffs would require significantly less land than cereal cultivation. Ignoring fish and meat consumption, that gives us the most basic situation, where modifications in the diet would likely result in a higher population cap. In numbers, this is usually translated to 250 kg of cereal-equivalent per person per year. To name one example, Magen Broshi indicates that somewhere around 180 to 200 kgs of wheat were allotted to labourers and soldiers in antiquity. In comparison, he gives figures for two Arab villages in the Galilee in 1930, consuming 190 and 237 kg per person respectively. He therefore gives 200 as minimum, but this would result in malnutrition, and therefore he uses 250 kg as a minimal average.[687] Of course, the exact amount of wheat also hinges on the calorific value of a kg of cereals (and of course, whether these were wheat or barley). Consider for instance Rinse Willet's remarks about different figures used by Garnsey and Engels, with the first using 3320-3330 calories per kg of wheat and 3320 calories for a kg of barley based on modern nutritional values, while Engels gives a far lower figure for barley, at 2158 kilocalories.[688] Garnsey's figures would put the required cereals per person just under 220 kg/ha, Engels' figure raises this to just over 390 kg. Assuming, however, that the nutritional value of barley did not differ as strongly from modern cultivars as Engels suggests, and for now, with a preference for wheat, the 250 kg average seems an acceptable figure.

Table 12 summarises the variables above, and how that translates into a low- and high-count scenario for carrying capacity. For obvious reasons a higher food consumption rate leads to a low-count scenario. Additionally, the final column shows the impact of each variable on the final

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[684] Jongman, 602–5.
[685] Justin Lev-Tov, '"Upon What Meat Doth This Our Caesar Feed…?"1 A Dietary Perspective on Hellenistic and Roman Influence in Palestine', n.d., 27.
[686] Butcher, *Roman Syria and the Near East*, 187.
[687] Broshi, 'The Population of Western Palestine in the Roman-Byzantine Period', 7.
[688] Rinse Willet, 'Whirlwind of Numbers. Demographic Experiments for Roman Corinth', *Ancient Society* 42 (2012): 130–31; Peter Garnsey, 'Mass Diet and Nutrition in the City of Rome', in *Nourrir La Plèbe. Actes Du Colloque Tenu a Genève Les*, vol. 28, 1991, 71–73.

result. For yield, consumption, fallow and the final carrying capacity, impact is calculated by simply dividing the higher by the lower value for each variable. The impact of reseed rate is far lower, as it is only a subtraction from the final yield. Therefore, its actual impact is the difference between the maximum and minimum of carrying capacity and that of yield, consumption and fallow. Essentially, this only quantifies the intuitively obvious fact that the larger the difference between the lower and higher estimates for a variable, the more it will impact the end result.

		low	high	mean	impact factor
yield	kg/ha	500	1000	750	**39%**
consumption	kg/person	300	200	250	**29%**
fallow		50%	66%	58%	**26%**
reseed	kg/ha	150	100	125	**5%**
car. cap.	person/ha	0.58	2.97	1.45	**100%**

Table 12 Impact of variables

Table 13 shows the effects of different yield rates on carrying capacity when keeping fallow and reseed rate constant. The seed-yield ratio has also been added for the sake of comparison to the ancient agronomists, as this is the typical way in which agricultural yield is expressed in ancient sources.[689] If Halstead is right that a 6:1 yield ratio is conceivable for medium or hilly soils, that gives a carrying capacity of 1.25 people per hectare. Compare also Mario Liverani, suggesting that Upper Mesopotamian yields were around 8:1 to 10:1, double that of Mediterranean rates.[690] Essentially, these tables show that a rule of thumb of one person per hectare, that lies at the basis of typical food production estimates for the Roman world, is indeed a safe baseline. Still, this is also quite pessimistic considering what it implies about the underlying assumptions: grain yields at around a third of the potential for ancient grain types, an entirely cereal-based diet, and a simple two-field system. Considering that, carrying capacity as suggested by Malanima (after Forni Marcone) from 1.5 to 2 people per hectare may not be farfetched.[691]

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689 See for instance Varro, *RR*, trans. W. D. Hooper and Harrison Boyd Ash, Loeb Classical Library 283 (Harvard University Press, 1934), I.44.1; Columella, *RR*, II.12.1.

690 Mario Liverani, in Wilkinson et al., 'Structure and Dynamics of Dry-Farming States', 508.

691 Malanima, 'Energy Consumption and Energy Crisis in Roman World', appendix.

yield	reseed	yield-seed ratio	consumption	fallow	carrying capacity per hectare
300	125	2.4 : 1	250	0.5	0.35
400	125	3.2 : 1	250	0.5	0.55
500	125	4 : 1	250	0.5	0.75
600	125	4.8 : 1	250	0.5	0.95
650	125	5.2 : 1	250	0.5	1.05
700	125	5.6 : 1	250	0.5	1.15
750	126	6 : 1	250	0.5	1.25
800	125	6.4 : 1	250	0.5	1.35
900	125	7.2 : 1	250	0.5	1.55
1000	125	8 : 1	250	0.5	1.75
1100	125	8.8 : 1	250	0.5	1.95
1200	125	9.6 : 1	250	0.5	2.15

Table 13 Carrying capacity and seed-yield ratios at different yield rates

3.2.2.3 Applying carrying capacity

Using these figures, it is possible to perform the following thought experiment. Say that the urbanisation rate was 20%, and that the urban territory included all land in a circle around it and was used to feed both the urban and rural population. Of course we must remain aware that an urbanisation rate of 20% might be true on a supraregional level, but can be vastly different on a local level, at least around large cities like Antioch and Seleucia Pieria, with far higher urbanisation rates. Perhaps in the case of small agro-towns a large part of the urban population may have been occupied in agriculture, as was the case in the region in the Bronze Age nucleated settlement pattern. For the Roman period, however, there are very few indications for a pattern like this, except in the later Roman 'cities' of the Negev. Assume the basic premise that 1 hectare of land can support 1 person for a year (so 100 people per km sq.). What follows is that for each city-dweller, there are 4 people in the countryside $\left(P_{City} = 0{,}2\ P_{Total}\right)$, so for each square kilometre of land, there are 20 city dwellers ($P_{Total} = 20\pi r^2$). The radius of the circle of land needed to feed the city is then $r = \sqrt{\frac{P_{City}}{20\pi}}$ (the surface area of the city itself is negligible, and on the assumption that 100% of the land lying within these zones was arable). A village of a hundred inhabitants (so with 400 farmers living around it) only needs a radius of 1.3 kilometres, a town of 5000 people requires 8.9 kilometres. An optimal 'market-radius' of 15 kilometres, ignoring terrain, would then feed a city of 14,137 inhabitants (for a total regional population of 70,686).

Using yet another typical figure, assume that the population density of a city is 150 persons per hectare. A single 'market radius' should then be able to support a city of 94 hectares. This is, naturally, an enormous simplification, but taking into account that the vast majority of cities throughout the empire measured well below 40 hectares in size, it does indicate that in most places local agriculture should not be seen as the limiting or even the defining factor of urban growth. In 'Rethinking Early Mediterranean Urbanism', Bintliff offers a more detailed model using this approach. The variables used differ slightly but the overall outcome is comparable, with an 80 hectare Iron Age settlement (and its subordinate settlements) requiring a territory with a 14 km radius, again highlighting that for most settlements, considerably smaller territories would be necessary.[692]

[692] John Bintliff, 'Rethinking Early Mediterranean Urbanism.', in *Mauerschau, Bd. 1. Festschrift Fuer Manfred Korfmann*, ed. R. Aslan et al. (Verlag Bernhard Albert Greiner, 2002), 157–61, 171, http://hdl.handle.net/1887/8440.

