GROMA

documenting archaeology | dept. of history and cultures, university of bologna

Open-Access E-Journal about methodology applied to archaeology
http://groma.unibo.it

Michele Abballe,

The medieval rural settlement in Bassa Romagna: a first predictive model and future directions

Volume 2-2017
ISSN: 1825-411X
pp. 1-X
DOI: 10.12977/groma7
Publisher: BraDypUS [http://books.bradypus.net]
Publication date: 29/10/2017

Section: Article

MICHELE ABBALLE

The medieval rural settlement in Bassa Romagna: a first predictive model and future directions

The paper presented here is an extraction of my MA dissertation and falls within the landscape project Bassa Romandiola. Considering the biases present in the dataset at disposal, predictive modelling has been chosen as a methodology potentially useful to gain more information about the medieval settlement patterns of the area. Both environmental and "socio-cultural" variables have been considered, to make the most of the data available. A first predictive map has been created using the Dempster-Shafer theory and possible future directions highlighted to improve the result obtained.

The Bassa Romagna landscape and the need for a model of the rural settlement

The landscape archaeology project "Bassa Romandiola" was started in 2009 by the University of Bologna, under the direction of Prof. Andrea Augenti and the field coordination of Dr. Marco Cavalazzi. The target area of the project is a sub-region of more than 550 sq. km called Bassa Romagna[1], located northwest of the city of Ravenna.

One of the biggest achievements of the four campaigns carried out so far (Fig. 1) is having brought to light archaeological evidence of a rural settlement dated to the early and high Middle Ages that was totally unknown before. The ceramic assemblages, mainly made of courseware and soapstone, suggest that these sites were rural houses or huts, probably made of perishable materials (Cavalazzi *et al.* 2015, in press).

After a period of environmental instability during the Late Antiquity, a long process of reclamation was started in the region, promoted by the main property owners of the time[2]. What is actually possible to see in the documents is the emergence of a growing number of *fundi*, i.e. cadastral unit, and farms, like *curtes* and *massae*, cultivated thanks to contracts between owners and farmers (Pasquali 1995).

Archaeologically, we know many of the *plebes*, i.e. rural baptismal churches, in which the *fundi* were located, while we had no evidence of the houses where the people who worked those lands lived. Indeed, for this typology of sites, there has always been very little room by historical documents and archaeology, with both focusing almost exclusively on lords' properties and major sites. Even during maintenance works of riverbeds and channels, which sometimes led to some archaeological discove-

[1] In the late Middle Ages the territory was known as *Romandiola*; see http://www.treccani.it/enciclopedia/romagna/ (accessed 28/06/2017).

[2] For instance, Enrico, Bishop of Imola, promoted the reclamation of the *silva de Lucae*, now known as Lugo (Bertoldi 1794, 62). For more information about the reclamation process see Chouquer 2015, 125-129.

