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Managing the marshes: An integrated study of the centuriated landscape of the Pontine plain

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ABSTRACT

The study of Roman centuriation has a long and rich tradition, and the past decades have witnessed the rise of new perspectives on these field systems. Even though these systems were considered for some time as static structures studied through metrological analyses, they are increasingly considered as dynamic elements in the management of landscapes and the reclamation of wetlands, that should be studied from a long-term perspective. Methodologically, this development has gone hand in hand with an integration of GIS-based archaeomorphological approaches, historical, geo-archaeological and, less commonly, ecological data. This paper builds on such approaches in order to study centuriation as a complex socio-economic, political and ecological phenomenon. It aims to show that the changing roles of centuriation in human engagements with the environment can only be understood by applying a framework that integrates perspectives and approaches from different disciplines. After introducing the characteristics of this integrated framework, the paper presents a case study that synthesises recent work on the centuriated landscape of the lower Pontine plain (Lazio, central Italy), an infamous marsh with a long history of (failed) reclamation projects.

A GIS-based analysis of cartographic and remote-sensing imagery, including geophysical prospection data, shows that this centuriation covered an area of some 120 km² and consisted of a hierarchical system of in-field and field-bounding ditches as well as larger collectors that drained towards the sea. Palaeoenvironmental reconstructions suggest that the centuriation and several associated canals improved the hydrological structure, although such improvements may have started before.

Archaeological prospections and geo-archaeological data allow us to consider both when the centuriation was established and how its role in managing and exploiting the Pontine wetland changed through time. It probably dates to the late 4th or early 3rd century BCE and presumably is one of the first of its kind. It was established in the context of Rome's territorial, economic and demographic expansion and represented a large-scale reclamation that expanded Rome's agricultural hinterland, providing dwellings, farmland and a new life for numerous colonists. But the exploitation of the Pontine wetland by a system of small farms that occupied the centuriated area proved not to be sustainable: within two centuries settlement had decreased significantly and by the Imperial period only a few sites remained, some of which represent elite-controlled estates. The decline of settlement and its associated land use system can be explained by a series of socio-economic, political and environmental factors, including Rome's on-going territorial expansion, changing elite interests in the area as well as environmental change. Individual features of the centuriation, however, remained in use for considerable time. Even though medieval and post-medieval reclamations used parcelling systems with a different orientation, the main channels associated with the centuriation remained the basis for later attempts to drain the Pontine wetland.

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1. Introduction

The study of centuriation¹ in Roman Italy has a long and rich tradition, in which due attention has been paid to metrological (the measures that

have been used) and chronological (date of construction and link to Roman colonization) issues. Over the past decades new perspectives have developed, using more integrated methodologies and seeking to understand centuriation as landscape management projects as well as wetland reclamations that transformed the structure and use of landscapes in the long term. However, few attempts have been made to understand how centuriation transformed the natural environment and conditioned the ways in which people and institutions involved in their creation, maintenance and exploitation actually interacted with and modified the environment.

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¹ With the term centuriation I here refer to Roman cadastral systems in general, although strictly speaking centuriation are only those systems using square land division units, usually of 20 by 20 *actus* in size.

This paper contributes to the development of such a perspective and aims to study centuriation not only as static, centrally organized management structures that mainly had economic purposes, but also as dynamic landscapes where people lived their daily lives and, intentionally or not, contributed to environmental change. To this end, I discuss a case study, drawing on recent desktop and field research in the Pontine Marshes, an infamous wetland situated in south Lazio (central Italy), and evaluate this case study in light of long-term human–environment interactions. But before turning to the Pontine case, I first briefly review current approaches to centuriation and introduce the assumptions that underpin the framework I use.

2. Centuriated landscapes: past and current approaches

Within the rich and long-standing tradition of research on Roman landscapes, the study of centuriation has an important place. The widespread availability of aerial photographic imagery has since WWII provided ample evidence for the existence of such systems all over the Roman World.² From the 1980s on it was especially Italian and French scholars that elaborated morphological approaches to identify centuriation and understand their functioning in relation to the works of the Roman land surveyors.³ Such work has been very successful in mapping centuriation; to some extent it has also contextualised them as management programs that were part of Rome's territorial and agricultural expansion and involved complex engineering operations and administrative and legal organization.

However, on-going scholarship has identified several weaknesses in exclusively morphological approaches. First, many of the hypothesised centuriation schemes have not been verified by alternative sources of evidence, and some have been exposed as erroneous.⁴ Second, remote sensing data by itself does not allow dating of centuriation and thus leaves open the question in which historical context they should be placed. Third, focusing on reconstruction does not necessarily help us understand how they functioned as cadastres and/or wetland reclamation projects. Thus, while morphological approaches allow the reconstruction of centuriation, they do not allow us to properly assess their historical context and functioning. In this light, it is not surprising that the prevailing image of centuriated landscapes is still that of a natural landscape that has been transformed rationally and radically into a uniform, agriculturally productive territory – a display par excellence of Rome's conquest over nature and indigenous societies.⁵

Over the past decades, more integrated GIS-based approaches rooted in landscape archaeology have been developed that are much more sensitive to issues of dating, function and historical context.⁶ Such research uses archaeomorphological approaches to reconstruct the long-term development of landscapes. In some cases they include excavation to test reconstructions, use geo-archaeological and/or ecological data to better understand the chronology and impact of centuriation, and survey data to relate them to changing patterns of settlement and land use.⁷ Such approaches have also been applied in recent work in northern Italy,

particularly the Po plain. They provide increasingly sophisticated reconstructions of centuriation and apply geoarchaeological approaches to understand the palaeogeography and/or use archaeological settlement evidence and ecological data to assess the diversity in settlement, land use and vegetation within centuriated areas.⁸ Additional field methods such as geophysical prospections and excavation are occasionally applied to investigate in detail traces of these systems.⁹

These integrated approaches are improving our understanding of how the Roman State and its engineers engaged with the Italian landscape. They show that centuriation were indeed not just rigidly designed cadastres that in conjunction with roads and rivers structured the landscape: they adapted to the landscape, drained wetlands and may to some extent be considered as reclamation projects.¹⁰ Long-term contextualisation and historical comparisons show that their scale and impact surpassed that of many medieval projects; they were resilient structures that profoundly influenced the subsequent development of landscapes. At the same time, centuriation should probably not be considered as integral reclamation projects in the sense that the entire landscape was drained and rendered cultivable in a uniform way. Rather, drainage conditions and land use varied within them, with marshlands and well-drained arable farmland existing side by side.¹¹ This makes a re-assessment of persistent, idealised conceptions of centuriated landscapes all the more important.

