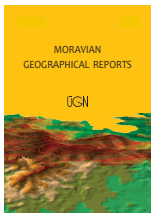

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Discovering extinct water bodies in the landscape of Central Europe using toponymic GIS

Jindřich FRAJER [a]*, David FIEDOR [a]

Abstract

Due to global climate change and anthropogenic pressures on the landscape, one of the current geographical problems is retention of water in agricultural landscapes. One possibility to tackle this issue is the construction of artificial water bodies, which has historical traditions in the form of fishponds in Central European landscapes. Unfortunately, many such water bodies were transformed into arable lands during the 18th and 19th centuries. In this study, the identification and spatial distribution of these extinct water bodies is subject to examination, using place names in a GIS environment. Some 375 place names were selected from the official database of place names in the Czech Republic. This set of names was compared to current maps, as well as to old maps from the Habsburg monarchy from 1783–1880 (1st, 2nd and 3rd Military Survey). The map resources were used to find out if a place name was related to an extinct fishpond, and in which period the pond ceased to exist. Using spatial statistics, the existence of areas with a high concentration of place names referring to extinct ponds is demonstrated. It has also been established that areas linked to fishpond extinction in the same period now face more frequent droughts. Thus, the set of place names can be used to identify not only extinct water bodies, but also to serve as being potentially useful in other analyses using GIS, as well as in the public sphere (reclamation).

Keywords: *place names; toponyms; historical landscape; ponds; GIS; Czech Republic*

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1. Introduction

Current European landscapes are witness to dynamic changes (Vos and Meekes, 1999), subject to anthropogenic pressures evidenced by many factors, such as the growing landscape impacts of urbanisation, industrialisation and intensive commercial farming on the one hand (e.g. Feranec et al., 2010), while rural landscapes are left idle due to their economic unprofitableness on the other hand (Lieskovsky et al., 2015). Either way, traditional European landscapes, which were created and acquired characteristic and stable structures for centuries, begin to vanish dramatically with the onset of intensive commercial agriculture and continuing urbanisation (Špulerová et al., 2017).

The monitoring and assessment of current anthropogenic activities on the landscape is connected to an increasing scientific interest in the historical landscape and its form, which is frequently used as a starting point for the comparison of the degree and intensity of changes (Haase et al., 2007; Van Eetvelde and Antrop, 2009). In addition, such research serves as a foundation for scenarios for its future development in connection with planning (Gaynor and McLean, 2008; Marcucci, 2000), or as a source of inspiration for its reconstruction or revitalisation (Spens, 2006; Stein et al., 2010). Specific parts of historical landscapes are subject to investigation in this article: artificial water bodies in the form of ponds or fishponds serving as small water reservoirs, which had been built for various purposes across most of Central Europe to a great extent since the Middle Ages (Jankowski, 2006; Squatriti, 2000). Many of them ceased to exist, however, with the onset of industrialisation and modern agriculture (Bičík, 2010; Lipský, 2001). Those that survive can play an important part in ecology (Jeffries, 1991) and hydrology (Smith et al., 2002), as well as in cultural terms (Rees, 1997). The restoration of some extinct fishponds, which could help maintain water in the agricultural landscape (David and Davidová, 2015), is being discussed in relation to increasing anthropogenic pressures on the landscape and their negative impact on its ecology and water capacity (Bastian et al., 2006; Šantrůčková et al., 2017), together with the changing climate and the increased probability of extreme hydrological phenomena (droughts) (Zahradníček et al., 2015).

[a] Department of Geography, Faculty of Science, Palacký University Olomouc, Czech Republic (*corresponding author: J. Frajer, e-mail: *jindrich.frajer@upol.cz*)

As a consequence, research on the historical extent of water areas is essential. Many studies apply the set of current and old maps for this purpose (e.g. Havlíček et al., 2014; Skaloš et al., 2011; Šantrůčková et al., 2017). These are mainly regional studies, however, as processing an area the size of a country is very demanding time- and capacity-wise (Pavelková et al., 2016). Therefore, current place names are used here as a primary indicator of the former existence of artificial water bodies.

We assume that place names are the basic building blocks of cultural landscapes (Penko Seidl, 2011) and they can be seen, apart from the actual naming of a location that facilitates orientation in space, as remnants of the symbolic processes of landscape anthropomorphism and space socialisation (McNiven, 2008). Thus, they bear historical information of some relations of facts which might have occurred during the process of naming a location or a specific object. They are basically "the storehouses of cultural information about people's relationship with the land" (Hunn, 1996, p. 22). Place names referring to fishponds could provide relevant information: with respect to their historical distribution; their spatial pattern concerning the former distribution of ponds (Pavelková et al., 2014); and their stability and the longevity of place names in the landscape (Calvo-Iglesias et al., 2012).

2. Theoretical background

2.1 Place names, geography and toponymic GIS

The study of place names represents quite a broad interdisciplinary scientific field where linguists, historians, ecologists, sociologists, folklorists and psychologists can meet (Jett, 1997; Senft, 2008). It might seem that the potential relations between place names and material and social phenomena in specific landscapes and at specific times would initiate a number of geographic studies, but research on place names in geography is often perceived as marginal (Rose-Redwood et al., 2010). This partly occurs as traditional perceptions of place names (emphasising etymology or linguistics), which are applied mostly in historical and cultural geography connected with the history of settlements or the historical appearance of landscape (Darby, 1957; Hoskins, 1969; Stewart, 1945), has been exhausted to a degree (David and Mácha, 2014; Zelinsky, 1997), and apart from regional curiosities, it as not brought any new advances in theory or method. Therefore, such studies have often been connected to a mere collection of local curiosities of antiquarian empiricism (Rose-Redwood et al., 2010). Moreover, many of the alleged connections between place names and historical processes in the landscape have been shown to be fallible (Johnson, 2008, p. 110). In addition, there might be a relation to the simple fact that the linguistic significance of individual words changes in time (Roberts and Wrathmell, 2002).

