Spatial analysis for an efficient use of data from trial trenching.

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Trial trenching

The practice of preventive archaeology in France takes place in two steps: first, preliminary survey ("diagnostic" in french) and second, excavations. In rural areas this means an opening in the form of trial trenches. This continuous trenching pattern is performed using mechanical devices. Trenches (2.5m width) are evenly spaced (aprox. 18m) so as to cover around 10% of the surface.
This first phase aims to provide sufficient information -on the nature, extent, chronology and degree of preservation of the sites in view to prescribe or not an excavation. The areas affected by these archaeological surveys are considerable, in some cases tens or hundreds of hectares.

On the 226 ha development project in Ozans (commune of Etrechet, Center of France), 412 trenches were opened for a cumulative total length of 124 km and a total area of 248,032 sqm. The overall open rate is 11%. Following these diagnostics, three excavations have been prescribed and performed in 2011.

Aims of the study

The study aims at testing and evaluating methods used in spatial analysis to propose archaeological hypothesis and compare them with those from the field. We focused on the geographic (location), geometric (dimensions) and chronological properties (dating) of archaeological remains. **The aim is to estimate the contribution of spatial analysis, on the one hand to interpret the diagnostic's results, on the other hand to understand land use and settlements pattern in this area. Our methods are both cartographic with the grid analysis and statistic with data clustering.**

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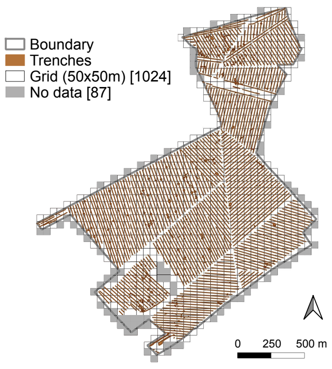
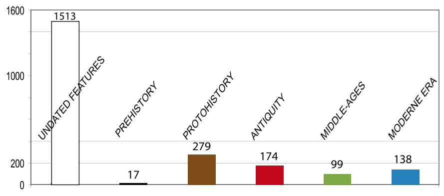
Grid Analysis

The use of a grid analysis (or tessellation) overcomes the limitations of the the trial trenches implementation which creates a mask for the representation of archaeological remains.

The choice of the cell size defines the resolution of the study and of the representation of the research area. The area was divided into 1024 cells of 50 m square that intersect at least two trenches.

grid implantation on trial trenches >>



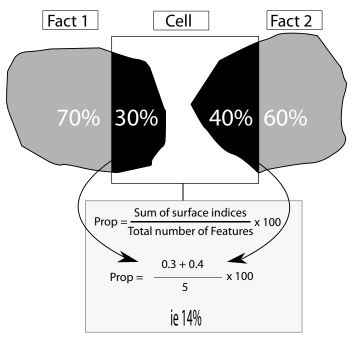


Number of archaeological features for each period

Several criteria are used for dating archaeological remains excavated during a diagnostic: the typo-chronological study of artefacts, stratigraphic or topological relations between the remains and ancient iconographic sources. In our project, datings were simplified and reclassified in a four classes called PERIODS: Protohistory, Antiquity, Middle Ages and Modern Era.

