# FLORISTIC DIVERSITY OF LAKES SUBJECTED TO LONG TERM CHANGES IN THE WATER NETWORK OF THE WEST POLESIE (EASTERN POLAND)

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**KEYWORDS**: amelioration, canal, lake, water reservoir, macrophytes, changes.

**ABSTRACT**

The Wieprz-Krzna Canal, built in 1961, is one of the longest in Poland (142 km). Although the drainage construction was intended to revitalize the region of wetlands and peat-bogs of the West Polesie, it caused large hydrological changes. Research on catchments of three natural lakes and three retention reservoirs involved cartographic analysis using photointerpretation, as well as the Braun-Blanquet method. In the studied area, between 1939 and 2016 the length of rivers and ditches increased more than three times. Macrophytes covered about 20-27% of the natural lakes water surface, whereas in retention reservoirs the coverage was 12-15.5%. Also a greater diversity of macrophytes occurred in natural lakes. In retention reservoirs it was restricted to only emerged macrophytes.

**RESUMEN**: Diversidad floristica de lagos sujetos a cambios a largo plazo en la red de aguas del Polesia Occidental (Polonia Oriental).

El Canal Wieprz-Krzna, construido en 1961, es uno de los más largos de Polonia (142 km). Aunque la construcción del drenaje tenía por objeto revitalizar la región de humedales y turberas de la Polesia Occidental, causó grandes cambios hidrológicos. Las investigaciones sobre captación de tres lagos naturales y tres reservorios de retención involucraron análisis cartográficos con el método de fotointerpretación, así como el método de Braun-Blanquet. En el área estudiada, entre 1939 y 2016 la longitud de ríos y zanjas aumentó más de tres veces. Los macrófitos cubrían alrededor del 20-27% de la superficie del agua de los lagos naturales, mientras que en los reservorios de retención era desde 12 al 15,5%. También se observó una mayor diversidad de macrófitas en lagos naturales. En tanques de retención sólo se restringió a las macrófitas emergidas.

**REZUMAT**: Diversitatea floristică a lacurilor supuse modificărilor pe termen lung în reţeaua hidrografică a Polesiei de vest (estul Poloniei).

Canalul Wieprz-Krzna, construit în 1961, este unul dintre cele mai mari din Polonia (142 km lungime). De altfel, realizarea drenării a fost destinată revitalizării regiunii zonelor umede şi a turbăriilor din Polesia de Vest, a provocat schimbări hidrologice mari. Cercetările privind captarea a trei lacuri naturale şi a trei rezervoare de retenţie au implicat analize cartografice utilizând metoda de interpretare a imaginilor – metoda fotointerpretării, precum şi metoda Braun-Blanquet. În aria studiată, între anii 1939 şi 2016 lungimea râurilor şi a canalelor a crescut de mai mult de trei ori. Macrofitele acoperă aproximativ 20-27% din lacurile naturale de suprafaţă, în timp ce în rezervoarele de retenţie între 12 şi 15,5%. De asemenea, o mare diversitate de macrofite este în lacurile naturale. În tancurile de reţinere acestea sunt limitate doar la macrofitele emerse.

## INTRODUCTION

It is well known, that each melioration action changes ecosystem and natural balance, e.g. in diversity of flora species. One of the most important factors determining the occurrence and diversity of aquatic and riverine plants in aquatic ecosystems is the water level fluctuations. (Soszka et al., 2012; Curtean-Bănăduc et al., 2014)

Since the 50s, in the researched Łęczna-Włodawa Lake District have been significant changes in the hydrological network. Almost in all lakes it caused the changes in the management of reservoirs, as well as in water supplying of lakes.

The creation of the Wieprz-Krzna Canal was proposed in 1953. The construction was intended to revitalize the region of the West Polesie by building a drainage infrastructure on wetlands and peat-bogs (Radwan, 1994).

Building of the Canal began in 1954 and was completed and opened in 1961. The Wieprz-Krzna Canal is the longest of its type in Lubelskie Region and one of the longest in Poland at 142 km in length. It draws water from the Wieprz River in the Borowica Village, where it begins, ending in the area of the Międzyrzec Podlaski City, where flows into the Krzna River (Dawidek et al., 2004).

The total area under the Wieprz-Krzna Canal's influence is almost 528,000 ha. More than 290,000 ha of meadows and about 280,000 ha of agriculture lands were under melioration works between 1956 and 1960 (Grzyb et al., 1982; Pichla and Jakimiuk, 2008). In the studied mesoregion of Łęczna-Włodawa Lake District most of the water reservoirs are included in the melioration system. Some of them are used for fishery management (Harasimiuk et al., 1998).

Melioration works caused large hydrological changes in the studied area and consequently changes in the land use, as well in the reservoirs. The aim of the study was to assess the degree of these changes and to identify trends in further changes related with phytocenoses of the examined lakes. Lakes with different land cover forms and management of catchment were analyzed.

The mesoregion of Łęczna-Włodawa Lake District is included in the area of the East European Plain (Harasimiuk et al., 1998; Kondracki, 2013), as well as the macroregion of Polesie Zachodnie (Kondracki, 1995, 2013).

A very small slope of terrain results in a specific slow surface runoff (Kowalczyk, 1974).

The researched area is characterized by a high variety of hydrogenic landscapes (peat-bogs, wetlands, rivers, ponds) and the occurrence of more than 60 natural reservoirs (Fig. 1). That's why a mesoregion of the Łęczna-Włodawa Lake District has high natural values (Harasimiuk et al., 1998) and constitutes one of the biggest touristic regions in the Lublin Region (Krukowska, 2009).

The whole research area is included inside the "West Polesie" Transboundary Biosphere Reserve. The study area is also included in many other types of protection areas, e.g. Polesie National Park, landscape parks, nature reserves, areas of landscape protection, as well as NATURA 2000 sites: OSO and SOO.

