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CHANGES OF LAND MANAGEMENT TYPES OF CHOSEN SOSNOWICA LAKES CATCHMENTS IN THE SOSNOWICA DEPRESSION, POLAND

Summary: The study included two lakes from so-called group of the Sosnowica lakes, located in the Sosnowica Depression, close to the Łęczna – Włodawa Plain. The aim of the study was to determine the changes in the catchment of two neighboring lakes, with different size of water surface and catchment areas, as well as different way of land-use before and after the construction of the Canal Wieprz-Krzna. Changes in land use structure of the individual catchments were analysed with the method of retrospective photointerpretative analysis using: a topographic map in a scale 1:25000 from 1945, satellite scenes taken by Rapid Eye in 2009, and analogue aerial photograt 1:25000, taken in 2007. Whole surrounding region, especially the Łęczna – Włodawa Plain, was subjected to highly intense transformations associated with the construction of a dense drainage network. On the examples of these two catchments it is possible to conclude that in period of 1945 – 1998 definitely more unfavorable changes occurred in nature than in period 1998 – 2009. Nowadays, the dominant type of land - use are forests that increased over three times during period under the study. The Białe Sosnowica lake was subjected to faster overgrowth processes than the Czarne Sosnowica lake. As a result, reduction of lake surface and significant increase of rush communities were observed.
Keywords: Sosnowica lakes, land-use changes, GIS photointerpretative analysis.

INTRODUCTION

Catchment is an area from which water flows to the specified receiver, that can be a river or lake. Its border is a watershed that separates water inflow to two different water systems. Depending on the form of water outlet, it is distinguished by: surface and underground catchments. Natural and anthropogenic factors occurring in the catchment have a great importance for shaping of flowing water's quality. Among natural factors there are: climatic, geologi-

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cal, soil, geomorphological and hydrological. Among others, temperature determines the content of dissolved oxygen in the water. The high oxygen content allows for efficient water purifying process, and determines the mixing effect of water in deep lakes. Type of rocks occurring in the catchment influence on the amount of dissolved substances in water, entering to the receiver with an underground runoff. The system of permeable and impermeable layers determines the speed of filtration. A land use structure is also a very important factor. Water flowing from forest and wetlands has an increased content of humus acids, colloidal ferrous, increased color and turbidity. On the other hand, a high capacity of retention of these environments allow to stop many impurities [4].

The second group of factors affecting conditions in a catchment and influencing on water quality are factors resulting from human activities. Different ways of land use in the catchment modify the quality and quantity of water significantly. Human often without any limitation modifies catchment by adapting it to his needs, for example by cutting forests, draining wetlands,

