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Surface visibility and the validity of settlement patterns in legacy survey datasets.

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The ground visibility of the terrain that is surveyed has a clear impact on detecting archaeological finds. Because the resulting distortions may influence the quality of the interpretation of single settlements and settlement patterns, various checks of the terrain and the collected data are needed. Therefore, in current survey projects different types of tests and data filtering are increasingly implemented both in the field and in the laboratory as a part of their methodology. However, some of the most important archaeological landscape projects were initiated long before an agreement on a standard methodology for field survey was reached. As a result, legacy datasets have been deemed to be of little value to present-day scholarship due to the current research standards. In this paper, we examine if legacy data can be useful to contemporary research by performing a study comparing legacy data collected by the Forma Italiae *survey project to contemporary data collected by the LERC project. The* Forma Italiae *survey project was carried out in the late 20th century and produced a large dataset of archaeological sites in the area around the ancient town of Venusia (located in Southern Italy). We first analyzed the relationship between surface visibility and the density of identified Hellenistic-period sites by means of a statistical analysis, and then tested the reliability of the legacy site patterns by comparing them with new data recovered from the field in a recent re-survey of this region by our team as a part of the LERC project. We thus assessed the compatibility of the clustered pattern of sites detected by the* Forma Italiae *and the new LERC field surveys. At odds with more pessimistic estimations, we conclude that on the regional level and coarse scale of analysis the legacy survey data is representative and offers significant evidence to current scholarship for the study of ancient settlement patterns.*

1. Introduction

Site patterns recorded during regional field survey are not exclusively determined by ancient settlement strategies: there are a multitude of other factors that influence the configuration of the surface record as we see it in the field[2]. In this paper we focus on one important biasing factor: surface visibility as a function of land use

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This article is the revised version of a chapter in a PhD thesis (CASAROTTO 2018: 91-103) conducted in the framework of the Landscapes of Early Roman Colonization project (NWO project 360-61-040, Leiden University, KNIR).
[2] See discussion and lists of biasing factors in AMMERMAN 1981; CHERRY, DAVIS, MANTZOURANI 1991; CAMBI, TERRENATO 1994: 151-158; TERRENATO, AMMERMAN 1996; BANNING *et al.* 2011, 2017. For a description on major visibility and geomorphological biases affecting field survey results, and how to possibly measure and filter out their effect: *e.g.,* CASAROTTO *et al.* 2018.

conditions. We assess whether visibility conditions affected the number and pattern of Hellenistic-period archaeological sites registered by the *Forma Italiae* (FI onwards) field survey project which ran from 1989 to 2000 in the area around Venosa in southern Italy (fig. 1)[3].

