Chapter 31

In the land of the highlanders: from the kingdom of Simurrum to Mazamua in the Shahrizor

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Introduction

In the late third and early second millennium BC, the large plain known today as the Shahrizor and its surrounding region, located in the province of Suleymaniyah in Iraqi Kurdistan, likely formed an important region of the kingdom of Simurrum (Fig. 31.1; Altaweel *et al*. 2012). For much of the remaining second millennium BC and into the first two centuries of the first millennium BC, the region was a contested border zone between northern and southern Mesopotamian kingdoms or became splintered into small kingdoms. In 842 BC, the region became incorporated into the Assyrian provincial system under Shalmaneser III and remained part of the province of Mazamua until the fall of the Assyrian empire in the late seventh century BC. As archaeologists are now embarking on projects in Iraqi Kurdistan, one major question that will certainly arise is how do settlements in the region transform in one period to the next under varying political and economic circumstances. While archaeological surveys will be critical in filling this knowledge gap, computational methods can be used to determine where major settlements should be generally located and what factors might cause deviations from expectations. When there are known historical shifts, such as during the Neo-Assyrian (NA) period, the same model is able to evaluate how settlement size hierarchies transform. This paper presents such a method and demonstrates how major sites, such as Yasin Tepe and Bakr Awa, could arise, while also presenting a method for assessing how sites transform between minor and major settlements and the interactions that enable such transformations.

Spatial interaction and structural dynamic models that apply entropy-based and Lotka-Volterra methods (Wilson 1970; Harris & Wilson 1978; Wilson 2012) have the potential to provide explanations that address settlement expansion or contraction within given geographic settings. Such models are particularly attractive because specific, often fundamental reasons (e.g., ideology, climate change, population pressures, etc.) for settlement transformations are difficult to recover or comprehend from the archaeological record, but such effects can be represented or applied within models that are general enough to explain and demonstrate urban growth and change. Furthermore, such models are powerful in providing clear quantitative explanations of settlement size hierarchies, helping to describe urban structure and process. The goal here is to present a simple simulation model that explores how the spatial setting and factors that affect the flow of goods and people can influence urban transformations and settlement in the Shahrizor during the NA period. Where data are available, these are used to validate or compare to results. We begin by presenting some background information about the region studied. We then discuss entropy and structural dynamics methods and use the Appendix to provide more specific details. The modelling data, that is the sites simulated, and code used to generate results are made available in the link provided above at the beginning of this work. Outputs from scenarios that investigate settlement dynamics in the Shahrizor are presented, assessing relevant causal factors that lead to settlement structure development and how well that matches our knowledge about Neo-Assyrian settlement patterns. The model results' significance to understanding the development of settlement change in the NA period is finally discussed.

Background

The Shahrizor is a wide valley that is east of the Chemchemal and Kirkuk regions, separated by double mountain barriers consisting of the Binzird Dagh and Beranan Dagh ranges and the higher Qara Dagh range directly west of the Shahrizor (Fig. 31.1). The Zagros

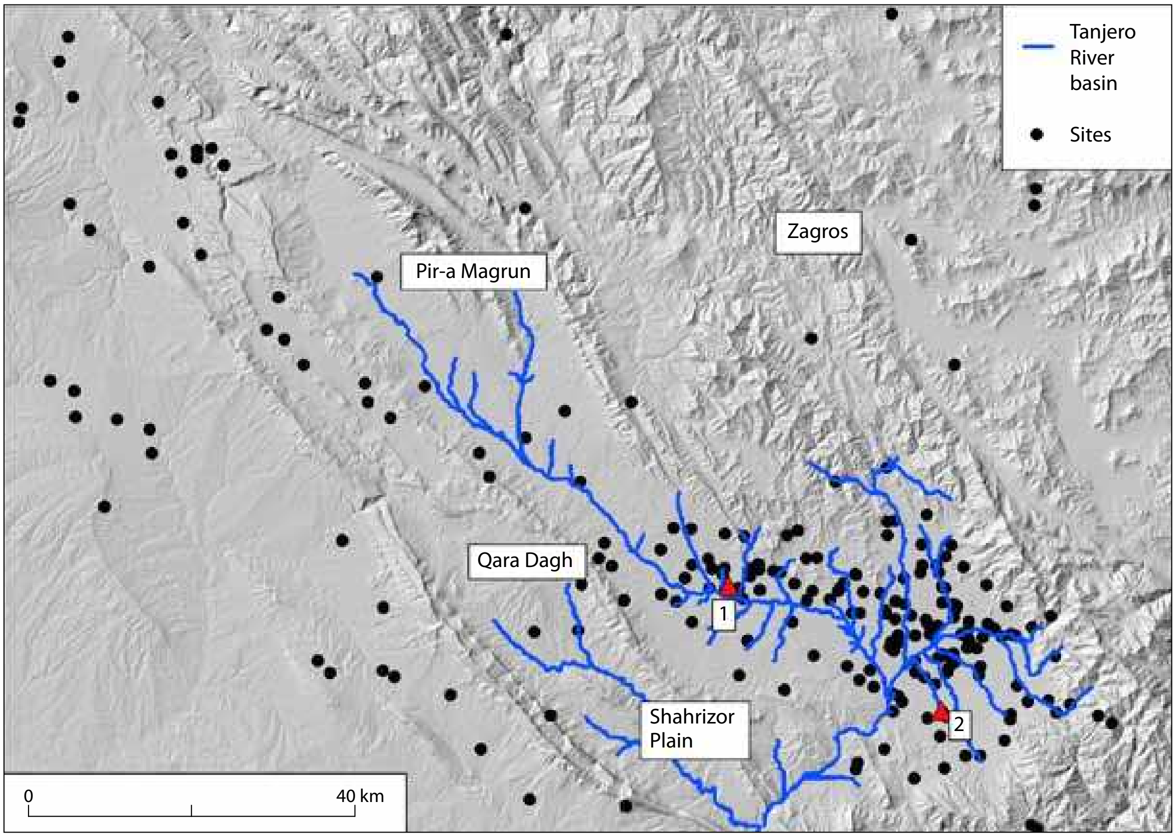


Figure 31.1. *The Shahrizor plain and surrounding region with known archaeological sites. The numbers 1 and 2 (triangles) indicate Yasin Tepe and Bark Awa respectively.*