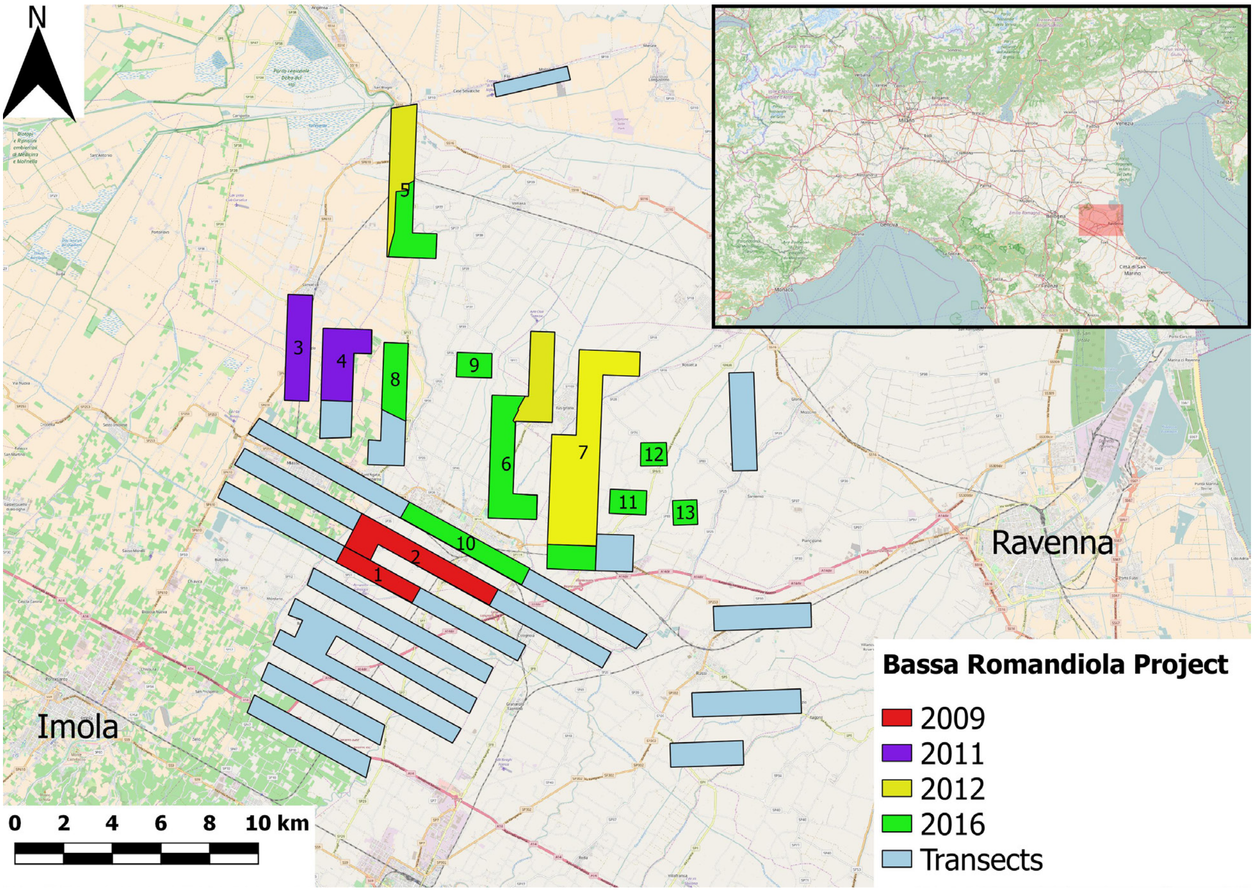

Fig. 1. Case study area and the sampling strategy of the Bassa Romandiola Project: transects with numbers have been already investigated, while the ones in pale blue have not yet.

ries, medieval houses were never identified (Cani 1980; Tamburini and Cani 1991; Franceschelli and Marabini 2007).

Nevertheless, clues of their existence could still have been found in the written sources. Indeed, the twelfth-century documents from Faenza Archives mention the existence of *supersedentes*, namely farmers who have received small pieces of land from their lords, with a low amount of dues, but with obligation to live on the land itself (Pasquali 1995, 161-163; Cavalazzi 2012, 707-708). Accordingly to the data we collected so far, it seems possible to hypothesize that similar settlements existed also in the previous centuries, though with some local differences. In fact, in the south-west of Lugo the sites discovered are dispersed and they seem located along the limits of the centuriation[3] (Fig. 2). Instead, in the area around Bagnacavallo, we recorded an early nucleation of the habitat in some complex and clustered settlements (Figs. 3-4), located mainly in proximity of the *plebs* of *S. Pietro in silvis* (Cavalazzi 2012; De Felicibus 2012/13; Cavalazzi *et al*. 2015, in press).

However, the alluvial dynamics that occurred in the area do not allow us to have a clear view of the archaeological phenomena that interested this landscape. The region is indeed an alluvial plain, part of the Po Valley, in which the level of the soil increased due to the deposition of sediment carried by this large river and others, like Senio and Santerno, which came down from the Apennines. This phenomenon, together with subsidence, often led to the burial of pre-historical and historical soils under metres of alluvium, thus that the traces of previous occupation remain invisible to surface techniques as fieldwork survey (Franceschelli and Marabini 2007, 78; Abballe 2015/16, 104). We also must take into account that our view is affected by other biases, which are strictly related to the methodology used so far, na-

[3] For a more in-depth study of the local centuriation see: Franceschelli and Marabini 2007; Chouquer 2015.

Fig. 2. The red diamonds correspond to early and high medieval rural sites located to the south-west of Lugo, RA (Image elaborated starting from Fig. 2, in Cavalazzi et al., in press).