Since the 1990s, geographic research on place names has changed significantly – with connections to the so-called "critical turn" in Human Geography. This new approach sees place names as social producers of space (Rose-Redwood et al., 2010). The 'catch-all' phrase "critical toponymies" has inspired a number of geographical studies which deal with place names with respect to the concerns of critical human geography, in the sense of their roles in politically and socially motivated space (re)organisation or power distribution (e.g. Alderman, 2002; Azaryahu, 2012; Creţan and Matthews, 2016; Karimi, 2016; Myers, 1996; Rose-Redwood, 2008; Yeoh, 1996). The role that place names play in creating the relationship of a person to space based on personal significance and memories (Radding and Western, 2010), regional identification (Machar, 2014; Semian, 2012; Semian et al., 2016), or the potential to be used commercially (Light and Young, 2015), is also being discussed with respect to new approaches to the perception of place names.

The broader application of Geographical Information Systems (GIS) methods to the study of place names can be seen towards the end of the 2000s (Wang et al., 2006). Many authors consider this change as new opportunities in the study of place names (Goodchild, 2004; Wang et al., 2014), especially in relation to possible applications of spatial statistics to the sets of place names, aiming at discovering their spatial patterns. As a principal reason, it is possible to analyse a large number of place names at various scales and to connect them to other attributes, human or environmental. There is often no need for their collection and classification, largely due to applications of existing place name dictionaries (Wang et al., 2014) or even better, national digital databases of place names and gazetteers (Cox et al., 2002; Feng and Mark, 2017; Wang et al., 2006). Place names can then be analysed with more detailed connections to their surroundings using some basic tools of GIS software, combining the place name databases with other types of available geo-data (digital elevation models, river networks, land cover, regional boundaries, population data, etc.). Overlapping place names and GIS can thus provide a unique connection for their qualitative and quantitative (spatial-analytical) potential, which can be applied both in both historical and cultural geography (Fuchs, 2015a). Hence, Fuchs (2015b) applies the term "toponymic GIS", which can be used in most studies thusly oriented. It is basically an analogy to 'historical GIS' (Bailey and Schick, 2009; Gregory and Ell, 2007; Knowles, 2002), which includes the analysis of both spatial and temporal data series acquired from historical resources – both at a scale and volume not known previously, such that the processing of such sources was too slow or too complicated in the past (Holdsworth, 2002).

Moreover, it is our belief that there is a close relation between Toponymic GIS and Historical GIS. The GIS application in historical research is widely applied by historical geographers (Gregory and Healey, 2007) in their studies of historical landscapes and change. Place names represent a significant source in the historical geography or environmental history of landscapes (King et al., 2007; Pospelov and Smolitskaya, 1986). Thus, the subjects of study of historical GIS and toponymic GIS may meet and overlap on this issue. Applying GIS methods to the study of place names introduces a new impulse for traditional approaches. The results of spatial analyses could support or complement the theoretical concepts through which we perceive place names. First of all, the previous hypotheses on connections between place names and certain landscape phenomena are easy to capture in GIS and can be verified (Chen et al., 2014; Wang et al., 2006). Not only can these connections be studied on far wider levels and on more numerous statistical data sets, but they can also be applied on an international level with inputs of a set of place names in different languages (Grădinaru et al., 2012). One example of applying place names, GIS and local geographical factors connected with ethnology, is a study in ethno-physiography (Derungs and Purves, 2014; Feng and Mark, 2017; Mark and Turk, 2003), or in ethno-pedology (Capra et al., 2015; Capra et al., 2016).

This case study deals with place names with reference to traditional historical-geographic approaches to their study in relation to historical landscapes, with new possibilities provided by the GIS methods applied to current place name databases. We follow the above-mentioned studies in that spirit and do not view them through the prism of critical toponymies.

2.2 Place names and historical landscape research

Interest in place names has also increased among scientific disciplines in recent years, to a great extent because place names are understood to be parts of historical landscapes (Rippon, 2013), as well as serving as special study materials and sources of a large amount of environmental information (David, 2008; Sousa et al., 2010). They are amply utilised in bio-geographical research on the historical distributions of selected species and their relations to specific landscape features (Aybes and Yalden, 1995; Boisseau and Yalden, 1998; Cox et al., 2002; Moore, 2002). In addition, they play the role of indicators of past use and the manner of landscape cultivation (Calvo-Iglesias et al., 2012; Conedera et al., 2007; Holl and Smith, 2007; Siderius and de Bakker, 2003), or they serve together with other sources as evidence of the overall management of natural resources (Lawson et al., 2005).

The above-mentioned studies use place names as a source of information about historical landscapes; however, let us not forget that place names do have a strong role per se and help create the atmosphere of local landscapes and their character in the rural space (Rippon, 2013). Penko Seidl et al. (2015) observe that landscape consists of three basic layers: historical, geographical (from the perspective of physical-geographical configuration) and cognitive (the manner in which people perceive and interpret landscapes). Place names penetrate all of the presented layers from this perspective. It is through them that the specific identity of places is created (Tilley, 1994), which is part of the relation formed between a person and a given place or landscape, while perceiving their historical continuity (Ingold, 2000).

In this context, knowledge of local place names should lead local residents to consider their significance and origin, as confirmed by a number of local studies. Our research focuses on the current place names that can inspire local people to consider the landscape and the way water was managed in the past. Therefore, we decided to combine the current place name databases with information on the appearance of historical landscapes acquired from old maps. Thus, this approach differs from studies which use old maps as the resource for place names for the purposes of landscape research (Loffler, 2000; Sousa and García-Murillo, 2001; Sousa et al., 2010; Spens, 2006).

3. Geographical context of the study

The present study uses Toponymic GIS and applies the procedures to the set of place names connected to ponds (fishponds), as examples of artificial water bodies. The Czech Republic was selected as the area of interest for this study. Its history of pond construction is long and ponds were widely spread here and became an important landscape phenomenon, mainly since the 1450s (Pavelková et al., 2016; Semotanová, 2009). Similar to other countries, Czech ponds fulfilled various roles, most of all as places to keep fish. That is the reason why the term pond merged with the term fishpond no matter what the purpose was (Pavelková et al., 2014). Resulting from socio-economic changes, most of fishponds (approximately two-thirds) were drained and turned into farm land. The process of pond abolishment occurred in two main waves: the first (major) one took place in the second half of the 18th century and it was connected with the transition to new procedures in farming and also with the Enlightenment reforms of society. The second wave occurred in the first half of the 19th century and was caused by attempts to increase the amount of soil available to grow sugar beet. Evidence of extinct ponds can be found, however – in the field (remnants of dykes and canals: Klápště, 2016), archives and old maps (Frajer et al., 2013; Skaloš et al., 2011), as well as in current place names.

