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ORIGINI

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PREHISTORY AND PROTOHISTORY OF ANCIENT CIVILIZATIONS

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EXPLORING TERRITORIES: BUBBLE MODEL AND MINIMUM NUMBER OF CONTEMPORARY SETTLEMENTS. A CASE STUDY FROM ETRURIA AND *LATIUM VETUS* FROM THE EARLY BRONZE AGE TO THE EARLY IRON AGE

Luca Alessandri

ABSTRACT – *This paper has two aims. The first is to introduce to a wider audience the recently proposed Bubble Model: a new method to reconstruct ancient settlement territories. After a preliminary discussion of similar methods that have been used in archaeology, such as Voronoi diagrams (Thiessen polygons), Multiplicatively Weighted Voronoi diagrams and XTENT, the Bubble Model is defined and its characteristics are compared. Strengths and weaknesses are identified and discussed. The main advantages of the new model are: a diachronic approach (the reconstructions of the territories depend on the order of appearance of the settlements); the possibility to detect federative polities.*
The second aim is to discuss the problem of contemporaneity between settlements. It is quite common to observe, in detailed regional studies, simple maps showing the increasing or decreasing number of settlements for each chronological phase. However, since we cannot be certain of the contemporaneity of all settlements, the trends over time might be biased by settlements with very short life (i.e. less than an archaeological phase). Thus, it is worthy to introduce the concept of Minimum number of Contemporary Settlements (MCS).
Finally a case study from Latium Vetus and Etruria (Italy) is presented. Using both methods, it has been possible to hypothesise the presence of hierarchical polities in the Tolfa Mountains, from the Early Bronze Age to the Final Bronze Age. Whereas, in the Cerveteri area only federative polities seem to exist from EBA till FBA1-2. Moreover, it is shown that the progressive decrease in settlement number in southern Etruria might partially be due to a gradual process of stabilization of the minor villages.
Since the EBA, major central settlements seem to be regularly distributed at about 100/120 minutes walking time distance, resulting in territories of 50/60 minutes radius. At least at the beginning of the EIA, the proto-urban settlements of Roma, Veii and Caere seem to almost double their territory radius.

KEYWORDS – settlement systems, Etruria, *Latium Vetus*, Bronze Age, Iron Age.

RIASSUNTO – Questo contributo ha due obiettivi principali. Il primo è di presentare ad un'ampia platea il Bubble Model: un metodo per ricostruire l'ampiezza dei territori degli antichi insediamenti. Dopo una discussione preliminare circa i metodi che fino ad ora sono stati utilizzati allo scopo (i Voronoi diagrams, conosciuti anche come poligoni di Thiessen, i Multiplicatively Weighted Voronoi diagrams e il modello XTENT), il Bubble Model è definito con precisione e messo a confronto, evidenziandone pregi e difetti. I maggiori vantaggi sono: un approccio diacronico, ovvero i risultati in una fase sono influenzati da quelli della fase precedente; la possibilità di individuare federazioni di insediamenti della stessa 'importanza'.
Il secondo obiettivo è di discutere il problema della contemporaneità tra gli insediamenti. Le carte di fase degli insediamenti, così frequenti in archeologia, mostrano spesso un numero di villaggi che varia allo scorrere del tempo. Tuttavia la tendenza che ne deriva è facilmente alterata dalla presenza di insediamenti di breve durata che, pur appartenenti alla stessa fase, non necessariamente

sono contemporanei. Viene dunque introdotto il concetto del numero minimo di abitati contemporanei (MCS) e vengono illustrate due procedure per calcolarlo.
Infine i due metodi (Bubble Model e MCS) vengono applicati allo studio dello sviluppo dei sistemi insediativi in Etruria meridionale e *Latium Vetus,* nell'età del Bronzo e nella fase antica della prima età del Ferro. Tramite di essi è possibile osservare, per esempio, la presenza di comunità gerarchiche nell'area della Tolfa, dall'antica età del Bronzo al Bronzo finale, contrariamente a quanto accade nell'area in cui sorgerà il centro protourbano di Cerveteri, dove invece è possibile ipotizzare la presenza di comunità federate, almeno fino al Bronzo finale 1-2. Inoltre si dimostra che la progressiva diminuzione di numero degli insediamenti in Etruria meridionale può essere dovuta, almeno parzialmente, alla stabilizzazione degli insediamenti più piccoli. Il territorio degli insediamenti, almeno a partire dall'antica età del Bronzo, sembra attestarsi su di un raggio di 50/60 minuti di cammino, mentre i centri protourbani, agli esordi dell'età del Ferro, sembrano controllare un territorio con un raggio radddoppiato.

PAROLE CHIAVE – *sistemi insediativi, Etruria, Latium Vetus, Età del Bronzo, Età del Ferro.*

INTRODUCTION

The goal of this article is to introduce to a wider audience both a new method to reconstruct ancient settlement territories (Bubble Model) and two techniques to calculate the minimum number of contemporary settlements (MCS). After a brief discussion of alternative methods (Voronoi diagrams, Multiplicatively Weighted Voronoi diagrams and XTENT), the Bubble Model is precisely defined and introduced. Advantages and disadvantages of each approach are compared. Afterwards, two different techniques to calculate the minimum number of contemporary settlements are proposed and analysed. Finally, the new methods are applied to the settlement patterns of the Bronze Age - beginnings of Early Iron Age 1 (2300 – 880 BCE), in the area between the Mignone River, the coast and the Astura River, that is in a portion of Etruria and *Latium Vetus* (Italy).The single phases will not be analysed in detail but some general trends in settlement systems will be discussed. It is shown that the simultaneous application of both Bubble Model and Minimum number of Contemporary Settlements (MCS)is an effective approach, especially when dealing with complex societies, for which settlements of different ranks can be detected or hypothesized.

HOW TO DETERMINE THE TERRITORY OF A SETTLEMENT– STATUS QUAESTIONIS

Three spatial methods have traditionally been used to reconstruct the ancient territory of a settlement: Voronoi diagrams(VD, also known as Thiessen polygons), Multiplicatively Weighted Voronoi diagrams (MWVD) and the XTENT model. Each of these is briefly described and defined here.

Voronoi diagrams

"Given a set of two or more but a finite number of distinct points in the Euclidean plane, we associate all locations in that space with the closest member(s) of the point set with respect to the Eu-

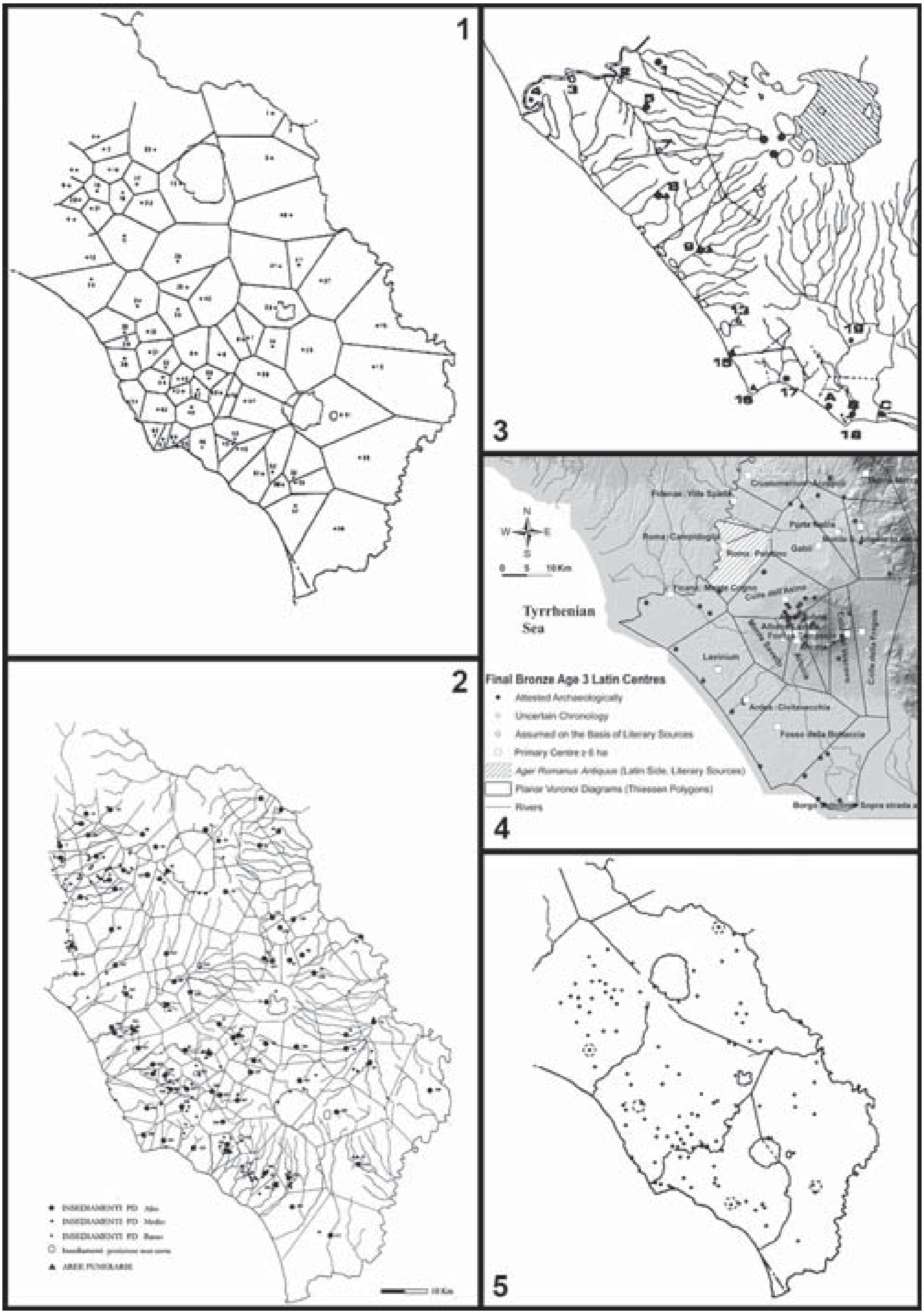


Fig. 1 – Voronoi diagrams applied to Etruria and *Latium Vetus*. *1*, di Gennaro 1982 (FBA); *2*, Barbaro 2010 (FBA); *3*, Pini, Seripa 1986 (FBA3); *4*, Fulminante 2014 (FBA3); *5*, di Gennaro, Guidi 2000 (EIA).