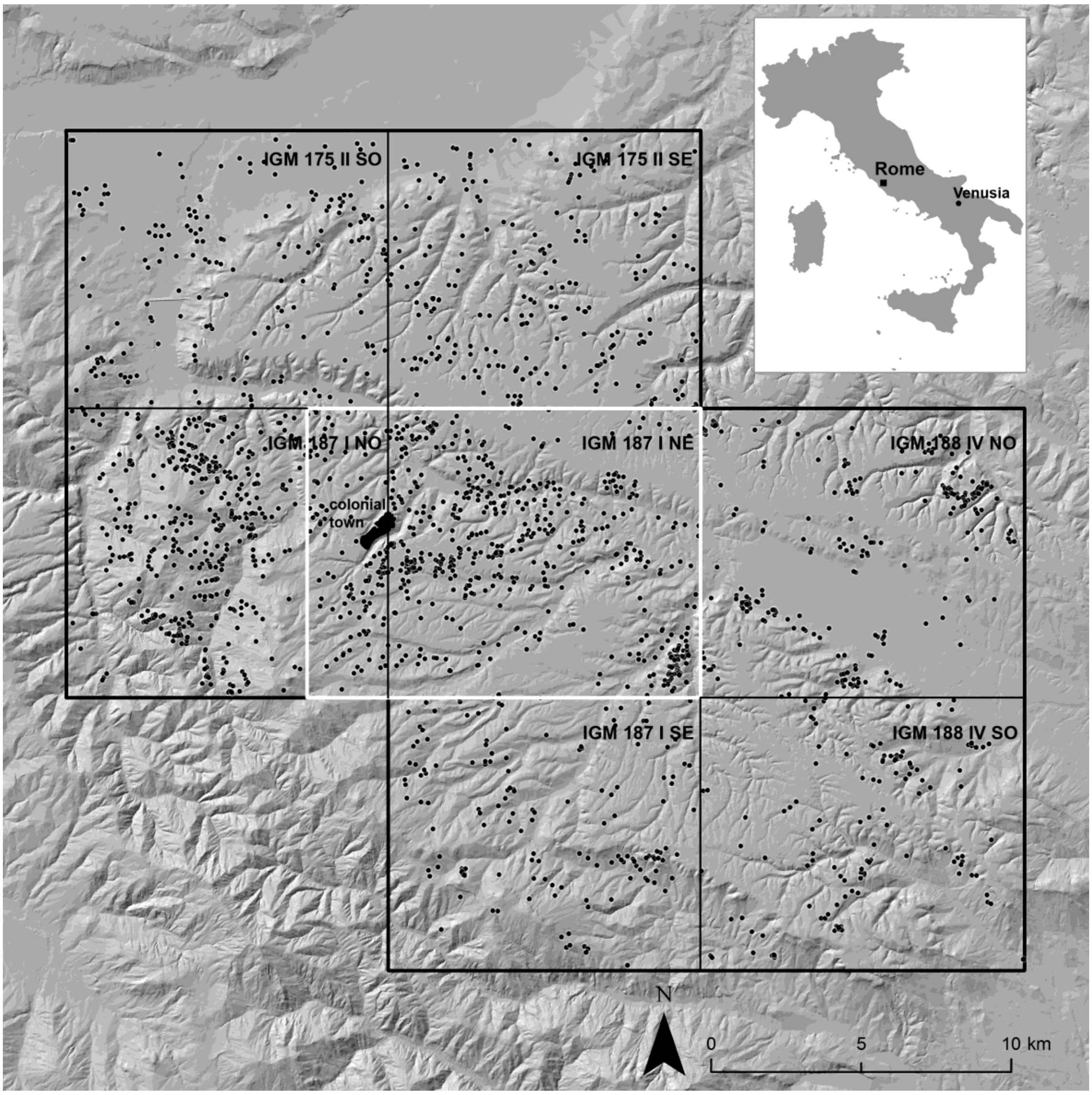

Fig. 1. Forma Italiae *site dataset for the territory surrounding the ancient town of Venusia. In total, 1899 archaeological sites (dating from Prehistory to the Middle Ages) were recorded in a territory of ca. 700 sq km (MARCHI, SABBATINI 1996; SABBATINI 2001; MARCHI 2010). The labels indicate the IGM maps (Istituto Geografico Militare, 1:25,000) used to register archaeological sites. The raster base map is the shaded relief calculated from the 10 m-resolution DEM named TINITALY/01 (TARQUINI et al. 2007). Figure by Anita Casarotto.*

The FI survey aimed to systematically map all archaeological traces onto IGM maps of the area (1:25,000) by using systematic field-walking surveys in all accessible fields (*i.e.,* teams of 3 to 5 persons with 5 to 10 meters spacing between walkers), as well as bibliographic studies and the analysis of aerial photography[4]. Our survey in the same area, conducted in the framework of the Landscapes of Early Roman Colonization project (LERC), employed the same intensity of coverage[5] and site recording methods to compare the two different datasets and patterns in a meaningful way (cf. paragraph 3 for more details). In particular, we were interested in comparing the number, extension, and distribution of the sites recorded by the FI to our surveys. The FI and LERC surveys used the same parameters for recording archaeological sites and tracing their contours, namely by artefact

[3] AZZENA, TASCIO 1996; MARCHI, SABBATINI 1996; SABBATINI 2001; MARCHI 2010, 2016.
[4] For more detailed information on the survey method and site classification: MARCHI 2010: 25-28; PELGROM *et al.* 2014: 33-36; CASAROTTO, PELGROM, STEK 2016; CASAROTTO 2017.
[5] By increasing the intensity of coverage, it may be possible to find more (small) sites during surveys (cf. DI GIUSEPPE *et al.* 2002). That is why we decided to use the same survey intensity, to have more control over significant differences between ours and the legacy data patterns.

density. Surface scatters with a material density of at least 5 artefact sherds (of pottery or building material) per square meter were loosely called 'sites' by both teams, and were classified on the basis of their size, observable material types, density, and chronology.

This paper consists of two parts. In the first part the number of sites recorded by the FI survey project is tested. Possible correlations between survey visibility conditions and the recorded number of Hellenistic sites were tested through a linear regression analysis. The aim of this approach was to evaluate whether localized concentrations of sites (registered by the original FI survey on distribution maps as point clusters) significantly occur in zones with good visibility conditions, and if low site density or empty spaces significantly appear in zones with low visibility conditions. Naturally, it is difficult to apply statistical tests *a posteriori* for previous landscape archaeological projects. However, by combining this analysis with a new survey carried out in the same area by our team, we think it may be possible to get a firmer grip on the measure of distortions that we can expect in legacy data, and thus assess their use for current scholarship.

For this reason, we designed a special testing strategy to analyze the spatial pattern of the Hellenistic settlements. In previous investigations, it was demonstrated that the spatial pattern behind the identified Hellenistic settlement distribution is clustered[6]. In this study, the aim is to test if this pattern is reliable or if it was affected by survey visibility conditions. To test the validity of the settlement distribution recorded about two decades ago by the FI team, we carried out a re-survey in the Venosa area as a part of the LERC project[7] (campaigns 2013 – 2016)[8]. Our re-survey targeted landscapes with clusters of Hellenistic sites, as well as low density and entirely empty zones. "Ground truthing" of the original dataset in these distinctive zones using the same method of the original FI survey allowed us to establish whether the site patterns documented in the FI survey remained the same or if they had changed.

2. Desktop-based analysis: testing the legacy site density

A goal of this research was to determine if the density of Hellenistic settlements as recorded by the FI team was affected by surface visibility conditions. For this analysis, we used the visibility map of the territory close to the ancient town of Venusia, which is based on land use and land cover factors (*c.* 120 sq km, contoured with a white rectangle in fig. 1)[9]. This map proved to be useful for the statistical analysis presented in this paper[10]. Within the said sample area, *c.* 600 archaeological sites were recorded by the FI team, of which 262 settlements were generally dated to the Hellenistic period (350 - 50 B.C.) (fig. 2)[11].

