

# **LONG- AND SHORT-TERM CHANGES OF THE STRUCTURE OF MACROPHYTES IN LAKE PIASECZNO IN RELATION TO LAND USE IN THE ŁĘCZNA-WŁODAWA LAKELAND (POLAND)**

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**KEYWORDS:** Poland, Łęczna-Włodawa Plain, land-use changes dynamics, lakes, macrophytes.

## **ABSTRACT**

The Łęczna-Włodawa Plain, known also as the Łęczna-Włodawa Lakeland, lies within the territory of the largest subregion of the Polesie region, covering over 1,300 km<sup>2</sup>. The main interest of the Łęczna-Włodawa Lakeland is that it is the oldest in the Central European Lowlands group of about 68 lakes. Among such a large number of lakes there exist all trophic types. However, since the late 1950's, enormous dynamics of change associated with the disappearance of oligo- and mesotrophic lakes and their transformation into eutrophic, even hypertrophic, lakes have been observed. One of the biocenotic elements of the lakes, which are indicators of these changes, is aquatic plants. The aim of this study was to determine the macrophyte structure of Piaseczno Lake and changes of land use in its surroundings. Piaseczno Lake still represents very high natural values. A reduction in the number of macrophyte communities, which occurred especially in 2008, was a consequence of the fast-growing recreation infrastructure.

From 1976 until 2010 an area of recreation infrastructure in the studied area increased more than 3.5 times, and in the built-up area more than five times, as well as a doubling of the total length of the roads. Meanwhile the surface area of wetlands and peatbogs significantly decreased - more than 11 times.

Long-term changes in the structure of the macrophyte communities show that the number of communities has varied in each year, probably as a consequence of changes in land-use. Analysis showed changes to the surfaces inhabited by macrophytes, which have decreased significantly over only four years, by more than 25%. However, the proportion of rush communities has increased.

**RÉSUMÉ:** Changements à court et long terme dans la structure des macrophytes du Lac Piaseczno en rapport avec les modifications de l'utilisation des terrains dans la région des lacs de Łęczna-Włodawa (Pologne).

La Plaine de Łęczna-Włodawa, également nommée la région des lacs de Łęczna-Włodawa, est la plus grande subdivision de la région de Polésie couvrant plus de 1.300 km<sup>2</sup>. L'intérêt principal de la région des lacs de Łęczna-Włodawa Lakeland est le plus ancien groupe de lacs, environ 68, de la plaine centrale européenne. Un nombre aussi important de lacs laisse présager différents types trophiques. Cependant, depuis la fin des années 50, une transformation des lacs oligo- et mesotrophes en lacs eutrophes voir hypereutrophes est

observée. Un des éléments de la biocénose lacustre indiquant ces modifications est la flore macrophytique. De ce fait, l'objet de cette étude a été la détermination de la structure des macrophytes du Lac Piaseczno ainsi que les changements de l'utilisation des terrains environnants. Le Lac Piaseczno présente malgré tout une grande valeur naturelle. La réduction du nombre des communautés macrophytiques, un phénomène qui s'est manifesté surtout en 2008, a été la conséquence de la croissance rapide de l'infrastructure récréationnelle.

Entre 1976 et 2010, la superficie de l'une des aires d'infrastructure récréationnelle de la zone étudiée s'est agrandi de plus de 3,5 fois, la zone construite plus de cinq fois et les routes couvrent désormais une surface deux fois plus importante que dans les années 70. En parallèle, la surface des zones humides et des tourbières a diminuée de manière significative plus de 11 fois.

L'observation des changements à long terme de la structure des communautés macrophytiques a montré que leurs nombres varient chaque année. Ce phénomène est probablement dû à une utilisation différentielle des terrains. En effet, l'analyse des modifications de la surface occupée par les macrophytes montre de manière significative une diminution de plus de 25% de leurs nombres durant les quatre dernières années. En revanche, la proportion de junces a augmenté.

**REZUMAT:** Modificările pe termen scurt și lung în structura macrofitelor din Lacul Piaseczno în urma schimbărilor în utilizarea terenurilor din regiunea lacustră Łęczna-Włodawa (Polonia).