clidean distance." (Okabe *et alii* 2000: 44)

Let $P = \{p_1, p_2, \ldots, p_n\}$ be a set of points in the plane. A Voronoi cell $V(p_i)$ for p_i, is the set of points q in the plane that are closer to p_i than to any other point. That is:

$$V(p_i) = \{q \mid dist(p_i,q) \leq dist(p_j, q), \text{ for } j \neq i\}$$

In the social sciences, Voronoi diagrams (Voronoi 1907, 1908, 1909) are alternatively called Thiessen polygons (Thiessen 1911; De Mers 2000: 305-307). Thiessen polygons have been widely used in archaeology; numerous scholars tried to apply the method to Etruria (Renfrew 1975; di Gennaro 1982; Barbaro 2010) and *Latium Vetus* (Pacciarelli 1986; Pini, Seripa 1986; Arietti 1996; Bouma, van't Lindenhout 1998; Capanna 2005; Fulminante 2014); each facing some inherent limitations (fig. 1):

1. In Voronoi diagrams the rule is that all of the given area has to be assigned to a single point, that is called the generation point. From an archaeological point of view, that means that every single piece of land must fall under the control of one of the settlements, regardless of the distance;
2. To obtain a plausible subdivision of the landscape, the (almost) complete archaeological record should be known. Since this is not always the case, usually the sizes of most of the resulting polygons are overestimated; in fact, the average polygon size varies inversely with point density. The discovery of even a single settlement might therefore greatly change the results. See for example the differences between the coeval diagrams in figure 1;
3. Since a boundary of a Voronoi polygon is always a result of the interaction between two points (it is equidistant from both), the Voronoi polygons remain open along the edges of the studied area, where there are no "second points";
4. It is not possible to establish a hierarchy among the settlements, you necessarily must decide it previously, or anyway set a further "rule". This is the case, for example, in Barbaro 2010, where settlements with higher defensive potential are considered "primary", and in Fulminante 2014, where the generation points are the settlements larger than 4ha (fig.1, *2* and *4*);
5. The distances between q and p_i and are usually calculated without considering the landscape morphology (isotropic surfaces), i.e. as the crow flies;
6. It is a synchronic model: the results obtained for one phase are not influenced by the results for the previous phase.

Multiplicatively Weighted Voronoi diagrams

The Voronoi approach has been modified in order to correct some of these limitations. In particular, a different "weight" has been assigned to any generation point in the plane (that is, in our case, to any single settlement) to modify its behaviour. The new technique is known as Weighted Voronoi diagrams (WVD) and can be subdivided in Multiplicatively, Additively, or Compoundly Weighted VD (Okabe *et alii* 2000). Multiplicatively Weighted Voronoi diagrams have been widely used in archaeology, with weights pro-

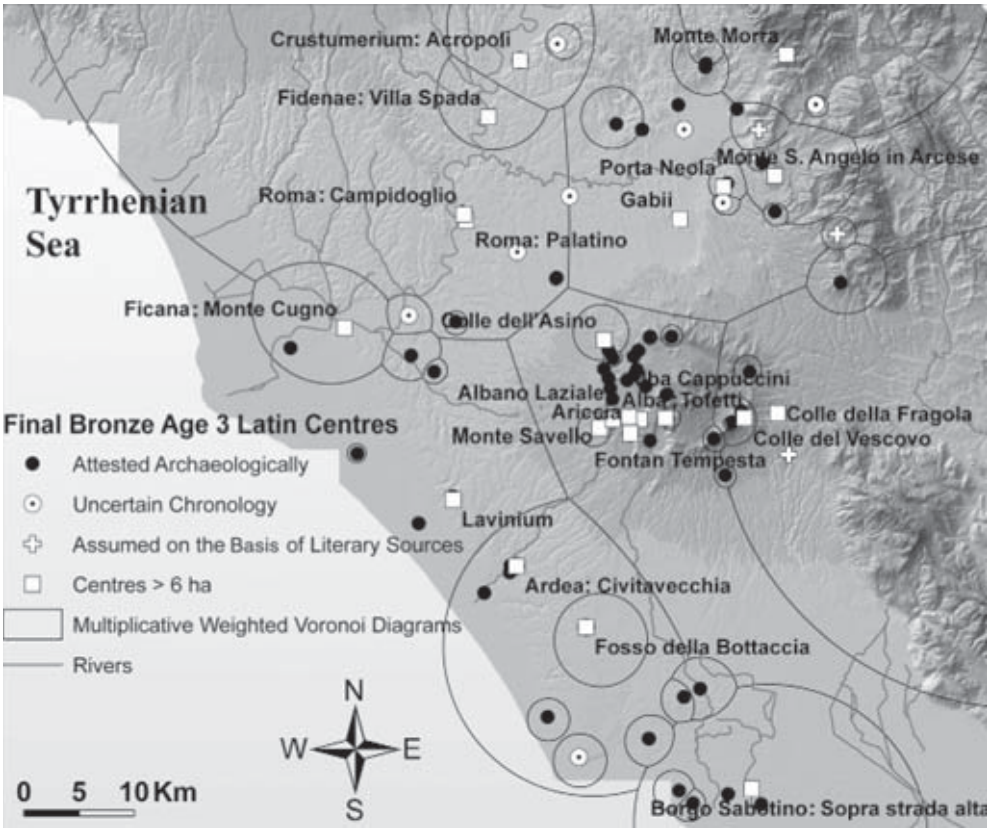


Fig. 2 – Multiplicatively Weighted Voronoi diagrams for *Latium Vetus* (FBA3) (after Fulminante 2014).

vided from settlement size, and have recently been applied to *Latium vetus* (Rajala 2005; Fulminante 2008, 2009, 2014, fig. 2).

Let w be a weight assigned to any single p_i:

$$V(p_i) = \{q \mid dist(p_i,q)/w_i \leq dist(p_j,q)/w_j, \text{ for } j \neq i\}$$

Unlike the Ordinary Voronoi diagrams, in the MWVD some areas (territories) might be enclosed in bigger ones.

However, the MWVD model has some limitations too:

1. In archaeology, the biggest problem of MWVD is the supposed connection between settlement size and political strength and the postulate that the bigger villages might control the smaller ones. Even if this is likely to hold true in most instances, it cannot be taken as axiomatic. Furthermore, establishing the size of a settlement is often very difficult (therefore highly subjective) and very often turns out to be impossible. It should be stressed that changing the settlement size can greatly modify the result;

2. It is not possible to construct territories for group of settlements of the same political strength (federations); either a settlement is alone or it partakes of some hierarchy;
3. As for VD, every single piece of land should fall under the control of one of the settlements, regardless of the distance. No unassigned areas are possible;
4. As for VD, some polygons remain open along the edges of the studied area;
5. To my knowledge, no MWVD based on anisotropic surfaces has been realized yet, so the landscape morphology has never been considered (isotropic surfaces);
6. As for VD, it is a synchronic model: the results obtained for one phase are not influenced by the results for the previous phase;
7. Limited efforts have been made to bring MWVD into GIS for practical use. To my knowledge, only three programs are able to make diagrams that can be used in a GIS environment: Gambini software (Gambini 1966; Tiefelsdorf, Boots 1997; used by Rajala 2005), WVD18 and MWVD_Shape 1.0 (Mu 2004; the latter used by Fulminante 2014) and an ArcGIS extension called Weighted Voronoi (Dong 2008). Each of these produces different results, since they use different implementations of the original algorithm.

XTENT model

The XTENT model was introduced in the 1970s by Colin Renfrew and Eric Level. When considering the size of settlements as a measure of their political strength, it assumes that the "influence of a settlement is proportional to a function of its size and declines linearly with distance"(Renfrew, Level 1979: 149):

$I = f(C) - kd$
with $I \geq 0$

Let $P = \{p_1, p_2, \ldots, p_n\}$ be a set of points in the plane; I is a measure of the influence of the settlement at point p_1, C is the settlement size, d is the distance between the settlement and p_1, k is a constant. Each point p_n is assigned to the settlement with the highest I in that place.

In the original paper, Renfrew and Level already pointed out the difficulty of assigning the 'correct' values to f and k. In literature, the f(C) is usually expressed as C^a, with a=0,5. Bigger 'a' values foster the domination of the major settlements; conversely smaller values lead to more autonomous centres. According to Renfrew and Level, changes in the value of k might be used to simulate the passage of time: if k decreases (thus k becomes a further variable) the influence of the bigger settlements increase. Thus, if the value of k continues to decline, a progressive increase in the influence of a few bigger settlements can be introduced into the model. David Redhouse and Simon Stoddart used this idea to simulate the development of the territories in Northern Lazio and Southern Umbria (Redhouse, Stoddart 2011). They use for k a range of values from 0,1 to 0,014, simulating a progressive expansion of some centres, for example Veio, Orvieto and Vulci (fig. 3). However, as James Conolly and Mark Lake (2006: 213) noted, referring to XTENT: "There are, however, very few applications [of the XTENT model] beyond their trial formulation, largely because of

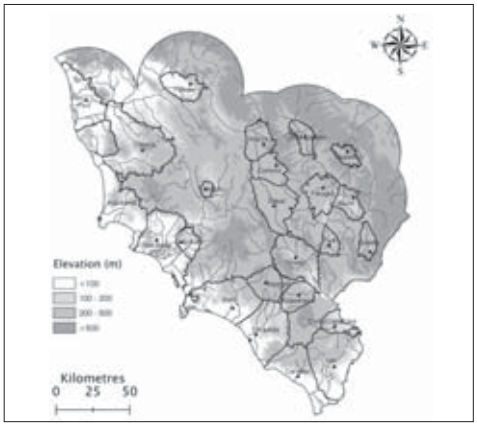
the acknowledged subjectivity in determining the value of the constant that determines whether territories are likely to be more or less autonomous".

