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Measurements of diachronic stability of agrarian exploitation

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Abstract:

Off-site material has two main interesting properties: it is spatially continuous and diachronic. Such data can be used to estimate how ancient societies invested in a space in terms of intensity, durability and stability, from Prehistory to Modern times.

This micro-analysis is based on a precise record of off-site material with collection units never exceeding five hectares. Each off-site sherd was dated and attributed to seven chronological phases over the long term.

Three new indicators are proposed to measure the level of investment of ancient societies. The computing and mapping of these indicators is done using a GIS software.

The data used in this paper come mainly from a fieldwalking project conducted in a study area of Berry (Center of France).

Keywords: off-site material, long term, spatial dynamics, agrarian space, micro-scale.

1 Introduction

The *Archaeodyn* project is endorsed by the French ministry of research in order to develop synthetic indicators of stability, instability and dynamics of spaces in the long term (NUNINGER *et al.* 2007). This paper is a case study, which can be considered as a test, for the analysis protocol we want to develop concerning the study of agrarian space over the long term. Two main kinds of data are used: remains of ancient plots preserved by the forest cover, and off-site artefacts collected by fieldwalking. The second kind of data will be the purpose of the present paper, the first one being studied in GEORGES-LEROY *et al.* 2007.

Interpreting off-site scatters as remains of manure practices is an idea now supported by most of researchers interested in the history of landscape and settlements (WILKINSON 1982 ; BINTLIFF, SNODGRASS 1988 ; NUNINGER 2003 ; JONES 2004 ; BERTONCELLO, NUNINGER *in progress*). This interpretation is based on several ancient texts proving this practice since Antiquity to nowadays (OSCHINSKY 1971). It's also based on recent examples of excavated structures used to prepare the manure (PUIG 2003) or manured zones identified by geochemical measurements, such as phosphates (NEIL RIMMINGTON 2000). Analysing artefacts scatters over the long term enables us to study precisely the dynamics of arable spaces, in terms of spatial variability and quantitative investment of ancient societies within these spaces.

In the *Archaeodyn* project¹, we want to identify areas formerly and durably exploited, areas formerly occupied but less continuously, and areas recently exploited. We also want to explain this variability in the occupation using environmental and socio-economic variables.

2 Data acquisition and processing

At first, we wanted to take into consideration field methodologies used to collect artefacts in all study areas involved in the project. We had to make sure that they were similar enough to compare the data collected. In all the study areas, the data came from fieldwalking on arable lands leading to an exhaustive collection of surface artefacts both on-site and off-site. Teams were usually composed of 6 to 8 persons walking with a constant spacing of about 10 meters. All the remains were collected: sherds, brick and tile fragments, etc... We considered all the artefacts collected off-site as remains of manure practices. A precise definition of a site is necessary at this point. For us, a site is a significant concentration of artefacts which can be delimited and dated. Off-site artefacts are grouped within collection units corresponding to a plot, several plots if they are too large, but more often part of a plot.

¹ This paper benefited of collective exchanges between all the members of the workshop 1 "Catchment's area, terroirs and community lands": F. Bertonecello (CNRS UMR 6530 CEPAM), F. Favory (University of Franche-Comté), E. Fovet (University of Franche-Comté, UMR 6565), M. Gazenbeek (INRAP), V. Hirn (University of Tours, UMR 6173), M. Georges-Leroy (SRA Lorraine), A. Moreau (University of Tours, UMR 6173), P. Nouvel (University of Franche-Comté, UMR 6565), E. Zadora-Rio (CNRS UMR 6173).

Every ceramic sherd collected off-site was dated as precisely as possible. Since ceramics are out of context, the dating is difficult and quite imprecise. Nevertheless, it should be mentioned that the ceramic references, available in each area and based on excavations, are good enough to overcome the traditional division in large periods such as Iron Age or Roman for example. According to the different dating capabilities and resolutions in each team, we defined a common chronological frame. The chronological phases do range between 3 and 4 centuries and concern a period from Protohistory to the end of Modern Times:

- Phase 1: 5th - 1st c. B.C.
- Phase 2: 1st c. B.C. – 4th c. AD
- Phase 3: 4th c. – 8th c.
- Phase 4: 8th c. – 11th c.
- Phase 5: 11th c. – 15th c.
- Phase 6: 15th c. – 18th c.