Mountains lie to the east, with the Pir-a Magrun, the Azmir, and the Hewrman ranges forming the plain's immediate perimeter. The Tanjero River is the main stream that flows in the valley following a southeast direction. After merging with various perennial and annual streams from the surrounding mountains, the Tanjero merges with the Sirwan, that is the Upper Diyala, and its eastern tributaries, which then flow into the Diyala region of Central Mesopotamia before merging with the Tigris. The Upper Diyala area is today largely submerged under the Darband-i Khan Dam Lake.

Historical

As stated, in the second half of the ninth century BC, the Shahrizor, including the surrounding region, became well integrated into the Neo-Assyrian provincial system within the larger province of Mazamua (Radner 2006). In the few decades before the region became part of the Assyrian province, we learn from Assurnasirpal that the region consists of a number of cities and local rulers, including the cities of Bunasi, Larbusa, Ammali, Zamru, and Arzizu (Grayson 1991). While it is not clear where many of these cities are located, the city of Amali is likely located in the Shahrizor plain (see Radner in Altaweel *et al*. 2012). Certainly the highly fertile Shahrizor plain would have enabled not only a significant population in the chief cities but also in the larger countryside (Sehgal 1976). While the eastern border of Mazamua was in flux and the regions beyond the Hewrman range were not always under Assyrian control (Levine 1989), the Shahrizor was never lost from the ninth century BC until near the end of the Neo-Assyrian empire.

The route over the Bazyan Pass and the Tasluja Pass across the Shahrizor remained very important throughout much of the eighth and seventh centuries, as it became the likely principal region of access to northwest Iran, the Lake Zeribar region, and beyond to the east. The region is an ideal staging ground, as the broad valley would enable the large Assyrian army to assemble prior to moving east, while the few mountain passes giving access to the region potentially make it easier to protect the region. In fact, we know Assurbanipal (668–627 BC) gathered his army to invade Mannea (south of Lake Urmiya; Hassanzadeh & Mollasalehi 2011) near the city of Dur-Aššur (possibly Bakr Awa; see Fig. 31.1). However, the Manneans were likely aware of this pending attack and attempted to surprise the Assyrian forces during a night operation. Nevertheless, or at least according to how the Assyrian annals describe it, the Mannean forces seem to have been thoroughly routed (Borger 1996). The Assyrians were then able to cross into Iran as planned and invaded Mannea. Perhaps the Shahrizor's importance in territorial access to Iran as well as Mesopotamia are further emphasized when Cyaxares invaded Assyria in 614 BC, as his forces may have had to first go through the Shahrizor route to Assur.

Archaeological

We are aware of many sites within and nearby the Shahrizor thanks to the publication of the Archaeological Sites of Iraq (ASI) and the Atlas of Archaeological Sites in Iraq (Directorate General of Antiquities 1970). During the salvage investigations that occurred when the Darband-i Khan Dam was under construction, two seasons of Iraqi excavations were carried out at Bakr Awa (Fig. 31.1), 7.3 km northwest of Halabja and the largest site in the valley (~ 50 ha). The University of Heidelberg has recently resumed excavations on the site of Bakr Awa in 2010 (Miglus *et al*. 2011). The Shahrizor Survey Project (SSP) has been conducted since 2009, with the methodology applied in this project discussed in Altaweel *et al*. (2012). The goal of this project is to better understand settlement development in the region, human impact on landscape formation, and socio-economic interaction with the environment.

So far, 13 of 30 sites for the SSP have shown NA or Iron Age remains. In contrast, the ASI showed 93 of 111 sites having NA or Iron Age evidence. While the latter results are likely to be incorrect, both results so far do confirm that the region was heavily settled during the first half of the first millennium BC. This is no major surprise, as so far all indications suggest the region was relatively fertile and well watered in the early part of the first millennium BC (Altaweel *et al*. 2012).

Method

Entropy maximizing methods have been widely used to model spatial interaction in a variety of settings (Wilson 1970). In this case, we apply the method to represent interaction between settlements, with interactions representing both migration and trade. Economic or population growth has been modelled using methods comparable to Lotka-Volterra in ecology (Harris & Wilson 1978); the combined settlement dynamics model is labelled as Boltzmann-Lotka-Volterra (Wilson 2008). In archaeology, publications that have applied similar approaches include Evans and Gould (1982) and more recent work by Bevan and Wilson (2013) and Altaweel (in press). The aim of our model is to produce simulations that explain why certain sites may have achieved relative prominence, as expressed in site size, as well as the general settlement size distribution and hierarchies of the study region. This is based on how important sites may have been, determined by any one of a number of social-ecological reasons: ease of transport, geographic location, cost of inter-site movement, and exogenous factors such as distant regions favouring one site to be relatively large. The key variables employed include:

αj: return of attractiveness of a settlement that leads to migration or movement of people,
β: ability to move in the landscape,
$l\ j$: external and internal influences that reduce or enhance a site's attractiveness,
Xj: population, used as a relative measure of site size and main output used in scenarios, Zj: the scale of population growth used to regulate flow S, and
dij: distance measured in cost of travel.

