Murielle Georges-Leroy – Florian Tolle – Pierre Nouvel

Analysis of the Intensity of Agrarian Exploitation by Spatial Analysis of Ancient Field Systems Preserved by Forest Cover

Abstract: As part of the framework for the ArchaeDyn project, this work aims to understand spatial discontinuities in ancient land use through the analysis of ancient agrarian structures preserved by forest cover in Lorraine and Burgundy, northeast France. The first step consisted of examining the intensity of landuse (the density of linear features, stone piles, and the mean length of features) and its structuring (degree of closure, shape and surface area of field parcels) indicators. The second step consisted of spatially analysing these parameters in order to identify homogeneous zones. These zones will then be compared to environmental and human factors in an attempt to understand how these field systems were established.

Remains of Fossilized Field Systems

This work aims at highlighting and characterizing spatial discontinuities in ancient land use through the variation of the intensity and structuring of fossilized field systems preserved by forest cover. It is conducted within the framework of the first working-group of the ArchaeDyn project under the supervision of François Favory and Laure Nuninger (Nuninger / Tourneux / Favory 2008). This group is focusing on supply areas as they are attested too by two kinds of remains: agrarian manuring (Poirier / Tolle et al. 2008) and ancient field systems[1].

Eight study areas were investigated in this study. They are located in two regions of north-east France, Lorraine and Burgundy. The observation of agrarian structures has been conducted on an area of approximately 10 000 hectares.

In Lorraine, five areas are located on the limestone plateau of the Côtes de Moselle in the vicinity of Nancy. Work has been undertaken since 1998 and involves an interdisciplinary team of researchers from the Regional Archaeological Institute of Lorraine (Ministry of Culture), from INRAP (National Institute of Preventive Archaeological Research), from the French National Institute for Agricultural Research in Nancy, and from the National Forests Institute (Laffite et al. 2002; Georges-Leroy et al. 2003; Georges-Leroy et al. 2007)[2]. The largest area is the Haye forest with more than 7700 ha surveyed. Other areas are located in the forests of Thuilley-aux-Groseilles (40 ha), Allain (330 ha), Selaincourt (80 ha), and Saint-Amond (425 ha).

In Burgundy, three areas north of Avallon in the Yonne region are studied: Arcis-sur-Cure (75 ha), Champlive (1000 ha), and Girolles (280 ha) (Kasprzyk / Nouvel 2002; Nouvel 2006; Nouvel in press).

This study focuses on preserved agrarian structures such as terraces and stone banks. These structures sometimes run for hundreds of meters and were protected by forest cover upon their abandonment. Stone banks are usually no higher than a few tens of centimetres but some survive as high as a meter and a half. These linear features are the result of stone being removed from the fields for cultivation and are therefore considered as marks of the agricultural exploitation. These structures delineate fields and animal enclosures and are more or less regular in form. They also indicate the alignment of tracks and roads. Settlements, usually small in size, related to these field-systems can also be identified.

The great majority of fossilized fields that can be identified in these forests date from the Gallo-Roman era. Their direct dating is not straightforward and they have similarities to more recent field-systems dating from the post-medieval and modern periods. Such comparable field-systems exist in nearby areas but are located outside of the forests. Nevertheless, some linear features have been dated through the analysis of related archaeological material (for

[1] The authors are grateful to Elise Fovet, Nicolas Poirier and François Favory for their help in the work sessions of work group 1, and to Florian Tolle and Tom Moore for the translation.

[2] Murielle Georges-Leroy, Jean-Denis Laffite, Etienne Dambrine, Jean-Luc Dupouey.