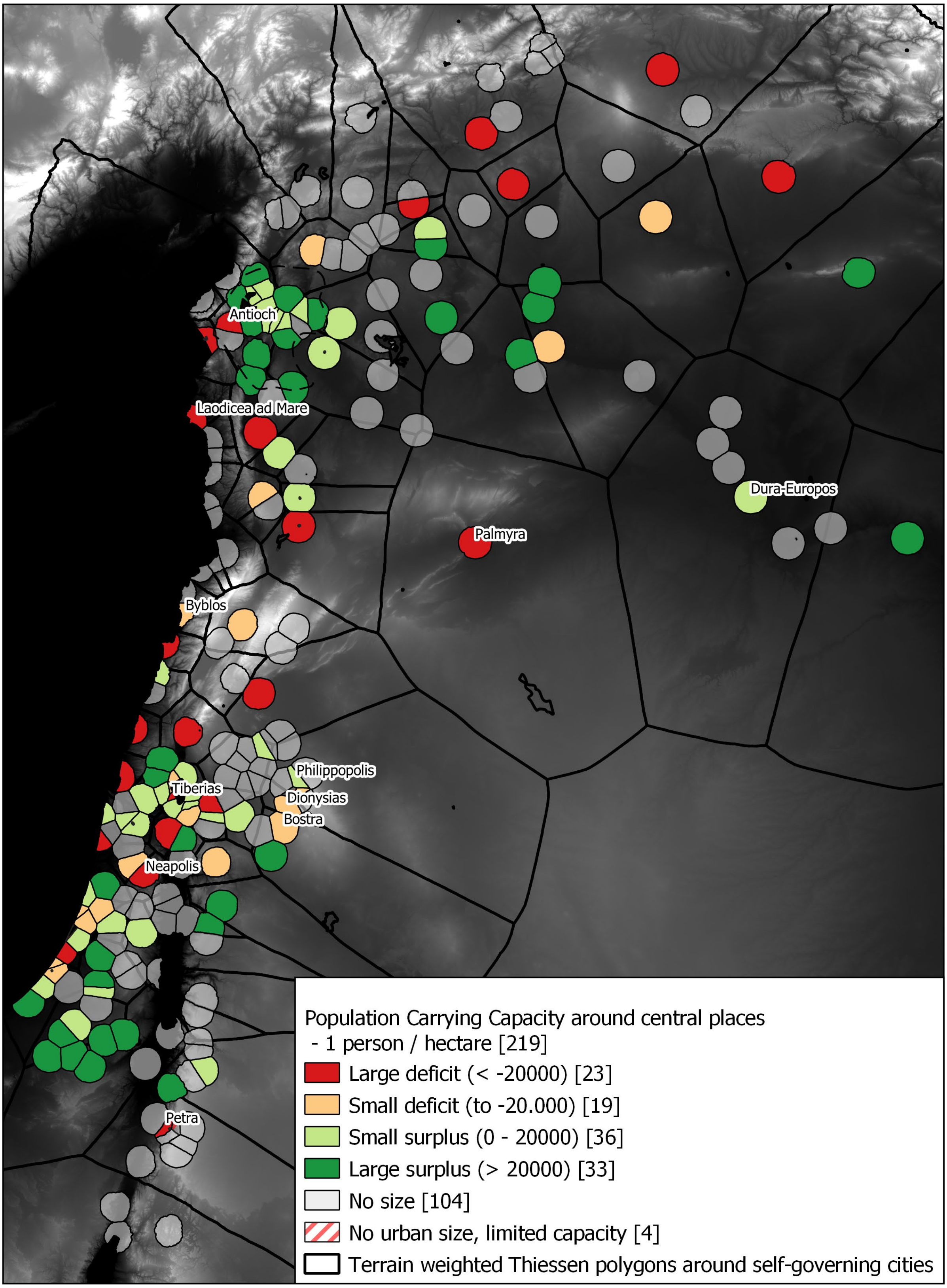

Figure 44 Carrying capacity - 1 person per hectare

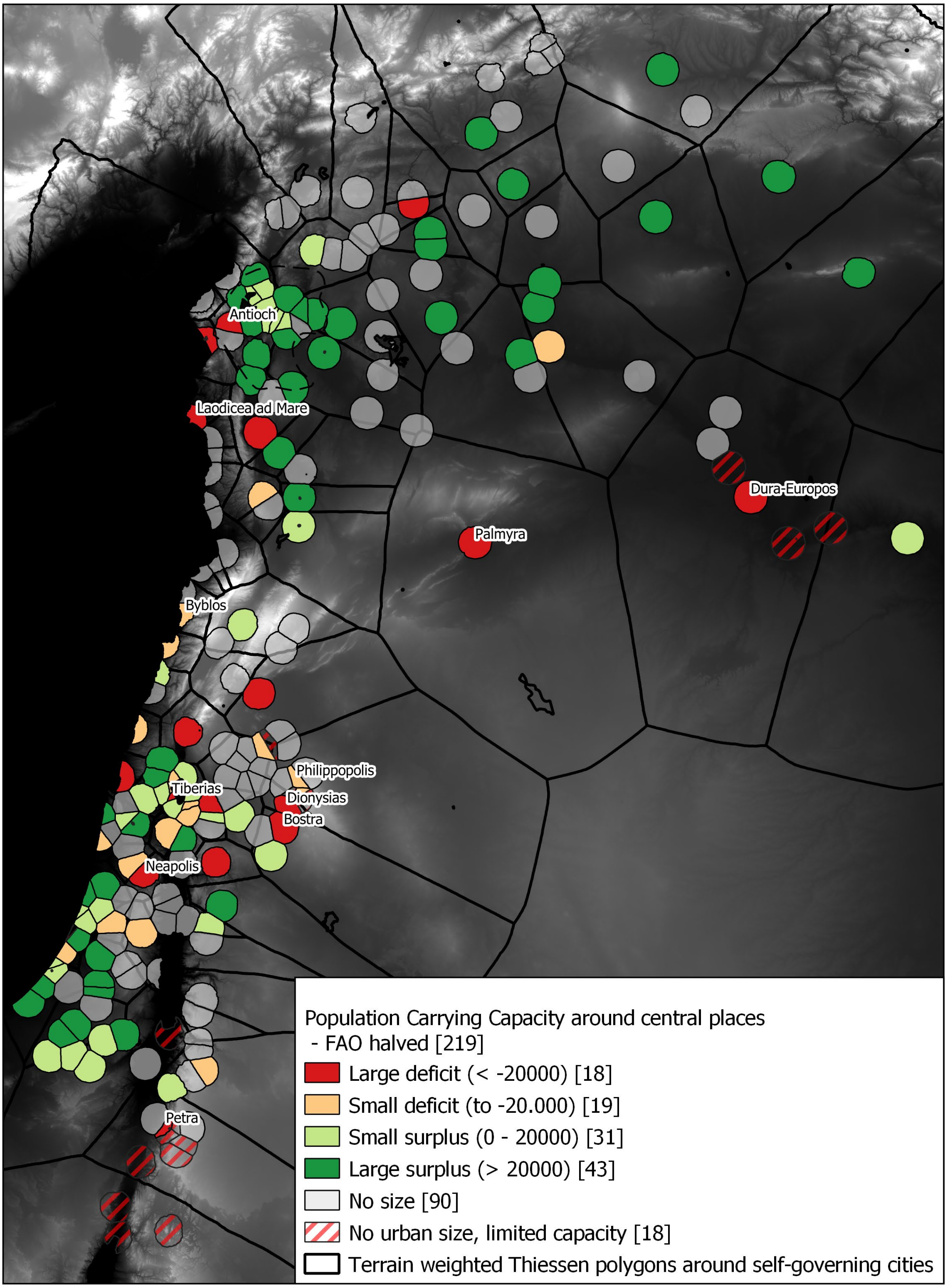

Figure 45 Carrying capacity based on FAO figures (halved)

Tony Wilkinson performed similar calculations for Early Bronze Age dry farming states in upper Mesopotamia, located in the same 300 to 600 mm rainfall band as the later cities of Roman Mesopotamia and Osrhoene discussed here. His model is more detailed, considering it assumes that half the population engaged in agriculture, and incorporates the amount of labour required for harvest (3 hectares per worker harvested in harvest season), the size of secondary settlements, the amount of surplus carried over from the satellites to the main settlement and different scenarios for different population densities.[693] The end result is, however, comparable: for a settlement with a 15-km radius territory (made up of seven circular sub-territories, that of the main settlement and that of its six satellites), the core settlement would have a maximum population between 11,734 to 14,374 inhabitants, with an area of 72 to 114 hectares. It should be noted that in the higher-count end scenarios, around 65% of the population would be living in the core settlement. With somewhat larger secondary settlements, measuring around 10 hectares, this percentage would drop to 49%, and still allow a settlement of up to 84 hectares.[694] Even so, it is clear that in this model too, a settlement dependent on its direct periphery would cap at a settlement size in a higher range than the vast majority of Roman settlements.

These models can also be applied directly to our available data: Figure 44 gives an overview of all the cities and places with potentially central roles. Given the same basis, 1 person per hectare, it shows that for a majority of town-like places, regional production within a 3-hour distance would be able to sustain the estimated urban populations, plus four times as many people in the surrounding countryside. Within these parameters, 42 out of 178 areas would not be able to support their population, against 69 with a definitive surplus. Of the 108 regions for which the central settlement has no known size, only 4 would have their potentially supported regional population capped at 10.000 people (therefore allowing at most 13,3 hectares for the regional centre, with 2000 people living in town).

Additionally, the map highlights that we lack market coverage for considerable parts of the Levant. In some cases, this makes sense, like in the Lebanese mountain ranges where one would expect low settlement coverage to begin with. Here the drastic effect of the mountains on travel time from the coastal cities nearby is also quite visible, showing a clear cut-off of the territory polygons at the foot of the mountains. But the vast empty areas between settlements in Osrhoene and Mesopotamia reflect what was already obvious from the settlement distributions in 3.1.1: we simply know far fewer lower-order settlements in these provinces than we should expect to have existed there.

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[693] Wilkinson et al., 'Structure and Dynamics of Dry-Farming States', 495–98.
[694] Wilkinson et al., 502, 503 table 3.

Figure 45 shows the same regions, but then with their carrying capacities based on the potential yield figures from the FAO. According to the documentation, the FAO figures already incorporate fallowing, assuming the simplest forms of natural grass or bush fallowing, thus essentially requiring biennial fallowing.[695] Note as well, that in figure 30, we assume only 50% of the land was actually cultivated.

In the FAO scenario (Figure 45), thirty-seven sites failed to sustain their population. A further eighteen, lacking an urban size, only sustained a population under 10.000. This is against 74 regions that were able to sustain their populations, and a further 90 areas with no known urban size, but able to support regional populations over 10.000 people. There does appear to be a clear shift towards the desert edge for lower-yield zones, with areas that are larger due to fewer obstacles in the terrain in fact producing less due to limited rainfall. This then already appears to be a more realistic reflection of the natural conditions. For some of these settlements, based on sizes for earlier or later periods, that may in fact be a realistic limit for the population of the settlement: the port of Aila, for instance, measured under three hectares in the Early Islamic period and as stated above was likely even smaller in the Roman period.[696] Another interesting difference is that the large centres in Upper Mesopotamia benefited from optimal conditions for rainfed agriculture. Table 14 shows an overview of the cities that were not able to sustain themselves from their market zone alone, following FAO figures.

[695] Fischer et al., 'Global Agro-Ecological Zones (GAEZ v3.0)- Model Documentation', 83–84.
[696] Parker, 'Preliminary Report on the 1994 Season of the Roman Aqaba Project', 27.

City name	province	market zone size (ha)	Estimated urban population	Estimated total regional population	Population Deficit based on halved FAO figures
Antioch	Syria-Coele	28151	75000	375000	-343555
Apamea	Syria-Coele	56302	37500	187500	-63877
Laodicea ad Mare	Syria-Coele	22430	25500	127500	-71290
Zeugma	Syria-Coele	35391	21000	105000	-23978
Seleucia Pieria	Syria-Coele	20241	19500	97500	-72698
Damascus	Syria-Phoenice	53850	18750	93750	-36315
Palmyra	Syria-Phoenice	56926	17783	88915	-88915
Neapolis	Syria-Palestina	37592	15000	75000	-46084
Akko	Syria-Phoenice	26253	15000	75000	-37392
Caesarea Paneas	Syria-Phoenice	44944	15000	75000	-32775
Gerasa	Arabia	47525	12750	63750	-31777
Scythopolis	Syria-Palestina	39185	12000	60000	-12468
Bostra	Arabia	47417	11985	59925	-44581
Abila Dekapoleos	Syria-Palestina	25259	11250	56250	-32670
Petra	Arabia	12950	10500	52500	-50947
Caesarea	Syria-Palestina	13242	9750	48750	-10533
Sebaste	Syria-Palestina	30554	9600	48000	-5982
Aelia Capitolina	Syria-Palestina	50240	9000	45000	-15911
Raphaneae	Syria-Phoenice	33720	9000	45000	-6255
Tyrus	Syria-Phoenice	20312	8700	43500	-6166
Dura-Europos	Syria-Coele	60008	8685	43425	-38197
Ascalon	Syria-Palestina	18851	8100	40500	-10300
Hegra	Arabia	54221	7875	39375	-39375
Berytus	Syria-Phoenice	16839	7500	37500	-13768
Emmaus Nicopolis	Syria-Palestina	34158	6750	33750	-7721
Dionysias	Arabia	27758	6315	31575	-23225
Byblos	Syria-Phoenice	17209	6000	30000	-18762
Tiberias	Syria-Palestina	2982	5565	27825	-24641
Thoana	Arabia	34769	5400	27000	-9838
Gadara	Syria-Palestina	22407	4500	22500	-899
Capernaum	Syria-Palestina	6448	2550	12750	-6364
Sharah	Arabia	21677	2550	12750	-1102
Canatha	Arabia	5535	2400	12000	-10760
Magdala	Syria-Palestina	1944	1500	7500	-5492
Philippopolis	Arabia	15367	1500	7500	-4580
Emmatha	Syria-Palestina	7019	960	4800	-508

Table 14 Cities with a deficit in local food production (FAO figures)