Every sherd collected within a collection unit is classified according to this chronological frame. It is now possible to compute, for each collection unit, the density of off-site artefacts for each chronological phase. Every collection unit is therefore defined by its sherds density for each chronological phase.

The data used in this paper come from a 50 km² area situated in the centre of France, of which about 10 % were systematically fieldwalked (Fig. 1). In this case, the mean area of collection units is 2 hectares and the maximum area is never larger than 5 hectares.

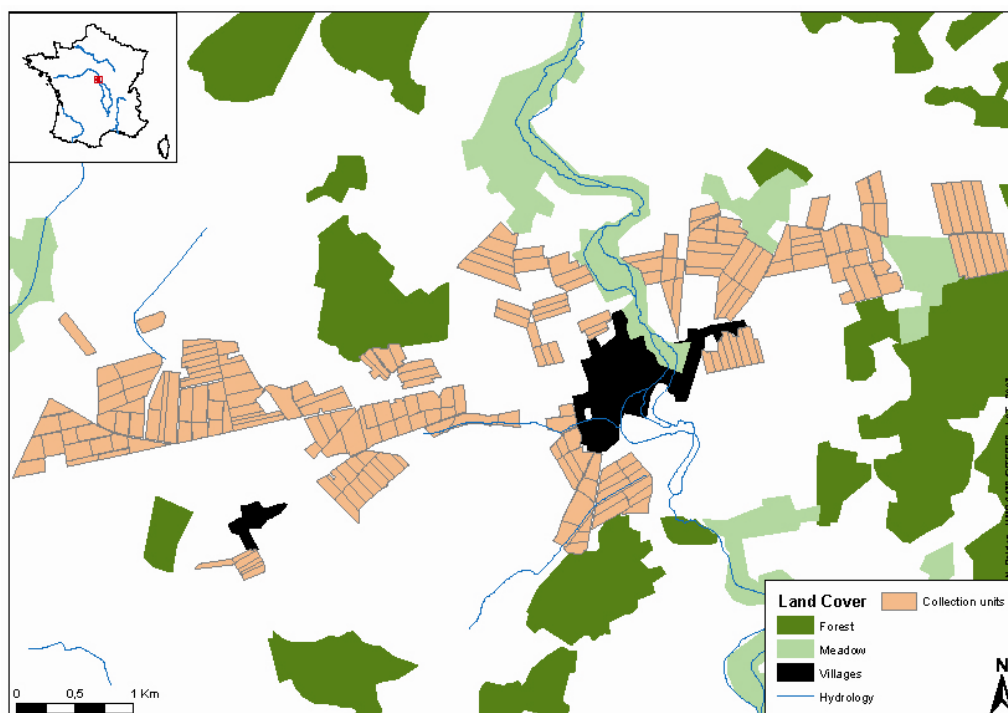


Fig. 1. Localization of the study-area in the centre of France and collection units.

3 Defining and using a synthetic indicator of stability for manured areas.

At first, we noticed a spatial and chronological variability in the extent and intensity of manuring. At a synchronic scale, we can see that the intensity of manuring is not homogeneous for the whole study area. Some zones provided much more artefacts than others. No artefacts and no agrarian occupation can be proved in some other zones. Depending on the chronological phases, the variations in density can also be large: for example, Protohistory gives the image of a contrasted agrarian space, with zones of high densities and others with no artefacts collected (Fig. 2a). On the contrary, Modern Times present a different image: densities are homogeneous and manuring appears to be a regular cover of sherds (Fig. 2b).

Over the long term, a great variability can be underlined. The same areas are not exploited with the same intensity over times. Some areas can be intensively cultivated during a phase, then being seemingly abandoned the

phase after. For example, the western part of the study area, which is intensively exploited during Protohistory and Roman period, delivers fewer quantities of artefacts for Middle Ages and Modern Times (Fig. 2).

