# Att hitta ny kunskap i historiska kartor med GIS och databaser

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*Gustaf Svedjemo and Erland Jungert: Extracting New Knowledge from Historical Maps with GIS and Databases*

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Historical maps are a vital and frequently used information source in a variety of disciplines and applications. They moved into the GIS –community a decade or so ago. A comprehensive scanning project by Lantmäteriverket will make most of the maps in Sweden available as raster images. Two major projects have modelled the maps for storage in databases, but they have several drawbacks. Our project models the maps as closely as possible to the original structure with a very data-oriented approach. This article presents various applications which go beyond the traditional use of historical maps in GIS. These brief examples involve data mining, statistics, retrogressive analysis and hypothesis testing.

*Key words:* Historical maps, GIS, database, applications, analysis.

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## 1 Introduction

This article is the last in a series of three, which describe the *GM1700 map project,* a database and GIS-project dealing with a series of historical maps of the island of Gotland in the Baltic Sea. In this article we will give some examples of how these and other historical maps can be used, once they reside in the database- and GIS-system. The prior two articles describe the conceptual modelling as an ontology [23] and the mapping between the ontology and the logical database schemata [24].

Domestic mapping in Sweden dates back to the late 16$^{th}$ and early 17$^{th}$ century. Maps in both small and large scales have been produced quite extensively in various time periods. The small scale maps are called geographical maps and the large scale maps are called geometrical maps. The latter depict the landscape at the land parcel level, normally in scales from 1:4 000 to 1:8 000. Text descriptions of the mapped features are linked to the map via a code marking system, see Fig. 1. The first generation of large scale maps are called *Äldre geometriska jordeböcker* (Older geometrical cadastres) and where created between 1630 and 1655. The results of the next phase of geometrical mapping are called *Yngre geometriska jordeböcker* (Younger geometrical cadastres). This phase started in the 1670–80's to fulfil several purposes, and lasted to the 1750's. Fiscal reasons were prominent, as the mapping provided a basis for setting taxes. Gotland and other incorporated areas were extensively mapped in this period [17] [19]. After the cadastral mappings, different land reforms between 1749 until 1972 have produced hundred of thousands of maps.

The results of all the mapping conducted over a period of several centuries are kept in various archives today and the map sheets can probably be counted in the millions (including duplicates). Sweden is rightfully famous for its large collection of large-scale historical maps. In other countries maps of this kind were made sporadically based on private initiatives by single land owners. The fact that in Sweden it was the initiative of the state and the maps cover most of the populated areas makes them quite unique.

For several years Lantmäteriverket (The Swedish National Land Survey Agency) has conducted a major scanning project. The goal is to digitise all historical maps (and the accompanying texts) in their archives. The plan is to finish the project in 2008 and gradually make the maps available via the Internet as a pay service for the public [27]. This will boost the use of historical maps in GIS- and database applications even more.

### *1.1 Previous research*

There is a multitude of smaller projects dealing with digitalisation of historical maps that are very narrow in scope and function oriented. They are set up for a restricted purpose and only deal with a few maps. The database modelling process is typically very limited and also poorly documented. Two projects have dealt with historical maps in a more comprehensive fashion. They are *Nationalutgåva av de äldre geometriska kartorna* at The National Archives of Sweden [16] and the *Digitala Historiska Kartor* (DHK) at The National Board of Antiquities of Sweden [1]. The former project only deals with the maps from the first phase of Swedish large scale mapping between 1630 and 1655. The project focuses on the text descriptions. The text descriptions of these first Swedish large scale maps were very brief . There is very little documentation available of their conceptual- and database models.

The other major project, *Digitala Historiska Kartor* (DHK) at The National Board of Antiquities of Sweden, is well documented with a series of preliminary reports and one final publication including a conceptual model [1]. The project identified three levels of information in historical maps; *map specific-*, *generation specific-* and *general information*. The map specific information is found in one or a few maps. A map generation is a series of maps created with the same objective during a shorter period of time, e.g., *Storskifte* and *Laga skift* (examples from two different land reforms in Sweden). General information can be found in any historical map. The DHK project conducted a user survey to analyse how the maps are used in the cultural heritage sector and mainly addressed the information used in this sector. The focus of the DHK project was the general information in the maps. The approach was to analyse the concepts found in many of the historical maps to find the lowest common denominator behind these concepts. This means that much of the map- or generation specific information is difficult or impossible to handle in their database model.

On the international scene, the author has not found any examples of work of this kind except the work by Pearson and Collier [28] with the British maps made between 1836 and 1850 in the Tithe Survey. These maps also depict the land at land parcel level. The work seems highly function oriented and not all of the information is extracted into databases and GIS-layers.

### *1.2 The GM1700 map project*

GIS applications and analysis using historical maps have mainly been focused on overall landscape or land use studies covering a small area. In these studies a limited amount of the information in the historical maps has been handled, which is mostly the land parcels, building sites, etc. Few of the text descriptions are handled, and when they are, it is done in using very simple database methods. Our project has a wider scope and attempts to deal with the maps and the text descriptions in more detail and to model how these maps are organized. We analyse the concepts contained in the maps and texts, the meaning of the concepts and how they relate to each other. This requires a broader perspective and a more *data oriented view* of the maps and the text descriptions.

