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Archaeological evidence for agrarian manuring: Studying the time-space dynamics of agricultural areas with surface-collected off-site material

Les preuves archéologiques de l'épandage de fumure : étudier les dynamiques spatiotemporelles des espaces agraires avec le mobilier hors-site de prospection

Archäologische Quellen zur Ackerdüngung. Erkenntnisse zur Entwicklung des Ackerlandes in Raum und Zeit durch die Prospektion des Scherbenschleiers

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Summary

Manuring is a farming practice that left archaeological traces. Indeed, the incorporation of waste into manure has resulted in the spreading of broken pottery across manured plots. The interpretation of off-site scatters as remains of manuring is based on ancient texts and archaeological evidences. The French *Archaeodyn* project aimed at identifying major trends and local peculiarities regarding the amendment of fields from Antiquity to Modern Times, on several French study areas. We defined indicators to estimate the stability and durability of agrarian occupation, based on the spatial analysis of off-site material. The results give the image of spatial and temporal changes of cultivated areas in the long term.

Zusammenfassung

Düngung ist eine Praxis der Landwirtschaft, die sich archäologisch erfassen lässt. Der Zuschlag von Abfall zur Mistdüngung führte zur Verteilung von Keramikscherben auf allen gedüngten Flächen. Die Interpretation dieses off-site-Scherbenschleiers basiert auf Schriftquellen wie auf archäologischen Indizien. Das französische Projekt *Archaeodyn* will in verschiedenen Regionen Frankreichs generelle Trends und regionale Entwicklungen der Bodennutzung von der Antike bis zur Neuzeit identifizieren. Aufgrund der räumlichen Ausprägung des Scherbenschleiers wurden Kriterien zur Abschätzung der Intensität und Dauer der Ackernutzung definiert. Damit lassen sich langfristige zeitliche und räumliche Wechsel der Landnutzung zeigen.

Résumé

L'épandage du fumier est une des rares pratique agricole qui a laissé des traces archéologiques. En effet, l'incorporation des déchets domestiques dans les fumures a entraîné la dispersion de poteries cassées dans les parcelles amendées. L'interprétation du mobilier hors-site de prospection comme vestiges de ces épandages est basée sur des textes anciens et des preuves archéologiques. Le projet français *ArchaeDyn* visait à identifier les grandes tendances et les particularités locales

concernant la mise en valeur agricole des champs, de l'Antiquité à l'époque moderne, sur plusieurs zones d'études françaises. Nous avons défini des indicateurs pour estimer la stabilité et la durabilité de l'occupation agricole, basée sur l'analyse spatiale de ce matériel hors site. Les résultats donnent l'image de pulsations spatiales et chronologiques des espaces cultivées dans la longue durée

Introduction

Off-site material collected while fieldwalking surveys has been considered for a long time as a 'background noise', an impediment to the detection of sites. In the last forty years, the extent of archaeologists' interest from the site to the territory has led to a reconsideration of this off-site material and the use of it as a marker of formerly cultivated areas (*Wilkinson 1982; Bintliff – Snodgrass 1988; Wilkinson 1989; Bakels 1997*). Whereas this interpretation is commonly accepted in most of Anglo-Saxon countries and used by few French researchers (*Raynaud 1989; Favory – Fiches 1994*), there is still a debate regarding the interpretation of this material (*Forbes 2013*). That is why we wanted to formalise it and to document the practice of improving the soil from Antiquity to Modern Period (*Poirier – Nuninger 2012*). At the same time, the French Archaeodyn Project was engaged in a study of the time-space dynamics of agricultural spaces from Protohistory to Modern Times based on off-site material collected during fieldwalking campaigns in different study areas of northern and southern France (*Poirier – Tolle 2008; Poirier et al. 2012*).

Off-site material as remain of manuring practices?

Even if this does not constitute a proof, we have to mention at the outset that most of the fieldwalking campaigns conducted in France during the last thirty years have led to the collection of off-site material dating from the Bronze Age to nowadays (*Ferrière – Zadora-Rio 1986; Ferrière – Rialland 1994; Favory – Fiches 1994; Ferrière – Rialland 1995; 1996; Poirot 1998; 2010*). If this presence is clearly visible, its interpretation as the product of manuring practices is based on an initial assumption that the spreading of livestock manure collected in barns was used during earlier periods. To confirm this hypothesis, we will first focus on the identification of written and iconographic sources attesting the ancient practice of manuring.