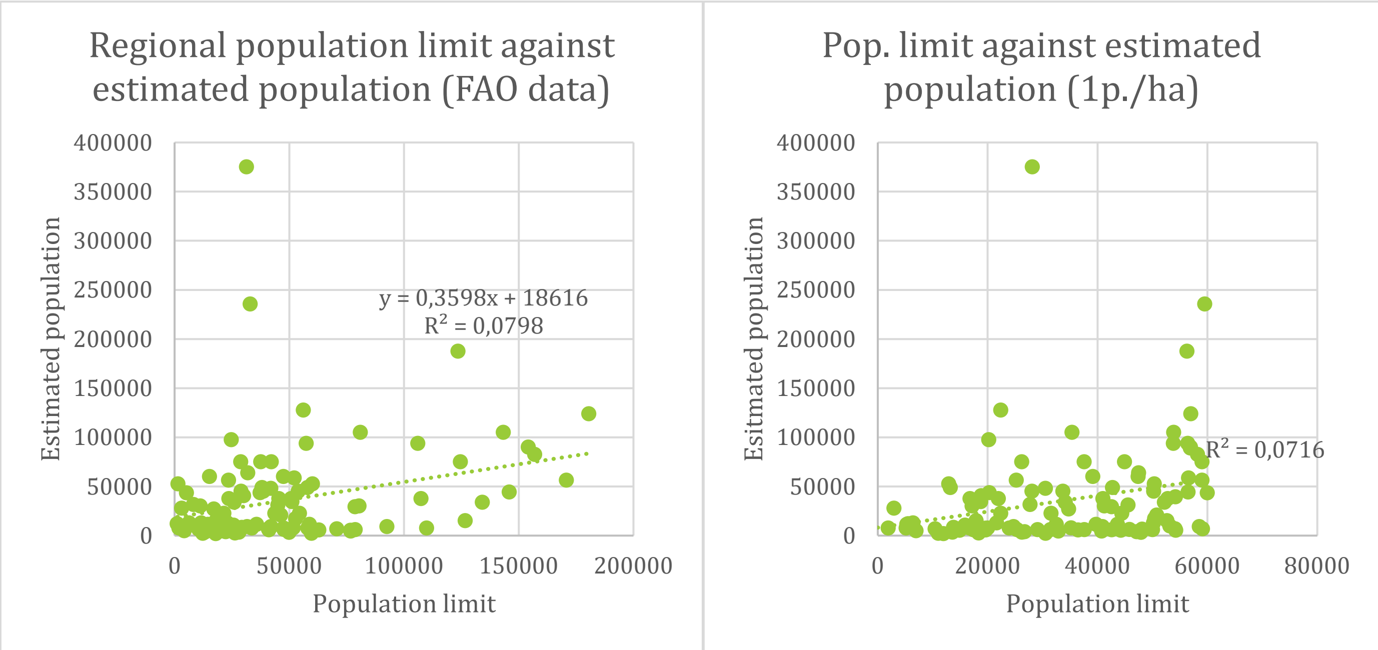


Figure 46 correlation estimated population versus population capacity based on FAO data and on market zone size

In Figure 46 it can be seen that in comparison to Thiessen polygons, there is clearly a better fit between estimated regional population and the derived population limit, for both the FAO data, as well as simply taking the size of market zone. Even so, the goodness-of-fit is still quite low. Filtering this to any subset (specific regions or settlement status) does not show any better fitting distributions. Only when filtering out the places with a population higher than what could be sustained based on the FAO data does the goodness-of-fit start to increase significantly. This underlines that in its basis, using cereal production within market zones is a reasonable baseline for predicting regional population levels, but that there will always be settlements whose size cannot be simply explained by such a simple model (larger actual territories, getting food over longer distances, different types of food sources etc.).

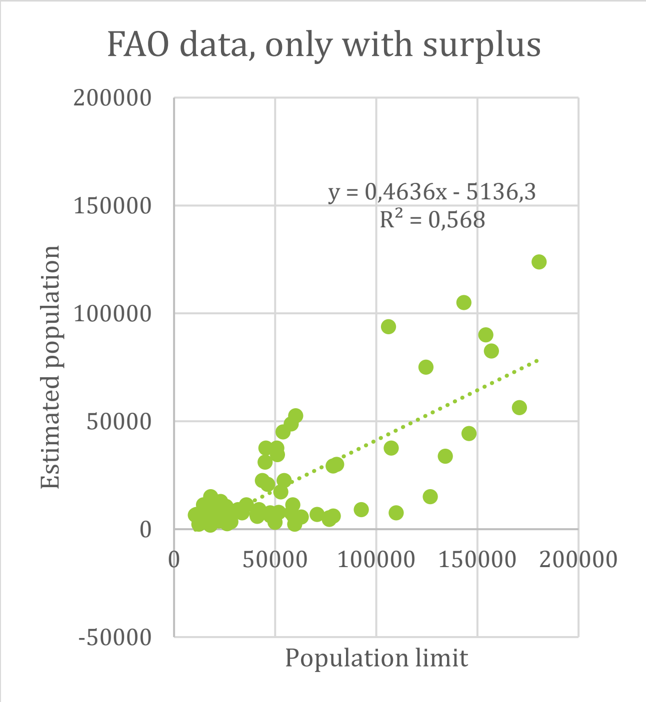


Figure 47 Regional population limit against estimated population (FAO data, only with surplus)

If this is further specified by settlement status (self-governing city versus non-urban central places), something else becomes clear: this model only works for self-governing cities. It would appear that for non-urban central places, local food production is not a limiting factor in their size. For the larger self-governing cities estimated populations are in most cases also far lower than the expected limits based on the FAO data. However, the graph suggests that even so, the limits of local production are very likely to have factored in the potential population size of the settlement. Especially in the population quadrant under a 100.000 potential regional inhabitants, we do find a larger number of cities where the estimated total population comes close to (or for the set in **Table 14**, surpasses) 100% of the local population limit. For the potentially more productive regions, this tapers off, with populations leaving large potential surpluses unused. In other words, the more limited local production, the better use is (or has to be) made of the land for food production.

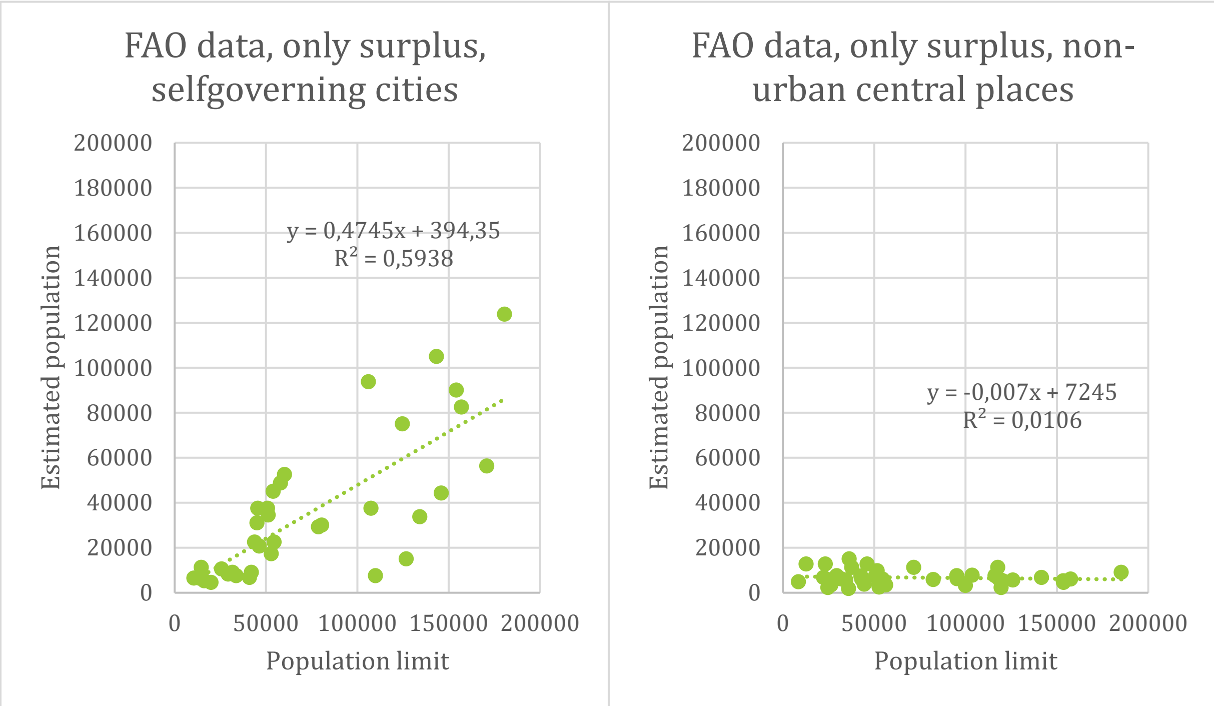
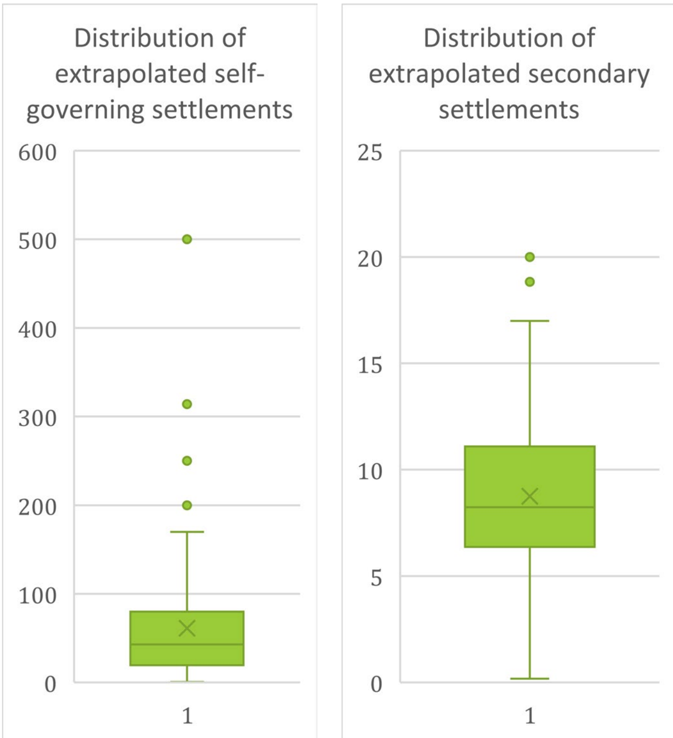


Figure 48 Regional population limit against estimated population (FAO data, only with surplus, split by settlement status)

3.2.2.4 Extrapolating population trends

This also allows us to generate a limited reconstruction of settlement sizes for those settlements where we lack data. For non-urban central places, we can assign random normally distributed sizes following the size distribution of the known sizes discussed above. For self-governing cities, we apply the derived relationship between population limit and estimated population as seen in Figure 48, y = 0.4745x + 394.35. This allows us to generate sizes for the remaining 108 settlements. See Figure 49 for the resulting adjusted rank-size curves by province.