And this research project focuses on the place names referring to extinct ponds. We follow two principal assumptions:

1. fish-farming is mentioned as one of the best-known human historical impacts on the landscape of the Czech lands (Semotanová, 2009), such that the abolishing of ponds as important elements of both the current and the historical farm landscapes must have been reflected in folk toponymy; and
2. as the wave of ponds abolished in the Czech lands (at the turn of the 19th century) coincides with the emergence of the first modern land cadastres in the Habsburg monarchy (Josephinian cadastre 1789; Stabile cadastre 1823), it is highly likely that many of these place names were standardised and are still used in map works. A number of these place names might thus be old and refer to several centuries-old facts (Calvo-Iglesias et al., 2012; Dohnal, 2016).

4. Aims and research questions

The aim of this study is to apply Toponymic GIS to evaluate the spatial distribution of current place names referring to extinct ponds and, using old maps to determine the relative time of the extinction of these water landscape elements, thus to ascertain the age of the place name. Our research tried to answer three essential questions:

1. Is it possible to identify extinct ponds in the Czech Republic using the current place names and old maps?;
2. How old is the event (the existence of the pond) that the place names refer to?; and
3. Is it possible to trace tendencies in the spatial concentration of the place names? Do areas of frequent occurrences of those place names overlap with the areas which currently face water shortages?

To answer these questions, we use data from the current database of the Geographical names of the Czech Republic (GEONAMES) and old maps of the Habsburg monarchy.

5. Data and Methods

5.1 Basic data

The database GEONAMES, managed by the Czech Office for Surveying, Mapping and Cadastre (ČÚZK), provided the main source of data for this study. The database was launched in the 1970s and its aim is to standardise geographical names in order to create and issue state map works. The database started the process of digitisation in 1997, completed in 2005. It has been regularly updated since then (ČÚZK, 2015). The database is available for GIS software through Web Map Service (WMS) or through the web Geoportal (http://geoportal.cuzk.cz/geoprohlizec/). The database distinguishes the categories of place names related to traffic, land and

ground, borderlines, protected areas, waters, residence and constructions. Downloading GIS layers with geographical names is charged. Processing the place names from the database took place in December 2015 and January 2016, partial adjustments were carried out in January 2017.

Maps from the Habsburg monarchy era, specifically the 1st Military Survey (at a scale of 1:28,000, from 1764–1783), the 2nd Military Survey (1:28,800; 1842–1852), and the special maps of the 3rd Military Survey (1:75,000; 1876–1880) were used as historical map sources, which allowed the detection of existing ponds. Historical maps are available through the web map browsers of the Geoinformatics Laboratory, University of J. E. Purkyne (oldmaps.geolab.cz) and the project Mapire (mapire.eu), which allow access to the historical maps from the Habsburg monarchy era (Timár et al., 2010). Sporadically, maps from the Stabile cadastre (1:2,800; 1824–1843) were used; they are also available via the web Geoportal ČÚZK. The selected historical cartographic sources are widely used by scientists from the perspective of researching water elements and their development in the landscape (Brůna et al., 2010; Havlíček et al., 2014; Petrovszki and Mészáros, 2010; Skaloš and Engstová, 2010).

5.2 Selection of place names

The selection of potential place names was an important step as they could refer to the existence of extinct ponds in the whole of the Czech Republic. The selected place name was "dyke", due to our consideration that a dyke had commonly been the only relict left after the extinct fishpond, which had also become a kind of landscape memento. Therefore, it might have contributed to the genesis of place names referring to the history of the local landscape. Moreover, dykes as the essential construction components were central to historical expert literature on ponds (Svanberg and Cios, 2014). The selection included variations of the plural of "dyke" ("hráze") and also some of the possible prepositional phrases referring to the direction or location of a dyke. The second-place name selected was the term "fishpond" itself. It was, however, necessary to proceed very cautiously here as it estimated the number of small water reservoirs to be 25,000 in total in the Czech Republic (Benešová, 1996), which often bear the popular name of fishpond. It is obvious that a large number of place names connected to "fishpond" will refer to large water areas. Therefore, the variations were selected which referred to the location (in the fishpond or at the fishpond), which might logically refer to a location of an extinct fishpond. An overview of all the selected place names and their variations is given in Table 1. We only focused on landscapes outside of urban areas which are sometimes called field names (Penko Seidl, 2011) or minor names (Imazato, 2010).

5.3 Methods of place name analysis

Based on the representative selection of the place names, respective place names were searched in the database GEONAMES using the Geoportal ČÚZK. Only the place names from the group "field and ground" were used with reference to field names. Each location carrying the representative place name was entered into a point GIS layer (using the program ArcGIS 10.4), and then it was assigned other attributes. First, it was visually confronted with the current map (or an orthophoto map). If the location matched an existing fishpond, it fell in the category "PRES" (Presence). Otherwise, another comparison of the above-mentioned historical maps took place with the aim of ascertaining whether there was a fishpond in the respective location in the past and in which map it was last recorded. Thus, the approximate age of the place name was determined or how old the landscape fact was that it refers to (Fig. 1).

In this manner, several relative time categories arose:

i. "B1MS" (Before 1st Military Survey) – the first military survey only recorded the dyke of an extinct fishpond, the fishpond itself had ceased to exist;
ii. "1MS" (1st Military Survey) fishpond was recorded for the last time in the first military survey and ceased to exist after that; analogous are then the categories
iii. "2MS" (2nd Military Survey); and
iv. "3MS" (3rd Military Survey).

An independent category ("NA") comprised those ponds which do not exist at present and their previous existence cannot be documented in the old maps. The issue of availability of the selected historical maps on the one hand and the spatial deviation in the case of geo-referencing the GIS environment on the other (Timár, 2004), were dealt with by applying the web map browser at the Mapire.eu portal. Not only are all the historical maps made available there – but they are also tessellated and geo-referenced. Moreover, the web interface allows the blending of individual surveys or their display in a synchronized view (two historical maps simultaneously). If a map of a medium scale was unclear, the detailed maps of the Stabile cadastre were used (it preceded the 2nd military survey) using the Geoportal ČÚZK.