Câmpia Łęczna-Włodawa, denumită și regiunea lacustră Łęczna-Włodawa este cea mai mare subdiviziune a regiunii Polesiei, cu o suprafață de peste 1.300 km<sup>2</sup>. Atracția principală a regiunii lacustre Łęczna-Włodawa este un grup de circa 68 lacuri, cel mai vechi ansamblu lacustru din Câmpia Europei Centrale. Având în vedere numărul mare de lacuri, aici se găsesc toate tipurile trofice de acvatorii dulcicole. Însă de la sfârșitul anilor '50 dinamica schimbărilor a devenit foarte importantă, fiind asociată cu dispariția lacurilor oligo- și mezotrofe și transformarea lor în lacuri eutrofe și chiar hipertrofe. Unul din elementele biocenozei lacustre, indicator al acestor modificări, este flora acvatică. Scopul prezentului studiu a fost determinarea structurii macrofite a lacului Piaseczno și a schimbărilor în utilizarea terenurilor din vecinătate. Lacul Piaseczno încă mai reprezintă o valoare naturală importantă. Reducerea numărului de comunități macrofite, apărută în special în 2008, a fost o consecință a creșterii rapide a infrastructurii recreaționale.

Între 1976 și 2010, una din ariile de infrastructură recreațională din zona studiată a crescut de peste 3,5 ori, iar zona construită a crescut de cinci ori în timp ce suprafața drumurilor a crescut de două ori. În același timp, suprafața zonelor umede și a turbăriilor a scăzut semnificativ - de peste 11 ori.

Modificările pe termen lung în structura comunităților de macrofite au arătat că numărul comunităților a variat de la an la an, probabil în urma modificărilor în utilizarea terenurilor. Analiza modificărilor suprafeței ocupate de macrofite arată că aceasta a scăzut semnificativ în decurs de numai patru ani, cu peste 25%. În schimb, a crescut procentul ocupat de comunitățile de *Juncus* sp.

## INTRODUCTION

Lakes are natural depressions filled with water, which have no direct connection to the sea and have a minimum surface area of 1 ha (Stańczykowska, 1990; Bajkiewicz-Grabowska and Mikulski, 1999).

One of the processes that all natural waters are subject to, regardless of human activity is eutrophication. Eutrophication is an increase of fertility caused by an increasing concentration of minerals (P, N and C) and some environmental and biological changes in water quality. Excessive fertility of aquatic ecosystems results from human activities, such as sewage discharges, agricultural intensification or deforestation in the catchment (Stańczykowska, 1990).

Recently, in Poland and in the world, the majority of lakes are eutrophic lakes - fertile reservoirs, with a high content of salt nutrients and organic matter. Generally, they are relatively shallow (6-24 m). At the bottom levels of the water oxygen deficits are common. Sedimentary processes outweigh the schedule. The color of the water is green and yellow, with little transparency. The number of the phytoplankton species is high and blooms are frequent, and the littoral zone is strongly developed in them as well. The coastal vegetation is abundant. Animal plankton is also rich in species. Benthic fauna, represented by only few species, but simultaneously by a large number of individuals, are adapted to live in conditions with a low oxygen level. Eutrophic lakes can turn into low peatbogs or disappear. The rate of their evolution is very different and depends on the intensity of the flow and the quality of allochthonous matter, as well on the catchment management. In the period of about 11,000 years that have elapsed since the creation of most of the glacial lakes in Poland, about two-thirds of the total surface area has already disappeared (Stańczykowska, 1990). The phenomenon of lake disappearance also occurs in lakes of the Łęczna-Włodawa Lakeland (Chmielewski, 2009).