An ontology was developed over the Universe of Discourse, since the concepts are the focus of the work. Ontologies are used to model concepts and their relationships existing in different domains. The differences between different Swedish historical map series can be quite great, because they are created at great distance in space and time and they are also developed for divergent purposes. Given the diversity and heterogeneity of Sweden's provinces and regions, the semantics are very rich and regionally dependent. The semantics of the concepts has also changed over time. They can be regarded as different domains, in some respects. To model all the variations in the various historical map series, several ontologies are needed. These ontologies can be semantically aligned and mapped to each other, since we wanted to be able to map the concepts from different kinds of maps, and relate their different ontologies to each other [21]. The ontology for the GM1700 is presented in [23]. The ontology is also a domain model/conceptual schema which is used as a basis for a database model to enable these maps and all the information in the databases to be stored in a form *as close to the original structure as possible*.

The logical database schema and mapping between the frame-based ontology and E/R-based logical schema are described in [24]. We see the GM1700 maps as *archive artefacts and documents*. For most researchers in the humanities, access to the unadulterated source is vital. This project is an attempt to make these maps available and manageable in a way that can be trusted by researchers in the humanities and that will reduce or even eliminate the need to go to the source itself for most problems formulated. As an analogy to the thoughts of Bittner and Smith [22] that a map in itself is an ontology, we can say that the document is an ontology and the focus of this work is to elucidate, clarify and repack the ontology to make it more explicit and easily understood.

The text descriptions are stored in a relational database and the maps are scanned and the features described in the text are vectorised. Other features not described in the text, such as roads, hydrology and various map symbols, are also vectorised.

The maps were made by seven surveyors between 1693 and 1705, and are therefore referred to as *GM1700* (Gotlandic Maps of 1700). These are the first maps produced of the island of Gotland. They are unique in many senses, both in terms of the type of information they contain and the fact that they cover the entire island. The purpose of the mapping was taxation and to acquire knowledge about Gotland. The maps are made at a scale of 1:8 000 in the manner described in the instructions for surveyors of the time. Text descriptions of mapped features and additional information accompany the maps (Fig 1). The mapped features and the texts are linked by a


***Figure 1.*** *Part of a map and text description from the GM1700 map series. The arrows show how the the map and text descriptions are linked via the code marking system.*

system of code markings. Not all features are code marked and not all text is linked to the map. There can be some variation in the contents and style, depending on which surveyor made the map [20]. An amateur researcher, Jakob Ronsten, has transcribed all the text descriptions into digital documents.

## 2 Usage of historical maps in GIS

Historical maps are in most cases used in GIS in the same fashion and for the same purposes as in the pre-GIS days. They are used to produce map overlays that can be compared with other historical or modern maps covering the same area and other types of spatial data in which the result is visually interpreted. In the pre-GIS days this was done by manually rectifting and geocoding the historical maps on plastic film into a modern coordinate system. This process has, with the help of GIS tools, now moved into the computer. There are numerous examples of this kind of analysis and approach dealing with interpretation and development of geographical areas over time. The landscape analysis of Holm parish in Uppland, Sweden is one example. In this study, historical maps and archaeological sites are used as the main sources for landscape analysis and are used in a GIS system, together with other sources [3]. In The DHK publication *Digitala historiska kartor – Tillämpningar i GIS för kulturmiljövården* [2] a series of example applications is presented giving a fairly good overview of how historical maps are used in various kinds of landscape analysis in GIS system. They deal mostly with analysis of land use, the overall development of the landscape from various perspectives and how one can visualize these changes. Examples are also given of how to use data from historical maps to visualize the impact of different activities, e.g. building a new road, on the historical continuity of the landscape.

These types of studies are of great value and are often used in the pilot study phase of major building and planning processes, but they do not go much beyond the traditional usage of historical maps. In the examples given in [2] the maps are often visualised in 2,5 or 3-D. The map or reconstructed land use is draped over a digital elevation model (DEM) and viewed as a fly-through etc. The capability of the modern GIS system to distribute maps and results to a larger audience over the Internet is also shown. The examples in [2] cover many aspects of the use of historical maps in cultural resource management and also point to some extended uses. The conceptual model of DHK is designed for these kinds of applications and for these purposes it is also a good model. For other kinds of questions calling for map specific- or generation specific information from different historical maps, the DHK model must be extended or new models created.