Using a linear regression analysis, we assessed whether there was a significant correlation between agglomerations of sites and survey units in good visibility conditions, and, conversely, if less sites were found in units with less optimal visibility conditions[12]. Since no information is available about the extension and/or the shape of the original survey units[13], we created an arbitrary sampling grid composed of units of 1 sq km (fig. 3), and assumed that all areas classified by the FI team as optimal for survey visibility (class 5, *cf.* below) were accessible and thus surveyed. We then tested each unit to determine whether a direct proportional relationship existed between the extension of the surveyed surface in good visibility conditions (*i.e.,* class 5)[14] and the number of Hellenistic sites that were recorded. If a significant relationship between the two factors exists, one expects that the more well visible the surface is within each unit, the higher the number of sites recorded.

[6] CASAROTTO, PELGROM, STEK 2016; CASAROTTO 2017.
[7] Based at Leiden University. Funds were provided by NWO (Netherlands Organization for Scientific Research) and the KNIR (Royal Netherlands Institute in Rome). See also STEK, PELGROM 2013.
[8] For similar approaches see ATTEMA *et al.* 2007; SEUBERS, TOL 2016; see also AMMERMAN, KOSTER, PFENNING 2013 and the discussion in WITCHER 2008.
[9] AZZENA, TASCIO 1996; MARCHI, SABBATINI 1996: 107.
[10] For another useful application see CASAROTTO 2017.
[11] MARCHI, SABBATINI 1996.
[12] For the same approach see TERRENATO, AMMERMAN 1996.
[13] PELGROM *et al.* 2014: 33-34.
[14] It is important to note that the tiny and localized zone in 'class 6' (optimal visibility, 0.48% of the territory) (see fig. 2) corresponds to a small land plot where a vineyard was in the process of being planted precisely when the survey took place there in July 1988 (MARCHI, SABBATINI 1996: 113, footnote 134). Sites in this zone were recorded under exceptional conditions (while sites were being dug up from the subsoil and destroyed immediately after when the field was leveled and prepared for the vineyard plantation). This site sample is thus unrepresentative for the process of recording sites at the surface through field walking. For this reason, in the following analyses, class 6 is merged with class 5, corresponding to the 'good visibility' land type, namely the deeply-ploughed, ploughed and milled fields (for more information: AZZENA, TASCIO 1996: 292-296).

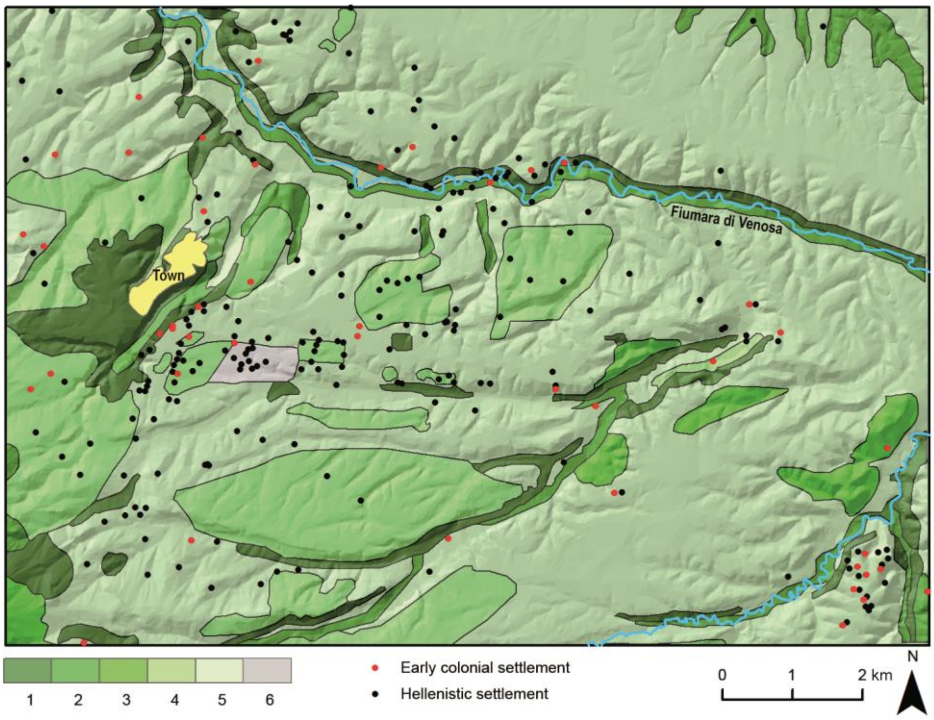

Fig. 2. Hellenistic settlement site distribution and surface visibility map (scale 1: 200,000, based on MARCHI, SABBATINI 1996: 107; AZZENA, TASCIO 1996. Graphic elaboration by Anita Casarotto) for the area close to the town, which corresponds to the area contoured by a white rectangle in fig. 1. Visibility values range from 1 (very low visibility) to 6 (optimal visibility) (see also AZZENA, TASCIO 1996). The raster base map is the shaded relief calculated from the 10 m-resolution DEM named TINITALY/01 (TARQUINI et al. 2007). Figure by Anita Casarotto.