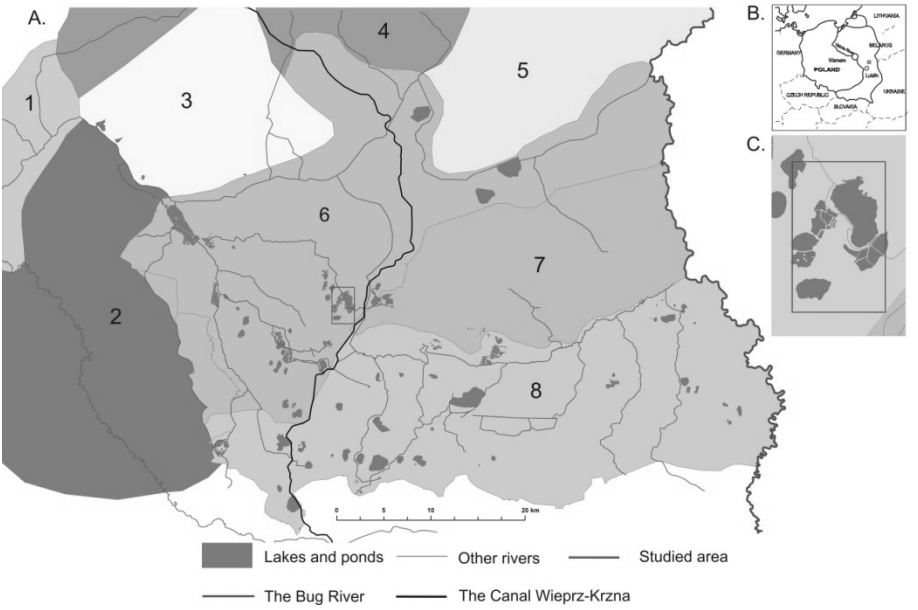

Fig. 1. *A) Studied area and its neighbouring geographic mesoregions: 1 – Wieprz Glacial Valley, 2 - Lubartów Upland, 3 – Parczew Plain, 4 – Łomazy Depression, 5 – Kodeń Plain, 6 – Sosnowica Depression, 7 – Włodawa Hummock, 8 – Łęczna – Włodawa Plain (according to Kondracki 1994). B) Location of studied area in Poland. C) Studied area in the detail: 1 - Białe Sosnowica lake, 2 - Czarne Sosnowica lake*

conducting intensive management, or not regulating management of water and wastewater in a catchment. However, any changes and restatements in the catchment introduced by man are perceived negatively, as a source of contaminants [8, 9].

The aim of the study was to determine the changes in the catchment of two neighboring lakes, with different size of water surface and catchment areas, as well as different way of land-use before and after the construction of the Canal Wieprz-Krzna.

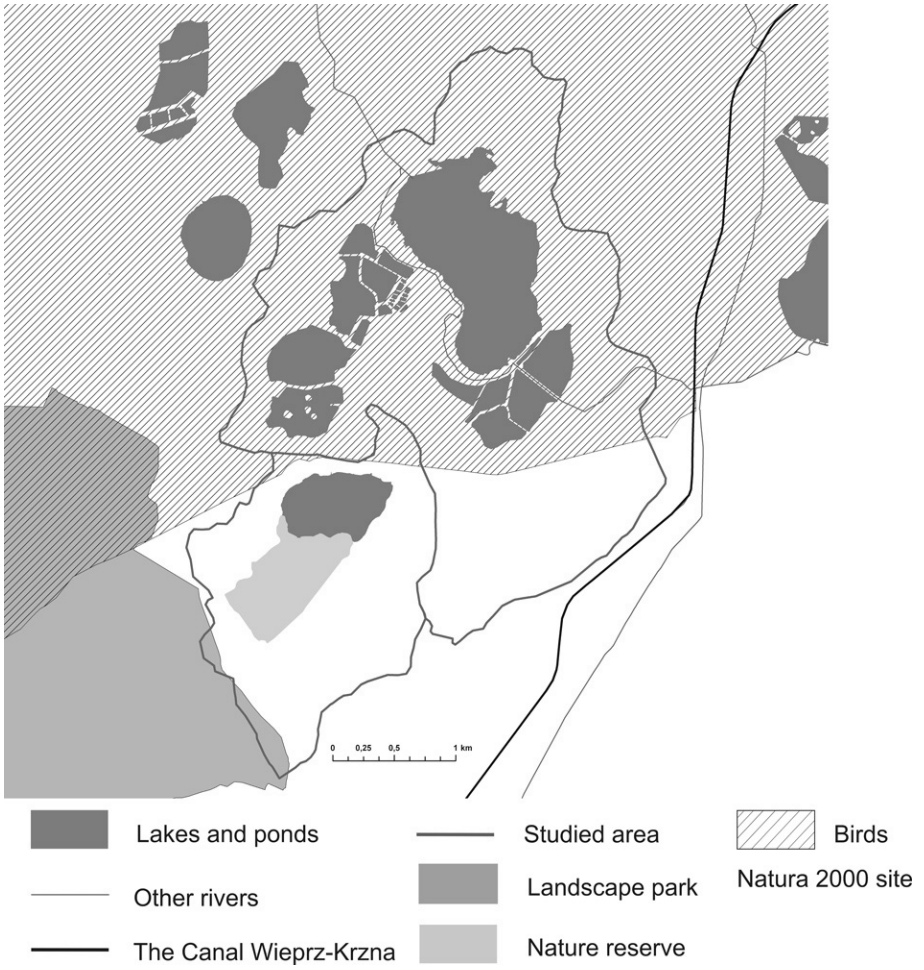

Fig. 2. *Location of lakes catchments under the study on the background of protected areas*

STUDIED AREA

The study included two lakes from so-called group of the Sosnowica lakes, located in the Sosnowica Depression, close to the Łęczna – Włodawa Plain (Fig. 1). These lakes are located in close proximity and their neighbouring catchments are significantly different in size (Table 1). Investigated lakes are situated within the Canal Wieprz – Krzna influence.

