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EFFECTS OF HYDROGENIC HABITATS RESTORATION IN LANDSCAPE-PROTECTED COMPLEX „OLSZYNA” IN WARSAW

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Summary. Areas that resemble natural ecosystems, occurring in urban areas, have a unique character. They create refuges for vegetation, often for rare plant species. For this reason protection of the remaining parts of natural vegetation, the same way as preservation of historical buildings, is essential for sustainable functioning of urban landscape. The aim of this work was the assessment of changes in habitat and vegetation of riparian alder-carr forest covering the research area of Landscape-Nature Protected Complex „Olszyna” in Warsaw, where during engineering investments in the 1970’s a drainage system was introduced. Changes of vegetation in the area were studied in the years 2006–2007. The results were compared with previous researches that were held in the 70’s and 90’s. Hygrophilous vegetation of riparian woodlands, after lowering of the groundwater table due to investments (neighborhood of the Toruńska Artery) has been slowly transforming into more mesophilic one. Despite the system of ditches whose purpose is to keep the water level elevated, maintaining proper functioning of the alder-carr forest ecosystem seems to be impossible. Lack of spring floodings for about 20 years causes adverse vegetation changes. Increase of total number of plant species, mostly synantrophical, was recorded. Changes shown in DCA graph reveal a linear tendency.

Key words: hydrogenic ecosystems, urbanization, vegetation, biodiversity, ecosystem restoration

INTRODUCTION

Restoration can be defined as „a complete structural and functional return to a pre-disturbance state”, *sensu* Cairns [1991]. The principle of ecological restoration is a procedure designed to enhance the input of nature conservation interests in decision-making on large-scale development projects and to counterbalance the ecological impacts of such developments when implemented. It is also defined as the substitution of ecological functions or qualities that are impaired by development [Cuperus *et al*. 1996]. The urbanization process has a great effect on structure and functioning of natural ecosystems within city landscapes [Grimm *et al*. 2000]. Hydrogenic habitats occurring in the Landscape-Protected Complex „Olszyna" in Warsaw are an example of ecosystems that remained within the boundaries of a large city tkanks to technical activities undertaken during the construction of the Toruńska Artery aimed at the preservation of this ecosystem. Such relicts of natural ecosystems play a significant role as biodiversity hotspots and refuges for fauna and flora in urbanised areas. This is why preserving the natural habitats is essential for sustainable management of urban areas.

This study was undertaken to assess changes of habitat and vegetation of alder woodland in the complex Olszyna, where in the second half of the 20th century an artificial system of ditches and pumps was created to prevent water outflow by construction of the Toruńska Artery in its closest neighbourhood.

STUDY AREA

The Natural Landscape Complex Olszyna is located in the north-western part of Warsaw and occupies an area of 2.23 ha, and is mostly covered by alder woodland *Fraxino-Alnetum*. The most valuable parts of the area are now protected

Fig. 1. Soils, water system and location of sampling points in „Olszyna" Park: 1 – sand, 2 – peat, 3 – Toruńska artery, range of peat before investment, 5 – canalised Rudawka river, 6 – pipelines, 7 – open channels and reservoirs, 8 – direction of water flow, 9 – pump, 10 – location of water sampling points, 11 – location of soil sampling points, 12 – location of phytosociological relevés [Pajnowska *et al.* 1996, modified]

as the Natural Landscape Complex Olszyna. Development of road infrastructure resulted in the decline of ground water table and in limited infiltration of rainfall waters that had fed this wetland before. In the 1970's actions were undertaken to protect Olszyna through the regulation of reservoirs and open ditches. Olszyna suffered most severe losses during the construction of the Toruńska Artery in its closest neighbourhood [Pajnowska *et al*. 1996, 1997, Sikorska 2008].