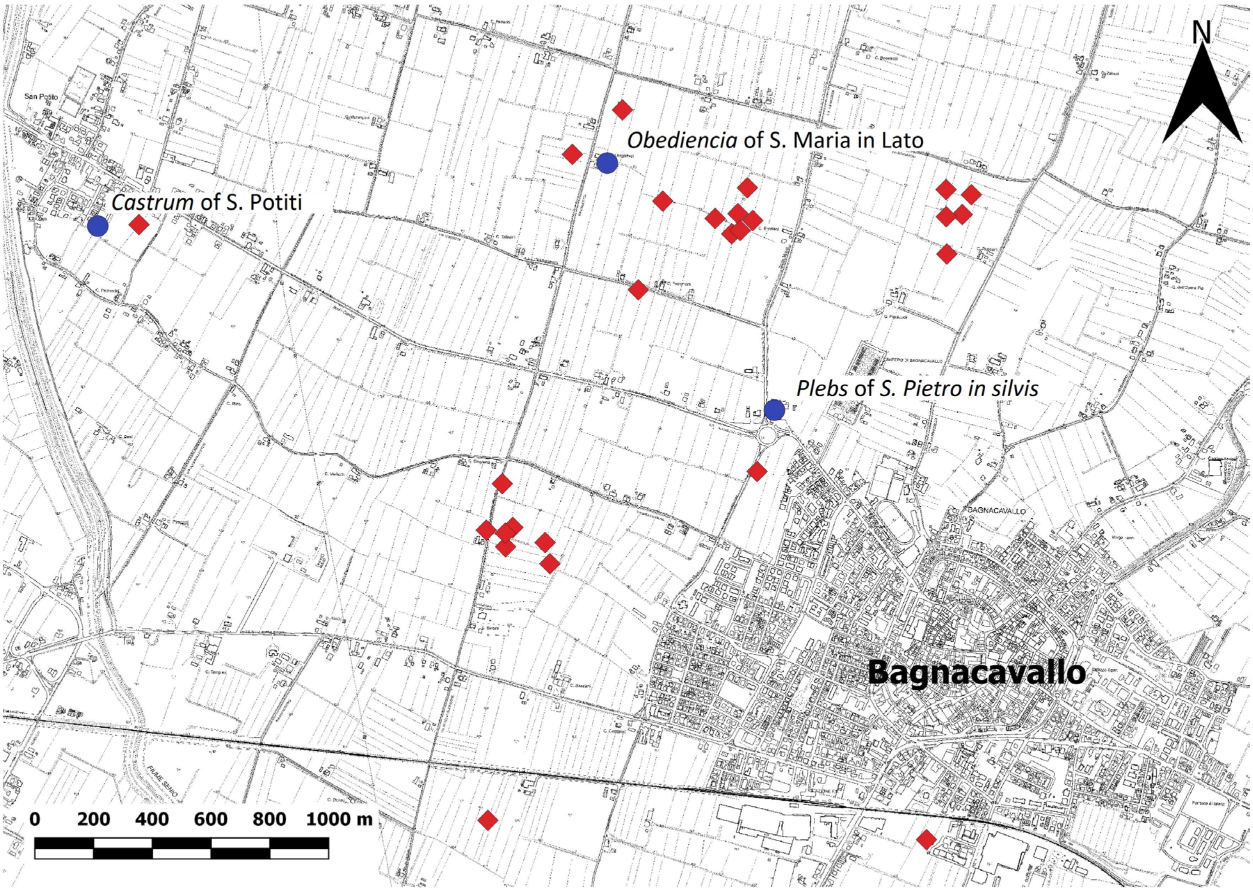

Fig. 3. The red diamonds correspond to early and high medieval rural sites located around Bagnacavallo, RA (Image elaborated starting from Fig. 2, in Cavalazzi et al., in press).

Fig. 4. In red, nucleated sites located around Bagnacavallo, RA (Image elaborated starting from Fig. 3, in Cavalazzi et al., in press).

mely the systematic field survey: these are visibility, land use/land cover and sampling (Van Leusen 2002, chapter 4).

Because of the above-mentioned limits, predictive modelling has been chosen as a methodology potentially useful to better understand where people lived across this territory[4]. However, in such environment, the parameters normally used, i.e. soil types, elevation, slope, etc., would have not worked very well, thus a different approach was needed. This is why we had to use fruitfully the data available along with our understanding of the "context", rather the ability of a certain type of geomorphological feature or site to attract settlements in their surroundings or not.

The dataset used

The data used to build the model were stored in a Microsoft® Office Access database[5] and georeferenced with QGIS[6]. Despite the limited number of archaeological data at disposal, an impressive persistence of toponyms in the modern landscape has allowed to place on the ground (Fig. 5) a large number of the sites known from the documents (Augenti, Ficara and Ravaioli 2012).

From a geomorphological point of view, inactive and active watercourses, marshes and *silvae,* i.e. woodlands, have been included in the model. In particular, palaeo-levees, linear and meandering features created by the accumulation typical of the alluvial rivers, are very important for archaeologists because they can permit the identification of sites also by non-invasive techniques like field survey (Mancassola 2012, 119-120). Furthermore, these geographical features have shown to be strictly related to the human occupation in this region, e.g. several of the *plebes* were built on these features (Abballe 2015/16, 38). This because man often chose these areas for dwelling and for economic activities since, being raised above the surrounding plain, they offered stability and security from alluvial events. For this reason, all the palaeo-levees previously recognised (Cremonini 1994; Franceschelli and Marabini 2007) and dated to the high Middle Ages or earlier, have been included in the model. In particular, the larger ones have been mainly identified analysing the microreliefs of the region, while several smaller ones, attributa-

[4] For a review of this methodology, see the following publications and relative bibliography: Kamermans, van Leusen and Verhagen 2009; Verhagen and Witley 2012; MapPapers 1-III 2013.

[5] In total, the database counts 710 entries, divided in the following sources: historical (282), archaeological (141), casual discoveries (96), Bassa Romandiola (77) and others (114).

[6] Dr. Marco Cavalazzi, field director of the project, filled the database and created the GIS before the start of the project.