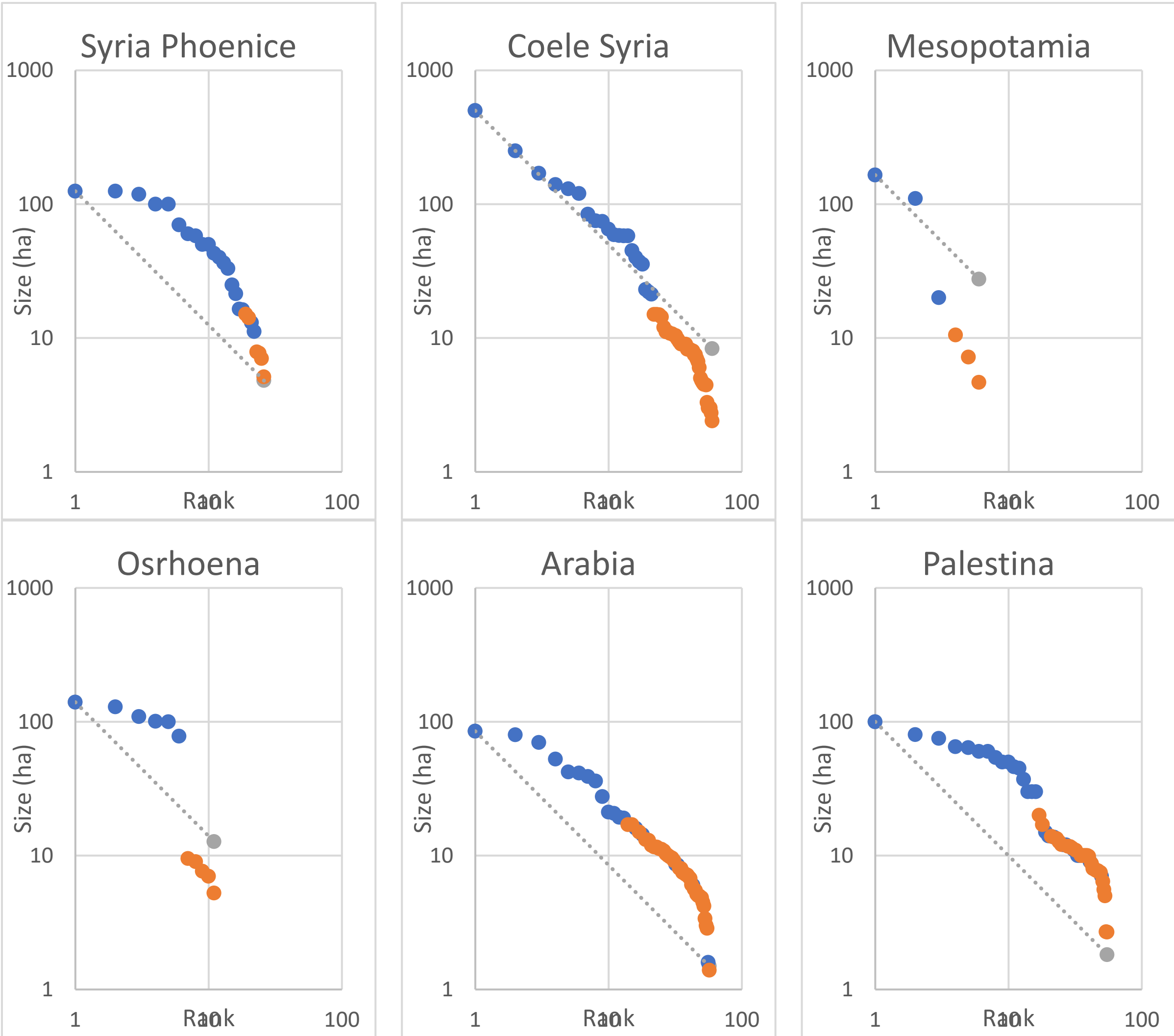


Figure 49 Extrapolated RS-curves by province

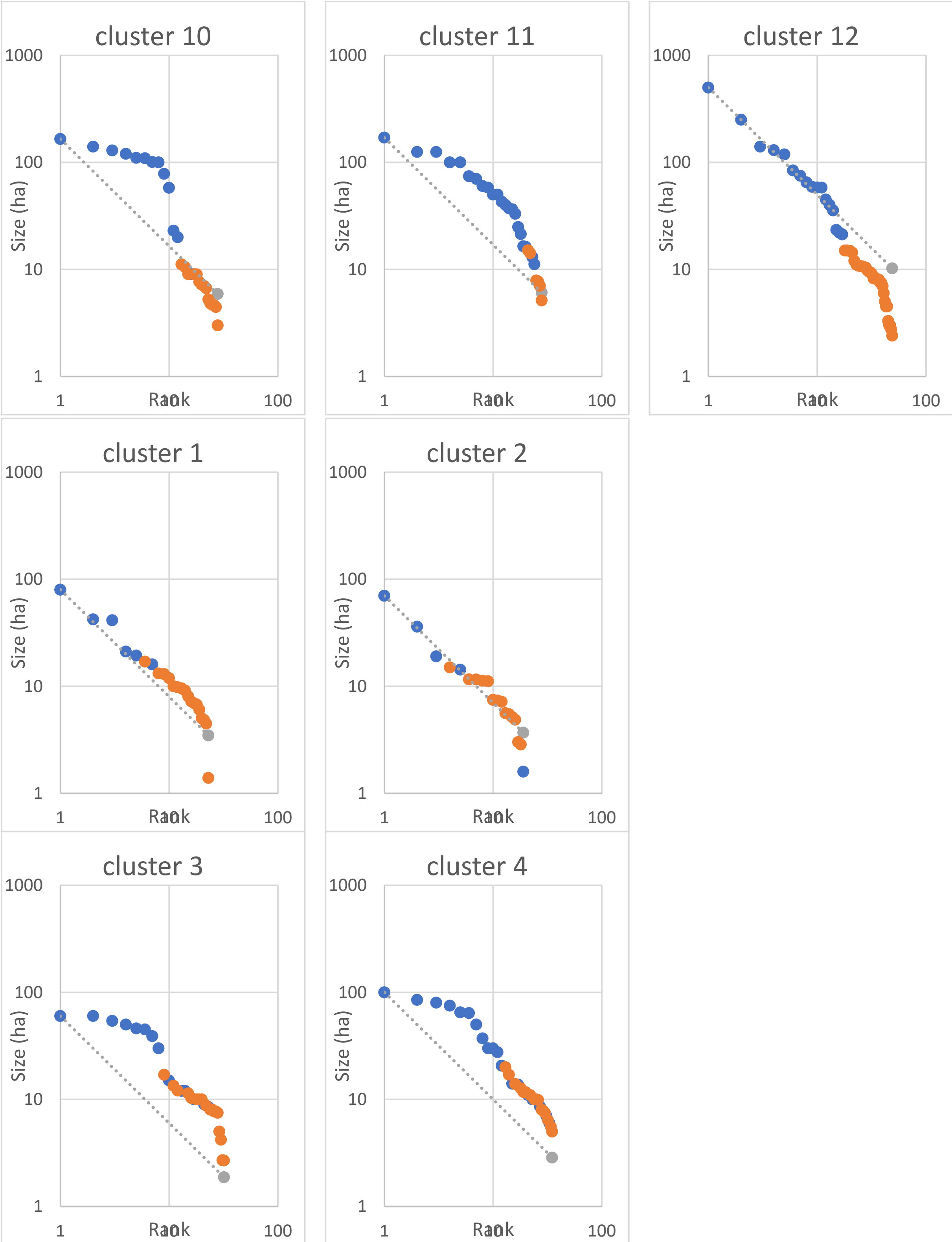


Figure 50 RS-curves extrapolated settlement sizes - by cluster

Here we see that the already existing patterns described in the preceding chapters are further reinforced. Coele Syria sticks relatively close to a Zipf-distribution, while Phoenice, Arabia and Palestina retain their convex distributions. Mesopotamia and Osrhoene still have rather low sample sizes, where Mesopotamia retains its primate distribution. The addition of the non-urban settlement sizes in Osrhoene shows a considerable break between the upper and lower tails, suggesting part of the distribution is lacking.

Using the proximity clusters defined in the previous chapters (Figure 51 Proximity clusters), rather than the provincial boundaries adds an additional perspective. Cluster 10, essentially a merge between Mesopotamia and Osrhoene, shows considerable convexity, but the issues of both provinces are alleviated. This suggests as much as that the relative proximity of these settlements could have stimulated them to interact as a single system.

Clusters 1 and 2, the two parts of Arabia, received the bulk of the extrapolated settlement sizes (with 34 settlements being assigned a new size). Interestingly, both areas retained the (close to) Zipfian distribution already discerned in chapter two. Considering the degree to which these data are informed by local agricultural production, it becomes far less likely that the shape of this distribution has anything to say about economic integration.

Looking at the above, it is clear that for the majority of Levantine settlements this 'blunt tool' of carrying capacity functions quite well as a baseline. To be sure, it cannot be stressed enough that actual territories probably differed from the 'market zones' defined here, which in the first place serve to create an equal basis for analysis and comparison between the various cities. Similarly, actual land use would not just consist of cereal cultivation, not all land would actually be cultivated, diets would be more varied and actual urbanisation rates – and as such, population densities – would in reality have differed regionally. And it is crucial to keep in mind that food is only one of several vital resources, with others such as potable water and fuel also being critical, albeit harder to quantify.[697]

Even in the more pessimistic scenarios, the majority of settlements could produce enough wheat or barley within their direct market radius to sustain both the urban and rural population. Of course, there is no reason to assume these were closed off, autarkic communities. They did not necessarily depend on their hinterlands, but probably could within the given parameters. Their existence, however, did not necessarily depend on the presence of a complex society. With or

[697] Janssen et al., 'Fuel for Debating Ancient Economies. Calculating Wood Consumption at Urban Scale in Roman Imperial Times'; S. Thomas Parker, 'Roman Aila and the Wadi Arabah: An Economic Relationship', in *Crossing the Rift: Resources, Routes, Settlement Patterns and Interactions in the Wadi Arabah*, ed. Piotr Bienkowski and Katharina Meisel Galor, 2006, 228; Kouki, 'The Hinterland of a City: Rural Settlement and Land Use in the Petra Region from the Nabataean-Roman to the Early Islamic Period', 110.

