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Historical medium-scale maps as a source of information on the overgrowing of lakes

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Abstract: In the work, medium-scale topographic maps from the first half of the 20th century and aerial photographs from the first decade of the 21st century were used to determine the rate of overgrowing of lakes. A comparison of results for lakes located in different parts of Poland demonstrated that the process of proliferation of emergent plants dominated – such a situation was recorded for 14 out of the 15 lakes analysed in the work. The calculated average overgrowing rate for all the lakes in the years 1945-2010 was 0.4 ha yr^{-1}. Lake Karaś (1.83 ha yr^{-1}) and Lake Oświn (1.2 ha yr^{-1}) were characterized by the highest overgrowing rates. Moreover, the work presents an attempt at discovering the factors which determine the scale of the lake overgrowing process. To this end, the main lake parameters were analysed and it was concluded that the rate of overgrowing of lakes was influenced, inter alia, by water level fluctuations and the shape and depth of a given lake. However, each lake should be treated as an individual object which responds to the processes occurring in its environment in a unique way.

Key words: overgrowing, macrophytes succession, lakes, historical maps

Introduction

Lakes undergo continual evolution, as a result of which they ultimately disappear. The rate of this process is determined by a number of factors, including the features of the lakes themselves (morphometric parameters) and the external conditions on which the functioning of lakes depends (such as, for example, the manner of exploiting the catchment area, the lake flow rate, etc.). The volume of overgrowing of lakes is one of the products of these relations, which can have a significant impact on the shrinking of the surface area of open water in lakes. The process of overgrowing of lakes is well-described in the literature. The final stage of this process, i.e. lake transformation into a peat bog, was described in detail by Marek (1992). The analyses of the contemporary lake overgrowing processes are based both on aerial and satellite photographs (Marshall and Lee 1994; Feldmann and Noges 2007; Ławniczak 2010; Brižš 2011, etc.), and topographic maps (Pieńkowski and Kupiec 2001; Kowalewski 2003; Kowalewski 2011). The latter have a special significance, since they allow an analysis of the volume of overgrowing of lakes in comparison to the first half of the 20th century – a period which has not been sufficiently researched in this respect. The work presents examples of the overgrowing of lakes over the past 65 years, using medium-scale topographic maps as source material.

Material and methods

The overgrowing rate for selected lakes was determined on the basis of 1:25000 German maps (*Messtischblatter*) and orthophotomaps. The lakes analysed in the study were chosen randomly in order to demonstrate that it is possible to find information on the condition of lakes in archival cartographic materials covering various parts of the country and various lakes (of different sizes, depths, etc.). German maps (Fig. 1) are one of the most reliable sources of information on the condition of the environment in the period when they were created. Their accuracy and the minuteness of presented elements were motivated by the military operations of Germany and the resulting need for the most accurate possible ground reconnaissance for the purpose of marching the army across the land. The