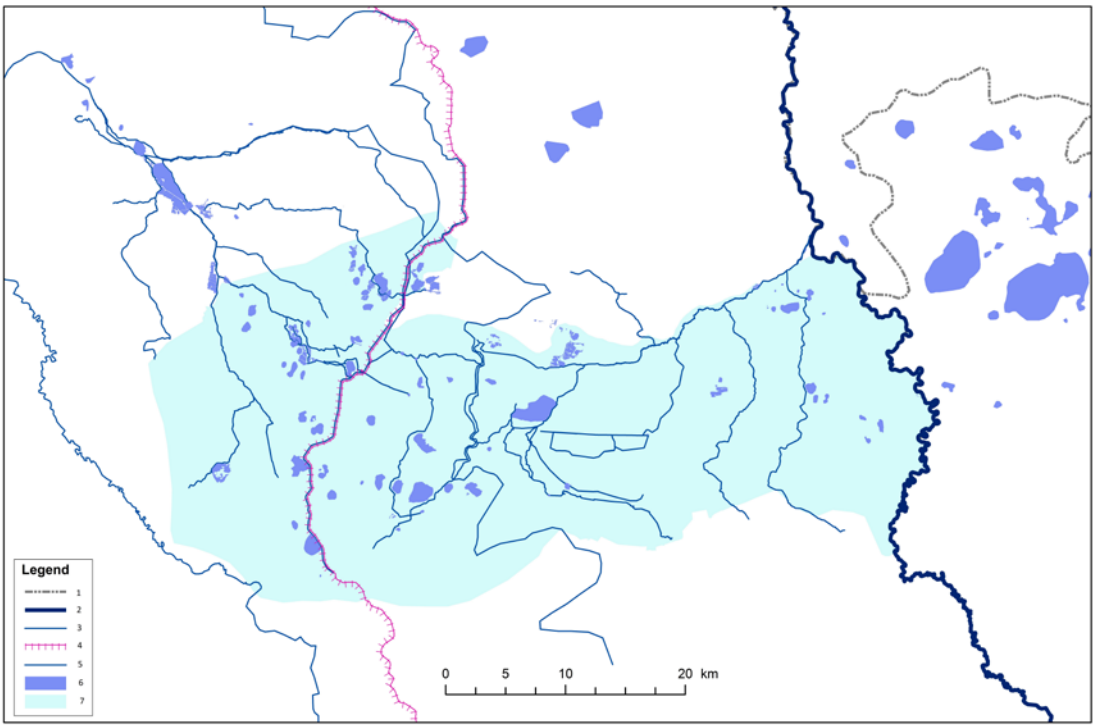


Figure 1: Studied area of Łęczna-Włodawa Lake District: 1 – national border, 2 – cross-border Bug River, 3 – rivers of studied area, 4 – Wieprz-Krzna Canal, 5 – other rivers, 6 – lakes and reservoirs, 7 – Łęczna-Włodawa Lake District.

Study area included lakes located in the central part of the Łęczna-Włodawa Lake District (Fig. 1). Three natural lakes, as well as three lakes converted into retention reservoirs after 1954, were chose under the study. For the group of natural lakes the following were selected:

1. Lake Łukcze (51°23'48.8" N, 22°57'57.8" E) is the smallest and the shallowest of the studied lakes, with surface of 56.5 ha, and maximum depth of nine m. Length of its shoreline is 3,876 km, and capacity of the lake is 2,091,000 $m^2$ (Wilgat et al., 1991).
2. Lake Rogóźno (51°22'36" N, 22°58'21" E) with a surface area of 57.1 ha, is relatively deep (25.4 m). The shoreline, in a shape similar to a circus, is poorly developed. The capacity of the lake is 4,209,000 $m^2$ (Michalczyk and Wilgat, 1998).
3. Lake Krasne (51°25'35" N, 22°57'31" E) is the deepest (33 m) and the largest (75.9 ha) of the studied lakes. Length of the shoreline is about 3.6 km, whereas the capacity is 8,180,000 $m^2$ (Michalczyk and Wilgat, 1998).

While the group of retention reservoirs included:

1. Tomaszne Reservoir (51°28'11.9" N, 23°00'09.5" E), before building the Wieprz-Krzna Canal it was a natural lake with a surface of 67 ha and maximum depth of 3.5 m. Nowadays its surface is 85.5 ha. Length of the shoreline is 3.65 km, whereas water capacity is 2,208,000 $m^3$.

2. Krzczeń Reservoir (51°23’59.64” N, 22°56’5.03” E), after building the Wieprz-Krzna Canal its surface increased eight times – from 20 ha to 160 ha. Length of the shoreline is about 6.7 km, length is about 1.84 km, width is 1.67 km, whereas maximum depth is 5.2 m.
3. Dratów Reservoir (51°20’26” N, 22°56’45” E), after building the Wieprz-Krzna Canal its surface increased almost two times – from 87 to 168 ha. Length of the shoreline is about five km, length is about 1.83 km, width is 1.5 km, whereas maximum depth is two m.

## MATERIAL AND METHODS

Cartographic analysis was made using raster maps, orthophotomaps and field studies. Maps were downloaded from the Geoportal service (www.geoportal.gov.pl). Lakes’ catchments were designated on the base of the topographic map in a scale 1:25,000, in ArcGIS 10.4. Maps of land cover and terrain formation, as well as analysis of hydrographical network of the studied Wieprz-Krzna Canal’s impact area were prepared. An analysis of the land cover structure of the catchment area was made using photointerpretation, a method often used in landscape ecology research. It was based on transformation of digital image data (so-called quantitative continuous data) into vector thematic data (so-called discrete qualitative data) in the form of land cover classes (Chmielewski et al., 1996; Lu and Weng, 2007; Chmielewski and Chmielewski, 2009; Lechowski, 2013; Kozak et al., 2014). A definition of land cover was adopted by the physical properties of the Earth’s surface (Fisher et al., 2005). A photointerpretation method was performed by visual – manual procedure, which involved a detailed analysis of the direct and indirect distinctive characteristics (size, shape, or color tone, structure and texture of the image, shadow, interconnected objects, etc.) of teledetection materials detected on the monitor screen and then manually outlining all elements of land cover forms by the interpreter (Pyka and Mularz, 1998; Longley et al., 2010). Outlining of all elements was made with the principle of mutual complementation of polygons and the correctness and topological consistency of the entire coverage.