The last step was the spatial analysis of the selected place names in the GIS environment. The cluster analysis of the STATISTICA system was used to define clusters of place names. The data was entered into the analysis in the form of a matrix of Euclidean distances obtained from ArcGIS: the nearest neighbour method was used for this analysis, as it gradually clusters the points with the closest distances. The authors' focus of interest, after the clusters had been created, was whether the relative representation of the individual place names (the place names relating to extinct ponds comprised one category) in the clusters was similar

Basic place name	Variations
CZ Rybník / Rybníky	Na rybníce, Na rybníku, Na rybníkách, V rybníce, V rybníkách
EN Fishpond / Fishponds	At the fishpond, At the Ponds, In the fishpond, In the Ponds
CZ Hráz / Hráze	K hrázi, K hrázce, Na hrázi, Na hrázce, Od hráze, Pod hrází, Pod hrázemi, U hráze, U hrázky, Za hrází, Za hrázkou, Za hrázemi
EN Dyke / Dykes	To the Dyke, To the Little Dyke, From the Dyke, Below the Dyke, Below the Dams, At the Dyke, At the Little Dyke, Beyond the Dyke, Beyond the Little Dyke, Beyond the Dams

Tab. 1: An overview of the selected place names (CZ – Czech name; EN – English equivalent)
Source: authors' elaboration

Fig. 1: Categories of place names based on a comparison with an old map
Source: authors' elaboration based on the maps from MAPIRE (2018)

to heir relative distribution throughout the Czech Republic. Therefore, Pearson's chi-square test was used for the most frequent clusters. A wide range of methods can be used for other spatial analyses (see Derungs and Purves, 2016; Luo et al., 2000; Qian et al., 2016; Wang et al., 2006; Wang et al., 2014). The methods of the Floating Catchment Area (FCA) with the search window set at 10 km and a Kernel density for the set of place names outside of the "NA" category were used. The spatial pattern of place names referring only to extinct ponds was further analysed using the Inverse Distance Weighing (IDW) procedure, where the place names referring to extinct ponds achieved the values of (1) and of (0) for the existing ponds. To determine the spatial concentration of place names according to the defined categories, cluster analysis was carried out in the SatScan software; this software is widely used for the given purposes (Wang et al., 2006), as here.

6. Results

Our criteria were met by 375 place names in the Czech Republic (ca. 78,800 km^2). Almost nine in ten (86%) place names (in the categories "B1MS", "1MS", "2MS", "3MS", "PRES") could prove a relation to an existing or extinct fishpond; no spatial relation to a fishpond could be proved in the remaining 14% (category "NA"). In other words, no existing fishpond could be found in their vicinity and its existence was not validated by old maps. The largest number of place names (159 in total) referred to ponds which had only been recorded within the 1st Military Survey ("1MS" category). This means that they ceased to exist between 1783–1842. Together with place names that refer to ponds extinct prior to the issue of this source (i.e. prior to 1783; category "B1MS"), this group comprises 58% of place names whose connection to a fishpond could be demonstrated. In total, both of these categories amount to approximately 50% of the total set of the studied place names (the details are illustrated in Fig. 2).

The spatial analysis of place names ascertained that the studied place names create spatial clusters typical for the distribution of individual categories. If any area is connected to one category of place names, it might be an area of mass pond extinction in the given period currently experiencing drought issues. The cluster analysis was stopped at 45 clusters, 8 of which contained more than 10 place names, 5 of which contained more than 20 place names (Fig. 3). Five of the most frequent place names (A [87 place names], B [60], C [42], D [28], E [21]), which were the only ones containing all the place name categories ("NA", extinct, "PRES") were tested using the Pearson's chi-square test. The concord of the relative representation of the individual types of place names in the input file was tested. The test in the case of the A, B, C and E clusters proved anomalies in the distribution of the individual categories, namely at the level of significance $\alpha = 0.05$. Cluster A contained more extinct ponds (more than 81% of all place names in this cluster). Cluster B contained a higher concentration of

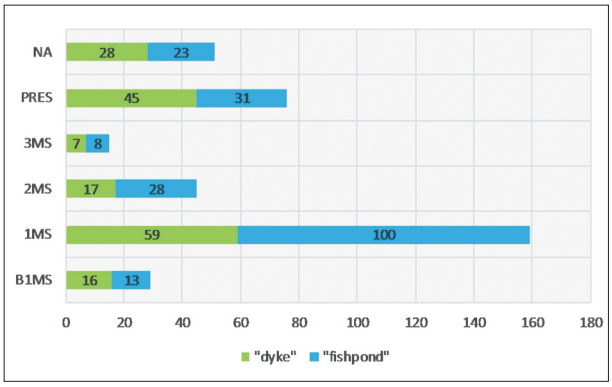

Fig. 2: Frequency of place names with the base of "dyke" and "pond/fishpond" referring to ponds in individual time categories.
Source: authors' calculations

the "PRES" category (more than 41%, which is more than double in comparison with the distribution of the "PRES" category in the entire Czech Republic). On the contrary, cluster C contained the "NA" category place names in a significant number (more than 35%). Cluster E contained a very similar structure of distribution of individual place names as cluster B (specifically, more than 38% of place name distribution referring to existing ponds).

In the next step, we dealt with particular types of place names as defined in the method ("B1MS", "1MS", "2MS", "3MS", "PRES"), and we did not work with the "NA" category where no relation to an existing or extinct fishpond could be proved. Using the cluster analysis in the program SaTScan the areas were limited where statistically significant (level of significance $\alpha = 0.05$) above-average occurrence of one type of place names appeared. This resulted in two clusters of place names of category "B1MS" and one cluster each for categories "1MS" and "PRES" (Fig. 4).

