POLISH ACADEMY OF SCIENCES • MUSEUM AND INSTITUTE OF ZOOLOGY

# MEMORABILIA ZOOLOGICA

| MEMORABILIA ZOOL. | 49 | 99–113 | 1994 |
|---|---|---|---|

Jerzy SOLON

## Vegetation differentiation and its changes in the Warsaw suburban zone - a general review

**Abstract.** Potential natural vegetation of the Warsaw voivodeship includes 15 types: *Peucedano-Pinetum*, *Leucobryo-Pinetum*, *Salici-Populetum*, *Carici elongatae-Alnetum*, *Circaeo-Alnetum*, *Querco-Pinetum*, *Potentillo albae-Quercetum*, *Ficario-Ulmetum typicum*, *Ficario-Ulmetum chrysosplenietosum*, *Tilio-Carpinetum* poor series, *Tilio-Carpinetum* rich series, *Oxycocco-Sphagnetea*, *Cladonio-Pinetum*, *Vaccinio uliginosi-Pinetum*, *Molinio-Pinetum*; but the last four occupy relatively very small areas. On these habitats no less than 100 types of terrestrial plant communities occur which belong to 13 phytosociological classes: *Epilobietea*, *Plantaginetea*, *Artemisietea*, *Phragmitetea*, *Sedo-Scleranthetea*, *Molinio-Arrhenatheretea*, *Scheuchzerio-Caricetea fuscae*, *Nardo-Callunetea*, *Rhamno-Prunetea*, *Salicetea purpureae*, *Alnetea glutinosae*, *Vaccinio-Piceetea*, *Querco-Fagetea*. On the basis of the spatial structure of vegetation it is possible to distinguish 16 regional units, which represent different vegetation landscape types, land use structure and the degree of synanthropization. The Warsaw Suburban Zone is not homogenous from the point of view of its historical development. It is possible to distinguish three different patterns of change.

## INTRODUCTION

Zones of a suburban character are on the increase both in Poland and in other countries. These are specific zones, which concentrate within their area multidirectional human activity, and fulfil a variety of functions. The most important ones include: residential; service and industrial; recreational; and agricultural functions. Within the suburban zone there are clearly defined areas whose functioning undergoes natural cycles of seasonal changes (e. g. agriculture and recreation), and others which are basically independent of those cycles (e. g. industry). The spatial overlapping of regions with varying functions and different dynamics, as well as separate requirements and conditions means that the suburban zone is a conflicting area, characterised by particularly sharply determined divergencies of aims.

From the point of view of socio-economic geography, the concept of the suburban zone is connected with the theory of urbanisation. This is based on the concept of an urban-rural dichotomy or on a concept of a continuum with a diffusional expansion of a complex of urban features (RYKIEL 1977). However, it seems that within that continuum one might distinguish relative discontinuities concerning different aspects of urbanisation, i. e. physiognomical, social, demographic and economic.

There is currently still a lack of agreed and precise criteria which would allow the definition of the extent of suburban zones. Most frequently the boundaries are determined in an arbitrary way by analysing spatial changeability of one or more selected indices related to the human population (e. g. population density, degree of migration, employment structure), agriculture (e. g. share of small-holdings, extent of gardening and fruit-farming, structure of cultivated areas) and urbanisation (e. g. density and types of houses, development of technical infrastructure).

In many works (ZAWADZKI 1979) it is assumed that the range of the suburban zone of Warsaw is identical to the 45-minute isochrone of commuting to work in Warsaw. The area delimited in this way conforms basically with the borders of the Warsaw voivodeship set in 1975. Such spatial borders of the suburban zones have also been accepted in a preliminary way in this paper.

From the point of view of landscape ecology, the suburban zone is a specific ecological pattern (i. e. distinct from the urban and rural ones), characterised by a specific complex of phenomena and processes, and by its pronounced spatial mosaic character (ROO-ZIELIŃSKA, SOLON 1988, 1989). All components of the natural environment change with the level of urbanisation, albeit not at an identical rate. The component most plastic and susceptible to change is the vegetation cover. At the same time this makes it a perfect indicator of the condition of and transformations to the whole natural environment, as well as of the present and future anthropogenic processes and phenomena, connected with the development of the suburban zone.

The suburban zone of Warsaw is particularly interesting. Within it natural patterns occur on which the influence of man is almost invisible. There are also semi-natural patterns, where there is still a dominance of natural mechanisms. Finally there are secondary systems, of varying degrees of dependence on man and with varying durability.

This paper presents basic information about the differentiation of potential and actual vegetation within the Warsaw voivodeship. The connections between vegetation (its character, degree of naturalness and spatial variation), and selected types of human influence are also mentioned briefly.