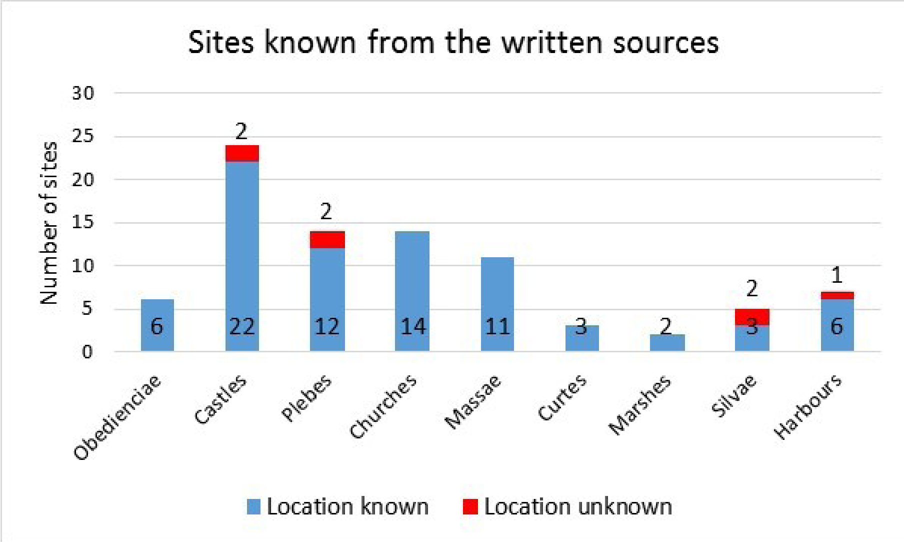

Fig. 5. Chart showing the evidence included in the model divided between location known and unknown.

ble to secondary courses or crevasse splays, can be seen through the study of aerial or satellite images since they were reused by the modern artificial channel network.

Marshes and *silvae* have been considered as "negative" factors because they hinder the settlement of people, while their limits have a "positive" value because they were often chosen to establish pioneer settlements to promote the exploitation of such areas[7].

From the historical point of view, the existence of a site in a certain location has been considered as sufficient proof of the fact that people were living in that area. Starting from this assumption, a different archaeological potential weight has been given to each type of site, according to its ability to attract or prevent possible rural settlements in its proximity.