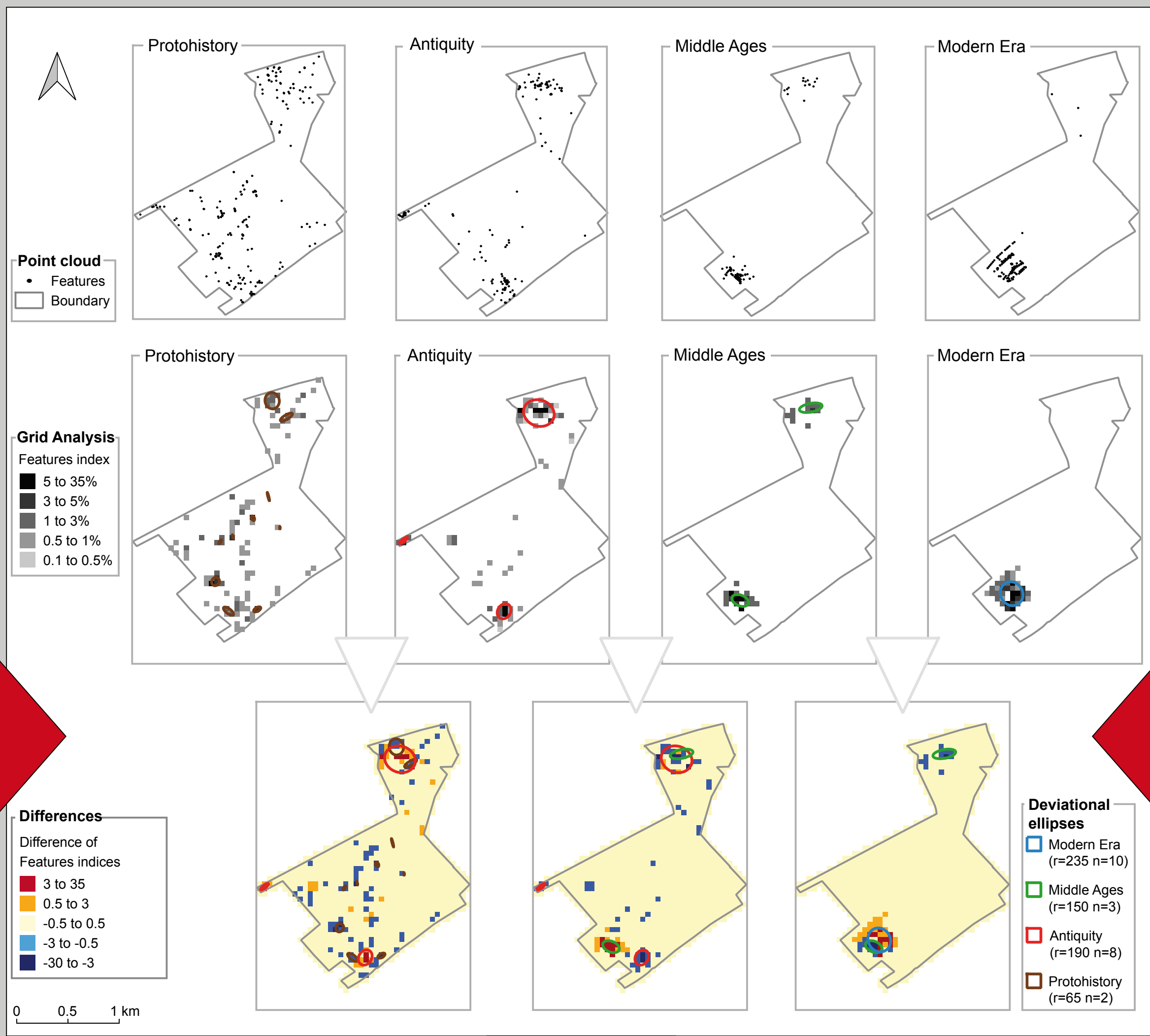
Modelisation and features indices

Summarize archaeological features in each cell ("addressed grid") is not relevant. Instead we used for each time class a "ventilated grid" with the "zonal clipping" algorithm. It follows a geometric principle: the intersection of the area calculation between the features area and the square.



In each cell the surface of archaeological features is weighted by the total number of remains of the period in order to obtain a more homogeneous class distribution between the different periods. The index obtained by cell was then classified with the Jenks algorithm.
Six classes were defined from [0.1%-0.5%] (light gray) to [5%-35%] (black).

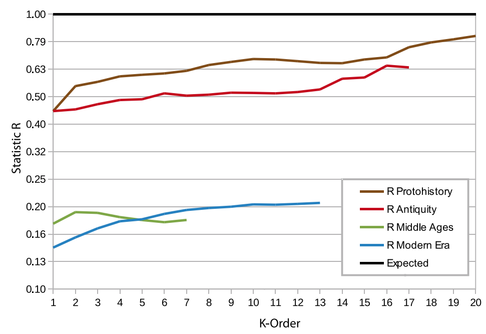
Finally, to represent distribution changes of the vestiges between two successive periods, the value of each cell for the earliest period was subtracted from the value of the corresponding cell for the other period.
Here again six classes were defined. The lowest class [-30 to -3] in dark blue represents a depreciation of the index, meaning a decrease in the proportion of facts in the most recent period compared with the earliest period. The highest one [3-35] in dark red shows conversely an increase in the index.



Data clustering

Data clustering aims at determining the geographic properties of archaeological feature distribution and organization for each period, then at defining and representing feature clusters. To obtain a point cloud, archaeological vestiges, initially represented by polygons, are reduced to their centroids.