Table 1. Surface of lakes and their catchments

Surface / lake	Białe Sosnowica lake	Czarne Sosnowica lake
Lake [ha]	108,26	37,60
Catchment [ha]	941,5	359,04

The majority of the Białe Sosnowica lake's catchment is included in Bird Natura 2000 site, whereas the Czarne Sosnowica Lake's Peatbog nature reserve adjacents directly to the Czarne Sosnowice lake (Fig. 2). Catchment of the Czarne Sosnowica lake is situated in near neighbouring of the Łęczna Lakeland Landscape Park.

MATERIALS AND METHODS

Changes in land use structure of the individual catchments were analysed with the method of retrospective photointerpretative analysis [1], using:

1) a topographic map in a scale 1:25000 from 1945,
2) satellite scenes taken by Rapid Eye in 2009,
3) supplementary source: analogue aerial photograt 1:25000, taken in 2007. The photographs were converted to the form of an orthophotomap, with one pixel representing 0.5 m in the field. To prepare the analysis in more detail way, satellite images from 2009, made by Rapid Eye were also used, but with lower accurate – with one pixel representing 5 m in the field.

The maps of land use structure and the measurements of area of chosen divisions were created in the environment of the Arc Gis 10.1 software. The same software was used to perform the measurements of surface area of the chosen divisions in catchments under the study.

In addition to determine directions of land use changes, the analysis carried out by Harasimiuk [5] in the same area in the 90's of XX century was used to compare and contrast occurred differences.

Orthophotomaps and satellite scenes (e.g. Rapid Eye) used for modern photointerpretative analysis are sources that undoubtedly allow to carry out much more precise identification of land use forms and measurement of individual syntaxons than topographical maps which are often the only source of information for retrospective studies (archival). Among others, a terrain

pixel size and the availability of spectral channels decide about high information value of modern scientific research.

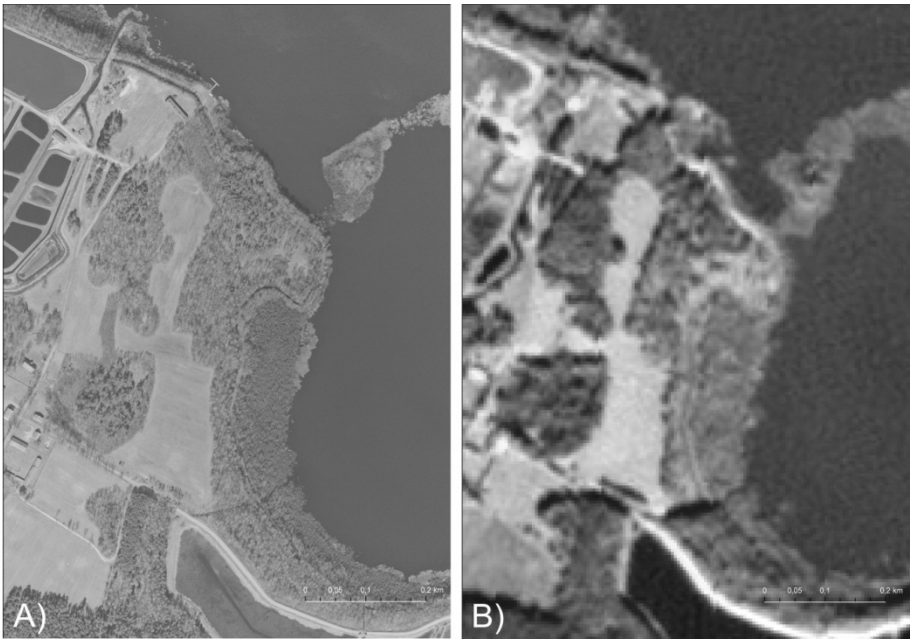

Fig. 3. *A) The orthophotomap in a grayscale with one pixel representing 0,5m in the field, 2007 B) The satellite scenes taken by Rapid Eye, with with three spectral channels and one pixel representing 5 m in the field, 2009*

