Pol. J. Environ. Stud. Vol. 23, No. 5 (2014), 1867-1873

Short Communication

The Diversity of Small Water Bodies in Chosen Landscape Parks Situated in a Biosphere Reserve

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Co-financed by National Fund for Environmental Protection and Water Management

Received: 30 October 2013
Accepted: 28 April 2014

Abstract

The West Polesie Biosphere Reserve includes three landscape parks, among which for analysis the two most peripherally located and with similar surfaces were selected: the Łęczna Lakeland Landscape Park and Sobibór Landscape Park. The aim of the study was to identify and characterize small permanent water bodies with an area less than 1 ha. Research was mainly based on the method of retrospective photointerpretative analysis of land use forms using aerial photographs and satellite images. Due to the hydrogenic character of protected ecosystems, in the reserve we found nearly 3,000 small water bodies, and 223 in areas of landscape parks under study. These small water bodies have various origins, surfaces, and nature of direct surroundings.

Keywords: small water bodies, Łęczna Lakeland Landscape Park, Sobibór Landscape Park, West Polesie Biosphere Reserve, GIS analysis

Introduction

As a result of human activities, landscape defined as a whole physiographical land along with weather conditions is subject to constant modifications. These transformations are associated with practically each type of human activity (settlements, acquisition of mineral resources, agriculture, tourism, business, etc.). The dominant type of landscape in the biosphere reserve is aquatic ecosystems, especially small water bodies whose size and diversity determine the uniqueness of this place on Earth. Due to the unique values of hydrogenic landscapes, the area is under the protection of many legal forms [1, 2].

The significance of small water bodies in shaping the landscape is highly complex and multidirectional. On the one hand they enhance the landscape, species, and habitat diversity. At a regional level, they contribute highly to freshwater diversity, with recent evidence showing that they often support considerably more species, both unique and rare, than other water-ecosystem types [3-7]. On the

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other hand, they retain the water in an uncontrolled way. Currently, the problem of increasing potential capacity retention is quite serious in the light of chaoitc catchment and river valley management, as well as increasing population density. What's more, the presence of any hydrogenic ecosystems helps to improve the ecological status of forest and wetland habitats [8].

Due to their huge dependence on the surrounding areas, small size, and depth, small water bodies constitute ecosystems highly vulnerable to degradation and highly sensitive to land use and/or human activities in surrounding areas [9, 10]. Unfortunately, in recent years the national and worldwide trend of the disappearance of stagnant reservoirs, and especially small water bodies, is observed. The causes of this phenomenon are natural factors, but primarily anthropogenic [11-18].

The differentiated way of small water bodies surrounding land use, as well as their use, appear to be one of the key components affecting the state and pace of change taking place in these reservoirs [19]. The aim of the study was to identify and characterize small permanent water bodies with an area less than 1 ha, located in the area of analyzed landscape parks, varied in terms of location and ways of land use. Accurate inventory of these valuable ecosystems should be the basis for the preparation of protection plans of these areas.

Investigated Area and Methods

There are three landscape parks in the West Polesie Biosphere Reserve (144,000 ha), among which for analysis the two most peripherally located and with similar surfaces were selected: Łęczna Lakeland Landscape Park and Sobibór Landscape Park. The area of Łęczna Lakeland consists of two parts, north and south, which together cover an area of 11,514 ha, while the compact Sobibór complex occupies 11,124 ha.

Research was based on the method of retrospective photointerpretative analysis of land use forms [20] using aerial photographs taken in 2007, as well as satellite images from Rapid Eye taken in 2009. The photographs were converted to the form of an orthophotomap, with one pixel representing 0.5 m in the field. Maps of actual structure of land use and surface measurements of individual precipitation were made using GIS software (ArcView, ArcInfo). Besides that, ecological valorization also was based on the following criteria: surface of small water bodies, their shape, origin, length of shoreline, the presence of a buffer zone as scrub and reed communities, diversity, and land use around them.