Despite increasing interest in the environmental context and functioning of centuriation, integrated approaches have so far not been applied in other parts of the peninsula. Also, the issue of how to date centuriation still poses challenges: consisting of ditches, canals and roads, they are extremely difficult to date directly, and archaeological settlement evidence to date them indirectly or to understand how centuriated areas were actually settled and exploited is not regularly used.¹² It is therefore not surprising that the ideological role of centuriation in Rome's expansion over the Italian peninsula has featured much more prominently in recent scholarship than their economic and ecological impact.

Elsewhere, however, current approaches still primarily consider centuriation from an economic perspective and pay less attention to the social and ecological dimensions.¹³ Centuriations are regarded as physical manifestations of top-down, large-scale management projects intended to structure landscapes and increase agricultural output. But dealing with centuriated landscapes that included reclaimed wetlands and could be quite hostile and unhealthy environments was part of the lives of many, including peasant farmers working small plots of land, slaves working on estates, elites that controlled such estates, and pastoralists seasonally exploiting wetlands for pasture. Whilst it was institutions such as the Roman state that initiated centuriation, the varying interests and actions of these agents exploiting centuriated areas would have a major impact on their subsequent development. Understanding their actions and the impact of these actions on the landscape is thus important for our understanding of the history of centuriated landscapes.

3. An integrated the study of centuriation: underlying assumptions

Centuriated landscapes are thus shaped by complex interactions between humans and the environment. To understand the development

² Pioneering work was done by scholars such as Castagnoli (1956) and Bradford (1957); see also Dyson, 2003: 58–60.

³ For Italy, the *Misurare la Terra* volumes remain a fundamental source. For French work in Italy, see in particular Chouquer et al., 1987; Ceraudo and Ferrari, 2010, building on pioneering work by Bradford and others. On the agrimensores and the *corpus agrimensorum romanorum*, see Dilke, 1971; Campbell, 2000. For work on the juridical aspects of centuriation as part of landscape management, see also contributions in *Agri Centuriati* 6 (2009).

⁴ Palet Martínez and Orengo, 2011: 383/84 with references.

⁵ See Stek, 2014, discussing the iconic image of a centuriation system as an expression of Rome's power to transform the lands of the conquered peoples of Italy and to impose order on nature, originally drawn by Moscarà (Settis, 1984, Fig. 129).

⁶ See contributions in *Agri Centuriati*, the founding of which is a clear reflection of the increasing interest in the subject (Dall'Aglio, 2004).

⁷ For archaeogeographical or archaeomorphological approaches developed in Spanish and French scholarship, see Orengo and Palet Martínez, 2009; Palet Martínez and Orengo, 2011; Chouquer, 2008; Chouquer and Watteaux, 2013.

⁸ For case studies, see Franceschelli and Marabini, 2004; Franceschelli, 2008; Dall'Aglio, 2009; Marchesini and Marvelli, 2009; Franceschelli and Trément, 2010; Matteazzi, 2014. On centuriation and transhumance, see Camerieri and Mattioli, 2011.

⁹ Mete, 2011.

¹⁰ Dall'Aglio, 2004.

¹¹ Dall'Aglio and Franceschelli, 2012; Palet Martínez et al., 2011; Frassine, 2013.

¹² See also Pelgrom, 2008. In many cases processes of erosion and deposition pose limitations on the available archaeological evidence; in other cases it is rather a lack dedicated research. For statistical approaches to measuring association between sites and cadastral traces, see also Peterson, 1993 and <https://www.uea.ac.uk/~jwmp/compmethods/cadks.html> (accessed August 18th 2015).

¹³ Palet Martínez and Orengo, 2011.

of these landscapes we therefore not only need to reconstruct the chronology, function and economic impact of centuriation, but also study them in light of social and ecological developments. To do so, I use a framework that is based on four assumptions:¹⁴

First, I consider change as multi-causal, multi-scalar and historically contingent and the result of reciprocal interactions between humans and the natural environment. We should therefore consider both environmental factors (soil and drainage properties, vegetation, sea-level, climate) and human agents (from the individual peasant farmer to the institutional decisions behind the design and execution of centuriation) to explain the development of centuriated landscapes. Crucially, environmental change itself is also an agent in processes of change.

Second, to understand the role of these agents and processes, we should accommodate and integrate concepts, methods and data from all relevant disciplines that provide information on them. Archaeological, ecological, (comparative) historical and ethnographic data are therefore all relevant if not indispensable to appreciate the complex and changing relations between humans and the natural environment.

Third, as environmental and cultural change result from interactions at various spatial scales, supra-regional, regional and local processes require study and integration. To explain why centuriation was conceived, we should therefore not only use historical, archaeological and environmental data to study the general socio-political, geographic and climatic conditions under which centuriated landscapes were created and how these conditions subsequently changed; we should also include regional field survey data and palaeoenvironmental data to understand how centuriation changed the environment (e.g., as drainage systems) and structured settled landscapes. Finally, detailed micro-studies building on geophysical prospections, coring, excavation and ecological work help understand how the physical features of centuriation (ditches, canals) were actually used by and affected human agents.

Fourth, as change is historically contingent, I adopt a temporal perspective that can accommodate both long-term processes such as climate change and demographic and economic cycles as well as short-term events such as natural disasters and political decision making. Being part of a much longer history of interaction between man and environment, centuriation may have built upon previous interventions in the landscape, or conversely have been responses to earlier unsuccessful attempts to manage the environment. An understanding of pre-Roman phases of settlement and land use and elements of continuity and change are therefore needed in assessing the changes their establishment brought about, and how these changes themselves affected the sustainable exploitation of centuriated landscapes. Finally, as centuriation left an enduring imprint on the landscape, the study of these imprints aids in understanding the formation of the past and present landscape.