In the case of analysis presented in this paper, the orthophotomap in a grayscale from 2007 with one pixel representing 0,5 m in the field (the most accurate available resolution) was supporting source, whereas satellite scenes taken by Rapid Eye in 2009 were a basic source for the analysis. What is worth to notice that satellite scenes are characterized by less accuracy (one pixel representing 5 m in the field), but with three spectral channels (Fig. 3) that make it easier to distinguish different land cover types such as wet meadows, fields or peatbogs.

RESULTS

Whole surrounding region, especially the Łęczna – Włodawa Plain, was subjected to highly intense transformations associated with the construction of a dense drainage network. Initial work began in the 40' ties of the XX century but were rewarded in 1976 with the commissioning of the Canal Wieprz-Krzna [3, 5, 7]. Unfortunately, from this period a highly wide range of chang-

es associated with the loss of identity of the natural environment is noticed. These changes are generally unfavorable, linked with eutrophication of the lakes of the Łęczna – Włodawa Plain, cause depletion of biological diversity and habitat homogenization. The results of undertaken analysis related to the changes of land use management in the catchment area of selected lakes confirmed the rapid growth of these changes. In the lakes under the study, highly significant changes in the catchment occurred (Fig. 4, 5).

In the period of 1945 – 2009 in the Białe Sosnowica' s catchment significant changes occurred (Table 2). The area of the lake decreased by 32,35 ha, i.e. by 23% as a result of appearance of rush communities after 64 years of abscence.

Surface of other water reservoirs increased by 14,29 ha after creation of new ponds. The most pronounced changes of natural and semi – natural forms in this catchment were those concerning meadows, swamps and peatlands, as well as shrub and woodlots which decreased significantly.

Table 2. Changes of land use management of the Białe Sosnowica' s catchment in the years 1945 – 2009 (*according to Harasimiuk [5])

Forms of land use	Area in particular years (ha)			Changes in area in 1945 – 2009 (ha)	Changes in area (%)
Years	**1945**	**1998***	**2009**		
Lake	140,61	136,9	108,26	-32,35	-23
Other water reservoirs	99,54	132,48	113,83	14,29	14
Rush communities	0	0	33,14	33,14	Appearance of a new form
Swamps and peatlands	83,80	1,74	24,47	-59,33	-71
Forest complexes	219,36	579,12	592,15	372,79	170
Meadows	106,56	37,46	41,62	-64,94	-61
Shrub and woodlots	58,31	13,74	6,76	-51,55	-88
Fields	230,11	34,93	17,93	-212,18	-92
Buildings	3,15	2,24	3,33	0,18	6
TOTAL	941,44	938,61	941,49	X	X

Meadows decreased by 65 ha and swamps and peatlands by 59 ha. The scale of meadows and swamps and peatlands' disappearance was notably higher in the period of 1945 – 1998, than in 1998 – 2009, similar to creation of large forest area surrounding the lake. Mainly it can be associated with failure of meadows' drainage and as a result transformation into forest. Worthy to notice is that area of forest increased more than two times as a result of

disappearance of fields and other forms mentioned below. Among two chosen lakes, definitely the majority of changes were subjected to the Białe Sosnowica lake'catchment. Surface of the lake was reduced significantly, connected mainly with the process of its overgrowth. Also the share of swamps and bogs, as well as meadows decreased, while the share of forest lands significantly increased. Depletion of hydrogenic areas is the result of drainage processes, however forested areas are results of plant succession of meadows and fallow fields. In lake under the study, as well as in ponds of the catchment, fishing is intensively used method of water management. Unfavorable changes in the catchment and the way of lake' management cause its less attractive from the nature point of view [10].

In comparing with the Białe Sosnowica lake, the Czarne Sosnowica lake is a reservoir with a significantly lower area of the lake, as well as its catchment area (Table 3).