Manuring of croplands is attested since Antiquity

Most of the Roman agronomists recommended the use of manure to improve the quality of soil: Cato (2nd century BC) details the necessary tools to spread the manure (*De Re Rustica*, V); Varro (1st century BC) suggests that the dunghill has to be located near the farmstead (*Res Rusticae*, I, 38, 3); Columella (1st century AD) is the most explicit regarding the spreading of manure, detailing the quantities needed for a given area (*De Agricultura*, II, 5). Pliny the Elder (1st century AD) specified which types of soil need improvement, the best time in the year to spread the manure, the required quantities of livestock to produce enough manure, etc. (*Naturalis Historia*, XVIII, 53).

Iconographic sources, such as the agricultural calendar found on a mosaic at Saint-Romain-en-Gal (France), illustrate the spreading of manure (*Fig. 1*).



Fig. 1. Mosaic illustrating the transport of manure (Saint-Romain-en-Gal, France).

These texts and recommendations regarding the use of manure were compiled and transmitted during the Middle Ages by means of the agronomic literature from the 13th century, for example in the *Ruralium commodorum libri duodecim* of Pietro de Crescenzi. From the Carolingian period, the 'Capitulaire de Villis' had already advised to spread not only the manure, but also all the waste from the farm (Delatouche 1977, 81). Taxation, rental and sale documents also contain information about the practice of manuring. For example, in southern France, we can find many references to structures that can be identified as manure pits, called *femoracius* (Puig 2003). We also sometimes have references to the sale of manure (Monnet 1992), or the duty of a tenant to spread manure over the land at least one time during the period he occupies it

(Brunel 2004; Viader 2006). The medieval iconography also attests to the practice of manuring (Mane 1985). The *Rustican* mentioned above contains an agricultural calendar illustrating this practice for the month of February: two men are spreading manure in a closed space where many other piles have been already dispersed (Fig. 2).



Fig. 2. Agronomic treatise from Pietro di Crescenzi, 1459. February dedicated to the spreading of animal manure, Condé Museum, Chantilly, France, Ms 340.

Domestic waste could be incorporated into the manure.

The second assumption is that domestic waste, including sherds of pottery, could be incorporated into the manure, deliberately or not. These sherds and fragments of building materials were mixed with other waste on manure piles usually located near the settlement, and spread with organic materials in the fields,. They alone would have survived once the organic matter had decomposed. This assumption is supported by a number of sources confirming the incorporation of household waste, including the sherds of broken pottery, within the manure spread.

The proximity between houses and stables or manure pits

The first argument is common sense. The proximity of residential and livestock buildings suggests that there would have been a more or less conscious mixture of organic and manufactured waste in the formation of manure. One cannot imagine why a strict separation would have been made between the different sources of organic matter production, when often the partition between the living spaces of humans and animal housing was only slightly marked materially. Such close proximity was also recommended in ancient (Varro, *Res Rusticae*, I, 13) and medieval agricultural treatises (Mane 1985, 736).

The incorporation was recommended by agronomists

Ancient agricultural literature also recommended the incorporation of domestic waste into the manure. Cato proposed that the periods of bad weather should be dedicated to the cleaning of stables, barns, and all the buildings of the farm (*De Re Rustica*, XXXIX). Columella indicates that the farmer should collect all the waste from the farm, and keep it in a pit (*De Agricultura*, II, 14). The same advice is given in the medieval treaties (*Fleta*, II, 73 cited by Grand – Delatouche 1950, 267).

This incorporation is attested by archaeological sources, geochemical observations, and archival texts.

Recent archaeological evidence also attest to the incorporation of household waste into manure.

During archaeological fieldwork, slight excavated structures have been interpreted as remains of manure pits (Ciezar-Epailly – Gonzalez 1998). This interpretation, based on the organic nature of the sediment and occasionally supported by chemical analysis, illustrates in concrete terms the practices and facilities mentioned in medieval texts. It is important to note that in the excavated examples, the pit is located close to residential buildings and sediment found in these structures contained sherds, thus proving the reality of the mixture of animal litter and waste from the house.

The iconography can once again support this argument. The few existing iconographic representations of the dunghill are those depicting the biblical parable of Job, a wealthy noble who should bear with resignation the loss of his property, his children, and the suffering of the disease. The text – and some iconographic representations – described him on a dunghill scattered with sherds which he uses to scratch his wounds (*Fig. 3*).