Field studies were carried out in August 2015 and August 2016 and included a phytolittoral of all studied lakes. The studies were conducted by the Braun-Blanquet method (Braun-Blanquet, 2013). Phytosociological units were determined by the analysis of dominant species using Matuszkiewicz’s nomenclature (2008). The plant communities analysis of lakes were carried out in transects from the shore to the maximum depth of the plant occurrences (from four transects in lakes to eight in reservoirs). In addition to the surface, the range (depth) of the occurrence of particular groups of macrophytes was analyzed.

In order to distinguish a group of similar lakes due to the researched features (like height above sea level, management of catchment and the qualitative and quantitative structure of macrophytes), cluster analysis was used. The Euclidean distance and the Ward method was used to estimate distance between clusters. Then a non-hierarchical method was applied – grouping by three-means, to indicate which variables play the main role in the division into clusters (that differentiate the examined lakes).

Spearman’s rank correlation coefficient was used to investigate a relationship between different forms of land development around lakes and the height above sea level.

Due to the fact that the Shapiro-Wilk test rejected the normality of some tested features, the Wilcoxon’s nonparametric test was investigated to determine whether the average surface area of particular land cover forms had changed since 1939.

**RESULTS**

The conducted analysis, covering 29,039 ha, proved large changes in the hydrographic network (Fig. 2). After the construction of the Wieprz-Krzna Canal, the length of the rivers and ditches nearly tripled. The surface of the water reservoirs have also changed considerably. Some of them completely changed the shape of the shoreline (Dratów, Tomaszne, and Krzczeń) leading to the surface of standing waters increasing about 300 ha (Tab. 1).

Table 1: Length of rivers and ditches and surface of reservoirs in 1939 and 2016 in studied area.

| Length of rivers and ditches (m) | | Surface of reservoirs (ha) | |
|---|---|---|---|
| 1939 | 2016 | 1939 | 2016 |
| 149,573 | 482,189 | 1,061 | 1,324 |

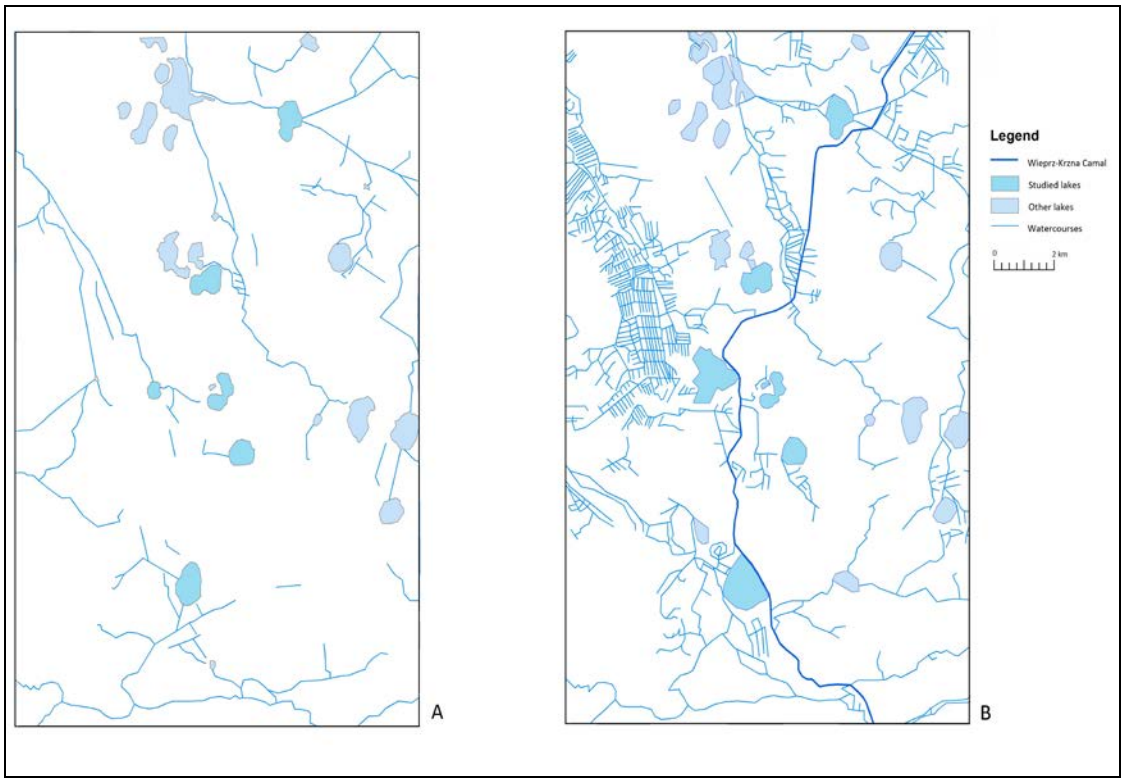


Figure 2: Water network changes in investigated area: A – 1939, B – 2016.

The largest catchment among examined lakes surrounded lakes Rogóźno (796 ha) and Łukcze – 437 ha, while lake Krasne was characterized by the smallest catchment – only 261 ha. Currently, the dominant land cover forms in the lakes' catchment area was agriculture fields, as well as forests in the Rogóźno and Łukcze lakes catchments. The smallest surface was covered by marshes and peat-bogs (Tab. 2). Since 1939, the dominant type of land cover has not changed substantially. Since the 1930's in the Łukcze Lake catchment the meadows dominated. It is the only lake area in which agriculture lands increased. Forests' surface increased in all studied lakes (Fig. 3).