In the remaining part of the paper we will give some brief examples of extended use of historical maps in GIS that make greater use of the statistical, calculative and visualisation capabilities of GIS. We firmly believe that use of GIS by researchers in the humanities in all kinds of problem solving and reasoning related to the spatial dimension will increase. Historical maps can be used as sources in investigation of many kinds of issues and theories as well as in hypothesis testing of a more academic research nature. The examples presented here do not, of course, cover all possible uses of GIS and historical maps. Some of these example applications could only be performed with a database model, which also models the map-specific information, as in our model. As we had limited access to scanned maps, the pilot system contains data from only one parish, Fröjel. This limits our demonstration of the analyses that are possible using our map-specific model. Many studies need a larger sample then one parish. One of the unique features of the GM1700 is its coverage of a whole region, the island of Gotland.

### *2.1 Locating abandoned farmsteads*

The geometrical cadastres from the $17^{th}$ and $18^{th}$ century depict the situation and features in Swedish villages or farms, which had bearing on the contemporary society and administration. The state of affairs shown in the maps was the result of development that goes far back in time. With proper analysis of the maps, together with other data, the situation in the area can be traced back in time to the medieval/Viking age or even earlier.

This kind of analysis is called retrogressive analysis, which is a firmly rooted tradition in

Swedish and European historical geography. The organization of the cultural landscape that can be seen in the geometrical cadastres was created long before the creation of the maps and could be traced back in time; maybe as much as two thousand years [10]. Dan Carlsson uses the GM1700-maps as the main source in a retrogressive analysis concerning the agricultural- and settlement development on Gotland during the Iron Age. In his thesis he argues that the organisation and structure of the Gotlandic farms we see today were established during the older Iron Age [13].

The older and younger cadastres are the most suitable maps for these kinds of studies. One reason for this is of course that they are the oldest depiction of the cultural landscape. Another reason is that later maps are made for the purpose of redistributing land and thus show two time horizons; the state of affairs before the redistribution of the land and after it. These two can sometimes be hard to separate in the maps [10] Cadastres are on the other hand created primarily to depict the current state of affairs. In a retrogressive analysis both the map itself and the text portion are important ingredients. The study conducted in GIS by Charlotte Fabech & Jytte Ringtved [9] is an example. They used analysis of historical maps and other methods to recreate the prehistoric landscape and land use in the Bjerringbro/Hvorslev area in Denmark. Sven-Olof Lindquist has shown [15] that later maps, such as a Lagaskifte map from 1878, can also be useful in retrogressive analysis. Because the purpose of the map was redistribution of land, the mapping was very careful and accurate in soil quality assessment. Without knowing it, the land surveyor mapped fossilised field systems dating from 500 B.C. The fields are depicted in the maps as regular patterns of differing soil quality resulting from the farming techniques of the time. With correct retrogressive analysis, historical maps can be used to study phenomena and processes with a much broader time frame than the creation date of the map.

The location of a farmstead's land parcels in space can also provide important clues to the history and age of a farmstead [13]. The patterns of scattered land parcels can reveal the sites of ancient farmsteads. Areas of interest can be located by taking into account other factors such as soil quality class (e.g. high amount of mould indicate intensive farming during a long period), land parcel names (names can indicate disappeared farmsteads) and ancient remains. This is a well established approach and parameters such as the ones listed are often used in retrogressive studies, for example [13] [10].

To graphically display the location of each farm's land parcel, standard techniques based on SQL and GIS functions can be used. The result is simple to interpret and the visual power is great, as shown in Fig. 2. The parameters of interest in this example are: ancient remains of Iron Age settlements, fields with mould, names of land parcels indicating old farmstead and «remote» areas where many different farmsteads own land (which the arrows from each farm to its own land parcels indicate). In the reddish (grey) zone, with the name *«Fyllegwie»* we see an area which may be an old farmstead, and is interesting for further investigation. These abandoned farms' infields have been requisitioned by the neighbouring farmsteads, probably following desertion for some reason.

### *2.2 The Christianisation of Gotland*

Sven-Olof Lindquist [4] has studied the formation of parishes and the introduction of Christianity on Gotland. He took a chorological point of view, which is very well suited for performing in GIS systems. At the time of the paper (1981) he had no access to GIS systems, so all calculations had to be done by hand using paper maps. This took a very long time, even though only a sample of parishes was selected (31 of 92). In 2001 [5] Sven-Olof Lindquist, together with one of the authors, performed some of the calculations in GIS. This time the entire island was included, 92 parishes, since data were now available in digital format for the entire island. This time it took only a few hours to do the calculations and create the resulting maps.