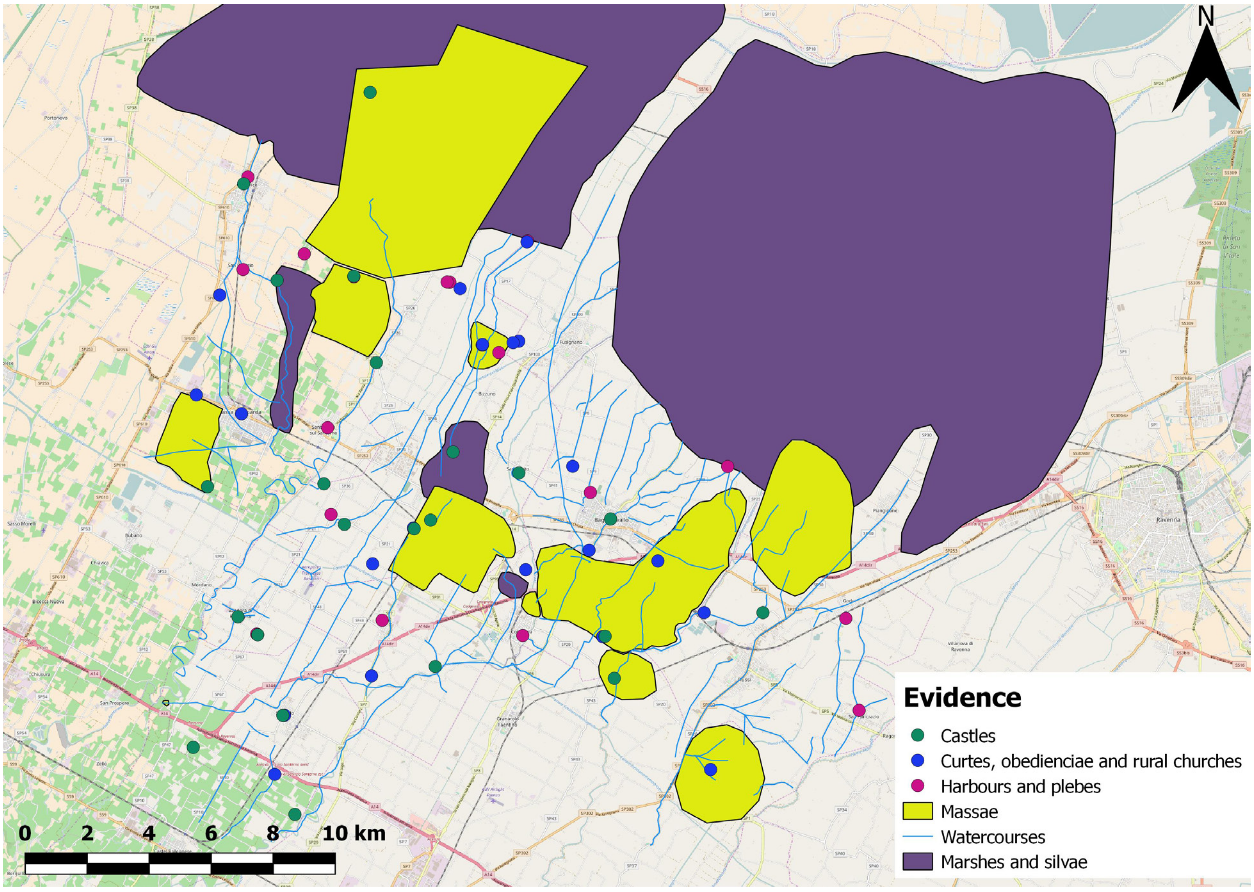

Fig. 6. Map showing all the evidence used to build the model.

[7] Like the farms called *massae*, as argued by Gianfranco Pasquali (1997, 18-19).

The evidence used to build the model are (Fig. 6):

- Castles;
- *Curtes*[8], *obedienciae*[9] and rural churches;
- Harbours and *plebes*;
- Boundaries of marshes and *silvae*;
- *Massae*[10];
- Watercouses;
- Marshes and *silvae*.

Evidence 1	Castles
Hypothesis	Site
Rule	High potential limited only to the castle itself and its immediate surroundings
Proof	Around the *castrum* of S. Potiti only one site has been found
Fuzzy	Sigmodal - Symmetric - a (350 m) - b (350 m) - c (350 m) - d (500 m)

Evidence 2	*Curtes, obedienciae* and rural churches
Hypothesis	Site
Rule	High potential for a large area and then slowly decreasing
Proof	Around the *obediencia* of *S. Maria in Lato* several sites have been recorded; the same happened around the rural church of *S. Andrea di Zagonara*
Explanation	The *curtes* are farms, so there has to be people who work in them; the *obedienciae* were used to collect goods from the countryside; the aim of a rural church is usually to offer "services" to the population
Fuzzy	Sigmodal - Symmetric - a (1000 m) - b (1000 m) - c (1000 m) - d (2000 m)

Evidence 3	Harbours and *plebes*
Hypothesis	Site
Rule	Potential limited only to the site or building itself, but considering also possible annex buildings
Proof	In the region, the *plebes* have never shown to have attractiveness on the rural settlement
Explanation	The particular location of the harbours, often situated at the join of levees and marshes, should have caused a shortage of farmland
Fuzzy	J-shaped - Symmetric - a (150 m) - b (150 m) - c (150 m) - d (300 m)

Evidence 4	Boundaries of marshes and *silvae*
Hypothesis	Site
Rule	High potential along the borders of both marshes and *silvae*
Proof	Presence of harbours along the limits of marshes
Explanation	Perfect location for pioneer settlements for wood exploitation and reclamation processes
Fuzzy	J-shaped - Symmetric - a (150 m) - b (150 m) - c (150 m) - d (300 m)

Evidence 5	*Massae*
Hypothesis	Site
Rule	Medium potential spread over a large area
Proof	Farm composed by several *fundi* and *casali*
Explanation	*Fundi* have to be cultivated, so maybe there were people living on them
Scalar	Value x 0.25

Evidence 6	Watercourses
Hypothesis	Site
Rule	High potential close to them, but quickly decreasing moving away
Proof	Almost all the sites found are located within 200 m from a watercourses
Explanation	These areas were chosen because higher than the surroundings, so safer
Fuzzy	Sigmodal - Symmetric - a (250 m) - b (250 m) c (250 m) - d (700 m)

Evidence 7	Marshes and *silvae*
Hypothesis	Nonsite
Rule	Zero potential
Explanation	Areas where dwelling was not possible

Fig. 7. Explanation of the evidence used to build the model.

The methodology

Considering the data available and the results of the field campaigns, it was decided to create a map of the areas where rural settlements could be located, during a historic period that goes from the early Middle Ages to the twelfth century. The following centuries have been excluded because during the thirteenth century a deep change in the settlement pattern seems to have occurred, representing a turning point for the entire region. In fact, the lords of the time promoted the concentration of the population in few central sites, often castles, suddenly causing a drop in the number of rural settlements

[8] Only the *curtes* mentioned before the eleventh century have been included, because then this term starts to indicate also a territorial district and not only a specific type of farm.

[9] Rural churches used by landlords to collect goods from the countryside.

[10] Regarding this type of farm, two hypotheses have been formulated so far: they were formed by scattered rural houses or they had a main centre, a proper village; see Pasquali 1997. Since there are no archaeological evidence in support of the second hypothesis yet, here, the first one has been chosen for building the model.

(Cavalazzi *et al*. 2015, in press).

Considering the several uncertainties existing in the dataset, the Dempster-Shafer Theory (DST) was chosen to build the model because of its capacity to handle uncertainty that involves ignorance.