Nevertheless, the XTENT model, especially when the distances are expressed in travel time (Ducke, Kroefges 2008; Redhouse, Stoddart 2011), constitutes a considerably more refined methodology than VD models and is much more similar to MWVD. The limitations of the XTENT model are:

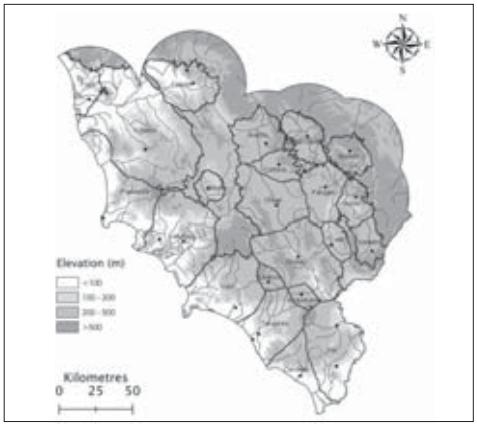
1. As for MWVD, establishing the size of a settlement, which usually provides the value of C, is often very difficult or even impossible;
2. As for MWVD, it is not possible to construct territories for federations of same size settlements. Either a settlement is alone or it partakes of some hierarchy;
3. The subjectivity in determining the value of k;
4. It is a synchronic model: the results obtained for one phase are not influenced by the results for the previous phase.

A NEW APPROACH: THE BUBBLE MODEL

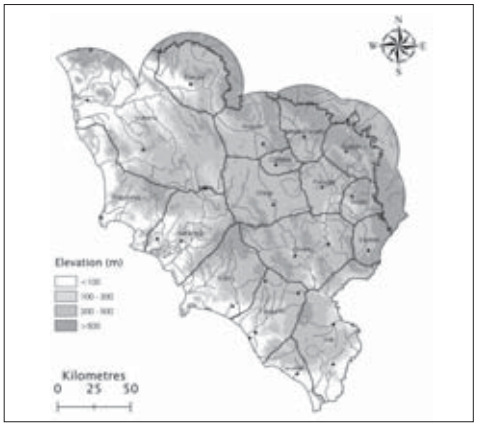
The Bubble Model has recently been applied in the *Latium Vetus* area (Alessandri 2013). There is only one parameter: the maximum distance within which it is likely that a settlement can deploy an effective influence (maximum distance of influence = mdi). This distance must be calculated in travel time on an anisotropic surface. A settlement territory includes all areas that can be reached by expending less than mdi; in other words, it is the circle with the settlement as the centre and mdi as the radius. It must be under-



K = 0.055



K = 0.03



K = 0.016

Fig. 3 – XTENT models for Etruria, 900-600 BCE (after Stoddart 2011).

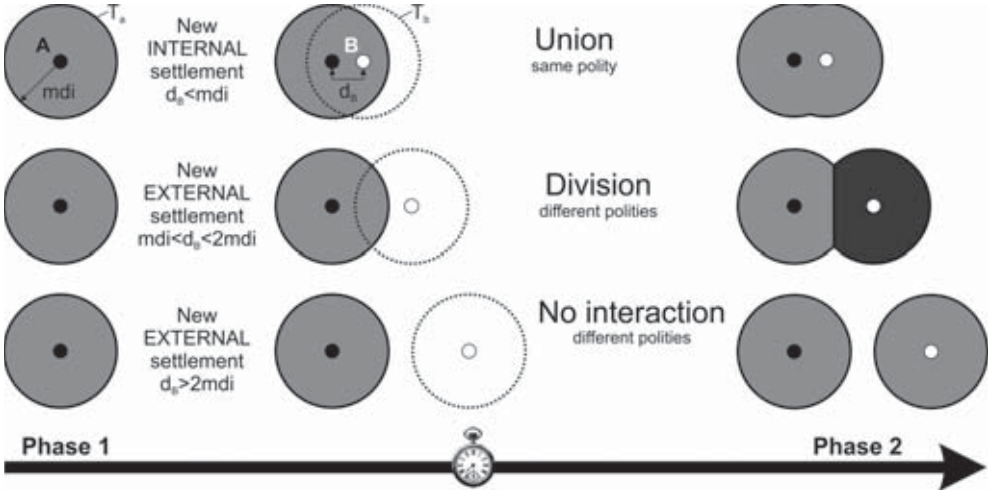


Fig. 4 – Bubble Model, the rules to analyse the evolution of the territories over time.

lined that the value of mdi should not be assumed, but has to be established empirically for each case (see the case study below for an example).

Once the territory of a settlement has been reconstructed, it is possible to introduce some rules to analyse its evolution over time, in a diachronic perspective.

Let A and B be two points (settlements) in a given plane, T_a the space associated to A (territory of settlement A), d_B the distance between A and B, mdi the maximum distance of influence; then, passing from one phase to the next, three circumstances might occur (fig. 4).

1. Settlement B is born inside T_a, at a distance $d_B \leq$ mdi. In this case both territories merge into a single polity;
2. Settlement B is born outside T_a, at a distance mdi$<d_B<$2mdi. Where the two territories overlap, the boundary is the line equidistant from A and B;
3. Settlement B is born outside T_a, at a distance $d_B>$2mdi. In this case T_a does not change.

Limitations

1. The major limitation is the accuracy in determining the maximum distance of influence (mdi). This value can depend on many factors. For example, if we consider the capacity to exploit the surrounding territory as a good approximation of the term 'influence', then we can use the average territorial radius for cereal farming economies (if applicable) suggested by the Cambridge palaeo-economy group in the 1970s (Vita-Finzi, Higgs 1970). But usually the most important parameter is the presence of a second settlement in the surroundings, which can be used as a measure of the influence of the first;
2. It is possible that mdi might change in different areas or periods;
3. A second issue relates to the function of the settlements. Special purpose sites (e.g. for salt production) probably do not have any political strength, and thus no autonomous territory. Since it is very often difficult to de-

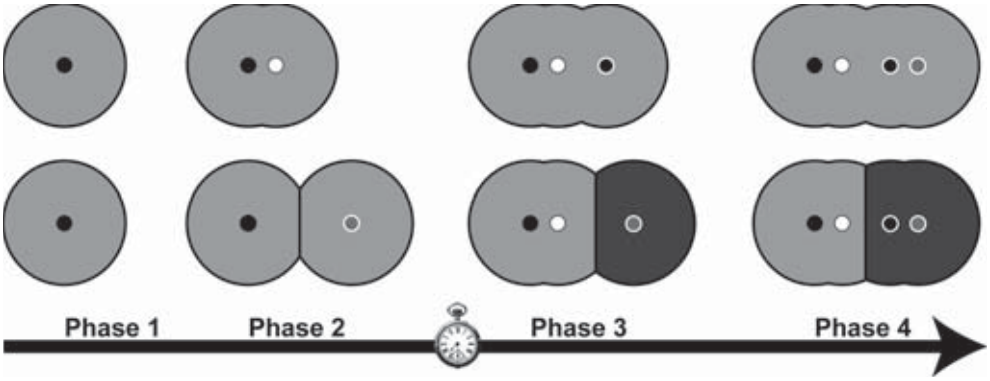


Fig. 5 – Hypothetical application of the Bubble Model. The reconstruction of the territories depends on the order of appearance of the settlements.

termine the function of a settlement, it is not always possible to exclude them from the model;

4. Of course, when trying to identify hierarchical relationships, the Bubble Model shares with all the other models the problem of determining the political strength parameter(s).

Differences with previous models

1. The Bubble Model is a diachronic model. This is a first big difference with the already discussed MWVD and XTENT: without changing the parameter (mdi), the reconstructions of the territories depend on the order of appearance of the settlements (fig. 5);
2. Furthermore, since more than one settlement can share a territory, and no other parameters than mdi have been used in the model, all such polities are supposed to be federative. Afterwards, it is possible to detect (or not) a hierarchy choosing a parameter (for example, size, antiquity or defensive potential) or a combination of them. It

CHARACTERISTICS	VD	MWVD	XTENT	BUBBLE
Existence of unassigned areas			●	●
Strongly depends upon the completeness of the archaeological record (settlements)	●	●		
Along the edge of the studied area, some polygons (territories) remain open			●	●
Hierarchy polities can be detected		●	●	●*
Federations can be detected				●
Anisotropic surfaces can be used	●	?	●	●
Synchronic model	●	●	●	●
Diachronic model				●

* to be evaluated on parameters external to the model

Tab. 1 – Synthetises the characteristics of each model.

is a central tenet of this approach that hierarchical relationships should be inferred *after* the reconstruction of the territories. This is a big difference with MWVD and XTENT, in which the hierarchical relationships between settlements, even if based on the same parameters, are based on *a priori* assumptions about the major settlements. In other words, in MWVD and XTENT the strength parameters change the behaviour of the model, in the Bubble Model they do not.

HOW TO DETERMINE THE CONTEMPORANEITY OF THE SETTLEMENTS - THE MINIMUM NUMBER OF CONTEMPORARY SETTLEMENTS

It is quite common to observe, in detailed regional studies, relatively simple charts showing the increasing (or decreasing) number of settlements for each chronological phase. From these charts, maps are created for different historical moments. But actually we cannot be certain of the contemporaneity of all settlements. Besides, it is possible (or likely?) that the increasing or decreasing number of settlements is partially altered, especially for the longer phases. To better understand the settlement pattern development, it is therefore useful to introduce the concept of Minimum number of Contemporary Settlements (MCS).

Definitions of terms that will be used:

1. *Phase*: the shortest chronological interval that can be discerned on the basis of ceramic (or metal, where available) analysis, for the complete study area;
2. *Duration of settlement*: the chronological interval between the first and the last dated artefact found in the settlement;
3. *Position of settlement*: the settlement position on the timeline with respect to the phases.

If we consider a phase (e.g. phase number 2), then we are able to observe three settlement positions:

Type A. Single-phase: the *duration* is smaller than that of phase 2; the *position* is unclear but inside the phase;

Type B. Including previous (B1) or following (B2) phases: the *duration* is equal to or smaller than the sum of the phases 1+2 or 2+3;the *position* is partially clear;

Type C. Including both previous and following phases: the *duration* is bigger than phase 2 and smaller than the sum of the three phases (2<duration<1+2+3);the *position* is partially clear.

