INTERPRETATION OF STABILE CADASTRE MAPS FOR LANDSCAPE ECOLOGY PURPOSES

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Abstract: *The maps of Stabile Cadastre dated to the middle of 19th Century are considered to be one of the most valuable sources for landscape history studies for the area of Czech Republic. They can serve e.g. as a base for reconstruction map of studied area and could be integrated with other maps, images and written records. During the process of map interpretation the GIS (Geographic Information System) represents perfect tool for creating, managing and analysing the spatial information. The amount of historical information regarding to landscape and their various reliability and comparability often causes the specialists in natural sciences (who mostly are not familiar with historical skills) to lose orientation and make some interpretation mistakes. This paper presents a way of gradual interpretation of historical maps which could be used in any type of study or project focused on landscape and its history. The Stabile Cadastre maps were used as an example map source to show the phases of the interpretation process and their results.*

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INTRODUCTION

In landscape ecology a great attention is paid beside other themes to spatial landscape structure (both horizontal and vertical), its function and dynamics (i.e. pace, extent and character of changes). These characteristics can be assessed in situ or by means of time series analysis of map sources, aerial photographs or satellite images. However once we need to know the character of the structure of the landscape dating 100 years ago or have an interest in long-term processes that created present semblance of landscape, contemporary maps will not be sufficient.

Antique maps and historical aerial photographs present a unique source of information about past landscape especially about its horizontal structure and dynamics. The maps of Stabile Cadastre (SC) have an important place amongst historical map sources mainly because of their accurateness and large scale (1 : 2 880) which enables us to study the landscape of the period of the map creation, that means cca 160 years ago. Map operate of Stabile Cadastre was founded for the purpose of land-tax rating. That is reflected in contents of the maps (land use, plot numbers, etc).

Interpretation of SC maps for the purpose of landscape-ecological studies is a process of successive gaining of information contained in the map whose character depends on the goals of given study, added by data acquired from other (written and image) sources. The following paper presents an integration of several approaches to interpretation of the original maps of Stabile Cadastre which were applied in studies made by Laboratory of Geoinformatics UJEP in previous years, into one systematic unit. Significant contribution during the interpretation itself and the following assesments and analyses of acquired data presents the use of geography information system (GIS). This tool allows performing of analytic and synthetic operations with spatial data of various time periods and various scales.

PROBLEMS WITH INTERPRETATION OF ANTIQUE MAPS

Antique map contains an enormous amount of data about landscape dated to the time when it was formed, nevertheless its potential is not always spent out and some of the data that could be obtained and could play an important role are left

unnoticed. In most cases the reason lies in little or none orientation of the scholars specialised in natural sciences who might have met with historical source for the first time in the area of historical sciences (historical cartography, archival science etc.). This is obviously comprehensible, but at result it leads to several variants:

- the information obtained from the map are describing the position and size of few important objects, which are the main point of study. It probably is the most frequently applied method of using antique maps. In case this amount of information is sufficient for given study, we cannot reprehend anything;
- from the map are obtained the same information about all mapped objects; if the map legend is available it is used, if not interpretation is based on intuitive knowledge of map language (grasslands – green, forests – dark green, buildings – red etc.). In some cases (line elements, point signs etc.) the interpretation mistakes can often occur, in addition to the other mistakes caused by worse quality or state of preservation of the maps.
- besides the data obtained by interpretation of an antique map there are also written (chronicles, gazetteers, etc.) and illustrated (vedutas, old photographs) sources being involved, an effort is paid not only to mapping the historical landscape but also explaining the processes of its evolution. Without wider knowledge of backgrounds of socio-economic development during the history it is too easy to make significant interpretation mistakes. In case the authors are aware of their deficiency in this area their outputs at best consist of unconfirmed (and sometimes unconfirmable) hypotheses. On this place there must be stressed that the questions emerging during the research are often more valuable than the answers formulated in conclusion, for they lead to new perspectives of viewing the landscape which might be omitted using the classical purely natural-science approaches.

Another significant difficulty of involving the historical sources into landscape studies presents the variability of acquired data, vast number of causalities and most probably several possible scenarios of development. It is often very difficult to distinguish the significant information from insignificant one, primary (i.e. directly drawn from the source) from deducted information and so on. It is evident that if we deal with more or less distant past of the landscape (and have to cope without usable analogies that could give us better idea), picture that we assemble will always remain incomplete in certain extent.