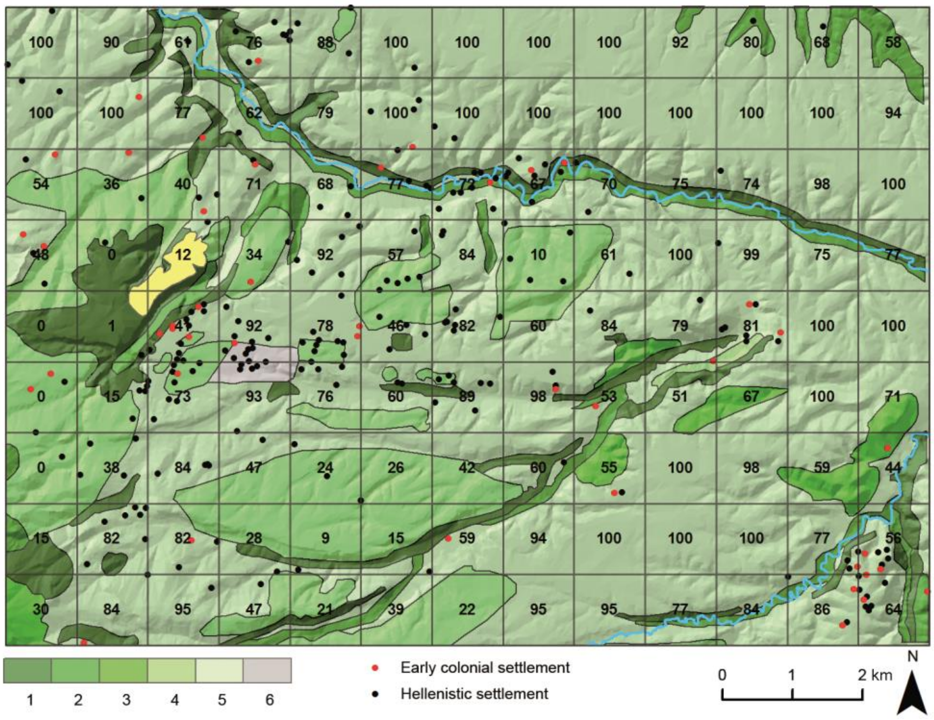

Fig. 3. Arbitrary grid composed by units of 1 sq km. The numeric labels indicate the percentage of the unit area in 'good visibility' conditions (class 5). The raster base map is the shaded relief calculated from the 10 m-resolution DEM named TINITALY/01 (TARQUINI et al. 2007). Figure by Anita Casarotto.

As shown in fig. 4, however, we did not find a direct proportional relationship between the percentage of areas with good visibility and the number of Hellenistic-period sites documented by the FI survey. This might suggest that the number of recorded sites, and also their pattern in space (*i.e.,* clustered pattern), is not the result of visibility conditions. However, it must be noted that the scale of the visibility map does not provide the level of detail required to allow for a finer analysis of visibility distortions[15]. Therefore, caution is needed in interpreting the results of this analysis: once higher resolution visibility maps for assessing smaller-scale visibility distortions become accessible, the results from this analysis will likely change. In light of these evident limitations, an additional test of a possible correlation between visibility and site patterns was carried out (see below).

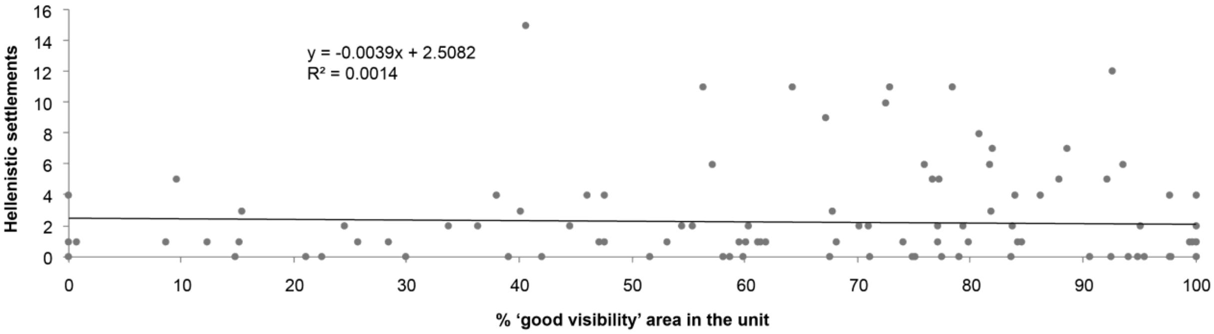

Fig. 4. Regression analysis on the Hellenistic settlements. The correlation coefficient (r) is -0.04. The least-squares method is applied to determine the best fit line to data (see also TERRENATO, AMMERMAN *1996).*
Figure by Anita Casarotto.

3. Control samples from new fieldwork: testing the legacy site pattern

Within the context of the LERC project[16], 3157 ha of the territory of Venosa (PZ, Basilicata) and its surrounding municipalities were systematically re-surveyed in the Autumns of 2013, 2014, 2015, and 2016 (fig. 5)[17]. As with the original FI survey, the LERC survey also worked with teams of five field walkers that were spaced ten meters apart in line transects within each field unit (20% coverage), and with a shard density threshold of five fragments per square meter to identify archaeological sites at the surface. These 'sites'[18] were mapped in the field using GPS positioning systems and mobile devices (*i.e.,* tablets), and in the laboratory they were integrated into the GIS platform.

