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A HAND TO THE PLOUGH.
A GIS-BASED CARTOGRAPHICAL ANALYSIS OF CHANGES IN ELEVATION DUE TO TERRAIN MODIFICATION AND EROSION IN THE SETTLEMENT AREA OF ANCIENT *CRUSTUMERIUM*

1. Introduction

When Lorenzo Quilici and Stefania Quilici Gigli discovered the location of the settlement of *Crustumerium* in the 1970s (Fig.1) they observed that the inhabited area would have originally been more elevated and that soil displacement or even soil removal would have caused significant changes to the geomorphology of the terrain (Quilici, Quilici Gigli 1980, 69). As pioneers of their trade they could not have known that in 40 years of landscape archaeology to come, the immeasurable variety of taphonomical processes would become one of the most serious challenges of survey archaeologists (Van Leusen 2002, chapter 4; Terrenato 2004, 46).

Ironically, the plough, which enables us to study surface archaeology in the first place, also prehibits a direct interpretation of the archaeological landscape. Apart from causing changes to the actual terrain, the uncertainty of post-depositional processes is a biasing factor for the interpretation of the location, dispersion and even composition of surface find assemblages (Francovich, Patterson 2000; Taylor 2000). In the case of *Crustumerium* the impact of these processes has been stressed (Amoroso 2002, 293; di Gennaro, Schiappelli, Amoroso 2004, 148), but it has been very hard to grasp the actual extent of their effect[1].

One of the objectives of the archaeological fieldwork on *Crustumerium* by the Groningen Institute of Archaeology (GIA), in collaboration with the Soprintendenza Speciale per i Beni Archeologici di Roma, has been to establish the nature and impact of processes that have affected the archaeological surface record over time. The tuff bedrock that is characteristic for the geology of large parts of Central Italy is well known to be prone to erosion. In fact, long term erosion is one of the main processes that has shaped the current landscape of North Latium. The movement and dislocation of topsoil due to weathering is a phenomenon that has been influenced by agriculture from antiquity onward and that has accelerated with the use of modern agricultural machines, allowing considerable plough depths.

[1] I would like to note the ongoing studies of F. di Gennaro and M. Pacciarelli into sediments that are migrating off the edges of ancient settlement areas. Their work is proving to be of great help for our understanding of the processes here described.

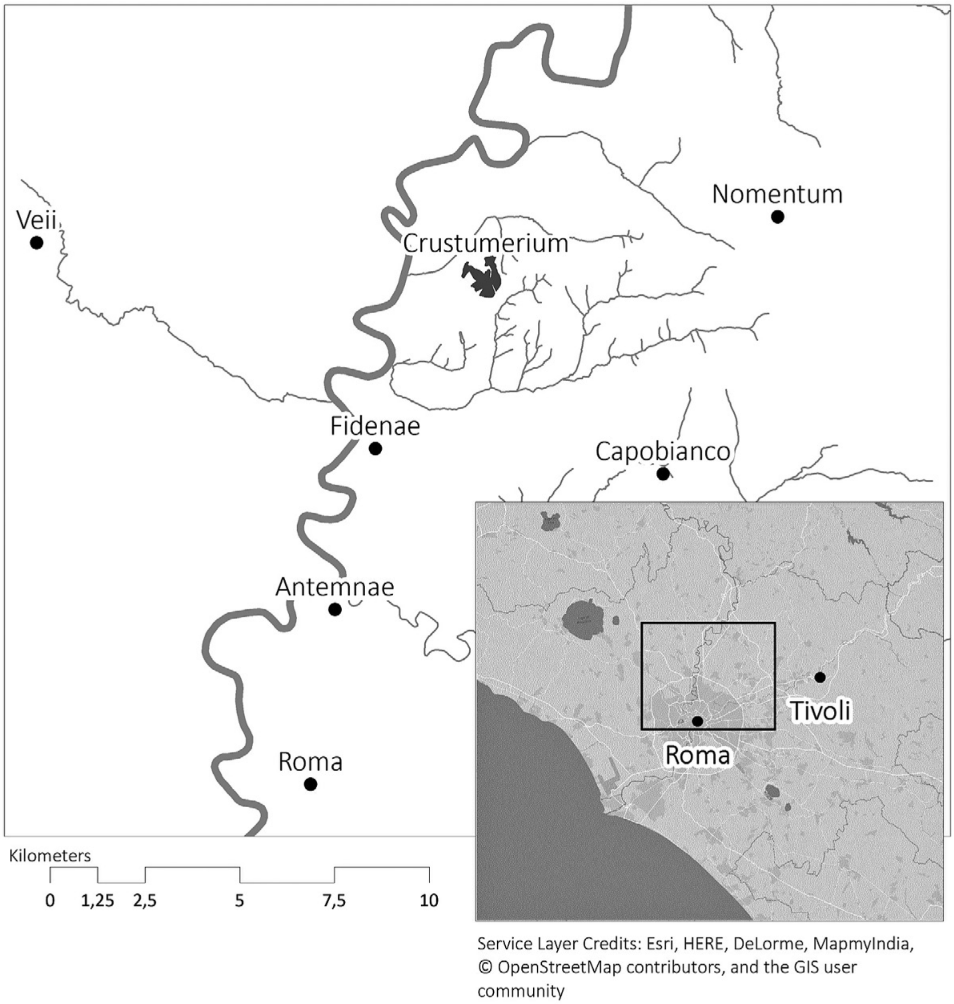

Fig. 1 – The location of *Crustumerium* in Central Italy with contemporary Iron Age settlements.

In this paper several topographical maps will be used to analyse the impact of land use and human intervention in the urban area of ancient *Crustumerium*. Especially before the discovery of the archaeological site, human activity may have destroyed or disturbed archaeological layers and has as such contributed to the creation and distortion of the current surface record. Luckily, because of *Crustumerium*'s location in the Roman *suburbium* and near the important Tiber river, the site has "accidentally" been captured in a number of historical maps, creating the opportunity to analyse the changes in the landscape as represented by a century of cartography.

The objective of the current paper is to investigate how these maps can be put to use in a GIS-based environment in order to create a so-called time-lapse of the changing landscape over the last century. An analysis of elevation changes, based on a diachronic comparison of georeferenced spatial records (along the lines of De Haas 2012, 116-120), seems viable considering the quality of the acquired cartography. The "differential digital elevation models" (difDEM) that can thus be acquired will reveal zones of depletion and accumulation of soil. Assuming that erosion and deposition have a large impact on the distribution of archaeological surface materials (Bell, Boardman 1992, 3; Boisier 1997, 1; Taylor 2000), a difDEM is expected to help specify expectancy values for the preservation of *in situ* archaeological remains in different areas.