As far as the contemporaneity is concerned, a limited number of scenarios are possible (fig. 6):

1. *Type A with type A*: it is never possible to establish the relative positions. In other words: for any number of single-phase settlements, it is not possible to determine their contemporaneity. Besides, the reality is placed somewhere in between the case 1 and the case 2 in figure 6;
2. *Type A with type B*: it is never possible to establish contemporaneity between settlements with a single phase (A) and others with previous or following phases (B1 or B2). The reality must be placed somewhere in between the case 1 and the case 2 in figure 6;
3. *Type A with type C*: it is always possible to establish the contemporaneity between single-phase settlements (A) and others with previous and following phases (C). The MCS will be the sum of C-type settlements plus one, since the reality must be placed some-

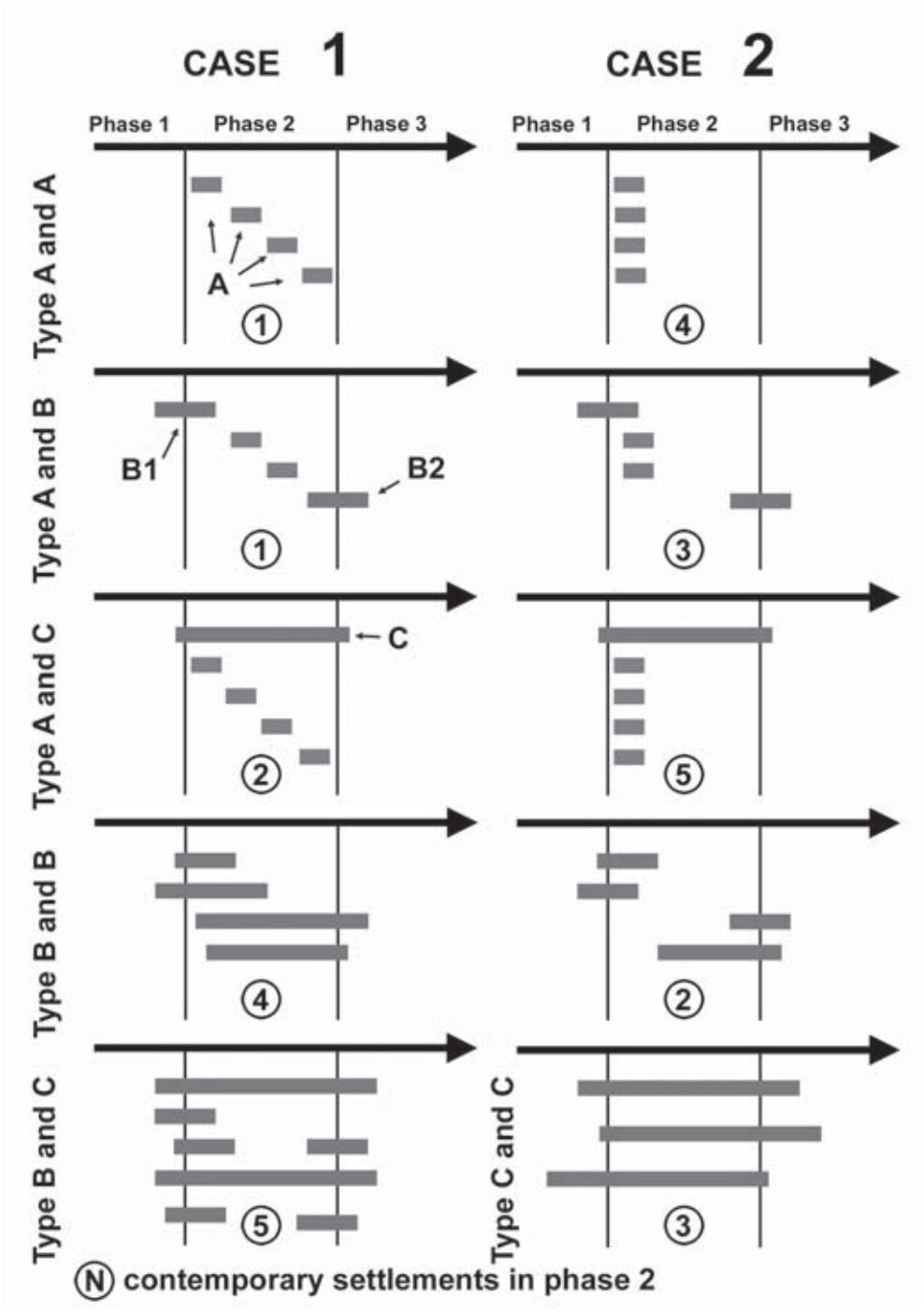


Fig. 6 – The contemporaneity between different types of settlements.

where in between the case 1 and the case 2 in figure 6;

4. *Type B with type B*:it is always possible to establish contemporaneity among settlements with the same two subsequent phases. It is never possible to establish contemporaneity between settlements that share only one phase (between B1 and B2 in figure 6). The MCS is the larger of the sum ofthe B1-type and the B2-type settlements;
5. *Type B with type C*: it is always possible to establish contemporaneity between settlements with previous or following phases (B1 or B2) and settlements with previous and following phases (C). In this case, the MCS is the sum of C-type settlements plus the larger of the sums of B1-type and the B2-type settlements;
6. *Type C with type C*: it is always possible to establish contemporaneity among C-type settlements.

Synthesizing, the contemporaneity can be established:

Settlement positions	A-type	B1-type	B2-type	C-type
A-type	No	No	No	Yes
B1-type	No	Yes	No	Yes
B2-type	No	No	Yes	Yes
C-type	Yes	Yes	Yes	Yes

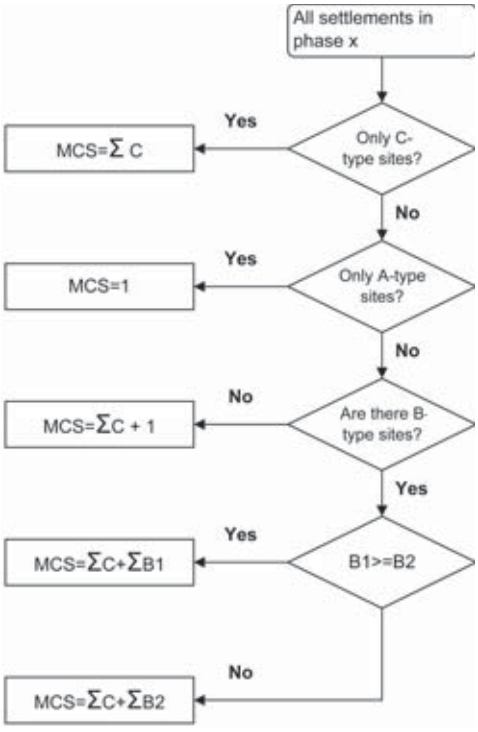


Fig. 7 – How to calculate the MCS inside the phases.

Given these facts, there are two ways to calculate the MCS:

Keeping the phase by phase approach, it is possible to use a (somewhat complex), algorithm (fig. 7). Alternatively, slightly changing the perspective, it is possible to count only the settlements that include materials of any two subsequent phases (fig. 8) which must necessarily be contemporary. In this case, the settlement map of the MCS crossing the phases 1/2 boundary will show only the settlements with archaeological materials from both phase 1 and phase 2. Thus the map does not represent a period of time, but a moment in time. Actually, to be more realistic, this moment could be approximated to the time frame in which phase 1 materials are completely replaced with phase 2 ones. Especially when reconstructing territories, this represents a safe datum, even if, of course, a contemporaneity with other settlements (with only phase 1 or only phase 2 materials)

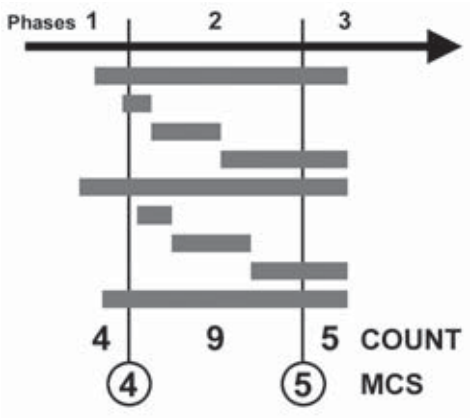


Fig. 8 – The difference between the simple phase count of settlements and the MCS.

could not be excluded. In the following case study I will use this second approach.

A CASE STUDY - *LATIUM VETUS* AND SOUTHERN ETRURIA

Data and methodology

The test area is a portion of the so-called *Latium Vetus*, from the Tiber River to the Astura River and including the Alban Hills, plus a portion of Southern Etruria, from the Tiber to the Mignone River including the Bracciano Lake and part of the Sabatini Mountains. The anisotropic cost surface is only based on the orography. A Digital Elevation Model with a horizontal grid spacing of 20 meters has been used. Only for the *Latium Vetus*, the coastline and the ancient lakes have been reconstructed, based on Alessandri 2013. No other parameters have been used, such as rivers or marshes. Indeed, further developments of the model could take these factors into account.

All distances are walking time distances calculated by means of the Naismith and Langmuir rule, which takes into account only the orography (Naismith 1892; Langmuir 1984). This rule has been applied using the Path Distance function of ArcGIS.

All data used are relative to settlement finds. For the positioning of the settlements, their chronology and characteristics, some existing repertories and lists have been used. For Etruria, the following repertories, resulting both from surveys and excavations, have been used: for the RBA, Damiani 2010; for the FBA, Barbaro 2010; for the other phases (EBA, MBA, EIA1), di Gennaro 2006; Belardelli *et alii* 2007; di Gennaro, Barbaro 2008*b*. For *Latium vetus*, data are taken from the analytical review of the evidence in Alessandri 2013. The interpretation as settlements is given by the authors.