As previously noted, the LERC team aimed to verify the reliability of the overall large-scale clustered pattern of the legacy Hellenistic site settlement distribution[19] documented by the FI by site-oriented field surveys[20]. In a previous paper, the reliability of the FI settlement patterns was analyzed by targeted re-surveys that focused on the immediate hinterlands of the colonial town which were severely affected by intensive farming practices[21]. Our analysis showed that in such landscapes the archaeological surface record was strongly distorted by modern landscape changes, and that as a result the FI legacy data provides invaluable information that would otherwise be lost. We continued and expanded upon this testing strategy by "ground-truthing" the settlement patterns recorded in the FI legacy data, focusing especially on areas that have remained quite stable in the last decades. Focusing on areas with stable and non-intensive land use allows us to test the reliability of the Hellenistic clustered site pattern recorded in the FI legacy survey data.

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[15] See discussion in CASAROTTO 2017; CASAROTTO *et al.* 2018.
[16] STEK, PELGROM 2013; STEK *et al.* 2016.
[17] Such re-visits offered the opportunity to assess the state of preservation of the legacy survey record. It was sadly acknowledged that mechanized agricultural activities (vegetation clearance, tillage, and land leveling) and water erosion (TORRI *et al.* 2006; TORRI, BORSELLI 2011), are triggering the disappearance of the archaeological record both at the surface and beneath it. In particular, modern plantations of vineyards, orchards, and olive trees, which require land leveling and extensive sediment movement, strongly affect the soil stratigraphy in this region (BORSELLI *et al.* 2006), and thereby the archaeology contained in it. This dramatic situation has called for the monitoring of the geomorphic modifications caused by unregulated plowing and land leveling activities. EU funds were budgeted to monitor and prevent the widespread degradation of this landscape, and to foster sustainable territorial planning strategies for the preservation of the soil (SCHWILCH, HESSEL, VERZANDVOORT 2012).
[18] The term 'site' was used in the field loosely to indicate concentrations of archaeological material on the ground surface (scatters). These material scatters indicate that in the surrounding or underneath the surface archaeological sites or evidence may be present.
[19] cf. CASAROTTO*,* PELGROM, STEK 2016.
[20] On these surveys see PELGROM *et al.* 2014, 2016.
[21] GARCÍA SÁNCHEZ, PELGROM, STEK 2017.

Fig. 5. LERC field survey activities in the territory of the Latin colony of Venusia (LERC survey 2015). Photo by Anita Casarotto.

We selected three areas to act as control samples which were re-surveyed by the LERC team (shown in fig. 6). The first sample area (A - Messero – Lo Scannato) was chosen because several high and localized site concentrations (clusters) were originally documented by the FI survey here (these clusters have a Hellenistic site density equal to or greater than five sites per sq km)[22]. In contrast, the second sample (B - Salto dei Paladini/Lasano) had a remarkably low density of Hellenistic settlements (an average of one or two Hellenistic sites per sq km). The third sample area was devoid of sites altogether (C - Lì Castellani) and located between the landscape zones that had clusters of sites.

In selecting the sample areas, we also considered the visibility conditions. We selected areas with comparable visibility conditions during the previous FI survey and our re-survey (for the FI survey, we used the published FI visibility maps[23]). Moreover, the Corine Land Cover 1990, 2000, 2006, 2012 (1: 100,000)[24], the Carta dell'Uso Suolo della Regione Basilicata 2013 (1: 5000)[25], and the Coltura Agricola 2006 (1: 5000)[26] maps indicated that the land use in these three sample areas did not remarkably change over the last decades (*i.e.,* mainly non-irrigated arable land, with associated sporadic vineyards, orchards, and other crops). Thanks to this continuity in visibility and land use conditions, we could theoretically exclude that major variations in surface conditions (occurring in the last decades, after the FI survey and before the LERC survey) were responsible for possible differences in site patterns recorded by the two surveys.

Fig. 7 exemplifies that the LERC data patterns are comparable to the FI data patterns in all three sample zones, in both empty and densely settled areas. In sample area A (surveyed area 748 ha) (fig. 8), the LERC team recorded localized site densities (clusters) in the same zones where the FI team had recorded them. Many LERC sites were even located in the precise position and extension as the recorded legacy sites. Additionally, some new sites were identified[27], and a few sites were not found in the re-survey. Unrecovered sites were likely caused

[22] see Casarotto, Pelgrom, Stek 2016.
[23] Marchi, Sabbatini 1996: 107; Sabbatini 2001: 59.
[24] European Environment Agency (EEA). https://www.eea.europa.eu/publications/COR0-landcover
[25] Regione Basilicata - Centro cartografico dipartimentale della Direzione Generale del Dipartimento Ambiente e Territorio, Infrastrutture, Opere pubbliche e Trasporti. http://rsdi.regione.basilicata.it
[26] Regione Basilicata - Centro cartografico dipartimentale della Direzione Generale del Dipartimento Ambiente e Territorio. http://rsdi.regione.basilicata.it
[27] It is possible that some of these new sites are the same sites recorded by the FI team but shifted on the map one or few dozens of meters away from their original position. If that is the case, this shift in mapped position can be explained in two ways. First, it is possible that topsoil movements within the field induced by ploughing, land leveling, and shallow landslides had moved the original sites (or, alternatively, had unearthed new material, thus creating new 'sites', cf. discussion in the text paragraph). Second, the different scale adopted by the two surveys

by these scatters being destroyed by recent intensive agricultural activities or their positions being changed by erosive forces, including ploughing activities. The phenomena of material scatters appearing and disappearing is well known in archaeological literature, and coined famously by Barker and his Biferno Valley team as "traffic lights" because the scatters may switch on and off according to changes in soil, land use, and survey conditions[28]. However, our research shows that despite these changes in site detection, the overall pattern and density of sites in both surveys remained more or less the same.