MATERIALS AND METHODS

Investigation of physiochemical properties of water was conducted in autumn 2007 according to the standard PN-EN 25667-2: 1999. 8 samples were collected in the field for further laboratory analysis. Three of them were repetitions of the investigation held in 1996. The following parameters were analysed: pH, colour, ash content, nitrates, nitrites, ammonium nitrogen, mineral phosphorus, sulfates, total iron (spectrophotometry), hardness, and alkalinity. Also 12 soil samples were collected and pH, total nitrogen using Kiejdahl method and total phosphorus using a spectrophotometer were measured. Vegetation inventory held in 1973 and 1996 [Wysocki, data not published] was repeated in 2007 using phytosociological methods according to Braun-Blanquet [Dzwonko 2007]. The inventory was conducted in April and September, 16 phytosociological relevés were performed in the same places as in previous studies. Biodiversity indicators were used with further application of PAST software [Hammer *et al*. 2005]. Indicators basing on the share of plant species belonging to different phytosociological groups [Matuszkiewicz 2005] were used for assessment of indirect reaction of plants to changes in habitat. Plant species most abundant in 39 relevés, representing classes *Phragmitetea, Stellarietea, Querco-Fagetea, Artemisietea* and *Molinio-Arrhenatheretea*, were compared. Qualitative changes of indicators within investigated period were compared using one-way analysis of variance and Tukey's test at significance level $p < 0.05$ using STATISTICA 6 software. Changes of water and soil physicochemical parameters in the years 1996–2007 were compared in STATISTICA 8 using t-test at significance level $p < 0.05$. On the basis of vegetation data from 1973, 1996 and 2007, DCA method (DCA – Detrended Canonical Analysis) was used to asses directions of occurring changes. Using phytoindicative methods, changes of diversity and naturalness were investigated by calculating the share of species mentioned in literature as ecological indicators.

RESULTS

Although protective actions were undertataken in Warsaw on hydrogenic habitats, long-term changes can be observed. Potasium content decreased (Tab. 1), which is a positive process, because this compound is mostly responsible for eutrophication. On the other hand, sulphates content has significantly increased in the water, along with alkalinity and hardness. Also ash content increased. A significant loss of iron content in the water was observed (Tab. 2).

Table 1. Detailed results of chemical soil analysis in Olszyna Park, mean values of pH, nitrogen and potassium content in years 1996 and 2007, significance level $p < 0.05$

Parameter	1996	2007	p
pH	5.940	5.830	ns
Total nitrogen, %	1.040	0.368	ns
Total potassium, %	0.101	0.023	0.00**

** Differences statistically significant in Tabs 1, 2, 3, 4

Table 2. Results of t-test, comparison of water physciochemical parameters in the years 1996 and 2007

Parameter	Units	1996	2007	p
pH	pH	6.966	7.255	0.062
Colour	mg Pt – Co cm^3	28.000	124.125	0.057
Ammonium nitrogen	mg $N\text{-}NH_4$ dm^3	0.333	0.505	0.312
Nitrites	mg $N\text{-}NO_2$ dm^3	0.001	0.051	0.273
Nitrates	mg NO_3^- dm^3	0.058	13.173	0.364
Sulphates	mg SO_4^{2-} dm^3	18.666	309.300	0.000**
Mineral phosphorus	mg PO_4^{3-} dm^3	0.216	0.301	0.571
Alkalinity	mval dm^3	4.200	6.243	0.000**
Hardness	mg $CaCO_3$ dm^3	440.000	649.211	0.000**
Suspended matter	mg dm^3	1620.000	62.937	0.105
Ash content	mg dm^3	0.706	1096.000	0.000**
Iron	mg Fe dm^3	4.800	1.707	0.015*

Vegetation was changing along with ongoing habitat changes. Plant communities naturalness dropped down, though not due to antropophytes loss, but due to apophytes – native species penetrating synantrophical communities (Tab. 3). Total diversity increased, which is a result of increased number of species. As far as species belonging to different ecological groups are concerned, most significant changes can be observed in this case (Tab. 4). The share of species belonging to classes *Phragmitetea* and *Molinio-Arrhenetheretera* decreased, on the other hand there was an increased number of plants typical for deciduous forest from class *Querco-Fagetea*, along with a higher number of *Artemisietea* species. It concerned mostly apophytes from the order *Glechometalia.*