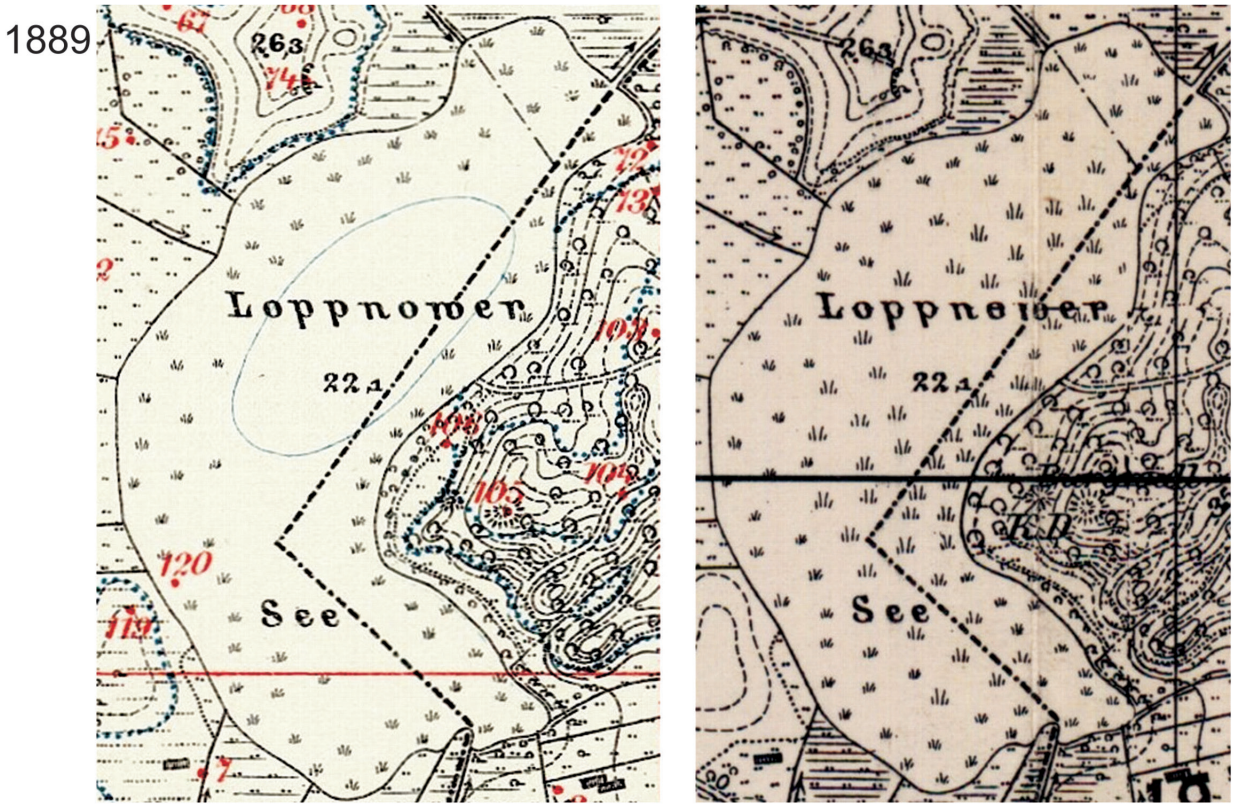


Fig. 1. An example of representation of macrophyte succession on archival 1:25000 maps – Łopianowskie Lake (south-east of Gryfice)

persons taking cartographic photographs of the area made sure that hydrographic elements, including the trophic condition of lakes, were covered, which is illustrated by the example of Łopianowskie Lake. These maps were updated several times, while one of the last revisions, dating back to the Second World War, was based on aerial photographs.

The calculated surface area of emergent macrophytes was compared with the situation presented on an orthophotomap from the early 21st century, while the calculations themselves were made using the MapInfo program. Two time reference points were adopted in the study in order to standardize the analysis, i.e. years 1945 and 2010. On the basis of the results obtained, the rate of overgrowing of lake basins in the analysed period was determined. At the same time, one should be aware of certain generalizations connected with the editing of topographic maps. However, such maps most reliably reflect the condition of the analysed lakes in the first half of the 20th century. Therefore, such material may constitute a source for the long-term analyses of the overgrowing of lakes. This fact was used, inter alia, in the work dedicated to the overgrowing of Lake Świdwie (Pieńkowski and Kupiec 2001), where German topographic maps were used as the starting point for the analysis of this process.

Results and discussions

The results obtained (Table 1) present the surface areas of the lakes in the adopted initial period of the study (1945) as well as the areas occupied by vegetation in the said period. The said data were compared with the areas currently occupied by vegetation.