Fig. 3. *Job on his manure pile strewn of bones and shards - Book of Hours of Anne of Brittany (XVth century). Copy of 1848, Curmer editions, Loches castle (Indre-et-Loire, France).*

It should finally be noted that the chemical and biological soil analyses identifying high levels of trace elements allow the recognition of sites themselves and their associated areas of activities. Human activities developed within a settlement have a tendency to enrich the soil with certain elements, including potassium, magnesium and phosphorus (Entwistle *et al.* 1998, 54). In particular, it has been repeatedly demonstrated that high levels of metals (lead, copper and zinc) were indicative of the presence of inhabited sites (Bintliff *et al.* 1990, 11; Linderholm – Lundberg 1994, 310; Entwistle *et al.* 1998, 66). Bintliff also noted that a halo of a hundred metres is detectable around the sites, probably due to inputs or the presence of animals (Bintliff *et al.* 1990, 12). It is even possible to observe a strict correlation between the levels of metals (lead, copper, zinc) and density of offsite material collected around the sites (Neil Rimmington 2000). The land-use can in turn be detected by high levels of phosphorus. Indeed, the spreading of manure, rich in phosphorus, contributes to mark chemically the areas that received significant inputs over time (Entwistle *et al.* 2000, 300). This association between phosphorus and manure has been well demonstrated by measurements in gardens which have much higher phosphorus rates than those on the associated areas (Entwistle *et al.* 1998, 64). There may also be a direct relationship between the amount of soil organic matter and density of archaeological artefacts collected in the topsoil (Poirier 2010, 97).

An ancient but still discussed interpretation

This assumption about the interpretation of off-site material as a vestige of agrarian inputs is sometimes denied by using other explanations. *Fentress (2000, 47)* recalled the main alternative interpretations.

Lost artefacts, ephemeral occupations?

The first is the archaeological myth of the 'vase that fell off the mule', identifying the off-site remains as lost and broken objects was already been considered and rejected in 1980s by Bintliff and Snodgrass (*Bintliff – Snodgrass 1988*). The second concerns the very ephemeral remains of meals left by field workers or transhumance routes and seasonal movements of people who may have left slight traces. These alternative interpretations are, however, not sufficient to explain the regular presence and quantities that can be very large, of pottery sherds scattered in the topsoil, up to several thousands of sherds per hectare in southern France at the Roman period, for example (*Raynaud 2000*).

A 'background noise' produced by eroded sites?

A third interpretation is to consider the presence of sites eroded by natural phenomena (alluvial or colluvial) or anthropogenic processes (eg. agricultural practices) that could not be detected in the usual form of definable concentrations. Sherds moved by runoff from natural erosion are clearly identifiable by their high wear, which often makes their typological classification problematic. Displacement by erosion leads to downslope concentrations of sherds, which look like pebbles and are radically different from manuring shards. The density and regular dissemination of manuring shards implies an activity that goes beyond the phenomenon of erosion. Far from being random, as if it resulted from a mechanical action of erosion, the spread of this material appears generally associated with that of contemporary archaeological sites.

The hypothesis of the erosion of sites due to post-depositional anthropogenic activities also seems unconvincing. Cultural practices are often put forward to explain the dispersion of artefacts related to a buried site rather than the spreading of manure material. However, the experimental archaeological work carried out in England in the Butser Ancient Farm by Reynolds has clearly demonstrated the low displacement of fragments in the topsoil on the horizontal plane as a result of agricultural practices (*Reynolds 1988; Clark – Schofield 1991*). We can also notice a good fit between the area of material concentration visible in field surveys, and

the surface of underlying excavated structures, which argues in favour of a low dispersion of these artifacts (*Ferdière – Rialland 1995*).

Too little manure and not enough transportation means?

A final objection to discuss is that the manure was rare and should be reserved for parcels requiring the most attention, such as enclosed gardens attached to houses; and that transportation means and necessary energy for their implementation did not permit a spreading of manure on a large scale or in spaces too far from the settlement.

However, this statement is contradicted by the agronomic literature itself, which speaks of manure spreading in the fields ('*in agrum*' in Varro, *Res Rusticae*, I, 13), for cereals ('*segelibus*' in Columella, *De Agricultura*, II, 14). In addition, some observations of the cultural practices of traditional societies in Africa show that it is possible to transport the dried manure with baskets over fairly long distances (up to 2 km) (*Sautter 1993*, 449). This transport of small regular amounts, which is also indicated in the texts of the Roman agronomists, ancient or medieval iconographic sources already cited, therefore suggest an input into plots that can be quite distant from the source settlement.

Preliminary conclusion: off-site material can be used as a marker of improved areas

Regarding all these arguments, we can conclude that the off-site material collected during fieldwalking surveys may reflect the location of intensely cultivated areas.