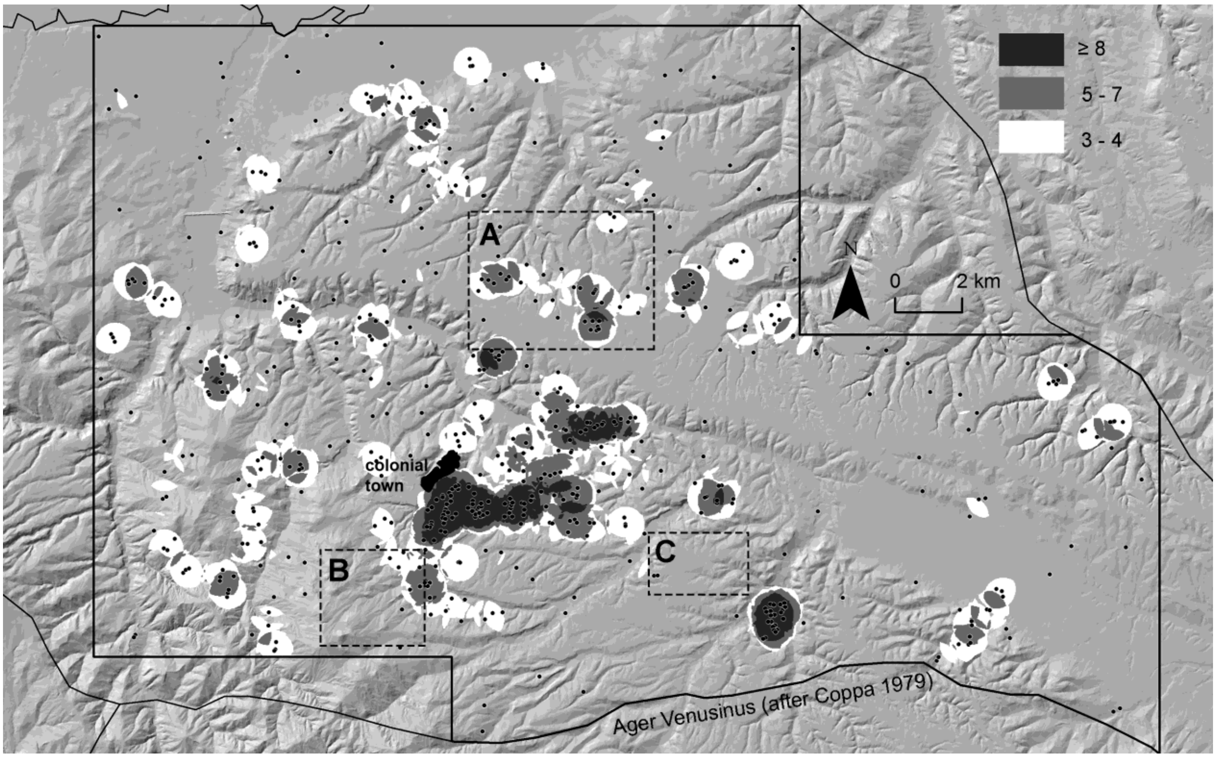

Fig. 6 Location of the three control sample areas re-surveyed by the LERC team. The palette indicates the density of legacy Hellenistic settlement sites (i.e. number of sites per sq km) recorded by the FI team (see also fig. 2 in CASAROTTO, PELGROM, STEK 2016). The raster base map is the shaded relief calculated from the 10 m-resolution DEM named TINITALY/01 (TARQUINI et al. 2007). Figure by Anita Casarotto.

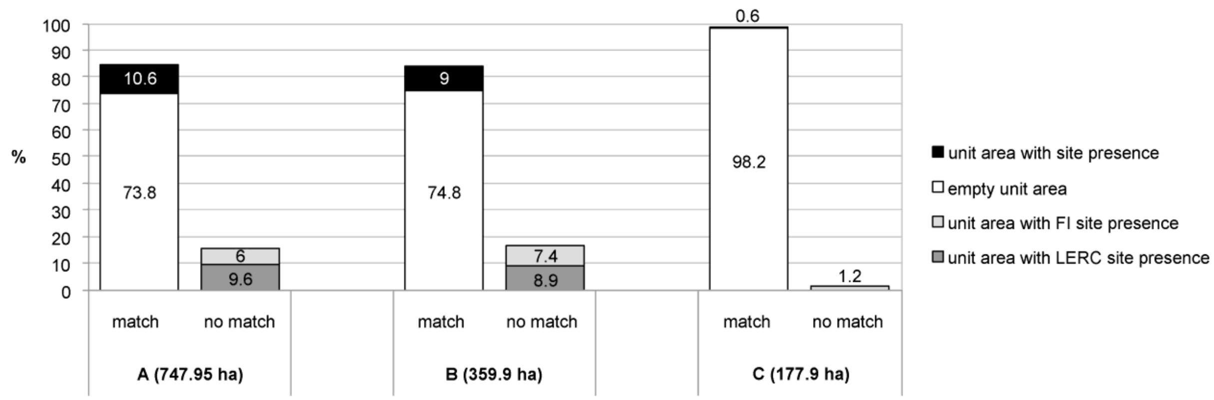

Fig. 7 Percentages of matching and non-matching re-surveyed area in each control sample zone (A, B, and C). Figure by Anita Casarotto.