Table 2: Land cover forms in studied natural lakes' catchment (ha).

| Land cover forms | Rogóźno (ha) | | | Krasne (ha) | | | Łukcze (ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1939 | 2016 | changes | 1939 | 2016 | changes | 1939 | 2016 | changes |
| Buildings | 100 | 63 | – 37 | 22 | 28 | + 6 | 64 | 93 | + 29 |
| Wetlands | 70 | 40 | – 30 | 0 | 0 | 0 | 6 | 23 | + 17 |
| Meadows | 46 | 55 | + 9 | 28 | 34 | + 6 | 183 | 48 | – 135 |
| Forests | 190 | 276 | + 86 | 0 | 34 | + 34 | 31 | 113 | + 82 |
| Water lakes surface | 55 | 52 | – 3 | 71 | 74 | + 3 | 58 | 54 | – 4 |
| Agriculture lands | 333 | 308 | – 25 | 97 | 54 | – 43 | 95 | 106 | + 11 |
| Ponds | 0 | 0 | 0 | 43 | 37 | – 6 | 0 | 0 | 0 |

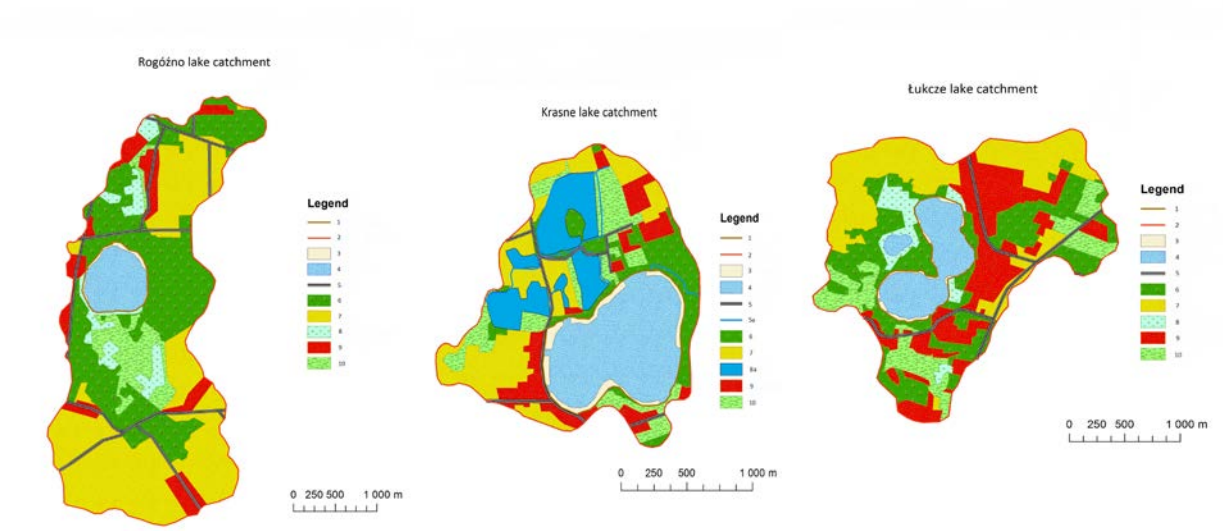


Figure 3: Land cover forms in studied natural lakes' catchments in 2016:
1 – shoreline, 2 – catchment border, 3 – rushes community, 4 – lake, 5 – road,
5a – river, 6 – forests, 7 – agriculture lands, 8 – wetlands, 8a – ponds, 9 – buildings,
10 – meadows.

Among the examined retention lakes (reservoirs) the largest catchment area surrounded reservoirs Dratów (1,283 ha) and Krzczeń (623 ha), while Tomaszne Reservoir was only 355 ha. These catchments covered mainly forest and meadow. Whereas Krzczeń Reservoir catchment covered mainly farmlands and meadows (Tab. 3). In the period of more than 70 years the biggest changes took place in the Krzczeń Reservoir' catchment: surface of the reservoir increased by 140 hectares, while the area of meadows and buildings decreased significantly (Fig. 4).

Table 3: Land cover forms in studied retention lakes'catchments (ha).

| Land cover forms | Dratów (ha) | | | Tomaszne (ha) | | | Krzczeń (ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1939 | 2016 | changes | 1939 | 2016 | changes | 1939 | 2016 | changes |
| Wieprz-Krzna Canal | 0 | 26 | + 26 | 0 | 7 | + 7 | 0 | 9 | + 9 |
| Forests | 0 | 42 | + 42 | 7 | 87 | + 80 | 33 | 83 | + 50 |
| Meadows | 604 | 421 | – 183 | 175 | 73 | – 102 | 294 | 141 | – 153 |
| Agriculture lands | 342 | 373 | + 31 | 79 | 58 | – 21 | 158 | 134 | – 24 |
| Wetlands | 176 | 179 | + 3 | 0 | 0 | 0 | 34 | 58 | + 24 |
| Buildings | 74 | 74 | 0 | 25 | 37 | +12 | 84 | 38 | – 46 |
| Water lakes surface | 87 | 168 | + 81 | 69 | 89 | + 20 | 20 | 160 | + 140 |
| Ponds | 0 | 0 | 0 | 0 | 4 | – 4 | 0 | 0 | 0 |

In other catchments of retention reservoirs, surface of meadows was significantly reduced, while the area of forests increased (Fig. 4).