This position has been supported since the 1970s by several researchers, especially G. Foard in England who was one of the first to draw attention to the importance of this material, previously interpreted as a 'background noise' (*Foard 1978*).

Research in this direction has permitted us to move on from a view of survey only focused on the discovery of settlement sites, in favour of an understanding of a continuous space, where 'off-site' material can mark the influence of settlements on the surrounding area.

However, the location of improved spaces only provides a minimal estimation of the effectively exploited area. Indeed, a number of conditions are necessary for the discovery of spread material. It only marks that part of the territory given over to agriculture, land where an input was necessary to obtain a satisfactory harvest, where an organic amendment was applied consisting of manure from animals living near the settlement for a sufficient period of time to allow the accumulation of material. Besides these conditions, the presence of off-site material is still

conditioned by a number of filters related to the amount of ceramic in circulation at different times, the management of waste and the number of cattle available.

The absence of off-site material does not allow the conclusion that the areas in question were not cultivated, but opens up a range of possibilities which it is not possible to decide between.

The study of agrarian spaces within the French Archaeodyn Project.

The ArchaeDyn¹ program aims to develop quantitative indicators of density and flows of population and economic activities in the long time, as well as space allowances of exploited areas. It proposes to clarify the question of links between the different levels of integration of the territorial system by multiscale and multidisciplinary approach (*Nuninger et al. 2008*).

A working group dedicated to cultivated areas has developed a protocol for analysing agrarian spreading identified through off-site material collected in fieldwalking surveys, compared to the inhabited sites, and the modelling of their spatial and diachronic dynamics, including the definition of relevant indicators to estimate the stability and durability of the human investment over time (*Poirier et al. 2012*).

A diachronic, comparative and quantitative approach

It is a comparative approach that aims to compare the trajectories of development of rural areas in six different micro regions of northern and southern France.

The study areas

The study area of Neuvy-le-Roi in Touraine was systematically surveyed between 1992 and 1996 (*Poirot 1998*), while the valley of Choisille was surveyed as limited windows between 2006 and 2008 in the part of the *ECLIPSE II* program which aimed particularly to measure the link between land-use and erosion dynamics (*Poirier et al. 2013*). In Berry, I surveyed the area of Sancergues between 2003 and 2006 as part of my doctoral research whose goal was to model the territorial dynamics in the long term (*Poirier 2010*). In Languedoc, the study areas of Lunellois and Vaunage were surveyed in 1980s and 1990s under the direction of C. Raynaud and F. Favory and have been the subject of extensive analyses of population dynamics within the

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Archaeomedes program (Van Der Leeuw et al. 2003). Finally, in Provence, the Maures mountains were surveyed by Dr. Gazenbeek in the 1990s (Bertoncello – Gazenbeek 1997) (Fig. 4).