The base of the map with the cluster analysis results comprises the Kernel density analysis, which is another method used to determine areas with an above-average occurrence of place names in referring to extinct or existing

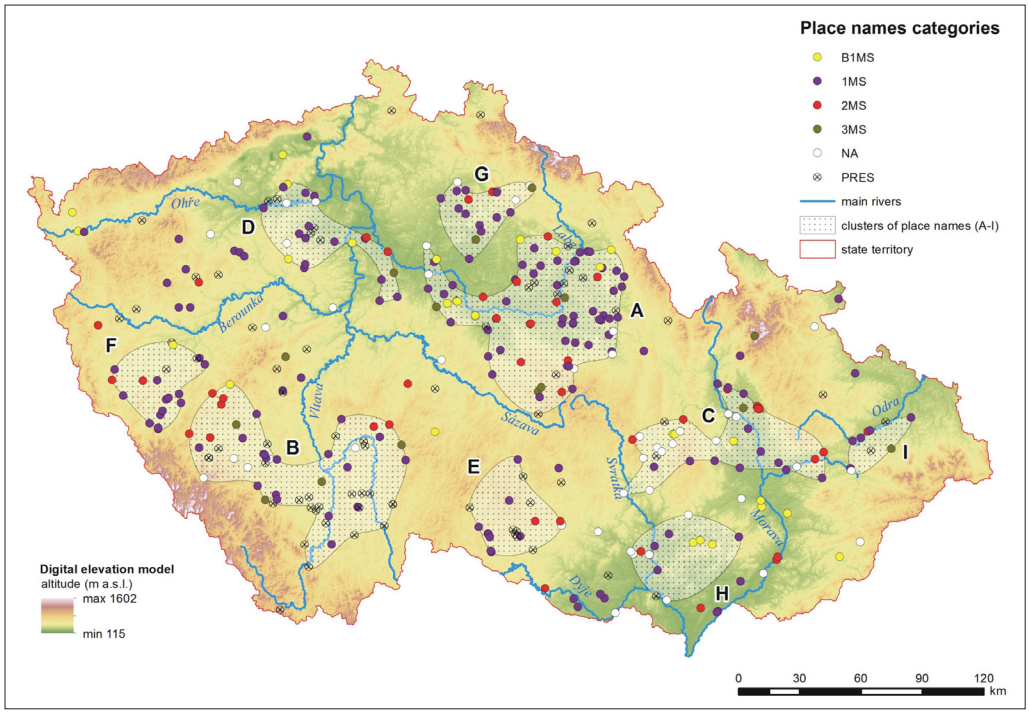

Fig. 3: Place names categories and spatial clusters following the nearest neighbour method
Source: authors' elaboration; ArcČR (2017)

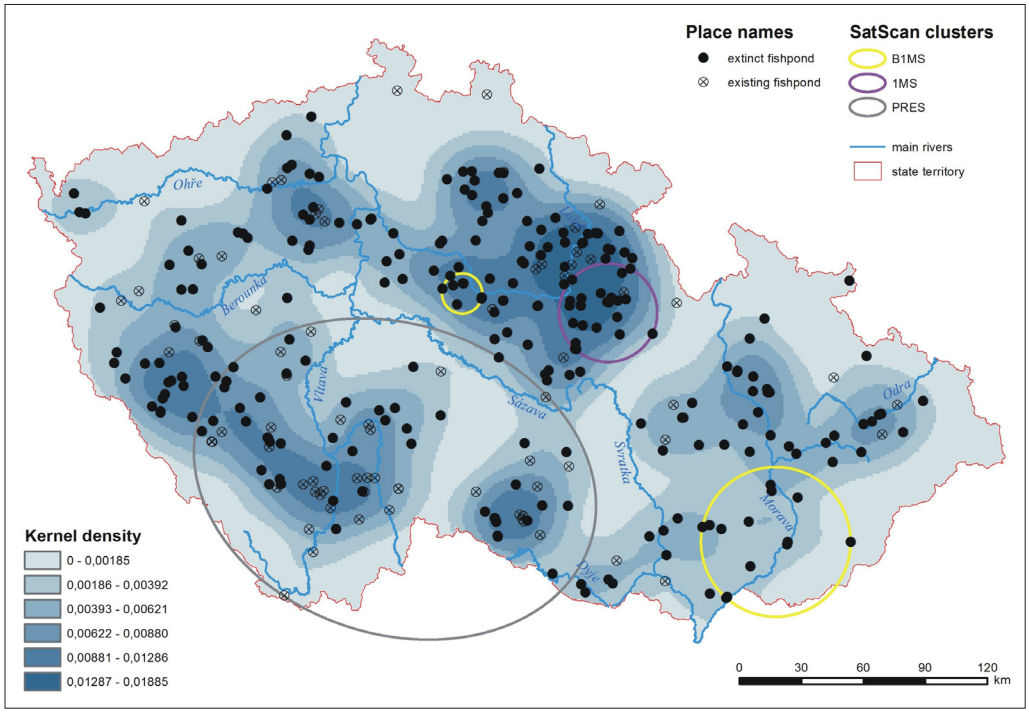

Fig. 4: Kernel density and SaTScan cluster analysis of place names with relation to fishponds
Source: authors' elaboration; ArcČR (2017)

ponds. The spatial connection of place names to the existing or extinct ponds is also shown in the IDW and FCA result (see Fig. 5).

7. Discussion

7.1 Discussion of the results

The results of the place name analysis provided some answers to the research questions outlined above: four points can be discussed.

(1) It is possible in most cases to trace the connection between the place name and an extinct fishpond whose existence can be validated using the selected set of old maps of the Habsburg monarchy. Furthermore, the references to extinct ponds prevail over references to those which still exist. Thus, the current place name may in the case of research of extinct ponds, be a significant indicator of their location in the landscape. We reached similar conclusions to those of Calvo-Iglesias et al. (2012), who detected successfully the specific field system based on place names, or those of Fagúndez and Izco (2016) who used a case study in Galicia to show the significance of phyto-toponyms as explicit geographical indicators of bio-cultural diversity.

(2) Our results also show that place names refer to the former water bodies that existed in the distant past. Most of them (62%) refer to ponds which had ceased to exist by the 1850s. Moreover, 12% of place names referring to extinct fishponds were recorded in the B1MS category, i.e. they had already been extinct in the 1st Military Survey, where only the remnants of their dykes were apparent. They are often hard to identify in the old maps and often blend with depiction of other ground formations. The place names facilitate the discovery of the existence and location of a fishpond. They might thus be the bearers of historical information of landscape elements which ceased to exist 170 years ago at minimum. Such ages of place names are not exceptional in the Czech lands. Ignoring the names of significant landscape elements (mountains and rivers) whose age might go back to the early Middle Ages, the ages of a number of field names are shown to be up to 300 years – depending on the historical written resources which prove their existence (Olivová-Nezbedová, 1995). Dohnal (2016) establishes in his case study that approximately 17% of local names were shown to have existed as early as the 17th or 18th century and have survived to the present day. Penko Seidl (2018) determines in her study of south-western Slovenia that almost 25% of place names found in the 200-year-old historical resources have survived to the present time.