Introduced by Arthur Dempster (1967) in the context of statistical inference, it was later developed by Glenn Shafer (1976) into a general framework for modelling epistemic uncertainty. It is essentially a mathematical theory of evidence, with connections to other frameworks such as probability, possibility and imprecise probability theories.

This method allows to combine evidence from different sources in order to reach a degree of belief, starting from a defined number of hypotheses (e.g. A, B) and including all the possible combinations of these (e.g. [A], [B] and [A, B]). The basic assumptions of DST are that ignorance exists in the body of knowledge, and that belief for a hypothesis is not necessarily the complement of belief for its negation. The basic probability assignment (BPA) for a given hypothesis may be derived from subjective judgment or empirical data and it is expressed in a fuzzy measure, or rather infinite number of values in the range [0, 1], with the sum of all BPAs that has to be equal to 1.0 (Eastman 2016).

The firsts to use the potentialities of DST for archaeological predictive modelling were Bo Ejstrud (2003, 2005) and Shaun Canning (2003, 2005). Both studies were carried out using the IDRISI32 software that had already incorporated a DST module called BELIEF. Instead, few years later Benjamin Ducke (2010) used an open source software called GRASS GIS to create a predictive model for the entire state of Brandenburg (Germany), developing by himself the modules necessary to use the DST theory[11]. These were also used to improve the model of the Rijssen-Wierden area, in the Netherlands (Van Leusen, Millard and Ducke 2009).

Each Evidence (Fig. 7) supports a hypothesis { [Site], [Nonsite] or [Site,Nonsite] } and the value of its archaeological potential (Rule) was chosen[12]. This has been decided considering archaeological or documentary information, if available (Proof), together with our theories about the medieval settlement patterns of the region (Explanation). Accordingly, a fuzzy classification has been applied to actually quantify the archaeological potential of each type of evidence in terms of distance in meters (Fuzzy).

What has been used is essentially a mix approach between inductive and deductive methods, as for long suggested (Kamerman, van Leusen and Verhagen 2009).

The software used to build the model is TerrSet, the newest version of IDRISI GIS, and in particular the module BELIEF, which can handle several lines of evidence in form of raster files to create a belief map. Before being able to build the model, all the vector files coming from the GIS of the project had to be processed through several steps (Figs. 8-9).

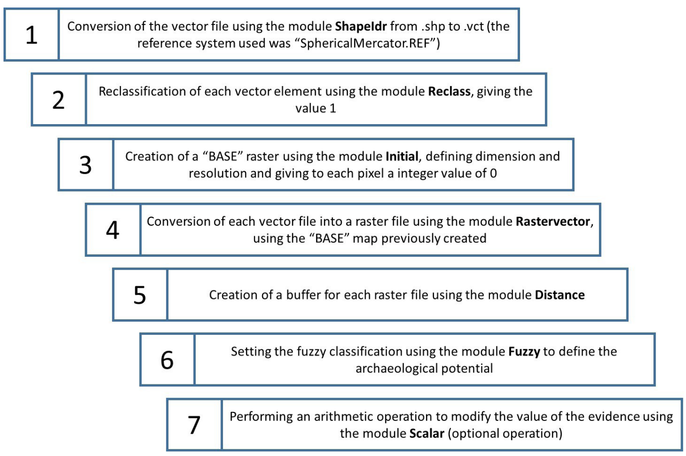

Fig. 8. Workflow

11 https://svn.osgeo.org/grass/grass-addons/grass6/dst/ (accessed 28/06/2017).

12 This phase has been done together with Dr. Marco Cavalazzi, here as expert of the case study area.

Fig. 9. Evidence watercourses (no. 6) within TerrSet software, after having applied the module Fuzzy necessary to define the archaeological potential.

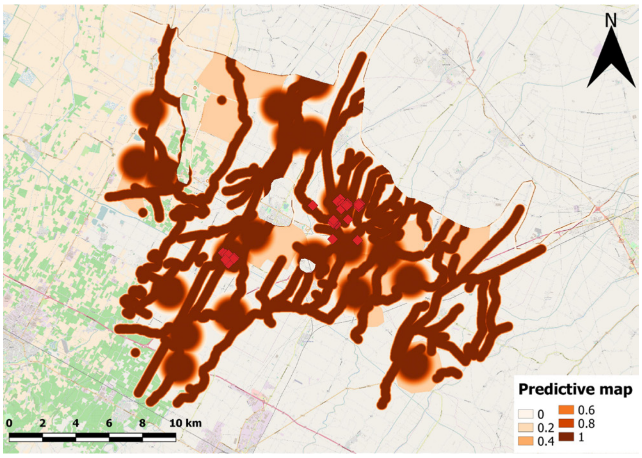

Fig. 10. The predictive map obtained with overlapped the sites (red diamonds) recorded by the Bassa Romandiola Project.