Only the settlements with an assigned certain chronology (i.e. without uncertainties, question marks etc.) have been plotted, with the following exceptions. In La Tolfa and Caolino del Fosso Eri the RBA phase has been assumed, since they both have the MBA3 and the FBA1-2 phases; in Castellina del Marangone, the FBA1-2 has been assumed, since the settlement has both the RBA and the FBA3. For the Early Iron Age, in *Latium Vetus* only Roma-Colli Albani (RMCA) IIA settlements have been considered, and for Etruria the Early Iron Age 1. See figure 9 for the adopted chronological scheme (Pacciarelli 2000; van der Plicht *et alii* 2009).

In Etruria, the defensive potential (PD) of the settlements is based on the list published by di Gennaro and Barbaro (2008*b*). For the twelve settlements

Early Bronze Age	2300-1700 BCE
Middle Bronze Age 1-2	1700-1400 BCE
Middle Bronze Age 3	1400-1325/1300 BCE
Recent Bronze Age	1325/1300-1175/1150 BCE
Final Bronze Age 1-2	1175/1150-1050 BCE
Final Bronze Age 3 (Roma-Colli Albani I)	1050-950 BCE
Early Iron Age 1 (Roma Colli Albani IIA)	950-880 BCE

Fig. 9 – The Bronze Age and the Early Iron Age phases in Central Tyrrhenian Italy, chronological scheme.

that are not in the list, the PD has been assigned by the author, following the same criteria.

The chronological maps are based on the contemporary settlements, as determined by the MCS method; therefore they do not represent the phases themselves but the transitions between them. Single-phase settlements have been plotted too, but with a different symbol (white symbols). Territories will be reconstructed by means of the Bubble Model described above.

Status quaestionis

From the Early Bronze Age to the Iron Age, some trends in the settlement patterns have already been detected, especially in Southern Etruria (Pacciarelli 1982, 2010; di Gennaro, Peroni 1986; Guidi 1992; Peroni 1996; Carandini 1997; Guidi 2006, 2010; di Gennaro, Guidi 2010; Barbaro 2010).

1. *Stabilization*: a gradual increase in the duration of the settlements, all over Italy;
2. *Selection and concentration*: a decreasing number of settlements, but an overall increase in the total size, combined with a gradual preference for places that can be more easily defended;
3. *Proto-urban centres*: large settlements of between 126 to 190ha in size, start to develop between FBA3 and EIA1 in Southern Etruria, whereas the earlier settlements, between 1 and 5 ha, mostly disappear. In *Latium Vetus*, only some settlements seem to enlarge the settled area between FBA3 and EIA1 (Pratica di Mare and Ardea), while the proto-urban phase of Rome coincides with the displacement of the Forum necropolis to the Esquiline hill, at the end of phase RMCA IIA.

It should be stressed that points 1 and 2 were first hypothesized or Southern Etruria (di Gennaro, Peroni 1986). Afterwards, similar trends have been suggested for most of Italy, however with local and significant exceptions.

Determination of mdi (maximum distance of influence)

In order, to apply the Bubble Model we first have to determine the mdi. In the case under discussion, it is possible to use the average distance between the contemporary settlements (MCS), at the transition between the EBA and MBA1-2. This has been calculated for the Tolfa Mountains, in which several studies(systematic surveys and occasional discoveries; di Gennaro 1990) have been conducted. The distances between two settlements have been calculated as half the time needed for a return trip. Some very near settlements are considered to be part of the same polity (group 1: Bufalareccia,

Bufalareccia q77 and Fosso del Laghetto, 11 minutes on average; group 2: La Sughera and La Tolfa, 18 minutes). The average distance between settlements turned out to be 106 minutes (fig. 10), which corresponds to a territory radius of 53 minutes. This value (adjusted to 50 minutes) will be applied to the whole of the study area, and is very close to the maximum radius of daily exploitation already proposed for Site Catchment Analysis (Vita-Finzi, Higgs 1970). Moreover, 5-kilometer radius territories, corresponding to around 60 minutes in flat terrain, have been hypothesized in different scenarios and constitute one of Bintliff's 'settlement quanta' (Bintliff 1999). For Southern Etruria, in the FBA, Barbaro proposed the presence of some 'micro-systems', composed of one major settlement, some minor villages in the surroundings, and one or more necropoleis. Using a different approach, she equated the radius of the territory of the major settlement to the maximum distance recorded between a settlement and its necropolis. This radius turns out to be 2500m, or around 30 minutes walking time, in flat terrain. However, she allows the possibility that other minor villages outside this radius still belong to the same micro-system (Barbaro 2010: 45).

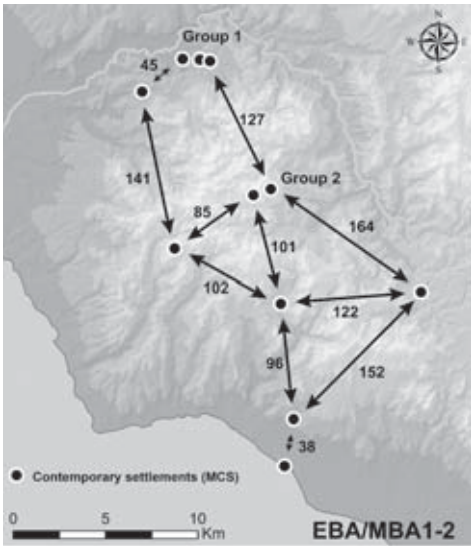


Fig. 10 – The walking time distances (minutes) between the contemporary settlements in the Tolfa Mountains (EBA/MBA1-2).

From the Early Bronze Age to the Final Bronze Age: hierarchical and federative polities

M. Pacciarelli already noticed the presence, in the Bagni di Stigliano area (in the Tolfa Mountains area), of a large-meshed net of larger and more defensible MBA settlements together with a small-meshed net of smaller and not much defensible ones, that are very often located in good agriculture landscapes (Pacciarelli 2000, 2010). A similar situation has been reported for the Vesca Valley (Cifarelli, di Gennaro 1993) and F. di Gennaro already proposed the presence, at least since the EBA, of settlement systems composed by primary and secondary villages (di Gennaro 2000). Indeed, the EBA/MBA1-2 MCS map (fig. 11) shows some quite regular patterns especially in the Tolfa Mountains area. Here, from EBA to MBA1-2, all the single-phase settlements are just inside the polities of the contemporary sites (defined by MCS) with only two EBA exceptions which, however, are located only a few minutes outside are constructed territory. To detect hierarchical polities in this case, we can use both the duration and the defensive potential of the settlements. The significance of the latter in the devel-

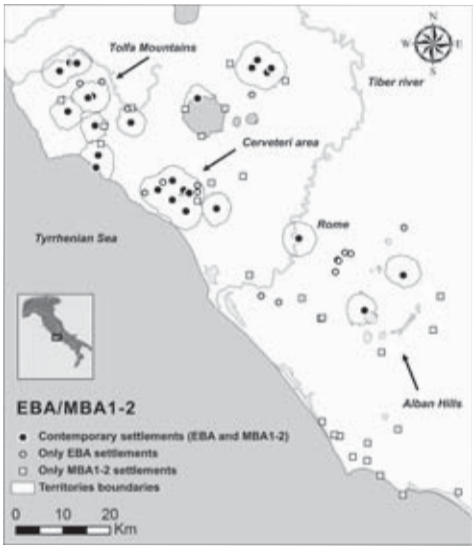


Fig. 11 – The reconstruction of the territories of the contemporary settlements, between EBA and MBA1-2. The single-phase settlements have been plotted too.

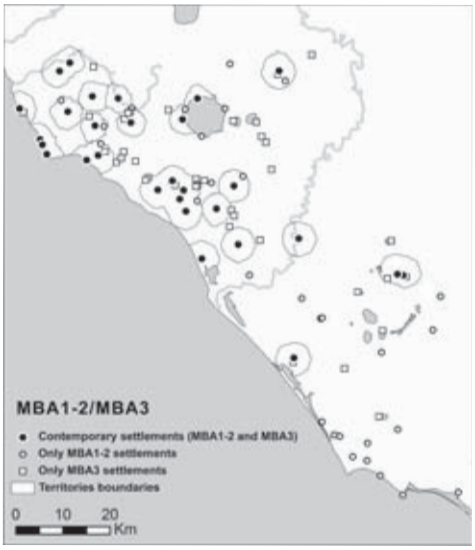


Fig. 12 – The reconstruction of the territories of the contemporary settlements, between MBA1-2 and MBA3. The single-phase settlements have been plotted too.

opment of the landscape of Etruria has been widely explored and a general increase in defensive potential has been detected, starting from the EBA (di Gennaro 2000; Schiappelli 2003, 2008; di Gennaro, Barbaro 2008*a*).

In the Tolfa Mountains area, from the EBA to FBA3 (figs. 11, 12, 14-16), in most cases a single major settlement (for both duration and defensive potential) shares its territory with minor villages (fig. 13; it must be recalled here that the contemporaneity is 'certain' only among the MCS settlements, i.e. black symbols, and uncertain with the single-phase settlements, i.e. white symbols). This configuration indicates the existence of hierarchical systems.

More to the south, in the Cerveteri area, the contemporary settlements are located at an average distance of 51minutes walking. Tracing the 50-minute radius around them, we are able to reconstruct a very large polycentric polity, from the EBA to FBA1-2.Contrary to what happens in the Tolfa Mountains, no settlement in this polity stands out for both its duration and defensive potential. This configuration points to a federative system.

However, it should be clear that even in a federative polity, minor settlements coexist with major ones. The two clusters of single-phase settlements that appear near the polity boundary in MBA3 (fig. 12) might be considered minor villages (with specific functions?).