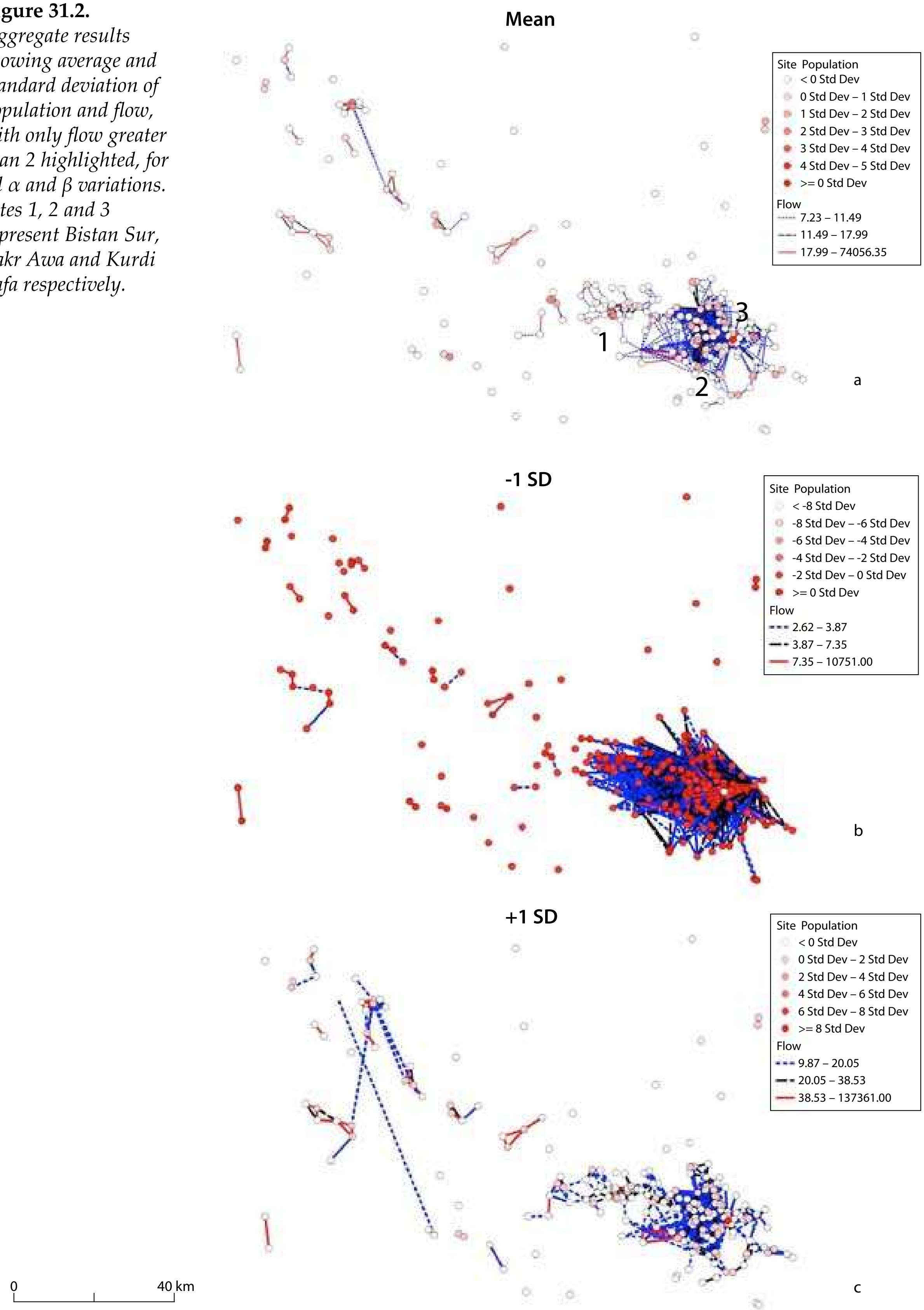
As sites grow or decline, that growth or decline can have a feedback effect, leading to the site becoming even smaller or larger. While the survey results of the Shahrizor are still at an early stage, we can now begin to apply these empirical results along with our simulated approach in order to see where likely settlements may emerge and which sites may become prominent in given periods. The examination of simulation parameters is intended to provide insight into the relative importance of the individual factors that contributed to settlement growth and change.

Results

Scenario 1: Location benefits

This first scenario tests to see where are the likely locations for populations to cluster in the Shahrizor based on geography within the Shahrizor and costs of travel between sites. This should then provide us a general expectation if sites such as Yasin Tepe and Bakr Awa should be relatively large due to their location. In order to execute this scenario, a parameter sweep (North & Macal 2007), that is a test of incremental changes to parameters, is done to the α and β values. This is done to see how variations of site attractiveness and impedance affect populations and whether certain sites consistently appear as relatively large or small settlements. In the scenario, α is incrementally increased to 20 and β to 73, with

Figure 31.2.
Aggregate results showing average and standard deviation of population and flow, with only flow greater than 2 highlighted, for all α and β variations. Sites 1, 2 and 3 represent Bistan Sur, Bakr Awa and Kurdi Safa respectively.



values greater than 73 causing simulations to fail. Fig. 31.2 represents (a) the mean results, (b) -1 standard deviation from the mean and (c) +1 standard deviation from the mean; Fig. 31.3 shows a closer view of the main Shahrizor plain. What this figure shows is that with variations made to α and β, results generally indicate that several sites consistently become larger, using population as the size measure, than other sites, while other sites consistently become small or even lose all their population over time. The mean output shows that Kurdi Safa (3) and Bistan Sur (1) are the most populated sites respectively, with Bistan Sur being closely behind. Bakr Awa, a known large site in the region, is the 43rd largest (top 18 per cent). The -1 standard deviation shows that all sites could be relatively similar in population, which generally occurs when β is low, while the +1 standard deviation shows there can be large variations between site populations with Bistan Sur and Kurdi Safa having generally higher populations, particularly when β increases. The results for Bistan Sur are particularly intriguing as Yasin Tepe (~31 ha) is within 1–2 km from Bistan Sur. While the model did not forecast Yasin Tepe as the largest site (i.e., most populous), it does forecast that the region very near Yasin Tepe should have a large site. For Kurdi Safa, it is also within a mounded area that seems to be somewhere between the third to ninth largest site so far known, roughly 13–18 ha based on CORONA imagery. Therefore, the results suggest that the immediate regions around Yasin Tepe and Kurdi Safa should have large sites; these results are primarily driven by geography, as the distance cost and interactions of many sites near these would suggest that the regions of Yasin Tepe and Kurdi Safa should greatly benefit from regional population interactions and economic flow.