The main aim of the research was to try to answer the debated question whether the formation of the parishes was a prolonged process, which some scholars advocate, or if it was a quite rapid process as Lindquist believes. A secondary question was who took the

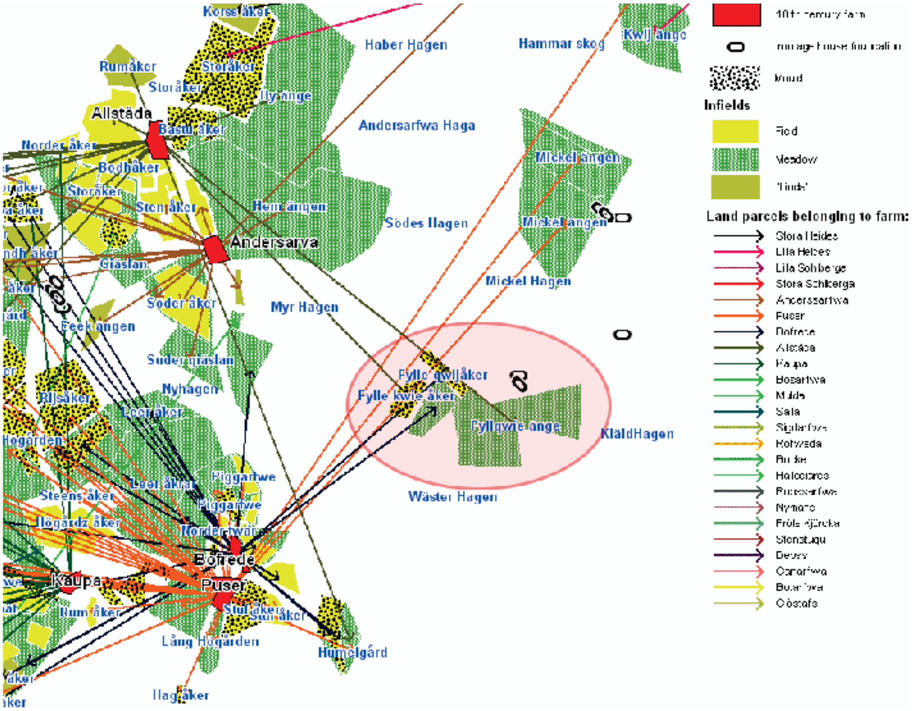


***Figure 2.*** *Maps showing an area which can contain the site of an ancient, abandoned farm (reddish / grey area). The main variables in the analysis are shown in the legend and the names of the land parcels are in blue text.*

initiative to erect the parish churches and decide where they should be located. Was it a single, powerful man or was a joint decision made among farmers who were all peers? The GIS analysis focused on the second question. The data used in the analysis were the positions of farmsteads in 1700 and the parish borders of that time. A retrogressive analysis based on the farm sites from 1700 was used to understand a process that took place 700 years earlier. The hypothesis was that the physical location of the church was a joint decision by the farmers and it was placed as «fairly» as possible, having a central location in relation to all of the farmsteads.

The first analysis was to compare the extension of the parishes around the churches with the «optimal» one. The optimal extension was defined as the thiessen polygon around the church. The location of the farmsteads was then compared to the optimal parish and the actual parish it belonged to. Only around 8 % of the farmsteads lay closer to another church than the church to which it belonged, supporting the hypothesis (Fig. 3a). If natural obstructions, such as bogs, were to be taken into account, the number would likely decrease.

As a further test of the hypothesis, the distance between the actual location of the church and the location which would give a minimum transport distance from the farmsteads was calculated. The rationale was that a short distance would indicate that the positioning of the church is «fair» and all farmers had a say in the decision. A long distance is interpreted as an indication that the decision around the placement of the church was not made in consensus. In the GIS system the transport minimum was calculated as the centre of gravity, by taking the mean position along the X- and Y axis of all the farmsteads in each parish. The distance between this point and the church was calculated. This distance was then visualised as a circle around each parish, where the distance is the radius as shown in Fig 3b.

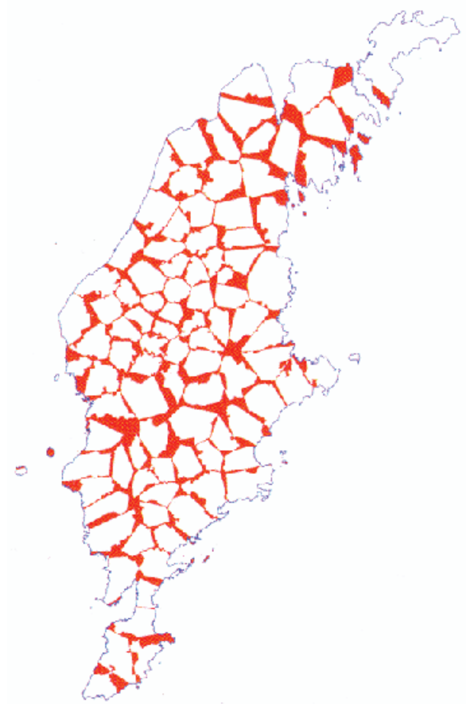

***Figure 3a:*** *The red areas are the difference between the optimal parishes, represented by thiessen polygons around the churches, and the existing parishes.*