These criteria allowed us to distinguish 4 categories:

I. Large natural reservoirs in its category with a developed buffer zone, large variety, and natural land use in its surroundings.
II. Natural reservoirs, the average of its category with a developed buffer zone, but small variety, but with natural land use in its surroundings.
III. Anthropogenic reservoirs, large in its category with poorly developed buffer zone, small variety, and natural land use in its surroundings.
IV. Anthropogenic reservoirs, small in its category, with the lack of a buffer zone, small variety, and anthropogenic land use in its surroundings. These small water bodies are the most vulnerable to degradation.

Results and Discussion

Due to the hydrogenic character of protected ecosystems, the West Polesie Biosphere Reserve is rich in water reservoirs. We found nearly 3,000 small water bodies with

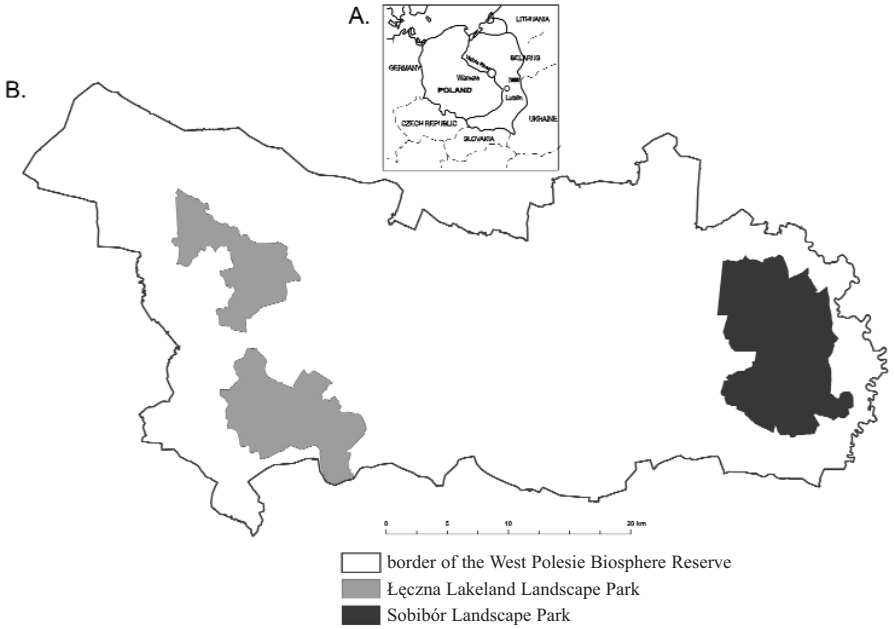

Fig. 1. Location of the studied area.

Table 1. Land use structure in the studied landscape parks

Land use forms/area	Łęczna Lakeland Landscape Park (north)	Łęczna Lakeland Landscape Park (south)	Sobibór Landscape Park
Water reservoirs	374.1	614.9	133.6
Flowing water	0	6.3	0
Rush communities	27.7	127.7	83.3
Open peatlands	50.2	38.3	134.4
Peatlands with plant succession	40.9	161.2	933.8
Forest complexes	2214.5	2185.4	8538.1
Meadows	741.2	599.1	728.1
Humid meadows	52.4	500.7	78.6
Shrub communities	139.9	299.9	127.5
Fields	904.0	1486.2	287.2
Fallow	19.3	48.6	0.9
Fallow with plant succession	25.6	120.3	8.2
Greenery production	112	18.3	3.3
Compact villages	63.42	116.1	37.3
Single farms	11.9	37.3	10.3
Animal and state farms	18.03	0	0
Summer and recreational resorts	25.3	324.6	11.0
Base, stores	1.2	0.4	0
Production factory	4.2	0	0
Cemetery	1.3	1.8	0
Wood storage	0	0	8.4
Total	4,827.15	6,687.1	1,1124

an area smaller than 1 ha in the whole area of the West Polesie Reserve.

Analyzed landscape parks differed in terms of surface and land use structure (Fig. 2, Table 1).

In the area of two studied landscape parks, the largest area was occupied by forest complexes, but in Łęczna Lakeland Park included a far greater variety of land use forms (Fig. 3).

In Łęczna Lakeland water ecosystems represented a significant share – 9%, but in Sobibór only 1.2%. (Mainly this is connected with a lower share of lakes, as well as the share of small water bodies.)