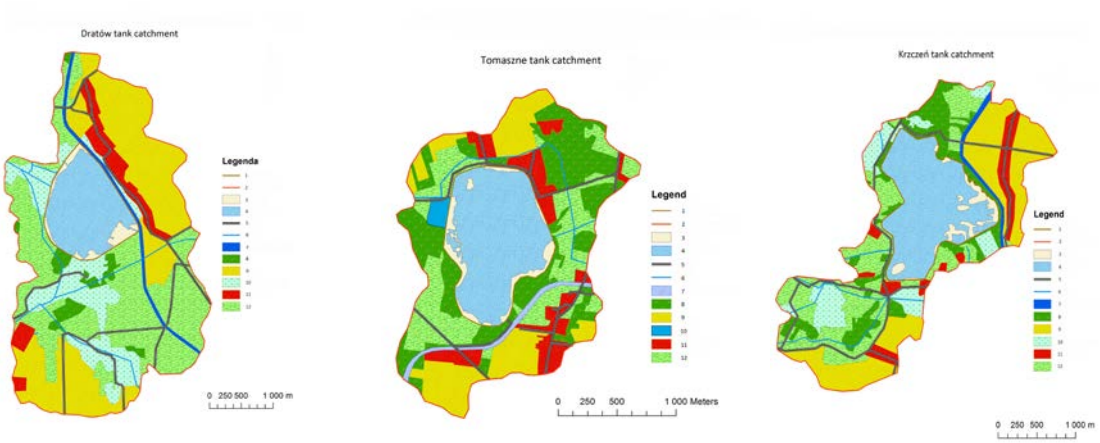


Figure 4: Land cover forms in studied retention lakes' catchments in 2016:
1 – shoreline, 2 – catchment border, 3 – rushes community, 4 – water lake,
5 – road, 6 – river, 7 – Wieprz-Krzna Canal, 8 – forests, 9 – agriculture lands, 10 – wetlands,
11 – buildings, 12 – meadows.

The largest area in the catchments of all examined lakes was located between 166 and 169 m a.s.l. The area around lakes Rogóźno and Łukcze was relatively the highest, respectively covering 652 ha and 197 ha (Fig. 5). The lowest terrain, between 162 and 165 m a.s.l., occurred in the most extensive areas in catchments of reservoirs Krzczeń (229 ha) and Tomaszne (160 ha) (Fig. 6).

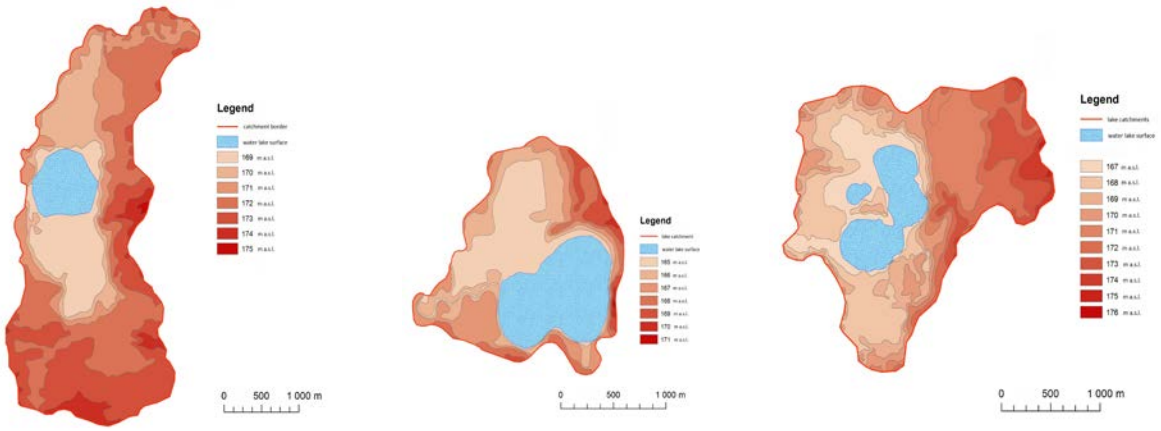


Figure 5: Terrain formation of studied natural lakes' catchments; from the left: Rogóźno, Krasne, and Łukcze.

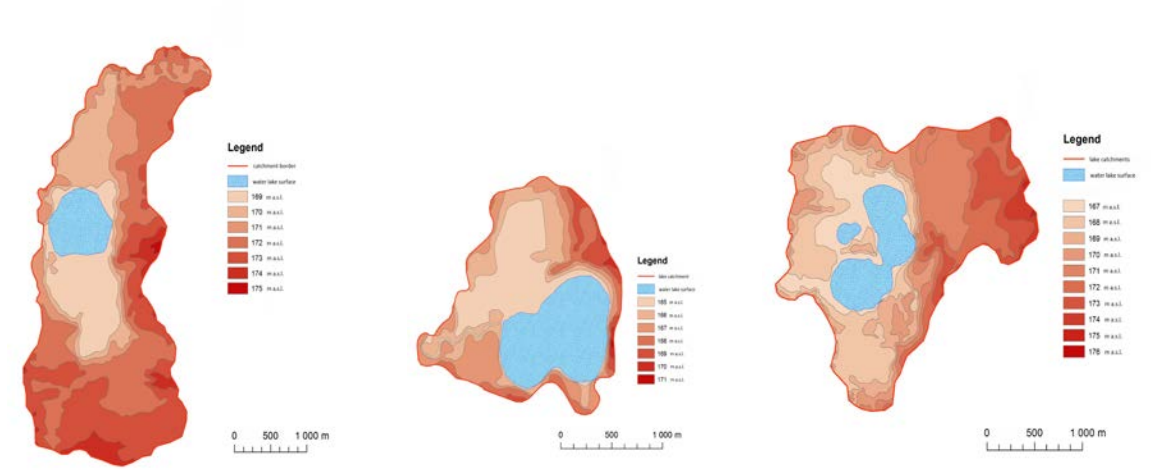


Figure 6: Terrain formation of studied reservoirs' catchments; from the left: Dratów, Tomaszne, and Krzczeń.

Differences of height around the lakes were noticeable. Usually the fastest height increase occurred from the north-east side of the lakes. The western and southern sides of the reservoirs usually constituted flat areas and were situated the lowest (Fig. 5).

On the base of agglomeration course made for catchment development and its terrain three groups of lakes were distinguished: Ist: Dratów, IInd: Krasne, Tomaszne, Łukcze, Krzczeń and IIIrd: Rogóźno (Fig. 7).