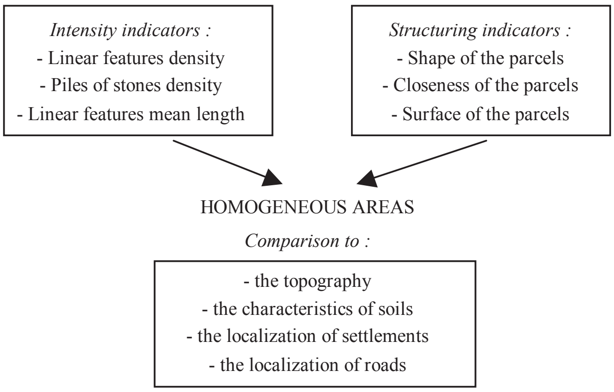

Fig. 1. Analysis process.

example ceramics and tegulae) found in the field. Other indirect elements also allow for more precise dating. The forests under examination are ancient in origin and this is confirmed by the examination of maps dating from the post-medieval period and more importantly by references in medieval texts. Furthermore, several features are directly related to Gallo-Roman settlements. These remains are therefore an illustration of the extension of cultivated land during the Gallo-Roman times, even though their relative dating and the evolution of their organization are not easy to characterize.

Prospection of the field-systems has been conducted differently depending on the areas studied and the recording methods have varied. It therefore proved necessary as a preliminary task to define the level of reliability of the archaeological information used for analysis. Two reliability criteria have been created. First, the reliability of the archaeological information *per se* is considered and then the reliability of the survey method, as variation in such methods does influence interpretation of the data. Two levels were designed to describe the reliability of the archaeological information which is dependent on the quality of the prospection. The first level encompasses areas where systematic prospection has been conducted and where visibility conditions were fa-

Fig. 2. Ancient agrarian structures preserved in the south of the Haye forest.