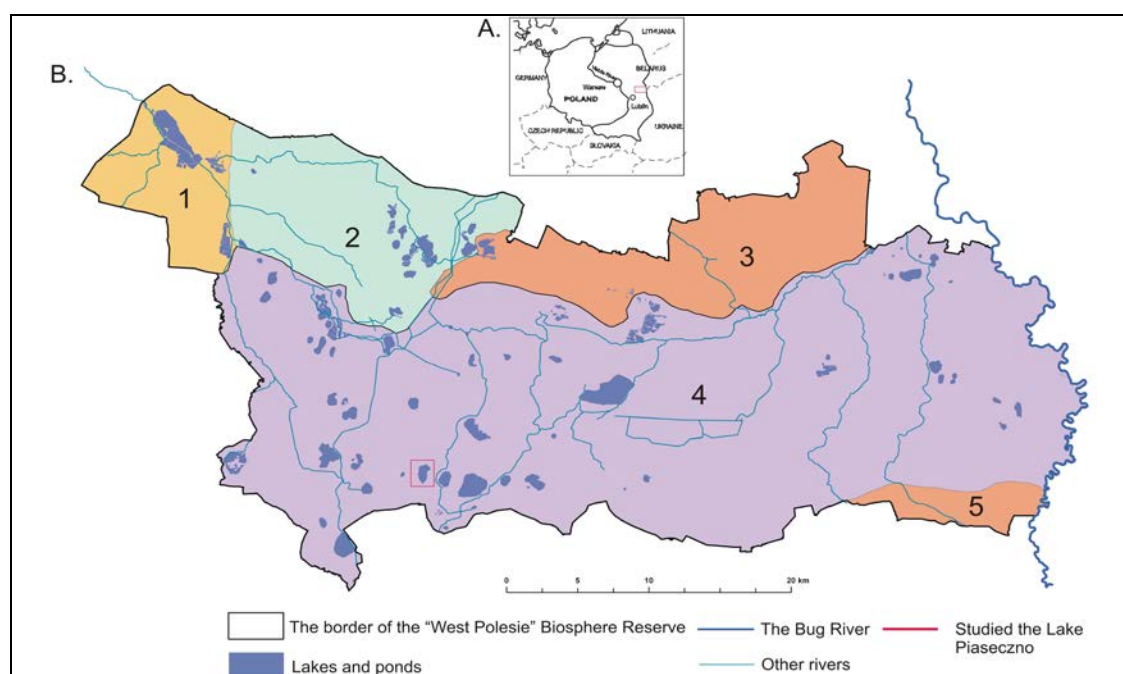


Figure 1: A) Location of the study area in Poland. B) The Łęczna-Włodawa Plain and its surroundings at the borders of the "West Polesie" Biosphere Reserve:

- 1 - Lubartów Upland (319 m above the sea), 2 - Sosnowica Depression (845 m above the sea),
- 3 - Włodawa Hummock (845 m above the sea), 4 - Łęczna-Włodawa Plain,
- 5 - Chełm Hill (845 m above the sea) (Kondracki, 1994).

The Łęczna-Włodawa Plain, called also as the Łęczna-Włodawa Lakeland is the largest subregion of the Polesie, covering over 1,300 km<sup>2</sup>. It is a former, wide river valley, in which after the end of the last glaciations, the water of large hollows started running down. It simultaneously concentrates vast swamps and a group of several dozen lakes. It is one of the most valuable regions in Poland, where in 2002 the “West Polesie” Biosphere Reserve was created (143,937 ha). In the central part, it contains the Polesie National Park, which is surrounded by three landscape parks (Łęczna Lakeland, Polesie and along the Bug River - Sobibór landscape parks), 12 nature reserves (among them seven on the Łęczna-Włodawa Plain) and 21 Natura 2000 sites (Figs. 1 and 2).

The river and stream network is quite dense (belong to the Wieprz and Bug River catchments), but because of the terrain's flatness, water flow is low or even minimal (Wójcikowski, 2006).

The main attraction of the Łęczna-Włodawa Lakeland area is the fact that is the oldest in the Central European Lowlands group of lakes, formed of about 68 lakes. There are both glacial lakes and lakes with karst origin. The largest lake is Uściwierz Lake (284 ha), and the deepest lake is Piaseczno Lake (about 39 m) (Harasimiuk et al., 1998). Among such a large number of lakes there are all trophic types. However, since the late 1950's an enormous dynamic of changes associated with disappearance of oligo- and mesotrophic lakes and their transformation into eutrophic lakes and even hypertrophic lakes is observed. One of the lakes' biocenotic elements, which are indicators of these changes, are aquatic plants. They are a stable component of lakes, reacting to adverse changes in its habitat (Sender, 2009, 2012). The aim of the study was to determine macrophytes structure of the Piaseczno Lake and changes of land use in its surroundings.