2. A brief history of land-use around *Crustumerium*

The site of ancient *Crustumerium* lies 15 km N of Rome in an area currently referred to with the toponyms Riserva della Torretta and Campo Grande. By car it can only be reached from the Via della Marcigliana, accessed either from the Via Salaria in the E, or from the Bufalotta area in the S (by Via della Bufalotta). From both sides the Marcigliana road winds upward to 100 m above sea level and reaches its highest point in the centre of the settlement area of *Crustumerium*. The full extent of the settlement area, inhabited between ca 850-500 BC, was determined on the basis of the terrain itself, the distribution of surface finds and the location of sepulchral areas that directly surround the area of former habitation. Geologically, the wide surroundings of the site consist of different kinds of (volcanic) tuff bedrock that have become deeply incised by several streams, creating distinctive elevated "plateaus". *Crustumerium* lies elevated about 70 m above the Tiber valley, with elevation values ranging from 75 to 102 m, and is surrounded by cliffs except for its eastern flank.

The abandonment of ancient *Crustumerium* in the 5th century BC is attested by both historical and archaeological sources (Amoroso 2000, 265; 2002, 317). Nonetheless, the area was probably exploited intensively for many centuries, at least from the archaic period onward: first as part of the territory of *Crustumerium* and later as part of the *Agro Romano*, when the countryside was dotted with farms and villas (Quilici, Quilici Gigli 1980, tav. CXX). Unfortunately, we lack the necessary information to comment on the possible impact of Roman land use on the physical landscape. Historical Roman sources discussing agricultural techniques and practices in detail are not numerous (Marcone 1997, 48) and no accurate topographical records of ancient times exist.

Fig. 2 – Excavation of the Monte Del Bufalo burial ground showing evidence for plough erosion and the thin layer of top soil. Rill and gulley erosion caused by heavy rainfall in the winter of 2013 and 2011, in GIA survey areas to the N-W (A) and S (B) of *Crustumerium* respectively.

The first proper map in which the environment of *Crustumerium* can be recognized is the Alessandrino cadastral map commissioned by the papacy in 1660 (di Gennaro 2013; Fig. 2), which was later replaced by the Gregorian cadastral map (1820). Unfortunately, both maps lack detailed elevation information. Considering land-use, the maps do reveal that the area was deforested and designated for agriculture or as pastureland, but it was not densely inhabited (Passigli 2004, Figs. 4-5). Very different than in Roman times, the *Campagna Romana* of the 17th, 18th and early 19th centuries appears to have been unproductive or even barren (Witcher 2006, 42). In the beginning of the 20th century, the few people that lived in the countryside survived on a subsistence level under very poor conditions in caves and huts (Eramo 2008, 10). In the territory of ancient *Crustumerium*, 19th century hut habitation has been recorded (Becchetti 1983, 13) and medieval cave dwellings or "case rupestri" are preserved to this day.

Initiatives to improve the land around Rome were taken by the young government of unified Italy at the end of the 19th century. This "bonifica" pro-

Fig. 3 – Photograph of tomb 253 on the Monte Del Bufalo cemetery before and after excavation (bottom left). The tomb has nearly disappeared due to decades of repeated ploughing, indicating that all archaeology and geology at several meters from the original surface may have been destroyed.

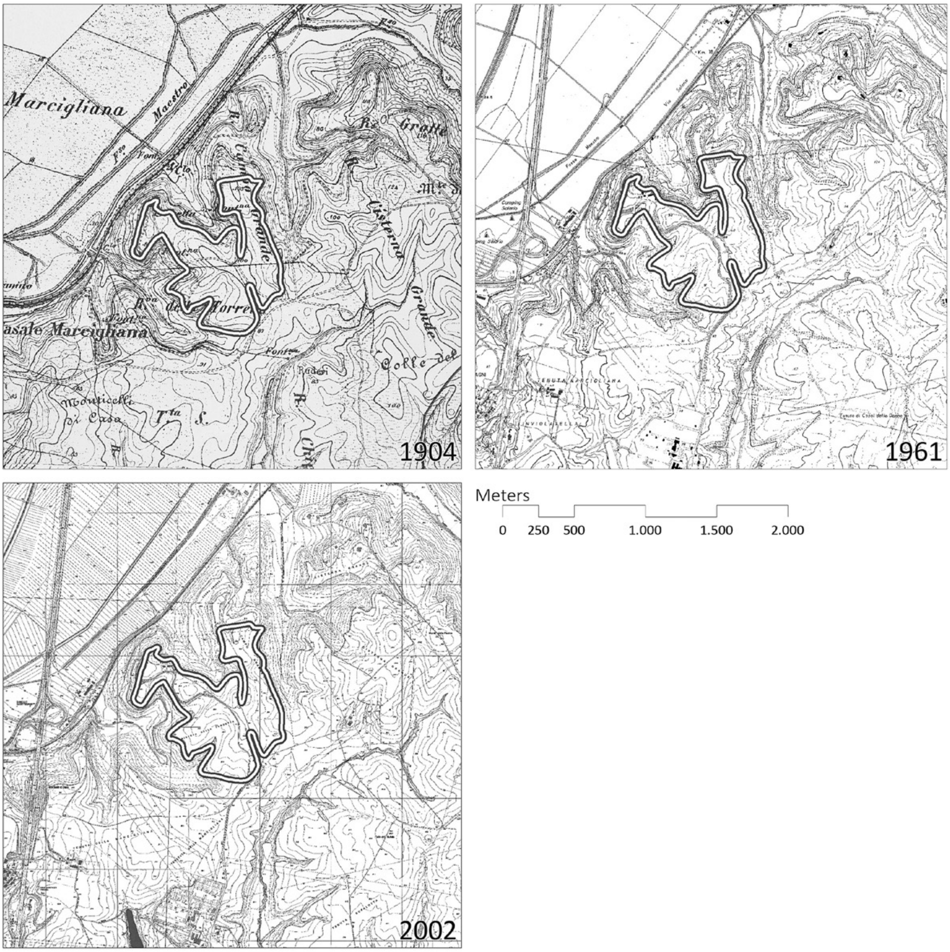

Fig. 4 – Overview of the three cartographical sources used in the analysis (see Table 1), compiled from sources of the Istituto Geografico Militare, Università di Roma “La Sapienza” and Sistema Informativo Territoriale Archeologico di Roma.

gram specified a wide range of land improvements that were deemed necessary to reclaim neglected and uncultivated lands for agriculture (Eramo 2008, 3). On the 19th of May 1922 the expropriation of lands around Settebagni and Marcigliana, which must have included the settlement area of *Crustumerium*, was decreed (Eramo 2008, 337-338). The expropriated land was to be sold to farmers or farming companies in plots of 15 hectares maximum, causing a substantial intensification of land use in comparison to the earlier estates of