Table 3. Mean values of ecological indicators for woodlands

Ecological indicators	1973	1996	2007	p
Synantropisation index	0.000	0.090	0.131	0.006**
Shannon diversity index	1.867	2.535	2.558	0.001**
Simpson diversity index	0.826	0.909	0.907	0.000**

Table 4. Percentage share of plant species belonging to different phytosociological classes

Phytosociological classes	1973	1996	2007	p
Phragmitetea	0.414	0.024	0.017	0.000**
Querco-Fagetea	0.020	0.100	0.241	0.000**
Artemisietea	0.047	0.305	0.358	0.000**
Molinio-Arrhenatheretea	0.420	0.143	0.030	0.000**

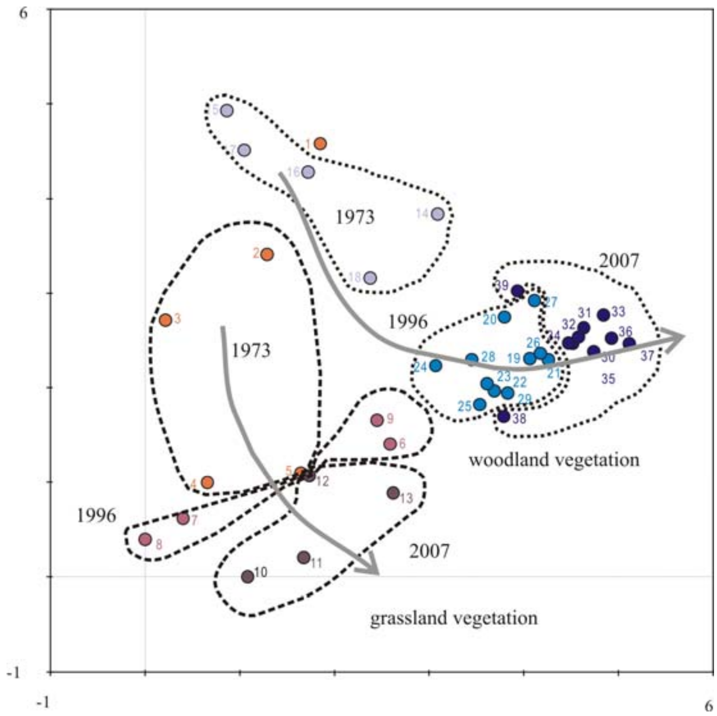

Fig. 2. Directions of vegetation changes in woodlands and grasslands in years 1973, 1996 and 2007 showed on DCA diagram

Detrended Canonical Analysis indicates significant changes in plant species composition within 1973–1996, thus long before the investment took place and soon after. In the period of 1996–2007 changes are much smaller and have a more linear character (Fig. 2).

DISCUSSION

Within the years 1996–2007 nitrogen content in Landscape-Protected Complex Olszyna has decreased significantly, which can indicate that the formerly nutrient-rich habitat is stabilised due to partial decay of organic soils. Potasium content at the level of 0.1% according to Okruszko [1993] points to moorshing process in peat soils. There is no significant difference in nitrogen content, mean values vary from about 0.3 to over 3% within samples. Similar results were formerly shown for peat soils by Maciak [1977], who reported mean values of this compound at the level of 0.5–1%. Elevated level of nitrogen in soils can be the result of neighbouring grassland fertilisation and release of nintrogen from soils due to mineralisation process. As far as sulphates content in water is concerned, values at levels over 309 mg dm^3 can be described as alarming, as mean values in natural waters are usually from 10 to 80 mg dm^3 [Dojlido 1995]. According to former studies [Pajnowska *et al.* 1996], the water could then be classified in the 3rd quality class, while this study proves worsening of quality and classifies it in the 5th class. Despite a small improvement of alkalinity being noted, hardness of the water has worsened.