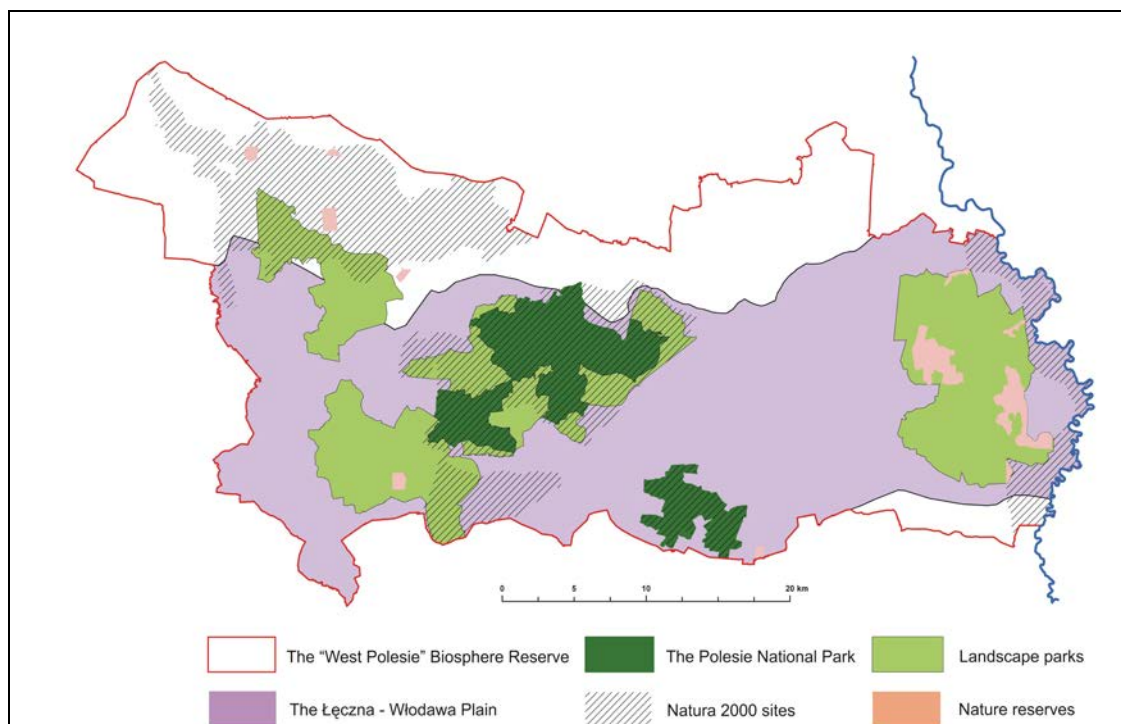


Figure 2: Network of protected areas in the Łęczna-Włodawa Plain, on the background of the “West Polesie” Biosphere Reserve.

### STUDY AREA AND METHODS

Piaseczno Lake is located in the south-west part of the Łęczna-Włodawa Lakeland. It doesn't have an outflow of surface water (Fig. 3, Tab. 1).