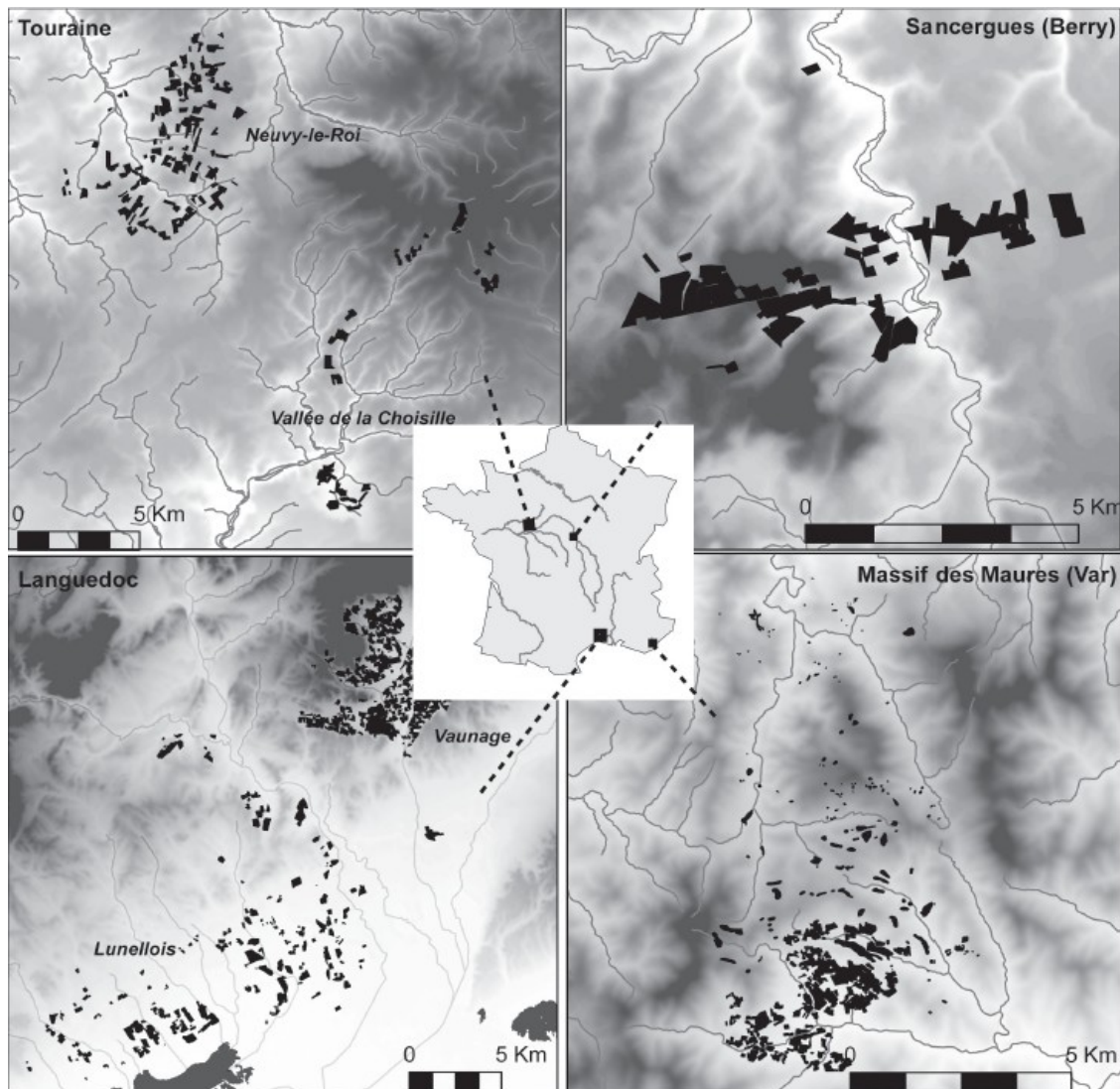


Fig. 4. Study areas.

A common chronological frame

The first obstacle encountered was the definition of a common timeframe for different study areas, even though the possibilities of dating ceramics are highly variable from one region to another, ranging from a half-century in Languedoc for the Roman period, to only three or four centuries in Berry and Touraine, for the particular type of material which is collected during fieldwalking operation and without any stratigraphic context. We decided to use the lowest

common denominator, i. e. the chronological framework for integrating a maximum of study areas. The observation time (from Protohistory to the modern period) has been divided into six chronological phases of varying lengths:

- 5th century BC– 1st century BC for Phase 1,
- 1st – 3rd century AD for Phase 2,
- 4th – 7th century AD for Phase 3
- 8th – 11th century AD for Phase 4
- 12th – 15th century AD for Phase 5
- 16th – 18th century AD for phase 6.

How to compare? relative indicators

Our approach is quantitative in order to be comparative. The desire to quantify the observed processes is to ensure the reproducibility of the analysis in each of the integrated microregions. But it also poses a number of challenges given the diversity of contexts of different study areas being compared. This quantitative approach has required the definition of indicators to estimate the duration, stability and intensity of the land enhancement. These indicators should enable a comparison of the study areas on a relative base, and not on absolute values (density, surface) that are quite incomparable.

Long term variations of extent and intensity of manuring

The calculation of the total area which delivered at least one example of manuring, for each study area and for each period, allows the interpretation of manured spaces' pulses in the long term in terms of extension or retraction.

Absolute area values are not comparable from one area to another, since they are determined by the size of these study-areas which is itself related to the extent of ground surveys conducted. So we chose to normalise the raw values obtained within the total area surveyed. Then the values can be compared. Each period is represented by the percentage of the total area surveyed which has yielded remains of manuring (*Fig. 5*).