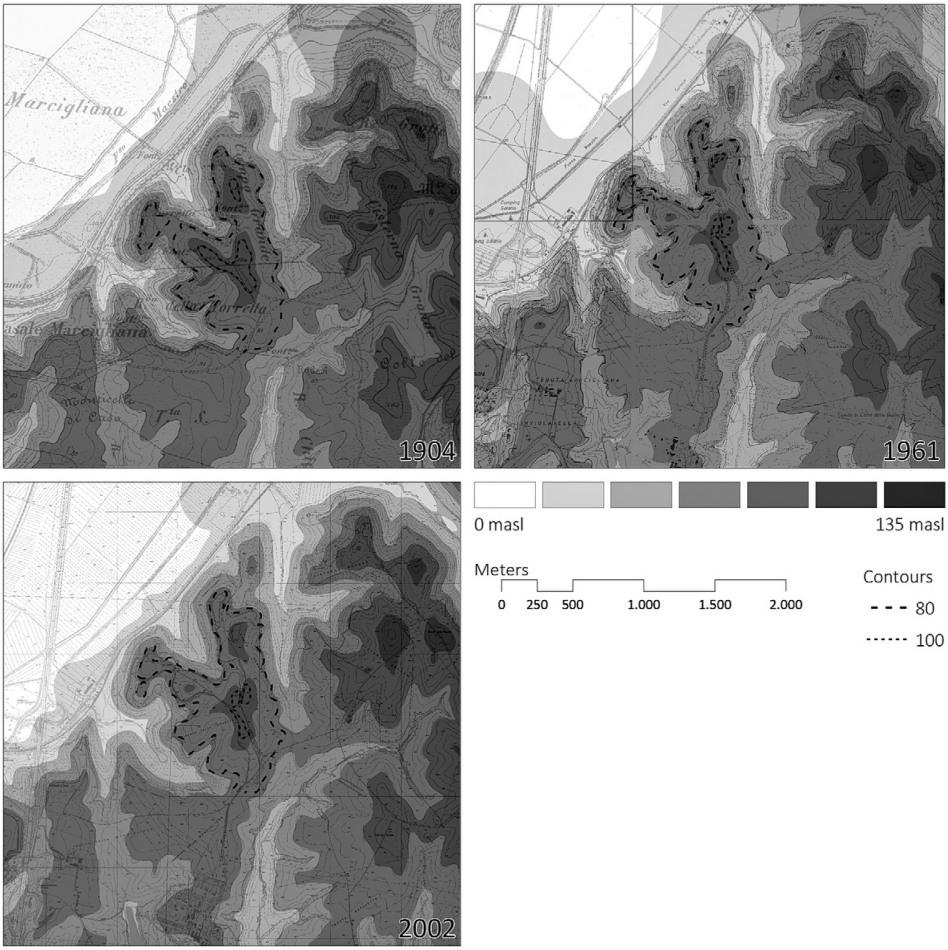

Fig. 5 – The digital elevation models acquired from the three topographical maps used in the analysis.

many hundreds hectares. Buyers were required to submit a five year plan for land improvement within one month of signing the contract. They were also obliged to construct a family house on their land and to see to the supply of drinking and irrigation water, electricity and the construction and maintenance of roads (Eramo 2008, 50).

Even the agricultural activities themselves became strictly regulated by the government with rules for the exact use of certain portions of land for certain crops. The rules also stated that 70 to 75 cm of mechanical tillage were required to make the soil suitable for cultivation and the removal of the top layer of "cappellaccio" tuff was advised to gain easier access to ground water (Eramo 2008, 53-54). Heavy ploughing with the use of a steam engine therefore became common at the end of the 1920s (di Gennaro 2010, 15).

2.1 *Physical evidence for tillage-induced erosion around* Crustumerium

It is plausible that some of the most fundamental changes to the ancient physical landscape were made during the bonifica, which involved the construction of roads, buildings, sewers and electrical poles that still stand today, but which also initiated repetitive ploughing as part of the cycle of actions needed for crop cultivation. Corings and excavations show that the current plough zone is now around 35 cm deep almost everywhere on the settlement. The top soil consists of weathered tuff, which is rich in clay, and is replenished with the scraping off of a new layer of bedrock with each plough cycle, accelerating paedogenesis and the deterioration of the natural geology. This process is evident from plough marks revealed in excavations (Fig. 2), but also from the frequent observation of tuff chunks in fresh plough soil. In fact, there is ample evidence that several meters of bedrock have been "eaten away" by the plough on specific places on *Crustumerium*'s Monte Del Bufalo burial ground and many tombs have probably been preserved only because they were dug deep into the bedrock (Fig. 3; Willemsen 2014, 28, fig. 3.6).

Today, even though the ancient settlement area itself is protected, the destabilisation of the natural geology due to ploughing continues to stimulate erosion in areas directly surrounding the site. Sheet, rill and gulley erosion is common in the tuff soils because rainwater penetrates the loose plough soil, but flows of the underlying bedrock, creating small streams or even torrents that are capable of carrying off large quantities of soil and artefacts, as seen in Fig. 2A (Taylor 2000, 23; Corazza, Giordano, de Rita 2006, 113). If there is no vegetation to hold it in place the topsoil is washed off the slopes, as witnessed in Fig. 2B, exposing the natural geology (and possible archaeological evidence) to the destructive force of a new plough cycle. The objective of the current paper is to analyse the long term impact of such tillage-induced erosion and other terrain modifications by considering elevation differences between several digital maps.

3. From maps to digital elevation models

A digital elevation model (DEM) adds relief information to an otherwise 2D GIS and it is used to approach the landscape as the 3D-environment it actually is. From a DEM the general morphology of the landscape and characteristics such as slope and aspect can be derived and used for quantitative analyses.

To study the impact of land use over time, the earliest suitable map available to us is the *Carta dell'Agro Romano* (IGM) that was drawn up in

Cartographical source	**Map date**	**Scale**
Carta dell'Agro Romano F.5	1904 (reconnaissance)	1:8000 (enlarged from 1:25.000) 1 mm = 8 m Elevation data in 5 m contour lines
SARA-Nistri (sheet 9S, 9N, 10S, 10N)	1961 (aerial photogrammetry) 1962 (reconnaissance) 1991 (updated)	1:10.000 1 mm = 10 m Elevation data in 5 m contour lines
Carta Tecnica Regionale, tenuta Bufalotta (sheet 365152 and 365153)	2002 (aerial photogrammetry) 2005 (reconnaissance)	1:10.000 1 mm = 10 m Elevation data in 5 m contour lines

Tab. 1 – Details of the base cartography used in this paper.

1904 «per la zona soggetta alla bonifica agraria». The earliest post-bonifica elevation information was acquired from maps that were created in the 1960s, which are also the first maps of the area that were produced on the basis of aerial photogrammetry in combination with field reconnaissance. To represent the current landscape we are using a topographical map of 2005, with elevation information based on flights operated in 2002 (see Fig. 4 for a comparison of the base maps and Table 1 for details).

Because the topographical maps used in this study are all of a different date and created with very different cartographic standards and methods, a comparison is not straightforward. The problems encountered during digitisation were for instance related to faulty planar translations, differing distances between fixed positions in the landscape and, especially problematic for the current study, contradictory elevation data. Of course, errors or inaccuracies of topographical surveys are untraceable and are involuntarily copied one-on-one during georeferencing and digitisation, influencing the comparability of different cartographical sources (Lechterbeck 2008, 75; De Haas 2011, 23-24). Consequently, a digital elevation model, based on the interpolation of z-values between spot heights and contour lines, can never exceed the quality of its source data.