We can minimize this extent of incompleteness by interpreting the antique map gradually in several levels. First level represents an interpretation of the map contents according to map legend where no other historical sources are involved; the next level interprets the results of the first level, etc. It depends of course on certain study goals how many levels of interpretation are passed, sometimes only one level is sufficient. The more complete is the picture we get in lower level, the more stabile would be a base we have for higher level. Careful distinguishing and gradual elaborating of each level will prevent above mentioned mixing of primary and deducted data and of course will also clarify the causalities and put them in order. Not least there is a human factor playing a crucial role, i.e. erudition of the scholar himself – his professional orientation, experiences in geography, cartography and also his interpretation skills, ability of using new technologies of geoinformatics and deal of subjectivity during the interpretation process.

The maps of Stabile Cadastre are very suitable example to explain the presented approach not only for their wide use but especially because they can be easily combined with data from other map or non-map sources. GIS tools are very useful not only in the first level, but also for integration of SC with other sources and for processing new data by means of various types of analyses. Of course, we can work with old maps without using GIS but we will not be able to proceed some tasks with antique maps in paper form. Using the digital terrain model brings also important advantages.

STABILE CADASTRE AND ITS TRANSFORMATION INTO THE GIS ENVIRONMENT

Foundation of Stabile Cadastre is tightly connected with rising needs of Habsburian empire apparatus to raise an income from taxes and as such supposed to secure all potential payers, set the area of their estates and set the tax value. An essential base for these operations represented the tabular data and cadastral maps.

Cadastral operate of Stabile Cadastre consists of three separate (but connected) files:

- map operate
- written operate
- assesment operate

Map operate had been at most cases created in scale 1:2 880, in more detailed plans (town centres) also 1:1 440 a 1:720. It was based on precise geometric survey; borders of cadastral units were following the Josephs Cadastre. Out of a vast amount of versions of maps of Stabile Cadastre which vary not only at quality but very often even at scale, the s.c. obligatory imperial prints are the best for studying the landscape evolution. The obligatory prints are copies of the

original maps drawn in situ and therefore show the landscape at the year of mapping (1826-1843 for Bohemia and 1824-1836 for Moravia and Silesia).

Written operate consists beside others of the so called Registry of Land Parcels, which contains data about the owner, area of each plot, grown culture, value class and netto profit. All data are in contemporary units but transformation into current units in metric system is to be found in relevant literature (Mašek 1948).

Assessment operate contains a great amount of information collected in order to evaluate the land parcels, separate them into different categories according to growth culture, value class and netto profit, compare the various areas of Czech lands and finally to set out the tax.

Stabile Cadastre operates are kept in the Central Archive of Geodesy and Cadastre (CAGC) in Prague, where they can be studied and copied.

To work with these maps in the GIS environment there is essential to convert them into a digital form that is mostly realised by means of scanning or less often vectorisation. The next step is represented by georeferencing, i.e. transforming the map into a geodetic system. This can be done with a help of many types of GIS software and according to the chosen software various methods can be used.

Probably most widely used method is the manual georeferencing based on identical control points which are possible to identify both on the map being transformed and on some already georeferenced base map. In the case of antique maps mainly the elements we do not expect to change their position could serve as control points, e.g. churches, crosses, pond dykes etc. Great attention should be paid to selection of the fitting base map – its character and scale should be comparable with the transformed map to achieve as high level of accuracy as possible.[1] In the case of Stabile Cadastre the current cadastre maps can be taken into account.

SUCCESSIVE INTERPRETATION OF ANTIQUE MAPS

First level – the legend

In the first level we are answering the questions concerning position, size and spatial relations of individual objects identified on the map. These objects can not be defined as landscape elements yet, for we are still thinking in the terms of map legend categories and the character and functions of the objects will be discussed in next levels.

The most important task of this level is to define the actual amount and character of information we would like to dig out of the map according to the aims of given study or project. Of course the changes of the needs (and also of the aims) can occur during the work but at least the spatial scale and general outline of the interpretation process should be stated firmly.

Beside that the crucial point of this stage is acquiring the original map legend which gives us a contemporary meaning of the map symbols. As in the case of Stabile Cadastre most of the antique maps use symbols which are either still used in modern maps or can be deciphered intuitionally (e.g. greenish trees = a forest), so we can in some cases work without the legend. There is of course impossible to achieve much detailed interpretation without the risk of mistake. If we possess the original legend[2] we can either follow the categories in full or join some of them and thus simplify the legend according to our needs but all the time making sure that any of important data will not be lost in the process.