The foregoing data demonstrate that the expansion of the plant-occupied area in lake basins was the dominant trend. Out of the 15 lakes analysed in the work, such a situation was recorded in 14. The total area of vegetation occupying lake basins increased by nearly 400 ha (398.2 ha) in the period under consideration, while the average overgrowing rate for all the analysed lakes amounted to 0.4 ha yr^{-1}. Figure 2 presents the spatial scale of overgrowing of the analysed lakes in the years 1945-2010

The scale of overgrowing varies between lakes. Łagowskie Lake (0.02 ha yr^{-1}) and Lake Wicimice (0.04 ha yr^{-1}) were characterized by minimum overgrowing rates, while the highest overgrowing rates

Table 1. Surface areas of the analysed lakes occupied by emergent macrophytes in 1945 and 2010

	Lake	Coordinates	Area of lake [ha]	Area of macrophytes [ha]		Altitude [m a.s.l.]		Percentage of the lake surface area occupied by macrophytes[1]	
			1945	1945	2010	1945	2010	1945	2010
A	Piniewo	N:53°56' E:19°41'	50.6	20.2	48.7	99.5	99.4	39.9	96.2
B	Łabuńsko	N:53°48' E:15°27'	27.0	17.2	12.3	43.7	42.7	63.7	45.6
C	Wicimice	N:53°52' E:15°23'	14.4	6.9	9.4	38.1	38.1	47.9	65.3
D	Dąbie	N:53°51' E:15°21'	53.9	21.2	32.0	36.5	37.2	39.3	59.4
E	Liwieniec	N:53°45' E:19°11'	120.4	26.1	57.4	80.2	79.9	21.7	47.7
F	Czarne Dolne	N:53°37' E:19°02'	36.7	10.0	21.6	89.0	87.2	27.2	58.9
G	Karaś	N:53°33' E:19°28'	419.7	56.6	175.7	98.6	98.7	13.5	41.9
H	Kruteckie	N:52°49' E:16°23'	88.4	6.3	24.5	59.7	59.7	7.1	27.7
I	Mochyńskie	N:52°00' E:16°09'	32.7	9.1	21.2	59.8	58.4	27.8	64.8
J	Lubiatowo	N:54°09' E:16°16'	340.9	67.9	97.9	28.8	28.0	19.9	28.7
K	Świerczyńskie	N:51°55' E:16°43'	81.6	15.5	49.7	72.9	71.5	19.0	60.9
L	Łagowskie	N:51°58' E:16°58'	20.1	9.8	10.9	–	77.2	48.8	54.2
M	Dolskie Wielkie	N:51°58 , E:17°2'	197.8	21.2	33.0	78.6	77.7	10.7	16.7
N	Małe Dolskie	N:51°59' E:17°04'	34.6	13.2	27.3	78.8	78.2	38.2	78.9
O	Oświn	N:54°17' E:21°34'	630.5	280.5	358.3	64.3	64.4	44.5	56.8

[1] – compared to the situation recorded in 1945

were recorded for Lake Karaś (1.83 ha yr^{-1}) and Lake Oświn (1.2 ha yr^{-1}). The foregoing results cannot be unambiguously compared with other works on this topic. As rightly pointed out by Tomaszewski (1974), it is difficult to generalize both on the current condition of vegetation and the process of overgrowing of lakes and plant succession. All the aspects related thereto should be considered in detail with reference to particular bodies of water and their types. For instance, Brižs (2011) estimated that over the past five years, vegetation in Lake Engure (Latvia) has been proliferating at the average rate of 15.0 ha yr^{-1}. Ławniczak (2011), on the other hand, assessed the overgrowing rate of Lake Niepruszewskie (Greater Poland-Kuyavian Lakeland) at 0.65 ha yr^{-1} (over a similar period). The foregoing examples demonstrate that, depending on the local conditions and genetic types of lakes, the rate of overgrowing may vary.

One of the basic factors which speed up plant succession is the falling of the water surface level in lakes. This process is often controlled by people, who drain the areas adjacent to lakes. Such works were done, inter alia, near Lubiatowskie Lake and Świerczyńskie Lake, where the network of drainage ditches was expanded, causing the water level in the lakes to drop. This gave an impulse for vegetation to enter the lake basins. Mochyńskie Lake, which has a direct hydraulic connection with the Southern Canal of the River Obra, constitutes yet another interesting example of this phenomenon (Fig. 3).