Table 3. Changes of land use management of the Czarne Sosnowica's catchment in the years 1945 – 2009 (*according to Harasimiuk [5])

Forms of land use	Area in particular years (ha)			Changes in area in 1945 – 2009 (ha)	Changes in area (%)
Years	**1945**	**1998***	**2009**		
Lake	39,12	38,96	37,60	-1,52	-4
Other water reservoirs	0	0,32	0,19	0,19	Appearance of a new form
Rush communities	0	0	1,18	1,18	Appearance of a new form
Swamps and peatlands	163,04	0	10,34	-152,7	-94
Forest complexes	97,73	273,33	307,41	209,68	214
Meadows	5,26	0,99	1,18	-4,08	-78
Shrub and woodlots	5,01	40,62	0	-5,01	Disappearance
Fields	45,12	3,99	1,15	-43,97	-97
Buildings	3,69	0	0	-3,69	Disappearance
TOTAL	358,97	358,21	359,05	X	X

Over the 64-year period under the study, the lake surface didn't decreased dramatically (just 1,52 ha). Similar to previous lake catchment, area of forest complexes increased significantly – more than 3 times, mainly at the expense of swamps and peatlands that decreased dramatically at the same time (94%). In the studied catchment, 2 new forms appeared – ponds and rush communities, as well as 2 disappeared – shrub and woodlots and buildings.

