Measurements of diachronic stability of agrarian exploitation

Nicolas Poirier[1]
With the collaboration of Florian Tolle[2]

[1]Université François-Rabelais de Tours – CNRS UMR 6173 CITERES, Laboratoire Archéologie et Territoires (France)
[2] Université de Franche-Comté - CNRS UMR 6565, Laboratoire de Chrono-Ecologie (France)

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, over the long term.

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.

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

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 *Archaedyn* project is endorsed by the French ministry of research and aims at developing synthetic indicators of stability 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 are developing to study agrarian spaces over the long term. Two main data types are used here: remains of ancient field systems preserved by the forest cover, and off-site artefacts collected by fieldwalking. This paper deals with the second type of data, the former being studied in GEORGES-LEROY *et al*. 2007.

Interpreting off-site objects dispersal as evidence of manure practices is an idea now supported by most of the 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 mentioning this practice from Antiquity up to the present day (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 dispersal over the long term enables us to study precisely the dynamics of arable spaces and the variability and quantitative investment of ancient societies within these spaces.

The *Archaedyn* project[1] aims at identifying areas constantly exploited over time, areas occupied from time to time, and areas recently exploited. Another main objective of the project is to explain the variability in occupation using environmental and socio-economic variables.

2 Data acquisition and processing

One first step of this work consisted in taking 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, data originated 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, bricks, tile fragments, etc... All artefacts collected off-site were considered as remains of manure practices. A precise definition of a site is necessary at this point. A site is defined as a significant concentration of artefacts which can be delimited and dated. Off-site artefacts were grouped within collection units corresponding to a field, several fields if they were too large, but more often part of a field.

[1] This paper benefited of collective exchanges between all the members of workshop 1 "Catchment areas, terroirs and community lands": F. Bertoncello (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, dating is difficult and quite imprecise. Nevertheless, it should be mentioned that the ceramic references available in each area and based on excavations were 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 are ranging from 3 to 4 centuries and cover a period lasting from Protohistory to the end of Modern Times:

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

Every sherd collected within a collection unit was classified according to this chronological frame. It was then possible to compute, for each collection unit, the density of off-site artefacts for each chronological phase. Every collection unit was 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. About 10 % of this area was systematically fieldwalked (Fig. 1). In this case, the mean area of collection units is 2 hectares and the maximum area never exceeds 5 hectares.

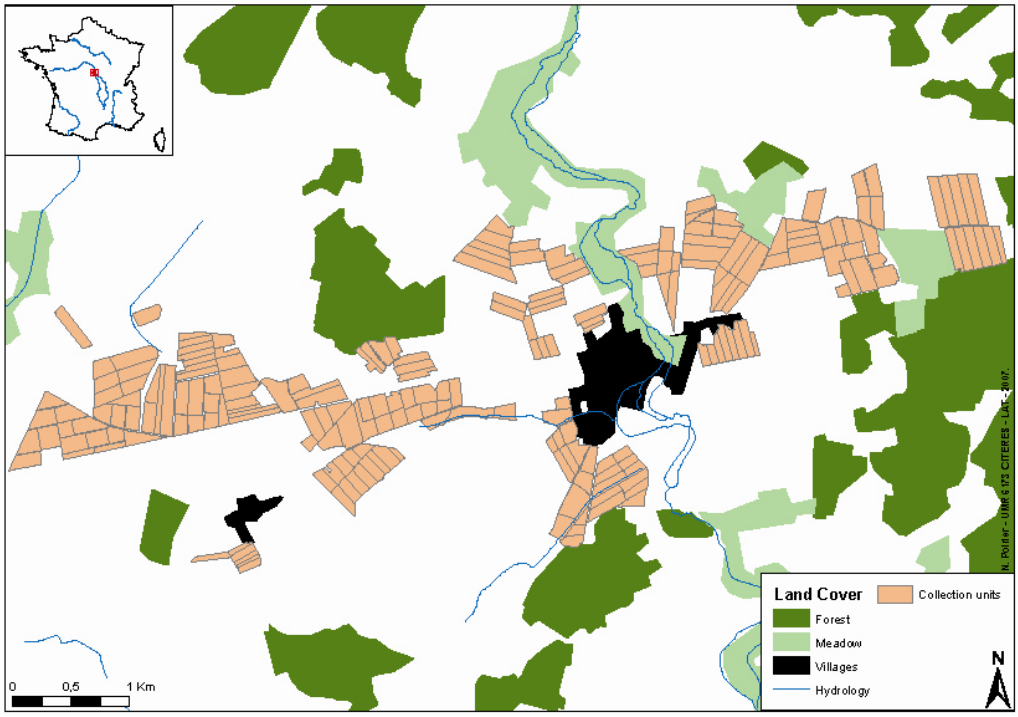

Fig. 1. Localization of the study-area in the centre of France and collection units.