The main water resources of parks were accumulated by lakes with an area of over 10 ha, a significant share had also reservoirs with an area of more than 1 ha, but not exceeding 10 ha. The smallest water bodies of surface of

Table 2. Water resources of studied landscape parks [%].

Water resources	Łęczna Lakeland Landscape Park (north)	Łęczna Lakeland Landscape Park (south)	Sobibór Landscape Park
Reservoirs < 1ha	2.3	3.1	4.1
Reservoirs 1-10 ha	22.9	7.9	3.6
Reservoirs >10 ha:			
Lakes	52.3	77.0	92.3
Ponds	22.5	11.0	0
Flowing water	0	1.0	0
Total	100%	100%	100%

less than 1 ha represented from 2.3% to 4.1% of the total water resources of the analyzed area. Despite the plethora of stagnant water, flowing water occurred only within the southern part Łęczna Lakeland as the Wieprz-Krzna water drainage channel (Table 2).

In 2009 in the area of studied parks there were a total of 223 small water bodies, with various origins, surfaces, and nature of the direct surroundings. Łęczna Lakeland includes 171 small water bodies occurred, of which the largest surface area was 0.86 ha and the smallest 0.003 ha (the average size of small water bodies was 0.139 ha, SD 0.17), while Sobibór consisted of 52, the largest 0.96 ha and the smallest 0.004 ha (the average size of small water bodies was 0.092 ha, SD 0.11). It has been proven that many small water bodies have higher value than 1 large reservoir [21].The specificity of the study area was the reason why the 'Łęczna Lakeland' Landscape Park from the earliest years was an object of mineral and peat extraction. Uncontrolled exploitation, as well as work related to the construction and use of the largest drainage canal in Poland (the Wieprz-Krzna system) subjected hydrological conditions in the whole area to clear and adverse changes [22].

Among the analyzed small water bodies, the vast majority was represented by reservoirs with anthropogenic origin, in Sobibór they constituted even 85% of the analyzed reservoirs, while Łęczna Lakeland – was 67% (Table 3). However, each small water body, even created as a result of human activity, is extremely valuable for nature [23, 24].

The method of land use in the direct surroundings of the reservoir significantly affects its functioning. The main factor influencing the degradation of small water bodies is agriculture [25]. Among all types of land use forms, surroundings of the studied reservoirs were dominated by one natural type of ecosystem. In Sobibór the most frequent type of surroundings were grasslands, but in Łęczna Lakeland its' forest complexes. Definitely, the majority of small water bodies were rectangular in shape (Table 3).

Among all identified small water bodies in the two landscape parks, their anthropogenic origin dominated (Table 3). Based on the literature overview this does not