## TYPOLOGICAL AND SPATIAL DIFFERENTIATION OF VEGETATION IN THE WARSAW VOIVODESHIP

Fifteen types of habitat were identified and correspond with types of potential natural vegetation with different ecological requirements (PLIT 1990): *Oxycocco-Sphagnetea*, *Cladonio-Pinetum*, *Vaccinio uliginosi-Pinetum*, *Molinio-Pinetum* (those four types occupy a very small area), *Peucedano-Pinetum*, *Leucobryo-Pinetum*, *Salici-Populetum*, *Ribo nigri-Alnetum*, *Circaeo-Alnetum*, *Querco-Pinetum*, *Potentillo albae-Quercetum*, *Ficario-Ulmetum typicum*, *Ficario-Ulmetum chrysosplenietosum*, *Tilio-Carpinetum* poor series, *Tilio-Carpinetum* fertile series.

In connection with the variety of habitats and types of land use, the actual vegetation is relatively rich from the syntaxonomical viewpoint, however, it is significantly fragmented. Many communities occupy very small areas (e. g. on the "model zone" of Łomianki with an area of about 38 sq km, the presence of 81 local phytocenones were recorded, of which only about 30 occupied larger areas (SOLON 1988a).

On five model areas studied in detail (KOSTROWICKI 1990) a total of 75 local phytocenones (mappable at the scale 1:10000) were recorded, most frequently of the rank of an association or lower. However, within the borders of the Warsaw voivodeship there are at least 110 local phytocenones, which represent 13 phytosociological classes: *Epilobietea*, *Plantaginetea*, *Phragmitetea*, *Sedo-Scleranthetea*, *Molinio-Arrhenatheretea*, *Artemisietea*, *Scheuchzerio-Caricetea fuscae*, *Nardo-Callunetea*, *Rhamno-Prunetea*, *Salicetea purpureae*, *Alnetea glutinosae*, *Vaccinio-Piceetea*, *Querco-Fagetea*.

Given fragments of the voivodeship differ considerable in syntaxonomical richness despite a general similarity in abiotic conditions and spatial structure of the vegetation. For example, in the model zone of Nieporęt there are 43 local phytocenones representing 11 phytosociological classes, while in the zone of Komorów only 25 phytocenones from 10 classes (Tab. 1).

Table 1. The number of local phytocoenoses on model areas (small-surface patches, treated as parts of vegetation complexes are not taken into account).

| | Łomianki | Karczew | Konstancin | Nieporęt | Komorów |
|---|---|---|---|---|---|
| area (kmq) | 38 | 32 | 69 | 27 | 15 |
| Vegetation Classes: | | | | | |
| *Epilobietea* | 2 | – | – | – | – |
| *Plantaginetea* | 1 | 1 | 3 | 1 | 1 |
| *Artemisietea* | 1 | 1 | 4 | 2 | – |
| *Phragmitetea* | 5 | 3 | 4 | 6 | 6 |
| *Sedo-Scleranthetea* | – | 1 | 2 | 4 | 2 |
| *Molinio-Arrhenath.* | 6 | 3 | 6 | 7 | 4 |
| *Scheuchz.-Caricetea* | 1 | 2 | – | 1 | – |
| *Nardo-Callunetea* | – | – | – | – | 1 |
| *Rhamno-Prunetea* | 1 | 1 | 1 | 1 | 1 |
| *Salicetea purpureae* | 3 | 4 | 3 | 4 | 1 |
| *Alnetea glutinosae* | 2 | 2 | 2 | 2 | 3 |
| *Vaccinio-Piceetea* | 4 | 6 | 2 | 8 | 4 |
| *Querco-Fagetea* | 3 | 4 | 6 | 7 | 2 |

Different types of plant communities are distributed neither randomly nor in a uniform way over the Warsaw voivodeship. Their spatial arrangement depends to a large degree on the distribution of habitats and the dominant directions of land use.

On this basis 16 regions were determined (PLIT 1990), differing both in the domination of given types of potential vegetation (PLIT 1990) and in the actual communities and their spatial distribution (SOLON 1990). The situation and boundaries of various geobotanical regions are shown in Fig. 1.

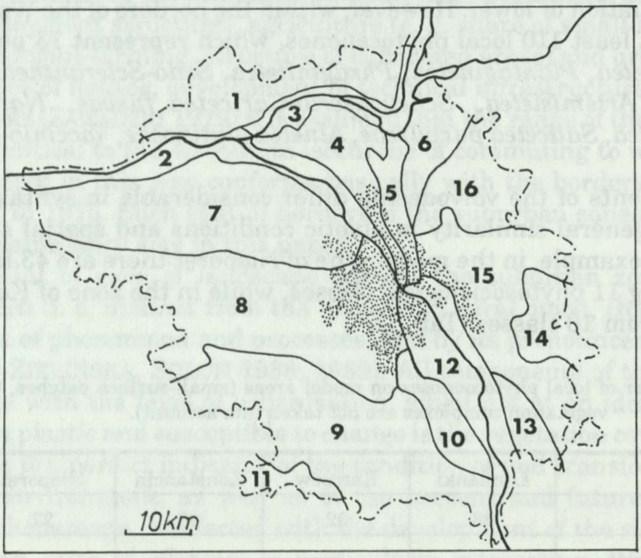


Fig. 1. Geobotanical regionalisation of Warsaw voivodeship (according to PLIT 1990). Dotted area – heavily urbanised areas in Warsaw agglomeration.