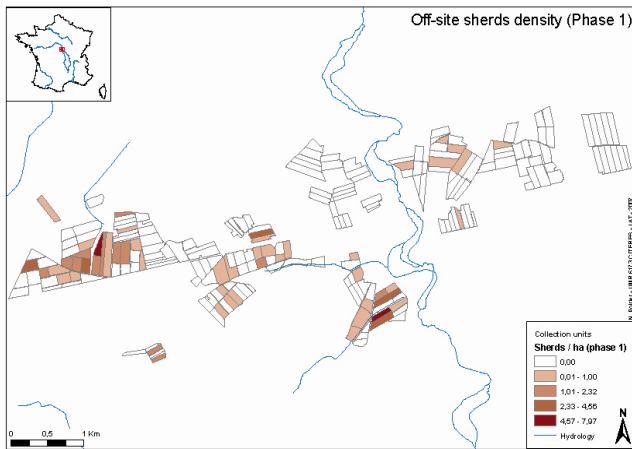


Fig. 2a. Off-site sherds density (phase 1)

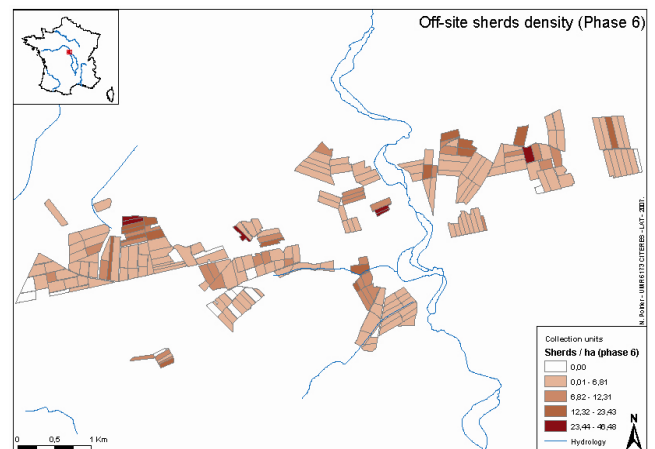


Fig. 2b. Off-site sherds density (phase 6)

This spatial, quantitative and chronological variability in the distribution of manured zones allowed us to study issues of continuity/discontinuity and stability/instability of agrarian investment. We have also modelled the dynamics of these areas through time and space using spatial statistics indicators, like mean centres and standard deviation ellipses (POIRIER 2006).

3.1 Defining the indicators

We defined three indicators to measure the agrarian investment. First, in order to measure the duration of agrarian occupation, the number of chronological phases occupied is computed (i.e. the number of phases delivering artefacts). A ratio is then defined between this value and the total number of phases potentially occupied (six, in this case). We obtain an index with values ranging from 0 to 1 and estimating the total duration of human investment in the given area. It can only be considered as an estimation given the fact that any hiatus could exist without being detected. This is due to the bad chronological precision obtained with surface artefacts. For example, a collection unit presenting occupation remains for the six chronological phases can't be interpreted as a zone which has been exploited continuously from Protohistory to Modern Times. Some brief breaks in occupation may have occurred but are invisible within the artefacts scatters. Nevertheless, it doesn't question the validity of our observations. From a relative point of view, there is more continuity in a collection unit delivering artefacts for all the chronological phases than a collection unit not delivering artefacts for one or more chronological phases. We could postulate that the same bias would have existed even if our dating capabilities had been better. Our interpretation is always limited by archaeological dating frames.

That's why we decided to also compute the number of breaks detected in the occupation for each collection unit. We count the number of unoccupied phases which succeed to occupied phases. Then we report this value to the number of occupied phases. The opposite of the result ($1 - [\text{breaks} / \text{occupied phases}]$) can be interpreted as an index (between 0 and 1) measuring the stability of human investment.

At last, in order to balance the global duration of occupation by the estimation of its stability, both indices were combined (multiplied) to obtain a third value which can be seen as a durability index for each collection unit (Fig. 3). It illustrates agrarian investment over the long term, taking into account the global duration of occupation and the breaks that occurred in this occupation.

In the study area presented here, the distribution of the durability index shows a concentration of high values only within 3 or 4 sectors. The highest values (up to 0,8) concern 20 collection units (9 %), which can be interpreted as regularly manured zones over the long term. More than half of the collection units have a durability index lower than 0,2 and can be interpreted as irregularly manured zones through time.

