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# IMPORTANCE OF THE BUFFER ZONE OF THE WATER INTAKE FOR THE MAINTENANCE OF AGROSYSTEM PHYTODIVERSITY

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## ABSTRACT

A change of the agricultural policy in Poland after 1990 caused significant changes in the structures of the agricultural landscape functioning in the area of West Pomerania (Pomorze Zachodnie). The field fragments, which had been in a form of barren land in the protective zone of Miedwie Lake for 30 years, were chosen for the detailed phytosociological studies. The aim of the current study was the analysis of anthropogenic impacts on flora in the surveyed terrain. In the studied area, the values of the synanthropization indices of the flora were as follows: synanthropization - 2.58, apophytisation - 2.0, anthropophytisation - 0.56, archaeophytisation - 0.38, kenophytisation - 0.16, and fluctuation changes in the flora - 0.04. It is assumed that the larger the share of nonsynanthropic species, the larger the naturalness of the flora inthese biotopes. The large values for the apophytisation index showed degradation in natural habitats A large share of anthropophytes indicates dominance of the processes of a decline in native species in a given biotope, which means that there are disturbances of the ecological balance of a given ecosystem. The 30 year cessation of agricultural use around the lake resulted in the improvement of the chemical state of waters. A significant role in stopping water runoff played dense sodification of the surveyed area. The state of the flora found in this area was influenced by both natural and anthropogenic factors. This is proved by thedominance of synanthropic over nonsynanthropic, and spontaneophytes over anthropophytes species.

**Keywords**: *intake protection buffer, flora, biodiversity, agroecosystem, Poland.*

## INTRODUCTION

Economic changes that occurred in Poland in the 1990s caused a significant transformation of the agrocenoses structure. In the area of West Pomerania, in particular, treated as feed area, the so-called polders, the area of meadows used has been dramatically reduced (Kochanowska, 1981). Many of these abandoned grasslands degraded, as a result of failure to perform mechanical treatments and fertilizing, - turning into worthless natural hairgrass or tall herb terrains (Kochanowska and Rygielski, 1994; Kochanowska, 1997).

The area of arable land has also changed. In order to protect drinking water intakes, as a result of the increasing pollution of surface waters, many field areas were excluded from use, ordering the compliance with numerous decrees and restrictions related to land and water use. A similar action was undertaken on the banks of Lake Miedwie - a reservoir of drinking water for 400 thousand residents of Szczecin. On the fertile soils around the lake, cereal crops, mainly wheat, were abandoned.

Currently, the fallowed area in Poland accounts for 20% of arable land. Natural succession of plants takes place on the abandoned fields, which gradually, increasing the growth over the surface become a protective buffer – they capture any excess of nutrients and all types of poison getting into the habitat or already present in there. This vegetation is one of the components most strongly related to all elements of the natural environment, that is why it is so frequently used to study the structure and the functioning of the whole environment (Roo-Zielinska *et al.*, 2011).

The phytodiversity of fallow land depends on many factors: soil type, degree of anthropopressure, the time of fallowing (Żarczyński *et al.*, 2008;Ziemińska-Smyk *et al.,* 2015). The species composition can serve to assess the degree of habitat synanthropization with the use of such anthropogenic indicators, as naturalness of flora, synanthropization, apophytization, archeophytization, and kenophytization. They allow to make an assessment of anthropogenic changes in time of the flora, and to set out the direction and rate in a given area being under the influence of a specific anthropogenic factor (Kutyna and Malinowska, 2011, Jírová *et al.*, 2012). In the last twenty years, it has become very important to block the process of synanthropization of plant communities, and to restore the ecological balance. These tasks were to prevent the degradation of agrocenoses diversity (Holzel *et al.*, 2012). The purpose of the research was to evaluate the transformation of the protection zone by analyzing indicators of flora synanthropization at a field fragment which had been fallow for 30 years.