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

At first, a spatial and chronological variability in the extent and intensity of manuring was noticed. At a synchronic scale, 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 showed a wide range of different situations. For example, Protohistory gives the image of a contrasted agrarian space with high density areas and others with no artefacts collected (Fig. 2a). On the contrary, Modern Times presents a different image with homogeneous densities and manuring displaying 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 time. Some areas can be intensively cultivated during a phase, then being seemingly abandoned during

the next time period. For example, the western part of the study area which was intensively exploited during Protohistory and the Roman period showed fewer quantities of artefacts for Middle Ages and Modern Times (Fig. 2).

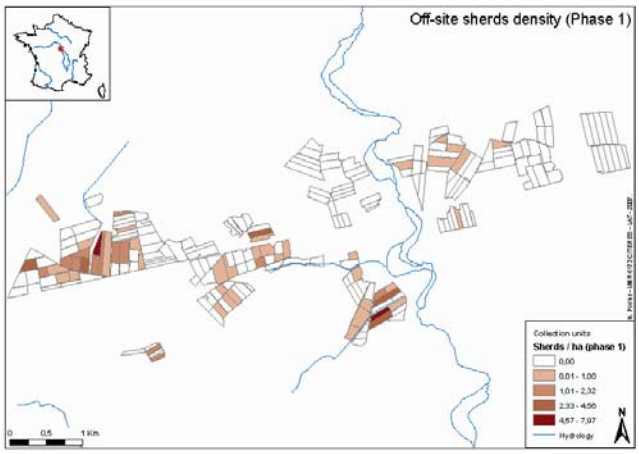

Fig. 2a. Off-site sherds density (phase 1)

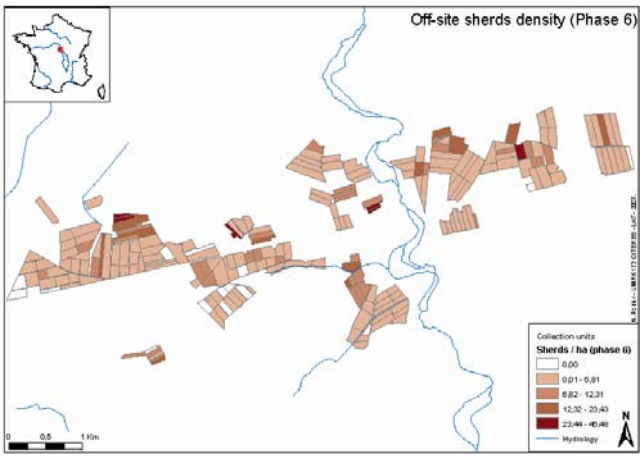

Fig. 2b. Off-site sherds density (phase 6)

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

3.1 Defining the indicators

Three indicators were defined to measure the agrarian activity. First, the number of chronological phases occupied was computed (i.e. the number of phases delivering artefacts) in order to measure the duration of agrarian occupation. A ratio was then created opposing this value and the total number of phases potentially occupied (six, in this case). We obtained 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 mainly 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 dispersal at this time scale. 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. It is most likely that the same bias would have existed even if our dating capabilities had been better. Our interpretation is always limited by archaeological dating frames.

For this reason, the number of breaks detected in the occupation for each collection unit was also computed. The number of unoccupied phases which succeed to occupied phases is recorded. This value is then divided by the number of occupied phases. The opposite of the result (*1-[breaks/occupied phases]*) can be interpreted as an index (ranging from 0 to 1) measuring the stability of human activity.

At last, in order to balance the global occupation duration and 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 activity over the long term and takes 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 in 3 or 4 sectors. The highest values (more than 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 zones irregularly manured through time.