What is also intriguing about the results is that on average interactions between settlements suggest that the region around Yasin Tepe, based on high interaction between sites, could become one sub-region that has many local interactions, while the regions of Kurdi Safa and Bakr Awa are more closely linked (Fig. 31.3). This demonstrates that the regions of Yasin Tepe and Kurdi Safa are somewhat separated, whereby clusters of sites in these two regions enable more nearby interactions and flow in these smaller sub-regions rather than across the entire plain. This result is more pronounced as β is increased, once again suggesting that large sites should be found in the Yasin Tepe region and near Kurdi Safa.

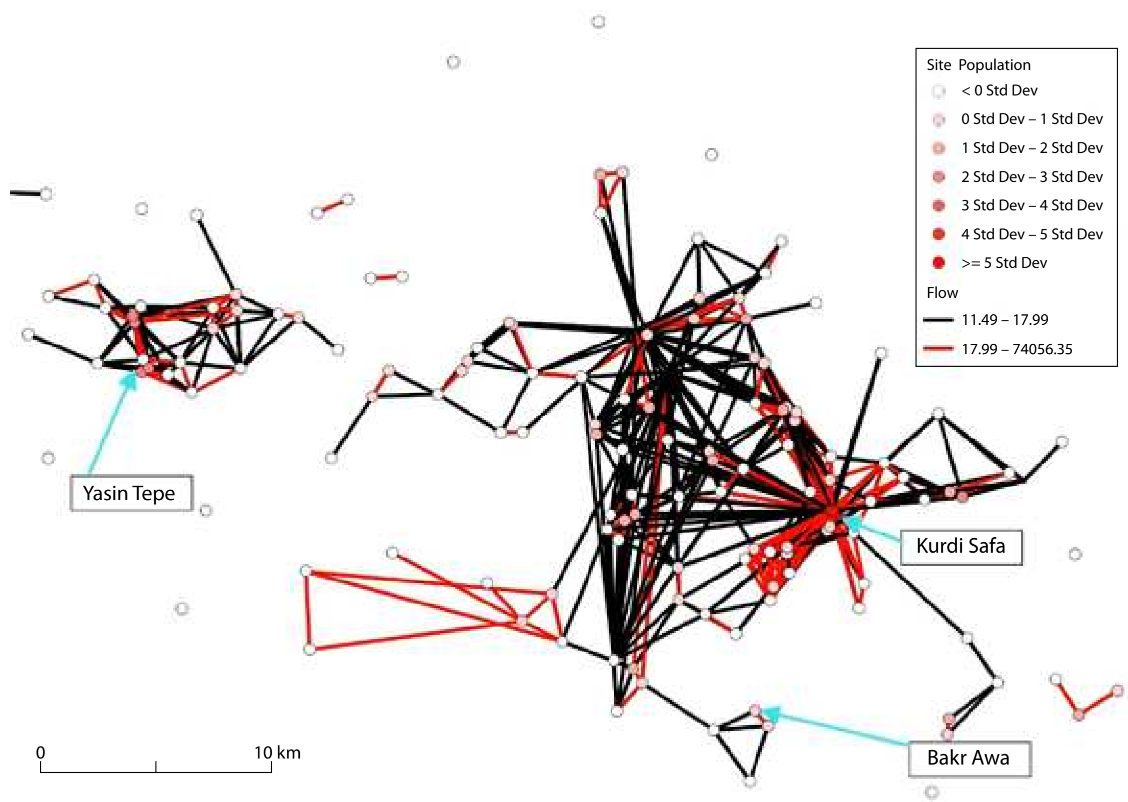


Figure 31.3. *Upper two octile interactions demonstrating two clear sub-regions around Yasin Tepe and Kurdi Safa.*