It is noteworthy that, both in the federative and in the hierarchical polities, the single-phase settlements are quite often located in the proximity of the territory boundaries. Considering that many scholars have already suggested for these periods a subsistence economy partially based on shifting cultivation (Bietti Sestieri, Gianni 1988; Piercy

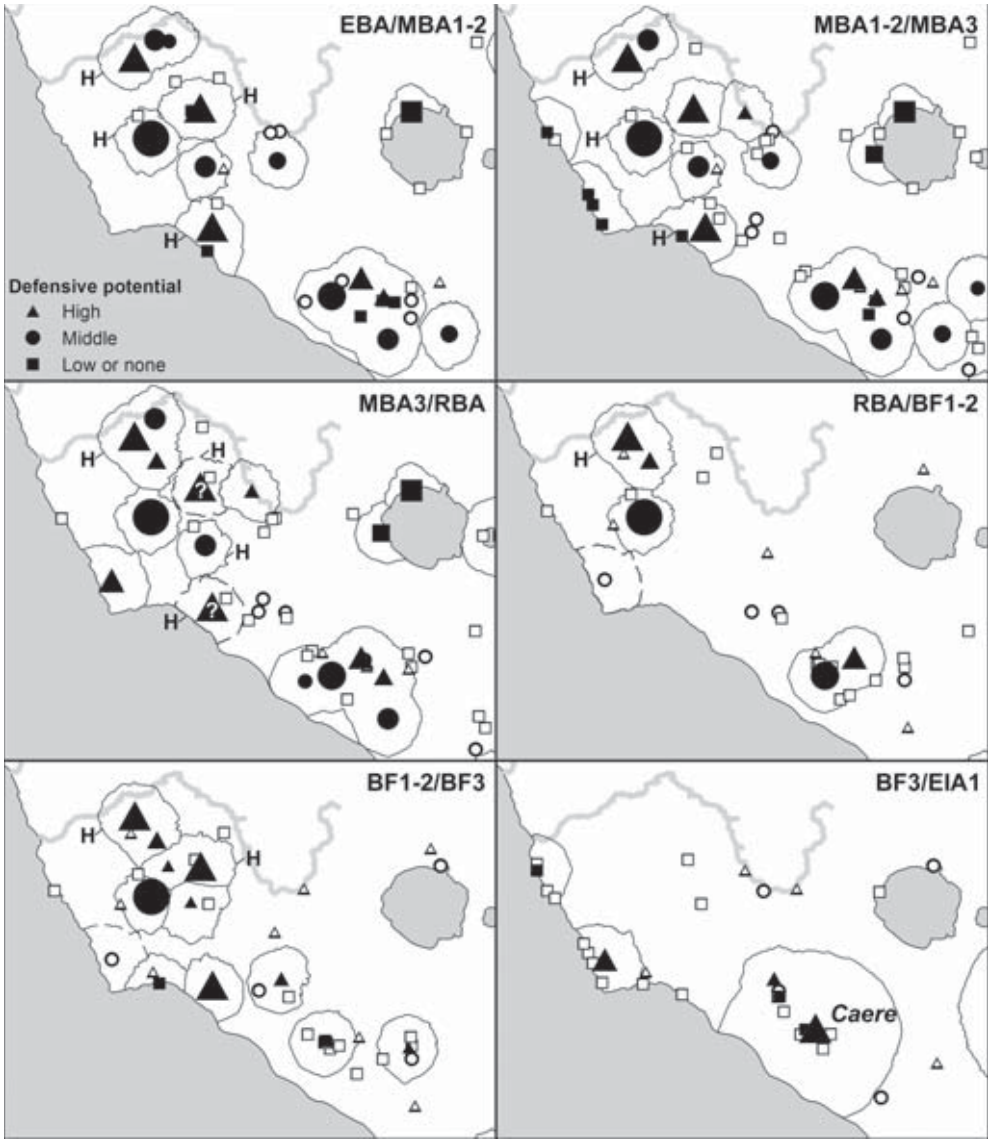


Fig. 13 – The development of the settlement systems in the Tolfa area, between EBA and EIA1. Symbol shapes indicate the defensive potential, symbol sizes are proportional to the overall duration; black symbols, MCS settlements; white symbols, single phase settlements; H, hierarchical polity.

Evans 1988; Gianni 1991; Alessandri 2013), it is possible that at least a portion of the smaller single-phase settlements would have moved around in search of fresh terrain not impoverished by agricultural use.

In *Latium Vetus*, data for the beginning of the Bronze Age are quite rare.

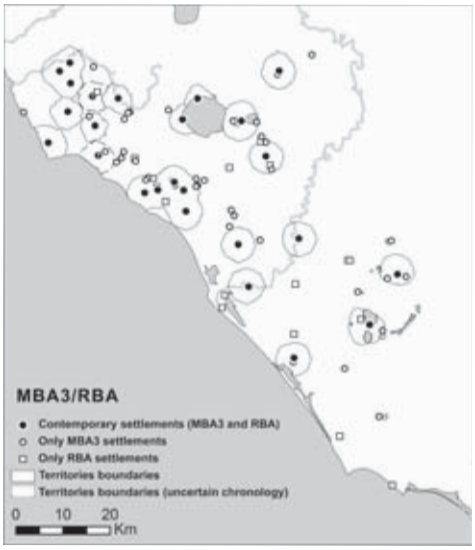


Fig. 14 – The reconstruction of the territories of the contemporary settlements, between MBA3 and RBA. The single-phase settlements have been plotted too.

Fig. 15 – The reconstruction of the territories of the contemporary settlements, between RBA and FBA1-2. The single-phase settlements have been plotted too.

However, from the Recent Bronze Age onwards, a 50-minute territory radius seems to fit very well with the settlement patterns (fig. 15). In the FBA3 some "older settlements, undoubtedly stable, are surrounded by other villages of less importance that are founded and abandoned in a much shorter time" (Alessandri 2013: 51, where a radius of 60-minute had been); most of the older settlements dated from the MBA. Moreover, federative polities appear since MBA1-2, in the Colonna area (fig. 12).

The transition from the Final Bronze Age to the Early Iron Age: the proto-urban centres

In Southern Etruria, the transition between FBA3 and EIA1 is marked by the rapid birth of the first proto-urban centres (early states). These are characterized by a radical change in size (Veii, 185ha; Caere 160ha) with respect to the FBA3 settlements (size between 1 and 5ha). At the same time, the large majority of the latteris abandoned (di Gennaro 1982; di Gennaro, Peroni 1986; Pacciarelli 1991, 2000, 2010; di Gennaro, Guidi 2000; Guidi 2006). Also in the coastal part of *Latium Vetus*, both Ardea and Pratica di Mare enlarge their size to respectively 41ha and 30ha (Modica 2007; di Gennaro, Guidi 2000). In Rome, at the end of the RMCA IIA phase, the use of the Forum area as a necropolis comes to a stop and, at the same time, the evidence for the start of the farther Esquiline necropolis becomes abundant. Some scholars have already connected this development to an enlargement of the inhabited area, which has been calculated to be in the range of 67-205ha (Müller-Karpe 1962; Guidi 1982; Bettelli 1997; Guidi 2006, 150ha; Carandini 2007, 205ha; Alessandri 2013, from 67 to 150ha). The identification of the proto-

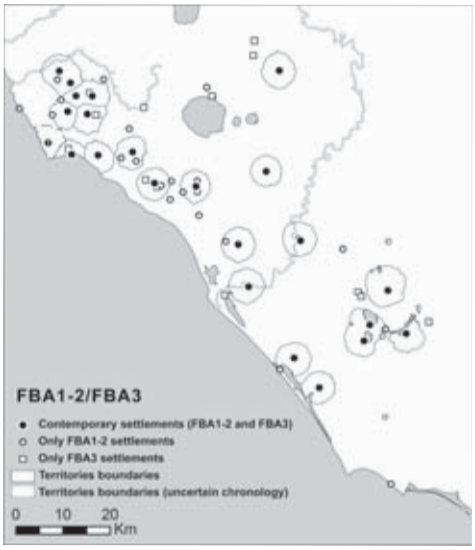


Fig. 16 – The reconstruction of the territories of the contemporary settlements, between FBA1-2 and FBA3. The single-phase settlements have been plotted too.

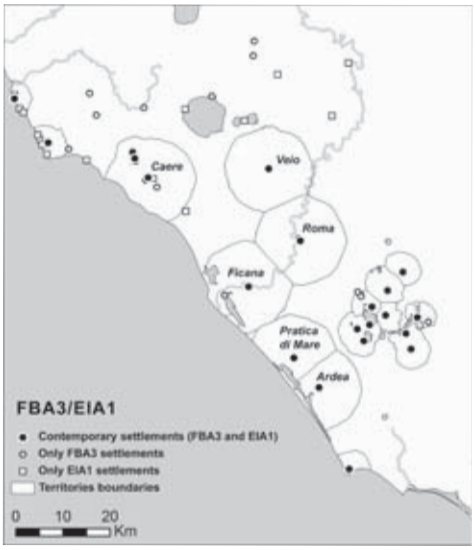


Fig. 17 – The reconstruction of the territories of the contemporary settlements, between FBA3 and EIA. The single-phase settlements have been plotted too.

urban phase at Ficana is more problematic: even if it is continuously occupied since the MBA3, its settled area seems to enlarge only in the VII century BCE. However, the overall magnitude of the phenomena might justify a recalculation of the territory radius, at least among the proto-urban settlements. The average walking distance between Caere, Veii and Rome is 146 minutes; if we take into account also Pratica di Mare and Ficana, it becomes 135 minutes. The only exception to this scheme is the distance of about one hour between Ardea and Pratica di Mare; since these two already coexist before EIA1, it is possible that they were unable to extend their borders at the expense of each other.

For Southern Etruria a similar radius (7-10km) for the territories of proto-urban settlements has already been proposed by Rendeli (1991). Using a slightly different argument, a territorial radius of 132 minutes has been reconstructed for Rome from FBA1-2 to EIA1, on the assumption that a number of small settlements were located along its boundary, thus marking its territory (Alessandri 2013: 40 and fig. 1.30). Moreover, it seems that, at least at the beginning of the EIA1, Rome, Veii and Caere coexisted with some other smaller settlements with their own territories (fig. 17). This result would confirm the gradual increase in the size of proto-urban territories, developing during EIA1, as opposed to the theory of an immediate and complete control of the landscape as depicted in some Thiessen-based maps. If this hypothesis turns out to be true, the provenance of the first settlers from very distant districts such as the Sabatini and Cimini Mountains, as has been suggested in the case of Veii (di Gennaro 2012: 45), becomes questionable.