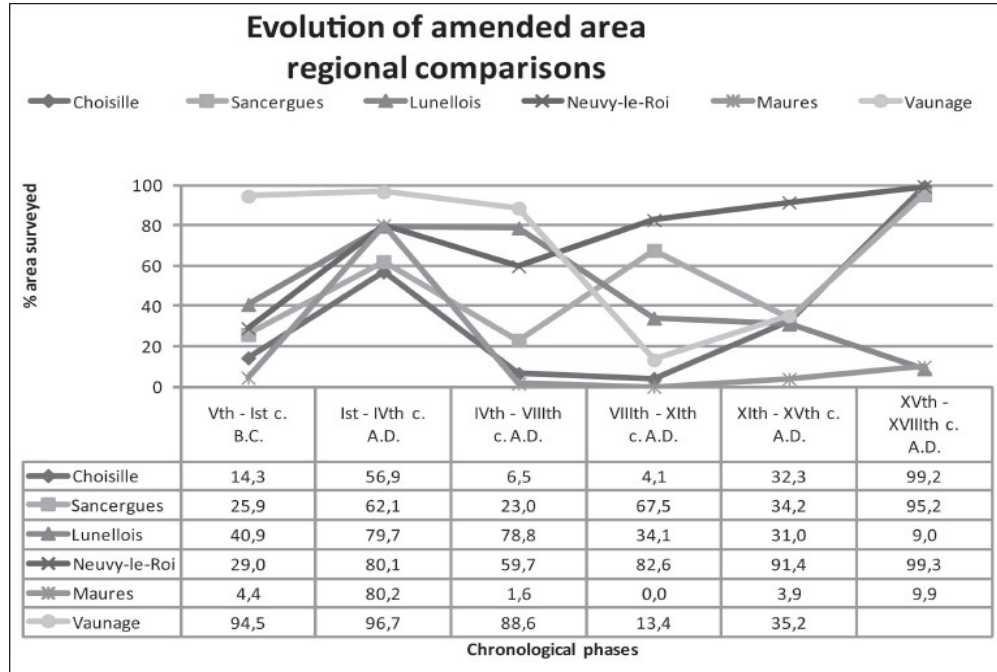


Fig. 5. Evolution of manured area.

We can identify first a variable start in the Protohistory, with manured areas ranging from less than 5% for the Maures mountains to 90% for Vaunage. The two most southern study-areas then do not give the same impression during the first chronological phase studied. The three northern-most areas appear less different from each other, with values ranging from 14% for the Choisille Valley to nearly 30% for Neuvy-le-Roi.

The Roman period (1st – 4th century AD) appears everywhere as a phase of growth in the manured areas, but not necessarily as a peak of settlement occupancy. The increase is quite spectacular in most study-areas, apart from Vaunage where the area manured grew by only 2 points, but the margin of increase was not very large given that the image of full landscape was already readable during the previous phase. Elsewhere, the area manured significantly increased by about 40 or 50 points, and 75 points higher for the Maures Mountains going from 4% in phase 1 to 80% of area manured in phase 2.

If we observe an extension of manured area everywhere during the Roman period (phase 2), we also see a kind of decrease during Late Antiquity (phase 3), but again in very different terms. While the manured area drops sharply in Touraine Choisille (6.5%) and les Maures (1.6%), the land use is maintained at more than 20% of the area surveyed in Berry (Sancergues), nearly 60%

in Touraine (Neuvy-le-Roi) and reduced to less than 10% of the area surveyed in Vaunage, whose manured area is maintained at more than 88%.

In three cases, the reduction in manured areas continued during the Middle Ages (phase 4). The proportion of manured land is reduced to 4% of the area surveyed in Touraine (Choisille) and 13% in Vaunage, while no evidence of manuring in this period was found in the Maures mountains. In contrast, in Berry (Sancergues) and Touraine (Neuvy-le-Roi), the manured areas increase in the early Middle Ages up to 67% for one and 82% for the other study-area.

The changes are very different for the central Middle Ages (phase 5). If three areas show approximately the same rate of around a third of area manured (Berry (Sancergues), Touraine (Choisille and Vaunage)), such figures masks real differences in trends. Out of the two study-areas which had witnessed a significant increase in manured areas during the previous phase, one (Touraine (Neuvy-le-Roi)) sees this influence confirmed by a further increase of the manured surface, while another (Berry (Sancergues)) shows a further decline in this area around 34%. In contrast, the three areas that had suffered decrease in Phase 4 show a more or less strong recovery in Phase 5. This recovery is very clear in Touraine (Choisille and Vaunage) from 4 to 32% and 13 to 35% respectively of manured area.

The modern period (phase 6) finally appears in the majority of observed cases as the period of maximum extension of the manured spaces that extend to all the land surveyed (between 95 and 99% of the surveyed areas Berry (Sancergues), and Touraine (Choisille) Touraine (Neuvy-le-Roi)). The Maures mountains do not belong to this model, the area manured in the modern period reaching only 10% of the area surveyed. The data have not been calculated for the Vaunage.