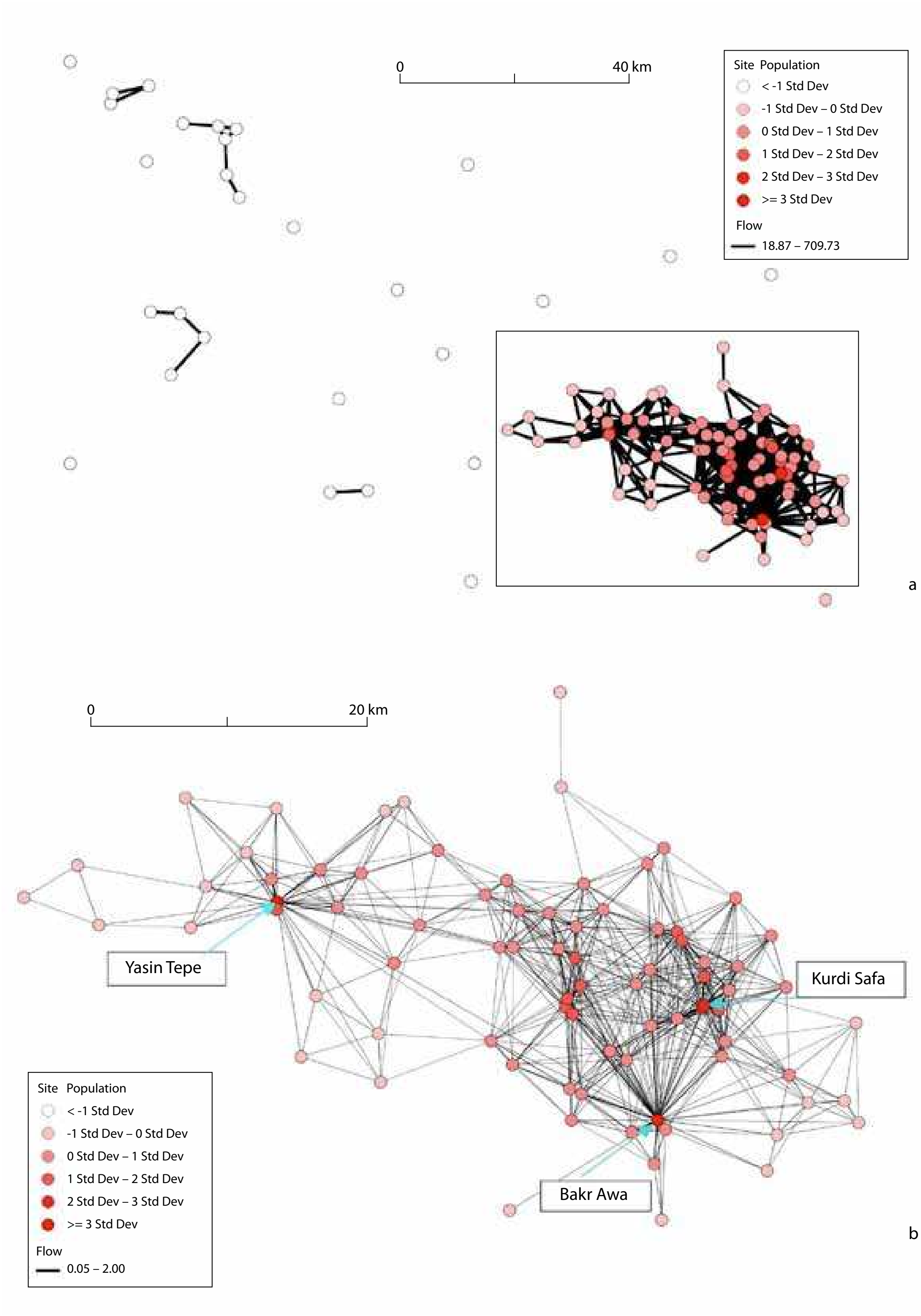


Figure 31.4. *Population simulation (standard deviation) showing Yasin Tepe and Bakr Awa as the two largest sties respectively using an interaction graph; Kurdi Safa is shown as the third largest site. Line thickness indicates relative flow with upper octile values displayed.*

However, one problem with the above result is that Bakr Awa (~ 50 ha) does not stand out in the model, although it is in the top 18 per cent of site population in model outputs. While geography and local interaction may have played some role in enabling this site to become large during the site's long history, the results suggest that other reasons might be needed to further explain Bakr Awa's dominate population. To explore why this site becomes dominant, and cases in which Bakr Awa and Yasin Tepe are relatively large, as is likely in the NA period, a second scenario tests to see what might enable this.

Scenario 2: Dominance of Yasin Tepe and Bakr Awa

While the previous scenario demonstrates that the region around Yasin Tepe is likely to have a large site, as the strategic location and access to many nearby sites enables this, Bakr Awa did not show a similar result. In this scenario, we test different α, l, and β for all sites in order to see what makes both these sites become dominant and relatively large in the Shahrizor. In this case, we randomly choose approximately 45 per cent of all sites to run in simulations, with Yasin Tepe and Bakr Awa always chosen. This percentage roughly replicates what we expect the number of NA sites to be in the region based on current dated sites (Altaweel *et al*. 2012). In simulations, sites are chosen randomly; therefore, runs were repeated ten or more times in order to account for stochasticity.

Once again, conducting a parameter sweep on variables, by incrementing 0.1 for each variable, enabled us to see which minimum results produce a situation where Yasin Tepe and Bakr Awa are the largest sites and how much variation in α and l are required between these sites and the others in the Shahrizor. This enables us to determine how strong do these sites' attractiveness (α) and exogenous (l) circumstances need to be for these sites to become the most dominant in size. If all sites except Yasin Tepe and Bakr Awa are set to α=0.1 and l=0.1, and for all sites β=1.0, Yasin Tepe and Bakr Awa need to have α=0.7 and l=1.0 before they consistently become the largest sites (Table 31.1). Other scenarios with greater differences in these variables produced similar or even more pronounced results that led to Yasin Tepe and Bakr Awa becoming dominant, but the variable settings in Table 31.1 are the minimum that enable these sites' dominance.

Table 31.1. *Summary of parameter settings for Scenario 2 showing settings for Yasin Tepe and Bakr Awa as well as other sites.*

	a	b	l
Yasin Tepe and Bakr Awa	0.7	1.0	1.0
All other Sites	0.1	1.0	0.1

Fig. 31.4 demonstrates what Table 31.1's variables result in, with Fig. 31.4a showing the wider region, while Fig. 31.4b shows the southern region of the simulated area, which is the Shahrizor plain. In Fig. 31.4b, interactions between settlements are shown, with thicker dark lines indicating greater flow into a settlement. In other words, sites with more lines connecting them and thicker lines have more goods and people flowing to them in local interactions. As a measure of degree centrality, in Fig. 31.4 Yasin Tepe and Bakr Awa have scores of 17 and 34 respectively for links to them with flow values greater than 0.09, which are the highest two scores. Yasin Tepe generally becomes the largest site when Bakr Awa has the same parameter setting. This demonstrates the geographic advantages that Yasin Tepe has, as its high flow interactions with sites enable it to more quickly reach a greater population. In fact, Yasin Tepe could have a=0.5 and l=1.0, with all other sites being 0.1 for both a and l, and Yasin Tepe would become the dominant site. This indicates it does not need too many additional advantages outside of its geographic location for such dominance. Interestingly, Kurdi Safa continues to be a relatively important site, with this site often being the third largest in simulations set to Table 31.1's parameters.