## MATERIAL AND METHODS

Between 2002-2003 and 2015 field flora research was conducted in the protection zone of a water intake on Lake Miedwie (West Pomeranian Region, Poland). Between 2002 and 2003 studied of the flora species which was verified in the year 2015.A part of the fields (7.1 hectares) set aside for 30 years (Fig. 1) was selected to assess the degree of transformation of the flora in the protection zone. The test area is located between the two towns Szczecin and Stargard. It covers an area of grasslands located around the lake Miedwie. In the neighborhood there is an area single-family housing.

Floristic inventories were made in the area studied, which were used to calculate the indicators of flora synanthropization, ie.:naturalness, synanthropization and proper and potential apophytisation, and archeophytisation and kenophytisation (Jackowiak, 1990). The value of the synanthropization index of (total $S_t$/ permanent $S_p$) flora showed the extent of the impact of human activity on the studied flora. Apophytisation index od (total $Ap_t$/ permanent $Ap_p$) flora determines the ability to maintain and spread of native species from habitats that have arisen and remain through human activity. Large values of indicator sindicate that the synanthropization process wasassociated with the transformation of natural habitats.The values ofthe antropophytisation index (total $An_t$/ permanent $An_p$) the presence of alien geographical species in the flora. Archeophytisation index of flora (total $Ar_t$/ permanent $Ar_p$) expresses the percentage of archeophytes (species that arrived in Europe before 1500 year) in the total flora.Kenophytisation index (total $Kn_t$/ permanent $Kn_p$) determines the degree of transformation occurring in plant communities. It determines the percentage of the "younger newcomers" in the flora of the total habitat. Index fluctuaction changes (F) in the flora antropophytes determines the percentage of diaphytes. Index defines the sharediaphytes throughout flora (Sp + A). Participation diaphytes within antropophytes testifies to the high lability floristic surveyed phytocoenoses.

$$S_t = \frac{Ap+A}{Sp+A} \times 100\%,\ S_p = \frac{Ap+M}{Sp+M} \times 100\%;\ Ap_t = \frac{Ap}{Sp+A} \times 100\%,\ Ap_p = \frac{Ap}{Sp+M} \times 100\%;$$

$$An_t = \frac{A}{Sp+A} \times 100\%,\ An_p = \frac{M}{Sp+M} \times 100\%\ ;\ Ar_t = \frac{Ar}{Sp+A} \times 100\%,\ Ar_p = \frac{Ar}{S+M} \times 100\%;$$

$$Kn_t = \frac{Kn}{Sp+A} \times 100\%,\ Kn_p = \frac{Kn}{Sp+M} \times 100\%;\ F = \frac{D}{Sp+A} \times 100\%$$

Ap – apophytes = synanthropic spontaneophytes, Sp – nonsynanthropic spontaneophytes, A – antropophytes, Ar = archeophytes, Kn = kenophytes, D – diaphytes, M – metaphytes

The flora was classified according to the forms of space use, socio-ecological along with geographical and historical groups (Chmiel, 2006).

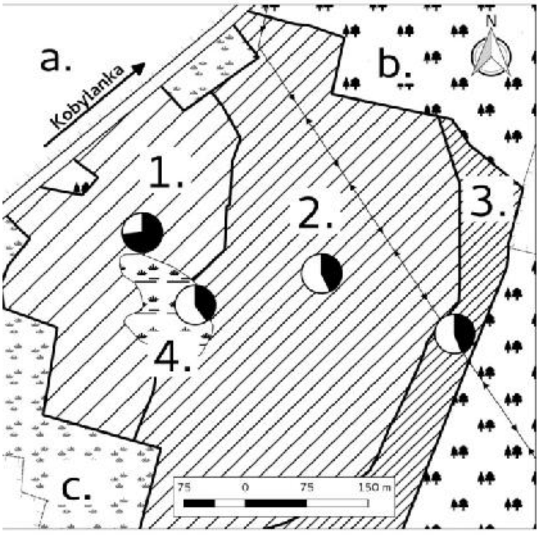


Figure 1. Location of the studied area
a. – buildings, b. – forests, c. – wet meadows; 1-4 habitats; ○ participation *Poaceae* species relative to the *Fabaceae*