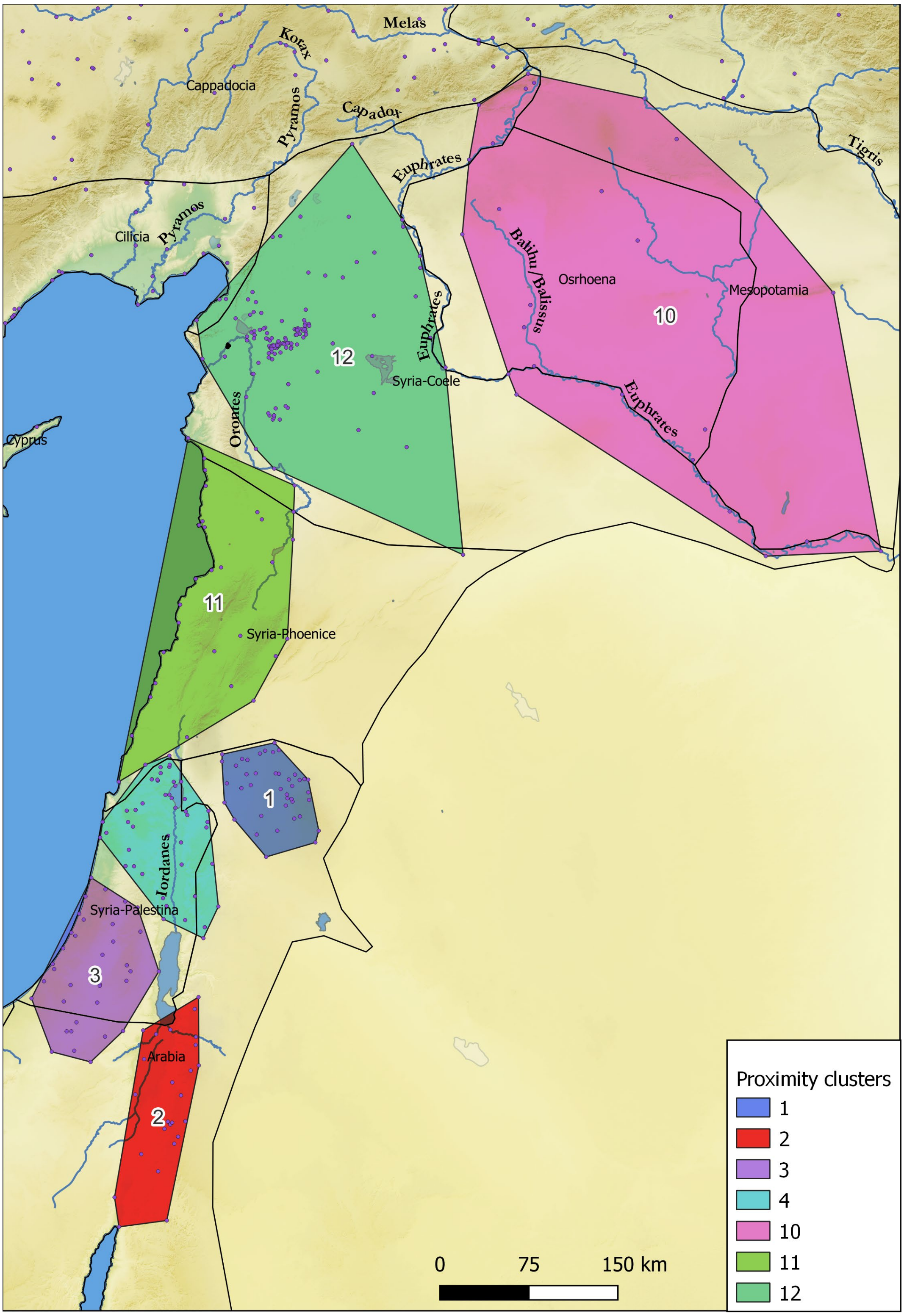


Figure 51 Proximity clusters

without the political integration that came with the Roman empire, these settlements would have been able to continue to exist in this form and size.

In the remainder, the explanations for why various cities were larger than the constraints of their surrounding 3-hour zones should be sought in the limitations of the model. This brings human agency back into the equation. Human actions impacted soil productivity in a myriad of ways, from better adaptation to the terrain using terracing, alternative methods to provide enough water and nutrients to crops, to larger actual political territories and more complex settlement hierarchies, different diets or the acquisition of foodstuffs through trade. For a number of cities, alternative forms of agriculture and non-agricultural wealth will be explored in sections 3.2.3 and 3.2.4, while Chapter 4 will take Antioch as a case study for political territory and settlement hierarchy.

3.2.3 Petra: alternatives to rain-fed dryland farming

Among those cities that would fail to sustain themselves in our basic model, we find those that speak most to the imagination, such as Petra and Palmyra. The surroundings of Petra give the clearest examples of how a local population could cope with a problematic territory.

In his 2016 study, Will Kennedy calculated the possible extent of Petra's effective agricultural hinterland using similar methods to those above, looking at travel cost on the basis of slope. Considering the exceptional landscape of Petra, with its extreme topography of steep slopes and elevation differences, this results in a markedly non-circular hinterland between 50 and 196 square kilometres.[698] Within most of this area, containing the sandstone slopes of what Paula Kouki classifies as the Escarpment Zone, the annual average rainfall of at most 150 mm was hardly sufficient for the farming of barley. As Kouki further adds, the nutrient-poor and shallow soils required manuring to support the cultivation of more demanding plants over longer periods of time.[699] On the eastern side Petra's hinterland also included the western side of the Jabal ash-Sharāh. This area is somewhat better suited for rain-fed farming: the higher elevation of this area results in a higher mean annual rainfall of 200 mm, lower temperatures and therefore lower evaporation rates. As pointed out by Besançon, further towards the summits of the Jabal ash-Sharāh, precipitation can probably reach around 400 mm per annum, with 301,7 mm measured at the Shobak weather station.[700] In addition, a diverse lithology of permeable limestones and nonpermeable sandstone layers allows for the existence of numerous springs.[701]

[698] Will M. Kennedy, 'Reassessing the Impact of Natural Landscape Factors on Spatial Strategies in the Petra Hinterland in Nabataean-Roman Times', *Proceedings of the Seminar for Arabian Studies* 46 (2016): 137–54; Jacques Besançon, 'Géographie, environnements et potentiels productifs de la région de Pétra (Jordanie)', in *Entre nomades et sédentaires : prospections en Syrie du Nord et en Jordanie du Sud*, ed. Pierre-Louis Gatier, B. Geyer, and Marie-Odile Rousset, Travaux de la Maison de l'Orient 55 (Lyon: Maison de l'Orient et de la Méditerranée, 2010), 22.
[699] Kennedy, 'Reassessing the Impact of Natural Landscape Factors on Spatial Strategies in the Petra Hinterland in Nabataean-Roman Times', 144; Kouki, 'The Hinterland of a City: Rural Settlement and Land Use in the Petra Region from the Nabataean-Roman to the Early Islamic Period', 103.
[700] Besançon, 'Géographie, environnements et potentiels productifs de la région de Pétra (Jordanie)', 28.
[701] Besançon, 39.

Even this more favourable agricultural zone had clear limitations. As mentioned before for the whole Levant, most of the rain falls between December and April, most heavily between January and March. Rains can come in very heavy rainstorms, with rains having been measured at Shobak of over 74 mm within 24 hours. Furthermore, interannual variation can be considerable, with dry years only reaching a third of average, and usually several dry years following each other.[702] Furthermore, the slopes on the Ash-Sharāh range are even more pronounced than in the Escarpment zone.[703]

In order to deal with this, the people of the Petra region practiced run-off cultivation. By building dams in wadi beds and terraces on hillslopes, during the rainy months water was diverted towards lower-lying agricultural plots. Furthermore, terracing was necessary to counter soil erosion on the steep slopes of the Ash-Sharāh. [704] Numerous structures related to run-off cultivation can be clearly dated to the Roman period around the Jabal Harun, to the southwest of Petra, but there are also good indications for Nabatean or Roman dates for water diversion structures throughout the rest of the region. In addition, to deal with annual and interannual variation in rainfall, both collected run-off water as well as water from springs was stored in reservoirs, as shown by cisterns found everywhere both in the Escarpment, the Jabal ash-Sharāh as well as the Wadi Silaysil regions. The locations of reservoirs and water conduits within agricultural fields further show that stored water was not just used for domestic use, but clearly intended for irrigation as well.[705]

As expected, water resources played a vital role in settlement location, so it is no surprise for instance to find Sabra, one of the suburbs of Petra, to be located at what was likely a perennial water source in Roman times. Similarly, the plentiful sources on the Jabal ash-Sharāh gave birth to just as many antique settlements.[706]

In the other, drier parts of the Levant similar practices can be found. Throughout Nabatean territory there are indications of terracing, run-off irrigation and ground-level aqueducts. John Peter Oleson gives an overview of various examples from Zoara down to Humayma, and includes

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[702] Besançon, 28–29; Kouki, 'The Hinterland of a City: Rural Settlement and Land Use in the Petra Region from the Nabataean-Roman to the Early Islamic Period', 104.
[703] Kennedy, 'Reassessing the Impact of Natural Landscape Factors on Spatial Strategies in the Petra Hinterland in Nabataean-Roman Times'.
[704] Kouki, 'The Hinterland of a City: Rural Settlement and Land Use in the Petra Region from the Nabataean-Roman to the Early Islamic Period', 104, 105–6.
[705] Kouki, 106–8; Susan E. Alcock and A. R. Knodell, 'Landscapes North of Petra: The Petra Area and Wadi Silaysil Survey (Brown University Petra Archaeological Project, 2010–2011)', in *Supplement to Proceedings of the Seminar for Arabian Studies*, vol. 42, 2012, 5–16; Knodell et al., 'The Brown University Petra Archaeological Project'.
[706] Besançon, 'Géographie, environnements et potentiels productifs de la région de Pétra (Jordanie)', 65.

an interesting example from the Babatha archive, where two papyri give a schedule for when certain landowners were allowed to irrigate their crops.[707]

As Tali Erickson-Gini writes about agriculture in the equally arid Negev, where an estimated 2000 square kilometres of land may have been exploited through run-off and flood farming, 4000 hectares of which were terraced fields.[708] However, available evidence suggests that most of this dates to the fourth century or later. There are some indications of small-scale, limited agriculture based on the capture of spring water around Nabatean sites and stations throughout the Negev, at a handful of sites even as early as the Bronze Age (Rehovot, Horwat Haluqim). Outside of Nabatean lands, there is a notable example somewhat further to the north. Jericho and the other villages and estates lying in the lower Jordan valley also used water from springs from irrigation. In the case of Jericho, the main source of water was the ʿAin al-Sultan spring (Elisha's Spring), which is fed from the watershed of the Judean Highlands. Its high volume and perennial water flow has always been the basis of the city and the agriculture around it. Jericho's water supply was furthermore augmented by two other clusters of springs along the Wadi al-Qelt and the Wadi Nueima.[709] While indications for the size of the settlement are unclear, its plantations were well-known in antiquity, and counted among the domains that Mark Antony had given to Cleopatra. Pliny, Strabo and Josephus mention the cultivation of cash crops in the irrigated Jericho plain, with a focus on dates and balsam.[710]

A study by Ruth Shahack-Gross et al. analysing livestock dung gives a good indication that at an Iron IIA site in the Negev (Nahal Boqer), there are only indications that animals were fed by free grazing, while at a Late Roman and Umayyad site (Wadi el-Mustayer) their diet included cultivated grains.[711] It was only after our period of study that considerable areas in the Negev were put under cultivation, much of it for viticulture, to be exported from Gaza. It should be no surprise then that up to that point settlements remained comparatively small and limited in number, with presumably a larger focus on pastoralism and trade.[712]

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[707] John Peter Oleson, 'Nabataean Water Supply, Irrigation, and Agriculture: An Overview', in *The World of the Nabataeans: Volume 2 of the International Conference, The World of the Herods and the Nabataeans, Held at the British Museum, 17-19 April 2001*, ed. Konstantinos D. Politis, vol. 2, Oriens et Occidens 15 (Stuttgart: Steiner, 2007), 217–49.
[708] Erickson-Gini, 'Nabataean Agriculture', 50.
[709] Michael Jennings, 'Beyond the Walls of Jericho: Khirbet al-Mafjar and the Signature Landscapes of the Jericho Plain' (ProQuest Dissertations Publishing, 2015), 16, 122, http://search.proquest.com/docview/1707689179/.
[710] Jennings, 96–97.
[711] Ruth Shahack-Gross et al., 'Subsistence Economy in the Negev Highlands: The Iron Age and the Byzantine/Early Islamic Period', *Levant* 46, no. 1 (1 April 2014): 98–117, https://doi.org/10.1179/0075891413Z.00000000034.
[712] Erickson-Gini, 'Nabataean Agriculture'; Rosen, 'The Nabateans as Pastoral Nomads. An Archaeological Perspective'.

