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SOCIAL SCIENCE

## Historical ponds of the Czech Republic: an example of the interpretation of historic maps

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### ABSTRACT

The paper presents a map of historical ponds of the whole Czech Republic which was created on the basis of the 2nd Military Survey (1: 28,000) from the period 1836 to 1852. This source was selected with respect to its age, precision, validity and accessibility at the Czech National Geoportal via the Web Map Service. All water areas, which had existed in the 2nd Military Survey within the current Czech Republic, were identified on this basis and vectorised in the Geographic Information System. Historical ponds larger than 0.5 ha were then picked from this layer, complemented with other attributes and analysed in combination with the current geodata (occurrence of pond, prevailing land use of extinct ponds, etc.). The resulting map may serve as a measure for potential attempts at restoring some extinct ponds, out of which over 3400 ponds larger than 15,500 ha have been discovered. This map source may be practically applied in Spatial Planning and in particular measures taken against changes in the global climate, specifically in the Czech Republic against droughts. The map source may be utilised by state authorities or local administrations.

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## 1. Introduction

Small water reservoirs are one of the fundamental elements of farm land in Central Europe (Jusycyak & Kędziora, 2003) where they play many roles. First and foremost, it is the important water management role: they hold water in the catchment and influence its further distribution (Krol, de Vries, van Oel, & de Araújo, 2010). They also play a significant role in the local ground water regime, serve as important biocentres and may also contribute to the improved quality of water in the basin (Rozkošný et al., 2013), in water reservoirs used in farming and by small industrial plants (Wood & Barker, 2002) through potable water resources for the city and the country, safety retention areas in case of fire to the important role of landscape aesthetics and recreation. The history of small water reservoirs is connected with the construction of medieval ponds which had been built in greater numbers as early as the fifteenth century although almost two-thirds of them disappeared at the turn of the nineteenth century as a result of social changes; they were converted into arable land (Pavelková, Frajer, & Netopil, 2014; Pokorný & Hauser, 2002). The current scientific and social interest in small water reservoirs is growing as a result of global climatic changes. State or European funds are applied to establish new reservoirs or to renovate many existing ones

for their retention and ecological functions. It is possible to reconstruct extinct ponds and pond systems in this context. The use old maps as important information sources about the historical landscape form to determine their original position and size is ideal (Baily, Riley, Aucott, & Southall, 2011; De Boer, 2010).

Using old maps as groundwork for basic and applied research is currently a phenomenon spread throughout different areas (Brůna, Křováková, & Nedbal, 2010), especially considering the possibilities which their processing and analyses in the Geographic Information System (GIS) provides (Fujihara & Hara, 2011; Gregory & Healey, 2007). In the regions where they existed historically as part of the Habsburg Monarchy there are significant map sources serving to analyse the historical landscape of the 1st Military Survey (1764–1783 in the Czech lands), the 2nd Military Survey (1836–1852) and the 3rd Military Survey (1876–1880) or the very detailed plans of the stable cadastre from 1826 to 1843. The above-mentioned maps served as resources in many different studies focusing on the issues of their cartographic and geodetic processing (Čada & Vichrová, 2009; Timár, 2009), positional accuracy (Veverka, Ambrožová, & Čechurová, 2011) and the possibility of geo-referencing in the GIS (Cajthaml, 2013; Molnár, 2010; Timár, 2004). The Habsburg military surveys laid

the groundwork for studies assessing the time-space development of the landscape structure or the individual landscape elements (Havlíček, Krejčíková, Chrudina, & Svoboda, 2012; Havlíček, & Chrudina, 2013; Pietrovski & Mészáros, 2010; Skaloš, Engstová, Trpáková, Šantrůčková, & Podrázský, 2012; Štefunková, Špulerová, Dobrovodská, Mojses, & Petrovič, 2013). Following from the research of water elements in the landscape, old maps were used, for example, in evaluating the development of watercourses (Langhammer & Vajskebr, 2003; Skokanová, 2005), changes in lake levels (Barabach, 2013), reconstructions of extinct ponds (Frajer, Geletič, & Kladivo, 2013), analyses of hydrological extremes and disasters (Raška & Emmer, 2014) and, last but not least, the impact of water areas on the land use of the surrounding countryside (Keken, Panagiotidis & Skaloš, 2015). Despite noticing a number of publications dealing with historical development of water areas following from their driving force in the countryside whose primary sources are the old maps (see Havlíček, Pavelková, Frajer, & Skokanová, 2014; Jusycyak & Kędziora, 2003; Kopp, Frajer, & Pavelková, 2015; Pavelková Chmelová, Frajer, Pavka, Dzuráková, & Adámek, 2012), these are mostly regional studies. Historical maps of reconstructed water areas in smaller territorial units in individual time periods can be found therein. However, the central-European region has not had a digital map of historical ponds of the mid-nineteenth century at the disposal that would depict all water areas in the whole country. This unique digital map of the Czech Republic with precise plotting of water areas is useable in the landscape planning and landscaping.

The aim of this study is to create a geographic layer and map of extinct ponds in the whole Czech Republic based on old maps. It could serve as expert groundwork for the purposes of practice, especially in planning new water areas, reintroduction of the retention function of the landscape and adapting to climate changes.

## 2. Methods and data

### 2.1. Used historical maps

The primary source in the creation of our map was the 2nd Military Survey (from 1836 to 1852), the Stable

cadastre maps (1824–1852) as a complement, the Prussian Military survey (1825–1827) and the 2nd Austrian Military Survey (1836–1852). The selection of these resources was limited by several factors. Firstly, we had to respect the fact that the recording of the highest possible number of extinct ponds required working with the oldest possible map source covering the whole area of the Czech Republic within the current borderline in an adequate scale. The time aspect is very important as historical research shows that most ponds in the Czech lands disappeared at the turn of the nineteenth century (Pavelková et al., 2014). Another important factor was the positional accuracy of old maps and their processibility in the GIS so that the acquired information was easy to apply in current maps and plans. The maps of the 1st Military Survey, the maps of the Stable (or Franciscan) Cadastre or the maps of the 2nd Military Survey were considered for the groundwork layer (map) of the extinct ponds (Table 1).