Figure 1 An example of pasture and barren land symbol on the original map of SC

[1] Process of digitalisation, raster adjustments and georeferencicng are in detail discussed in the issue „Identification of historical net of landscape ecological stability on the military mapping" (Brůna, Buchta, Uhlířová 2002, in Czech)

[2] The original SC legend is stored together wit the maps in Central Archive of Geodesy and Cadastre and in digital form also at http://oldmaps.geolab.cz/stkatr/zoom/legenda.htm

As an example we can take the building parcels – on the Stabile Cadastre map they are represented by crimson or yellow rectangles where the crimson colour stands for durable buildings (of stone or brick) and yellow colour for buildings endangered by fire (of timber), mainly build for husbandry purposes, e.g. barns. Nevertheless the shape and spatial position of the rectangles allow no other interpretation than the right one and the used material is rarely significant, we would this time easily manage without the map legend. On the other hand the grasslands could be included either in the pastures or in the meadows (hayfields) category which are on the map distinguished by a slightly different tone of green colour and the letter W (*Weide*) at pastures (see Fig. 1). This difference could be very important for landscape studies, for the meadows used for hay production and the cropped pastures are often occupied by different plant species and have a different character (e.g. the water regimes, retention ability etc.).

In the GIS environment the process of vectorisation is inevitably connected with this level. Vectorisation means a transformation of the digital map from raster to vector form, i.e. to point, line or polygon layers with non-spatial data collected in attribute tables. Each layer represents a category of map legend (see Tab. 1) either the original or the modified one. Vectorisation is a very arduous time-consuming process which nevertheless gives us the chance to use the advantages of GIS analytical tools in the next levels.

Table 1 An example of a GIS layer an its attributes (forests)

Layer	Attribute name	Attribute description
sk_lesy.shp	Type	Forest type: 1 – broad-leaved; 2 – coniferous
	Growth	Forest age: 1 – „Jungmais"; 2 – „Stangenholz"; 3 –„Mittelholz"; 4 – „Hochstämmig Schlagbar"

Second level – reconstruction

On this level we are interpreting the information acquired on the first level – answering questions concerning the meaning of legend categories and map symbols, trying to define the actual character of the real contemporary objects represented by these categories and symbols and working out the picture of the past landscape as faithful as the maps and other sources allow. To achieve this we obviously can not rely on the Stabile Cadastre map alone but need to employ all the reachable sources.

The useful sources can be defined as:

- recent or contemporary sources describing the creation of the maps of SC (and other maps involved), e.g. the purpose of their foundation (military, tax politics etc.) and mapping methods, which give a certain idea of their accuracy in spatial and contentual sense;
- written records containing details of past agriculture and forestry, e.g. assessment operate of SC mentioned above or forest-management plans mapping the structure of age and species of the forest trees[3], see also Brůna, Křováková, Nedbal 2004;
- antique photographs catching the landscape character (and often important details as well);
- other map sources (military maps[4] etc.);
- 3D model of terrain (geomorphology of the studied area);
- etc.

At this level we deal with a vast amount of data generated from various types of sources and to integrate them sensibly presents a difficult task, it is then essential to choose sources and data significant for the study goals. In spite of the data amount there will still remain some questions unanswered. Most of the problems are generated by contemporary terms, for example the expression *Raum Recht* (on the SC map marked as R.R. at the wooded areas) which is generally translated as "a rights of spatial use of the forest".[5] What kind of economical or legal relations between the owner and the user of the forest this formulation represents can not be exactly told, the impact on character of the given forest is even more unclear.

The output of this level is then a reconstructed map of historical land use compiled in the GIS environment from various data sources where the Stabile Cadastre map plays the role of spatial fundament whereas other information being added

[3] Assessment operate is available almost for the whole area of Czech Republic but the antique forest-management plans are of local matter being carried out by local nobility for the areas of intensive forestry (e.g. in Southern Bohemia the Schwarzenbergs).

[4] http://oldmaps.geolab.cz

[5] Ing. Kostková, CAGC, personal communication (29.7. 2004)

in the form of attributes or (in case of other map sources) additional GIS layers. The importance of answering questions and elimination of revealed doubts and unclearnesses as much as possible (especially in the case this level is a prelude to our advance to higher levels) must be again stressed here.

The reconstructed map gives us a relatively clear picture of character of the past landscape and spatial distribution of landscape elements. This can be used e.g. in studies aimed at erosion processes and their changes during past few centuries where a knowledge of arable land, grassland, woodland patterns interacting with relief and climate of the area is essential. Through employing the data of assessment operate we can discuss the intensity of human impact on given area, other contemporary sources can be used to reveal the possibility of occurrence of protected plant and animal species and their habitats in the past (Trpák, Trpáková 2002) etc.