This is even more valuable in the case of extinct ponds, however, considering the fact that their connection to a real object in the landscape does not exist any longer (Olivová-Nezbedová, 1995). Moreover, the form of the Czech landscape has been changing dynamically in the last 200 years (due to industrialisation, urbanisation, socialist collectivisation, post-socialist reconstruction), which had a negative impact on the conservation of place names. Therefore, the surviving place names are rather unique, as their original areas were changed by the different land use (Havlíček et al., 2014; Skaloš et al., 2011) or mechanical field changes were carried out which might have destroyed all tangible traces of an original fishpond (Kopp et al., 2015). A number of such place names resisted these dramatic changes, such that they may comprise a living part of local histories (Fagúndez and Izco, 2016) and be inseparable parts of the cultural heritage in the landscape (Piko-Rustia, 2012).

(3) Spatial analyses have demonstrated that the set of the studied place names connected to well-known fishpond areas (Semotanová, 2009) can or could be found in the lowlands along major rivers and their tributaries: for the extinct ponds, this holds true mainly along the Elbe and the Morava Rivers. The area of South Bohemia – the most traditional fishpond area which is still preserved today and presents a significant example of historical cultural landscapes – exhibits some interesting results. Its analysed place names refer to the current fishponds, as has been shown also by cluster analyses (Figs. 3 and 4). This fact appears highly

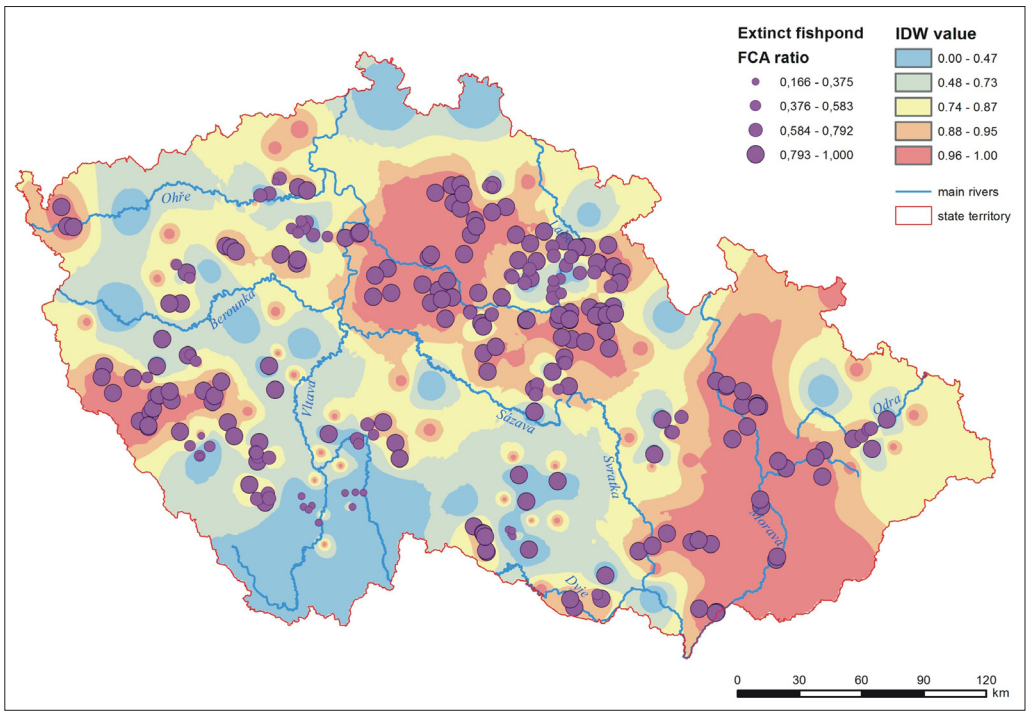

Fig. 5: Results of an FCA and IDW application on the set of place names
Source: authors' elaboration; ArcČR (2017)

logical (there is a high concentration of water areas), but we can also consider the results with respect to the phenomenon stated by Šmilauer (1963) for place names referring to inanimate nature. Naming objects in the landscape was usually connected with something extraordinary that stood out from its surroundings. If we apply this assertion to fishponds, their drainage and extinction could be a strong enough motive for the local inhabitants to create an imaginary cultural reference in the form of a place name in the location of the extinct fishpond, or the fishpond was such a distinctive landscape element that it had served for generations as a landmark and the place names related to it had survived despite its drainage. Logically, it would be more appropriate not to use general place names referring to fishponds in a location with high concentrations of them, as it might be confusing. In the case of abolished ponds, however, a higher number of place names referring to them may be expected as abolished fishponds would be rare in these areas. Nevertheless, our analyses did not ascertain this assumption for the above-mentioned region of South Bohemia.

The cluster analysis and the subsequent Pearson chi-square test demonstrated the rarity of the clusters A, B, C and E. As for cluster A, a number of references to extinct fishponds in the place names can be connected to the extensive fishpond system which was constructed along the Elbe River, primarily related to the aristocratic family of Pernštejn at the turn of the 16th century (Lochman, 1970). These fishponds located in the fertile alluvial soils were being gradually drained from the 1750s, as demonstrated by the occurrences of clusters of the categories "B1MS" and "1MS" (Fig. 4). Resulting from the revolution in agriculture and its intensification, other fishponds were drained during the 19th century in this area. The rarity of clusters B with a high occurrence of place names referring to existing fishponds located in South Bohemia was discussed above (a similar situation to cluster E), the results of cluster analysis using the program SatScan (Fig. 4) show a higher concentration of place names in the category "PRES" in this location.

The large number of place names of the category NA in cluster C then may be related to the place names from the input set which bore the name "dyke", as they might not have been connected to a fishpond but could have referred to an anti-flood dyke. There is a relatively high number of such dykes along the central course of the Morava River (so-called rustic dykes or peasant's dams; Simon et al., 2014). Such a connection could only be demonstrated through more thorough regional research, however.