For the creation of the DEMs, ESRI's ArcMap has been the primarily used software package. After digitising the contour lines and spot heights, the tool "topo to raster" was employed to interpolate the elevation information and create a continuous surface in a raster format. The tool uses a version of the "ANUDEM" program which is specifically written for interpolation of elevation data, but different algorithms have been tried to find the most accurate result[2].

[2] Testing other software like GRASS, integrated in (open-source) QGIS, and Surfer 8, that use a thin sheet spline interpolation, did not result in the creation of significantly different models and eventually testing many different settings of the "topo to raster" tool in ArcMap helped to produce reliable DEM's of the study area. These experiments encompass converting contour into point data to accommodate different interpolation methods, like the inverse distance weighted (IDW) technique.

However, the weaknesses in the models, in relation to the interpolation of elevation data of uncertain accuracy, have to be recognised. Creating models of high resolution for our comparison soon proved not only to be misleading, but also to give results of incomprehensible detail. To keep the resulting rasters comprehensible and to even out potential errors in the alignment of the topographical maps, the DEMs were generated with a resolution of 20 m, assigning a single elevation value to a 400 m^2 surface (see Fig. 5 for a comparison of the acquired DEMs). To eventually acquire the desired information – the so-called difDEM – the "older" DEMs were simply subtracted from a younger DEM using "raster calculator". This approach resulted in the creation of new rasters that contained information on elevation differences. The negative and positive values in these layers were interpreted as soil loss or soil accumulation respectively (Tab. 1).

4. A digital history of terrain modification and erosion in the settlement area of ancient *Crustumerium*

4.1 Crustumerium *between 1904 and 1961*

The maps and DEMs (Figs. 4-5) show that the ancient settlement area of *Crustumerium* is a well-defined geomorphological unit consisting of a single large hilltop just over 100 m in height, with outcrops above 90 m to the N, S and W. The central large hill is surrounded by smaller isolated hilltops and, to the E, by an ancient artificial mound (Quilici, Quilici Gigli 1980, 114) that is still quite conspicuous in the terrain today and where substantial walls were uncovered in excavations carried out in 1997 (Barbaro, Barbina, Borzetti 2013, 24-25). An ancient road trench, up to 10 m deep, dissects the settlement, ascending to the most elevated point of the hill from the S and descending into the Tiber valley to the N. The road trench was not included in the elevation information of the 1904 map, but excavations have shown that its construction should be dated to the 7th century BC (Jarva *et al.* 2013).

Just by visually comparing the digital elevation models of the ancient settlement area, substantial changes over time can be noted. First of all the integrity of the central hilltop is compromised significantly between 1904 and 1961, leaving no trace of the original Y-shape that is characteristic for the entire settlement area. The elevation of a large part of the central NW hill was severely reduced and the smaller hilltop further E was also significantly altered. These major terrain modifications can possibly be attributed to the construction of the Via della Marcigliana. In the 1904 map a road with a totally different trajectory, which did not interfere with the terrain, has been recorded. A road similar to the Marcigliana can be distinguished on maps of 1936 (Carta d'Italia F.144, Casale Marcigliana) and aerial photographs

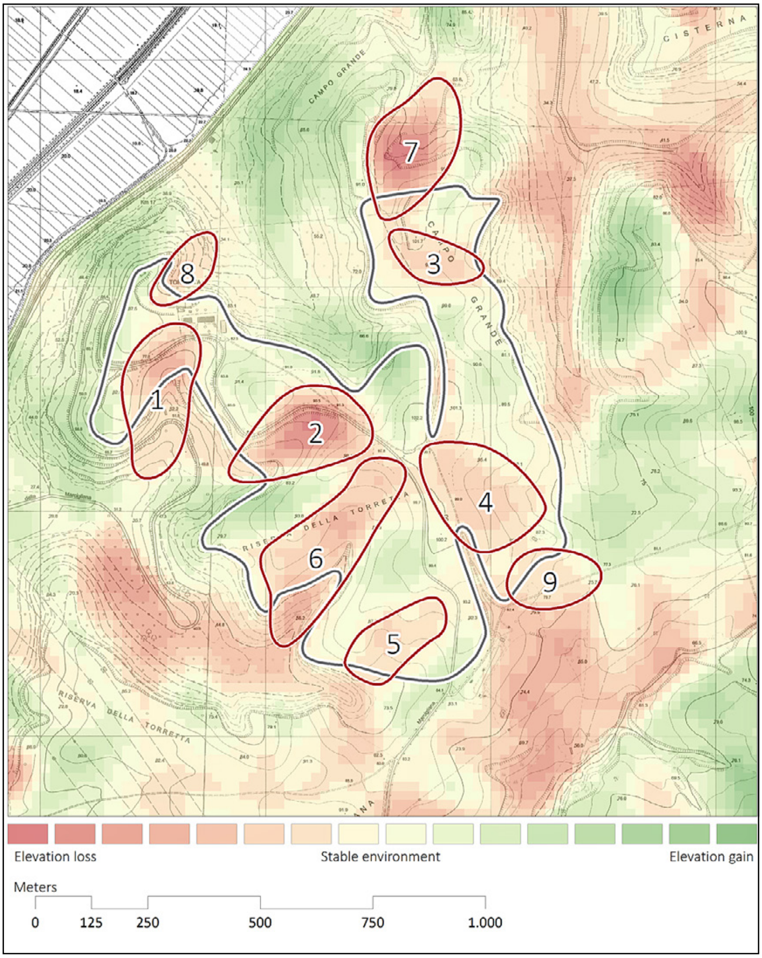

Fig. 6 – The differential digital elevation model acquired from the comparison of elevation data of 1904 and 1961.

of 1944 (RAF) clearly show that the Marcigliana road had been constructed exactly as it is today. Hence, we can safely date the infrastructural work to the late 1920s or 1930s. On the eastern part of the settlement, changes in elevation seem less severe, but some reduction of elevation is noted.

The introduction of a difDEM to the comparison of the landscapes of 1904 and 1961 is of great use to pinpoint the exact areas of suspected terrain modification, erosion and sedimentation (Fig. 6). The map corroborates that a significant reduction of elevation can be associated with the Marcigliana