I stress that these assumptions are already applied in the study of centuriation – and that thorough archaeomorphological analyses remain fundamental to their study. At the same time, studies that integrate morphological research with historical contextualization and scalar, long-term archaeological and palaeoenvironmental approaches are rare. The following case study of the centuriated landscape of the lower Pontine plain (Lazio, Central Italy) therefore seeks to illustrate how such an integration helps understanding processes of socio-economic and environmental change in relation to centuriation. In it, these four assumptions are used to study the Pontine centuriation both as an adaptation to changing environmental and socio-economic conditions and as an agent of environmental and cultural change; they also allow us to consider the different agents involved in the creation and exploitation of the centuriation and to assess their role in the development of the centuriated landscape over time.

¹⁴ My framework is very similar to historical ecology, “[...] a research program concerned with the interactions through time between societies and environments and the consequences of these interactions for understanding the formation of contemporary and past cultures and landscapes (Balée, 2006: 76; see also Meyer and Crumley, 2012).

4. A case study: the context, function and impact of centuriation in the Pontine marsh

The case study concerns the Pontine marshes, situated on the Tyrrhenian coast of central Italy (Fig. 1). This area is especially suited for development as a case for several reasons. First, the University of Groningen has carried out an extensive program of archaeological and palaeoenvironmental field research in this area. In particular, recent field research undertaken within the Minor Centres and Hidden Landscapes Projects provide high-resolution data on the development of landscape and settlement in the centuriated area.¹⁵ Second, aerial photography, cartographic sources, remote sensing data and pilot field studies provide detailed information on the elements and traces of the centuriation and their relations to other features of the landscape.¹⁶ Third, this centuriation was one of the first of its kind and provides a key source for a not well-known phase of Rome's territorial and agricultural expansion. Finally, the system itself is relatively well-preserved, and hypotheses developed here can therefore be tested through targeted work in the future.

The case study discusses five aspects of the Pontine centuriation: its metrological characteristics and date; the palaeogeographical and hydrological context and function; settlement and land use in the centuriated area; the decline of the centuriation; and its influence on long-term landscape development. In line with the four assumptions discussed before, I combine morphological, historical, archaeological, geoarchaeological and ethnographic data and explicitly refer to different spatial and temporal scales at which they help understand these five themes. In the concluding remarks the outcomes of the case study are used to arrive at a fuller understanding of the centuriation.

4.1. The centuriation: characteristics and historical context

Traces of a centuriation in the Pontine plain were already identified in the 19th century, and a first systematic study of its traces was undertaken by Cancellieri in the 1980s.¹⁷ More recently, the author analysed additional sets of aerial photographs and cartographic sources.¹⁸ Together, these studies show that the centuriation consisted of blocks of 10 by 10 *actus* oriented North-South East-West and that it covered an area of at least 120 km² (Fig. 1). Although there is an apparent trigonometrical relationship with the via Appia, the angle between this road and the centuriation is not exactly 45°. ¹⁹ As we will see, a canal situated further north may rather have been used as the central axis of the system.

A Roman date for the system seems beyond doubt as the centuriation's measures are clearly Roman and its orientation matches none of the known post-antique parcelling systems. On the basis of its orientation and historical events, it has been attributed to the period between the establishment of the *tribus oufentina* (318 BCE) and the construction of the via Appia (312 BCE).²⁰ Although not confirming this exact chronology, the field survey data discussed below does point to a mid-Republican date for the grid: farm sites were founded in the

¹⁵ The archaeological data derive from De Haas, 2011 and Tol & de Haas (in preparation). Palaeoenvironmental research was undertaken by Feiken (2014), who builds on work by Sevink et al. (1982, 1984) and Attema et al. (1999).

¹⁶ The reconstruction of the centuriation is a preliminary one, made on the basis of 1:5,000 maps from the 1920s and sets of aerial photographs from 1936, 1955 and 2000 (courtesy IGM). LiDAR data and additional sets of aerial photographs will be used in the near future to refine this reconstruction.

¹⁷ De La Blanchère, 1884; Cancellieri, 1985, 1990.

¹⁸ De Haas, 2011: 210–213.

¹⁹ Peterson, 1992. Magli et al. (2014a, 2014b) suggest that both practical and symbolic factors explain the orientation of the grid and its peculiar relation to the Via Appia. While their suggestion that both belong to a single project might be true, their reconstruction of the grid needs to be assessed on the basis of the on-going study of the traces of the system and an improved model of the grid.

²⁰ Cancellieri, 1990: 66/67: whilst it must have followed on Roman land distributions in the area, she asserts that the *agrimensores* would have followed the orientation of the Via Appia if it had been constructed later. For counterarguments, see Pelgrom, 2012: 99–104.

Fig. 1. Location of the Pontine centuriation in the lower Pontine plain (inset: location of the Pontine region within central Italy).

area in the late 4th/early 3rd century BCE and it seems unlikely that these farms existed without prior drainage and parcelling. As site numbers rapidly decline in following centuries, it is also unlikely that the centuriation relates to a later phase of occupation.

An additional argument for placing it in a late 4th – early 3rd century BCE context is its relation with the Decennovium, a canal that runs parallel to the Via Appia and one of the main waterways draining the Pontine wetland. Some of the major features of the centuriation were canals that drained into the Decennovium (cf. Figs. 3 and 4); it is therefore unlikely that the Decennovium did not exist when these canals were laid out. If we accept that the Decennovium is contemporaneous with the Via Appia, we should place the centuriation in the same chronological context.

4.2. The palaeogeographical and hydrological context

To understand the function of the centuriation, it is important to consider its hydrological and physical geographic context (Fig. 1). The Pontine plain, enclosed by the Lepine and Ausoni Mountains to the north and east and the Alban Hills to the northwest, consists of two parts: along the coast, a system of marine terraces with sandy and clayey deposits that lie between c. 1 and 45 m above sea level; and a lower-lying inner plain consisting of peaty and clayey deposits at altitudes between 0 and 15 m above sea level. Rainfall from the Alban Hills and the Lepine Mountains and water from springs along their edges therefore flows in a south-eastern direction through the lower plain, to discharge into the Tyrrhenian Sea near ancient Tarracina. The centuriation lies in this inner plain, a graben in geological terms, that has very adverse drainage conditions and requires adequate, continued management in order to render it cultivable.