An additional method of water capture is found throughout the Syrian provinces, especially around the Damascus region and in central Syria, east of Hama. Here groundwater was collected by means of qanats (also called foggara). As Dale Lightfoot describes it, these are gently sloping underground aqueducts that bring water from a mother-well dug into aquifers towards lower-lying fields to be irrigated. These tunnels can bring water over tens of kilometres; the gravity-fed flow is generally steady and continuous, hardly influenced by variations in precipitation (modern-day desiccation of qanats that have been functional over centuries is often caused by lowering water tables due to the proliferation of motor-powered water pumping.[713]) A number of shafts allow access to the tunnel for maintenance. As Oleson suggests, the near absence of qanats in Nabatean territory may be due to the need for maintenance, with run-off agriculture being considered more reliable.[714]

As is to be expected, most qanats can be found where they could actually be constructed and would be of most use: at shallow aquifers at the base of hills or mountains, in areas with limited annual rainfall and high evaporation, allowing water to be diverted for long distances into the steppe zone without suffering from evaporation. Only in areas with permeable rock layers (e.g. limestones) were aquifers were able to recharge seasonally, so no qanats are found in for instance the basaltic region of the Hauran.[715] The dating of qanats is no exact science, and while this method of irrigation may have already been introduced in the Persian or Hellenistic period, only from the Roman period onwards are there clearly dated examples, with the majority of qanats located at Roman or Late Roman settlements. Continued construction of qanats in later centuries is also clear, with Late Roman examples known from the arid margin around Andarin, and from Umayyad and Abbasid examples throughout the Islamic world.[716]

Beyond the Roman empire, it should also be highlighted that under Parthian and especially Sassanian rule, the Mesopotamian heartlands came to new levels in the scale and sophistication of irrigation. Over several thousand years, this had evolved from simply farming in floodplains, through managing and damming natural canals, to, as Tony Wilkinson puts it, 'the construction of massive, region-scale canal and irrigation systems'.[717] Here state-sponsored irrigation and settlement programs gave rise to a considerable population boom.[718] In other words, while the local solutions for rainfall limitations in the Roman Near East can explain some of the exceptions

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[713] Lightfoot, 'Syrian Qanat Romani: History, Ecology, Abandonment', 323.
[714] Oleson, 'Nabataean Water Supply', 230–36.
[715] Lightfoot, 'Syrian Qanat Romani: History, Ecology, Abandonment', 329; figs 5, 6.
[716] Lightfoot, 325; Marie-Odile Rousset, 'Qanāts de la steppe syrienne', in *Entre nomades et sédentaires : prospections en Syrie du Nord et en Jordanie du Sud*, ed. Pierre-Louis Gatier, B. Geyer, and Marie-Odile Rousset, Travaux de la Maison de l'Orient 55 (Lyon: Maison de l'Orient et de la Méditerranée, 2010), 266, 267.
[717] Wilkinson, *Archaeological Landscapes of the Near East*, 92.
[718] Wilkinson, 94.

to what could be expected in a dry climate, they are not comparable in scale to the massive agricultural projects found in central Mesopotamia.

3.2.4 Alternatives to cereal cultivation: cash crops, industry and trade

As stated above, besides better adaptation of farming techniques to the local environment, one should of course also consider other sources of food, and the cultivation of cash crops for trade (allowing import of food through trade), as in reality cereal cultivation will only have made up part of the land use, albeit the larger one. So, it is sensible to assume that coastal settlements would in part depend on fishing, and that some terrain unsuitable for much else could be used for pastoralism - see for instance the issue of grazing rights at Palmyra mentioned in 3.2.4.1. Concerning cash crops, throughout the entire region there are many examples of viticulture, and Strabo's example of Laodicea mentioned in 1.2.1.2 clearly shows that the wine produced could be exported. When taking a look at the hinterland of Antioch, we find the Massif Calcaire dotted with presses – originally considered to have been intended for olive oil, many have now been re-identified as wine presses. Either way, at least for the later Roman period a strong case can be made for surplus production intended for export, as the total output of all the presses in the region would have been far higher than local consumption could have been.[719]

And of course, non-primary production should also be considered for some of the cities whose direct surroundings would probably not be enough to sustain their populations. Unfortunately, source material on the subject is very limited for Syria. There are certainly no quantitative indications of income, production or trade. It is still possible to refer to Louis C. West's article from 1924 as a relatively complete and up to date overview of Syrian commercial production, albeit mostly based on written sources. Besides Pliny and a bit of Strabo, most of this information comes from 4th-century sources like the Diocletian Price Edict, the works of Julian and *Expositio Totius Mundi*.[720] Archaeologically, his list can at best be expanded with a pottery production site at Palmyra (a complex consisting of five kilns from the late second century), dye-works at Gaza, a pottery workshop of the Legio X Fretensis outside of Jerusalem, some small-scale local pottery production at various sites, a facility for producing garum at Ashkelon and

[719] Michael Decker, 'Food for an Empire: Wine and Oil Production in North Syria', in *Economy and Exchange in the East Mediterranean during Late Antiquity: Proceedings of a Conference at Somerville College, Oxford, 29th May, 1999*, by Sean Kingsley and Michael Decker (Oxford [etc.]: Oxbow Books, 2001), 69–86; Dimitri Van Limbergen, 'Olivier Callot, Déhès II : Les Pressoirs', *Syria. Archéologie, Art et Histoire*, 4 June 2019, http://journals.openedition.org/syria/8051.
[720] Louis C. West, 'Commercial Syria under the Roman Empire', *Transactions and Proceedings of the American Philological Association* 55 (1924): 159–89, https://doi.org/10.2307/283014.

Late Roman or Byzantine glassworks at for instance Apollonia, Hadera and Khirbat ʿAsafna.[721] Thus, we know that specific production existed at certain sites. Furthermore, throughout the previous chapters, while identifying and describing the cities of the Roman Levant, for a number of these we could determine what activity they were known for. This may not be conclusive evidence that these activities were the foundation of their urban success, but nonetheless hint in a certain direction.

So, among the cities with a potential food deficit in Table 14, one finds a number of cities that were well-known for their industries. A good example is Tyre, known for its silk weaving and purple dyes, and Berytus for its linen and silk weaving. And while not actually in the table (as its 3-hour zone would be sufficient for its food production), Sidon deserves to be mentioned alongside its neighbours Tyre and Berytus, as it was known for its production of glass, textiles, dyes and, apparently, ointments. Furthermore, all three cities are known to have exported wine, and this productive stretch of coastline would additionally have benefited from the wood coming from the Lebanon mountain range for fuel, production and trade. In fact, for most Syrian exports with a known provenance, either Antioch or these three cities of Syria Phoenice are named. The major exceptions are wine and slaves, with several cities, both coastal and inland, exporting these throughout the wider empire.[722]

That these industries were located at port cities creates an additional sense that, with reduced barriers to transport costs, these industries may have catered to a relatively large market. For Tyre there is of course the well-known example of the Tyrian merchants stationed in Puteoli. But consider also for instance the article by Wilson, Schörle and Rice, who highlight that "most Roman glass has a chemical signature matching the sand from the Syro-Palestinian coast, which was especially well suited to glass-making with a natron flux; this region must have been the

[721] Tali Erickson-Gini, 'The Good Life: Evidence for the Production of Wine and Garum in an Early Roman Estate and Byzantine Monastery South of Ashkelon', *English Editor*, 2020, 7; Agnès Vokaer, 'Pottery Production and Exchange in Late Antique Syria (Fourth–Eighth Century A.D.). A Study of Some Imported and Local Wares', *Late Antique Archaeology* 10 (1 January 2013): 567–606, https://doi.org/10.1163/22134522-12340042; A. Ovadiah, 'Excavations in the Area of the Ancient Synagogue at Gaza (Preliminary Report)', *Israel Exploration Journal* 19, no. 4 (1969): 197; Elizabeth A. Murphy, Haim Goldfus, and Benny Arubas, 'The Jerusalem Legio X Fretensis Kilnworks: Contextualizing Ceramic Manufacture and "Legionary Wares"', *Oxford Journal of Archaeology* 37, no. 4 (2018): 443–66, https://doi.org/10.1111/ojoa.12153; Ian C. Freestone, Yael Gorin-Rosen, and Michael J. Hughes, 'Primary Glass from Israel and the Production of Glass in Late Antiquity and the Early Islamic Period', *MOM Éditions* 33, no. 1 (2000): 65–83; Chen Chen et al., 'A Glass Workshop in 'Aqir, Israel and a New Type of Compositional Contamination', *Journal of Archaeological Science: Reports* 35 (1 February 2021): 102786, https://doi.org/10.1016/j.jasrep.2020.102786; Limor Talmi, 'Kh. 'Asafna: Final Report', *Hadashot Arkheologiyot: Excavations and Surveys in Israel / חדשות ארכיאולוגיות: חפירות וסקרים בישראל* 131 (2019), https://www.jstor.org/stable/26904642; Oren Tal, Ruth E. Jackson-Tal, and Ian C. Freestone, 'New Evidence of the Production of Raw Glass at Late Byzantine Apollonia-Arsuf, Israel', *Journal of Glass Studies* 46 (2004): 51–66.