to register sites on maps can explain small discrepancies in the mapped position between some FI and LERC sites. In this analysis we used the 1:25,000 scale distribution maps produced by the FI team (MARCHI, SABBATINI 1996; SABBATINI 2001; MARCHI 2010) as a support to digitalize in GIS the position of the legacy sites. GPS coordinates were used, instead, to map the position of the LERC sites. To take this into account, field units, rather than the point locations of the FI and LERC sites, were considered when comparing the two datasets (see figs. 8-10).

[28] LLOYD, BARKER 1981.

The same effect is also documented for sample area B (surveyed area 360 ha) (fig. 9). For this area there was a strong correlation between the pattern mapped by the LERC re-survey and the pattern recorded by the original FI survey.

Particularly interesting is the comparison of the settlement patterns identified in the FI survey and in the LERC survey for sample area C, the 'empty' area (fig. 10). The LERC team adopted an intensive survey strategy for mapping an area of 178 ha. Within rectangular units of *c.* 2500 sq m in size, all sherds and all other finds were collected by surveyors along each transect. GPS and tablets were used to record the position and the extension of archaeological sites. Despite surveying decades apart and under perfect visibility conditions (clear, arable fields), both teams found little to nothing. Only two scatters of material culture were detected at the edge of this empty zone (by both teams, in the same area, with comparable extension), both of which were interpreted as the remains of a Republican period settlement.

Fig. 8 Comparison between the LERC site pattern and the FI site pattern in sample area A. The material scatters documented by the LERC team are indicated as well (black polygons).
Figure by Anita Casarotto.

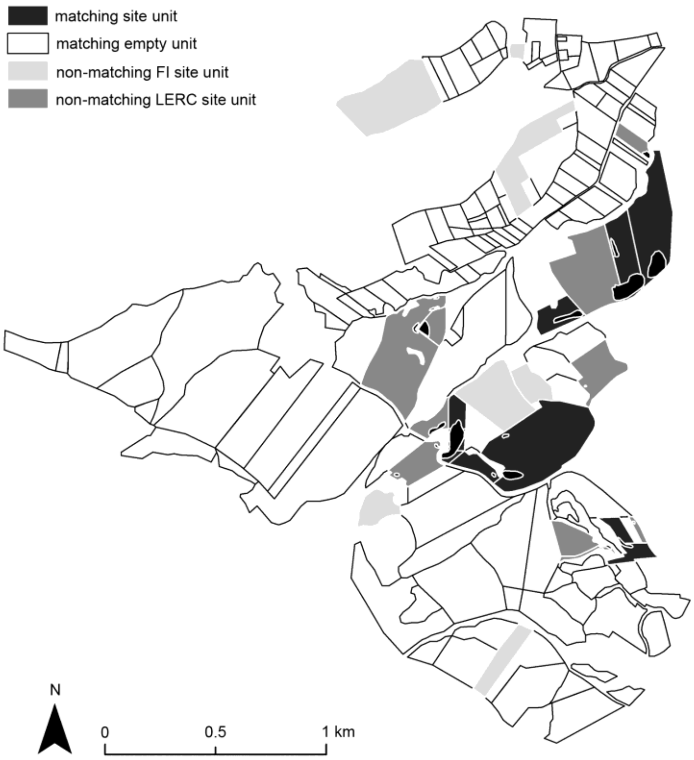

Fig. 9 Comparison between the LERC site pattern and the FI site pattern in sample area B. The material scatters documented by the LERC team are indicated as well (black polygons).
Figure by Anita Casarotto.

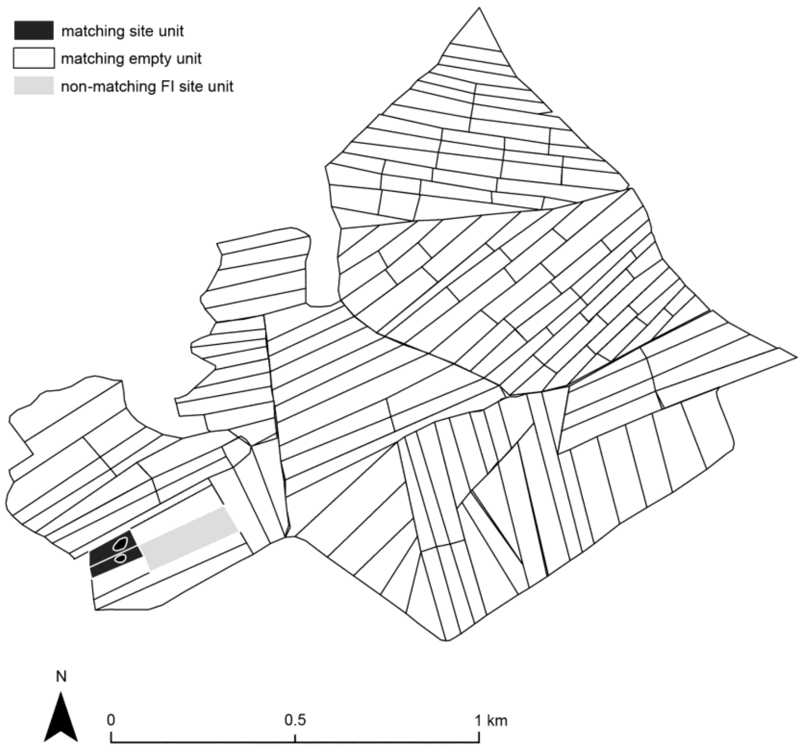

Fig. 10 Comparison between the LERC site pattern and the FI site pattern in sample area C. The material scatters documented by the LERC team are indicated as well (black polygons).
Figure by Anita Casarotto.