The 1st Military Survey presents a unique image of the Habsburg Monarchy landscape of the eighteenth century. The survey records most pond surfaces in the Czech lands prior to their desiccation and modification to another type of use. The ponds in this survey are easy to recognise and interpret. However, the survey as a whole shows significant positional inaccuracies following from the method used without a geodetic network (Pietrovski & Mészáros, 2010). It might also be difficult to geo-reference individual map sheets in the GIS. Despite the positional inaccuracies, this mapping can be applied in GIS analyses of landscape ecological studies (Skaloš et al., 2011). On the other hand, the requirement of a minimum positional deviation is vital with respect to the follow-up analyses of the current map materials.

The formation of a stable cadastre in the Czech lands, Moravia and Silesia falls between 1824 and 1836, that is shortly before the creation of the 2nd Military Survey maps which followed from the stable cadastre maps. The survey was mostly carried out in the scale 1:2880, over a geodetic network and it is a great deal more accurate than the 2nd Military Survey maps derived from it. However, scanned copies of the individual sheets are not available for free and above

**Table 1.** Assessment of potential sources of data to create the target map.

	1st Military Survey	2nd Military Survey	Stable cadastre
Origin	1764–1783	1836–1852	1826–1843
Scale	1:28,800	1:28,800	1:2880
Geodetic base	No	Yes (triangulation network)	Yes (triangulation network)
Positional accuracy	150–1000 m	25–100 m	High
Accessibility	Colour scan (separate sheets – portal oldmaps.cz or the mosaic for viewing mapire.eu)	Colour scan (geo-referenced mosaic available through Web Map Service)	Colour scan (separate sheets – geoportal of State Administration of Land Surveying and Cadastre)
Water areas identification	Effortless	Difficult	Effortless
Main advantages	The highest occurrence of water areas recorded prior to their mass desiccation	Positional accuracy and availability for processing in the GIS	Detail

all they are not geo-referenced (located in coordinate system). Thus they are unsuitable for processing of a larger area in the GIS (Fuchs, Verburg, Clevers, & Herold, 2015).

Therefore the 2nd Military Survey was selected as a primary source of information on extinct ponds. Timár (2009) calls this survey ‘the masterpiece’ of Habsburg Monarchy maps. It was used as late as the 1960s. Contrary to its predecessor, it was based on more precise cartographic groundwork using a network of trigonometric points (more details in Timár, 2009). The positional deviation is low compared to the 1st Military Survey. Furthermore, the 2nd Military Survey in the Czech Republic is available through Web Map Service in the form of a seamless geo-referenced mosaic in the coordinate system S-JTSK/Krovak East North (Czech National Geoportal, 2015).

Several locations in the Czech Republic are not included in the 2nd Military Survey maps. Two missing sheets of the index map of the 2nd Military Survey near Brno and Nový Jičín were completed by plotting carried out over the stable cadastre geo-referenced maps. It was unnecessary to correct the position with ponds thus plotted. Three larger locations did not use to be part of the Czech lands and therefore they were not part of the 2nd Military Survey although they were included in the Prussian Military survey (the region of Hlučínsko, the area of the so-called Prussian Silesia) and the 2nd Austrian Military Survey (the regions of Valticko and Vitorazsko). The Prussian Survey (Die preußische Uraufnahme) was carried out in 1825–1827 in the scale 1:25,000 for the area of Hlučínsko. These maps are more positionally inaccurate than the maps of the 2nd Military Survey and no alternative map source is available in these locations (e.g. old cadastre maps). Thus the plotting had to be corrected significantly on the basis of topological elements in the maps (preserved communications in place of extinct dams, etc.).

## 2.2. Identification of historical ponds in the maps of the 2nd Military Survey

Although the 2nd Military Survey is rated as very convenient for the purposes of surveying the water elements of a landscape on the regional level (Chrudina, 2009; Kovács, 2010; Havlíček et al., 2014; Skokanová, 2005), the studies of larger areas encounter issues of varied quality of individual well-preserved map sheets which consequently makes their interpretation difficult. The original colour of water areas was well-preserved in some map sheets (light blue with dark blue contour of bank lines) while the original blue colour of water areas was bleached down to a light colour due to light in some other cases. The original contours of water areas blackened. Their identification was thus considerably more difficult and could lead to confusion

with a different type of area (fields, meadows and pastures).




Therefore it was necessary to verify whether the area in question was a water area or not using some of the auxiliary indicators (Table 2).

Detailed maps of the stable cadastre (1:2880) were used as reference source in disputed cases. The 2nd Military Survey proceeded from its groundwork. The stable cadastre maps were applied in some concrete historical studies of landscape changes in Central Europe which focused on all elements of the landscape including water areas (Druga & Falfan, 2014; Klich, Gielarek, & Antosiewicz, 2013; Popelková & Mulková, 2011; Skaloš & Engstová, 2010).