If mere one segment of time is insufficient for our purposes, we are to advance to the next level.

Third level – evolution

At this point we are again attempting to interpret the results of previous level, this time in the light of their relevance for recent landscape. We have been so far occupied by a single period but this level demands a broader time scale reaching the present in most cases. There are in general two possible approaches – we can either compare the present landscape of an actual area with its ancestral phase at certain moment of history or observe its evolution by means of examining various comparable map sources (not forgetting the value of non-map ones) dated most desirably to the periods of a relative stability of landscape evolution (sensu Lipský, 2000, p. 11) in order to catch the changes developing during the destabilised periods. The latter approach is generally termed as a multitemporal analysis.

The questions we are solving at this stage could be as follows:

- how had the landscape structure (percentage share of land-use categories or spatial patterns) changed through time?
- are there any landscape elements or structures which had persisted (landscape relicts) to be found?
- what processes were dominating in the landscape evolution, which of them had directly influenced the recent landscape character?
- what socio-economic impulses were driving these processes?
- had there been any changes to the function of landscape elements during the studied period?
- etc.

Beside another sources needed for successful pass through third level (which would vary according to the goals of the study, there is no reason for listing them here, moreover they mostly belong to recent data widely known and accessible) there should be an important role of field survey pointed out. The picture of landscape as we can see it on the map or an aerial photograph (the “birds-eye” perspective) much differs from the normal position we are accustomed to observe the landscape from (the “common mortal being” perspective). Some significant circumstances and interactions could then remain unnoticed, not mentioning the fact that any map (which had undergone the process of generalisation) could not catch every object present in landscape, in case of an aerial photograph we are limited by resolution and reach (e.g. ruins in dense forest are often not visible for the camera). The importance of field survey is even enhanced by equipping with GPS receiver to locate the objects not identified on the map.

When studying the landscape evolution we meet many relationships across time and space and it is too easy to mistake the cause for the result. The inevitably subjective approach also presents a certain problem; we are unable not to view the given landscape through the prism of our personal experience and (less obvious) psychical fundaments. We have also to cope with the uncertainnesses, speculations and even mistakes penetrating from previous levels. These unwanted circumstances could be in part altered by means of strict following the research line and study aims, reaching maximal objectivity (employing exact methods) and (being one of the cores of presented strategy) pursuing as detailed outputs of previous levels as possible.

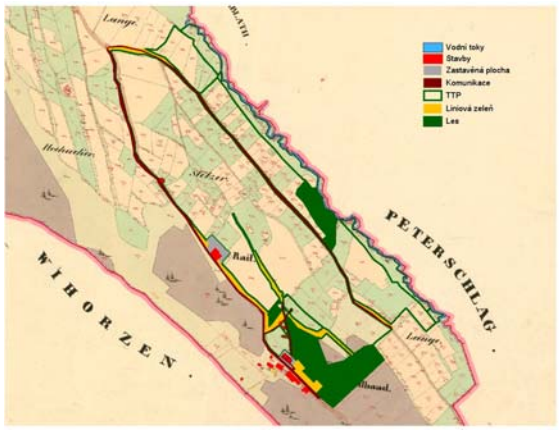

Figure 2 Historical and contemporary land parcels at Záblatí (Southern Bohemia) cadastral unit (raster image – SC map, vector layers – contemporary situation)

In spite of all these problems the results obtained on third level are extremely valuable. As an example of their use we can mention studies dealing with changes of landscape diversity observed on the changes of parcel size after the collectivisation (see Fig. 2) or changes of landscape microstructure caught by methods of landscape ecology (Fig. 3)[6]. The speed, character and causes of the changes could be studied also at each of the landscape elements, e.g. evolution of settlement forms and communications, forests etc. We can also be interested in more specific themes such as succession speed, presence and quality of recent biotopes in correlation with methods of historical agriculture or the role of landscape relicts in water management of the area, to name but a few.