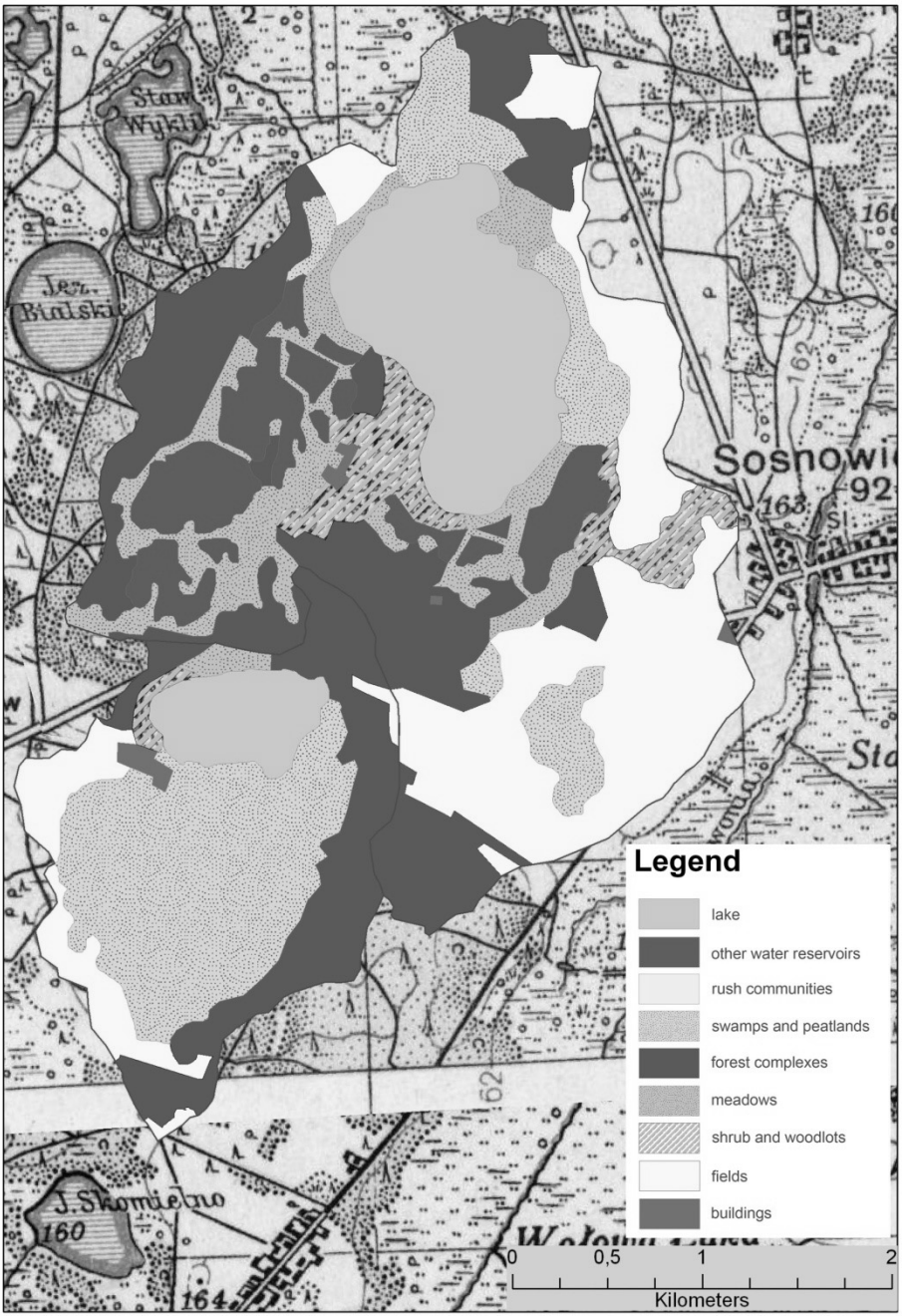

Fig. 4. *Land-use management of two chosen lakes in 1945*

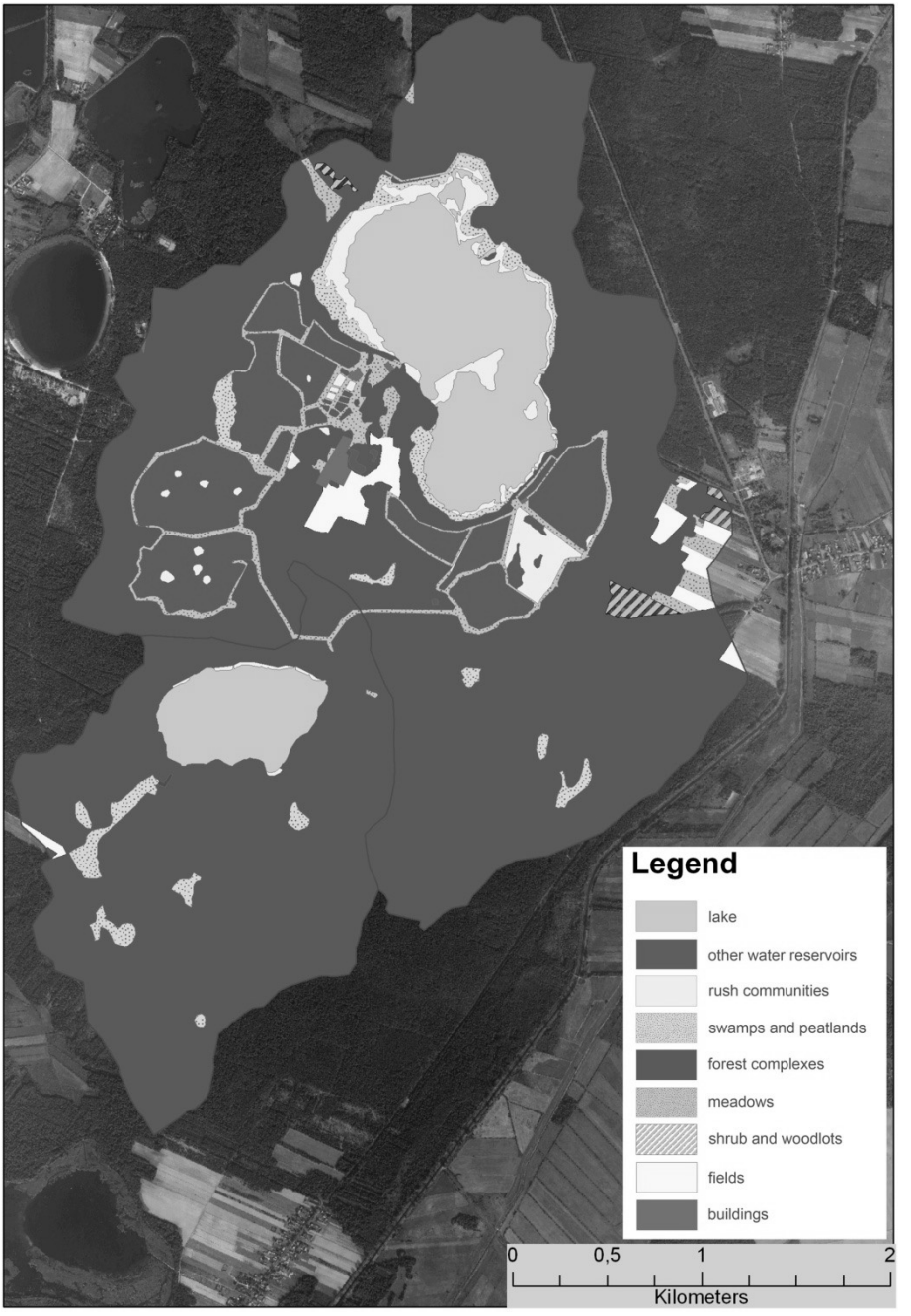

Fig. 5. *Land-use management of two chosen lakes in 2009*

Worthy to notice was that the scale of disappearance of meadows, swamps and peatlands was notably higher in the period of 1945 – 1998, than in 1998 – 2009. On the examples of these two catchments it is possible to conclude that in period of 1945 – 1998 definitely more unfavorable changes occurred in nature than in period 1998 – 2009, what can be linked with higher ecological awareness.

As a result of the drainage works, swamps and bogs were subjected to a significant reduction in this catchment (Fig. 6). The main assumption of building such a large hydraulic engineering infrastructure was the acquisition of lands for agriculture purposes. However, overestimated possibilities of the production did not yield the expected results, thus the