The changing level of water in the canal results in the water level fluctuation in Mochyńskie Lake. The exposition of the lake bed is conducive to plant proliferation. Korolec (1968), when describing shoreline processes in Mikołajskie Lake, notes that every time when the lake bed is exposed, shallow-water plants, such as bulrush and sweet rush, and sometimes even clumps of grass, settle on it. Once such macrophytes get hold of the ground, they do not retreat even when the water level rises, and use each subsequent emergence to grow stronger and proliferate. Therefore, a significant fluctuation of the water level is conducive to the proliferation of lakeshore vegetation (Fig. 4).

A reverse situation is observed when the water level rises, i.e. the habitat of emergent plants changes, thus leading to their disappearance. Partanen and Hellsten (2005) describe the examples of certain lakes in Finland, where the area occupied by vegetation shrank as a result of the rise in the average water level. In Lake Tamnaren the area covered by vegetation shrank from 80 to 14% as a result of the rise in the water surface level (Wallsten and Forsgren 1989).

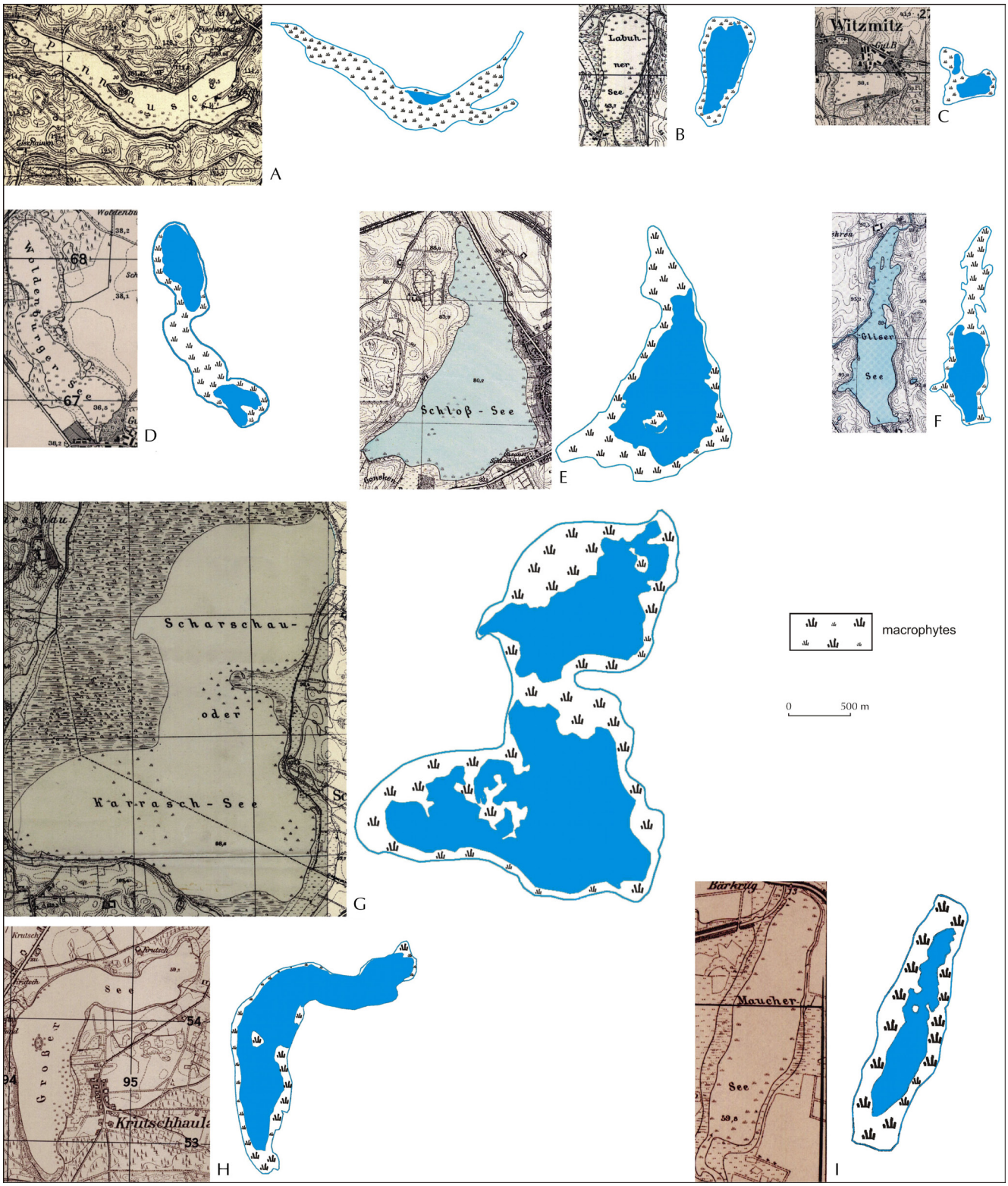


Fig. 2 A-I. Spatial scale of overgrowing of the analysed lakes



Fig. 2 J-O. Spatial scale of overgrowing of the analysed lakes

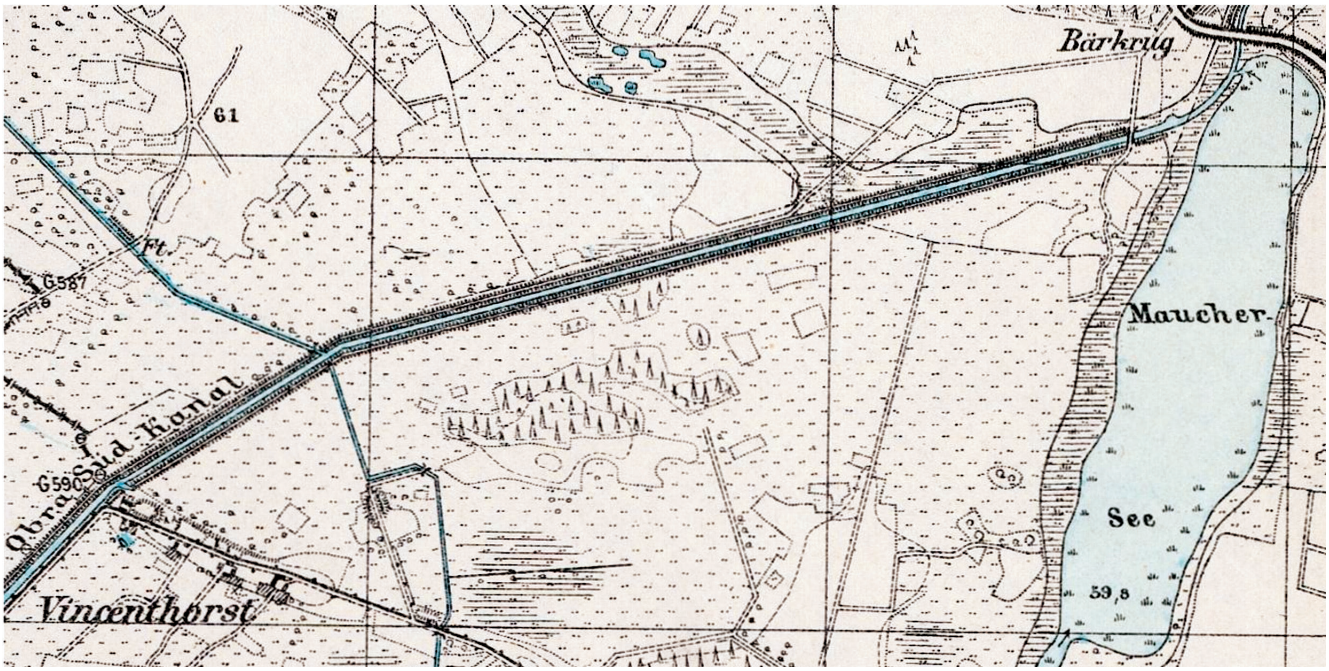


Fig. 3. The connection between Mochyńskie Lake and the Southern Canal of the River Obra is conducive to plant succession



Fig. 4. Access to open waters is limited by a wide belt of lakeshore vegetation – Mochyńskie Lake

When it comes to the lakes analysed in the work, an interesting situation was observed in Lake Karaś and Lake Oświn, where, despite the decreasing surface area, a rise in the water level was recorded. It may be assumed that such a situation was closely connected with the largest scale of plant succession. As a result of plant proliferation and deposition of autochthonic organic matter, the volumes of both lake basins were reduced – which led to the successive rising in the water surface level. Thus, the proliferation of vegetation determined other processes – the rise in the surface of water and its outflow from the lakes.