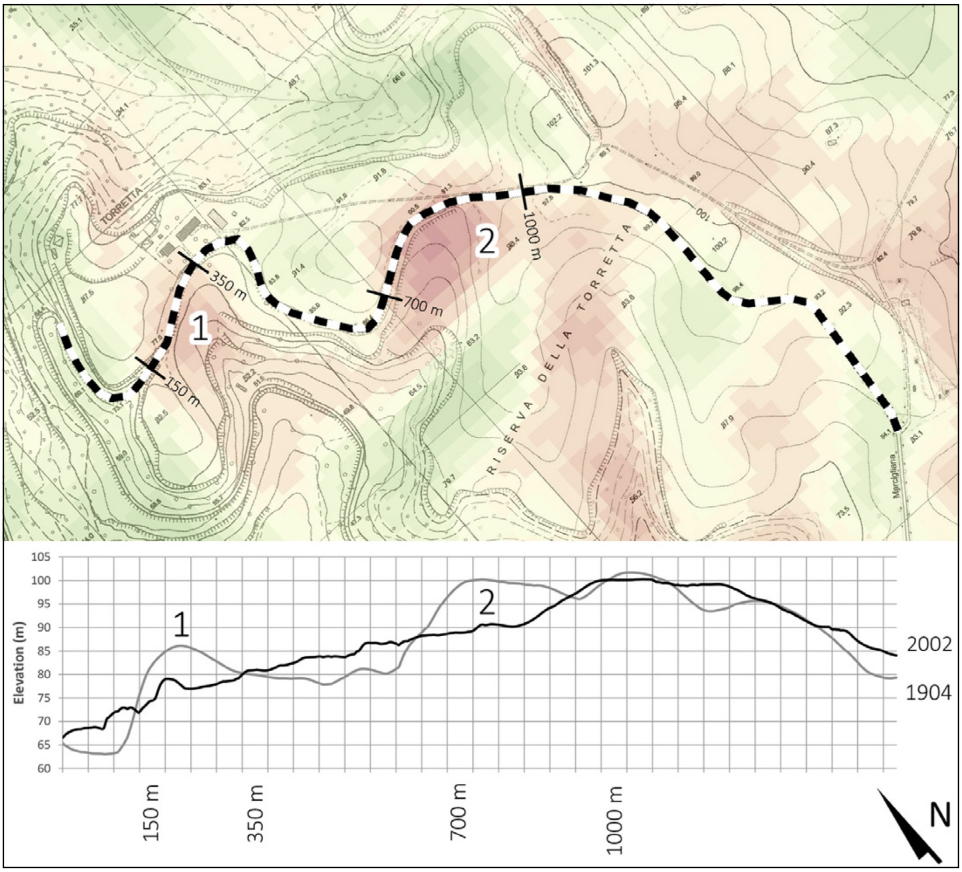

Fig. 7 – A comparison of the elevation values along the trajectory of the Via della Marcigliana in the pre-bonifica landscape of 1904 and the modern landscape of 2002.

road, especially in areas 1 and 2. This impact of the infrastructural works can be illustrated even better when the trajectory of the road on the 2002 DEM is compared with the elevation values of the same trajectory in 1904 (Fig. 7).

From NE to SW Via della Marcigliana winds through the settlement area for about 1500 m and essentially climbs about 30 m uphill over a distance of 1000 m. This would give only a 3% rise if the road was properly constructed, which obviously required some terrain modifications. At the W entrance a 25 m cliff of bedrock had to be partially demolished to create a 350 m stretch of road with a gradual ascent, providing access to the farmhouses that were also constructed during the bonifica. The final 200 m of this part of the road corresponds to significant elevation loss in area 1. Here the original hill was

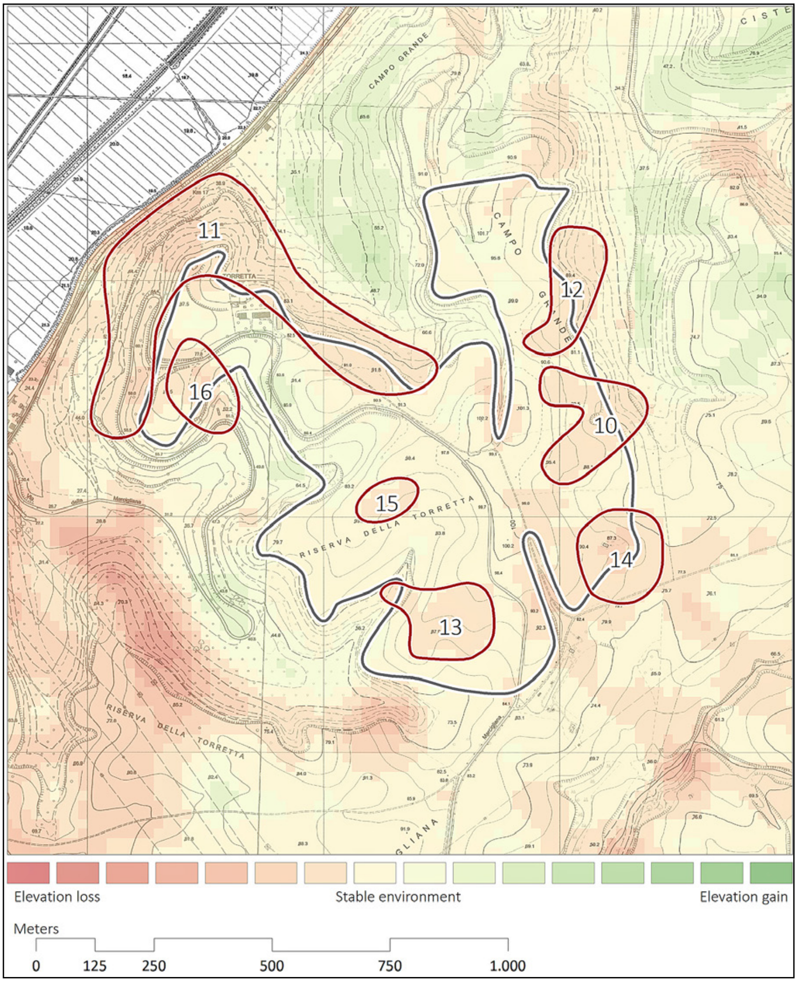

Fig. 8 – The differential digital elevation model acquired from the comparison of elevation data of 1961 and 2002.

cut in two and levelled, which would have required digging into the bedrock up to 10 m deep.

Further down the road, the second obstacle was the steep ascent up the large central hill, starting at the 700 m mark. Again, this required digging up to 10 m deep over a 300 m stretch of land, corresponding to substantial elevation loss in area 2. Here the road bends twice, at a 90^{o} angle, to circumvent a deep valley. To ensure a gradual ascent up the central hilltop the roadbed was entrenched and levelled. By doing so, a small-elevated area directly N of area 2 became separated from the central hill. Area 2 has some of the steepest slopes of the area and additional soil loss here should be attributed to erosion.

The gulleys that are evident in the current terrain in areas 3, 4 and 5 were not recorded in 1904 and are therefore marked as areas of elevation loss. We may expect that the destabilisation of the topsoil and damage to the bedrock produced by repeated ploughing has caused concentrated flow erosion here, slowly forming gulleys that transport sediments from the slopes to the valleys (Casalí, López, Giráldez 1999, 66; Casalí *et al.* 2006). Together with areas 2 and 6, these gulleys form the main routes of transport for flowing water from the central hilltop. The large gulley, of which area 6 is part, empties out into the Tiber valley and is eroding over a length of 500 m at least. Areas 7 and 8 are part of the same natural drainage system of the elevated settlement plateau. These gulleys are already evident in 1904, but the incision at area 7 especially has become much more pronounced, again suggesting substantial loss of soil due to flow erosion, not only in such specific areas, but all over the steep cliffs on the E side of the settlement.

