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Measurements of Diachronic Stability of Agrarian Exploitation

Abstract: Off-site material has two main interesting properties which are that 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 based on collection units which never exceed five hectares. Each off-site sherd was dated and attributed to one of 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 software. The data used in this paper come mainly from a fieldwalking project conducted in a study area of Berry (Central France).

Introduction

The ArchaeDyn project is endorsed by the French ministry of research and aims at developing synthetic indicators of the stability and dynamics of spaces in the long term (Nuninger et al. 2008). 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: the 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 / Tolle 2008.

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 press). 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 examples of recently excavated structures used to prepare the manure (Puig 2003) or manured zones identified by geochemical measurements such as phosphates (Rimmington 2000). Off-site sherds are widely and regularly distributed all over the fields, which excludes seeing them as a simple refuse disposal. 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.

Data Acquisition and Processing

To begin this work, it was necessary 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 allow comparison of the data collected. In all the study areas, data originated from fieldwalking on arable lands which lead 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 m. 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
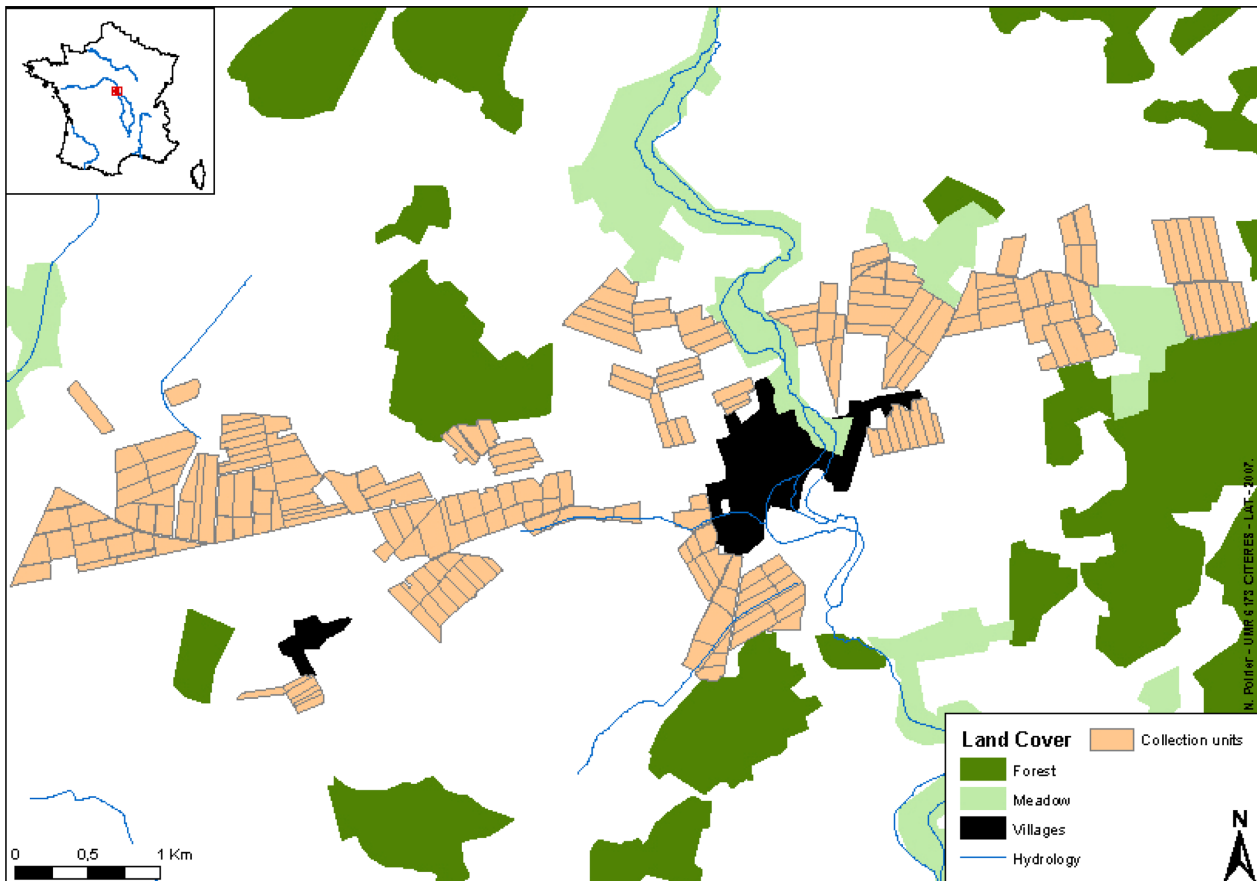
Fig. 1. Localization of the study-area in the centre of France and collection units.

field, several fields if they were too large, but more often part of a field.

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 the excavations were good enough to overcome the traditional division between large periods such as Iron Age or Roman Age. 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: 5th – 1st century BC
- Phase 2: 1st century BC – 4th century AD
- Phase 3: 4th century – 8th century
- Phase 4: 8th century – 11th century
- Phase 5: 11th century – 15th century
- Phase 6: 15th century – 18th century.