Durability of human investment and socio-environmental constraints

In the long term we were interested in estimating the durability of the agricultural investment by calculating an indicator for each single collection unit :

$$(n \text{ phases occupied} / n \text{ total phases}) \times [1 - (n \text{ hiatus} / n \text{ phases occupied})]$$

Where *n phases occupied* is the number of occupied chronological phases which have delivered at least one proof of manuring, *n total phase* is the maximum score possible occupation (six phases in this case), and *n hiatus* is the number of phases which delivered no sign of manuring following an occupied phase. This durability index ranges from 0 (for a study area which would

present no trace of occupation) to 1 (for a study area that presents a continuous and uninterrupted occupation (*Fig. 6*).

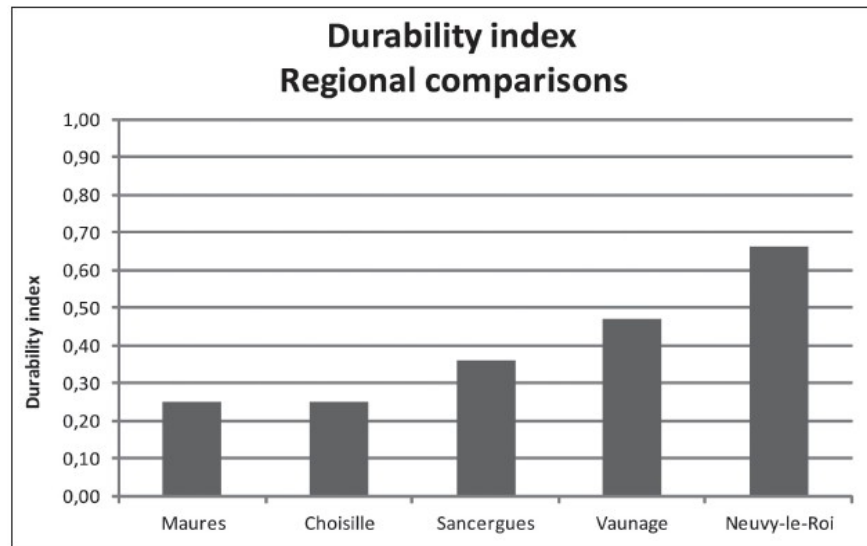


Fig. 6. Average durability index for each study-area.

The Maures mountains and the Choisille valley in Touraine appear as the two study areas with the lowest durability index (0.25). Then we find the areas of Berry (Sancergues and Vaunage) with average durability indices (0.36 and 0.47 respectively), while Touraine (Neuvy-le-Roi) area clearly stands out with a durability index of 0.66.

We then sought to determine the factors that explain the variability of the values of durability indicators of land-use by comparing their distribution to other socio-environmental variables. Each collection unit of offsite material has been described with several geographic settings, thanks to GIS: slopes' intensity, solar radiation, soil quality and density of the surrounding settlement system. All of these criteria, associated with durability indicator, were combined in a factor analysis (*Fig. 7*).