Data clustering involves three steps:



1-Nearest Neighbour: characterize distribution

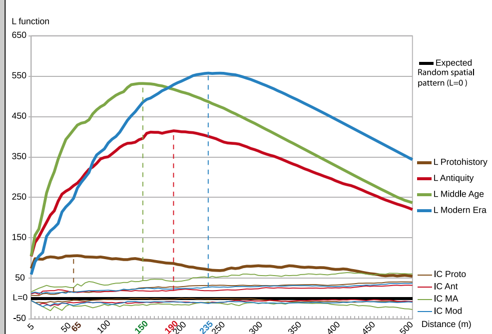
The method is based on a first-order property of the point cloud: the average distance from any point to its nearest neighbour. This distance is compared with the expected (theoretical) distance of a random distribution called null hypothesis. A K-Order is set to study the distance to the first nearest neighbour and then to the second, until the K-th one.

The functions for all periods point clouds are represented in a graph with K-Order in x-axis and the R statistic in y-axis. The Expected (random distribution) value is 1. For each period, the more R function tends to 0 the more distribution of the point cloud is concentrated.

Results: For all periods, scatter points have a relatively grouped distribution with R statistic approaching 0.

2-Ripley's K (Besag's L) function: characterizes distribution and determines scales of aggregates

Ripley K function compares the density expected under the null hypothesis to the observed density by drawing search-circles of increasing radius. The various search radius produce a correlogram representing the spatial aggregation function (y-axis) and the search distance (x-axis). Scales of aggregates are identified by the inflection points of the function.



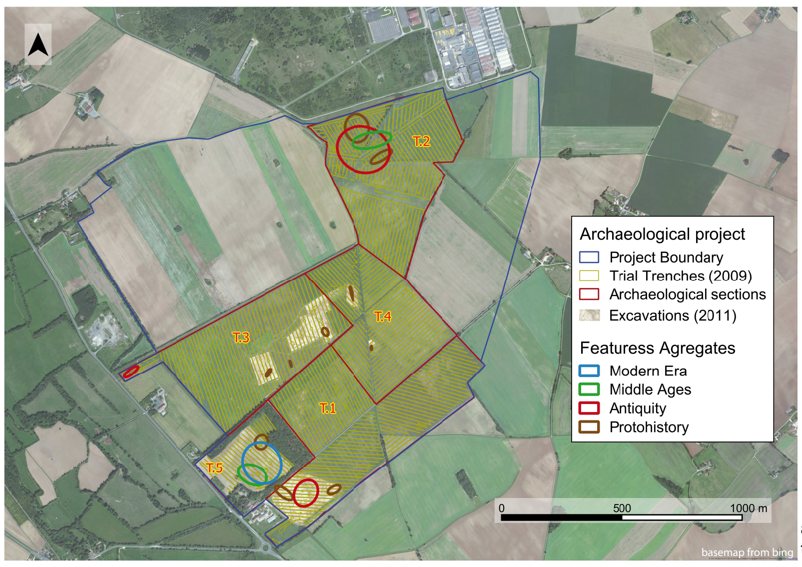
Results: Unlike the first-order analysis, the point set of Protohistory emerges clearly from those of other periods with a tendency to lower aggregation. Point clouds of the three following periods are similar, with a strong trend of clustering. The curve reaches a maximum and then decreases gradually until the confidence interval (IC on the graph).

3-The «moving windows method»: Represents aggregates with a spatial scan algorithm

A spatial scan algorithm allows a local analysis of a set of points, ie to determine significant local aggregates.
This spatial scan algorithm is called "moving windows method" because it identifies the aggregates within a circular window that scans the study area.

The algorithm points out concentration windows that are above what could be expected in the case of a null hypothesis.
The spatial scan was performed for each period. Identified aggregates are represented as deviational ellipses around the centroids of the identified clusters.

Results: Unlike the grid analysis which only allowed the comparison of the remain's concentrations for two periods, deviational ellipses -derived from the spatial scan- can all be represented together on the same map to overlay and compare aggregates for all periods.



Results

The result of this study is synthesized in the superposition of deviation ellipses and grid analysis maps. It allows a synthetic reading of the diagnostic data based on a robust and reproducible spatial analysis protocol.

Results show that it is possible to check interpretive hypothesis on the distribution of the remains. Indeed, spatial analysis reveals patterns by periods, that must be confronted to the essential archaeological interpretation.

Results meet the two objectives of an archaeological assessment. First, they are useful for the archaeologist to interpret the remains and to understand the dynamics of land-use and settlements pattern. Secondly, as decision-making tool, they provide elements for the authorities to deal with the archaeological sites (excavation or preservation).

aerial view of the study area with the excavations that followed the diagnostics. The overlapping ellipses shows the correlation between the results of the spatial analysis and that of field archaeologists.

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