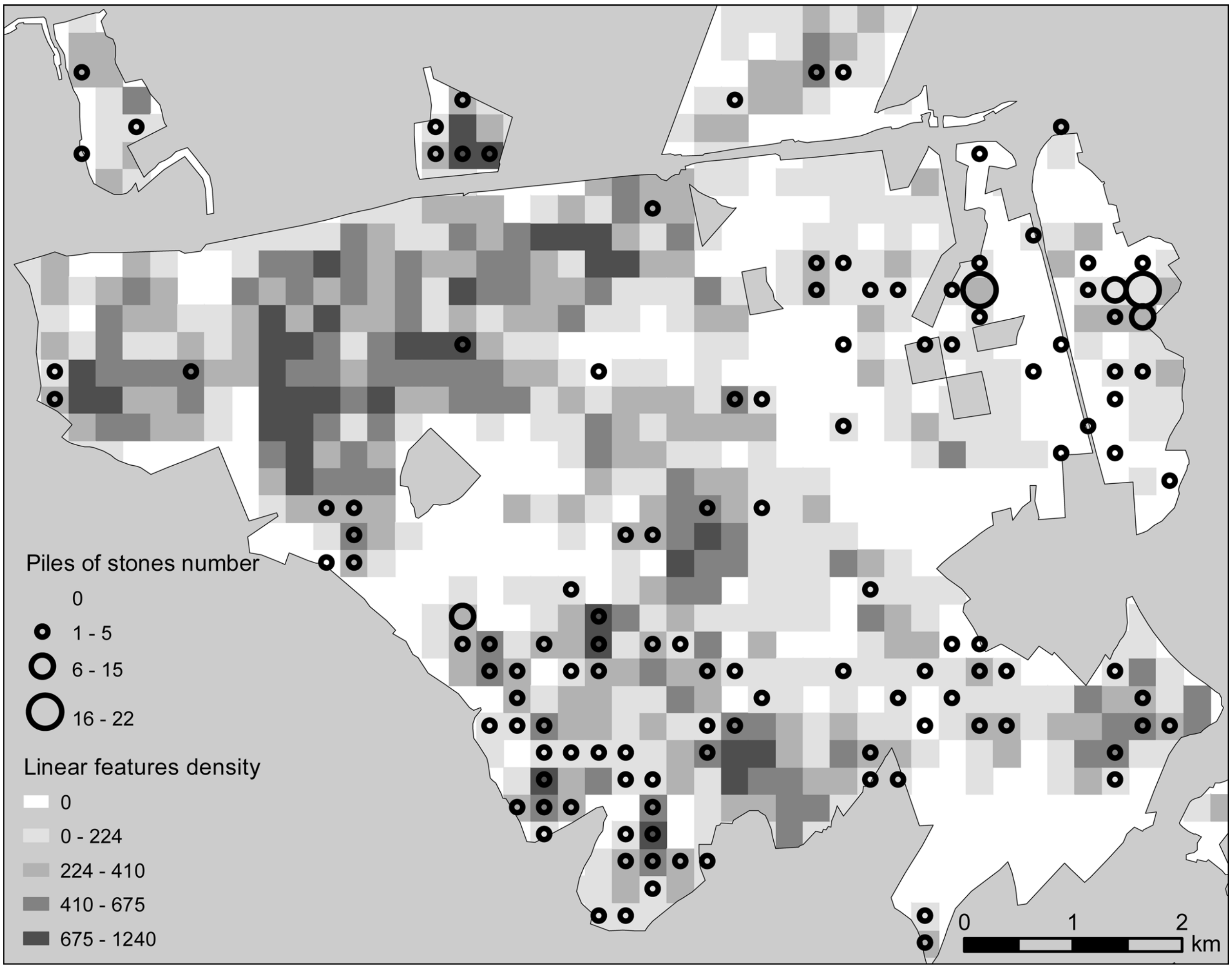

Fig. 3. Intensity indicators in the south of the Haye forest.

vourable. This is the highest level. The second level comprises partially prospected areas (due to limited prospection for example), or areas with bad visibility conditions (usually due to dense vegetation cover or the inaccessibility of forest areas which were damaged by the 1999 Lothar storm). The reliability of the survey method has also been defined in two categories. Features have been recorded using GPS with differential correction, using tape measure and compass, or using Topofil thread measuring device and compass. These data recording devices led to very heterogeneous precision levels, varying from a meter to tens of meters in some areas. Data transcription from paper recordings also led to a loss of precision while georeferencing. Two recording reliability levels were created. The first level corresponds to a precision of 10 m or less, usually GPS data. The second level is defining errors greater than 10 m. A new Lidar campaign has been conducted in April 2007 in order to improve the quality and precision of archaeological information. This work was undertaken on the entire Haye forest (110 km^2) and is comparable to the project on ridges and furrows conducted in forests near Rastatt, Germany (Sittler 2004).

Spatial Analysis: Creating Indicators to Describe Field Systems

The analysis process was based on the creation of indicators intended to describe the features and their spatial arrangements *(Fig. 1)*. In the first phase, intensity and structuring indicators were analysed. The second phase consisted in integrating these indicators using spatial analysis in order to identify homogeneous areas. These areas will then be compared to environmental elements (human and natural) in an attempt to understand how these field systems were established.