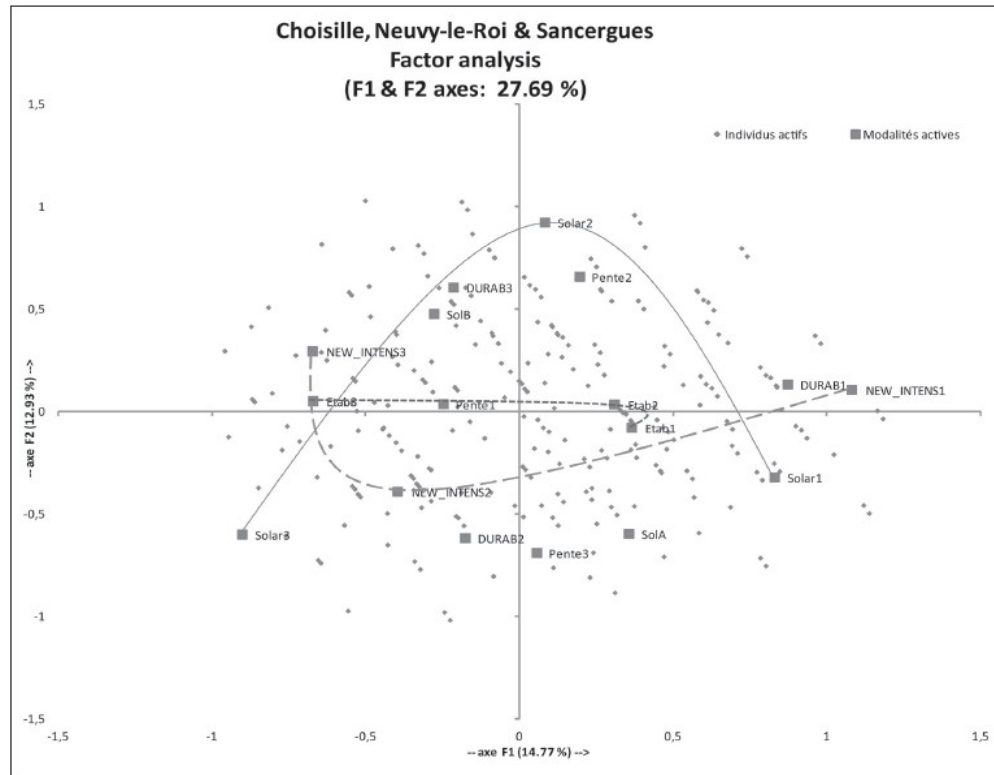


Fig. 7. Factor analysis of durability and intensity indices and socio-environmental variables.

The first axis is clearly structured by variables of intensity, solar radiation, and to a lesser extent by the surrounding settlements indicator. The right side of the factorial plan combines the lowest variable modalities of durability, intensity, solar radiation and surrounding settlement, while the left half contains the highest modalities, whose association is well highlighted. The different qualities of soils are in opposite quadrants of the factorial plane.

The hierarchical clustering (AHC) made following this factor analysis enables us, in general terms, to group the collection units with low intensity and durability values associated with unfavourable socio-environmental conditions (steep slopes, low solar radiation values, unfavourable soil and surrounding settlement undeveloped) in classes 2 and 3. Collection units with the highest intensity and durability values associated with more favourable socio-environmental parameters are grouped in Class 5.

But there is also, in class 4 for example, any areas where durability index is sometimes strong, despite very average socio-environmental parameters. In contrast, class 1 includes manured areas

whose durability and intensity values are average despite good socio-environmental conditions. This is therefore a question of the simple geographical determinism.

Classe	Classe 1	Classe 2	Classe 3	Classe 4	Classe 5
Size	22,7%	29,5%	11,5%	17,1%	19,2%
Description	Average durability & Intensity, on indifferent slope values or soil quality, benefiting from good sunlight and a good settlement network	Average durability & low intensity, on steep slopes with low sunlight, with low quality soils and low settlement network	Low durability & intensity, low to average slopes, average sunlight, benefiting from good soil quality and indifferent settlement network	Low to average durability but indifferent intensity value, on average slopes, with average sunlight, benefiting from good soil quality and average settlement network	Maximum intensity & durability values, on indifferent slopes, with a pretty good sunlight, good soil quality and good settlement network
Interpretation	No socio-environmental determinism	Strong socio-environmental determinism	No socio-environmental determinism	No socio-environmental determinism	Strong socio-environmental determinism

Fig. 8. Hierarchical clustering of collection units.

Conclusion

This approach allows the restitution of the ‘trajectories’ of rural areas’ enhancement in the long term by ancient societies. The interpretation must, of course, remain tentative, given the limitations related to the presence or absence of offsite material. The absence of this material does not necessarily mean absence of exploitation, and the results are only a minimum estimation of the areas effectively cultivated, probably those most intensely cultivated. However, the monitoring of these privileged spaces has permitted us to identify the pulses of these intensive agricultural areas in terms of increase and decrease of development, and thus address the economic rhythms that affected these areas over time. The comparative approach does not question the existing macroeconomic models as a whole, but light has been cast on the local modulations by going down to the micro-regional level and varying the observation contexts.

For the medieval period, this study documents the debated question of the existence and terms of some form of agricultural growth in the early Middle Ages (*Centre culturel de l’abbaye de*

Flaran 1990; Devroey 2008). Different readings and re-readings of Carolingian cartularies and polyptics had focused the debate in the 1980s. If the data of rescue archaeology today provide prompt information on this issue – by the discovery of silage areas, organized plot systems and many agricultural settlements – the estimation of the surface occupied by cultivated areas is precious information to assess growth. It is very clear in Touraine and Berry, where progression of manured areas is spectacular, but it is much more difficult to demonstrate in the southern contexts.

This study also demonstrates the ability of the ancient rural societies to overcome geographical constraints. If the increase in cultivated areas is made of successive gains and losses, it is constant over the long term. The growth of needs in the production of agricultural products led successive societies to include in their cultivated areas geographical contexts which were *a priori* unfavourable: steep slopes or less sunny spaces, heavy or acidic soils, areas away from populated places. This integration had to be accompanied by technological advances and additional efforts in terms of soil improvement, as indicated by the increase in densities of off-site material.

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