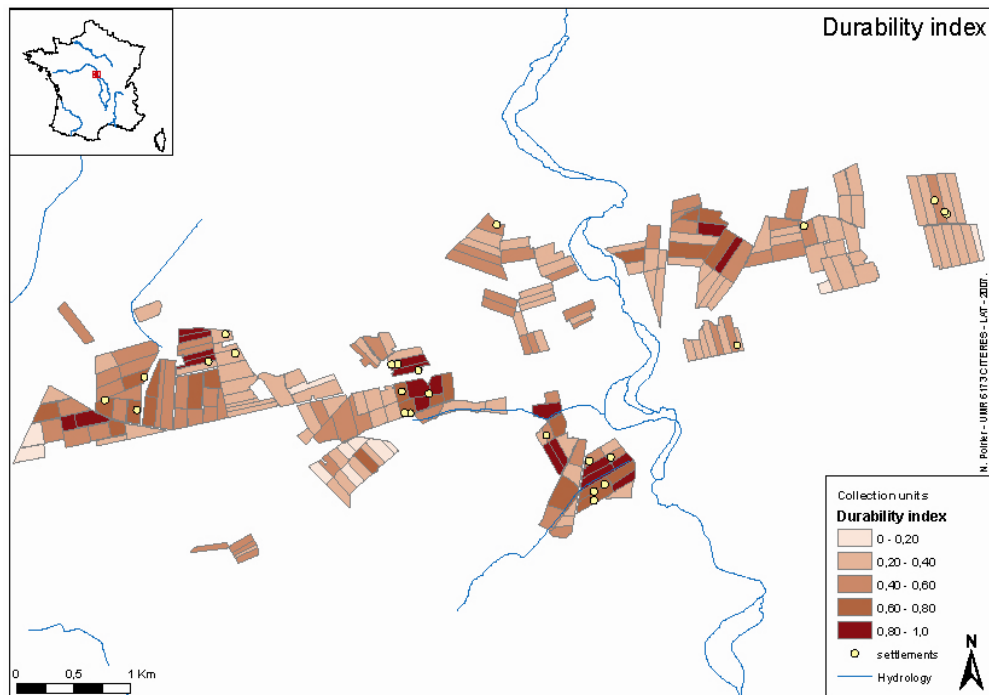


Fig. 3. Spatial variability of the durability index.

3.2 Characterizing areas depending on the durability index.

The last step of this study aims to characterize the different areas depending on the ancient societies' investment over the long term. Using the capabilities of a GIS software, we tried to compare the distribution of durably and irregularly exploited areas to various environmental (relief, soil quality, hydrology) and socio-economic variables (number and proximity to settlements). Such approach is meant to explain the variability of human frequenting through the time.

A zonal statistic function was used to compute, for each collection unit, its own environmental characteristics based on raster layers (DEM, soils and geological maps):

- mean value of slope,
- majority value of aspect,
- majority value for soil quality,
- distance to the closest water flow.

Archaeological (or socio-economical) variables were also computed. If we can assume a link between physical environment and the choice of a specific arable zone, we can also start from a hypothesis that a link exists between those spaces and the proximity with settlements, because settlements are the sources of the manure spreading material. We computed the number of settlements located within each collection unit, all phases included. But we noticed that some collection units had a high durability index while they had no settlement. So we added a second variable: the number of settlements (all phases included), located in a 500 meters distance area. This distance can be considered as the most likely to find settlements associated with manured areas, given the high costs in time and effort to bring the manure in the fields. Several studies proved this link between productivity and distance (for example CHISHOLM 1968). This variable is computed using buffers around each collection unit.

Using the Pearson coefficient, the correlation of environmental and socio-economical variables, and durability index was tested (Fig. 4).

	settlements	settlements_500m	mean_slope	majority_aspect	majority_soil	water_distance	durab_index
settlements	1						
settlements_500m	0,29	1					
mean_slope	0,05	0,28	1				
majority_aspect	0,07	0,05	0,30	1			
majority_soil	0,02	-0,09	0,21	0,04	1		
water_distance	0,02	0,02	-0,05	-0,12	0,10	1	
durab_index	0,25	0,30	-0,03	0,02	-0,19	-0,18	1

Fig. 4. Correlation values using Pearson coefficient.