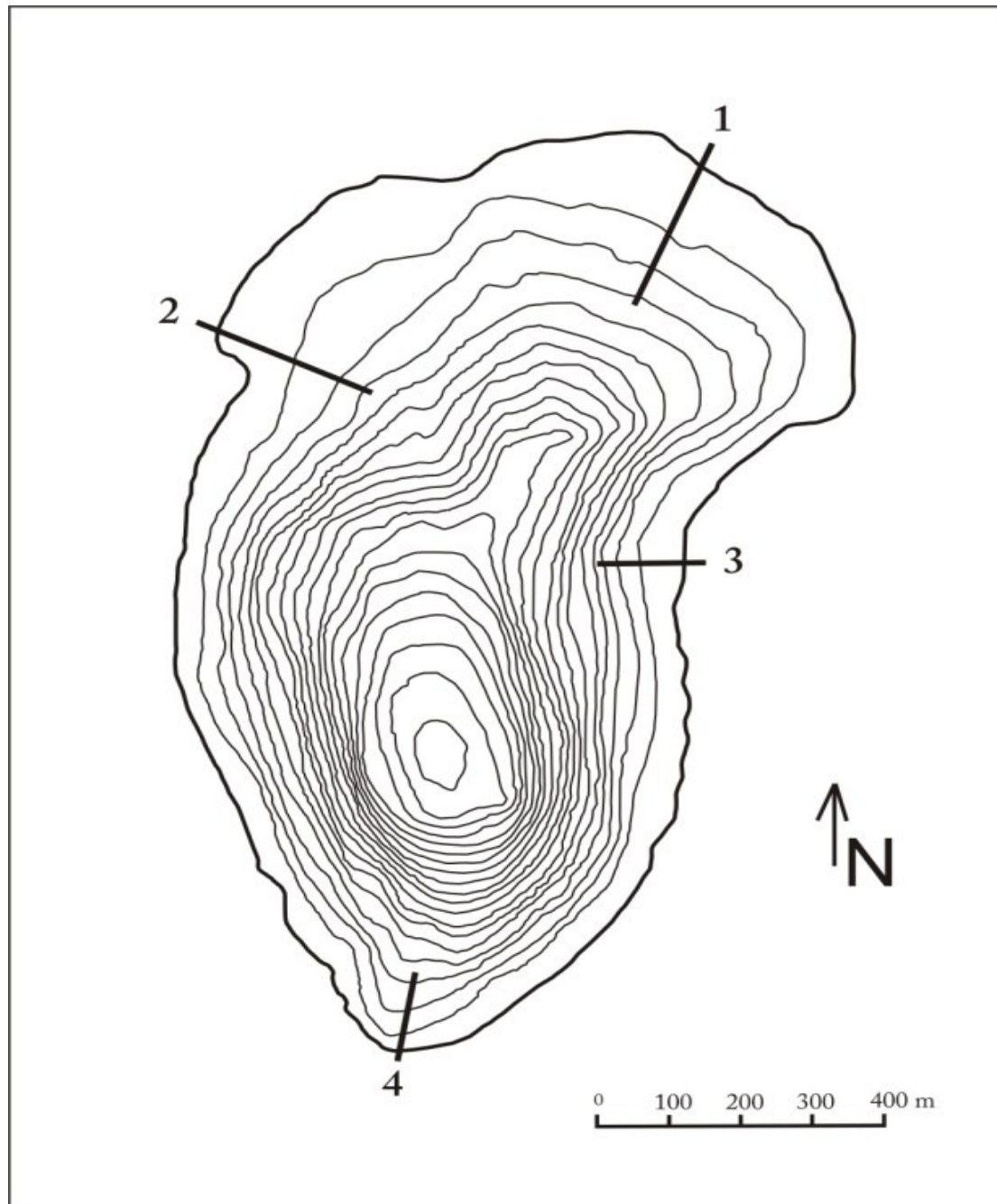


Figure 3: Distribution of research transects in the Piaseczno Lake;  
1 - re-creation of ordered water sewage services, 2 - peatlands,  
3 - re-creation of not ordered water sewage services, 4 - forest.



Table 1: Some morphological parameters of the investigated lake.

Water surface (ha)	84.7
Capacity (tys. m <sup>3</sup> )	10.674
Depth (m)	38.8
Average depth (m)	12.6
Length of shore line (m)	3.788

In the 1950's it occurred as an oligotrophic lake, however actually it is defined as a mesotrophic lake, and some of its features may even suggest an eutrophic character nowadays. At a distance of about 700 m from the lake there is a water-bog reserve called Brzeziczno Lake, which contains many rare northern and Atlantic plants. The lake water is used for fishery. Due to the type of fishing, the lake was considered as a common bream and vendac type lake. It is restocked with eel, pike, crucian carp and common bream. Piaseczno Lake is situated in the catchment of the South Piwonia River. The catchment's surface area is 284.88 ha, out of which 29% constitutes agricultural lands, and 24% constitutes forests (Harasimiuk et al., 1998).

Phytosociological studies were carried out in the years 2008 and 2012 with the generally accepted phytosociological method (Braun-Blanquet, 1951). Phytosociological units (determined by the dominant species) were distinguished using a systematic and nomenclature system by Matuszkiewicz (2005). Trials of emergent and submerged macrophytes were collected along profiles highlighted after the inventory in the field (Fig. 3) (Bernatowicz, 1960; Szymeja, 2006). Based on the analysis of aerial photographs from the years 1976, 1984 and 2010, an analysis of the direct land use of Piaseczno Lake catchment was carried out. For the analysis Arc Gis 10.1 software was used.

## RESULTS AND DISCUSSION

Direct land uses of the Piaseczno Lake catchment area are: forests, agricultural land, scrubs and forests, wetlands and recreational zones with built-up areas. During the analysis period of the study, there was an increase of areas occupied by forests and scrubs, as well as recreational areas and associated buildings and roads. A significant increase of recreational areas resulted in a significant reduction of wetlands, where the water extraction was related with drainage. From the point of view of the functioning of the catchment as a biofilter, such changes are very unfavorable, especially for peat bogs in which drainage causes the phenomenon of decay of peat and water penetration by the vast amounts of matter, accelerating eutrophication processes (Stachurski and Zimka, 1994). Also, agricultural land decreased, mainly because of allocation for recreation. The water surface remained at a stable level with a tendency to increase in recent years (Figs. 4 and 5).