(4) The last but not least point of discussion is the significance of research of the relations of place names to the extinct fishponds. As was mentioned in the introduction, current European landscapes are undergoing intensive changes, similar to those for the whole environment. The Central European region is widely discussed with respect to the theme of unsatisfactory landscape water regimes, among others in connection with coping with increasing periods of droughts (Štěpánek et al., 2016). The restoration of small water reservoirs as one of the most valuable natural elements of the cultural landscape (Waldon, 2012) may provide a possible solution (David and Davidová, 2015; Rozkošný et al., 2014). The results of the research of Trantinová (2015), surveying the representatives of more than 100 municipalities in the Czech Republic, show that almost 30% of mayors believe (in relation to a better water retention in the landscape) that investments should go to the maintenance of the existing fishponds or restoration of the extinct ones. It is interesting that most mayors are not aware of the existence of extinct fishponds from old maps (22%) – but rather from general awareness of them in the municipality (47%), part of which is also the knowledge of local place names as part of regional and local identity (Šrámková, 2016). For example, Siderius and de Bakker (2003) state that the knowledge of place names linked to the land allowed farmers to find the correct manner of farming in specific locations.

In this context, Fagúndez and Izco (2016) indicate that the justification for the protection of historical place names is important because they represent complex historical relationships between local people and their environment. We assume that place names may contribute to an expansion of awareness of historical landscape elements, fishponds in this case, and provoke the local inhabitants and authorities to consider or act for the restoration of some of them, aiming at an improved water regime in the landscape. The restoration of a reservoir has already started or is being planned in a number of places in the original location of a fishpond (Rozkošný et al., 2014). Knowledge of local environmental history is vital in the case of revitalisation or preservation projects, as shown in many studies (Ravit et al., 2017; Stevenson, 2017). Moreover, the results of cluster analyses suggest that many areas with occurrences of place names referring to extinct fishponds, are in areas which have been detected as high-risk with respect to the degree of drought threats. In addition, climatic models of future landscape water regimes also place them in areas with negative values of water regime (Fig. 6). Interestingly, they are clusters (A, D) with a higher frequency of place names of the categories B1MS and 1MS, i.e. those referring to the period of the first wave of pond abolishment when the ponds were dried hastily. Inhabitants at that time were aware of this fact. As (Roubík, 1937) states in his historical study, the governor of the Kouřim Region addressed the state authorities as early as 1792 to ask for restoration of fishponds as their draining had led to the loss of moisture in the landscape and "the danger is imminent that the Czech lands will become as dry as Italy" (Roubík, 1937).

7.2 Discussion of the methods used in this study

Although the results of the spatial analyses showed the connections of the sampled place names to extinct ponds, it is necessary to realise that it was a selection out of a very high number of place names that could be considered. In particular, various prepositional phrases with the term "fishpond", which are numerous in the database GEONAMES (e.g. Beyond the Fishpond, Below the Fishpond, To the Fishpond) were disregarded under the assumption that they refer to existing ponds rather than to extinct ones. Processing the whole set of potential place names connected generally to fishponds would be complicated as it would be necessary to visually compare each individual place name with the situation in the old maps. Automatic processing in GIS is currently impossible. It would require complete access to the layer of place names in the database GEONAMES, combined with the vectorised layer of fishponds of all the old maps that were used. Such a layer only exists for the 2nd Military Survey for the Czech Republic (Pavelková et al., 2016), although our research has demonstrated the importance of surveying an historical landscape, especially for the 1st Military Survey. Its more precise processing in GIS could, however, be difficult with respect to the absence of geodetic data (Demek et al., 2008; Petrovszki and Mészáros, 2010).

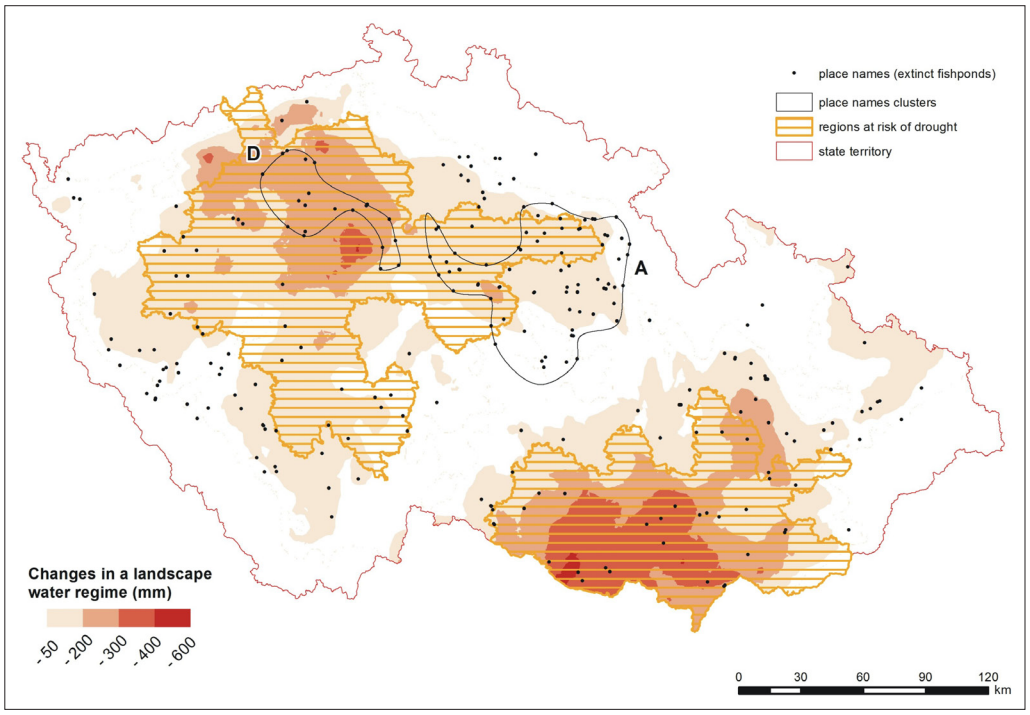

Fig. 6: Extinct fishponds and prediction of changes in landscape water regime
Sources: ArcČR (2017); authors' elaboration based on the data from AgriClim model – CzechGlobe (2017); T. G. Masaryk Water Research Institute (2017); ArcČR (2017)

Place names themselves present another methodological issue. As pointed out by Conedera et al. (2007), a place name is commonly reduced to a point for the purposes of GIS analyses although it refers to an area, whose boundary may be arguable and rather vague. Thus, more place names may in practice refer to one landscape fact, e.g. in neighbouring villages (Penko Seidl, 2011) or the imaginary boundary of an area within the field name is familiar only to the local inhabitants (Penko Seidl et al., 2015). An issue concerning automatic GIS processing is what buffer zone to set? Where does the location of a place name begin and end? We suggest that this is one of the key issues of Toponymic GIS. We realise that the connection of place names and GIS cannot be seen as a simple translation between place names and coordinates (Goodchild, 2004). While GIS analyses allow the researcher to discover the spatial-quantitative context, it is necessary to interpret the context with respect to the qualitative aspect of place names which might, despite original expectations, prove to be multifocal or ambiguous (Conedera et al., 2007). They might have been included in the input analysis by mistake or be left out (Luo et al., 2010).