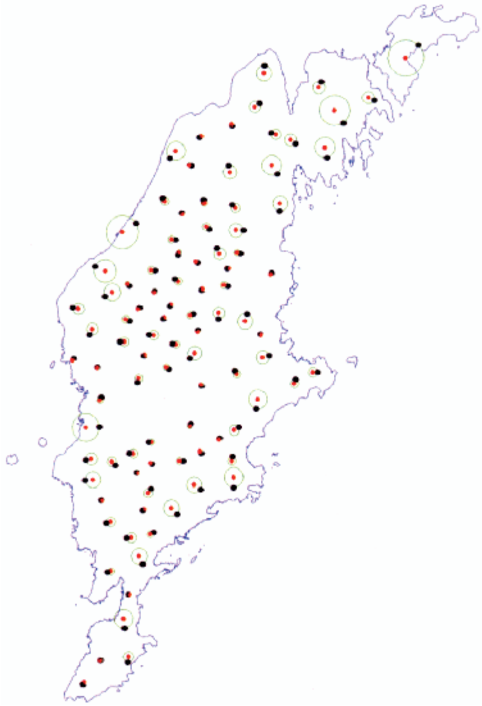

***Figure 3b:*** *The distance between the centre of gravity of the farmsteads and the church, in each parish. The red dots are churches and the black dots are the centre of gravity for the farmsteads in each parish.*

The results further support the hypothesis. The parishes that have long distances are all known to be anomalous, and there were known explanations for these anomalies.

### *2.3 Statistics and calculations*

Statistical calculations and other quantitative methods have a long tradition in studies of past times using historical maps as source material, often combined with other sources. These calculations have, in the past been very tedious. With a system such as ours, they will be rapid and precise. Calculations can be made easily, both from tabular data in the text portion and from the geometrical properties of the mapped features in the map itself. One classical study of this kind is *Svenskt agrarsamhälle under 1200 år* [12] in which data from historical maps are used in calculations of yield, consumption and other parameters in the agricultural societies of the past to depict development trends over a longer period. There are numerous examples of these kinds of studies.

Calculations and statistics may not provide answers to most research issues formulated in the humanities, but they often make a very good starting point or support for interpreting many of the issues. They may help by describing and giving a good overview of a situation or state of affairs, which can be useful in reasoning about a problem. In a GIS system the information can be presented in a graphically powerful way and displayed in the map. Here we will show some examples of how calculations and statistics can be used and presented in a system.

#### *2.3.1 Means of farm acquisition*

In the GM1700 maps, there are often notations of the owner and how s/he acquired the farm. There is also often information about ownership and the way by which the farm was acquired, that goes back as much as 4 generations. This is very unusual in other historical maps and can be an important source in many kinds of studies, such as studies about the mobility of the peasant population and ownership matters. To illustrate this, we can show figures and maps of the ways the present owners (in 1702) acquired their farms. Of the 39 different farms (23 registration units, divided into 39 farms) 23 are freeholder farms. Of these 10 (43.5 %)