While the results do largely replicate the largest two sites, along with enabling a third large site to emerge, what has not been demonstrated is how well the approach can be used to better understand overall site size hierarchy in the Shahrizor. Fig. 31.5 shows the Shahrizor's settlement rank distributions, using a natural log scale for simulated population size in the Shahrizor and under conditions shown in Table 31.1. In addition, if we look at settlement sizes during the NA period in the Habur (Khabur) Triangle (KT) as a comparison, using site size and normalizing this to population, we can then compare how closely simulated settlement hierarchies in the Shahrizor match up to better surveyed regions. Fig. 31.5 shows that the Shahrizor and KT do not match closely, particularly for middle-range and smaller sites. Other scenarios are, therefore, needed to show what the Shahrizor's settlement size hierarchy may look like if it resembles the KT's site size hierarchy.

Scenario 3: Settlement hierarchies

To create site hierarchies that are more similar to the KT, which would enable us to see what one would expect if we use a relatively well dated and more thoroughly surveyed region for comparison, we did another parameter sweep on α, l, and β *and compared the* simulated Shahrizor site size hierarchies to the KT in the NA period. We checked to see which distributions had the closest hierarchies to the KT by comparing slopes of the two regions' ranked size curves. This allows one to measure how similar the curvature of the hierarchy graphs are between the two regions, even if settlement sizes are different. Fig. 31.6a is a heat map of *α* and *β* that shows which parameter settings match closely to the KT for Shahrizor sites. From the results, when *α*=0.7, *β*=0.5, and *l*=0.5 for all sites, with Yasin Tepe and Bakr Awa set to *α*=1.0 and *l*=1.0, we see the settlement size hierarchy curves becoming more similar between the two regions (Fig. 31.6b; population used as size proxy). The results show that relatively low β, with minor differences between Yasin Tepe's and Bakr Awa's *α* versus other sites, led to more similar populations between sites. In this case, while low *α* indicates relatively less importance placed on each individual site, with various sites being similar in their importance, low *β* indicates easier movement and flow between sites. This facilitates population movement and a more equitable population distribution across sites (Figs. 31.6b and 31.7).

While a direct comparison of the distributions is difficult, as the number of sites vary and the sizes of sites likely vary, we can at least try to replicate the general hierarchy curve. Using parameters obtained in Fig. 31.6, how settlement hierarchy would look for populations in the Shahrizor is displayed in Fig. 31.7. Not only do we now see that many site populations are more similar, we also see that the regions around Yasin Tepe (flow > 0.09=19 degree centrality), Bakr Awa (flow > 0.09=22 degree centrality), and Kalkl Sheikh (flow > 0.09=6 degree centrality) are the most central and have high interaction flow. In addition, the sub-regions seen in scenario 1 are not apparent. Even

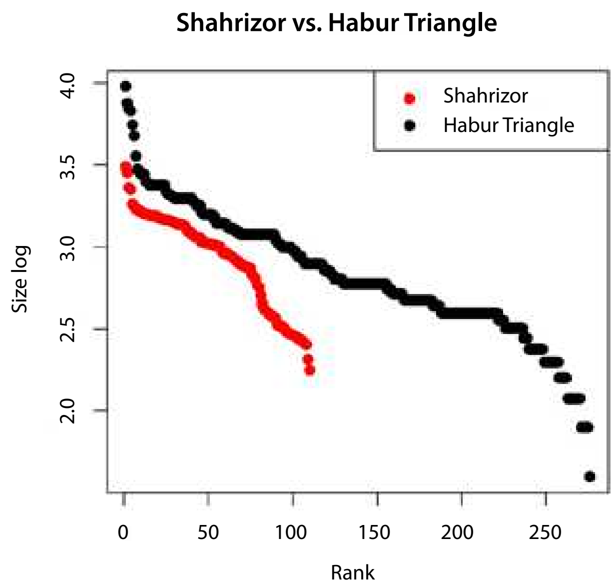


Figure 31.5. *Comparison of site sizes for the Shahrizor and the Habur Triangle (KT) in the NA period.*