Results and future directions

It is worth to underline that, while defining the archaeological potential of the environmental features was easier, giving it to the sites known from the written sources was definitely more complicated. On one hand, the view of historians and archaeologists about the settlement dynamics has deeply changed since the 1980s (Pasquali 1984, 1997, 2008; Augenti *et al*. 2005; Mancassola 2008), on the other hand we do not have sufficient archaeological data yet.

Nevertheless, the predictive map obtained marks gradually the areas where rural settlements were more likely to be located. By calculating all the variable input in the model, a map with a 32x30m resolution was produced, where values close to 1 mean a high potential, while the ones close or equal to 0 a very low or a null one. To the map created, the rural sites discovered by the Bassa Romandiola Project have been overlapped (Fig. 10): these correspond almost perfectly with the areas with the higher potential proving that the model has been built, relatively to the input data used, in a methodologically correct way. However, even though these archaeological sites were not part of the dataset used to build the model, they were still considered to make several of the assumptions about the rural settlement at the base of the model itself, so they cannot be used to actually test the map produced.

Therefore, future research in the remaining part of the sampling area are of crucial importance to test the model, especially because those areas have been interested by less intense alluvial dynamics and the settlement patterns should be clearer. New data could confirm the vision we have or contradict it, allowing us to potentially recognize the cases where the settlement pattern follows the "rules" and where it does not. The model, which is repeatable, can thus orientate the research and soon after benefit from it, creating a continuous positive process of updating and validation that can considerably help us in understanding where and how people lived in the area during the Middle Ages. Moreover, also archaeological data from excavations could be used to improve the model.

Finally, a further way to refine the model would be the inclusion of a DEM of the medieval landscape. A first attempt of building such a reconstruction has already been done, but being based only on archaeological data, the result must still be considerably improved before to be used (Abballe 2015/16). This could be achieved including coring data paired with targeted field campaigns, in order to reach a level of quality sufficient to produce a hydrologically correct palaeo-DEM[13]. This could be used to considerably refine the predictive model here presented, but also to apply further methodologies, such as past flood or path modelling.

To conclude, the model here presented must be considered as a first attempt, which requests still much work. However, with the directions suggested above, but not only, this initial model can be enhanced considerably and then be used not only to direct field research, but also to improve the current cultural resources management practices in the region.

Bibliographical note

Abballe, Michele. 2015/16. *Landscape archaeology in Bassa Romagna: using GIS for modelling the archaeological potential*. MA diss., Università di Bologna.

Augenti, Andrea, Giulia De Brasi, Marilisa Ficara and Nicola Mancassola. 2005. "L'Italia senza corti? L'insediamento rurale in Romagna tra VI e IX secolo", in *Dopo la fine delle ville: le campagne tra VI e IX secolo*, edited by Gian Pietro Brogiolo, Alexandra Chavarria Arnau and Marco Valenti, 17-52. Mantova: SAP.

Augenti, Andrea, Marilisa Ficara and Enrico Ravaioli. 2012. *Atlante dei beni archeologici della provincia di Ravenna. Vol. 1: Il paesaggio monumentale nel Medioevo*. Bologna: Ante Quem.

Bertoldi, Francesco Leopoldo. 1794. *Notizie istoriche dell'antica selva di Lugo*. Ferrara.

Cani, Norino. 1980. *Ritrovamenti archaeologici nel territorio di Lugo di Romagna e comuni del comprensorio*. Lugo: Walberti.

Canning, Shaun. 2003. *Site Unseen: Archaeology, Cultural Resource Management, Planning and Predictive Modelling in the Melbourne Metropolitan Area*. PhD diss., La Trobe University, Melbourne.

———. 2005. "'BELIEF' in the past: Dempster-Shafer theory, GIS and archaeological, predictive modelling", *Australian Archaeology* 60: 6-15.

Cavalazzi, Marco. 2012. "Progetto 'Bassa Romandiola'. La campagna di ricognizione nel territorio di Lugo di Romagna (RA)". In *Paesaggi, comunità, villaggi medievali*, Atti del Convegno internazionale di studio (Bologna, 14-16 gennaio 2010), edited by Paola Galetti, 703-713. Spoleto: CISAM.

Cavalazzi, Marco, Michele Abballe, Anna Benato and Michela de Felicibus. 2015. "Archeologia dei Paesaggi in Bassa Romagna. Il progetto 'Bassa Romandiola'". In *Romagnola Romandiola: Storiografia e archeologia nella "Romandiola": tradizione e nuove ricerche sul territorio*, conference proceedings (Lugo novembre 2012), 129-172. Lugo: Walberti.

———, in press. "The Late-Antique and Early Medieval landscape in the north-west of Ravenna. The 'Bassa Romandiola' project", in *TRADE*, conference proceedings (Zadar, 11/02/2016), in press.

Chouquer, Gerard. 2015. Les parcellaires médiévaux en Émilie et en Romagne. Centuriations et trames coaxiales. Morphologie et droit agraires, Paris.