High groundwater level and spring floodings lasting for many weeks are typical for alder forests, such as the one covering „Olszyna Park" [Matuszkiewicz 2001]. Great increase of the number of species is a result of higher number of species representing *Artemisietea* class. Constant increase of antropophytes indicates a long-term effect of changes in water regime that began from the 90's. In natural, not disturbed habitats, the number of species is also stabilised [Czerepko 2008]. In „Olszyna" there are more and more forest species from *Querco-Fagetea* class, which is explained by Czerwiński as a process leading to the formation of oak-lime-hornbeam forest connected with decreased groundwater level and peat mineralisation. An effect of habitat drainage is a rapid loss of *Phragmitetea* and *Molinio-Arrhenetheretea* species. This is also a result of limited amount of light reaching the undergrowth. The canopy here is very dense, and the effect is also supported by high density of *Sambucus nigra* growing in the undergrowth.

Preventing negative changes in alder forests is difficult because it requires actions covering whole watersheds [Pawlaczyk 2004]. In big agglomerations possible actions are limited. Wetland habitats suffering negative changes require regeneration aimed at bringing them back to a condition as close as possible to the natural one [Kloss 2001]. Thanks to the system of ditches and reservoirs, a fragment of the valuable ecosystem was preserved. Although it allowed to keep the groundwater level not affected by the investments, severe vegetation changes still occur in the ecosystem. This is because of the lack of spring floodings which are necessary for alder forests proper functioning. Positive effects achieved in short-term scale, such as preserving groundwater level, are not always followed by long-term processes occurring in restored ecosystems, as it is in the case of the investigated area.

CONCLUSIONS

1. Water system applied in „Olszyna" Park caused significant changes of water flow in this object. However, it has provided a certain protection against severe dewatering effect of the neighbouring infrastructure. On the other hand, lack of spring floodings causes improper functioning of the alder forest ecosystem.
2. Soil chemical analysis showed significant loss of potassium. Analysis of water showed increase of sulphates and decrease of iron content.
3. Phytosociological analysis indicates loss of *Phragmitetea* class species along with increased number of forest and meadow, but mostly ruderal plant species. General condition of the forest can be assessed as good, however vegetation changes are directed to become oak-lime-hornbeam forest.

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EFEKTY RENATURALIZACJI SIEDLISK HYDROGENICZNYCH W ZESPOLE PRZYRODNICZO-KRAJOBRAZOWYM „OLSZYNA" W WARSZAWIE

Streszczenie. Ekosystemy zbliżone do naturalnych, występujące w granicach dużych miast, mają unikalny charakter. Stanowią wyspy siedliskowe dla rzadkiej często roślinności. Z tego względu zachowanie reliktowych siedlisk, podobnie jak zabytkowych obiektów architektonicznych, ma istotne znaczenie dla zrównoważonego funkcjonowania przestrzeni miejskiej. Celem niniejszej pracy było określenie zmian w siedlisku i roślinności łęgu olszowo-jesionowego, znajdującego się w obrębie Zespołu Przyrodniczo-Krajobrazowego Olszyna w Warszawie, gdzie podczas prac inżynierskich w latach 70. stworzono system odwadniająco-nawadniający. Badania zmian w roślinności prowadzono w latach 2006–2007. Uzyskane wyniki odniesiono do wcześniejszych obserwacji, które były prowadzone w latach 70. i 90. XX w. Higrofilna roślinność zadrzewień łęgowych, po obniżeniu się zwierciadła wody w wyniku postępujących inwestycji (sąsiedztwo Trasy Toruńskiej), przekształca się stopniowo w zbiorowisko mezofilne. Pomimo istniejącego systemu rowów do piętrzenia zwierciadła wody, podtrzymanie prawidłowego funkcjonowania ekosystemu łęgowego jest niemożliwe. Brak wiosennych zalewów powoduje niekorzystne od około 20 lat przekształcenia roślinności. Zanotowano zwiększenie liczby gatunków, przy czym sukcesywnie przybywa gatunków synantropijnych. Tendencje zmian w diagramie DCA wykazują charakter liniowy.

Słowa kluczowe: ekosystem hydrogeniczny, urbanizacja, roślinność, bioróżnorodność, odbudowa ekosystemu