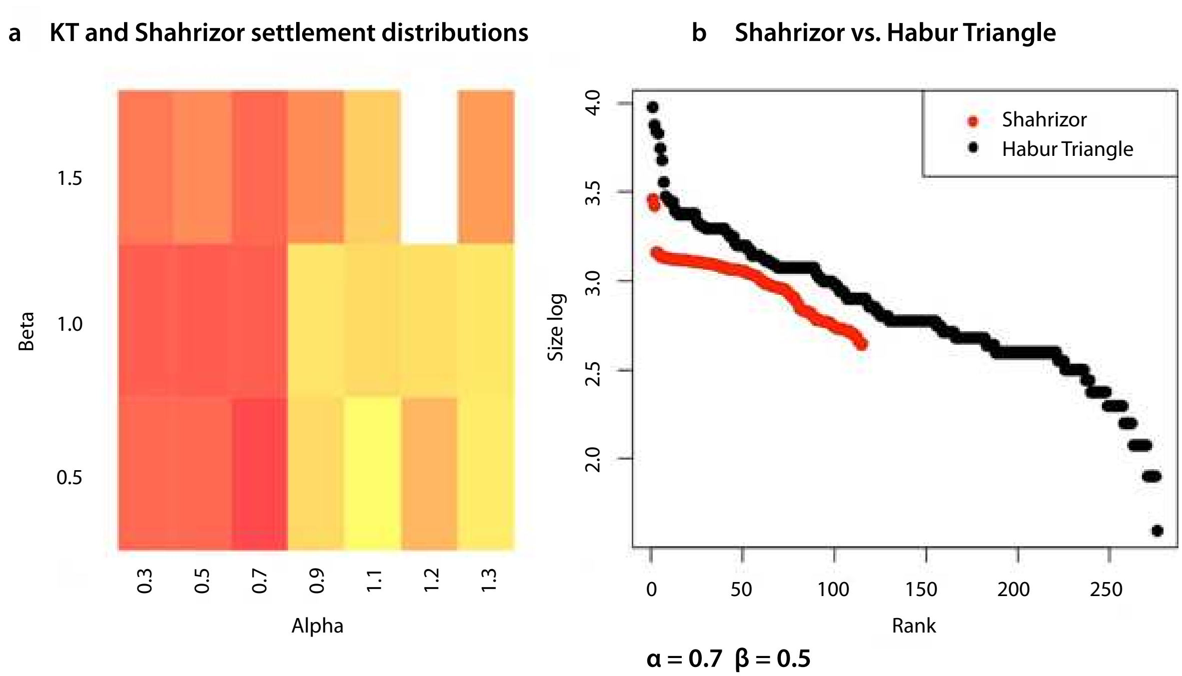


Figure 31.6. *Heat map (a; darker colour = greater agreement) comparing site size hierarchies in the Shahrizor and Habur Triangle (KT) under different α and β settings. The closest matching α and β values and hierarchies are indicated (b).*

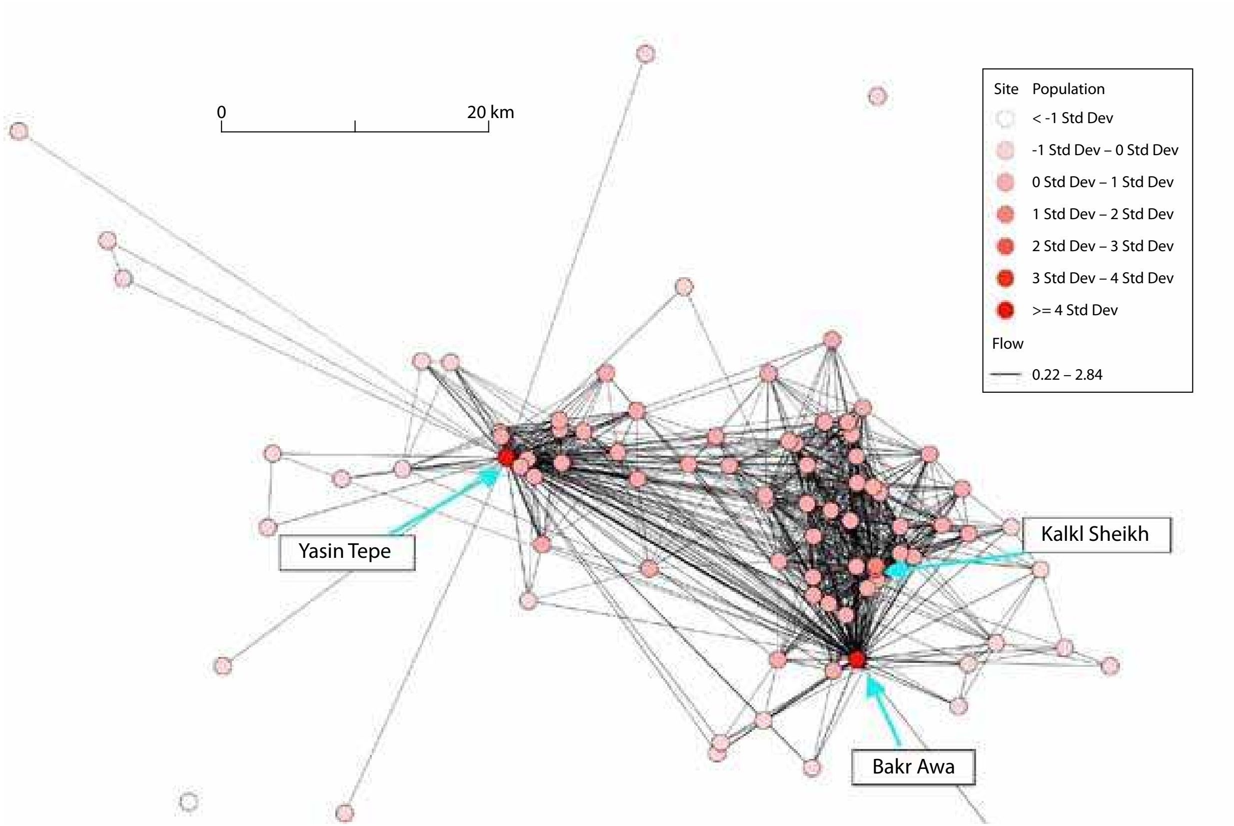


Figure 31.7. *Site size indicated using standard deviation of population and flow into sites using a modified interaction graph.*

more distant sites can now be seen to have relatively high flow into central sites such as Yasin Tepe. In cases where Kurdi Safa was not modelled, nearby sites such as Kalkl Sheikh (~2.5 km for Kurdi Safa) did become the third largest site, indicating that the general area around Kurdi Safa leads to larger sites.