## 2.3. Vectorisation and complementation of basic attributes

Following their identification, the water areas were vectorised into polygon shapefile in the ArcGIS 9.3.1. program. All water areas were vectorised in a fixed scale of magnification (1:5000). Apart from the vectorisation itself, the key element in this stage was assigning the attributes to the individual polygons of the water areas. First, it was necessary to determine whether it was a pond (or an artificial water reservoir) or a lake. All recognised ponds were marked as historical and other attributes were determined (the presence or

**Table 2.** Auxiliary indicators to determine water areas in the 2nd Military Survey.

Auxiliary indicator	Description	Examples in the 2nd Military Survey
Dam	Most water reservoirs have dams which were marked in the maps using a bold or double line. A	
Interrupted water flow	communication usually led on the crest of the dam. The presence of a water area is also marked in the map by an interrupted water flow.	
Toponym	The presence of the name of a water area facilitated its identification most. Ponds were often denoted with the German name ‘Teich’ or only the abbreviation ‘T.’, lakes were ‘See’	

Sources: Austrian State Archive/Military Archive, Vienna, Geoinformatics Laboratory, University of J. E. Purkyne, Ústí nad Labem.

absence of a dam, detectable inflow or outflow, the historical name and area).

#### 2.4. Corrections and adjustments

The first vectorised data set of historical ponds was made for the Chrudimka River basin in East Bohemia. This data set became a pilot study and an experimental probe for partial analyses (Pavelková Chmelová et al., 2012). About 356 historical ponds of an entire area of 6.18 km<sup>2</sup> were identified within the 2nd Military Survey on the entire area of the river basin which covers 859 km<sup>2</sup>. The accuracy of plotting was tested on this sample of ponds and their compatibility with the current maps. The digital vector model ZABAGED® was applied again whose part is the spatial layer ‘water areas’ containing all the current Czech water. The intersection of the historical pond layer with the current water area layer provided an opportunity to identify the ponds which had not been plotted in the 2nd Military Survey maps and still exist today (in the original or decreased expanse). However, the results of the spatial analysis were disappointing. Above all, it proved that due to the scale of the old map too small historical ponds (up to 0.5 ha) may exhibit deviations in the area occurring during the vectorisation. It also reflected the overall spatial deviation which burdens the 2nd Military survey. The plotting of the existing historical ponds was shifted by several dozens of metres compared to their current position.

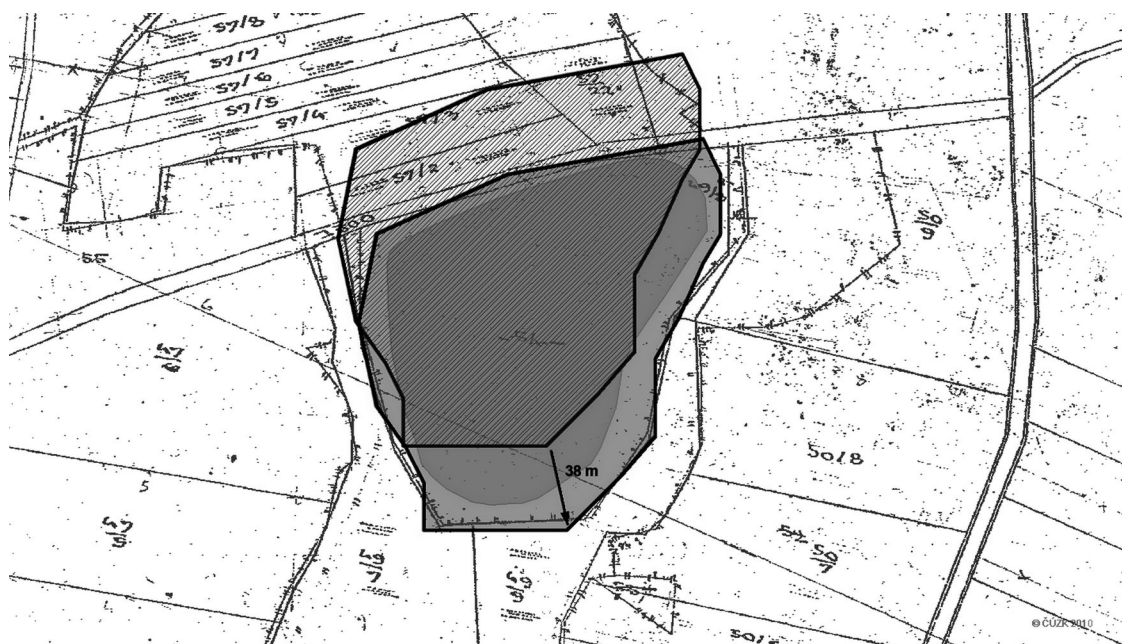
The position of most plotted historical ponds had to be adjusted manually, mostly on the basis of its comparison with the maps of the old land registry (the parts accessible via the Web Map Service (WMS),

Figure 1) or the current topographic maps. The positional corrections could not be automated as each map sheet contained a different value deviation. It was also resolved that manual corrections would only be applied in the historical ponds larger than 0.5 ha.

#### 2.5. Spatial analyses, database completion

It was possible to process some data automatically thanks to accurate positioning of the plotted objects. The first essential items completed in the database were the identification of a plotted object in the past, the type of the object at present (in case the water area has been somehow preserved) and the degree of preservation which was aggregated into two categories for the purposes of further work – the extinct object and the preserved object (both from the view of area and its use).

Another important attribute was the current prevailing use of the area of a historical pond. This information was acquired penetrating the polygon layer of historical ponds with the layer ‘Vegetation and surface’ which was created by combining selected layers of the digital vector model of the Czech Republic ‘The geographic base data of the Czech Republic’ (ZABAGED®) which had been under construction until 2004 by vectorising the Basic map of the Czech Republic (1:10,000) in the coordinate system S-JTSK. The layer ‘Vegetation and surface’ was upgraded in 2014 (State Administration of Land Surveying and Cadastre, 2015) and it contains the basic division of land use (arable land, forest, parks and orchards, permanent grasslands, built-up areas, water and others). The category of prevailing land use was determined on the area of a historical



**Figure 1.** Correction of an object position according to an old cadastre map (Source: State Administration of Land Surveying and Cadastre).

pond, apart from the representation of the individual categories of land use.

Further processing of geographic data assigned further information to each plotted object (over 0.5 ha), for example, of the soil cover, precipitation and temperature conditions, altitude, affiliation with an administrative or hydrological unit, etc.