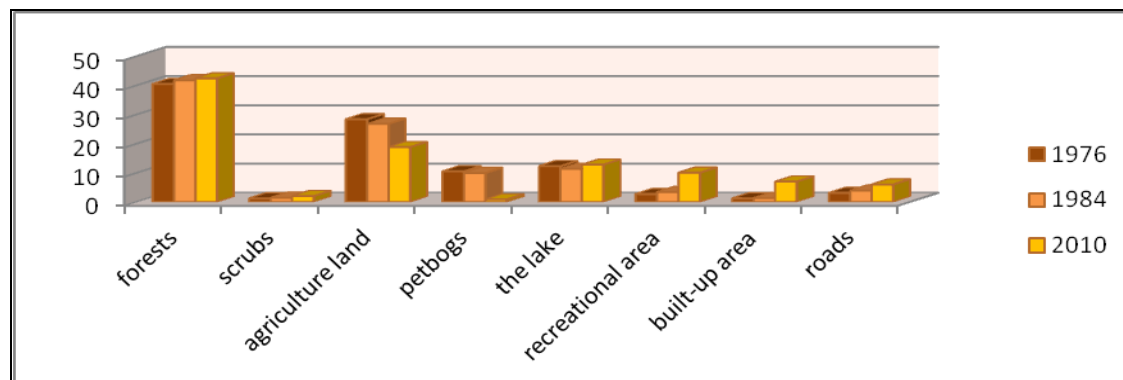


Figure 4: Land use changes in the surroundings of the Piaseczno Lake in 1976, 1984, 2010.

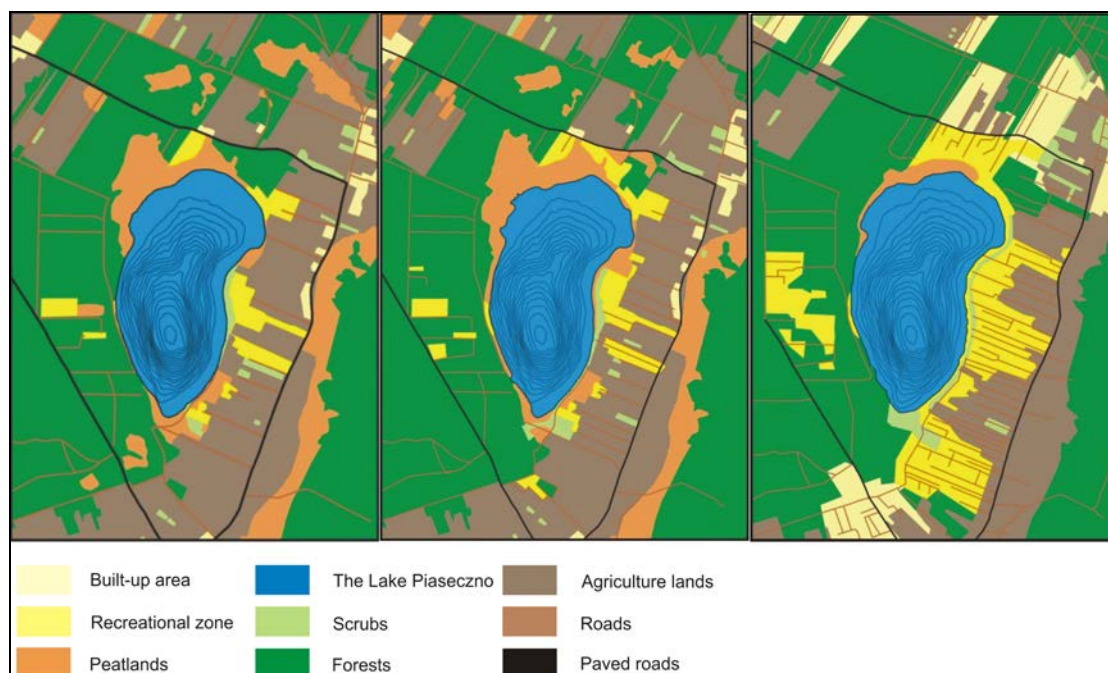


Figure 5: Land use changes around Piaseczno Lake in 1976, 1984, 2010 (percentage share).

Littoral zone was inhabited by 14 macrophytes communities in 2012. The total surface inhabited by macrophytes amounted to 25.3 ha, among it 17 ha constituted communities of submerged plants, whereas 8.3 ha of emergent plants (Tab. 2).

Table 2: Area covered by main types of plant communities in the studied lake in 2012.

Community	Area (ha)
Submerged plants	17.005
Community with <i>Utricularia vulgaris</i>	0.046
Community with <i>Chara delicatula</i>	0.685
<i>Nitelletum flexilis</i>	0.169
<i>Charetum fragilis</i>	1.6
<i>Myriophyllo-Littorelletum</i>	12.33
<i>Ceratophylletum demersis</i>	1.667
<i>Elodeetum canadensis</i>	0.508
Emergent plants	8.283
<i>Epilobio-Juncetum effusi</i>	0.041
<i>Salicetum pentandro - cinereae</i>	0.6619
<i>Caricetum rostratae</i>	0.028
<i>Typhetum latifoliae</i>	0.093
<i>Typhetum angustifoliae</i>	0.029
<i>Eleocharitetum palustris</i>	0.154
<i>Phragmites australis</i>	7.276
Total	25.288

The plant communities' number occurring in Piaseczno Lake was subjected to significant changes. At the end of 1950's, the lake under study was inhabited by 12 plant communities. In 2008 only ten plant communities were noticed, however, currently there are 14 (Tab. 3).