The correlation results show that environmental variables have almost no influence on the durability of agrarian occupation. Mean values of slope and aspect are identical whatever the durability index value. Soils properties are quite the same, even if few variations are noticeable: Most of the zones have favourable soils for agrarian activities. The only differences concern the texture. While irregularly manured zones have light texture soils, the most regularly exploited zones have heavier soils, which probably needed more investment for ancient societies. The differences are weak but seem to be statistically significant. The only environmental variable which seems to be correlated with the durability index is the distance to the closest water flow. Irregularly manured spaces have the highest distance to the closest water flow. This distance decreases as the durability index increases. The distance to the closest water flow is 266 meters for the most durable manured spaces. It is half less than the most irregularly exploited spaces (Fig. 5).

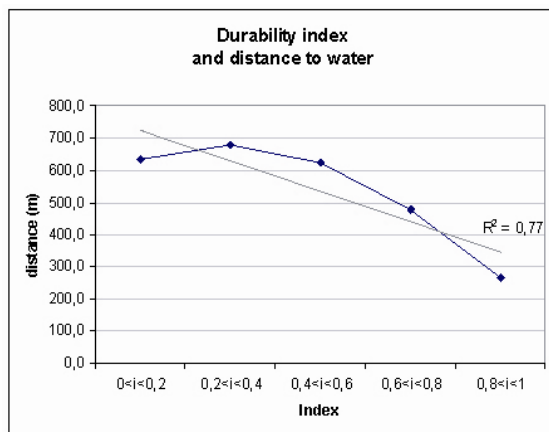


Fig. 5. Durability index and distance to waterflow

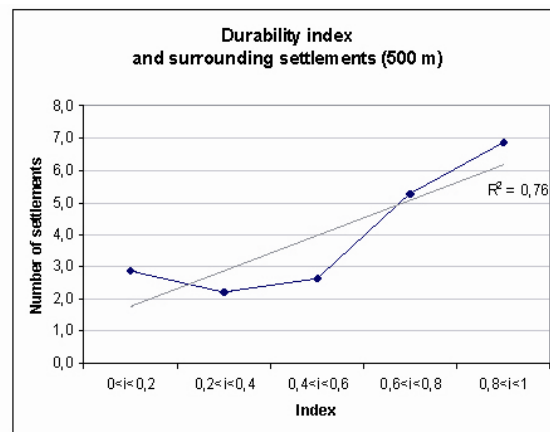


Fig. 6. Durability index and surrounding settlements.

On the contrary, archaeological variables seem to be positively correlated to the durability index. The number of settlements within and surrounding collection units increases with the durability index. The average number of settlements within collection units is 0,06 for durability indices between 0 and 0,2 and this value is 0,4 for settlements within spaces with a durability index between 0,8 and 1. This trend is confirmed if we look at the number of surrounding settlements in a 500 meters buffer area around units. We count a mean of 2,8 settlements around irregularly manured spaces, and almost 7 settlements around the most regularly manured spaces (Fig. 6).

4 Conclusion

The various indicators presented here allowed us to measure the spatial and quantitative variability of manuring over the long term. By measuring the durability of agrarian occupation within each collection unit, we can distinguish areas which benefited of a former and durable human investment, and areas recently or irregularly exploited. The comparison of the distribution of these areas with several environmental and archaeological variables sheds light on the limits of a geographical determinism. It seems that environmental constraints have almost no influence on the location of the most regularly manured spaces. Socio-economic variables seem to have more influence than the environmental ones used for this study.

We notice that the development of spaces can be durable only if the installation of several settlements ensures their continued existence. The settlements are the sources of manure spreading material. Given the high costs in time and effort to transport manure in the fields, it seems that the stability of agrarian exploitation has to be ensured by the surrounding settlement network's stability (GANDINI *et al.* 2007).

Within the *Archaedyn* project, we have now to apply this analysis protocol to all study-areas invested in the program, in order to observe common trends, local particularities, or different ways of interpreting. In particular, we

could be able to compare diachronic trends and synchronic choices for specific areas documented by other remains of arable occupation, such as ancient field systems preserved by the forest cover (GEORGES-LEROY *et al.* 2007).

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