The genesis and land use history of the Pontine graben can be reconstructed in detail on the basis of geological and geoarchaeological

research.²¹ In pre-Roman times, a large part of the area was covered by a fresh water lake, with surrounding woodland swamps crossed by streams and relatively high and dry levees that were settled and used for small-scale agriculture from the Bronze Age onwards.²² From the later Iron Age, processes of erosion caused the streams entering the wetland to deposit increasing amounts of sediment, pushing back the lake. By the Roman Republican period, the lake had largely disappeared. To the north and east alluvial fans had formed, while to the northwest, an extensive sheet of colluvial-alluvial sediments had been deposited by a series of streams. ‘Tongues’ of such sediments were deposited along active canals towards the southeast, further into the lower plain, which consisted of peat land surrounded by floodplains (Fig. 2a).

Apparently, this process of sedimentation was not only human-induced in the sense that it was caused by erosion that followed on the exploitation and deforestation of the Alban Hills and Lepine Mountains.²³ It may also have been consciously steered by human agents in the lower plain. The palaeogeographical reconstruction (Fig. 2a) shows that several of the streams that traversed the marsh, such as the River Oufens, the Murillo stream that runs almost parallel to the Via Appia c. 1.2 km to its north, were canalised in order to regulate the flow of water and sediment in a NW-SE direction. This process of hydrological management may have started before the actual laying out of the centuriation: some of the centuriation traces cross and therefore probably post-date the Murillo stream and the stream directly

²¹ Feiken, 2014; see also Sevink et al., 2013 and Walsh et al., 2014 for a summary. Feiken's reconstruction does not cover the entire centuriated lower plain; on-going geoarchaeological research will extend it towards the southern part of the centuriated area.

²² Feiken et al., 2012.

²³ Attema et al., 1999.

Fig. 2. a/b. Palaeogeographical reconstruction (c. 2200 BP, Roman Republican period; after Feiken, 2014: Fig. 9.2) of the northern part of the Pontine marsh overlaid with the observed centuriation traces (a) and the reconstructed grid (b).

north of the Murillo.²⁴ Also, Republican period sites lie on top of sediments deposited by the Murillo.

Unfortunately we currently do not have any further evidence to establish the exact chronological relations between the various streams, canals and the deposits associated with them. However, it seems clear that the centuriation was laid out in conjunction with at least four main waterways: first, the abovementioned Murillo, which runs at exactly 45° to the centuriation system, and has a regular metrological (1:1) relation with it (Fig. 2b).²⁵ It may have been used as a central axis in laying out the centuriation and initially must have formed one of the main water collectors; second, the Decennovium, that captured run-off from the northern Lepine Mountains; third, the canalised Oufens river that improved the run-off from the southern Lepine Mountains; and fourth, the Rio Martino, a canal that runs through the marine terraces to the southwest and provided an exit towards the Sea for water flowing into the lower plain from the Alban Hills and the north-western Lepine Mountains. The latter canal decreased the flow of water into the lower plain significantly.²⁶ The Ninfa River may have run along the southern edge of the graben, forming a fifth main water collector. Together, these streams improved and partly diverted the run-off of water through the lower plain and provided the necessary preconditions for laying out the centuriation and for the subsequent cultivation of the plain.

Recent morphological research allows us to interpret the traces of the centuriation and to understand their functioning at the micro-scale as well. Besides the main grid divisions (visible in aerial photographs as heavy single or double-line features²⁷), remote sensing

imagery in certain areas also shows slighter, narrower traces (Fig. 3a).²⁸ Considering the inclination of the terrain, which slopes down mildly from west to east, it seems likely that these represent an intricate and hierarchical system of canals and ditches that serve to drain agricultural fields towards the Decennovium (Fig. 3b).²⁹

Field investigations conducted as part of the Minor Centres Project support this hypothesis. Geophysical prospections identified a series of magnetic anomalies with positive responses that pertain to the centuriation system (Fig. 4a/b). There are two major ones (nos. 1 and 2 in Fig. 4b) that have a width of c. 6.5 m, with on both sides contrasting negative values. No. 1 connects to an inlet that passes below the Via Appia into the Decennovium, and is therefore surely to be interpreted as a drainage canal; the same interpretation seems very likely for anomaly no. 2. Some of the smaller anomalies, measuring between c. 1 and 2.7 m in width, connect to no. 1 and have similar magnetic characteristics. As these characteristics resemble drainage ditches recorded elsewhere in magnetic surveys³⁰, they should be interpreted as ditches and canals.

Following up on these geophysical prospections, coring was conducted across anomalies 1, 2 and 7. The resulting data confirm the interpretation of these anomalies as canals (Fig. 5 and Table 1). Around anomaly no. 1, the natural stratigraphy consists of Holocene dark brown clays and, from a depth of 40 to 50 cm, grey heavy Pleistocene clays. In terms of landscape evolution, this stratigraphy represents a pre-Holocene marine environment, which in the early Holocene had been closed off from the sea and became an inland lake, later on filled with lacustrine clays and peat. In coring 50 the ashes deposited by the Bronze Age Avellino eruption were recorded at the base of the Holocene deposits, providing a *terminus post quem* for the formation of the clays.³¹ In this natural sequence, we found clear traces of anomaly 1 in corings 51–53 as a fill of up to 80 cm deep and 5 to 6.5 m wide. The fill consisted of an upper layer of dark clay with red fragments and small

²⁴ We cannot exclude the possibility that originally these canals did run into the canal and only later, when the canal had ceased to exist, were extended across it (John Peterson, personal comment).

²⁵ The model displayed in Fig. 2b was created by John Peterson on the basis of several intersections as mapped by the author.

²⁶ Although there is no evidence to date this canal, there may be an oblique trigonometrical link with the centuriation. A Roman date was first proposed by Hofmann (1956): 1137/1138, 1143). Further circumstantial evidence to assign a Republican date to this canal is provided by the presence of an associated site dated to the Republican period that produced large storage containers (De Haas, 2011: 98–101).