Discussion and conclusion

What the above presentation has attempted to demonstrate is a model that is useful in describing site hierarchies and relative settlement sizes in order to determine what, at least at some population level, might be causing some sites to become relatively larger than others. We can see that local geography may have played a role into why regions around Yasin Tepe and Kurdi Safa are important, as local interactions and ease of access can make sites there relatively large. This can possibly be explained by the fact that valleys such as the Shahrizor do provide some relative isolation, possibly minimizing exogenous influences from more distant settlements and regions. Nevertheless, we see that geography alone does not explain why Bakr Awa is a likely large site in the NA period. Here, we utilize the model to determine at what parameter levels do we begin to consistently see Yasin Tepe and Bakr Awa both becoming relatively large. While α and/or l do need to be higher for both these sites than other sites, the values do not have to be very large and it seems in general Bakr Awa would need an even greater α or exogenous effects to enable it to consistently become the largest site. This greater α or l value could represent rulers placing greater importance on the site or local environmental benefits (e.g., better access to water) the site may have relative to other sites. Finally, when applying a similar site hierarchy for the Shahrizor as the KT in the NA period, we begin to see the effect this has on all settlement types in the region. In this case, many sites become more similar in population and interaction now enables greater movement between the Yasin Tepe, Kurdi Safa and Bakr Awa regions. While Yasin Tepe and Bakr Awa are relatively large sites in simulations, increased interactions result in more evenly dispersed populations.

With work in the Shahrizor still in preliminary form, from the sites that seem large during the NA period and for which we have a rough idea of the percentage of sites occupied, the model enables our effort to forecast what to anticipate in a settlement survey now being conducted in the region. If the Shahrizor will largely mimic the KT, then we should expect sites such as Yasin Tepe and Bakr Awa to have a greater NA presence, but the differences in population to other settlements might be smaller than other periods and few large sites for this period might be expected. The region of Kurdi Safa could also be an area where we would expect greater population concentrations. Overall, not only can the model be used to forecast regions of likely greater population presence, the model demonstrates a quantitative method that can describe settlement size hierarchies and can be used to assess how major and minor sites emerge.

Acknowledgments

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Appendix

Model Data and Code Link:
http://discovery.ucl.ac.uk/1394440/

The spatial data required for our model is provided in the form of archaeological sites located using CORONA satellite data, although many identified sites have yet to be dated by the SSP, with only ASI dates available. The total number of sites is 228; these represent sites in the Shahrizor plain as well as in the surrounding region. For the work presented here, site data include cost matrices for travel, which is expressed as distance (*d*) in the model, calculated via cost surface analysis and using the method applied by Fontenari *et al*. (2005). This allows us to integrate terrain and the cost of moving across different elevations between two sites as derived from digital ASTER DEM data (ASTER 2013). This appendix contains the algorithms and variables used in the model.

The model takes the form of a standard spatial interaction model (SIM) and is similar to that used previously in other contexts (e.g., Harris & Wilson 1978; Bevan & Wilson 2013), with minor modifications. Below we list the variables and notation to further describe how the model functions; however, users can also download the model and data for further details.

Key variables

The model has several variables that allow settlement population, which is used as a proxy and representative of relative size in this paper, to evolve during simulation time. The key variables applied in our approach include:

αj: Return of attractiveness of a settlement that leads to migration or movement of people
β: Ability to move in the landscape, with higher β signifying greater restrictions
lj: External and internal influences that reduce or enhance a site's attractiveness.
Xi : Population, used as a relative measure, originating at a given site *i*
Zj: The scale of population growth *j*; this is used as a relative proxy to regulate flow
dij: The distance (i.e., cost of travel) between any two sites *i* and *j* using cost surface (Fontenari *et al*. 2005).

In the model, impedance, and therefore restrictions in moving to sites, is represented by β, which incorporates various factors that cause movement to be difficult (e.g., political restrictions, physical barriers, etc.). On the other hand, α can vary for sites, as a site could be more important than other sites and can potentially mitigate the effects of transport limitations for some sites. In this case, α (i.e., attractiveness) can be a variety of factors, including political, economic, religious, or other social and environmental reasons that make a settlement attractive for migration or commerce.

The flow (*Sij*) between each pair of sites *i* and *j* is calculated using the following formula:

$$S_{ij} = X_i \frac{Z_j^{\,l_j * \alpha_j} e^{-\beta d_{ij}}}{\sum_k Z_k^{\,l_k * \alpha_k} e^{-\beta d_{ik}}} \quad (1)$$

These flows between sites are summed to give the total incoming flow *Dj* to each site *j*:

$$D_j = \sum_i S_{ij} \quad (2)$$

This incoming flow is used to calculate *Zj* at the next time step (i.e.,), with used to control the speed of change for *Z* and *k* a constant that can be used to scale *Zj*:

$$Z_j^{\,t+\delta t} = Z_j^{\,t} + \varepsilon(D_j - kZ_j^{\,t}) \quad (3)$$

Table 31.2. *Initial values used in Scenario 1a.*

Population (X)	Population Scale (Z)	Attractiveness (α)	Travel (β)	ε	Size Cost (k)	External/Internal Influence (l)
1000	1	0.1	0.3	10-5	1	1

Next, $Xi(t+dt)$ (i.e., in the following time step) is determined by taking the corresponding $Zi(t+dt)$ value, normalized for the total of $Zi(t+dt)$ for all sites, and rescaling (n) for sites so that sum of all $Xi(t+dt)$ continue to have the same mean as the simulation start and population is adjusted for the next simulation time for each site (i):

$$X_i^{t+\delta t} = n \frac{Z_i^{t+\delta t}}{\sum_k Z_k^{t+\delta t}} \quad (4)$$

Then the model goes back to (1) for the next time step and continues until the end of the simulation. In this paper, simulations are run for 120 time ticks to allow results to reach a relatively steady state.

Modelling scenarios are here applied to sites in and around the region of the Shahrizor, with data kindly provided by Simon Mühl. Table 31.2 lists default parameter settings used for the first scenario in the paper, with other scenarios derived from these initial inputs. While only a small portion of sites are relatively well dated, we will use our knowledge that Bakr Awa and Yasin Tepe were relatively significant sites and likely the largest in the Iron Age/Neo-Assyrian period.

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