Area 9, finally, corresponds to part of the Monte Del Bufalo necropolis, where evidence for plough erosion and the obliteration of several meters of bedrock has been repeatedly illustrated by the excavation of nearly disappeared tombs (Fig. 3). Elevation loss seems to have affected a much larger area to the S, all the way down to the nearest stream. Area 9 also includes part of the artificial mound (Quilici, Sito O) but no substantial erosion of this feature can be reported between 1904 and 1961.

4.2 Crustumerium *between 1961 and 2002*

Between 1961 and 2002 elevation loss and elevation gain seem to be overall less severe (Fig. 8). The difDEM reveals no massive terrain modifications and almost all phenomena can be explained by ongoing flow erosion in the same areas already highlighted between 1904 and 1961; on the cliffs around the settlement and in specific gulleys where flow is concentrated (areas 10, 11, 12 and 16).

What is more evident than in the previous map is the gradual plough erosion, which appears to have a levelling effect on some more elevated parts of the settlement area, for example area 13, 14 and 15. In area 14 we can now witness that the artificial mound is becoming less prominent due to its agricultural exploitation and very probably because of intentional levelling (di Gennaro 1993, 513; 2003, 33-34). To some degree, the mound can even be said to be "moving" to the W as the steepness of its slopes is declining. Plough erosion has also continued to affect the burial grounds in the same area since 1961.

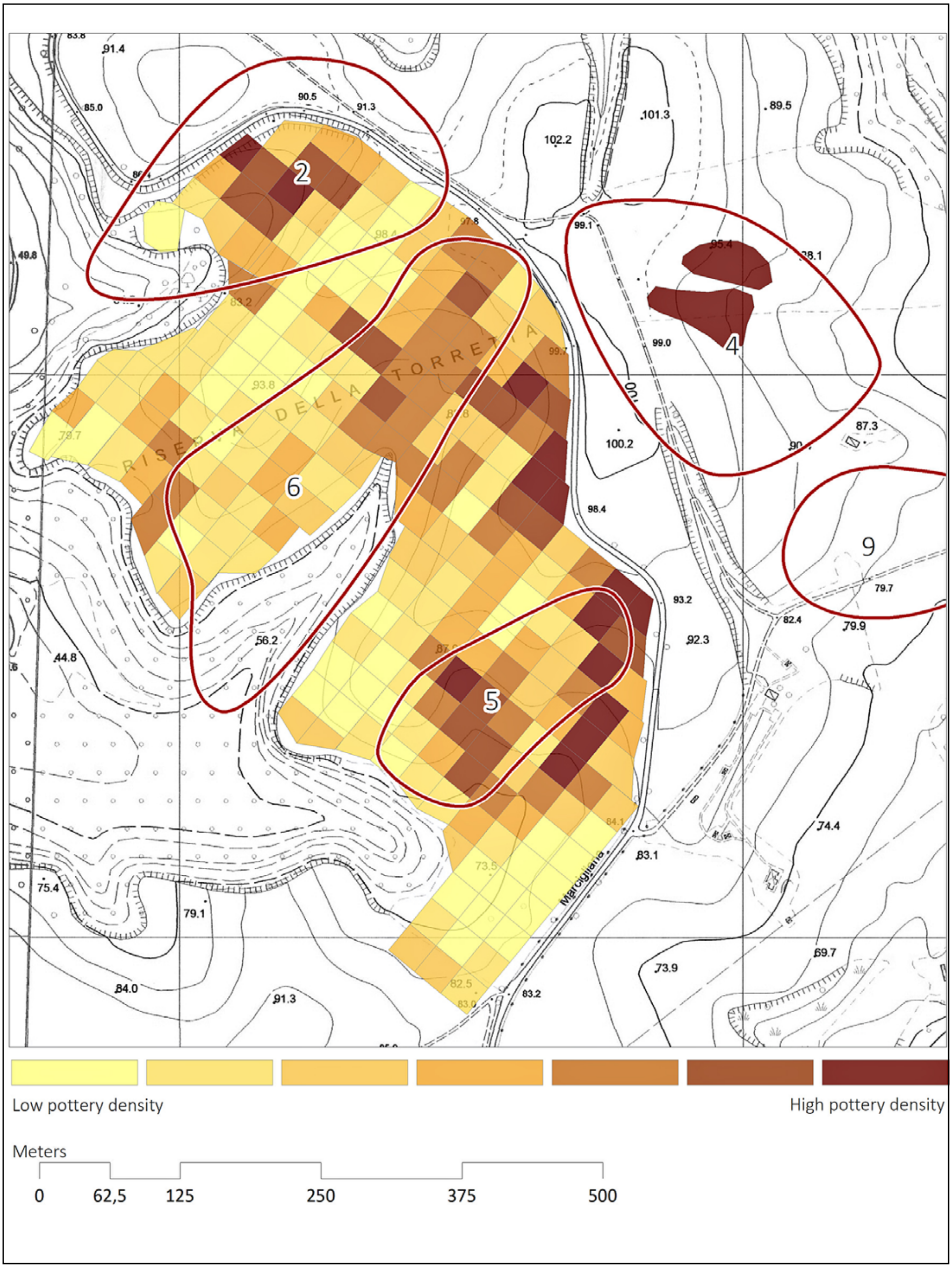

Fig. 9 – The areas of soil loss recorded between 1904 and 1961 in association with recorded (ceramic) surface find densities (map by authors with additional data from Amoroso 2002, fig. 5).