Cremonini, Stefano. 1994. "Lineamenti evolutivi del paesaggio fisico del territorio di Bagnacavallo nel contesto paleoidrografico romagnolo", in *Storia di Bagnacavallo* I, edited by Alda Calbi and Giancarlo Susini, 1-40. Bagnacavallo, Bologna: Comune di Bagnacavallo, Banca popolare dell'Adriatico.

De Felicibus, Michela. 2012/13. *Il territorio della pieve di San Pietro in Sylvis tra tarda Antichità e alto Medioevo*, BA diss, Università di Bologna.

[13] Using the ANUDEM program, available at http://fennerschool.anu.edu.au/research/products/anudem-vrsn-53 (accessed 28/06/2017).

Dempster, Arthur. 1967. "Upper and lower probabilities induced by a multivalued mapping", *The Annals of Mathematical Statistics* 38: 325-339.

Ducke, Benjamin. 2010. "Regional Scale Predictive Modelling in North-Eastern Germany", in *Beyond the Artifact. Digital Interpretation of the Past* - CAA2004, edited by Franco Nicolucci and Sorin Hermon, 296-301. Budapest: Archaeolingua.

Eastman, J. Ronald. 2016. *TerrSet. Geospatial Monitoring and Modeling System: manual*. Clark Labs, Worcester, Clark University.

Ejstrud, Bo. 2003. "Indicative Models in Landscape Management: Testing the Methods", in *Symposium, The Archaeology of Landscapes and Geographic Information Systems: Predictive Maps, Settlement Dynamics and Space and Territory in Prehistory*, edited by Jürgen Kunow and Johannes Müller, 119-134. Wünsdorf: Forschungen zur Archäologie im Land Brandenburg 8.

———. 2005. "Taphonomic Models: Using Dempster-Shafer theory to assess the quality of archaeological data and indicative models", in *Predictive Modelling for Archaeological Heritage Management: A research agenda*, *Nederlandse Archeologische Rapporten 29, Rijksdienst voor het Oudheidkundig Bodemonderzoek*, edited by Martin van Leusen and Hans Kamermans, 83-194. Amersfoort: ROB.

Franceschelli, Carlotta and Stefano Marabini. 2007. *Lettura di un territorio sepolto. La pianura lughese in età romana*. Bologna: Ante Quem.

Kamermans, Hans, Martin van Leusen and Philip Verhagen. 2009. *Archaeological prediction and risk management*. Leiden: Leiden University Press.

Mancassola, Nicola. 2008. *L'azienda curtense tra Langobardia e Romania: rapporti di lavoro e patti colonici dall'Età Carolingia al Mille*. Bologna: CLUEB.

———. 2012. "Uomini e acque nella pianura reggiana durante il Medioevo (Secoli IXXIV)", in *Acque e territorio nel Veneto Medievale*, edited by Dario Canzian and Remy Simonetti, 115-132. Roma: Viella.

MapPapers I-III 2013. *Opening the Past 2013. Archaeology of the Future (Pisa, 13-14-15 giugno 2013), pre-proceedings. Available at: http://www.mappaproject.org/wp-content/uploads/2012/12/ OP2013_ pre_ atti_rid.pdf (accessed 28/06/2017).*

Pasquali, Gianfranco. 1984. *Agricoltura e società in Romagna nel Medioevo*. Bologna: Pàtron.

———. 1995. "Terre e contadini nel Lughese: forme insediative e organizzazione rurale (secoli VI-XIII)", in *Storia di Lugo* I, edited by Leardo Mascanzoni and Augusto Vasina, 145-165. Faenza: Edit Faenza.

———. 1997. "Pievi, Masse e Castelli nella pianura faentina e imolese", in *Romagnola Romandiola: opere e giorni, studi promossi dalla Università popolare di Romagna con la collaborazione della Biblioteca Trisi* (Lugo novembre 1994), 17-22. Lugo: Walberti.

———. 2008. *Sistemi di produzione agraria e aziende curtensi nell'Italia altomedievale*. Bologna: CLUEB.

Shafer, Glenn. 1976. *A Mathematical Theory of Evidence*. Princeton: Princeton University Press.

Tamburini, Anna and Norino Cani. 1991. *Archeologia e storia di una città e di un territorio*. Lugo: Walberti.

Van Leusen, Martin. 2002. *Pattern to process: methodological investigations into the formation and interpretation of spatial patterns in archaeological landscapes*. PhD diss., Leiden University.

Van Leusen, Martin, Andrew Millard and Benjamin Ducke. 2009. "Dealing with uncertainty in archaeological prediction", in. *Archaeological prediction and risk management* edited by Hans Kamermans, Martin van Leusen and Philip Verhagen Leiden: Leiden University Press, 123-160.

Verhagen, Philip and Thomas G. Witley. 2012. "Integrating Archaeological Theory and Predictive Modeling: a Live Report from the Scene", *Journal of Archaeological Method and Theory* 19: 49-100.