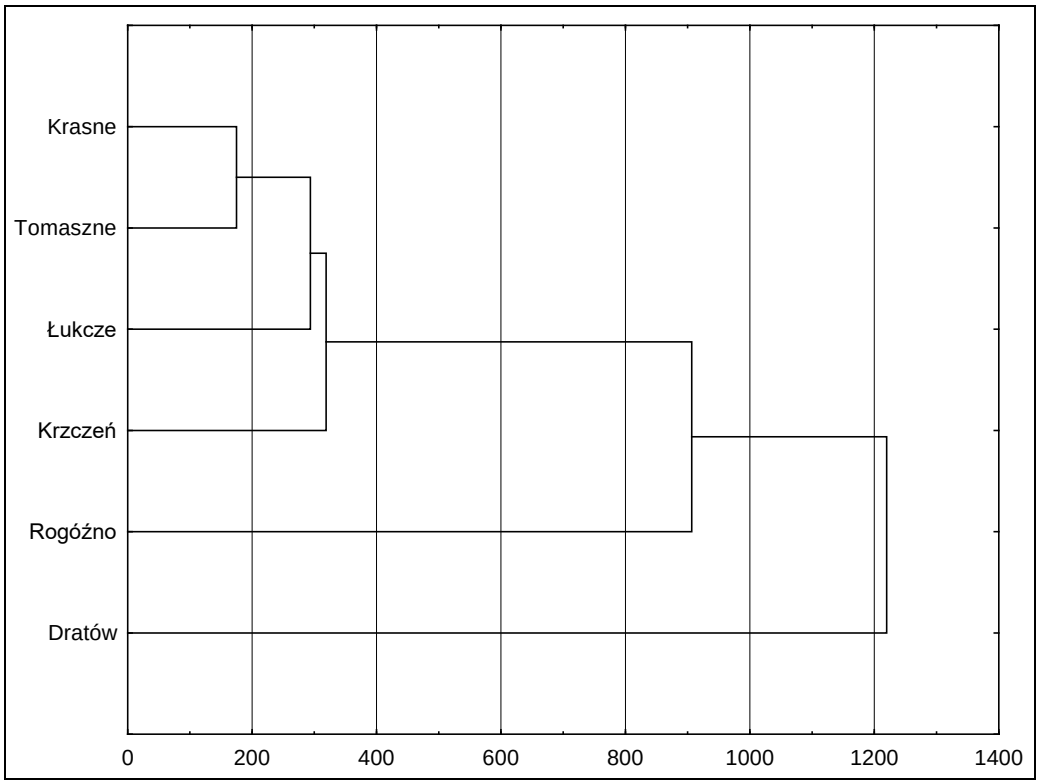


Figure 7: Similarity of studied lakes
due to catchments' land cover forms and terrain formation.

On the base of non-hierarchical method of grouping by the three-median, a size of the area over 165 m a.s.l., the area of marshes, peatlands, forests and fields ($p < 0.05$) were indicated as variables which decisively differentiated the examined lakes (Tab. 4).

Table 4: Variance analysis.

| Variables | df | F | p |
|---|---|---|---|
| 162-165 m a.s.l. | 3 | 0.857 | 0.507 |
| 166-169 m a.s.l. | 3 | 60.840 | 0.003 |
| 170-173 m a.s.l. | 3 | 16.563 | 0.023 |
| 174-177 m a.s.l. | 3 | 35.453 | 0.008 |
| Buildings | 3 | 0.312 | 0.744 |
| Wetlands | 3 | 13.645 | 0.031 |
| Meadows | 3 | 20.799 | 0.015 |
| Forests | 3 | 16.495 | 0.024 |
| Water lakes surface | 3 | 1.659 | 0.327 |
| Agriculture lands | 3 | 19.066 | 0.010 |
| Wieprz-Krzna Canal | 3 | 7.213 | 0.045 |

Compared to the lakes Krasne, Tomaszne, Łukcze, and Krzczeń, the Dratów Reservoir was surrounded by much lower area above sea level, had less wetlands and agricultural fields in its catchment area, on the other hand it was surrounded by similar surface of buildings and forests. However, lake Rogóźno was surrounded by the area of 170-173 m a.s.l. with a dominant share of forests.

Spearman's rank correlation coefficient indicates a very strong and positive relationship between the area of agriculture fields and the area at 170-173 m a.s.l. ($r = 0.8697$).

Research has shown that since 1939 significant changes have occurred only in forested area ($p = 0.0277$). More than half of the surveyed lakes were characterized by forest areas exceeding 80 hectares. In other cases, there were no statistically significant differences.

**Floristic diversity**

Usually macrophytes covered about 20-27% of the natural lakes water surface, while in retention reservoirs they covered 12-15.5%. Share of particular groups of macrophytes was also distinctly different. In the lakes, the share in the phytolittoral of emerged macrophytes ranged from 8% (Łukcze, Rogóźno) to 12% (Krasne), in retention lakes this value was similar and amounted to 13%. However, submerged macrophytes covered from 0.06% in Dratów Reservoir to 3.6% in Tomaszne, while in lakes these values were much higher: from 9% in Łukcze Lake to 19% in Rogóźno. In the lakes emerged macrophytes occurred from 1.4 m (Rogóźno) to two m (Krasne), while submerged from 2.1 m (Rogóźno Lake), even to 3.5 m in Łukcze Lake. In retention lakes any group of macrophytes didn't exceed one m. A width of rushes was significantly higher in the retention lakes and ranged from 160 m (Tomaszne) to 411 m (Krzczeń). The rushes in the lakes formed a belt reaching a maximum width of 76 m (Krasne) (Tab. 5; Fig. 8).