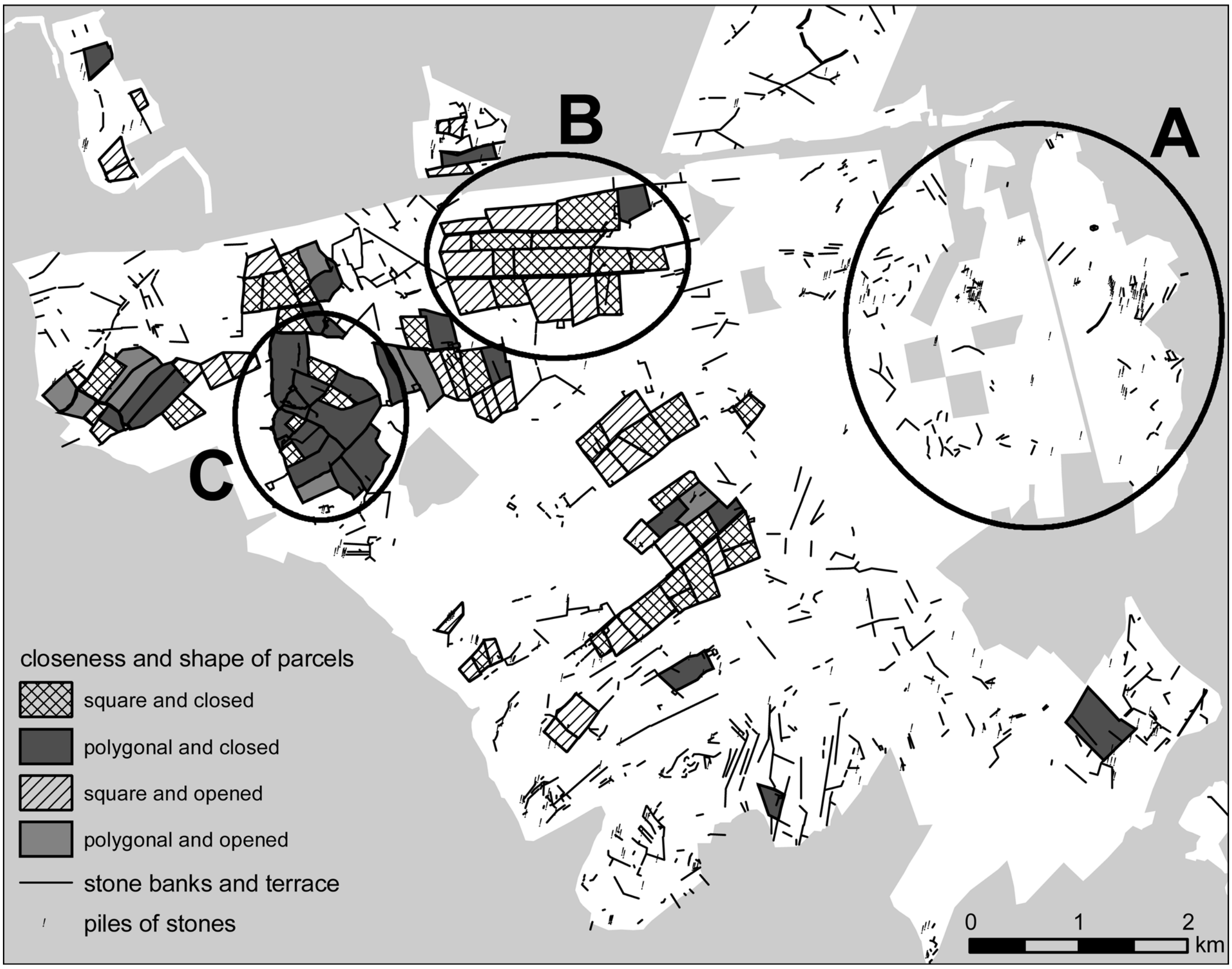

Fig. 4. Homogeneous areas in the south of the Haye forest.

This work is still in progress and only the first analyses of the southern part of the Haye forest are presented here. In this area, covering 7700 ha, 125 km of stone banks, 95 km of terraces, 35 km of roads, 425 stone piles and 51 settlements were recorded. All agrarian structures were integrated into a GIS software as polylines (stone banks, terraces and roads) or as points. However, such raw data is not straightforward to analyse and interpret as can be seen on *Fig. 2*.

Characterizing Field Systems: Intensity and Structuring Indicators

The first category of indicators aims at describing the intensity of occupation. Two indicators have been computed and displayed using a 250 m resolution canvas. The density of linear features (total length of stone banks and terraces) and the density of stone piles (number of pile stones recorded in each cell of the canvas) were calculated. The combination of these two indicators gives an initial insight into the spatial variation of such features. Some areas have a high density of linear features whilst others display an association of linear and point features and other areas are empty *(Fig. 3)*. The density differences are only partly explained by prospection issues, as is shown when comparing density and reliability maps.