²⁷ Field observations suggest that some of these traces represent roads (Cancellieri, 1985: 44).

²⁸ De Haas, 2011: Figs. 8.4 and 8.5.

²⁹ The DEM in Fig. 3b is derived from (10 cm resolution) elevation data (points and contours) from maps from the 1920s and was created using the Topotaster tool in ArcGIS. The proposed interpretation is not unlike systems that are documented for more recent parcelling and drainage systems (Frassine, 2013: 134–6).

³⁰ Keay et al., 2014.

³¹ Sevinck et al., 2011.

Fig. 3. a/b. Traces of the centuriation system visible on a 1955 aerial photograph (a; courtesy IGM) and a proposed interpretation (b).

stones, and a lower layer with various inclusions, such as shells, biotite, snails, flint, and charcoal that represent the gradual filling up of the canal.

Anomaly 2 was also visible in the stratigraphic sequence, although the natural Holocene deposits were not encountered here. The upper 50 to 60 cm consist of mixed brown clays with red fragments and lime inclusions very similar to the canal fill itself that was observed in corings 26–28. The canal fill has a width of c. 5 m and irregularly extends up to a depth of 120 cm, consisting of loose red-brown clay with various inclusions (red fragments, lime concretions, shells, and charcoal). In its lower part, we observed remains of thin sandy layers with volcanic minerals that represent stream deposits. We believe that the deposits on top of and along the canal that are similar to the ditch fill arise from flooding events.

Anomaly 7, which is less clearly visible in the geophysical data, was observed in corings 58–60 as a fill below a recent anthropogenic layer that here covers the underlying Pleistocene heavy grey clay deposits; only in coring 61 did we find slight traces of the Holocene lacustrine peaty clays observed around anomaly 1. The ditch fill consists of brown, slightly plastic clay of at maximum 55 cm thick and c. 3.5 m wide with large charcoal fragments and some red fragments. Whether this ditch was indeed shallower and narrower than nos. 1 and 2 remains unclear, as the upper part may have been topped off when the

anthropogenic top layer was deposited. The fact that the ditch is covered by recent deposits may explain why its geophysical signal is weaker.

4.3. Living and working in the reclaimed marsh

Thus, desktop studies and small-scale field research that integrates geoarchaeological and remote sensing methods provides insight in the context and functioning of the centuriation at different scales: it was part of a program of hydrological management that had probably started with the canalization of natural streams and was supplemented by artificial collectors such as the Decennovium and the Rio Martino. The centuriation itself added an intricate system of smaller canals and ditches to drain plots of land and rendered the Pontine wetland suitable for settlement and agricultural exploitation.

Field surveys have investigated various transects in the lower plain and although not covering the entire centuriated area, they provide insight into the ways in which people lived and worked in this reclaimed marshland (Fig. 6a/b). The road stations of Forum Appii, at the north-western edge of the centuriated area, and Ad Medias, situated centrally within it, were the primary central places in the area. Forum Appii was probably already in mid Republican times a nucleated settlement of several hectares, and in the Late Republican and Imperial period performed

Fig. 4. a/b. Magnetic survey data and location of coring transects (a) and interpretation of magnetic anomalies related to the centuriation (b).

Fig. 5. Cross sections of anomalies 1 (top), 2 (middle) and 7 (bottom).

various public functions. With its river port it also became a trade hub of regional importance. Ad Medias, by contrast, was a small agglomeration that provided a limited range of services (ceramic production, metal working, sanctuary). It never developed into a nucleated settlement or service centre of more than local importance.³²

Some 9 km² of terrain has been field surveyed systematically as part of the Minor Centres Project within the centuriated area, and previous surveys complement these data. In total 90 Roman rural sites have been mapped, mostly on the colluvial-alluvial deposits, the floodplain and Pleistocene clays. Only few have been recorded in the peat areas, but this may well be due to the fact that only a small proportion of this peat area has been surveyed. The sites consist of artefact scatters

of c. 0.02 to 0.6 ha in size with reasonably standardized artefact assemblages, usually including tile, amphorae, coarse kitchen and storage wares and fine table wares. In a few cases there are traces of more monumental architecture such as stone-and-cement walls, wall paintings and mosaic floors. The sites can be classified into at least three types: the bulk are small, isolated farmsteads; the smallest artefact scatters are probably non-settlement sites (outbuildings or other activity areas); the few larger sites and/or those with more elaborate architectural remains probably represent either small clusters of farms or elite estates (e.g., villas).³³

The chronology of the sites is, compared to other areas in the Pontine region, restricted. Whereas on the edge of the Lepine Mountains or in

³² Tol et al., 2014.

³³ See also De Haas, 2011: 100–104.

Table 1Core profile descriptions of transects across magnetic anomalies 1, 2 and 7 (for a description of the levels and deposits see [Sevink et al., 1982](#)).