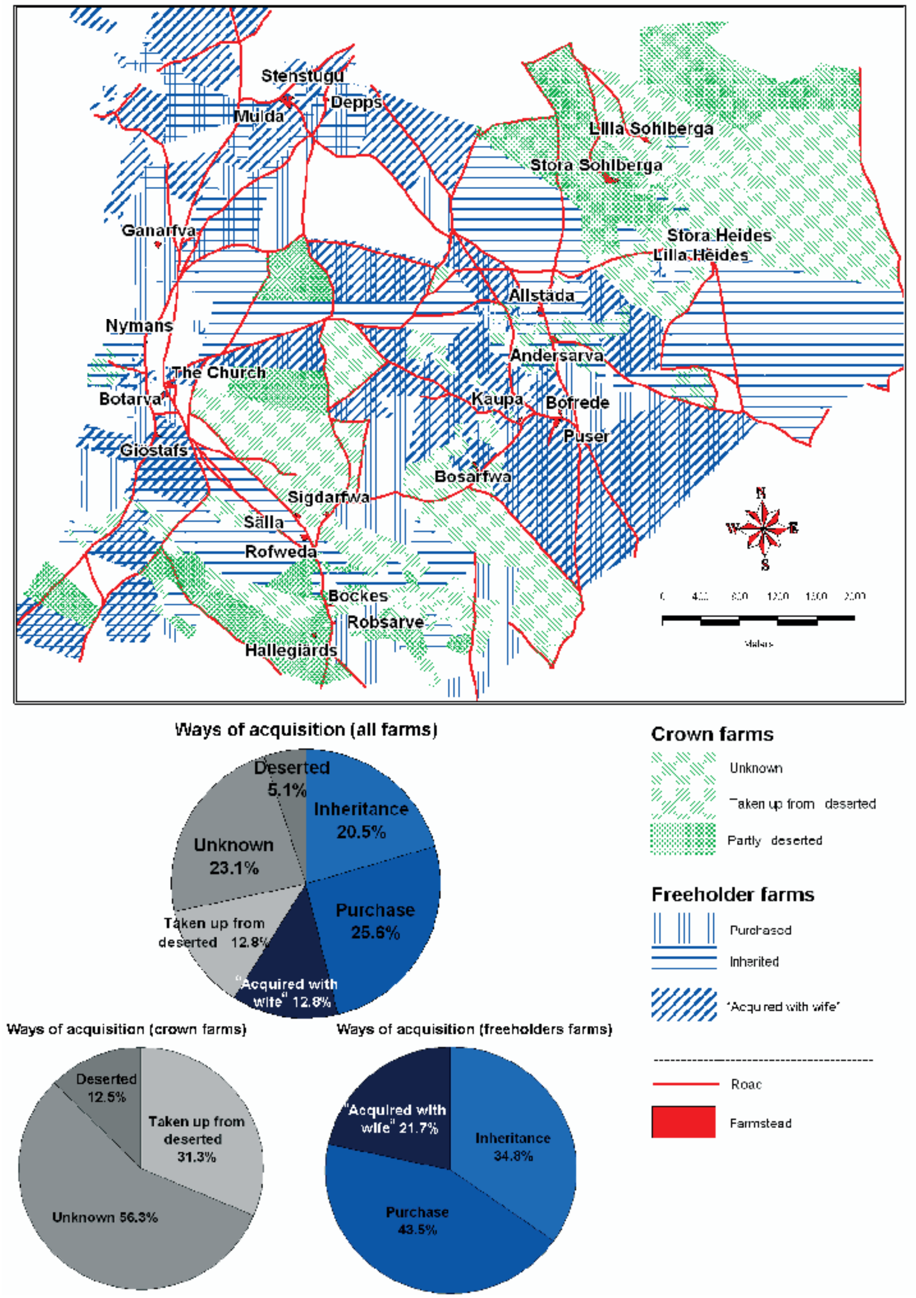


***Figure 4.*** *Map and statistics showing the means of acquisitions of farms in Fröjel parish*

are purchased by the present farmer. The legislation of the time gave a freeholder the right to freely sell his farm (not parts of it), but kin had the first purchase option. The maps, together with other sources such as parish church records, can be of great value in studies of questions concerning purchases and other forms of transfer of property or lease.

This example uses the map-specific information in the GM1700. These basic statistical calculations could have been performed for any of the unique kinds of information found in these maps, such as tax commodities or wood supplies.

### *2.4 Location of iron-age settlements*

An issue of great importance in both cultural resource management (CRM) and academic research in archaeology, is the need and demand for ways to predict and understand the reasons for location of various archaeological sites. A predictive model attempts to predict where archaeological sites or features are located, by looking for tendencies and patterns observed in a region or by employing theory and notions about the distribution of sites or features [14]. One example is a major Danish project called «Foranderlige landskaber» [11] in which different techniques for predictive modelling were tested to identify archaeolo-

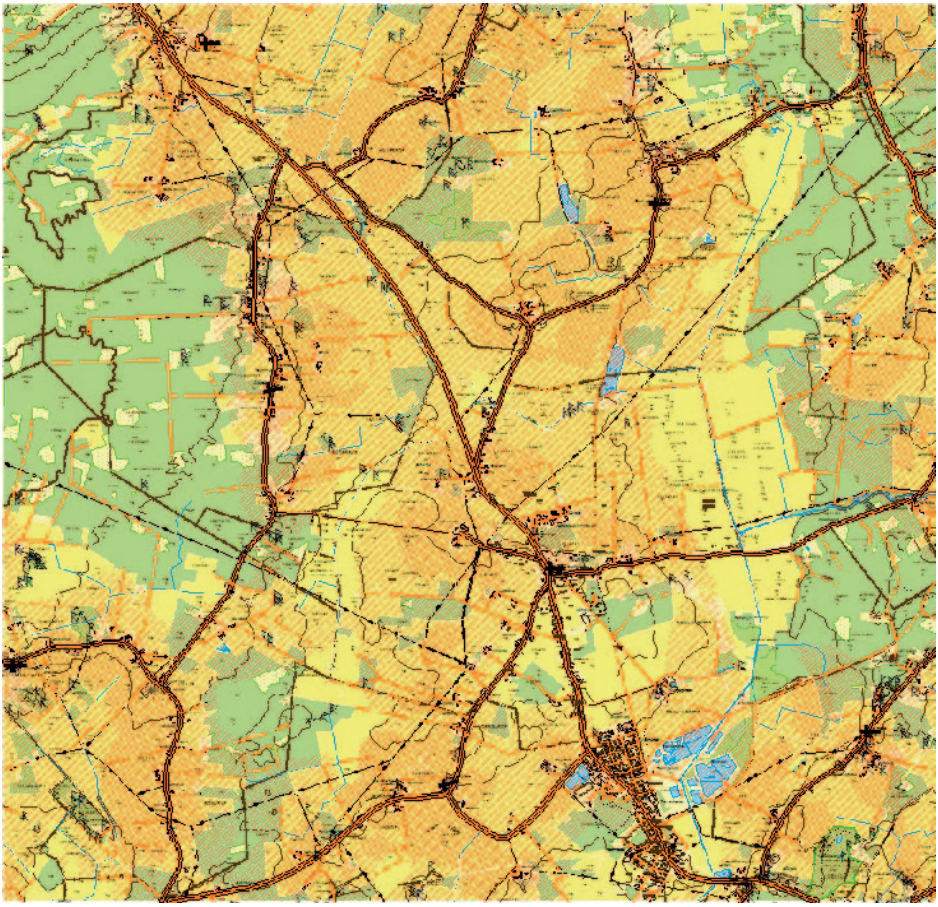

***Figure 5.*** *Prediction map for Iron Age house foundations in the Roma district on Gotland. The method used is logistic regression based on independent variables from the GM1700 and other data. The intensity of red color indicates the odds of the place having the same characteristics (based on the chosen variables) as sites with known Iron Age settlements. The redder the color, the higher odds.*

gical sensitive areas, base on methods developed and tested in another project [8].