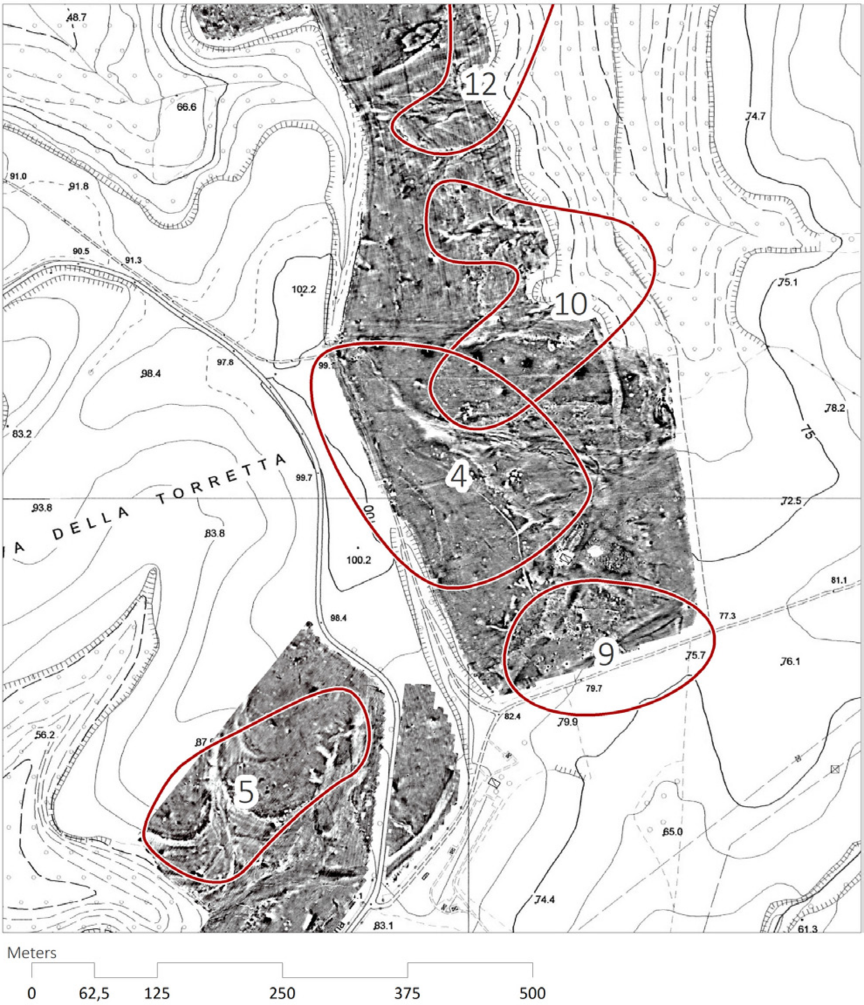

Fig. 10 – Geomagnetic prospections at *Crustumerium* reveal anomalies in the subsurface that are spatially related to areas of soil loss and surface find accumulation (adapted from Attema *et al.* 2014, fig. 9).

4.3 *Elevation changes in relation to archaeological and geophysical evidence*

In 2011 a partial block survey of *Crustumerium* was performed in combination with geophysical prospections to investigate the status of preservation of the surface and subsurface archaeological record (Attema, di Gennaro, Jarva 2013). Together with records of previous research, these data can also be used to interpret the difDEM maps in terms of their significance for our understanding of post-depositional processes.

Overlaying the surface find density map with recorded elevation differences reveals that they share spatial properties (Fig. 9). Surface finds seem to have primarily accumulated in areas 2, 5 and 6 that are marked for substantial elevation loss. In area 4 a concentration of finds was recorded by Amoroso (Amoroso 2002, fig. 5). The spatial matches support the idea that ceramic fragments are migrating with the topsoil and that the urban archaeological record as a whole has been severely distorted. Reversing this logic it means that areas that are empty now could have been occupied in antiquity. Even though this has been a generally accepted idea, already voiced by di Gennaro and Amoroso, the analysis presented here offers conclusive evidence that the distribution of surface finds on *Crustumerium* is not significant in terms of any spatial relations to subsurface archaeology and that it can certainly not be used directly to comment upon patterns of ancient habitation.

More evidence is offered by the as yet incomplete geophysical map, which reveals clear erosion features, specifically gulleys, in the geomagnetic signature of the subsurface that correspond to areas 4, 5, 9, 10 and 12 highlighted in the difDEM and to areas of surface find concentrations (Fig. 10). All find concentrations recorded by Amoroso and by the GIA that overlap with the geophysical map can be shown to be largely confined to areas where the natural geology has been disturbed. These erosion features may be expected to transport colluvium, filled with *ex situ* ceramic fragments, from hilltops and slopes to the lower parts of the landscape.

Despite the clear evidence for the substantial distortion of the archaeological record, there is room for some optimism. A strong relation between surface and subsurface archaeology may still be assumed for areas with high find concentrations without recorded soil loss. In the elevated area directly W of the central hilltop and the Marcigliana road, between area 5 and 6, for example, surface finds are less likely to have migrated far from the original archaeological deposit. Since no strong erosion of this area is indicated in the difDEM the surface finds could be indicative for a local stratigraphy, which may still be partially preserved.

5. Conclusion

The objective of this paper has been to investigate if a GIS-based comparison of elevation data from different cartographical sources could be useful to study the nature and impact of processes that have affected the archaeological record. In the case of *Crustumerium* we have found that the quality of the source material was sufficient to create differential elevation models in which elevation differences over time could be captured. We have to admit that the difDEMs seem inadequate for quantifying erosion and colluviation in great detail and fail to describe precise patterns of soil movement. Furthermore, inaccuracies in the cartography and translation errors can come across as absurd elevation differences in specific areas (up to 17 m loss and 28 m gain) especially on the steep slopes (as also noted by De Haas 2012, 116-120).

Apart from these obvious errors, however, the models testify to severe disturbances in the natural geomorphology of the ancient settlement area of *Crustumerium*, especially due to infrastructural works and decades of agricultural exploitation. In total the models suggests a loss of nearly 1.400.000 m^3 of soil within a 100 m radius of the ancient settlement area between 1904 and 1961. This may seem a lot, but it suggests that, on average, over a meter of the original surface has disappeared, which is not surprising given the evidence from the burial grounds presented at the start of this paper. In fact, archaeological and geophysical data corroborate that the difDEMs have successfully identified areas where the subsurface record has been disturbed and where active erosion is taking place.

The damage done to the natural and anthropogenic stratigraphy of the ancient urban centre of *Crustumerium* by agricultural work since the bonifica is hard to fathom. Although the density of the surface finds supports the idea that the Marcigliana Vecchia hill once hosted a busy urban centre, the distribution of the surface materials seems to allow no straightforward interpretation of its spatial characteristics. Excavations on different parts of the settlement occasionally yield small bits of additional information on the nature of the ancient settlement, but more frequently give negative results, revealing nothing but plough marks (di Gennaro 1990; Amoroso 2000, 268-272; Barbaro, Barbina, Borzetti 2013; Jarva 2013; Attema, di Gennaro, Jarva 2013, 185-189). Over several decades, the combined effort to peer into the subsurface of *Crustumerium* at the trowel's edge has remained relatively small scale, possibly because of the effort this intensive method requires and the high risk of failure it has entailed.

As much as the GIS analysis presented here forces us to open our eyes to the widespread and irreversible destruction of the archaeological record, it can also be considered to be a tool to help us rescue what remains. The difDEMs, together with the gradiometric maps, can be considered to carry unique information as to where *in situ* archaeology has the best chances of having been preserved. The difDEMs reveal the parts of the ancient settlement area where no severe erosion and elevation loss appears to have taken place, or where the subsurface is covered by colluvium. These areas can be considered to be most promising for continued research. Additionally the geophysical prospection gives an idea of the actual structural remains one might expect in these "quiet" areas. The Groningen Institute of Archaeology, in collaboration with the Soprintendenza Speciale per i Beni Archeologici di Roma, is only beginning to explore these new results and the opportunities it offers for more focused invasive investigations in the future.

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REFERENCES

Amoroso A. 2000, Crustumerium, *da città antica a* suburbium *di Roma*, «Bullettino della Commissione Archeologica Comunale di Roma», 101, 263-282.

Amoroso A. 2002, *Nuovi dati per la conoscenza dell'antico centro di* Crustumerium, «Archeologia Classica», 53, 3, 287-329.