## RESULTS AND DISCUSSION

In consequence of political and economic transformations that occurred in the late 1980s and in the 1990s, a lot of fallow land appeared in the agricultural landscape in Poland, which is subject to spontaneous secondary succession, leading to the formation of numerous plant communities (Adamczyk and Kurzyp, 2014). In the studied site, the abandoned cultivation of cereals contributed to primary succession, or a sequential change in the combination of plants species in places previously unoccupied by vegetation. 157 species of vascular plants, altogether were found out here which belonged to 43 families. *Asteraceae* (16%), *Poaceae* and *Fabaceae* (12% each), as well as *Rosaceae* were most abundantly represented. Research after 15 years showed no significant differences in the floristic composition A similar share of species within the largest syntaxonomic groups was shown by Ziemińska-Smyk *et al.* (2015) in the segetal flora of rendzine soil near Zamość. These authors have noted 130 species, belonging to 30 families, of which the most represented were *Asteraceae, Fabaceae*, *Poaceae*, *Lamiaceae*, *Scrophulariaceae* and *Brassicaceae*.

The increase in the phytodiversity of fallow land is related to the duration of being set aside. Much more taxa occurred in areas with a long-term human failure to act than in case of several years (Marks *et al.*, 2000). The more diverse the phytocenoses were, the more intensive soil respiration took place. That is why, the highest values were proven on the fallowed soils - 1185 g C $m^{-2}$, then, in communities of single season grasses - 1020 g $m^{-2}$ and crops of soybeans and corn - 750 g C $m^{-2}$. Areas strongly overgrown featured better soil breathing than crop fields, which indicates a greater soil biological activity in these habitats. By the same, these areas can act as a buffer in relation to stress factors (Tufekcioglu*et al.*, 2001).Numerous research studies are undertaken in relation to the forecast of the plant succession as a possible manner to restore degraded or heavily transformed land. Research carried out on the succession of communities by Jírová *et al.* (2012) after 30 years showed that a spontaneous natural succession of plants quickly occupies the areas previously characterized by low intensity farming. Only in such areas, is there a wealth of seeds of plant species appropriate for given soil habitats. Floristic composition of the studied area of fallow land proves its substantial phytodiversity, confirmed by a diversified pool of seeds of 72 species associated with meadows complex, 44 forest species, 24 segetal and 17 ruderal species. For 15 years the species of forest habitats have significantly increased occupied space Fallows sown over with perennial plants (perennials such as *Galega orientalis*) start more frequently the movement of nutrient elements and incorporate them into circulation than the natural vegetation of the fallow dominated by therophytes (Żarczyński *et al.*, 2008). However, attention must be drawn to maintaining an adequate variety, as the dominance of papilionaceous plants may cause a risk of nitrates (V) transmission into groundwater. This is prevented by the presence of grasses e.g. *Bromus inermis*. In the study on the fallow in the protection zone of lake Miedwie, perennial plants, including hemicryptophytes accounted for 53%,

phanerophyte 10%, chamephytes 3%, cryptogams 10%, and therophytes 24%. Such a share of the perennial plants prevents soil nutrients from being washed out and thus protects the water in the lake against any degradation of quality.
The environment can be evaluated on a landscape scale, with the use of landscape indicators (matrix) of assessing synanthropization (Solon, 2002). It is worth noting that even a partially depleted vegetation does not lose its indicator value. Basic indicators: synanthropization, apophytisation, antropophytisation, archeophytisation, kenophytisation, fluctuation changes in the flora were used in the studied area to assess the degree of changes in the landscape.
Flora synanthropization is defined as a whole of changes in vegetation caused by human activity (anthropopressure). It is featured by native elements being driven away by foreign, cosmopolitan ones. It consists of two processes taking place paralelly - apophytisation and antropophytisation. The apophytisation is an earlier process of changes in phytocenoses as it is associated with the original forms of anthropopressure. Its essence has been the transition of native species from natural habitats to anthropogenic ones. In the studied site of fallow land, the native species, i.e. apophytes and spontaneophytes dominated (21 and 95 respectively). The values of synanthropization indicators of flora ranged from 0.04 to 4.76 (Table 1).