The intensity of occupation has also been compared to the stoniness of the soils based on pedological maps. A direct link between features and stoniness is not clearly apparent. Differences in the stoniness of the soils do not, therefore, provide an explanation for the different intensities witnessed. This suggests that some variability existed in the ancient use of these soils.

The second category of indicators intended to describe structures was created according to a qualitative and non-automatic protocol. A layer of polygonal units has been created by visual analysis of the linear elements. When a "space" can be singled out

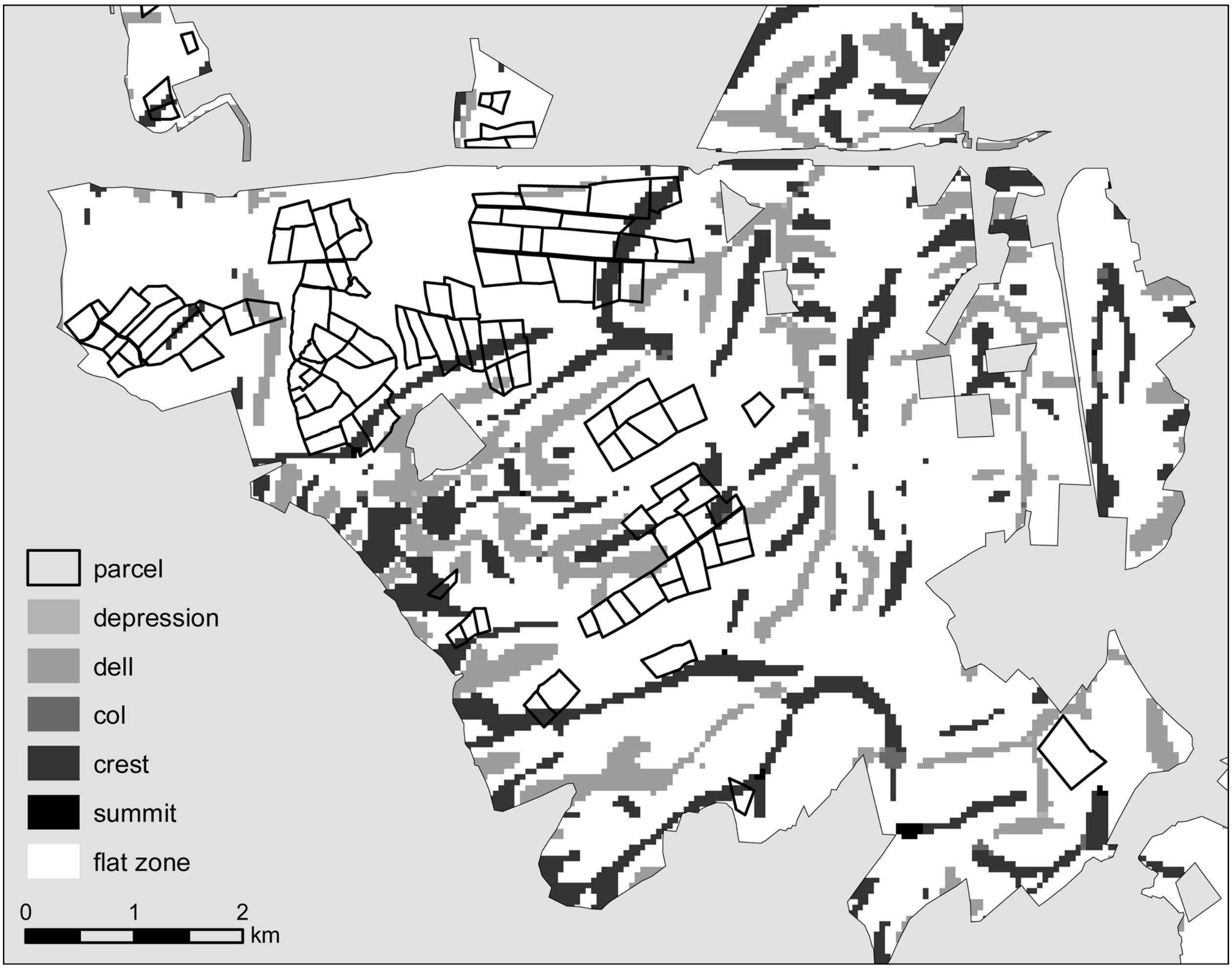

Fig. 5. Topographic settings and field systems in the south of the Haye forest.