Anomaly	Coring	Depth (cm)	Description	Interpretation
1	49	0–45	Dark humic clay with some red fragments	Holocene lacustrine deposits
		>45	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	50	0–45	Dark humic clay with some red fragments	Holocene lacustrine deposits
		45–48	Yellowish brown ash layer with sanidine, biotite and pumice	Avellino ash layer
		>48	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	51	0–80	Dark clay with red fragments, very small stones and especially in lower part shells, biotite, snails, flint, charcoal and wood	Canal fill, upper part mixed by recent ploughing lower part undisturbed
		>80	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	52	0–50	Dark clay with red fragments and very small stones	Canal fill mixed by recent ploughing
		50–75	Dark clay with red fragments, very small stones, shells, biotite, snails, flint, charcoal	Canal fill
		>75	Grey heavy clay	Borgo Ermada level Pleistocene deposits
2	53	0–70	Dark clay with red fragments and especially in lower part a lot of shells	Canal fill, upper part mixed by recent ploughing, lower part undisturbed
		>70	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	54	0–40	Dark humic clay	Holocene lacustrine deposits
		40–70	Grey sandy clay	Borgo Ermada level Pleistocene deposits with blown-in dune sand
		>70	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	24	0–55	Mixed brown clay with some brick-like fragments and lime inclusions; glazed ware fragment at 50 cm	Holocene deposit (flooding deposits mixed by recent ploughing?)
		>55	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	25	0–55	Mixed brown clay with some brick-like fragments and lime inclusions	Holocene deposit (flooding deposits mixed by recent ploughing?)
		>55	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	26	0–115	Mixed brown clay, top mixed, lower down looser with red-brown brick-like fragments, some lime concretions, and especially in lower part shells, charcoal, clay balls and sandy layers	Canal fill, upper part mixed by recent ploughing; lower part undisturbed stream deposits
7		>115	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	27	0–80	Mixed brown clay, top mixed, lower down looser with red-brown brick-like fragments, some lime concretions, and especially in lower part shells, charcoal, clay balls and sandy layers	Canal fill, upper part mixed by recent ploughing; lower part undisturbed stream deposits
		80–85	Greyish brown clay with light ash with sanidine and leucite	Transitional layer with Avellino ash layer
		>85	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	28	0–120	Mixed brown clay, top mixed, lower down looser with red-brown brick-like fragments, some lime concretions, and especially in lower part shells, charcoal, 'clay balls' and sandy layers as well as mixed-in ash with biotite, pyroxene, sanidine	Canal fill, upper part mixed by recent ploughing; lower part undisturbed stream deposits with remains of Avellino ash
		>120	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	29	0–60	Mixed brown clay with some brick-like fragments and lime inclusions	Holocene deposit (flooding deposits mixed by recent ploughing?)
		>60	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	30	0–60	Mixed brown clay with some brick-like fragments and lime inclusions	Holocene deposit (flooding deposits mixed by recent ploughing?)
		>60	Grey heavy clay	Borgo Ermada level Pleistocene deposits
7	57	0–65	Very dark clay with lime, red particles and mica	Anthropogenic (post-Roman) deposit
		>65	Grey heavy clay with Iron concretions	Borgo Ermada level Pleistocene deposits
	58	0–60	Very dark clay with lime, red particles and mica	Anthropogenic (post-Roman) deposit
		60–90	Brown, slightly plastic clay with charcoal, some red particles and a depurated pottery fragment	Ditch fill (Roman to medieval?)
		>90	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	59	0–45	Very dark clay with lime, red particles and mica	Anthropogenic (post-Roman) deposit
		45–100	Brown, slightly plastic clay with charcoal and some red particles	Ditch fill
		>100	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	60	0–50	Very dark clay with lime, red particles and mica	Anthropogenic (post-Roman) deposit
		50–75	Brown, slightly plastic clay with charcoal and some red particles	ditch fill (radiocarbon dated to medieval period)
7		>75	Grey heavy clay	Borgo Ermada level Pleistocene deposits
	61	0–55	Very dark clay with lime, red particles, mica and coarse pottery fragment	Anthropogenic (post-Roman) deposit
		55–65	Dark peaty clay with pyrite, red particles, jarosite and biotite	Holocene lacustrine deposits
		>65	Grey heavy clay with Iron concretions, slightly mixed	Borgo Ermada level Pleistocene deposits
	62	0–50	Very dark clay with lime, red particles and mica	Anthropogenic (post-Roman) deposit
		>50	Grey heavy clay with Iron concretions	Borgo Ermada level Pleistocene deposits

the coastal areas, large-scale rural settlement emerged in the 6th century BCE, in the Pontine wetland there is hardly any evidence for 6th to early 4th century BCE settlement.³⁴ By contrast, we witness a major phase of rural infill in the mid Republican period (e.g., late 4th/early 3rd century BCE): of the 90 sites, 72 have a Republican phase and 18 sites can due to a lack of datable ceramics only be described as

“Roman”. The widespread occurrence of stamped black gloss pottery dated to the second quarter of the 3rd century BCE and the presence of late 4th century BCE ceramics on a smaller number of sites place their foundation in the same period as the Via Appia, the centuriation and concomitant changes to the hydrological structure of the area.³⁵

³⁴ Whereas [De Haas \(2011\)](#) suggested that some of the sites were perhaps founded earlier, the ceramic data from the surveys of 2012–2014 confirms that most if not all of the sites were indeed founded in the late 4th/early 3rd century BCE.

³⁵ The stamped black gloss bowls almost exclusively belong to the third phase of the *gruppo dei piccoli stampigli*, to be dated between 280 and 260 BCE; slightly older ceramics include fish plates as well as early Graeco-Italic amphorae (vanderMersch type 3) ([Tol in preparation](#)).

Fig. 6. a/b. Roman Republican (a) and Imperial (b) sites in the centuriated area.

There is also archaeological evidence to reconstruct how people exploited the centuriated area.³⁶ First, off-site artefact distributions in one of the intensively surveyed transects show that terrains directly around farms, preferentially situated on the well-drained floodplain were being manured and hence probably farmed intensively. By contrast, lower-lying areas with heavy clayey soils lacked traces of settlement or off-site scatters and were more likely used as communal grazing land.³⁷ In addition, the common occurrence of loom weights in site assemblages reflects the role herding had in the economy. In the Republican period the centuriated area was therefore probably exploited through a system of small land holdings practicing mixed farming.

Geo-archaeological data complement this archaeological evidence. In corings, strata of *terra bruciata* commonly occur in the Holocene deposits. X-ray analysis of this irregular, red-brown to red material shows that these are lumps of clay that have been burnt at a temperature of 400 to 500 °C.³⁸ They result from the burning of the vegetation and are probably indicative of slash and burn agriculture, a practice that is also attested by micro-morphological and pollen analyses. Whereas this practice in the lower plain seems to have its origins in the Bronze Age, the strata of burnt clay also occur in association with Roman ceramics and it was therefore also applied in the Roman period.³⁹

The ditches and canals that were part of the centuriation also had practical roles in maintaining the area fertile and cultivable. They provided water to irrigate fields and feed animals, and the main canals and streams continued to deposit colluvial-alluvial sediments through occasional flooding. This would raise ground level and add clastic materials to the peaty and clayey soils, improving the agricultural potential of the area and/or creating relatively high and dry settlement locations in the marsh environment. Again, both environmental factors (flash floods) and human agency (intentional colmatage, the impounding of silt-laden water to build up low-lying areas) probably contributed to this.⁴⁰