[722] Butcher, *Roman Syria and the Near East*, 137–40; West, 'Commercial Syria under the Roman Empire'.

overwhelmingly dominant supplier of raw glass for the secondary production centres all over the Roman world".[723]

On the other hand, while access to the sea also facilitated the import of foodstuffs, there is little evidence that these cities indeed imported these, except for the above-mentioned imported amphorae intended for fish or garum found in cities on the Levantine coast. Of course, as Maurice Sartre shows, there are good indications that in general, trade in foodstuffs took place in Syria. In the first place, in a number of cities an *agoranomos* is attested in inscriptions,[724] the official tasked with market supervision and, relevant in this context, ensuring an adequate supply of foodstuffs for the city. However, it should be kept in mind that this does not necessarily imply extra-regional imports, as an *agoranomos* could just as well be focussed on regulating the regional food market. Grain markets are attested in Palestine, for instance at Scythopolis, Diocaesarea (Sepphoris) and Sussita, and in Rabbinic literature there is a good example of rabbis from Tiberias going to Iamnia to purchase grain.[725]

In his economy of Roman Palestine, Zeev Safrai suggests that the presence of a year-round grain market in Diocaesarea, and apparently cheaper grain at neighbouring Tiberias, suggests that Diocaesarea was dependent on imports.[726] Surely the presence of Lake Tiberias will have facilitated transport of surpluses from surrounding regions such as the Decapolis and may well have resulted in lower grain prices than in Diocaesarea. But as noted above, the presence of a market does not mean a structural dependence on interregional trade, and the territory of Diocaesarea appears to be sufficiently productive. Safrai's example that Caesarea Maritima depended not just on its own production but on food imported from its far smaller neighbouring cities in the Sharon Plain does seem believable.[727]

Apart from cities thriving on commerce and industry, there is also the matter of military presence and its impact on urban communities. In multiple cities there are indications of military garrisons within the confines of cities. For this, it is worthwhile looking at Nigel Pollard's *Soldiers, cities, and civilians in Roman Syria*. In this book, he responds to Keith Hopkins' 1980 centre-periphery model on taxation and trade from a Syrian perspective. In this model, both the centre of Italy and Rome and the armies stationed in frontier regions consumed more

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[723] Candace Rice, Andrew Wilson, and Katia Schörle, 'Roman Ports and Mediterranean Connectivity', *Rome, Portus and the Mediterranean*, 2012, 374.
[724] in the case of Tyre for instance in M. Chéhab, 'Tyr à l'époque Romaine. Aspects de La Cité, à La Lumière Des Textes et Des Fouilles', *Mélanges de l'Université Saint-Joseph*, 1962, 17, but there are examples from all over the provinces.
[725] Sartre, *D'Alexandre à Zénobie*; Alla Stein, 'Gaius Julius, an Agoranomos from Tiberias', *Zeitschrift Für Papyrologie Und Epigraphik* 93 (1992): 144–48; Daniel Sperber, 'On the Office of the Agoranomos in Roman Palestine', *Zeitschrift Der Deutschen Morgenländischen Gesellschaft* 127, no. 2 (1977): 227–43.
[726] Safrai, *The Economy of Roman Palestine*, 112.
[727] Safrai, 113.

taxes than were generated there, while an inner ring of provinces including Asia Minor, Syria and Egypt produced more taxes than they consumed. The implication is that tax-importing regions would also import goods, causing producers in the intermediate zone to start surplus production for sale, in order to raise money for taxes.[728] The army thus plays a major role in this model: both soldiers receiving pay in money (which increased money supply, as more people used money, Hopkins' fifth proposition) and by raising state and military expenditure in general (integrating the monetary economy into a single system).[729]

Nevertheless, Pollard shows mixed evidence for economic interaction between soldiers and the local population. There is some evidence for food being purchased from civilians, as well as supply from an imperial estate (at Appadana), bypassing the market. On the topic of estates, consider as well the quarries around Zeugma or the above-mentioned legionary pottery workshops at Jerusalem. Still, with indications of soldiers using civic coinage and locally produced pottery, overall, Pollard finds that 'the army was a key element in the provincial economy through its position in a chain of cash taxation, army pay and army spending. This economic network appears to have been regional in scope, because of the combination of a wealthy civilian sector and a large army presence in the same province'.[730] Even with what he describes as a distinct social and cultural separation between the civilian population and the military, their sheer physical proximity – being stationed within the same urban settlements – stimulated economic interaction.[731] And both as individuals spending their pay, as well as a funded institution acquiring supplies, the presence of the army meant the presence of an additional market for local goods and services, essentially increasing the purchasing power of a community.

Looking at the settlements with a military presence, an interesting city is Seleucia Pieria. It was certainly one of several exceptionally large settlements in the region (even though we should take into account that a considerable part of the walled area includes slopes of the acropolis, where habitation will have been limited). At the same time, its territory is severely constrained, so we can be reasonably certain that the Seleucians did not just live off locally cultivated food. The city's importance for the logistics involved in supplying the armies during the Parthian conflicts is obvious. In his 1985 article Denis van Berchem paints a clear picture of the challenges involved and potential supply routes to support the campaigns in the east. He

[728] Hopkins, 'Taxes and Trade'.
[729] Hopkins, 111, 112.
[730] So, partly in disagreement with Hopkins' sixth proposition, on how integrated the monetary economy was. Pollard, *Soldiers, Cities, and Civilians in Roman Syria*, 211, 241–42, 253; See also Hopkins, 'Taxes and Trade', n. 33, Pollard essentially argues for Hopkins' 'counter-hypothesis' that at least here, we are looking at a more localised monetary economy with limited impact on other regions.
[731] Pollard, *Soldiers, Cities, and Civilians in Roman Syria*, 165–67.

suggests that the Syrian fleet based in Seleucia played a central role in this logistical puzzle.[732] A further example are the canals that were dug to facilitate river transport to Antioch, and beyond it over the Orontes at the very least up to Gephyra. Besides the campaigns, there is no evidence for structural military supplies being imported into the province. Even so, Seleucia was the permanent base of the fleet, which mean that there was a stable presence of military personnel, as well as potential labour requirements servicing and supplying the fleet. We can therefore assume that at least the city would have seen regular supplies.

It is safe to assume that the army used the optimal available routes for its supply chains. It is then also likely that for access to the Mediterranean, Seleucia Pieria served as the commercial port for northern inland cities like Cyrrhus, Zeugma, Edessa, Beroia, and Hierapolis, but most obviously for the city of Antioch itself. Like the examples of Acco, Tyre, and Sidon, Antioch thus had access to maritime imports, but potentially also to surplus production from these inland communities.

A good number of other cities can also be considered to be military towns. We've discussed garrisons at cities on the Euphrates like Zeugma and Dura Europos, in all Mesopotamian cities, in southern cities like Aelia Capitolina and Bostra, and, naturally, the bases of Legio and Raphanea. However, only a few of these cities are 'too big' for their hinterlands (or exceptionally large to begin with), and certainly not to the degree of Seleucia Pieria. It seems that for these cities, the presence of a garrison did not stimulate urban growth as much as, say, the commercial potential of a city.

3.2.4.1 Palmyra as a commercial centre and the caravan cities

Another example of a mismatch between estimated local food production and city size, which certainly deserves to be highlighted, is the much-discussed city of Palmyra. It will be discussed in some more detail simply because it is one of the few settlements in the study area actually offering considerable evidence for its trade activity. The characterisation once given by Rostovtzeff of Palmyra as a caravan city is not altogether undeserved, as a large body of inscriptions attest to caravans going as far as Spasinou Charax on the Persian Gulf, and there is evidence of Palmyrene presence even further away, for instance merchants returning from India (travelling on a ship owned by a Palmyrene).[733] It should be noted that the majority of the Palmyrene caravan inscriptions are dated between 130 and 161 C.E., while under the Severans only three are known, and none between 211 and 247 C.E. As Sartre states, perhaps this was a

[732] Berchem, 'Le port de Séleucie de Piérie et l'infrastructure logistique des guerres parthiques'.
[733] Seland, *Ships of the Desert and Ships of the Sea*, 71, 80.

sign of increased insecurity with the arrival of the Sassanids, or perhaps only a change in the epigraphic habit.[734]

Furthermore, in the other cases referred to by Rostovtzeff, in Petra, Dura Europos and Gerasa local agriculture probably played a far larger role in the local economy than trade, whether short- or long-distance, at least under Roman rule – as was also discussed above. And, as a recent article by Jiménez et al. on food security in Palmyra shows, much of what we stated about Petra above is true for Palmyra as well. They find that while Palmyra's growth into a prominent city was dictated by its role in trade networks, it nonetheless depended on local food production to sustain its population's primary needs, enabled by a well-adapted subsistence strategy and proper water infrastructure.[735]

Their detailed analysis shows that our simple estimate for regional population, just under 89.000 people, can be fine-tuned further. In the first place, whereas we took a simple urbanisation rate of 20%, so multiplied our urban estimate by 5, they looked at actual arable land, its production capacity and the amount of labour required to work said land. To start with, they assume a far larger (three day distance) catchment area than the direct market zone we used above. As there were no other urban centres around competing for production from the same area, this would certainly make sense. Within this area, they find that in optimal conditions, there are four areas of arable land that together could produce enough food to sustain a regional population of around 65.000 to 90.000 people. To produce this would require a labour force of 6.000 to 9.000 people. [736] In other words, the urbanisation rate of the Palmyrene could potentially be quite the inverse of our baseline, and we should not necessarily expect tens of thousands of people to have lived in the surrounding countryside.

Note, however, that this shows the optimal situation. They expect that this may have been possible for 5 out of every 10 years at the beginning of the first century, but deteriorated over time to 72.000 people by the second half of the third century. Reliable levels of carrying capacity, that could be achieved 9 out of every 10 years, lay considerable lower, dropping from 43.000 supported people in the early first century to 31.000 by the mid-third century.[737] As they say, food security dropped to critical levels at a point in time where considerable changes in the socio-political landscape of the Palmyrene take place.[738] The overall take-away from this is that within certain limits, the Palmyrene territory would have in fact been able to sustain an urban

[734] Sartre, *D'Alexandre à Zénobie*, 844, 850.
[735] Jiménez et al., 'Food Security in Roman Palmyra (Syria) in Light of Paleoclimatological Evidence and Its Historical Implications'.
[736] Jiménez et al., 12.
[737] Jiménez et al., 13–14.
[738] Jiménez et al., 14–16.

population of the order of magnitude we estimated above, albeit with a smaller total regional population.

That it was possible to sustain a moderate settlement in this area does not however explain the urban trajectory of this city, so let us return our focus to Palmyra's economic foundations. Seland discusses in more detail the connection between Palmyra and long-distance trade. He shows the various attested and potential routes traders from the city could have taken. The most attested caravan route, towards the Persian Gulf, likely travelled past Hit, rather than Dura Europos (in other words, the route identified by Mouterde and Poidebard, rather than that proposed by Rostovtzeff). As the Palmyrene community in Dura shows, trade with the city took place, but was of lesser significance. The route took about a month from Palmyra to Spasinou Charax, partly overland, partly using rafts down the Euphrates. A limited period with optimal conditions for travel, as well as the specific timeframe for goods to arrive from the Indian Ocean due to sailing seasons, make it likely that caravans only travelled once a year along the route.[739] In addition, Seland shows potential routes towards the Mediterranean, either northwest towards Antioch or west through the Homs gap, or potentially by way of Damascus, although this required crossing the Lebanon and Anti-Lebanon. He also considers it likely that for funerary needs, goods like myrrh (also mentioned in the Palmyrene tax law) were in fact brought from the Red Sea in the south.[740]

Concerning trade from the city towards the west, Michał Gawlikowski warns that besides a single mention by Galen of Indian goods arriving in Phoenicia by camel, there is no other evidence at all.[741] With Nabatean trade already reaching Gaza and thus covering the southern Levant, and Antioch more easily reached from the east by way of Zeugma, he supposes it more likely that Palmyrene trade was focused mostly on the region of central Syria, rather than towards Rome and the Mediterranean. Even so, he considers trade to have been the major source of income for the Palmyrene economy.[742] Seland, however, suggests that trade by way of Palmyra towards the Mediterranean reached the sea at the start of the sailing season, while routes towards the Mediterranean across the Red Sea and the Nile only arrived at the end of the sailing season. As such, direct competition between traders using the different routes was limited, and the advantageous time of arrival was another incentive to carry goods further west from Palmyra.[743] Additionally, Terpstra suggests that the Palmyrene temple in Rome is evidence