and is delimitated on at least three sides, a polygon is drawn in a GIS environment and characteristics are attributed to the new spatial object. Three indicators were generated to describe this layer:

- The surface area of these polygons is calculated. This information can be refined by only analysing complete parcels. This data is represented as surface area classes;
- The shape of parcels is defined as quadrangular or polygonal (more than four sides);
- The degree of closure of parcels is characterized depending on whether it is enclosed on three or four sides.

A simple observation of this layer allows us to identify structured and non-structured zones. An initial combination of shape and closure indicators gives an indication of homogeneous blocks *(Fig. 4)*. A further step could involve all three structuring indicators by using k-means methods.

The complete combination of intensity and structuring indicators is still under way but should allow for the definition of homogeneous areas. As an example, three different zones can be mentioned in this part of the forest *(Fig. 4)*:

- Zone A is not structured with a low density of linear features that are of a short average length. Numerous stone piles are present but they are clustered in space;
- Zone B is highly structured with a high density of linear features. No stone piles are present and parcels have a quadrangular shape;
- Zone C is also highly structured with a high density of linear features. Parcels are polygonal and show a high degree of closure.

Comparison of Field Systems to the Surrounding Environment

Homogeneous areas are subsequently compared to environmental and human data. The influence of topography on the nature and location of field systems has been studied using two descriptors (topo-