Table 5: Phytolittoral characteristic in studied lakes (E – emergent; S – submerged macrophytes).

| Lakes | Surface (ha) | Phytolittoral of emergent macrophytes (ha) | Phytolittoral of submerged macrophytes (ha) | Total phyto-littoral (ha) | Width of rushes (m) | | | Max. depth of macro-phytes occu-rrence | | Number of plant commu-nities | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | max. | min. | av. | E | S | E | S |
| Dratów | 168 | 21.7 | 0.1 | 21.8 | 303 | 12 | 156 | 0.6 | 0.7 | 5 | 1 |
| Krzczeń | 160 | 20 | 2.6 | 22.6 | 411 | 12 | 212 | 0.5 | 0.3 | 4 | 1 |
| Tomaszne | 89 | 11 | 3.2 | 14.2 | 160 | 17 | 89 | 0.7 | 0.9 | 5 | 2 |
| Krasne | 71 | 9.2 | 7.3 | 16.5 | 76 | 10 | 43 | 2 | 2.7 | 5 | 6 |
| Łukcze | 54 | 4.4 | 4.8 | 9.2 | 41 | 8 | 25 | 1.9 | 2.1 | 5 | 6 |
| Rogóźno | 52 | 4.2 | 9.8 | 14 | 61 | 11 | 36 | 1.4 | 3.5 | 6 | 6 |

The phytolittoral of studied lakes consisted of a different number of plant communities. In the lakes this number ranged from 11 (Łukcze, Krasne) to 12 (Rogóźno), whereas in reservoirs the range was from five (Krzczeń) to seven (Tomaszne). In retention reservoirs communities of emergent macrophytes dominated, whereas in natural lakes submerged macrophytes were dominant (Tab. 5; Figs. 8 and 9).

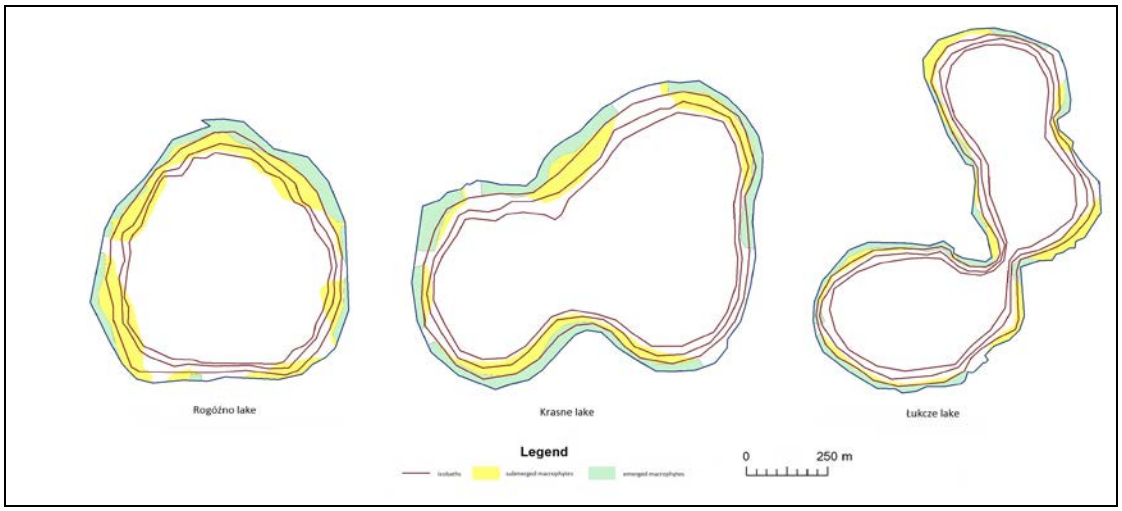


Figure 8: Distribution of macrophytes communities in natural lakes.

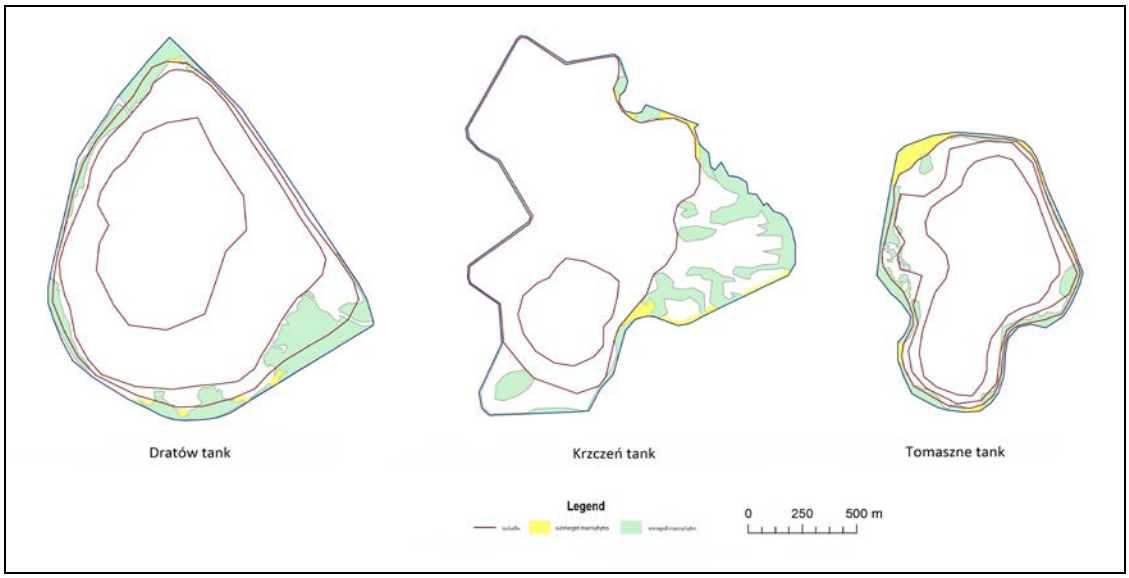


Figure 9: Distribution of macrophytes communities in retention reservoirs.

Macrophytes' cluster analysis of six aquatic ecosystems, based on qualitative and quantitative composition indicated a significant similarity of macrophytes' groups (Fig. 10). Retention reservoirs formed a floristically similar group. The greatest similarity in this group was shown by macrophytes of Krzczeń and Dratów lakes (89%). High similarity was also observed between macrophytes of studied lakes (80-85%). By far the smallest similarity of only 32-37% occurred between retention reservoirs and natural lakes (Fig. 10).