### 2.6. A map of extinct ponds

The basic topographical groundwork of the map consists of coloured hypsometric expressions of altitudes of hillshade terrain complemented with basic elements of topography – the borders of the state and the administrative units, railroads, roads, watercourses and water areas, built-up areas and the locations of the capitals. There are lines of reference grid (S-JTSK) above it in the map face labelled in the map frame. The [Main Map](#) ‘Historical ponds of the Czech Republic: an example of the interpretation of historic maps’ is in the scale 1:430,000 (the detail is in the scale 1:100,000), the format of the map sheet is ISO A0.

The theme of the maps consists of a geodetic field of centre points of the plotted ponds in the form of graduated symbols (five size categories of ponds) with colour expressions corresponding to the prevailing land use in the location of an extinct pond. The white

semitransparent mark is used to plot preserved ponds. Unclassified ponds with area under 0.5 ha are not marked in the map.

A high concentration of objects around the city of Ostrava is marked in a map detail.

### 3. Results

A total of 33,713 water areas covering 63,923 ha in the current Czech Republic were identified in the old maps used. A total of 11,064 historical water areas of over 0.5 ha were selected for further processing (manual corrections, spatial analyses and attributing). About 10,952 water areas out of the above-mentioned number were identified as historical ponds. We discovered that as many as 68.8% of historical ponds have been preserved in the landscape up to the present time. The rest of them may be considered extinct (3416 ponds of 15,754 ha). The areas of the extinct ponds are currently used mostly as arable land or as permanent grasslands. The land use of the extinct ponds in dependence on the interval of altitude is shown in [Figure 2](#).

In terms of size, small historical ponds of 0.5–3 ha prevail. This concerns 70.2% of the total number of ponds. Only 0.6% of large ponds exceeding 100 ha were noted; this is depicted in greater detail in [Figure 3](#)

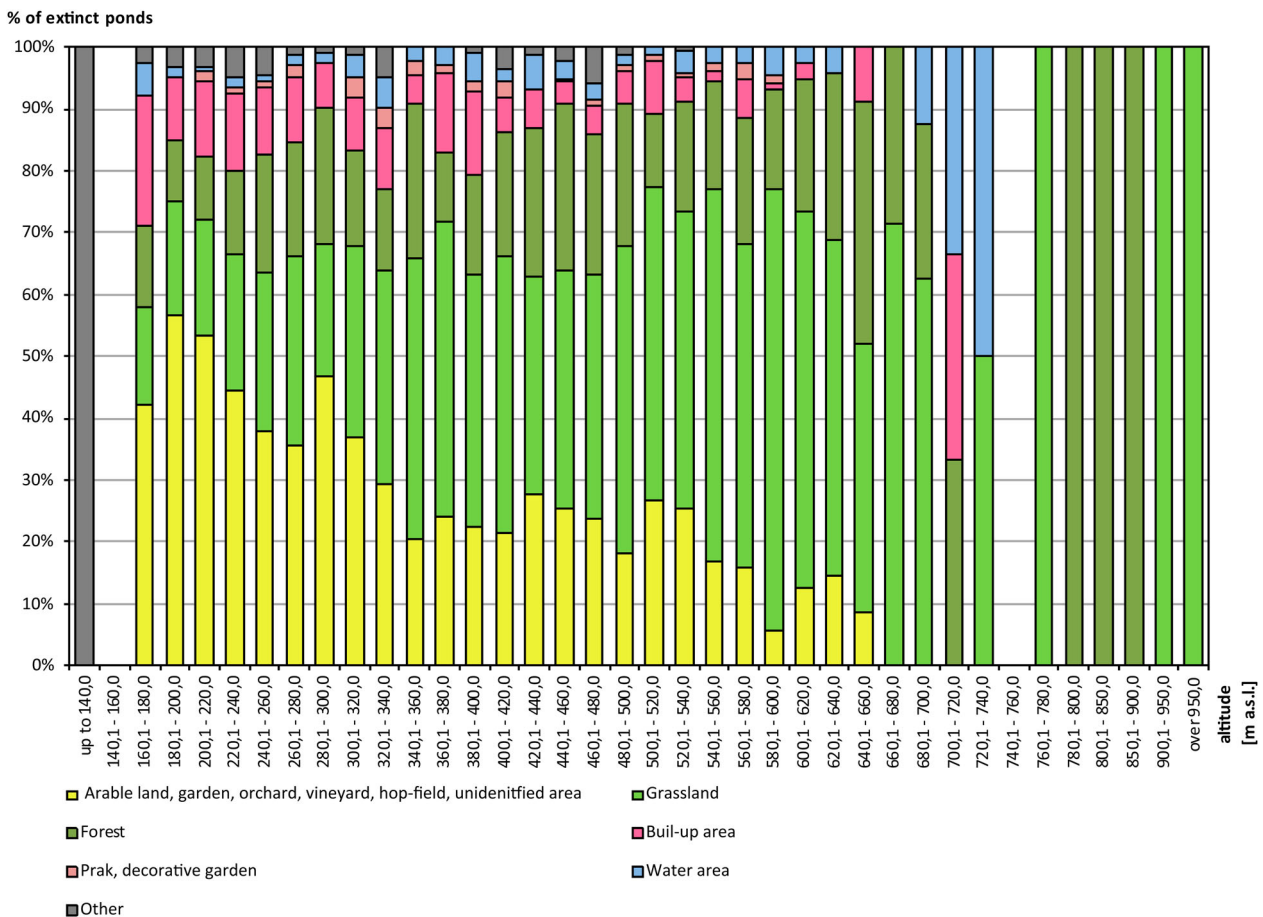
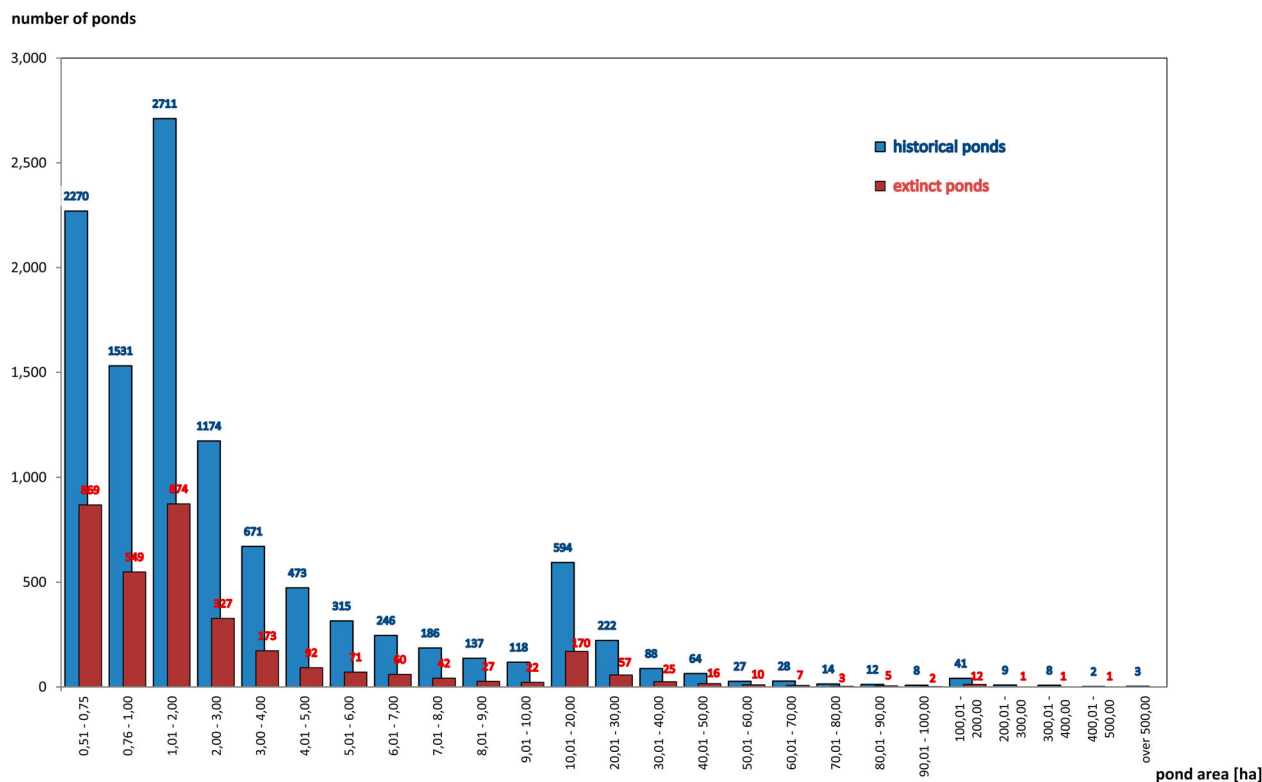