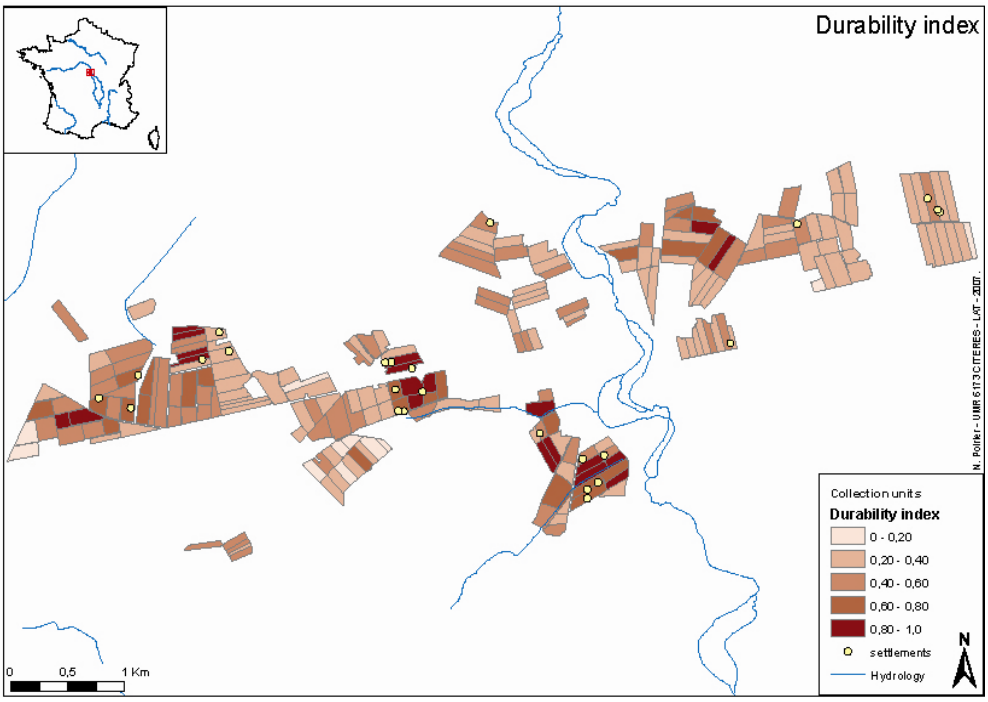

Fig. 3. Spatial variability of the durability index.

3.2 Characterizing areas depending on the durability index.

The last step of this study aims at characterizing the different areas depending on the ancient societies' investment over the long term. Using the capabilities of a GIS software, the distribution of durably and irregularly exploited areas and its link to various environmental (relief, soil quality, hydrology) and socio-economic variables (number and proximity to settlements) were explored. Such an approach was meant to explain the variability of human activity over time.

Zonal statistics were 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. Starting form the assumption that there is a link between the physical environment and the choice of a specific arable zone, we can also hypothesize that a link exists between those spaces and the proximity with settlements, because settlements are the sources of the manuring material. The number of settlements located within each collection unit was therefore computed, includig all phases. But it was noticed that some collection units had a high durability index while they had no settlement. A second variable was then added: the number of settlements (all phases included) located within 500 meters. 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 was computed using buffers around each collection unit.

Pearson coefficient, the correlation of environmental and socio-economical variables, and durability index were then 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 similar even if few variations are noticeable: most of the zones have soils favourable for agrarian activities. The only differences are in the texture. While irregularly manured zones have lightly textured 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 stream. Irregularly manured spaces have the highest distance to the closest water. This distance decreases as the durability index increases. The distance to the closest water stream averages 266 meters for the most durable manured spaces. This is half less than the value encountered in the most irregularly exploited spaces (Fig. 5).

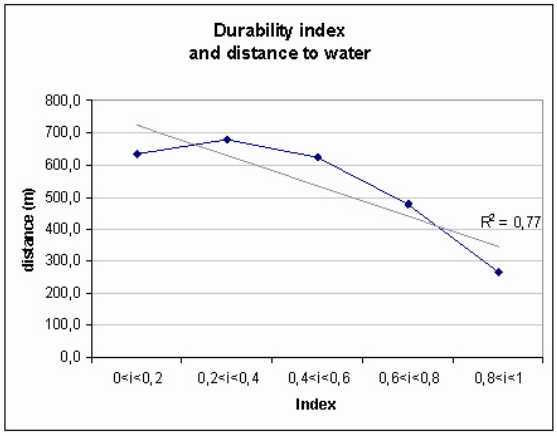

Fig. 5. Durability index and distance to waterflow

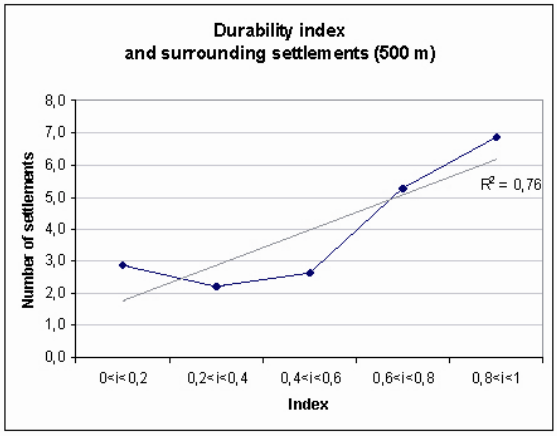

Fig. 6. Durability index and surrounding settlements.