Table 1. Synanthropization index.

| Index | The value of the study area |
|---|---|
| Synanthropization index of total flora/ permanent | 2.58/2.64 |
| Apophytisation index of total flora/ permanent | 2.00/2.08 |
| Anthropophytisation index of total flora/ permanent | 0.58/0.56 |
| Archeophytisation index of total flora/ permanent | 0.38/0.39 |
| Kenophytisation index of total flora/ permanent | 0.16/0.17 |
| Indicator of fluctuactions changes | 0.04 |

**Source: Own results*

It is assumed that the greater the share of non-synanthropic species, the greater the natural flora of a given biotope. Large values of apophytisation indicators signal the transformation of natural habitats, and a large share of antropophytes shows the prevalence of processes of native species regression in a given habitat, which is evidence of an ecological balance disturbance of the ecosystem.
Floristic research of Kutyna (Kutyna and Malinowska, 2011) on a dozen or so years old fallow of winter cereals in the south-western part of Szczecin Lowland and a fragment of Drawskie Lake Land showed 286 taxons (number of flora

species), at an indicator of naturalness of 4.5 and respectively 4.6, and archeophytisation 18.6 and 16.0 respectively, and kenophytisation 4.2 for both regions. The high values (generally exceeding 90%) of the sustainability rate of the total flora testify to relative stability of the floristic composition of communities of long-term fallows.

Following the rapid invasion on Zamość fallow rendzine soil, such segetal species as *Consolida regalis, Cichorium intybus, Sinapis arvensis,* and *Papaver rhoeas*, were defined as threatening to the biodiversity (Ziemińska-Smyk *et al.*, 2015). In the studied area, due to the occupied area, 49 species showed the most dynamic trends - as strongly expansive individuals.

The anthropogenic factors associated with various forms of space being used have an impact on the abundance and expansiveness of individual species. They can influence positively or negatively a given taxon (Table 2). 96 species having positive influence on the forms of use of space were shown to exist in the studied area, including 79 species with the only positive effect. These were, for example *Anthriscus sylvestris*, *Chelidonium majus*, *Urtica dioica*having an impact on most forms. There were 82 species negatively affecting the space, including 62 species with the only negative effect. These included among other things: *Agrostemma githago*, *Alium rotundom*, *Anagalis arvensis*, *Armeria elongata*, *Bromus mollis*, *Bupleurum rotundifolium*, *Cardamine pratensis*, *Chrysanthemum segetum*, *Ononis spinosa*, *Erigeron canadensis*, *Erysimum diffusum*, *Euphorbia helioscopia*, *Fallopia convonvulus*. Of all the forms of use of the space **(**agriculture; communication; forestry; recreation,urbanization), agriculture had the greatest impact (115 species („+”36 /„-“79 species), next forestry 56 (35/3) and communication 51 (51/0), and the leastinfluences positively urbanization (26) and recreation (19).

Too intensive farming led to the degradation of natural vegetation and the unification of species composition. The recreation and holiday makers did not have such a material adverse effect on vegetation. All forms of space use had a positive impact on the inventory of the species and stimulated the expansiveness of a large group of synanthropic species. These results come from the complexity of impacts. Several factors of space use affect one species. Furthermore, the efficiency of anthropogenic factors may have been strengthened or shielded by natural elements. Only owing to natural features of habitats can there gather numerous native species. However, all elements geographically foreign shaped by anthropogenic factors are not wanted (Krupa, 2010).