Attema P.A.J., di Gennaro F., Jarva E. (eds.) 2013, Crustumerium. *Ricerche internazionali in un centro latino. Archaeology and Identity of a Latin Settlement near Rome*, Groningen, Groningen Institute of Archaeology & Barkhuis.

Attema P.A.I., Nijboer A.J., Willemsen S.L., Seubers J.F. (eds.) 2014, *Current Research into Pre-Roman Burial Grounds in Italy*, «Caeculus», 8.

Barbaro B., Barbina P., Borzetti M.R. 2013, *L'abitato di* Crustumerium*: acquisizioni del 2007*, in Attema, di Gennaro, Jarva 2013, 21-34.

Becchetti P. 1983, *Immagini della campagna romana, 1853-1915,* Roma, Quasar.

Bell M., Boardman J. 1992, *Past and Present Soil Erosion: Archaeological and Geographical Perspectives,* Oxford, Oxbow.

Boismier W.A. 1997, *Modelling the Effects of Tillage Processes on Artefact Distributions in the Ploughzone: A Simulation Study of Tillage-induced Pattern Formation,* Oxford, Archaeopress.

Casalí J., Loizu J., Campo M.A., De Santisteban L.M., Álvarez-Mozos J. 2006, *Accuracy of methods for field assessment of rill and ephemeral gully erosion*, «Catena», 67, 2, 128-138.

Casalí J., López J.J., Giráldez J.V. 1999, *Ephemeral gully erosion in southern Navarra (Spain),* «Catena», 36, 1-2, 65-84.

Corazza A., Giordano G., de Rita D. 2006, *Hydrogeology of the city of Rome*, in G. Heiken (ed.), *Tuffs: Their Properties, Uses, Hydrology, and Resources*, Geological Society of America, Special Paper 408, 113.

de Haas T.C.A. 2011, *Fields, Farms and Colonists: Intensive Field Survey and Early Roman Colonization in the Pontine Region, Central Italy*, Groningen, Barkhuis.

di Gennaro F. 1990, Crustumerium *(circ. IV) I. Ricerche del 1982,* «Relazioni su scavi, trovamenti, restauri in Roma e Suburbio», 467-468.

di Gennaro F. 1993, *11.* Crustumerium *(Com. di Roma),* «Studi Etruschi», 58, 512-514.

di Gennero F. 2003, *Una raffigurazione schematica a tutto tondo di edificio protostorico da* Crustumerium, in I. von Kampen (ed.), *Dalla capanna alla casa. I primi abitanti di Veio. Catalago della mostra*, Formello, 33-37.

di Gennaro 2010, *Introduzione*, in B. Barbaro, *Insediamenti, aree funerarie ed entità territoriali in Etruria meridionale nel Bronzo finale*, Firenze, All'Insegna del Giglio, 13-16.

di Gennaro F. 2013, *Alla ricerca dell'identità di* Crustumerium, in Attema, di Gennaro, Jarva 2013, 3-20.

di Gennaro F., Schiappelli A., Amoroso A. 2004, *Un confronto tra gli organismi protostatali delle due sponde del Tevere: le prime fase di Veio e Crustumerio*, in H. Patterson (ed.), *Bridging the Tiber: Approaches to Regional Archaeology in the Middle Tiber Valley*, London, The British School at Rome, 147-177.

Eramo N. (ed.) 2008, *Mutui per la bonifica agraria dell'agro romano e pontino (1905-1975)*, Roma, Ministero per i Beni e le Attività Culturali, Pubblicazioni degli archivi di Stato.

Francovich R., Patterson H., Barker G. 2000, *Extracting Meaning from Ploughsoil Assemblages*, Oxford, Oxbow Books.

Jarva E., Kuusisto A., Lipponen S., Suuronen M., Tuppi J. 2013, *Excavations in the Road Trench area of* Crustumerium *and research prospects in the future,* in Attema, di Gennaro, Jarva 2013, 35-44.

Lechterbeck J. 2008, *The potential of ancient maps for quantifying slope processes – Comparison of historical and modern elevation models,* in B. Frischer, A. Dakouri-Hild (eds.), *Beyond Illustration: 2D and 3D Digital Technologies as Tools for Discovery in Archaeology*, Oxford, Archaeopress, 208-219.

Marcone A. 1997, *Storia dell'agricoltura romana: dal mondo arcaico all'età imperiale,* Roma, Nuova Italia Scientifica.

Passigli S. 2004, *L'insediamento e l'ambiente nei possessi di San Ciriaco in Via Lata in San Silvestro in Capite presso le anse del Tevere (secoli XII-XIII)*, in H. Patterson (ed.), *Bridging the Tiber: Approaches to Regional Archaeology in the Middle Tiber Valley*, London, The British School at Rome, 125-141.

Quilici L., Quilici Gigli S. 1980, *Crustumerium,* Latium Vetus III, Roma, Consiglio Nazionale delle Ricerche.

Taylor J. 2000, *Cultural depositional processes and post-depositional problems*, in R. Francovich, H. Patterson (eds.), *Extracting Meaning from Ploughsoil Assemblages*, Oxford, Oxbow Books, 16-29.

Terrenato N. 2004, *Sample size matters! The paradox of global trends and local surveys*, in S. Alcock, J. Cherry (eds.), *Side-by-Side Survey: Comparative Regional Studies in the Mediterranean World*, Oxford, Oxbow, 36-48.

van Leusen P.M. 2002, *Pattern to Process: Methodological Investigations into the Formation and Interpretation of Spatial Patterns in Archaeological Landscapes,* Groningen, Groningen Institute of Archaeology.

Willemsen S.L. 2014, *Into the Light: A Study of the Changing Burial Customs at* Crustumerium *in the 7th and 6th Centuries BC*, Groningen, Groningen Institute of Archaeology.

Witcher R. 2006, *Broken pots and meaningless dots? Surveying the rural landscapes of Roman Italy*, «Papers of the British School at Rome», 74, 39-72.

ABSTRACT

Plough zone archaeology is revealed to us by post-depositional processes that move, abrade, disperse, obscure and change the composition of surface find assemblages, biasing the interpretation of survey data. The tuff bedrock that is characteristic of the geology of large parts of Central Italy is well known to be prone to erosion, which has been accelerated due to the long and intensive agricultural exploitation of the landscape. In the case of the ancient Latin settlement of *Crustumerium* (North-Rome) the adverse effects of erosion on the preservation of the archaeological record have been stressed by several scholars. One of the objectives of the archaeological fieldwork on *Crustumerium* by the Groningen Institute of Archaeology, in collaboration with the Soprintendenza Speciale per i Beni Archeologici di Roma, is to investigate the nature and impact of these taphonomic processes for the archaeology of this ancient urban area. The current paper investigates the history of land-use on the site of *Crustumerium* on the basis of elevation information in topographical maps covering a period of a century. The authors will quantify the geomorphological changes on the basis of a diachronic analysis of digital elevation models generated and compared within a GIS. The result is a series of maps in which the degree of erosion and subsequently the expected preservation of subsurface archaeology is defined for the entire settlement area. Maps like this can help guide future research plans, but can also assist in the interpretation of currently available data.