Stabilization, selection and concentration

A few more observations can be made by observing changes in the MCS overtime. Assuming a territorial model partially based on shifting villages, the misleading nature of the simple phase count of settlements becomes clear. In Etruria (fig. 18) the decreasing number of the settlements might partially be due to a gradual process of stabilization of the minor villages (fig. 19). In all Italy, a similar trend has been already hypothesized and related to the spread and diffusion, from the EBA to the FBA, of some capital intensive form of subsistence technologies (Gilman *et alii* 1981) such as olive domestication and oil production, animal powered plough use and salt production (di Gennaro, Peroni 1986; Guidi 1992; Mandolesi 1999; Pacciarelli 2000; Alessandri 2013). Although, in Etruria a process of settlement concentration it is undeniable, using the MCS it appears to be much more gradual: in about one millennium, from EBA/MBA1-2 to FBA12/FBA3 the contemporary settlements drop from 24 to 13. That also means that the nucleation process on

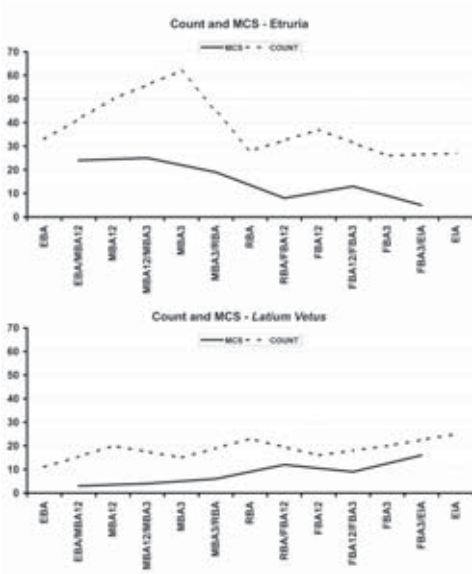


Fig. 18 – The MCS compared with the simple phase count of settlements for Etruria and *Latium Vetus*, from the EBA to the EIA.

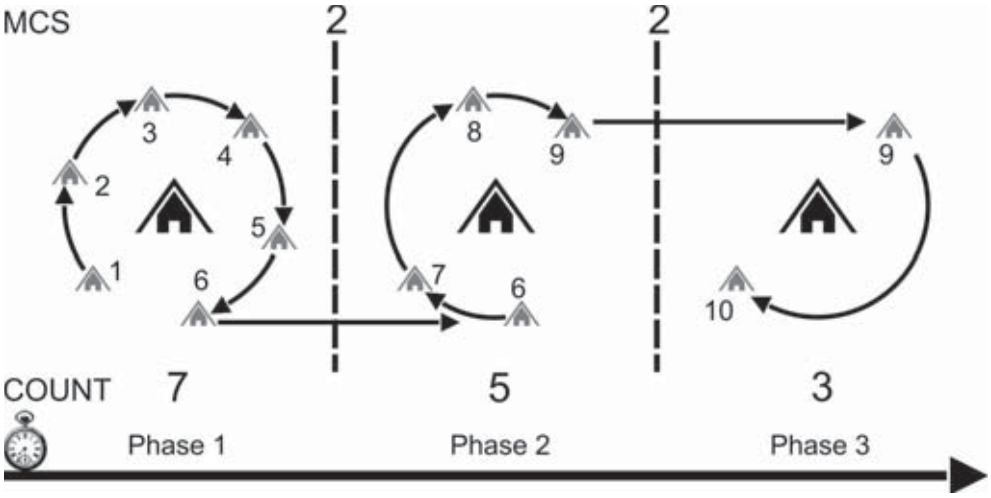


Fig. 19 – The effect of one shifting village (grey hut) on both the MCS and the simple phase count of settlements. 1 to 10, subsequentmoments inside the phases; black hut, stable settlement.

the Caere and Veii plateaus must have been very rapid.

The overall picture for *Latium Vetus* is different. Here the MCS is a precise mirror image of that of Etruria and shows a continuous increase from EBA, with the exception of a slight decrease between FBA1-2 and FBA3. This confirms that no concentration processes are detectable in *Latium Vetus*.

SYNTHESIS

Using the MCS and Bubble Model methods together it was possible to make some observations:

1. In the Tolfa Mountains area it is possible to hypothesize hierarchical polities from EBA to FBA3. Whereas, in the Cerveteri area only federative polities seem to exist from EBA till FBA1-2;
2. Both in Etruria and *Latium Vetus*, in the Bronze Age, the major settlements are regularly distributed at about 100/120 minutes walking time distance, resulting in territories of 50/60 minutes radius;
3. It seems that at the beginning of the EIA1, proto-urban settlements control only a portion of the surrounding landscape, probably to around 132 minutes walking distance (mdi);
4. In Etruria, selection and concentration appear to be very slow processes, as opposed to the rapid nucleation on the proto-urban plateau between FBA3 and EIA.

FUTURE RESEARCH

Small scale landscape reconstructions are necessary to better understand the settlement patterns and to simulate the walking time, and a similar small scale reconstruction of the ancient roads would be of extreme interest. In fact, the incorporation of other parameters (e.g. ancient rivers and lakes) should make the model much more realistic. Moreover, the boundaries of the territories could be tested against other features, like necropolis or hoards.

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BIBLIOGRAPHY

ALESSANDRI L. 2013 - *Latium Vetus in the Bronze Age and Early Iron Age / Il Latium Vetus nell'Età del Bronzo e nella Prima Età del Ferro*, BAR International Series, 2565, Oxford.

ARIETTI F. 1996 - Gli Albani e il loro territorio nell'VIII e VII Secolo a. C., in *Alba Longa, Mito Storia Archeologia*, Pasqualini A. eds., Roma: 29-48.

BARBARO B. 2010 - *Insediamenti, Aree Fu-*

nerarie ed Entità Territoriali in Etruria Meridionale nel Bronzo Finale, All'Insegna del Giglio: Firenze.

BELARDELLI C., ANGLE M., DI GENNARO F., TRUCCOF. eds. 2007 - *Repertorio dei Siti Protostorici del Lazio. Province di Roma, Viterbo e Frosinone*, All'Insegna del Giglio: Firenze.

BETTELLI M. 1997 - *Roma, la città prima della città: i tempi di una nascita. La cronologia delle sepolture ad inumazione di Roma e del Lazio nella prima età del ferro*, L'Erma di Bretschneider: Roma.

BIETTI SESTIERI A.M., GIANNI A. 1988 - L'Eneolitico recente - I età del Bronzo nel territorio di Roma, *Rassegna di Archeologia* 7: 578-80.

BINTLIFF J.L. 1999 - Settlement and Territory, in *The Routledge Companion Encyclopedia of Archaeology,* Barker G., Grant A. eds., Routledge, London: 505-45.

BOUMA J.W., VAN'T LINDENHOUT E. 1998 - Light in Dark Age Latium. Evidence from Settlements and Cult Places, *Caeculus* III: 91-102.

CAPANNA M. C. 2005 - Dall'ager Antiquus alle espansioni di Roma in età regia, in *Workshop di Archeologia classica. Paesaggi, costruzioni, reperti*, 2, Carandini A., Greco E. eds., Fabrizio Serra Editore, Pisa: 173-88.

CARANDINI A. 1997 - *La Nascita di Roma: Dèi, Lari, Eroi e Uomini all'alba di una Civiltà*, Einaudi: Torino.

– 2007 - *Roma: il primo giorno*, Laterza: Bari.

CIFARELLI F.M., di GENNARO F. 1993 - I Bacini della Paternale e della Vesca nella Preistoria: Informazioni sullo Sviluppo del Territorio della Tuscia dallo Studio dei Valloni Torrentizi, in *La Cultura Di Rinaldone - Ricerche E Scavi*, Negroni Catacchio N. ed., Atti del Primo Incontro di Studi Preistoria e Protostoria in Etruria, Farnese - Saturnia 1991, Milano: 223-33.

CONOLLY J., LAKE M. 2006 - *Geographical Information Systems in Archaeology (Cambridge Manuals in Archaeology)*, Cambridge University Press: Cambridge.

DAMIANI I. 2010 - *L'età del Bronzo Recente nell'Italia Centro-Meridionale*, All'Insegna del Giglio: Firenze.

DEMERS M.N. 2000 - *Fundamentals of Geographic Information Systems*, Wiley J.: New York.

di GENNARO F. 1982 - Organizzazione del Territorio nell'Etruria Meridionale Protostorica: Applicazione di un Modello Grafico, *Dialoghi di Archeologia* IV, 2: 102-12.

– 1986 - *Forme di Insediamento tra Tevere e Fiora dal Bronzo Finale al Principio dell'età del Ferro*, Olschki L.S.: Firenze.

– 1990 - Aspetti delle ricerche sull'assetto territoriale dell'area mediotirrenica in età protostorica, in, *Gedenkschrift fur Jürgen Driehaus*, Andraschko F. M., Teegen W. eds., Mainz: 203-224.

– 2000 - "Paesaggi di potere": l'Etruria meridionale in età protostorica, in, *Paesaggi di potere. Problemi e prospettive*, *Quaderni di Evtopia*, 2, Camassa G., De Guio A., Veronese F. eds., Quasar, Roma: 95-119.

– 2006 - Individuazione, Formulazione e Percezione Comune di Caratteri Significativi degli Insediamenti Protostorici, in *Studi di Protostoria in Onore di Renato Peroni*, All'Insegna del Giglio, Firenze: 485-94.

– 2012 - I Ritrovamenti Protostorici del Territorio di Formello e le Fasi Formative di Veio, in *Il Nuovo Museo dell'Agro Veientano a Palazzo Chigi di Formello*, van Kampen I. ed., Quasar, Roma: 33-46.

di GENNARO F., BARBARO B. 2008*a* - Territori e paesaggi mediotirrenici nella mente dei protostorici, in *Paesaggi Reali e Paesaggi Mentali*, Negroni Catacchio N. ed., Atti dell'Ottavo Incontro di Studi Preistoria e Protostoria in Etruria, Pitigliano 2006, Milano: 117-28.