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 the sherds density of 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 ha and the maximum area never exceeds 5 ha.

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 many more artefacts than others. No artefacts or agrarian occupation can be proved in some other zones. Depending on the chronological phases, the variations in density showed a wide range of
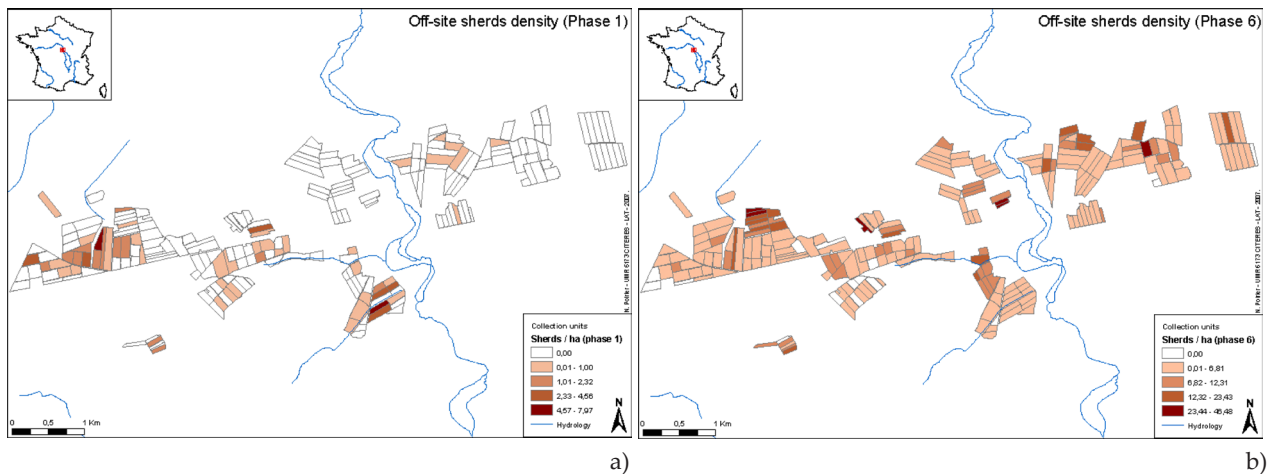
Fig. 2. (a) Off-site sherds density (phase 1). (b) Off-site sherds density (phase 6).

different situations. For example, Protohistory gives the image of a contrasted agrarian space with high density areas and other spaces with no artefacts collected at all *(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)*.

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).

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 which estimated 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 from 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 affect 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 more 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 succeeded 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) which measured the stability of human activity.

Finally, 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
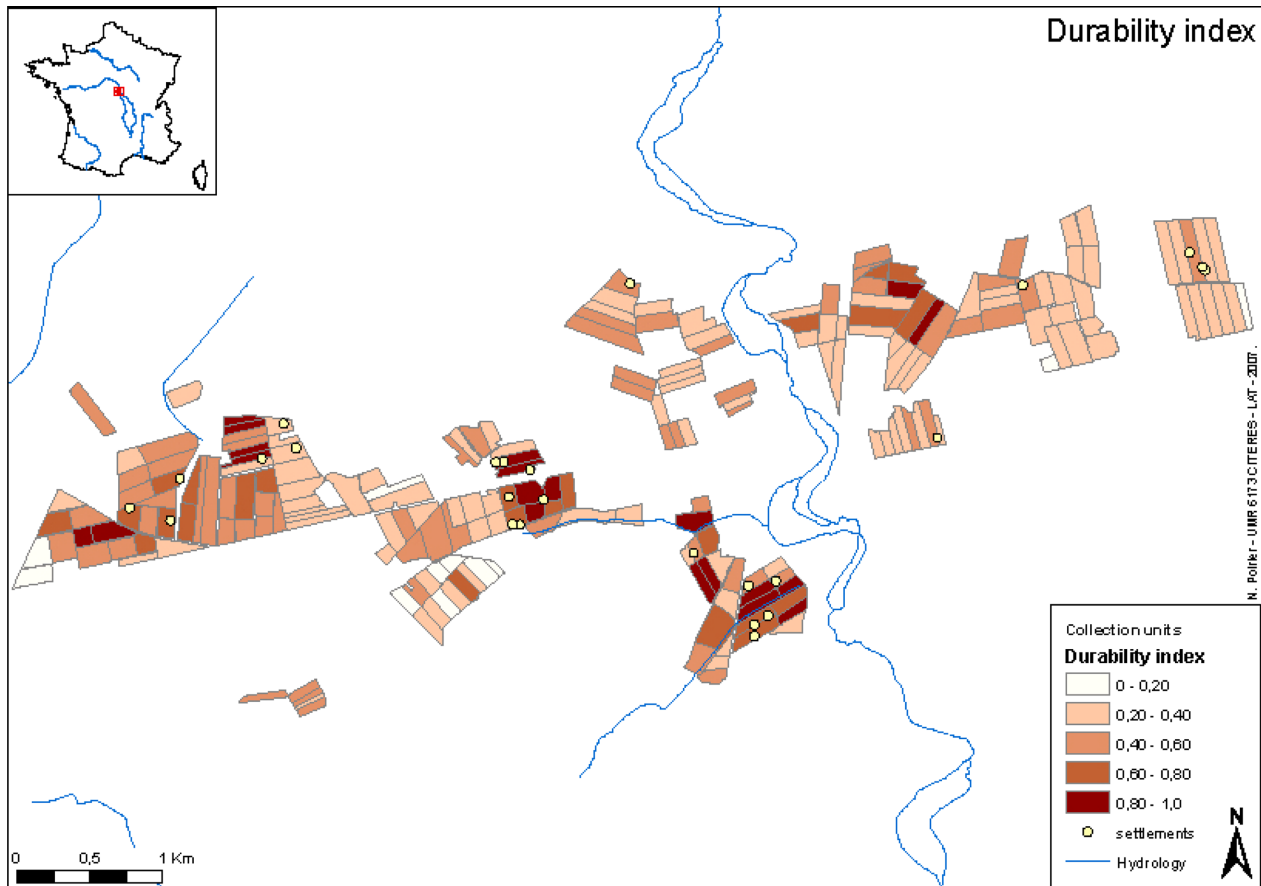
Fig. 3. Spatial variability of the durability index.