[739] Seland, *Ships of the Desert and Ships of the Sea*, 45–61.
[740] Seland, 53–54.
[741] Michał Gawlikowski, 'The Indian Trade between the Gulf and the Red Sea', *Polish Archaeology in the Mediterranean* 26(2), no. null (9 July 2018): 24–25.
[742] Gawlikowski, 25.
[743] Seland, *Ships of the Desert and Ships of the Sea*, 53.

of a Palmyrene trading community in the capital, which also fits in with the argument put forward by Grout.[744]

In his recent thesis, John Grout studied how Palmyrene temples may have been connected to long-distance trade. There are several indications of Palmyrene temples set up abroad along trade routes, the prime example being a temple for the *Augusti* set up in the Parthian city of Vologesias. Grout also argues that the temples of Palmyra itself played a role in facilitating trade, and at least the Vologesias example shows evidence of connections with a more remote temple. If anything, this adds another layer of depth to the view that temples played a role in the ancient economy. Furthermore, this ties in with the way that the religious 'rhythm' of Palmyra seems to have been connected to the rhythm of the caravan trade, as pointed out by Seland.[745]

In Seland's view, Palmyrene trade depended on a trust network developed over time. The routes required access to camels (and related factors such as grazing grounds), the security offered by stations and caravan leaders, and access to information and social ties with trade partners or authorities, offered by expatriate trade communities.[746] A strong ethnic identity based on the Palmyrene polity formed the basis of this trust network, sharing kinship and tribal ties as well as legal and civic institutions.[747] Seland does find that the model needs to be expanded with the personal role of elites, who maintained (external) ties with camel nomads and allowed the Palmyrene network to functioning within the Roman and Arsacid imperial framework.[748]

Either way, it is clear that Palmyra saw considerable commercial activity, and inscriptions by the Palmyrene elites clearly reveal that they were actively involved. Whether they were Will's landed aristocrats and military men, Rostovtzeff's merchant princes or Sommer's universal tribal leaders, powerful Palmyrene notables were honoured by Palmyrene merchants for organising, supporting or protecting the caravans.[749] Gawlikowski points out a nice detail: 20 out

[744] Grout, 'The Role of Palmyrene Temples in Long-Distance Trade in the Roman Near East', 112; Taco T. Terpstra, *Trading Communities in the Roman World: A Micro-Economic and Institutional Perspective*, Columbia Studies in the Classical Tradition ; Vol. 37. 802459145 (Leiden [etc.]: Brill, 2013), 152–60.
[745] Grout, 'The Role of Palmyrene Temples in Long-Distance Trade in the Roman Near East', 228–31, 267–75; Seland, *Ships of the Desert and Ships of the Sea*, 45–61.
[746] Seland, *Ships of the Desert and Ships of the Sea*, 63–74, 80.
[747] Seland, 74–85.
[748] Seland, 25.
[749] See for a more detailed overview: Michał Gawlikowski, 'Trade Across Frontiers: Foreign Relations of a Caravan City', in *Palmyrena: City, Hinterland and Caravan Trade between Orient and Occident*, ed. Jørgen Christian Meyer, Eivind Heldaas Seland, and Nils Anfinset (Oxford: Archaeopress Publishing Ltd, 2016), 19–28; Michael Sommer, 'The Venice of the Sands: Palmyrene Trade Revisited', in *Palmyrena: City, Hinterland and Caravan Trade between Orient and Occident*, ed. Jørgen Christian Meyer, Eivind Heldaas Seland, and Nils Anfinset (Oxford: Archaeopress Publishing Ltd, 2016), 11–18.

of 59 statues that were set up in the Palmyrene agora honoured leaders and benefactors of caravans, while the rest mostly honoured their recipients without any specification.[750]

The tax law gives a list of goods and the taxes exacted at import and export, mentioning high-value goods such as slaves, perfumed oils, bronze statues, and purple-dyed fleeces, as well as less spectacular items such as dry goods, dried fish, and animal fat. In the case of slaves, in the 'new law', the export tax is split up into the sale of slaves in the city itself and their actual export.[751] The tax law additionally mentions monthly taxes for workshops, bazaars, sellers of unguents and prostitutes. The 'old law' furthermore mentions salt and water coming from the territory, and the taxation on animals brought into the territory, such as camels (loaded as well as unloaded), but also animals for slaughter and sheep to be sheared. Furthermore, for animals from outside the territory, grazing rights have to be paid. Interestingly, foodstuffs coming from within the territory are explicitly not taxed.[752]

The law gives considerably more insight into commercial activities taking place in Palmyra and its territory than is known from any other city in the region. Notably absent, as many others have stated before, are most of the high-value luxury goods expected to have played a role in long-distance trade.[753] To assume that it only dealt with local consumption is nonetheless clearly incorrect, as export taxes are indicated for all goods as well. Gawlikowski supposes that international trade was "of course controlled by Imperial agents."[754] While there are clearly two *publicani* known from the city in the first century, curiously enough, only their role in establishing these municipal taxes can be confirmed, while there are no links with imperial taxation.[755] Seland suggests a situation wherein the inspection of goods did take place at Palmyra, but actual taxation only in Antioch, similar (perhaps) to goods transported under seal through Egypt to Alexandria.[756] Safest to say is that the details remain hazy at best.

Further evidence for exchange comes from pottery finds in the city. A recent study discussing amphora finds from Syrian-German excavations shows the presence of amphorae from many parts of the empire (including southern France, Italy and Rhodes), as well as Parthian amphorae, ranging from the third century B.C.E. (with additional evidence from three Hellenistic amphora

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[750] Gawlikowski, 'The Indian Trade between the Gulf and the Red Sea', 26.
[751] Sartre, *D'Alexandre à Zénobie*, 821–22; J. F. Matthews, 'The Tax Law of Palmyra: Evidence for Economic History in a City of the Roman East', *The Journal of Roman Studies* 74 (1 January 1984): 174–80, https://doi.org/10.2307/299013.
[752] Sartre, *D'Alexandre à Zénobie*, 821–22; Matthews, 'The Tax Law of Palmyra', 174–80: camel skins, apparently, are also tax-free.
[753] Matthews, 'The Tax Law of Palmyra', 172; Seland, *Ships of the Desert and Ships of the Sea*, 30–31.
[754] Gawlikowski, 'Palmyra as a Trading Centre', 28.
[755] Michał Gawlikowski, 'Deux publicains et leur tombeau', *Syria. Archéologie, Art et histoire* 75, no. 1 (1998): 145–51, https://doi.org/10.3406/syria.1998.7545.
[756] Seland, *Ships of the Desert and Ships of the Sea*, 53–54.

stamps from Rhodes) to the end of the third century C.E. Transported goods included the usual set of wine, garum and/or olive-oil. The same goes for tableware, with besides considerable local production, imports from both empires, including large amounts of Eastern Sigillata A (Roman tableware produced in northern Syria, possibly in the Antiochene) and Parthian glazed wares.[757] And clearly, wine imports continued into the later Roman period as well.[758] Perhaps the number of finds is not of the order of magnitude needed for solid analyses that may suggest changes over time in trade directions or volumes, but they do reinforce the idea that the settlement was clearly connected with both the Roman and Parthian empires, long before the city gained its monumental qualities in the later centuries of its existence.

What emerges is that for a city that generated so much evidence of trade over land, what we find among the goods being traded and taxed were not just expensive and exotic goods from far afield, but also regular goods and foodstuffs. One wonders then to what degree local agricultural production was supplemented by imported goods. Perhaps (or probably) these were goods coming from neighbouring regions, as it is hard to imagine the exorbitant cost of importing, for instance, dried fish overland from Persia. Most importantly, it shows that even with transport by camel, it could still be worth the effort to bring in lower-value bulk goods. One option could be that low value goods were transported as return cargoes from more lucrative outbound trade. Profits made on the outbound trip would then cover any transport expenses made for the return. Consider comparable arguments that are made in the context of for instance tableware in maritime trade.[759] Lucinda Dirven suggests for instance that Palmyrenes traded down the Euphrates by way of Dura Europos, while importing foodstuffs (and possibly wine) back from that city with returning camels.[760] But see also Seland's arguments for a route towards Hit instead of Dura Europos which would avoid taking rafts over a particularly difficult stretch of the river. Based on water sources, sites studied by Poidebard and Stein and a good dose of network analysis, he identifies an overland route that bypasses Dura entirely.[761] We should in any case not be too dismissive of the possibilities for coastal cities to actually import the food necessary for their population, as these would have had access to far cheaper transport by sea.

[757] Andreas Schmidt-Colinet and Waleed Al-As'ad, eds., *Palmyras Reichtum durch weltweiten Handel. archäologische Untersuchungen im Bereich der hellenistischen Stadt / Band 2, Kleinfunde*, vol. 2 (Place of publication not identified Holzhausen der Verlag, 2013), 20, 269–76.
[758] Grzegorz Majcherek, 'Filling the Gap: Mediterranean Amphorae in Late Antique Palmyra', *Syria. Archéologie, Art et Histoire*, no. 96 (31 December 2019): 395–418, https://doi.org/10.4000/syria.10620.
[759] Elizabeth Fentress et al., 'Accounting for ARS: Fineware and Sites in Sicily and Africa', in *Side-by-Side Survey* (Oxbow Books, 2016).
[760] Dirven, *The Palmyrenes of Dura-Europos*, 38–40.
[761] Seland and Meyer, 'Palmyra and the Trade Route to the Euphrates'.

3.3 Conclusion

As the figures in 3.1.1 showed, the number of cities in the Roman Levant was actually quite limited, and in general they were not particularly large – This leaves Antioch in a separate category, one of the largest cities of the Roman Empire, and a handful of major centres like Seleucia Pieria (albeit smaller than sometimes suggested), Apamea and Laodicea. As a result, when looking at how much food they could have produced within their direct surroundings, we find that most cities would have been quite capable to sustain themselves from what could be cultivated within three hours' walking distance. A conclusion similar to what one sees for instance in Roman Egypt around this period, with only a few cities, like for instance the port of Pelusium, growing beyond their local agricultural ceiling.[762]

On the other hand, there are a number of exceptions. Particularly large cities, dense clusters of nearby towns, coastal cities hemmed in between the sea and the mountains, and desert cities are all examples where urban demand might outstrip local supply. A number of different solutions arose to solve the supply problem: from adaptation of farming techniques to environmental demands, alternative sources of income, andthe acquisition of food through the market. Last but not least, limiting the studied production only to three-hour 'market zones' leaves quite some open space on the map. The following chapter will look at the prime example where the actual territory of a city encompassed considerably more land than just its direct surroundings, and what this implies for its food potential.

[762] Ligt, 'The Urban System of Roman Egypt in the Early Third Century AD', 288–89.