obvious decrease of agricultural lands. This area, without agriculture use, but with disturbed hydrological regime overgrown, and after a period of almost 65 years is covered by forest in the vast majority. The lake is surrounded by forest, and even connected with the Canal Wieprz-Krzna, is characterized by good ecological status [10].

The area is also clearly subjected to depopulation processes, resulting in a significant decrease of the built – up areas surface (Fig. 5, 6).

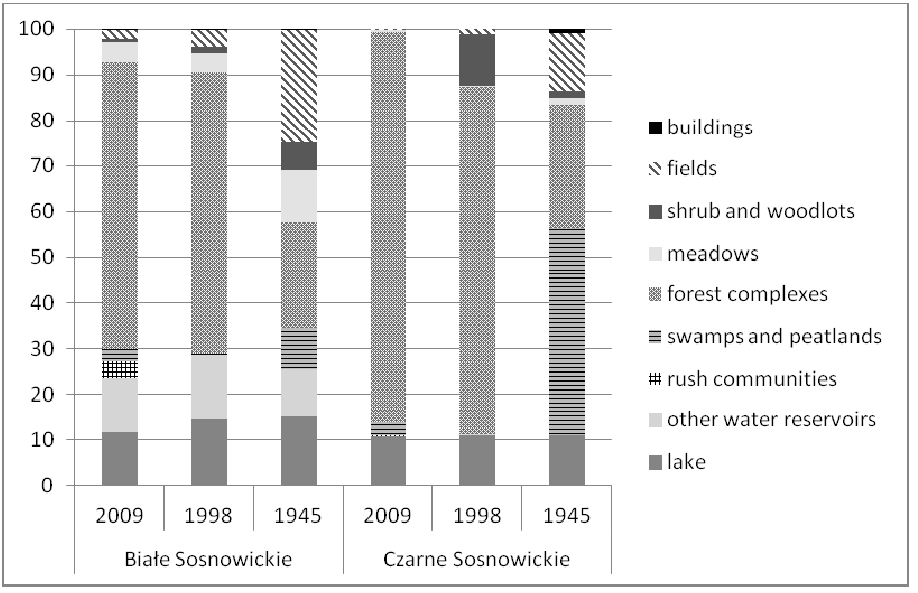

Fig. 6. *Percentage share of individual land-use forms in catchments of chosen lakes*

Similar studies were undertaken on other lakes of the Łęczna – Włodawa Plain, mainly in retention reservoirs included in the drainage system, in which

degradation processes have a great momentum [11], or in other lakes under different forms of protection, definitely in which changes progress to a gradual disappearance of lakes [2].