The information used in the model consists of the dependent variables and the independent variables. The dependent variables are the archaeological sites or features whose distribution is sought. The independent variable is the characteristics recorded for each land parcel. These characteristics can be divided in four major themes, according to Kvamme [14]: environmental variables, cultural and social factors, positional characteristic and radiometric characteristics. With a basis in retrogressive analysis, historical maps can be used in predictive modelling. The information from historical maps is a social factor and is used the same way as other ancient remains.

Relatively few ancient remains have been recorded in the national database of ancient remains (FMIS) in the agricultural district areas around Roma in the centre of Gotland. The general belief is that there have been many ancient remains, but that modern farming has obliterated most of the visible traces of past times in the landscape. With predictive modelling it can be possible to find the areas where it is most likely that some of these ancient remains once lay.

Several researchers in Gotland have noticed that there is a correlation between «Kämpegravar» (Iron Age house foundations dating from about 200-600 AD) and the land use found in GM1700 maps. Meadows and farmstead sites from the GM1700 as well as other variables, were used in a predictive model to verify this theory and to attempt to predict areas where such house foundations where located [7]. The method used was logistic regression. The model preformed very well and had a high degree of significance. Even if the areas selected by the model are too large to be really useful in field archaeology, predictive modelling techniques can be very useful in finding patterns in the data hypothesis testing and also in finding archaeological «sensitive» areas. These are areas with a greater likelihood of containing various types of ancient remains than other areas. The retrogressive analysis methods show that historical maps can be a very good source of variables in such studies.

### *2.5 Distances*

Distances were probably of great importance for a number of reasons in historic agrarian society [13]. The farmstead lot was generally placed near the fields that had the highest economic value and were also the most vulnerable. Distances were also costly in terms of transportation and time; the greater distances between the land parcels, the more time had to be spent on transportation. Distances are of vital importance not only in studies of contemporary society at the time of the creation of the maps, but also in many other analyses. An example of a study that would have benefitted by our system,we believe, is Östergrens thesis [25] concerning Viking Age silver hoards. In that study, the distance between various features found in the GM1700 and the sites of finds of silver hoards is of paramount importance in the analyses. In a GIS these distances are very easy to calculate using standard techniques.

As mentioned above, the scattering of a farmstead's land parcels can reveal something about the age and earlier phases of the farmstead's history. It also affects the farming itself, as discussed above. It is hard to pinpoint exactly how this works, but generally a more scattered farm has been subject to more change in its history, thereby indicating a longer history. As in the examples shown above, the changes may involve inheritance of other farms, strategic marriage, moving of a building site or requisitioning of abandoned farms land. As a tool to visualize this degree of land scattering in statistical terms, we have created an index which shows the distribution of distances to the lands on a farm. The index is obtained by summing, for each farm, the land parcel acreage and finding the median distance (i.e. the distance to the 50 % remotest areas of the farm's land). The median of these values is set at 100. Values above or below 100 indicate a higher or lower degree of scattering. The calculations can of course also be done at other break points such as quartiles (25 %, 50%, and 75 %) and others. The resulting numbers can then be visualized in various ways.