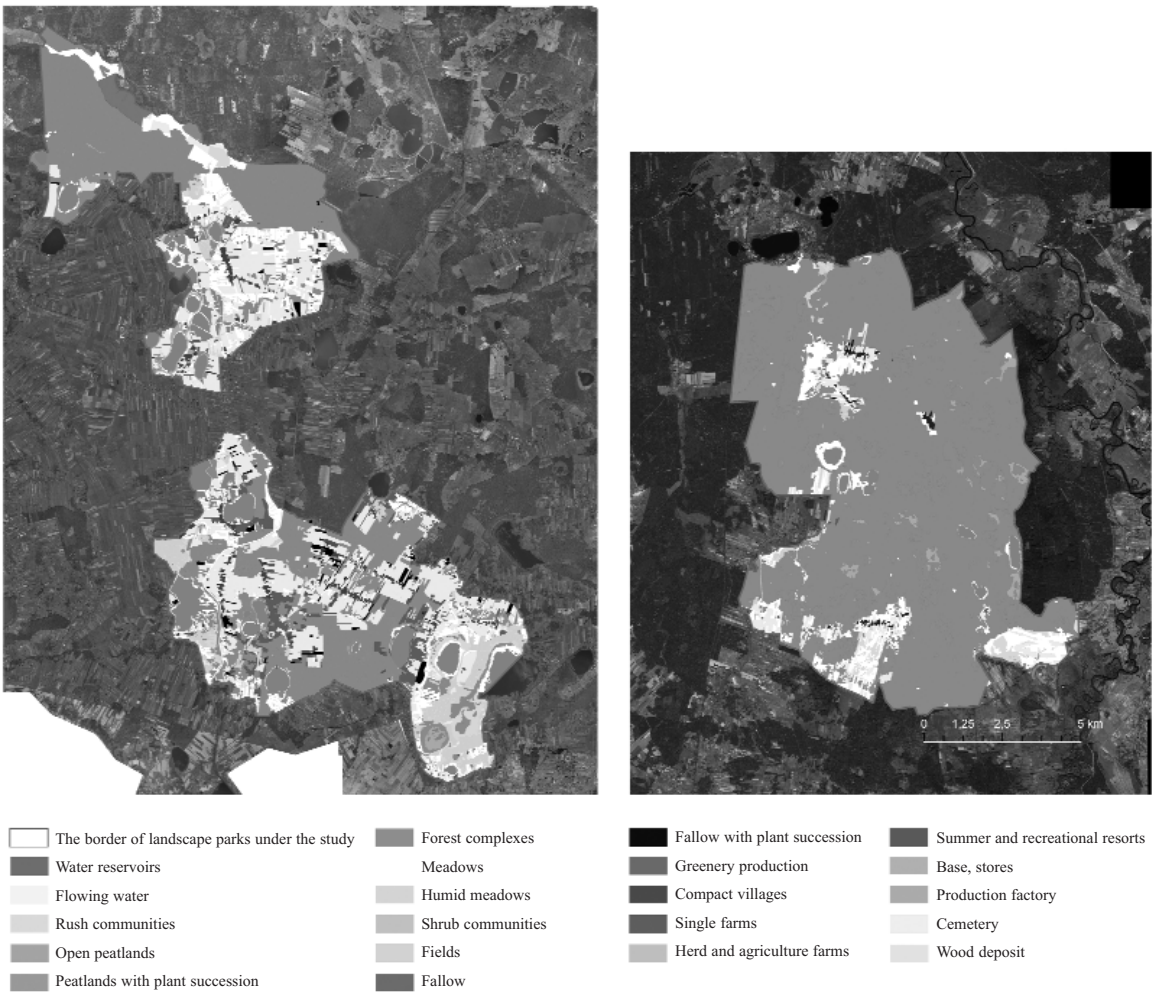

Fig. 2. Land use forms in the studied landscape parks.

mean that they are less valuable biodiversity refuges than natural [26, 27].

Particularly areas with high density of small water bodies are important, because they can support landscape connectivity as stepping stones, mainly for amphibia [28, 29]. The density of small water bodies is three times higher in Łęczna Lakeland than in Sobibór, reaching 1.48 per km^2, which is almost the highest value of average density of ponds of different landscapes of Europe, usually reaching a value of about 0.3-1.5 ponds per km^2 [9, 30-32].

On the basis of small water bodies' valorization, generally their good status was concluded. Even 65-77% of them belonged to category III (Fig. 4). In the majority of them there were anthropogenic reservoirs, in Łęczna Lakeland the average size was 0.25 ha (SD 0.012), and the average was 0.22 ha (SD 0.02) in Sobibór. Their buffer zones were moderately developed, and their surroundings were homogeneous and natural.

Inventory and valorization of 171 small water bodies in rural areas of the Olsztyn Lakeland showed their negative status [33]. However, studies included valorization of small water bodies among agricultural fields in the area of General Dezydery Chłapowski Landscape Park, with a much larger area of landscape park and 68 small water bodies showing a similar condition [34].