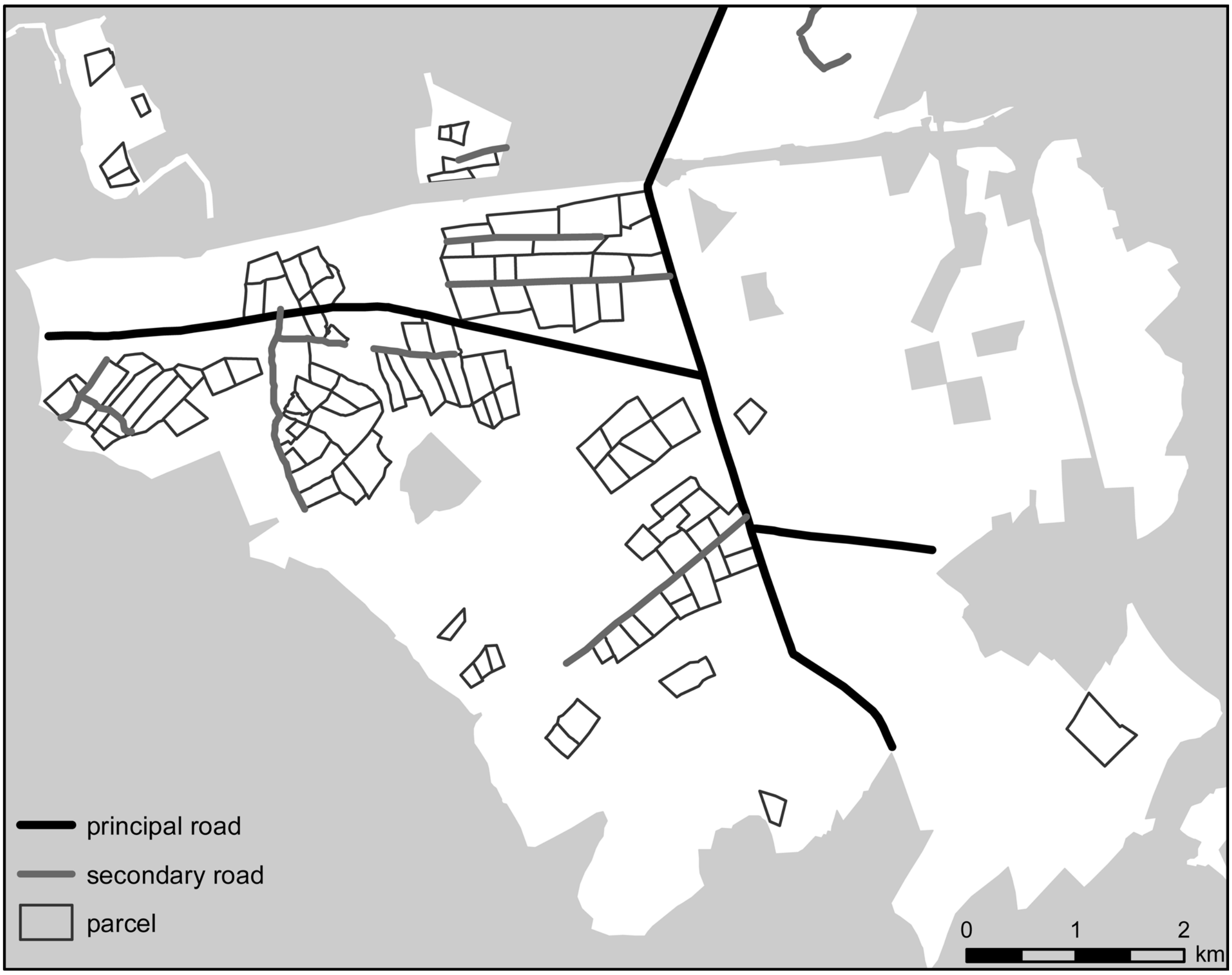

Fig. 6. Road system and field systems in the south of the Haye forest.

graphic location and orientation). The topographic characteristics of each area of the forest have been derived from a DEM (source: IGN – National Geographical Institute) and classified in six categories: depression, dell, col, crest, summit and flat zones. By overlaying the structured blocks on this map, we observed that field systems are preferentially located on flat areas. Steep depressions seem to be avoided even though some crests and small valleys are occupied *(Fig. 5)*. In some places, crests and valleys have a strong influence on the orientation of the linear features. Another observation is that zone A where no structure was identified displays a more difficult topographic setting with numerous valleys and crests.

Another descriptor has been tested. Linear features are expected to be influenced by topographical features and the method used here aims at understanding the influence of relief on the field systems spatial arrangements. The orientation of linear features is expected to have an influence on the location of highly structured field systems. The general orientation of features will be computed in each cell of a canvas and expressed as a histogram. The consistency of these orientations with the orientation of topographic slopes should allow us to determine the level of planning and human effort involved in the organization of the agrarian structures.

Agrologic characteristics of soils will also be used as environmental parameters. The soils of these areas are being classified according to different parameters such as thickness, stoniness, water content, texture, structure, etc. It is particularly worth noting that zone C is located on a great diversity of soils and some of these soils have poor agrologic properties (for example, particularly dry soils). This zone might have been undergoing a different kind of agricultural use, representing pasture for example.

Human elements in connection with field systems were also examined. In particular, roads and settlements were identified. The low number of roads and structured field systems led to a simple visual inspection of their interactions. Two different categories of roads can be found in the Haye forest. The general orientation of structured field blocks is different from the orientation of the main roads *(Fig. 6)*. Yet the blocks are clearly connected to these roads sometimes with an adaptation in the orientation of the blocks in the linking zone. Secondary roads are much more strongly linked to structured blocks. They display similar orientations or shapes and are servicing blocks. In zone A, no road has been recorded whereas zone B is highly structured by two straight, axial roads. Zone C is serviced by a road running sinuously along the edge of the block.