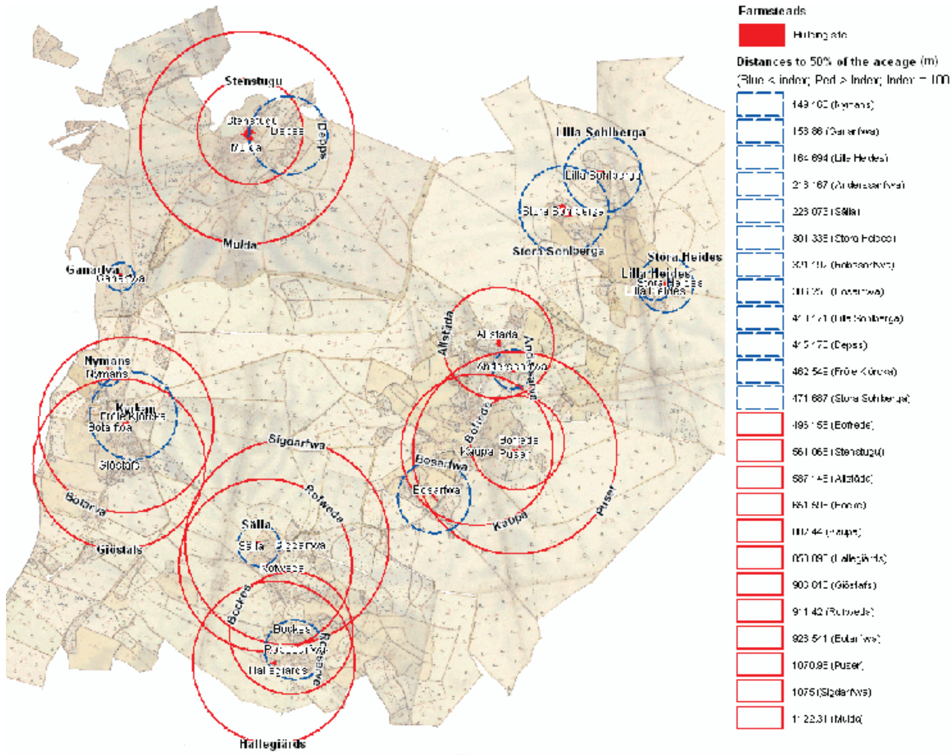


***Figure 6.** Map of Fröjel parish showing each of the parish scattering indices as a circle.*

**3 Discussion and future work**

Swedish large-scale historical maps are a unique source for many types of historical analyses. They are not only used in historical research, but also in ecology, archaeology, geography, linguistics etc. They are also used extensively in non-research tasks, for example in cultural heritage management and social- and physical planning at all levels.

Use of historical maps in GIS has, in most cases, focused on using GIS as merely a display tool. The maps have mainly been displayed «as they are,» not trying to reveal and display any nested or hidden information in the maps. The analytic and statistical capabilities of modern GIS packages have seldom been used. In this paper we have shown some examples of use of historical maps, in which more of these capabilities of GIS are used. The graphical and display capabilities of GIS are also an essential part of our examples, but we focus on using them to highlight and display the more deeply nested knowledge only visible after the information has been processed and analysed.

Some of these analyses are only possible to carry out using a domain model like ours that picks up map specific information and handles both the map and the text portion. As an example, we used the notations about the owners and how they acquired the farm. As we have limited access to scanned maps, we could not fully demonstrate the analyses that can be performed. We only had access to scanned maps from one parish, Fröjel. A lot of the map-specific information present in other parts of the island, remains to be accessed. This includes very interesting notations about disputes over land and co-ownership. With the full database, these questions could be analysed. Interesting questions would be whether there are any special distributions or characteristics of the farms and land that are disputed or co-owned? One working hypothesis could be that the disputed or co-owned land once belonged to now abandoned farms (at the time of the mapping, about year 1700). Notations of the commodities farmers used to pay taxes would also be interesting to analyse, to describe the spatial distribution patterns.

With our model, essentially every piece of information from historical maps can be digitised and stored in a database for the first time. This enables searches for novel and as yet undiscovered patterns and correlations using advanced data mining techniques, to acquire new knowledge from the maps. One example was given of predictive modelling of Iron Age settlements using information from the GM1700. We used logistic regression analysis, but other data mining techniques can probably also be used to investigate a great variety of problems and theories. This is a largely undiscovered field of research and further work is needed to explore all the possibilities.

Historical maps are often used in retrogressive studies. In these analyses the depicted state of affairs found in the maps is traced back in time to reveal the situation several hundreds, or even thousands, of years prior to the creation of the maps. We did a fairly elementary, but very powerful graphical analysis to predict the location of abandoned farmsteads. In some areas very unusual situations emerged, such as in the parish of När. Farms from many surrounding parishes owned land on the coast at a place called Hammaren. We believe that a method like the one presented here can help clarify and reveal the true nature of these situations. This could be an apt starting point for a deeper analysis. A number of other less obvious locations could probably also be located with this method.

This paper provides some relevant examples of how properly modelled historical maps can be used in a variety of different applications and problems. The examples we have given do not, of course, comprise a comprehensive set of analyses. This field is largely an undiscovered area of research and we hope many others will follow in our steps and work to extract more knowledge from historical maps using advanced data processing.

In these examples we have only worked with one time horizon of historical maps. We argue that creating an ontology, rather then a traditional conceptual model, gives the benefit of being able to map concepts from different maps onto each other. In order to demonstrate the capabilities of such a system, we focused on developing a working system and a demo application using only one map series. The next phase of the work will be to create more ontologies for different map generations/series from Gotland and map these ontologies onto each other to enable temporal studies. This is a non-trivial issue since these later maps had a completely different focus: land redistribution among neighbouring farmers. The map is not ordered by the Crown, but by the farmers themselves. This means that the main concept is no longer the fiscal unit, but the operating unit, e.g. the land each farmer owned, not which fiscal farm to which it belonged. At least for the later lagaskiftes maps (1827-1972), this means that it can be hard to identify which fiscal unit a land parcel belongs to. Farmers could have an operating unit consisting of a combination of parts of many fiscal units.

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