In our case, it was the troublesome category "NA", which may have referred to the types of dykes other than those of a fishpond, or it may have referred to a fishpond whose traces had specific name of an extinct fishpond; such place names are very difficult to discover without detailed historical micro-regional information. It is also necessary to bear in mind the fact that the input database GEONAMES is being continuously updated and that it is at the same time an official collection of current place names stated in the basic maps of the Czech Republic, i.e. the resource which standardised the place names or documents while commonly ignoring the living place names which are used by the local inhabitants (David and Mácha, 2014). It is, however, the only available source which maps the place names for the whole country. A combination of current place names and old maps proved to be successful in our research, especially if the old maps were part of a set of the so-called comparative cartographic sources (Skaloš et al., 2011), which display the same landscape in different time intervals at an adequate scale. It is necessary to emphasise in this respect, however, how essential it is to make available these historical cartographic works to the wider scientific community (Fuchs, 2015a).

Despite the fact that the quantitative analyses of place names in GIS in our study presented relevant results, some rather misleading interpretations should be avoided. As for the FCA analysis, we agree with Wang (2015) that the selection of the right setting of the window size leading to an appropriate spatial smoothing is vital. The search radius in our case was set to 10 km. The results were greatly inaccurate with higher levels of setting as is shown in Figure 7, where in an occurrence of a place name referring to an existing fishpond the IDW indicated low levels, but it is sufficient in the FCA analysis that only one place name appears in the search radius which refers to an extinct fishpond and the FCA ratio achieves high values.

8. Conclusion

In this study we have carried out a spatial analysis of the relationship between place names in the rural landscape and the extinct artificial water bodies (ponds, fishponds) using GIS. For this purpose, we used the current official Geographic Names database of the Czech Republic (GEONAMES), in combination with current and old maps. Using the old maps allowed not only the discovery of the connections of place names to extinct fishponds but also their comparison to various time periods, and allowed the determination of the age of such a datum. Our example showed that 66% of the selected set of place names are connected to an extinct pond, 20% to an existing one, and in 14% of the sample no connection to a fishpond was identified. Thus we can determine – albeit with a degree of caution – that field names containing words such as "fishpond" or "dyke" may indicate

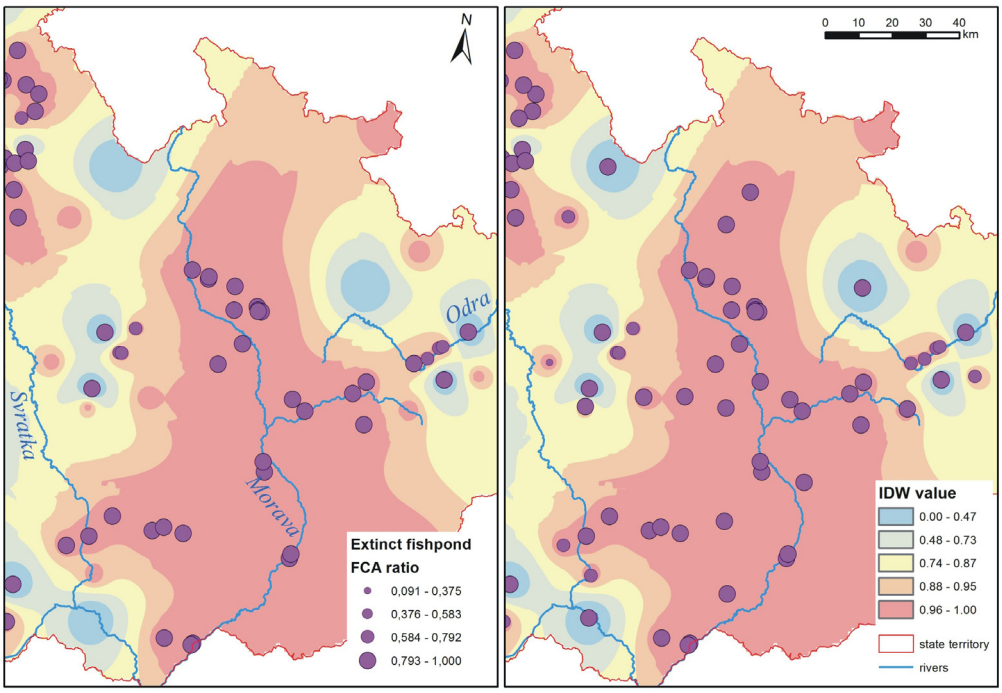

Fig. 7: Comparison of the FCA results for the window size 10 km (left) and 20 km (right)
Source: authors' elaboration; ArcČR (2017)

a small extinct water reservoir. Moreover, one half of the total number of place names referred to reservoirs which had ceased to exist in the 18th century or earlier, based on the old maps. Spatial analyses discovered regional clusters of place names referring to fishponds which had ceased to exist in a specific period. Many of these clusters are connected to the first wave of mass abolishment of fishponds in the second half of the 18th century and are located in areas which today struggle with a negative water balance in the landscape and with drought.

Overall, the results of the analyses indicated the great potential for the use of place names combined with GIS, labelled as Toponymic GIS by Fuchs (2015b). It can be used to process a large number of place names and to explore their spatial distribution and relations at a large scale. At the same time, we believe that this connection gives a new impulse to traditional geographic approaches that work with place names, especially in connection with the exploration of historical landscape features and their links to the contemporary landscape. Place names can thus be a useful indicator to discover the historical form of landscapes and their functioning, which we can learn from and be inspired to adopt various measures face-to- face with the current dramatic changes in European landscapes and the overall environment. Our researched place names could be a source of awareness of a large number of existing small water reservoirs which were an integral part of the historical landscapes of Central Europe, and whose restoration might help to solve the issues of negative water regimes in the landscape.

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