Table 2.The impact of the forms use the resources of the species.

| Flora | The impact of use | |
|---|---|---|
| | „-” | „+” |
| *Anthriscus sylvestris, Chelidonium majus, Trifolium repens, Urtica dioica* | - | UAFCR |
| *Lolium perenne, Senecio vulgaris, Stellaria media, Taraxacum officinale,* | - | AUCR |
| *Amaranthus retroflexus, Artemisia vulgaris, Capsella bursa-pastoris, Convonvulus arvensis, Dactylis glomerata, Melandrium album, Plantago major, Polygonum aviculare* | - | AUC |
| *Allaria officinalis, Galium aparine, Oxalis europaea, Rumex obtusifolius* | - | AUF |
| *Festuca rubra, Galium mollugo, Potentilla reptans, Viola arvensis* | - | AFC |
| *Calamagrostis epigejos, Convallaria majalis, Holcus mollis, Geranium robertianum,Lapsana communis,Lupinus polyphyllus, Stenactis annua,* | - | FR |
| *Achillea millefolium, Agropyron repens, Arrhenatherum elatius, Heracleum sphondylium, Leontodon autumnalis, Plantago lanceolata 6* | - | CA |
| *Berteroa incana, Melilotus album, M. officinalis* | - | CR |
| *Alopecurus pratensis, Acorus calamus,Lycopus arvensis, Potentilla anserina, Phalaris arundinacea, Phleum pratense,Trifolium pratense* | - | A |
| *Artemisia absinthium,Chenopodium album, Matricaria chamomilla,Poa trivialis, Solidago gigantea, Tripleurospermum inodorum* | - | U |
| *Bromus sterilis, Echium vulgare, Lotus corniculatus, Oenothera biennis, Sedum acre, Tanacetum vulgare, Jasione montana,* | - | C |
| *Acer platanoides c, Betula pendula a, c, Crataegus monogyna c, Fraxinus excelsior c, Helichrysum arenarium, Juncus effusus,Padus avium b, Pinus sylvestris b, c, Pirus communis c, Populus tremula a, c, Prunus cerasus c, Prunus spinosa b, Quercus robur a, c, Rosa canina b, Rubus caesius c, Salix cinerea b, Solidago virgaurea, Syringa vulgaris c, Ulmus minor* | - | F |
| *Anchusa officinalis, Carex hirta, Cerastium arvense, Coronilla varia, Daucus carota, Equisetum arvense, Euphorbia cyparisias, Galium verum, Hieracium pilosella, Hypericum perforatum, Lathyrus pratensis,Linaria vulgaris,Pimpinella saxifraga, Ranunculus acris, Trifolium arvense,Veronica chamaedrys, Vicia cracca* | A | C |
| 3 species negatively affects agriculture and forestry, 59 species negatively affects agriculture | | |

A –agriculture, C – communication, F –forestry, R – recreation, U – urbanization, a – trees, b- bushes, c – herbs (phase of growth of bush)

The species response to the forms of the space use can be interpreted in conjunction with other indicators, as the features of pressure on the environment (Roo-Zielińska *et al.,* 2011). In terms of compliance of the fallow studied with its buffer function, the fallow studied was divided into 4 habitats (Fig. 1). Of these, three (1 - dominated by *glaucae* species 2 – by meadow plants and 3 – by scrubs) demonstrated the appropriate ratio of grasses - fulfilling a protective role - to the number of legume plants which increase the fertility of soil (1 – 14/11, 2 – 12/9, 3-10/8).

Changes in the structure of Polish landscape caused by new political or economic view, were to counteract the degradation of biodiversity. The main objective of the conservation and ecological research is to explore and anticipate further successional vegetation and to develop methods to drive them towards the desired habitats and ecosystems (Holzel *et al.*, 2012). However, the natural succession of plants should be aided in the form of sowing or seeds in consequence of a significant transformation of soils, occurring in many agricultural regions (Jírová *et al.,* 2012).