Figure 2. Share of ponds in various intervals of altitude and land use of extinct ponds (%).



**Figure 3.** Number of ponds according to the area (ha).

(a graph according to the intervals). Adequately to this trend, we also note the numbers of extinct ponds. Almost 77% of them are in the size category of 0.5–3 ha, while 0.4% in the intervals over 100 ha. The largest extinct pond (Velká Čeperka Teich in the Labe basin) had the area of 527.48 ha.

The current numbers of water surfaces is possible to find in the geographic base data of the Czech Republic (ZABAGED) which is a digital vector model of the territory of the Czech Republic. ZABAGED currently contains 76,357 objects of the area of 85,229 ha in the WaterArea layer (data from 2013). This database does not sort the water areas into any categories and it contains ponds as well as dams, small water reservoirs, lids, fire reservoirs, remnants of coal, sand and sandy gravel mining, sludge lagoons, etc.

## 4. Discussion

### 4.1. Discussion of the results

The results have shown that there are a large number of historical ponds in the current Czech Republic and thus the statement of Jusycyak and Kędziora (2003) claiming that water reservoirs belong among the fundamental elements of agricultural landscape in Central Europe can be confirmed. However, if the numbers of historical ponds discovered within this study in the old maps of the mid-nineteenth century for the area of the current Czech Republic are compared with the numbers and areas of ponds in historical professional

literature, significant differences will be found. Růžička (1954) states that up to 180,000 ha of ponds were present here in the sixteenth century. According to the Official list of ponds, there were 76,816 ha of ponds (Mokrý, 1935) in Bohemia alone (one of the three historical areas of the Czech Republic). This data prove that there were a great deal larger number of ponds in the researched area. They ceased to exist at the turn of the eighteenth and nineteenth century, therefore they do not appear in the 2nd Military Mapping or their existence is only referred to in map toponyms. Thus the second wave of pond extinction is noted in our study. In relation to the driving force of the pond extinction stated by Pavelková et al. (2014), ponds at the turn of the eighteenth and nineteenth century ceased to exist in relation to the reforms of Enlightenment (abolition of serfdom, dissolution of monasteries) and their bad technical condition and economic unprofitability. Ponds then cease to exist during the nineteenth century in connection with the transition to alternate farming and extensive cultivation of sugar beet along with replacing water power with fossil fuels, which has been recorded in our map.

The current prevailing use of areas of the extinct ponds then differs logically with respect to the physical-geographic facts of the locations (especially the altitude). Lower altitudes are mainly covered by farming land and built-up areas (they are densely populated fertile lowland areas around major rivers) while in higher altitudes we notice a greater representation of permanent grassland and forests, or water areas (in

situations where some ponds were dissolved in connection with constructions of large dams). And it is in those areas where the original pond areas are utilised extensively where the potential locations for restoration of ponds can be searched.