Many activities like controlling agricultural activities in the surrounding catchment area and alien invasive species, clearing and mowing, and grazing management are recommended in Management of Natura 2000 habitats – Mediterranean ponds [35]. Maintaining the current state or the creation of new small water bodies seems to be the most environmental friendly way of supporting small retention in the region. It is possible to achieve by e.g. supporting local activities to underline and promote the importance of such elements in the landscape like in UK, Switzerland, or

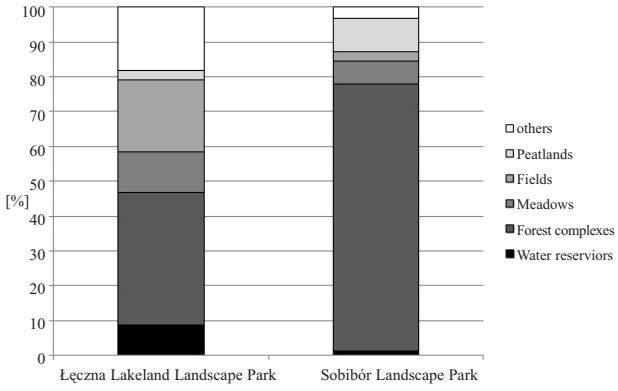

Fig. 3. Percentage share of individual land use forms in the studied landscape parks.

Table 3. Characteristics of small water bodies in the studied area [% share].

Water body's feature	Types	Łęczna Lakeland Landscape Park	Sobibór Landscape Park
Shape	Quadratic	2.9	6
	Rectangular	34.5	62
	Oval	19.3	2
	Amoeba	28.1	12
	Geometric	14.6	4
	Longitudinal	0.6	15
Dominant type of land use in a buffer zone (5m)	Summer and recreational resorts	2.3	2
	Forest complexes	49.1	13
	Agriculture fields	3.5	10
	Meadows	34.5	67
	Peatlands with plant succession, rush communities	10.5	8
Shore diversity	Homogeneous	57	62
	Heterogeneous:		
	2 kinds of land use types	34	29
	3 kinds of land use types	8	10
	More than 3 kinds	2	0
Origin	Anthropogenic	67	84.6
	Natural	33	15.4

France [29]. School education also seems to be an important factor. In Poland in many voivodships there are conducted programs of small retention, especially strongly implemented after our entrance to the EU in 2004. Oertli [21] underlined the importance of local initiatives to conduct programs for small water ecosystems' conservation, because in a global conservation policy all size ranges of aquatic ecosystems should be promoted and protected. In the EU there have been a few international three-year projects, like the Pond-Life Project (1994-97) [36, 37] and the Mediterranean Temporary Ponds Life Project (1999-2004) [38, 39]. In 2004 the international forum called the European Pond Conservation Network was launched.

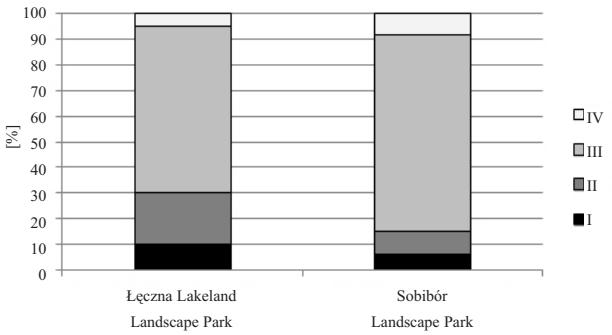

Fig. 4. Percentage share of individual categories among studied small water bodies.

In our opinion a detailed inventory and valorization of small water bodies should be the first step in conservation policy. Then, if such elements are in the area under protection, some law restrictions should be written down, e.g. included in plans of protection. The last step is monitoring management tools, checking whether their quality and quantity is appropriate [40]. Also, implementation of subsidies for farmers to keep small water bodies in the agricultural landscape should be supported by European Union programs.

Conclusions

Landscape Parks under study are areas with different forms of land use. Parks included in the West Polesie Biosphere Reserve showed a huge diversity of water ecosystems, especially of small water bodies.

The great majority of these small water bodies have an anthropogenic origin and represent good ecological status due to limited human activity in the studied area, formed natural barriers, and the method of land use around small water bodies.

So far the presented analyzes are the pioneer analyzes of this scale in this area. The carried out inventory and valorization of small water bodies will provide the basis for monitoring, which will determine the pace and direction of

changes among ecosystems extremely sensitive to degradation.

The density of small water bodies in Łęczna Lakeland reached 1,48 per km^2 – almost the highest value of average density of ponds of different European landscapes.

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