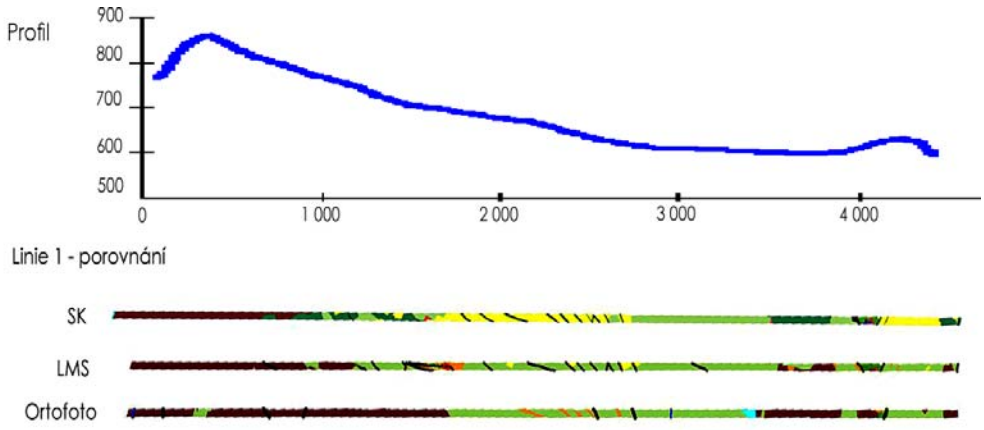

Figure 3 An output of assessment of the landscape structure change of the Řepešín cadastral unit (Southern Bohemia)[7]

Fourth level – prognosis

At the fourth level we again interpret information obtained from the previous stages with interest on their significance for future. Data describing the landscape evolution and reaction to various socio-economic impulses could serve as a base of modelling the future development. We are dealing with a greatly difficult goal, for in fact unverifiable (the historical landscape could not be described at full detail as the modern one) and often badly quantifiable data are problematic when used in scenario models.

[6] Some methods of studying the landscape structure changes see Lipský (2000), Brůna, Křováková (2005).
[7] Fig. 3 derives from diploma thesis (Křováková 2004)

At certain extent we can as an application of the fourth level think of various activities encompassed under the term of landscape planning. It is generally defined as "a rational doing which mostly by means of preventively elaborated documents regulates human activities in landscape." The aim is "to harmonize trends of human society development with interests of nature and landscape protection." (Sklenička 2003). The Stabile Cadastre is one of the antique map sources being widely used for landscape planning purposes.

Landscape revitalisation projects are the case of a planning activity where the antique maps are essential, namely for revitalisations of little streams transformed into straight canals with fast outflow during the period of agriculture intensification (in Czech Republic at 70´) which had lost partially or at all the functions of water streams. Revitalisation projects are aimed at returning the streams to their original state or to recover their functions at maximum extent which could not be obviously done without knowing the character of the given area before melioration. The project should not be reduced on curing the stream itself and its closer surroundings but should cope with management of the whole watershed in order to minimise erosion and enhance or keep water quality of the stream, there the importance of historical information is also highly significant. If we have an idea of behaviour of certain landscape at certain situation in its history (e.g. deforestation to certain extend followed by more frequent and higher floods, to give but a simple example, reality being far more complicated) we have an advantage when seeking the optimal condition and management – at least an outline to follow.

Antique maps can be utilised also in nature protection when the focuses of species diversity are traced. The landscape relict persisting without changes in some cases through a century could be such a focus in the surrounding more or less anthropogenised landscape. In Czech law system there is for more than ten years embedded the term of territorial systems of ecological stability (TSES) which is defined as nets of biocentres (acting as refugia and dispersion sources of species) and biocorridors (linear elements connecting biocentres enabling the species to migrate) (Löw et al. 1995). The landscape relicts identified through multitemporal analyses and proved to house original biotopes are often included to TSES as biocentres (Lipský 2002).

CONCLUSION

The strategy of level interpretation of antique maps for landscape ecology purposes outlined in this paper on the example of Stabile Cadastre presents the way of dealing with historical information which enables to evaluate their potential for various project and studies and simultaneously minimises the danger deriving from misinterpretation.

The fundamental theses could be as follows:

- completing the information at each level as much as possible in order to build a strong base for the next level
- separating carefully the individual levels, resisting the temptation to formulate a final conclusion without completing the level results and leaving it for the next stage
- following the outline of the project or study, distinguishing relevant and irrelevant data.

The approach is meant as a help to scholars of various fields of nature sciences who are lacking the skills of historians when dealing with antique sources of different quality, character and relevance. The fundament of the approach results from experience, achievements, mistakes and failures performed during the studies of Laboratory of Geoinformatics UJEP on the field of landscape history. The open and universal character of the strategy gives an opportunity to employ it in various types of studies and precise it into some (or rather several) methodical instruction which can help to the better evaluation of unique historical map sources.

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