Table 3: Plant communities of the Piaseczno Lake in selected periods of research (Fijałkowski, 1959).

Community	Years		
	1960/70*	2008	2012
Cl. Charetea (Fukarek 1961 n.n.) Krausch 1964; O. Charetalia fragilis Sauer 1937; Ass. Charion fragilis Krausch 1964			
<i>Charetum fragilis</i> Fijałkowski 1960	+	+	+
<i>Charetum asperae</i> Corillion 1957	+		
Community with <i>Chara delicatula</i> Desev.	+	+	+
<i>Nitelletum flexilis</i> Corillion 1957	+	+	+
Cl. Potametea R. Tx. et Prsg 1964; O. Potametalia Koch 1926; Ass. Potamion Koch 1926 em.			
<i>Elodeetum canadensis</i> (Ping. 1953) Pass. 1964	+	+	+
<i>Potametum lucentis</i> Hueck 1931	+		
<i>Potametum perfoliati</i> Koch 1926	+		
<i>Ceratophylletum demersi</i> Hild. 1956		+	+
Cl. Littorelletea uniflorae Br. - Bl. et R. Tx. 1943; O. Littorelletalia uniflorae Koch 1926; Ass. Lobelion (Vanden Berghen 1944) R. Tx. et Dierss. ap. Dierss 1972			
<i>Myriophyllo-Littorelletum</i> Jaschke 1959	+	+	+
Cl. Phragmitetea R. Tx. et Prsg 1942; O. Phragmitetalia Koch 1926; Ass. Phragmiton Koch 1926			
<i>Eleocharitetum palustris</i> Sennikov 1919	+	+	+
<i>Phragmitetum australis</i> (Gams 1927) Schmale 1939	+	+	+
<i>Typhetum angustifoliae</i> (Allorge 1922) Soó 1927	+		+
<i>Typhetum latifoliae</i> Soó 1927			+
<i>Caricetum rostratae</i> Rübel 1912			+
<i>Scirpetum lacustris</i> (All. Chouard 1924)	+		
Cl. Scheuchzerio-Caricetea (Nordh. 1937) R.Tx. 1937; O. Scheuchzerietalia palustris Nordh. 1937; Ass. Caricion lasiocarpae Vanden Ber. ap. Lebrun et al., 1949			
Community with <i>Juncus articulatus</i> L.		+	
Cl. Utricularietea intermedio - minoris Den Hartoget Sedal 1964 em. Pietsch 1965; O. Utricularietalia intermedio - minoris Pietsch 1965; Ass. Sphagno - Utricularion Mull. et. Gors 1959			
Community with <i>Utricularia vulgaris</i> L.		+	+
Cl. Molinio-Arrhenatheretea R. Tx. 1937; O. Molinietaalia caeruleae W. Koch 1926 Ass. Calthion palustris R. Tx. 1936 em. Oberd. 1957			
<i>Epilobio-Juncetum effusi</i> Oberd 1957			+
Cl. Alnetea glutinosae Br.-Bl. and R. Tx. 1043; O. Alnetalia glutinosae R. Tx. 1937; Ass. Alnion glutinosae (Malc. 1929) Meijer Drees 1936			
<i>Salicetum pentandro-cinereae</i> (Almq. 1929) Pass.			+
Total	12	10	14



Such significant fluctuations in the number of macrophyte communities inhabiting the lake are probably connected with changes in land use in the lake's surroundings, as well as with a trend of increasing of the water surface observed in the last few years. The number of communities is also associated with a reduction of the surface inhabited by macrophytes and it decreased from 33.9 ha in 2008 to 25.3 ha in 2012 (Fig. 6). An increase of the participation of rush communities in creation of phytolittoral zone also provides enrichment in the nutrients processes in the reservoir (Sender, 2007). Communities of evergreen stoneworts, often treated as an indicator of clean, oligo- and mesotrophic lakes were subsided (Pełechaty, 2006).