#### 4.2. Discussion of methodology

Some weaknesses have been discovered in the applied methods which must be dealt with while interpreting and analysing old maps. First of all, the research of a certain phenomenon in a large area using old maps requires a different and often unique method (Fuchs et al., 2015) compared to regional or micro-regional studies. Personally, we had to deal with issues connected with interpretations of map content – water areas in individual map sheet of the 2nd Military Survey whose colourisation and original hues were altered to a degree due to light conditions. This fact made it virtually impossible to apply the potential methods of automatic classification (Herrault, Sheeren, Fauvel, & Paegelow, 2013). Each water area thus had to be identified individually. The use of another set of maps (the Stable Cadastre) from a similar period proved to be highly beneficial. Despite being in the form of non-geo-referenced thumbnails, it served as a reference layer in some cases of an unclear identification or it replaced the lost sheets of the 2nd Military Survey. The 2nd Military Survey is based on accurate geodetic foundations which facilitate its application in comparing the current and past topographic features within a tolerated spatial deviation (Timár, 2009), however, it is necessary to take into account the spatial deviation within several dozens of metres and eliminate it to be able to apply it in the follow-up analyses in the GIS combined with the current digital map sources. A number of adjustments must be manual which is very time-consuming. However, these adjustments are important for the future practical application of digital results combined with the current map resources.

#### 5. Conclusions and discussion

The creation of a map of extinct ponds of the Czech Republic confirmed the importance of old maps and their value for the purposes of current landscape research whether from the view of landscape planning (Marcucci, 2000) or discovering long-term human influence and activities in the landscape (Latocha, 2015). It also confirmed the importance of man-made water reservoirs as part of the historical landscape of the Czech Republic. Comparing the maps of the 2nd Military Survey from the mid-nineteenth century with the current maps, it was ascertained that there are 10,952 historical ponds larger than 0.5 ha in the current landscape. Most of them are smaller than

3 ha. On the other hand, a large number of extinct ponds are noticed (3416 ponds larger than 0.5 ha) whose area is currently utilised mostly as farmland. The areas are used more extensively with growing altitude which allows considerations for potential pond reconstructions in these locations. The completed map may be applied in practice. The spatial information on the extinct ponds, their locations, current use or the historical existence of dams on such ponds may result in projects of their reconstructions (David & Davidová, 2015). The resultant geodata, with the exception of the overall maps of extinct ponds of the Czech Republic, were made freely accessible through the Web Map browser within the Hydroecological information System (HEIS) which is managed by T. G. Masaryk Water Research Institute (see [http://heis.vuv.cz/data/webmap/isapi.dll?map=mp\\_historickerybniky](http://heis.vuv.cz/data/webmap/isapi.dll?map=mp_historickerybniky)). The authors of this map hope that publishing the results through a web browser will result in the use of the map of extinct ponds for potential government bodies or private entities who would be interested in recovery of some extinct ponds either using their own resources or various subsidy programmes (Rozkošný, Dzuráková, Pavelková Chmelová, & Konvit, 2014). Restoring these extinct water reservoirs can contribute significantly to local adaptation to the global climate changes or restoration of biodiversity in intensively farmed cultural landscape (Ruggiero, Céréghino, Figuerola, Marty, & Angélibert, 2008).

#### Software

The vectorisation of historic ponds, the follow-up analyses and the creation of the resulting map were made in the program ArcGIS by ESRI.

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#### References

- Baily, B., Riley, M., Aucott, P., & Southall, H. (2011). Extracting digital data from the first land utilisation survey of Great Britain e methods, issues and potential. *Applied Geography*, 31, 959–968. doi:10.1016/j.apgeog.2010.12.007
- Barabach, J. (2013). The history of Lake Rzecin and its surroundings drawn on maps as a background to