Besides agricultural and pastoral activities, the Pontine wetland offered other natural resources that were exploited. Fishnet weights and

fish hooks have been found during surveys, and fishing, fowling and hunting must have provided an important component of the diet. The centuriation with its ditches and canals would have provided easily accessible fishing and fowling locations. Other activities, including wood cutting, charcoal production and dairy processing must have taken place as well, as in more recent periods.⁴¹

Another important resource of the wetland were its clays: the colluvial-alluvial deposits in particular provided raw materials that were exploited for the production of ceramics, as field surveys and geophysical prospections at Forum Appii and Ad Medias show.⁴² At these sites, both building materials and pottery were produced. The Decennovium and other canals facilitated cheap transport of the raw clays and the finished products. Considering the labour and capital investments involved in the establishment of productive facilities and the procurement and transport of raw materials, it was probably the elites that developed these economic activities. This is also suggested by the fact that wine amphorae were among the produced ceramic shapes: their production was certainly linked to commercial wine production, and the involvement of local elites in this type of specialised agriculture is well attested along the nearby Lepine mountains.⁴³ Interestingly, these productions occurred in the late Republican period, when settlement and agricultural exploitation of the centuriated area was already declining.

4.4. The decline of the centuriated area: human agency and environmental processes

The ceramic evidence collected during the field surveys shows that the pattern of widespread settlement in the Pontine wetland did not last very long. Already in the 2nd century BCE many of the small farms were abandoned, a process that continued in the Imperial period: 29 were inhabited in the 1st century CE, and by the 2nd century CE only very few sites still existed. With this decrease in site numbers, we also note a change in site typology: the Imperial period sites are mostly the larger ones and at least three have elements of elaborate architecture (such as marble decorative elements and remains of mosaic floors) typical of elite estates. By this time, the site of Ad Medias may also have become the seat of a large elite estate, as suggested by the presence of a large mausoleum.⁴⁴

³⁶ No sites have been excavated in the centuriated area and we do not dispose of ecological data. However, at a site slightly north of the centuriated area botanical samples included lentil, broad bean, emmer and barley (Feiken et al., 2012: 120).

³⁷ De Haas, 2012.

³⁸ Sevink, 2014: 243/244.

³⁹ For the Bronze Age, see Feiken, 2014: 263–267; for the Roman period, see Feiken, 2014: 270/271. These red clays also occur in the fill of the canals described in Fig. 5 and Table 1.

⁴⁰ De Haas, 2011: 213/214; Walsh et al., 2014: 41. These deposits are visible in Fig. 7 as a band of lighter soil in the field left of the canal.

⁴¹ See also Walsh et al., 2014: 33–36.

⁴² Tol et al., 2014; Tol and Borghers, 2016.

⁴³ De Haas et al., 2012; Attema et al., 2014.

⁴⁴ Cancellieri, 1975; Coarelli, 1998.

Various environmental processes may have contributed to the progressive abandonment of the lower plain. First, diseases, especially malaria, must have been widespread and mortality rates were probably high.⁴⁵ Moreover, improving drainage conditions favoured breeding conditions for the *anopheles* mosquitoes, making this problem worse.⁴⁶ Also, draining the land would have induced erosion and soil subsidence and the centuriation itself therefore contributed to soil degradation and/or renewed drainage issues.⁴⁷

Large-scale and external environmental processes also contributed to a decline of drainage conditions and concomitant changes in land use. Geo-archaeological work shows that processes of colluviation not only affected the centuriated area itself, but also the lower Amaseno on its eastern edge (Fig. 1). Here, a first phase of colluviation occurred somewhere in the first millennium BC and actually rendered this area more suitable for cultivation, as the wet environment was silted up. In a second phase of colluviation, to be dated between CE 400 and 800, these colluvial sediments expanded in a southward direction right up to the point where the Via Appia and Decennovium reach the coast.⁴⁸ Whilst these colluvial deposits raised the terrain and therefore locally improved the agricultural potential, they further blocked the run-off of water from both the Decennovium and the Oufens River, thereby worsening drainage conditions in the centuriated area.

In addition, changing climatic conditions may also have contributed to environmental change in the Pontine wetland. Whilst the first centuries BCE and CE formed a climatic optimum, this optimum may well have had negative effects on drainage and land use. Higher average temperatures would have improved breeding conditions for mosquitoes and bacteria, thus potentially worsening living conditions. Also, higher temperatures would have led to an increased frequency of storm events, in turn leading to more frequent flooding's and higher maintenance costs of drainage works.⁴⁹

Besides environmental factors, there are also several human agents that caused change. We may first point to the changing socio-political context. With the on-going expansion of its territory, Rome acquired other large tracts of land that required smaller investments to enable agricultural exploitation than the lower Pontine plain. Hence, the need to maintain this area as an agricultural area may no longer have been felt, and thus the investments needed for maintenance of the drainage system were no longer made, leading to a gradual decline of environmental conditions.

But besides the Roman State, other human agents also played a part in this process. As suggested above, among the few remaining sites in the centuriated area in the Imperial period were several elite estates, situated in relatively favourable locations near the Via Appia and along canals. We might imagine that elites seized the opportunity to gain control over tracts of land which had been abandoned by small farmers. Although perhaps less well drained than before, the wetland would have remained an important economic asset: these larger estates could exploit or lease out parts of the area for ceramic production, fishing, hunting, fowling and pastoral activities – as was also the case between medieval times and the early 20th century.⁵⁰

4.5. The centuriation: elements of long-term continuity

The archaeological and geo-archaeological data and historical evidence thus suggest that the centuriation with its associated settlement pattern of small farm estates did not function for more than two centuries, and that we should consider a range of factors in explaining its

decline. However, the impact of the centuriation on the landscape endured beyond the Roman period, as components of the centuriation continued to function.