4. Conclusions

The two types of analyses carried out in this paper reveal that the site patterns recorded by the FI field survey are not the sole product of visibility factors. Alone, this evidence does not demonstrate the validity of legacy survey data for reconstructing ancient settlement organization and historical developments on a regional scale. However, it does indicate that the legacy data provides reliable information on overall patterns of sites that are visible on the surface[29]. Although site locations might change on a microscale[30], our research suggests that in fairly preserved landscapes overall macro patterns may remain quite stable over time and between different survey campaigns[31]. It is important to emphasize that we only selected areas with good visibility and minimal impact by modern anthropogenic practices following the FI survey, and thus with optimal preservation of the archaeological record. This selection was suitable for our research questions, however the results would be quite different for areas that were subjected to concentrated human interventions after the FI survey[32]. In Venosa and its surroundings, the land has been drastically modified in recent years through intensive agricultural activity by the planting of permanent crops such as vineyards and olive orchards[33]. While surveying these portions of the landscape, it became clear that the surface record registered only two decades ago is rapidly disappearing.

Modern agricultural practices are unsustainable for the preservation of the soil and the archaeological record above and beneath the surface. However, in well preserved zones where archaeological information can be retrieved, the distribution of the legacy survey data and the new survey data is comparable, enhancing the usability and value of the original legacy survey dataset. This is especially important for zones where new survey data cannot be collected because the soil has been disturbed or destroyed. For the areas of the Venosa landscape which have had intensive agricultural use, as well as in other intensively exploited parts of the Mediterranean, the data recorded prior to the diffusion of large-scale agricultural mechanization and urbanization is the most complete record archaeologists have to analyze ancient settlement patterns. We believe that this conclusion holds true despite the often obsolete documentation formats and heterogeneous and intrinsically fragmented nature that often characterize legacy survey datasets[34].

As to the case study presented in this paper, the FI team was able to record sites on a regional scale immediately before the rise of destructive, intensive, mechanized agriculture and the rise of a massive production of wine and olive oil in this region. Therefore, in light of the analyses presented here, we conclude that the FI legacy dataset offers a unique and precious source of information to current scholarship for understanding ancient regional settlement patterns.

Acknowledgements

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[29] See discussion in BARKER 1991; WITCHER 2008. For a description of the Hellenistic-period site patterns in Venosa see CASAROTTO, PELGROM, STEK 2016, 2019. It is important to highlight that for finer-scale analysis (*e.g.,* with intra-site analysis based on small-scale off-site surveys) legacy survey datasets do not always provide the detail that would be needed to tackle site-based research questions. On the other hand, they may inform more "coarse"-scale analysis and regional research questions, as our paper suggests. Cf. discussion in ATTEMA *et al.* 2020.

[30] See discussion in LLOYD, BARKER 1981; GARCÍA SÁNCHEZ, PELGROM, STEK 2017.

[31] Of course, due to the generally problematic nature of survey data (LLOYD, BARKER 1981; AMMERMAN 1985; PASQUINUCCI, TREMENT 1999; FENTRESS 2000; FRANCOVICH, PATTERSON, BARKER 2000), we cannot expect that the sites recorded by the FI team are the very same sites recorded by the LERC team; this is not our point here. It is significant, however, that on a regional scale the macro patterns produced by the FI and LERC surveys are very similar, and lead to similar historical reconstructions of ancient settlement in this area (CASAROTTO, PELGROM, STEK 2019).

[32] See DI GIUSEPPE *et al.* 2002; ATTEMA *et al.* 2007.

[33] Discussion in BORSELLI *et al.* 2006.

[34] Cf. discussion in WITCHER 2008; CASAROTTO 2021 provides a description of a possible method to unlock legacy survey datasets and deal with data inhomogeneity and obsolescence.

Melkebeek, Serban Micu, Koos Mol, Ben Naylor, Zizi Rico Neves, Bianca Olteanu, Ine de Pape, Isabel Perales Pérez, Manuel Peters, Jorge Santamaría Treceño, Jacqueline Splinter, Eef Stoffels, Niels Stoffels, Nele Struyf, Ivar Svensson, Sofia Taipale, Leon Theelen, Eduardo Arancón Torrecilla, Vanesa Trevín Pita, Ties Verhoeven, Eva Visser, Naomi Vlieks, and Evelien Witmer. We are also grateful to the Soprintendenza Archeologia Belle Arti e Paesaggio della Basilicata, the staff of Museo Archeologico Nazionale di Venosa, and to Prof. Maria Luisa Marchi who kindly gave us access to the Forma Italiae data, and for our productive collaboration. Finally, we sincerely thank the community of Venosa for their warm hospitality.

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