- palaeoecological reconstruction. *Limnological Review*, 12, 103–114. doi:10.2478/v10194-011-0050-0
- Brůna, V., Křováková, K., & Nedbal, V. (2010). Historical landscape structure in the spring area of the Blanice River, southern Bohemia – An example of the importance of old maps. *Acta Geodaetica et Geophysica Hungarica*, 45, 48–55. doi:10.1556/AGeod.45.2010.1.8
- Čada, V., & Vichrová, M. (2009). Horizontal control for stable cadastre and second military survey (Franzische Landesaufnahme) in Bohemia, Moravia and Silesia. *Acta Geodaetica et Geophysica Hungarica*, 44, 105–114. doi:10.1556/AGeod.44.2009.1.10
- Cajthaml, J. (2013). Polynomial georeferencing method for old map series. In *13th international multidisciplinary scientific geoconference and EXPO, SGEM 2013* (pp. 859–865). Albena: International Multidisciplinary Scientific Geoconference. doi:10.5593/SGEM2013/BB2.V1/S11.032
- Chrudina, Z. (2009). Changes of streams in the Litava river basin from the second half of the 18th century until the present (1763–2006) based on study of old maps. *Acta Pruhoniciana*, 91, 35–44. Retrieved from [http://www.vukoz.cz/acta/dokumenty/acta\\_91/Acta-91\\_komplet-en.pdf](http://www.vukoz.cz/acta/dokumenty/acta_91/Acta-91_komplet-en.pdf)
- Czech National Geoportal. (2015). *Metadats* (2nd Military Survey). Retrieved from <http://geoportal.gov.cz/web/guest/catalogue-client>
- David, V., & Davidová, T. (2015). Analysis of available retention volume in extinct ponds – case study for Blanice river catchment. *Agriculture and Agricultural Science Procedia*, 4, 79–87. doi:10.1016/j.aaspro.2015.03.010
- De Boer, A. (2010). Processing old maps and drawings to create virtual historic landscapes. *e-Perimetron*, 5, 49–57.
- Druga, M., & Faltán, V. (2014). Influence of environmental drivers on the land cover structure and its long-term changes – case study of Malachov and Podkonice villages in Slovakia. *Moravian Geographical Reports*, 22, 29–41. doi:10.2478/mgr-2014-0016
- Frajer, J., Geletič, J., & Kladiivo, P. (2013). Reconstruction of extinct ponds using old maps, historical cadastres and the digital terrain model of the Czech Republic of the 5th generation. *Acta Universitatis Palackianae Olomucensis – Geographica*, 44, 59–69. Retrieved from [http://geography.upol.cz/soubory/vyzkum/aupo/Acta-44-1/AUPO\\_Geographica\\_44-1\\_Frajer\\_et\\_al\\_RGB.pdf](http://geography.upol.cz/soubory/vyzkum/aupo/Acta-44-1/AUPO_Geographica_44-1_Frajer_et_al_RGB.pdf)
- Fuchs, R., Verburg, P. H., Clevers, J. G. P. W., & Herold, M. (2015). The potential of old maps and encyclopaedias for reconstructing historic European land cover/use change. *Applied Geography*, 59, 43–55. doi:10.1016/j.apgeog.2015.02.013
- Fujihara, M., & Hara, K. (2011). Changes in landscape structure in a rural area of Boso peninsula, central Japan. *Journal of Landscape Ecology*, 4, 31–40.
- Gregory, I., & Healey, R. (2007). Historical GIS: Structuring, mapping and analysing geographies of the past. *Progress in Human Geography*, 31, 638–653. doi:10.1177/0309132507081495
- Havlíček, M., & Chrudina, Z. (2013). Long-term land use changes in relation to selected relief characteristics in Western Carpathians and Western Pannonian basin – case study from Hodonín district (Czech Republic). *Carpathian Journal of Earth and Environmental Sciences*, 8, 231–244.
- Havlíček, M., Krejčíková, B., Chrudina, Z., & Svoboda, J. (2012). Long-term land use development and changes in streams of Kyjovka, Svratka and Velička river basins (Czech Republic). *Moravian Geographical Reports*, 20, 28–41.
- Havlíček, M., Pavelková, R., Frajer, J., & Skokanová, H. (2014). The long-term development of water bodies in the context of land use: The case of the Kyjovka and Trkmanka River Basins (Czech Republic). *Moravian Geographical Reports*, 22, 39–50. doi:10.1515/mgr-2014-0022
- Herrault, P.-A., Sheeren, D., Fauvel, M., & Paegelow, M. (2013). Automatic extraction of forests from historical maps based on unsupervised classification in the CIElab color space. In D. Vandenbroucke, B. Bucher & J. Crompvoets, J. (Eds.), *Geographic information science at the heart of Europe, lecture notes in geoinformation and cartography* (pp. 95–112). Cham: Springer.
- Juszycki, R., & Kędziora, A. (2003). Threats to and deterioration of small water reservoirs located within Wyskoć Catchment. *Polish Journal of Environmental Studies*, 12, 567–573.
- Keken, Z., Panagiotidis, D., & Skaloš, J. (2015). The influence of damming on landscape structure change in the vicinity of flooded areas: Case studies in Greece and the Czech Republic. *Ecological Engineering*, 74, 448–457. doi:10.1016/j.ecoleng.2014.11.002
- Klich, D., Gielarek, S., & Antosiewicz, M. (2013). Land cover dynamics in western Bieszczady Mts between 19th and 20th century. *Ekologia (Bratislava)*, 32, 95–103. doi:10.2478/eko-2013-0008
- Kopp, J., Frajer, J., & Pavelková, R. (2015). Driving forces of the development of suburban landscape – A case study of the Sulkov site west of Pilsen. *Questiones Geographicae*, 24, 51–64. doi:10.1515/quageo-2015-0028
- Kovács, G. (2010). The advantages of using the Second military survey maps in fluvial studies. *Acta Geodaetica et Geophysica Hungarica*, 45, 64–70. doi:10.1556/AGeod.45.2010.1.10
- Krol, M. S., de Vries, M. J., van Oel, P. R., & de Araújo, J. C. (2010). Effects of small reservoirs on large scale water availability. In D. A. Swayne, W. Yang, A. A. Voinov, A. Rizzoli, & T. Filatova (Eds.), *Modelling for Environment's Sake: Proceedings of the Fifth Biennial Conference* (pp. 1649–1656). Ottawa: The International Environmental Modelling and Software Society. Retrieved from: <http://www.iemss.org/iemss2010/index.php?n=Main.Proceedings>
- Langhammer, J., & Vajskebr, V. (2003). Historical shortening of river network in the Otava river basin. *Acta Universitatis Carolinae – Geographica*, 38, 109–124.
- Latocha, A. (2015). Past human activities recorded in the landscape. *A case study from the Glenveagh National Park, Ireland. Landscape Research*, 40, 338–358. doi:10.1080/01426397.2013.829807
- Marcucci, J. D. (2000). Landscape history as a planning tool. *Landscape and Urban Planning*, 49, 67–81. doi:10.1016/S0169-2046(00)00054-2
- Mokřý, T. (1935). *Hospodářství rybníční* [Fishpond management]. Písek: Nakladatelství Františka Podhajského.
- Molnár, G. (2010). Making a georeferenced mosaic of historical map series using constrained polynomial fit. *Acta Geodaetica et Geophysica Hungarica*, 45, 24–30.
- Pavelková, R., Frajer, J., & Netopil, P. (Eds.) (2014). *Historické rybníky České republiky. Srovnání současnosti se stavem v 2. polovině 19. století* [Historic ponds in the Czech Republic: Comparison of the current situation with the condition of the second half of the 19th century]. Prague: T. G. Masaryk Water Research Institute.
- Pavelková Chmelová, R., Frajer, J., Pavka, P., Dzuráková, M., & Adámek, P. (2012). Identification and analysis of areas of historical ponds (Chrudimka River Basin). *Acta Universitatis Palackianae Olomucensis – Geographica*,