The creation of indicators concerning settlements remains to be addressed. Different ideas have been explored such as the connection between settlements and parcels or roads. These connections were interpreted manually in order to avoid topological problems. The level of connection is high as 80% of settlements are connected to one element of the field systems. Moreover, 50% of settlements are connected to structured blocks. The location of settlements depending on their kind (isolated buildings, farms) is still to be examined.

Conclusions

These first steps in the analysis of field systems need to be further explored. Some areas in the north of the Haye forest do not appear structured with the selected indicators but do seem to display some degree of organization. The definition of homogeneous zones needs to be refined so that real comparisons with available environmental and human elements can be undertaken. These procedures will then have to be extended to all the field systems in the program. Some of the other systems are smaller but have specific characteristics, for instance Saint-Amond which is located in a topographically complex area. A clear set of common indicators is the key to effective comparisons between study areas.

References

Georges-Leroy et al. 2003

M. Georges-Leroy / E. Dambrine / J. L. Dupouey / J. D. Laffite, Habitats gallo-romains et structures agraires fossiles du plateau de la Côte bajocienne (Meurthe-et-Moselle et Vosges): Etat de la question. In: Favory / A. Vignot (eds.), Actualité de la recherche en histoire et archéologie agraire. Actes du colloque international AGER V (Besançon 2003) 173–180.

Georges-Leroy et al. 2007

M. Georges-Leroy / D. Heckenbenner / J. D. Laffite / N. Meyer, Les parcellaires anciens fossilisés dans les forêts lorraines. In: J.-L. Dupouey / E. Dambrine / C. Dardignac / M. Georges-Leroy (eds.), Actes du colloque Forêt, Archéologie et Environnement (Velaine-en-Haye 2004) 121–132.

Kasprzyk / Nouvel 2002

M. Kasprzyk / P. Nouvel, Les campagnes de Noyers-sur-Serein durant l'Antiquité, premier bilan des recherches en cours. Bulletin de la Société d'études d'Avallon 79, 2001, 43–55.

Laffite et al. 2002

J. D. Laffite / E. Dambrine / E. D. Dupouey / M. Georges-Leroy, Le parcellaire gallo-romain de la forêt domaniale de St-Amond à Favières (Meurthe-et-Moselle). Relevé et étude du parcellaire du «Grand Rinchard». Revue Archéologique de l'Est 51, 2001–2002, 465–476.

Nouvel 2006

P. Nouvel, L'Avallonnais sous la domination romaine. Bulletin de la Société d'études d'Avallon 81, 2005, 5–32.

Nouvel in press

P. Nouvel, Saltus et espaces de marge en Bourgogne du Nord au Haut Empire. In: Saltus et silva, espaces de marge en Gaule romaine. Actes du colloque AGER de Rennes, Octobre 2004.

Nuninger / Tourneux / Favory 2008

L. Nuninger / P. F. Tourneux / F. Favory, From Archaeomedes to ArchaeDyn. In: Present volume, 278.

Poirier / Tolle 2008

N. Poirier / F. Tolle, Measurements of diachronic stability of agrarian exploitation. In: Present volume, 278.

Sittler 2004

B. Sittler, Revealing historical landscapes by using airborne laser scanning. A 3D model of ridge and furrow in forests near Rastatt (Germany). In: M. Thies / B. Koch / H. Spiecker / H. Weinacker (eds.), Laser-Scanners for Forest and Landscape Assessment. Proceedings of the ISPRS working group VIII/2, Freiburg, Germany, October 3–6, 2004. International archives of photogrammetry, remote sensing and spatial information sciences 36, part 8/W2 (Freiburg 2004) 258–261.

Murielle Georges-Leroy

Direction Régionale des Affaires Culturelles de Lorraine
Service régional de l'Archéologie
6 pl Chambre
57000 Metz
France
murielle.leroy@culture.gouv.fr

Florian Tolle
Pierre Nouvel

CNRS
Laboratory of Chrono-Ecology UMR 6565
16 Route de Gray
25030 Besançon
France