Conversely, 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 areas with a durability index between 0,8 and 1. This trend is confirmed when looking at the number of surrounding settlements in a 500 meters buffer area around units. An average of 2,8 settlements around irregularly manured spaces is highlighted and almost 7 settlements are found 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, a distinction was made between 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 environmental variables used in this study.

The development of areas can be durable only if the installation of several settlements ensures their continued existence. The settlements are the sources of manuring 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 involved in the

program in order to observe common trends, local particularities, or different interpretations. In particular, the comparison of 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) could prove of great interest.

poirier.nico@gmail.com

Acknowledgments: many thanks to Laure Nuninger (CNRS UMR 6565, Laboratoire de Chrono-Ecologie (France)), who was kind enough to read this paper and enrich it of her comments.

References

- BERTONCELLO, NUNINGER *in progress*
Bertoncello, F., Nuninger, L. – "From Archaeological Sherds to Qualitative Information for Settlement Pattern Studies" in: Niccolucci, F. (ed.), *Beyond the artifact: digital interpretation of the past CAA2004, Computer Applications and Quantitative Methods in Archaeology*, BAR International, Archaeopress, Oxford.
- BINTLIFF, SNODGRASS 1988
Bintliff J., Snodgrass A. - "Off-site pottery distributions: A regional and interregional perspective", *Current Anthropology*, 29, 506-513.
- CHISHOLM 1968
Chisholm M. – *Rural settlement and land use. An essay in location*, Science Editions, New-York.
- GANDINI, *et al* 2007
Gandini C., Bertoncello F. et collab. – "Hierarchical typology and settlement patterns modeling at inter-régional scale", in: *Layers of perception, proceedings of the CAA 2007 Conference, Berlin 2-6 april.*
- GEORGES-LEROY *et al.* 2007
Georges-Leroy M., Tolle F. et collab. – "Measurements of the intensity of the agrarian exploitation by spatial analysis of the ancient field systems well preserved by the forest cover" in: *Layers of perception, proceedings of the CAA 2007 Conference, Berlin 2-6 april.*
- JONES 2004
Jones R. - "Signatures in the soil: The use of pottery in manure scatters in the identification of medieval arable farming regimes", *The Archaeological Journal*, 161, 159-188.
- NEIL RIMMINGTON 2000
Neil Rimmington J. - "Soil geochemistry and artefact scatters in Beotia, Greece", in: Pasquinucci M., Trément F. (ed.), *The archaeology of mediterranean landscape : non-destructive techniques applied to landscape archaeology*, Oxbow Books, Oxford, 190-199.
- NUNINGER 2003
Nuninger L. - "Exploitation et spatialisation des indices protohistoriques épars en Vaunage (Gard), VIIème-Ier siècles av. J.-C." in: Favory F., Vignot A. (ed.), *Actualité de la recherche en Histoire et Archéologie agraires. Actes du colloque AGER V - 19-20 septembre 2000*, Presses Universitaires Franc-Comtoises, Besançon, 365-375.
- NUNINGER *et al* 2007
Nuninger L., Tourneux F. P., Favory F., "From Archaeomedes to Archaedyn", in: *Layers of perception, proceedings of the CAA 2007 Conference, Berlin 2-6 april.*
- OSCHINSKY 1971
Oschinsky D. - *Walter of Henley and other treaties on estate management and accounting*, Clarendon Press, Oxford.
- POIRIER 2006
Poirier N. - "Du temps long au temps court : modéliser l'évolution spatiale de l'exploitation du sol", communication affichée, colloque *Interactions Natures-Sociétés*, UMR 6554 LETG, La Baule, 3-5 mai 2006, http://letg.univ-nantes.fr/colloque/pdf/PO_POIRIER.pdf
- PUIG 2003
Puig C. - "Du fumier à l'épandage, enrichir le sol en Rousillon entre les XIe et XIVe siècles ap. J.-C." in: Favory F., Vignot A. (ed.), *Actualité de la recherche en Histoire et Archéologie agraires. Actes du colloque AGER V - 19-20 septembre 2000*, Presses Universitaires Franc-Comtoises, Besançon, 67-77.
- WILKINSON 1982
Wilkinson T. J. - "The definition of ancient manured zones by means of extensive sherd-sampling techniques", *Journal of Field Archaeology*, 9, 323-333.