- 43, 117–132. Retrieved from [http://geography.upol.cz/soubory/vyzkum/auPO/Acta-43-2/AUPO\\_Geographica\\_43-2\\_Pavelkova-et-al.pdf](http://geography.upol.cz/soubory/vyzkum/auPO/Acta-43-2/AUPO_Geographica_43-2_Pavelkova-et-al.pdf)
- Pietrowszki, J., & Mészáros, J. (2010). The great Hungarian plain in the sheets of the Habsburg military surveys and some historical maps – A case study of the Körös/Cris drainage basin. *Acta Geodaetica et Geophysica Hungarica*, 45, 56–63. doi:10.1556/AGeod.45.2010.1.9
- Pokorný, J., & Hauser, V. (2002). The restoration of fish ponds in agricultural landscapes. *Ecological Engineering*, 18, 555–574. doi:10.1016/S0925-8574(02)00020-4
- Popelková, P., & Mulková, M. (2011). Landscape changes mapping: Central part of Ostrava-Karviná mining district, Czech Republic. *Journal of Maps*, v2011, 7, 363–375. doi:10.4113/jom.2011.1165
- Raška, P., & Emmer, A. (2014). The 1916 catastrophic flood following the Bílá Desná dam failure: The role of historical data sources in the reconstruction of its geomorphologic and landscape effect. *Geomorphology*, 226, 135–147. doi:10.1016/j.geomorph.2014.08.002
- Rozkošný, M., Pavelková Chmelová, R., Dzuráková, M., Konvit, I., Hudcová, H., Frajer, J., & Pavka, P. (2013). The use of abandoned ponds for creation of wetlands and small water bodies intended for nutrient elimination in agricultural landscape. In Vymazal, J. (Ed.), *8th International Workshop on Nutrient Cycling and Retention in Natural and Constructed Wetlands* (pp. 73–76). Třeboň: ENKI, o.p.s.
- Rozkošný, M., Dzuráková, M., Pavelková Chmelová, R., & Konvit, I. (2014). Development of small water reservoirs with water management restoration of the landscape with regard to areas of abandoned ponds. *Acta Pruhoniciana*, 107, 15–25. Retrieved from [http://www.vukoz.cz/acta/dokumenty/acta\\_107/Acta-107\\_komplet-cz.pdf](http://www.vukoz.cz/acta/dokumenty/acta_107/Acta-107_komplet-cz.pdf)
- Ruggiero, A., Céréghino, R., Figuerola, J., Marty, P., & Angélibert, S. (2008). Farm ponds make a contribution to the biodiversity of aquatic insects in a French agricultural landscape. *Comptes Rendus Biologies*, 331, 298–308. doi:10.1016/j.crv.2008.01.009
- Růžička, K. (1954). Z historie rybníkářství [From the history of fishponding]. *Vodní hospodářství*, 12, 365–367.
- Skaloš, J., & Engstová, B. (2010). Methodology for mapping non-forest wood elements using historic cadastral maps and aerial photographs as a basis for management. *Journal of Environmental Management*, 91, 831–843. doi:10.1016/j.jenvman.2009.10.013
- Skaloš, J., Engstová, B., Trpáková, I., Šantrůčková, M., & Podrázský, V. (2012). Long-term changes in forest cover 1780–2007 in central Bohemia, Czech Republic. *European Journal of Forest Research*, 131, 871–884.
- Skaloš, J., Weber, M., Lipský, Z., Trpáková, I., Šantrůčková, M., Uhlířová, L., & Kukla, P. (2011). Using old military survey maps and orthophotograph maps to analyse long-term land cover changes – case study (Czech Republic). *Applied Geography*, 31, 426–438. doi:10.1016/j.apgeog.2010.10.004
- Skokanová, H. (2005). Channel changes of the lower part of the Dyje river in the 1830–2001 period caused by human activities. *Geografie – Sborník České geografické společnosti*, 110, 271–286.
- State Administration of Land Surveying and Cadastre. (2015). *Fundamental base of geographic data of the Czech Republic – introduction*. Retrieved from [http://geoportal.cuzk.cz/%28S%28kd3xfnbepvsez22tmqc50bzt%29%29/Default.aspx?mode=TextMeta&text=dSady\\_zabaged&side=zabaged&menu=24](http://geoportal.cuzk.cz/%28S%28kd3xfnbepvsez22tmqc50bzt%29%29/Default.aspx?mode=TextMeta&text=dSady_zabaged&side=zabaged&menu=24)
- Štefunková, D., Špulerová, J., Dobrovodská, M., Mojses, M., & Petrovič, F. (2013). Traditional agricultural landscapes – a model of detailed land use mapping. *Tájökölógiai Lapok*, 11(1), 1–21.
- Timár, G. (2004). GIS integration of the second military survey sections – a solution valid on the territory of Slovakia and Hungary. *Kartografické listy*, 12, 119–125.
- Timár, G. (2009). System of the 1:28800 scale sheets of the second military survey in Tyrol and Salzburg. *Acta Geodaetica et Geophysica Hungarica*, 44, 95–104. doi:10.1556/AGeod.44.2009.1.9
- Veverka, B., Ambrožová, K., & Čechurová, M. (2011). Mathematical approaches to evaluation of old maps contents and accuracy. *Acta Montanistica Slovaca*, 16, 291–298.
- Wood, P. J., & Barker, S. (2000). Old industrial mill ponds: A neglected ecological resource. *Applied Geography*, 20, 65–81. doi:10.1016/S0143-6228(99)00015-6