CONCLUSIONS

The catchments of studied lakes in the analyzed period of time were subjected to very intense changes, based on habitats homogenization. What's more, period of 1945 – 1998 years was definitely more unfavorable for nature than period 1998 – 2009, what can be linked with higher ecological awareness.

Nowadays, the dominant type of land - use are forests.

The Białe Sosnowica lake was subjected to faster overgrowth processes. As a result, reduction of lake surface and significant increase of rush communities were observed.

The main reason for these significant changes was the construction of the Canal Wieprz-Krzna and the way of lake use, influencing simultaneously on its natural beauty.

REFERENCES

1. Chmielewski T. J., Olenderek H., Sielewicz B.: Fotointerpretacyjna analiza retrospektywna zmian struktury ekologicznej Kampinoskiego Parku Narodowego w ostatnim 40-leciu. [In]: Kistowski M. red. Badania ekologiczno-krajobrazowe na obszarach chronionych. Uniwersytet Gdański, Polska Asocjacja Ekologii Krajobrazu, Gdańsk 1996, 125 – 129.
2. Chmielewski Sz., Chmielewski T. J.: Analiza zmian struktury użytkowania ziemi 1952-2007. [In Polish]: T.J. Chmielewski (red.) Ekologia Krajobrazów hydrogenicznych Rezerwatu Biosfery „Polesie Zachodnie". Uniwersytet Przyrodniczy w Lublinie, Lublin 2009, 47-70.
3. Dawidek J., Sobolewski W., Turczyński M.: Transformations of catchment-areas of lakes converted into storage reservoirs in the Wieprz-Krzna Canal system. Limnological Review 2004, 4, 67-74.
4. Górniak A.: Rola hydrologii i charakteru zlewni w kształtowaniu chemizmu wód jezior [In Polish]. Ogólnopolska Konf. Naukowa. Współczesne Kierunki Badań Hydrobiologicznych. Supraśl 1999, 61-67.
5. Harasimiuk M., Michalczyk Z., Turczyński M.: Jeziora Łęczyńsko-Włodawskie. Monografia Przyrodnicza. [In Polish] Wyd. Bibl. Monitoringu Środ. Wyd. UMCS - PIOŚ Lublin, Lublin 1998, 176.
6. Kufel L.: Transport pierwiastków biogennych w zlewniach Mazurskiego Parku Krajobrazowego. [In Polish] [In]: Zdanowski B., Kamiński M., Martyniak A. (red.) Funkcjonowanie I ochrona ekosystemów wodnych na obszarach chronionych. Wyd. IRŚ Olsztyn 1999, 153-165.
7. Radwan S., Kornijów R.: Hydrobiologiczna i hydrochemiczna charakterystyka wód powierzchniowych [In Polish] [In:] S. Radwan (ed.) Środowisko Przyrodni-

cze w strefie oddziaływania Kanału Wieprz-Krzna, AR Lublin, TWWP, Lublin 1991, 47-58.
8. Sender J.: Struktura jakościowa i ilościowa zbiorowisk makrofitów w wybranych jeziorach Pojezierza Łęczyńsko-Włodawskiego. [In Polish] (PhD thesis) UAM Poznań 2004, 190.
9. Sender J.: Przekształcenia struktury hydrobotanicznej pod wpływem czynników naturalnych i antropogenicznych wybranych płytkich jezior na Pojezierzu Łęczyńsko-Włodawskim. [In Polish] [In:] A. Nędzarek, J. Kubiak, A. Tórz (ed.) Anthropogenic and natural transformation of lakes. PTLim, Szczecin 2010, 4, 111-117.
10. Sender J.: Quantitative investigations of vascular flora in deep and shallow eutrophic lake. TEKA Komisji Ochrony i Kształtowania Środowiska Przyrodniczego PAN, Polska Akademia Nauk, Oddział Lublin; vol. IX, 2012, 206 – 214.
11. Sugier P., Tracz J., Lorens B.: Changes of use structure in areas adjoining lakes Krzczeń and Mytycze transformed into retention reservoirs. TEKA Komisji Ochrony i Kształtowania Środowiska Przyrodniczego PAN, Polska Akademia Nauk, Oddział Lublin; vol. IV, 2007, 255-262.