One indication for this continued use comes from the coring on ditch no. 7 described above (cf. Fig. 5). A charcoal sample from the ditch fill gives a calibrated date of CE 782–1020,⁵¹ suggesting that it was used and re-used for a long time before being filled up definitively in the medieval period. Although perhaps not being maintained in its entirety by the State, other agents (peasants, local elites) may have maintained features of the centuriation locally, giving ditches and canals complex and long use histories.

New reclamations were undertaken in late Roman, Medieval and post-Medieval times, often by order of the Vatican, in some cases by popes with ties to local elites. Most of these projects intended to drain restricted areas within the former centuriation and/or to reconstruct the Via Appia and the adjacent Decennovium.⁵² Because of technical, political and financial limitations as well as local opposition these attempts did not have long-lasting effects, let alone result in more sustained reclamations. Sometimes they had devastating environmental effects, which in turn caused considerable social and political conflicts.⁵³ Only few post-Roman reclamations covered more extensive areas and were successful.⁵⁴

While these post-Roman reclamations used parcelling systems with a different orientation than the Roman centuriation, they built upon the main drainage structure as developed in Roman times: the Decennovium canal and the Rio Martino were the primary collectors also in later projects, and the The Ninfa along the southern edge of the centuriated area was re-excavated as the Fiume Sisto. Also, the streams that were in Roman times canalized, were re-used in medieval times to reclaim land through colmatage.⁵⁵ Thus, the hydrological structure of the landscape was shaped by Roman efforts, and the centuriation and concomitant canals continued to play a role in its development. This is also clear from the fact that some of the larger canals and ditches still function today (Fig. 7).

5. Concluding remarks

Whilst the integration of historical, cartographic, archaeological and palaeoenvironmental approaches has become more common in the study of centuriation, the case presented here shows how these integrated approaches can be further developed by applying a long-term, multi-scalar perspective that considers not only economic but also social and ecological dimensions of centuriated landscapes. Such a perspective can significantly improve our understanding of the role of centuriation at three levels.

First, this perspective can shed light on the context in which the centuriation was established and the changing role it subsequently played in human interactions with the landscape. It therefore improves our understanding of the historical importance of centuriation. The Pontine centuriation was part of long-established interactions between humans and the Pontine wetland, but also part of a program of interventions in the region's hydrological structure and of an even broader socio-political context of territorial expansion, demographic growth, leading to increasing demand for foodstuffs and arable land. The increasing availability of labour, capital and perhaps also technological advances in engineering would have facilitated the exploitation of marginal

⁴⁵ The *bonifica integrale* provides useful comparisons: in 1932 some 16% of the population suffered from malaria; 3.3% died from it (Massaro, 2005: 75/76).

⁴⁶ Sallares, 2002: 184–186.

⁴⁷ Giraudi, 2011: 1238–1240; on subsidence: Serva and Brunamonte, 2007.

⁴⁸ Van Joolen, 2003: 78–84.

⁴⁹ McCormick et al., 2012; Giraudi, 2011. Sea level change (Lambeck et al., 2004) may also have affected drainage conditions, but there is no data to properly assess this.

⁵⁰ Walsh et al., 2014.

⁵¹ GrA-60697: 1100 ± 35BP (95.4% confidence level).

⁵² De Haas, 2011: 205–207; Linoli, 2005: 30–32. On the scale of reclamations under Theodorico: Dall'Aglio and Franceschelli, 2012: 85/86.

⁵³ A notorious case are the reclamations by Bonifacio VIII in 1298. He drained the lands below Sermoneta by redirecting the flow of water, causing major flooding in the territory of nearby Sezze (Linoli, 2005: 32).

⁵⁴ E.g., those by Pius VI in the late 18th century and by the Fascist regime in the 1920s and 1930s.

⁵⁵ Feiken, 2014: 272–274; Walsh et al., 2014: 41.

Fig. 7. North-south oriented canal pertaining to the centuriation.

areas such as the Pontine marsh.⁵⁶ But a lack of maintenance and the draining of the land itself may have led to deteriorating drainage conditions and in turn to the abandonment of the land by small farmers. This enabled elites to acquire extensive stretches of marshland.

Second, the perspective promotes the integration of methodologies, which has proven very fruitful in this case study: the integration of morphological approaches with geophysical prospection and coring in combination allow us to reconstruct and understand the palaeogeographical context and functioning of the system in more detail than a morphological analysis would allow. Also, the integration of archaeological settlement data with geo-archaeological work and information deriving from written sources helps us better understand how people lived in and with the centuriation.

Third, the perspective enables us to evaluate centuriation in light of dynamic and complex processes. By drawing together data that relate to different chronological and temporal scales, it allows us to assess the role of both environmental and cultural factors and agents in processes of change in relation to centuriation. In this case study these agents not only include the State, elites and peasant farmers, but also the centuriation itself, which by draining the land induced environmental change. The processes that explain the changing use of the centuriation range from Roman Imperialism to land use strategies, erosion and deposition, and possibly climate change. The interplay of these agents and processes in their specific historical setting helps to explain how the centuriated landscape developed over time.

This case study has illustrated the usefulness of an integrated approach to centuriation, mainly by providing hypotheses on the role of the Pontine centuriation in changing human-environment interactions. However, it has not been possible to fully discuss the morphological, archaeological and geo-archaeological evidence in the context of this paper, and in some respects additional empirical data would allow more firm conclusions. In particular, we still know little about variability in land use within the centuriated area and about changes in land use

strategies over time. Further ecological work (e.g., systematic botanical and zoological sampling of sites and fills of canals and ditches) is therefore foreseen for the near future. This will improve our understanding of how people lived in and with the centuriation, and what their role was in processes of change.

Another important issue concerns the links between the centuriation and the hydrological modifications observed in palaeoenvironmental reconstructions: whilst various canals were very likely constructed in the same context as the centuriation, their precise chronological and functional relations for now remain unresolved. A re-evaluation of the system as a whole on the basis of additional cartographic and remote sensing data, continued geophysical prospections and geo-archaeological research will result in an improved model of the centuriation and the hydrological structure of the Pontine marsh. In combination, such work will further clarify what roles the centuriation had, both in the daily lives of those living with it, and within the broader socio-political context of Roman expansion.

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⁵⁶ Similar reclamations were developed in the first half of the 3rd century BCE (Camerieri et al., 2009).

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