– 2008*b* - Tabella Riassuntiva degli Insediamenti dell'età del Bronzo dell'Etruria Meridionale, in *Paesaggi Reali e Paesaggi Mentali*, Negroni Catacchio N. ed., Atti dell'Ottavo Incontro di Studi Preistoria e Protostoria in Etruria, Pitigliano 2006, Milano: 129-49.

di GENNARO F., GUIDI A. 2000 - Il Bronzo Finale dell'Italia centrale. Considerazioni e prospettive di indagine, in *Il protovillanoviano al di qua e al di là dell'Appennino*, At-

ti della giornata di studio, Pavia, 1995, Harari M., Pearce M. eds., New Press, Como: 99-131.
– 2010 - Ragioni e Regioni di un Cambiamento Culturale: Modi e Tempi della Formazione dei Centri Protourbani nella Valle del Tevere enel Lazio Meridionale, in *Le ragioni del cambiamento / Reasons for Change*, Cardarelli A., Cazzella A., Frangipane M., Peroni R. eds., Atti del Convegno Internazionale del Dipartimento di Scienze dell'Antichità, Università Sapienza di Roma 2006, *Scienze dell'antichità* 15: 429-45.

di GENNARO F., PERONI R. 1986 - Aspetti Regionali dello Sviluppo dell'insediamento Protostorico nell'Italia Centro-Meridionale alla Luce dei Dati Archeologici e Ambientali, *Dialoghi di Archeologia* 2: 193-200.

DIRICHLET G.L. 1850 - Uber die Reduction der Positeven Quadratischen Formen mit Drei Unbestimmten Ganzen Zahlen, *Journal Fur die Reine und Angewandte Mathematik* 40: 209-27.

DONG P. 2008 - Generating and updating multiplicatively weighted Voronoi diagrams for point, line and polygon features in GIS, in *Computers & Geosciences* 34, 4: 411-421.

DUCKE B., KROEFGES P.C.2008 - From Points to Areas: Constructing Territories from Archaeological Site Patterns Using an Enhanced Xtent Model, in *Layers of Perception,* Posluschny A., Lambers K., Herzog I. eds., Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Berlin 2007: 245-51.

FULMINANTE F. 2008 - Paesaggi di Potere nel Latium Vetus (prima Età del Ferro). Alcune Analisi a Conferma del Modello di Sviluppo Proto-Urbano nell'Italia Medio-Tirrenica, in, *Paesaggi Reali e Paesaggi Mentali*, Negroni Catacchio N. ed., Atti dell'Ottavo Incontro di Studi Preistoria e Protostoria in Etruria, Pitigliano 2006, Milano: 377-94.
– 2009 - Landscapes of Power and Proto-Urban Developments toward Urbanization in Bronze Age and Early Iron Age Latium Vetus, in *Forces of Transformation: The End of the Bronze Age in the Mediterranean*,C. Christoph Bachuber, G. R. Roberts eds., Oxbow, Oxford: 119-30.
– 2014 - *The urbanisation of Rome and Latium Vetus. From The Bronze Age to the Archaic Era*, Cambridge University Press: Cambridge.

GAMBINI R., 1966 - *A Computer Program for Calculating Lines Equilibrium between Multiple Centers of Attraction,*Center for Regional Studies, University of Kansas, Lawrence.

GIANNI A. 1991 - Il Farro, Il Cervo ed il Villaggio Mobile: Economia di Sussistenza, Insediamento, Territorio, tra III e II Millennio a.C. nel Lazio Meridionale e nella Campania Settentrionale, *Scienze dell'Antichità* 5: 99-161.

GILMAN A. 1981 - The Development of Social Stratification in Bronze Age Europe, *Current Anthropology* 22 (1): 1-23.

GUIDI A. 1982 - Sulle prime fasi dell'urbanizza zione nel Lazio protostorico, *Opus* 2: 279-285.
– 1992 - Le Età dei Metalli in Italia Centrale e in Sardegna, in *Italia Preistorica*, Laterza, Roma-Bari: 420-70.
– 2006 - The Archaeology of Early State in Italy, *Social Evolution & History* 5: 55-89.
– 2010 - The Archaeology of Early State in Italy: New Data and Acquisitions, *Social Evolution & History* 9: 12-27.

LANGMUIR E. 1984 - *Mountaincraft and Leadership*, Cordee: Leicester.

MANDOLESI A. 1999 - *La "Prima" Tarquinia: L'insediamento Protostorico sulla Civita e nel Territorio Circostante*, All'Insegna del Giglio: Firenze.

MODICA S. 2011 - La forma urbana di Ardea. Dalla protostoria all'epoca medio-repubblicana, *Atti dell'Accademia Lancisiana* 118: 279-288.

MU L. 2004 - Polygon characterization with the multiplicatively weighted Voronoi diagram, *The Professional Geographer* 56: 223-239.

MÜLLER KARPE H. 1962 - *Zur Stadtwerdung Roms*, Kerle: Heidelberg.

NAISMITH W.W. 1892 - *Scottish Mountaineering Club Journal*.

OKABE A., BOOTS B., SUGIHARA K., CHIU S.N. 2000 - *Spatial Tessellations: Concepts and Applications of Voronoi Diagrams*, J. Wiley: Chichester.

PACCIARELLI M. 1982 - Economia e Organizzazione del Territorio in Etruria Meridionale nell'età del Bronzo Media e Recente, *Dialoghi Di Archeologia* n.s. 4, 2: 69-79.

– 1986 - Considerazionisugli Insediamenti Perilacustri dell'Italia Centrale, in *Gli Insediamenti Perilacustri dell'età del Bronzo e della Prima Età del Ferro: il Caso dell'antico Lacus Velinus*, Carancini G. L. ed., Atti dell'Incontro di Acquasparta 1985, Perugia: 269-99.

– 1991 - Insediamento, territorio, comunità in Etruria meridionale agli esordi del processo di urbanizzazione, *Scienze dell'Antichità* 5: 163-208

– 2000 - *Dal Villaggio alla Città. La Svolta Protourbana del 1000 a.C. nell'Italia Tirrenica*, All'Insegna del Giglio: Firenze.

– 2010 - Forme di complessità sociale nelle comunità protourbane dell'Etruria meridionale, in *L'Etrurie et l'Ombrie avant Rome. Cité et territoire*, Fontaine L. ed., Actes du colloque international, Louvain-la-Neuve, Halles Universitaires, Bruxelles: 17-33.

PERONI R. 1996 - *L'Italia alle Soglie della Storia*, Laterza: Bari.

PIERCY EVANS S. 1988 - Proposta per un Modello Socio-Economico per la Valle del Fiume Fiora durante l'Età Del Bronzo,in *Museo di Preistoria e Protostoria della Valle del Fiume Fiora*, Manciano: 130-44.

PINI E., SERIPA A.1986 - Per un Tentativo di Ricostruzione dei Territori dei Centri Protostorici Laziali, *Rivista di Archeologia* X: 15-21.

RAJALA U. 2005 - From a Settlement to an Early State? The role of Nepi in the Local and Regional Settlement Patterns of the Faliscan Area and Inner Etruria during the Iron Age, in *Communities and settlements from the Neolithic to the early medieval period,* Attema P., Nijboer A., Zifferero A. eds., Proceedings of the 6th conference of italian archaeology, Papers in Italian Archaeology VI, Archaeopress, Oxford: 706-12.

REDHOUSE D.I., STODDART S. 2011 - Mapping Etruscan State Formation, in *State Formation in Italy and Greece. Questioning the Neoevolutionist Paradigm*, Terrenato N., Haggis D. eds., Oxbow, Oxford: 162-78.

RENDELI M. 1991 - Sulla Nascita delle Comunità Urbane in Etruria Meridionale, *AION Archeologia* XIII: 9-46.

RENFREW C. 1975 - Trade as action at a distance: questions of interaction and communication, in *Ancient Civilisations and Trade*, Sabloff J. A., Lamberg-Karlovsky C. C. eds., Albuquerque: 3-59.

RENFREW C., LEVEL E. V. 1979 - Exploring Dominance: Predicting Polities from Centers, in *Transformations, Mathematical Approaches to Culture Change*, C. Renfrew, Cooke K. L. eds., Academic Press, New York: 145-68.

SCHIAPPELLI A. 2003 – Tipologia degli insediamenti protostorici in Etruria meridionale e il caso particolare del distretto volsiniese*, Histria Antiqua* 11: 203-208.

– 2008 - *Sviluppo storico della Teverina nell'età del Bronzo e nella prima età del Ferro*, All'Insegna del Giglio: Firenze.

THIESSEN A.H. 1911 - Precipitation Averages for Large Areas. *Monthly Weather Review* 39: 1082-84.

TIEFELSDORF M., BOOTS B. N. 1997 - GAMBINI, A GIS utility program to calculate multiplicatively weighted Voronoi diagrams (v1.01), *http://www.wlu.ca/~wwwgeog/special/download/gambini.htm* (no longer available online, 8.4.2015).

VAN DER PLICHT J., BRUINS H. J., NIJBOER A. J. 2009 - The Iron Age Around the Mediterranean: A High Chronology Perspective from he Groningen Radiocarbon Database, *Radiocarbon* 51: 213-242.

VITA-FINZI C., HIGGS E.S. 1970 - Prehistoric Economy in the Mt. Carmel Area of Palestine: Site Catchment Analysis, in *Proceedings of the Prehistoric Society* 36: 1-37.

VORONOI G.F. 1907 - Nouvelles Applications des Paramètres Continus à la Théorie des Formes Quadratiques. Premier Memoire: Sur Quelques Propriétés Des Formes

Quadratiques Positives Parfaites, *Journal Fur Die Reine Und Angewandte Mathematik* 133: 97-178.
– 1908 - Nouvelles Applications Des Paramétres Continus à La Théorie Des Formes Quadratiques. Deuxiéme Memoire: Recherches Sur Les Paralléllоèdres Primitifs, *Journal Fur Die Reine Und Angewandte Mathematik* 134: 198-287.
– 1909 - Nouvelles Applications Des Paramétres Continus à La Théorie Des Formes Quadratiques. Deuxiéme Memoire: Recherches Sur Les Paralléllоèdres Primitifs. Second Partie. Domaines de Formes Quadratiques Correspondant Aux Different Types de Paralléllоèdres Primitifs, *Journal Fur Die Reine Und Angewandte Mathematik* 136: 67-181.

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