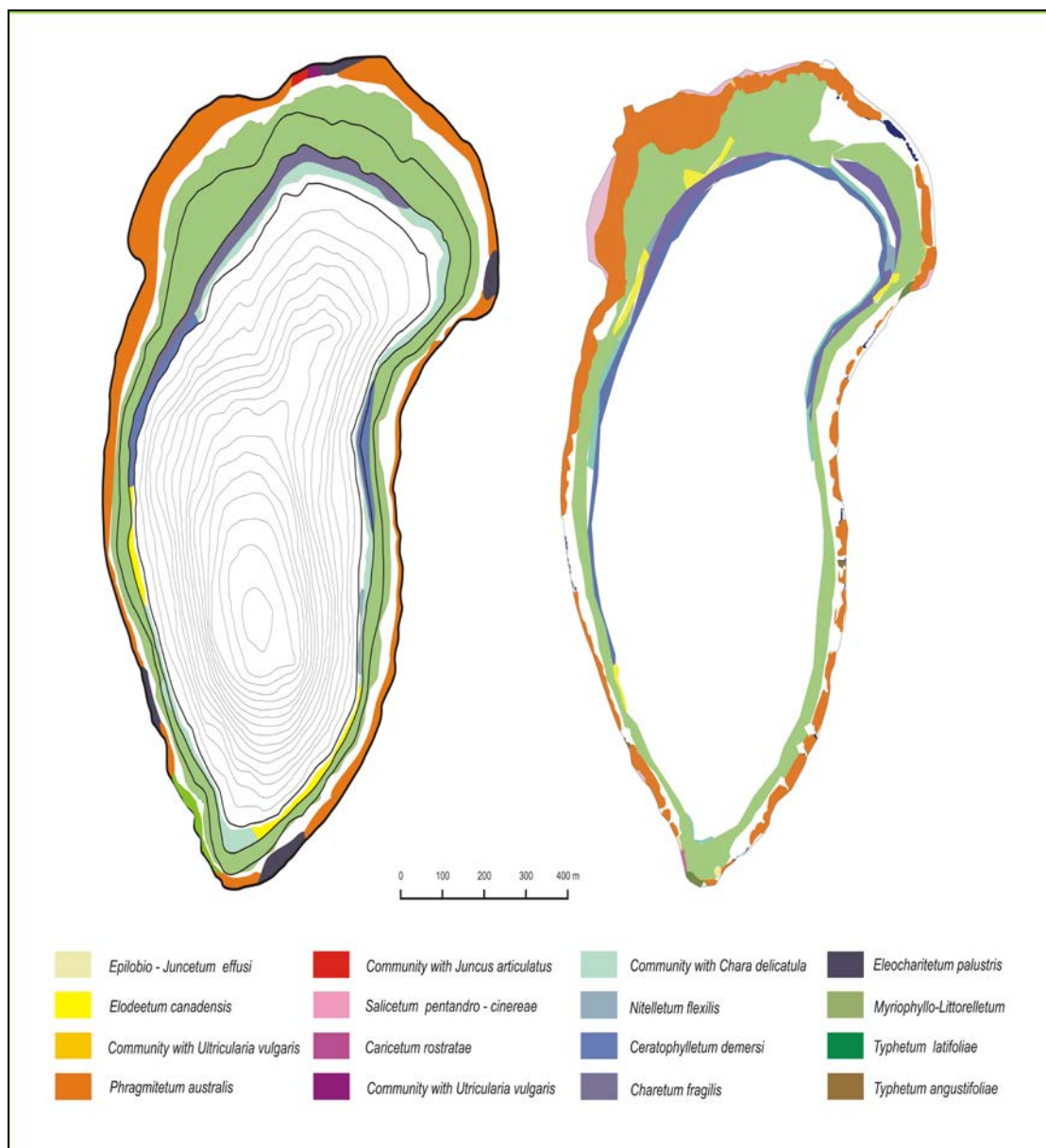


Figure 6: Phytolittoral of the Piaseczno Lake in 2008 and 2012.

## CONCLUSIONS

The Piaseczno Lake still harbour very high natural values, but the reduction in the number of macrophyte communities that occurred especially in 2008, was a consequence of the fast growing recreational infrastructure.

From 1976 to 2010, the area of recreation infrastructure in the study area has increased over 3.5 times and the built-up area over five times, as well as roads over twice, while the surface of wetlands and peat bogs significantly decreased - over 11 times.

Long-term changes in the macrophyte communities' structure showed that the number of communities has varied in each year, probably as a consequence of changes in land-use. The analysis of the surface changes inhabited by macrophytes only over four years has decreased significantly, by about 25%. However, the share of the rush communities increased.

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