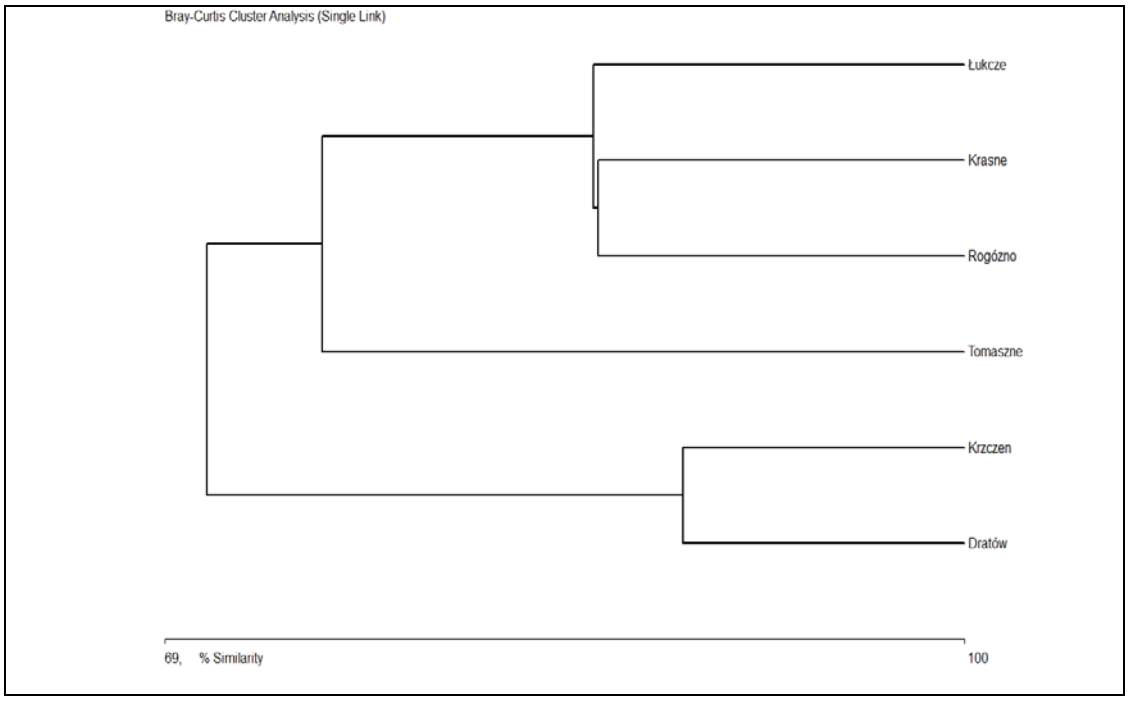


Figure 10: Floristic similarity of studied lakes.

**DISCUSSION**

The previously planned target of economic recovery of the region did not produce the expected results. It was rather degraded to nature, which is the pearl of that part of Poland. Certainly in the present day another direction of development, identical with regional possibilities, would allow for dynamic development, especially in the direction of tourism. At present, however, many lake ecosystems in the Łęczna-Włodawa Lake District are subjected to continuous eutrophication, at various rates. The construction of the Wieprz-Krzna Canal contributed to changes in water relations, primarily resulting in a decrease of the water level in lakes (Radwan and Chmielewski, 1997). The appropriate amount of water was provided by a network of retention reservoirs (six with embankments and five newly built retention tanks) (Solis, 2012).

By the construction of a drainage system in the Łęczna-Włodawa Lake District, the surface of wetlands and peat lands has decreased significantly (Pichla, 2011). In the analyzed area it resulted in almost three times increase of the length of watercourses and ditches. Human activity has contributed to the multiplication of an occurrence of a large number of waterways in the Lake District (Wojciechowski, 1976; Wilgat et al., 1997). The surface of the lakes also increased by as much as 300 hectares. The changes that occurred during the period 1939-2016 in the management of the catchment area were noticeable. In the catchments of natural lakes forested area increased, whereas area of meadows was reduced. The surface area of the natural lakes has changed only slightly.

Changes in water relations in the Łęczna-Włodawa Lake District led not only to morphometric changes, but also affected their trophy. Currently, apart from mesotrophic Rogóźno Lake, all of the studied lakes belonged to eutrophic type (Wojciechowska and Solis, 2009). Retention tanks were characterized by very high trophic levels, primarily caused by direct impact of waters of the Wieprz-Krzna Canal (Solis, 2012).

Apart from differences in trophy between tanks and lakes, there was a clear distinction among macrophytes. Retention reservoirs, exposed to greater influences, both connected with their origin and impact of Wieprz-Krzna Canal waters were significantly poorer in qualitative and quantitative vegetation than natural lakes.

In the past the studied retention reservoirs were natural lakes. By transformation into retention tanks and connection to the Wieprz-Krzna Canal, their surface area increased. Because of their shallowness they are characterized by fewer predispositions for self-cleaning (Traczewska, 2012). Water relations in retention reservoirs have undergone a great change, and the factor that fostered a trophic growth was touristic and recreational use of the catchment areas, mainly by development of summer buildings, the creation of beaches or fishing (Michalczyk and Wilgat, 1998; Krukowska and Krukowski, 2012). In the retention tanks there was also an intensive fishery. Inadequate fishery management can lead to negative impacts, resulting in decreased biodiversity, reduces of water transparency or disappearance of underwater vegetation (Opuszyński, 1997), and vice versa the high trophy reduces the quality of habitat conditions for fish (Jezierska-Madziar and Pińskwar, 2008).

The visible difference between lakes and reservoirs, their trophy and vegetation is primarily a result of the way of management and changes occurring inside. The method of the tanks catchments' management was dominated by natural forms of land cover. Lake catchments were more transformed by human activity.

## CONCLUSIONS

Based on the analysis of the catchment characteristics, the studied lakes formed three groups without a clear division into natural lakes and retention reservoirs, whereas botanical analysis clearly distinguished them.

After construction of the Wieprz-Krzna Canal the number of watercourses and lakes' surface increased in the researched area.

Despite lakes catchments being subject to greater anthropogenic pressure, they are characterized by far greater natural values.

Catchments of examined lakes and retention reservoirs have changed the land management towards increased forest cover and reduction of agricultural fields.

Greater diversity of macrophytes occurred in natural lakes. In retention tanks it was only restricted to emerge macrophytes.

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