## CONCLUSION

The establishment of a protection zone around the lake waters Miedwie - which is a drinking water reservoir for Szczecin - hindered the process synanthropization plant communities. Low values of synanthropization and high apophytisation are evidence of slight invasion of synanthropic species. A significant share of grass on the fallow under study contributes to its role of buffer zone - lake water protection being fulfilledand thus the area of research is in the ecological balance.

## REFERENCES


Adamczyk J., Kurzyp R. (2014). Using of fallows in agricultural lanscape in planning of ecological architecture. Journal of Civil Engineering, Environment And Architecture JCEEA, 31, 61 (3/II/14): 9-17.

Chmiel J. (2006). Spatial diversity of flora as the basis for nature conservation in the agricultural landscape. Prace Zakładu Taksonomii Roślin Uniwersytetu im. Adama Mickiewicza, Poznań. Wydawnictwo Naukowe Bogucki, 14: 250.

Holzel N., Buisson E., Dutoit T. (2012). Species introduction a major topic in vegetation restoration. Applied Vegetation Science, 15: 161–165.

Jackowiak B. (1990). Anthropogenic transformation of the flora of vascular plants of Poznan. Wydaw. Naukowe im. Adama Mickiewicza, Poznań., Ser. Biol. 42: 232.

Jírová A., Klaudisová A., Prach K. (2012). Spontaneous restoration of target vegetation in old fields in a central European landscape: a repeated analysis after three decades. Applied Vegetation Science, 15: 245–252.

Kochanowska R. (1981). The dynamics of the development and growth of some grass species in different habitat conditions. Rozprawy Naukowe, 115, AR w Poznaniu: 3-62.

Kochanowska R. (1997). Natural consequences of the regress of the economy meadow Western Pomerania.Przegląd Przyrodniczy, VIII-1/2: 73–76.

Kochanowska R., Rygielski T. (1994). Changes and threats meadow ecosystems as a resultof human pressure. Wiadomości Melioracyjne i Łąkarskie, 1: 40–42.

Krupa A. (2010). Landscape protection in agri-environmental program. Wydawnictwo Biblioteczka Programu Rolno-środowiskowego 2007-2013, Warszawa: 20.

Kutyna I., Malinowska K. (2011). Geographical and historical structure of the flora communities of winter crops cultivation and of a dozen year old fallow. Folia Pomeranae Universitatis Technologiae Stetinensis Agricultura, Alimentaria, Piscaria et Zootechnica, 283 (17): 31–40.

Marks M., Nowicki J., Szwejowski Z. (2000). Uncultivated land and fallow in Poland. Reasons for resting and accompanying phenomena. Fragmenta Agronomica1:6–19.

Roo-Zielińska E., Solon J., Degórski M. (2011). The use of environmental indicators to assess the state and changes in the geographical environment. Wydawnictwo Instytutu Geografii i Przestrzennego Zagospodarowania, PAN, Warszawa: 49–87.

Solon J. (2002). Evaluation of landscape diversity on the basis of the analysis of the spatial structure of vegetation. Wydawnictwo Prace Geograficzne, Warszawa: 185.

Tufekcioglu A., Raich, J.W., Isenhart, T.M., Schultz, R.C. (2001). Soil respiration within riparian buffers and adjacent crop fields. Plant and Soil 229(1): 117–124.

Ziemińska-Smyk M., Wyłupek G.T., Skwaryło-Bednarz B. (2015). Flora in abandoned fields and adjacent crop fields on rendzina soils in the Zamość region. Acta Agrobotanica, 68(3): 197–203.

Żarczyński P., Sienkiewicz St., Krzebietke S. (2008). Accumulation of macroelements in plants on newly established fallows. Journal of Elementology 13(3): 455–461.