When taking the size of the lakes into consideration, it should be noted that the highest overgrowing rate was recorded for the two largest lakes in the analysed group. This fact may be connected with the longest shoreline, i.e. with the largest possible area of inflow of pollutants from the catchment area to the lakes. Out of the other parameters which could possibly affect the rate of overgrowing of lakes, the average depth and the shoreline development index were also analysed.

For eight out of the analysed lakes it was possible to determine the average depths on the basis of the data provided by the Inland Fisheries Institute (Choiński 2006). Lakes: Czarne Dolne (1.8m, 0.18 ha yr^{-1}), Dolskie Wielkie (1.7m, 0.18 ha yr^{-1}) and Liwieniec (1.2m, 0.48 ha yr^{-1}) were characterized by the greatest average depths. In the first two bodies of water (where the average depth exceeded 1.5 m), the average overgrowing rate was lower than the one established for all the lakes presented in the work jointly. It may be assumed, after Lange (1993), that due to the greatest depth, the said lakes are the most resistant to evolution (among the analysed ones). Lake Liwieniec – the last of the analysed lakes the average depth of which exceeds 1 m – was characterized by an average overgrowing rate higher than the one established for all the lakes. Such a situation was the result of the shape of the lake and the location of the mouth of the river disgorging into it, since the greatest proliferation of aquatic and marsh flora was recorded in the northern part of the lake – which is a bay (Fig. 2E). Based on the example of Lake Vőrtsjärv, Feldmann and Mäemets (2004) observe that such enclosed places are protected against the activity of the wind, which destabilizes the processes of lake shallowing conducive to flora proliferation. As for Lake Liwieniec, a river disgorges into its narrow part, which accelerates the shallowing processes as a result of debris deposition. Such a situation facilitates plant succession. Similarly, in the case of Lakes Dolskie Małe and Czarne Dolne, the greatest proliferation of macrophytes occurred in places where the tributaries of the said lakes disgorged into their bay sections. The shoreline development index represents this phenomenon in measurable terms. It was the highest for Lake Pniewo (2.9). Currently, only 3.8% of the lake surface area from the mid-1940s survives. A high degree of overgrowing was also recorded in the lakes with high shoreline development indices located in Poznań (Świerk et. al. 2010). Lake Łabuńsko, where the area occupied by vegetation shrank, was characterized by the lowest shoreline development index (1.2).

The example of Lake Liwieniec demonstrates that it is extremely difficult to identify the elements which determine the scale and rate of overgrowing of lakes. On the one hand, the bathymetric conditions of the lake are good (compared to other lakes), and on the other – as a result of the shape of the lake and its hydrological connection with other surface waters – the rate of plant succession is different for different parts of the lake. Such a situation was mentioned, inter alia, by Brzęk (1948), in his description of Góreckie Lake located in the Wielkopolska (Greater Poland) National Park.

Conclusions

The work presents examples of use of medium-scale topographic maps as a source of information on the overgrowing of lakes. Earlier works on this topic describe single lakes or cover small areas The work demonstrates that it is possible to find 60-year-old data describing the trophic condition of lakes not just for single lakes but for the three main lake districts and for various lake types. The analyses performed on the basis of cartographic material revealed that over the past sixty years, there has been a significant proliferation of aquatic and marsh flora. Only in one of the analysed lakes the area occupied by vegetation decreased compared to the situation recorded in the 1940s. When analysing the impact of selected lake parameters on the rate of flora proliferation, one should bear in mind that this process depends on a number of factors, characterizing both the lakes themselves and their surroundings. For each lake, different factors played the key role in the overgrowing of lake basins (e.g. deposition of rubble in the mouth of a river, drainage works, etc.).

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