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 (exceeding 0.8) concern 20 collection units (9%), and 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.

Characterizing Areas
Depending on the Durability Index

The final part 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 their link to various environmental (relief, soil quality, hydrology) and socio-economic variables (number and proximity to settlements) were explored in order to explain the variability of human activity over time.

Zonal statistics for each collection unit were used to compute their 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 stream.
Archaeological (or socio-economical) variables were also computed. Starting from 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, as the settlements are the sources of the manuring material. The number of settlements located within each collection unit was therefore computed, including all phases. However it was noted that some collection units had a high durability index while they had no settlement. A second variable was then added which included the number of settlements (all phases included) located within 500 m. This distance can be considered as the most likely to find settlements as-

	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. The Pearson correlation coefficient between the durability index and several variables.

sociated with manured areas, given the high costs in time and effort to bring the manure into 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.

By calculating the Pearson coefficient, the correlation between environmental and socio-economical variables, and the durability index was tested *(Fig. 4)*.

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. This is due to the fact that the landscape of this area is not very hilly. Soil properties are quite similar even if a 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 minor but seem to be statistically significant. The only environ-

mental 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 m for the most durable manured spaces. This is less than half the value encountered in the most irregularly exploited spaces *(Fig. 5)*.

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 m 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)*. This calculation takes into account all the re-
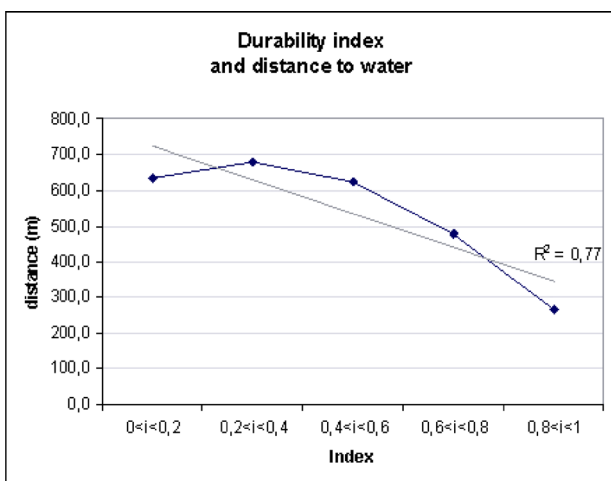

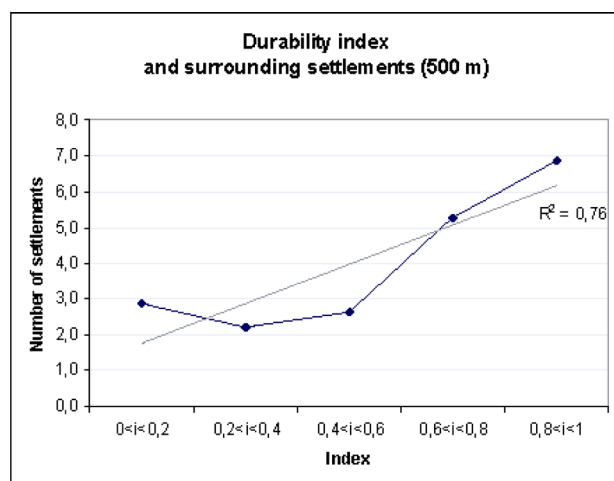Fig. 5. Durability index and distance to water stream.

Fig. 6. Durability index and surrounding settlements.

corded settlements, independent of the variations in internal settlement density over time *(Fig. 3)*. Given that we were attempting to estimate global stability of agrarian space over the long term, these variations don't have a great influence.

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 from 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 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 when 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. 2008).

Within the ArchaeDyn project, we will aim 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 / Tolle / Nouvel 2008) could prove of great interest.

Acknowledgements

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