## DEGREE AND DIRECTIONS OF ACTUAL VEGETATION CHANGES

Apart from the dominant social function of certain parts of the suburban zone, there are always places differing from these in their utilisation and development. In very simple terms the following types of area can be distinguished:

a. settlement areas;
b. areas of arable land;
c. orchard areas;
d. meadow and pasture areas;
e. forest areas in use;
f. areas of no economic significance.

Over most of the suburban zone there is a clear and regular correspondence between the type of habitat (defined in categories of potential vegetation) and certain types of land development. Settlement occurs most frequently on habitats of the poor series of *Tilio-Carpinetum* and *Querco roboris-Pinetum*. Only in special cases are other habitats also built over. Arable lands are mainly concentrated on the *Tilio-Carpinetum* and *Ficario-Ulmetum* habitat of both fertility type series, only rarely do they play a larger role in the *Querco-Pinetum* habitat. Such a close association does not exist between the habitat and orchard areas. They occur in places which are locally most fertile or most easily accessible. Meadow areas prevail on damp areas and the biggest role is played by them in the *Circaeo-Alnetum* and *Salici-Populetum* habitats and a slightly smaller one on *Ficario-Ulmetum*. Forest areas dominate on dry and slightly less fertile lands. They dominate on the *Leucobryo-Pinetum*, *Peucedano-Pinetum* and *Cladonio-Pinetum* habitats, and a considerable role is played on the *Potentillo-Quercetum* and *Querco-Pinetum* habitat. Areas of no economic rank comprise habitats of *Ribo-Alnetum* and *Vaccinio uliginosi-Pinetum*. On these areas various herbaceous, shrubby and forest communities occur. These are basically not utilised, or used sporadically, but have a particular ecological importance.

This review shows that the most widely used habitats are the *Tilio-Carpinetum* poor series and *Querco-Pinetum*, and to a small extent also *Ficario-Ulmetum*. The range of ways in which an area is used is connected with the number of substitute communities in it (Tab. 2). Over the greater part of all the model areas, dynamic series of substitute communities are most numerous on the *Tilio-Carpinetum* poor series and *Querco-Pinetum* habitats. The number of substitute communities depends not only on the number of land-use types, but also on the size of the analysed habitat. Hence, for example, the dynamic series of substitute communities on the *Tilio-Carpinetum* poor series habitat has at least 26 phytocenones in Łomianki, and in Komorów only seven.

Table 2. The number of substitute phytocoenoses on different habitats (small-surface patches, treated as parts of vegetation complexes are also taken into account).

| | Łomianki | Karczew | Konstancin | Nieporęt | Komorów |
|---|---|---|---|---|---|
| *Salici-Populetum* | 13 | 9 | 12 | 23 | 2 |
| *Ficario-Ulmetum* | 31 | 9 | 14 | 3 | 1 |
| *Circaeo-Alnetum* | 13 | 8 | 12 | 11 | 5 |
| *Ribo nigri-Alnetum* | 8 | 6 | 8 | 7 | 5 |
| *Tilio-Carpinetum*, fertile | 17 | – | 8 | – | 4 |
| *Tilio-Carpinetum*, poor | 36 | 13 | 8 | 16 | 7 |
| *Potentillo-Quercetum* | 1 | – | 7 | 4 | – |
| *Querco-Pinetum* | 31 | 14 | 7 | 20 | 10 |
| *Vacc. uliginisi-Pinetum* | – | – | 2 | – | – |
| *Leucobryo-Pinetum* | – | – | 5 | 4 | – |
| *Peucedano-Pinetum* | 3 | 3 | – | 3 | 1 |
| *Cladonio-Pinetum* | 2 | – | – | – | – |

Different preferences in land use and management were the causes of different levels in the synanthropisation of vegetation in given habitats (Tab. 3). The highest levels of synanthropisation in actual vegetation may be seen in habitats of Tilio-Carpinetum (both fertility series) and *Ficario-Ulmetum*, and also, but to a lesser extent,

Table 3. The degree of vegetation transformation of different habitats (in 5-grade conventional scale: 0 – natural vegetation; 5 – fully anthropogenic vegetation).

| | Łomianki | Karczew | Konstancin | Nieporęt | Komorów |
|---|---|---|---|---|---|
| *Salici-Populetum* | 3 | 2 | 2 | 4 | 2 |
| *Ficario-Ulmetum* | 5 | 5 | 4 | 1 | 3 |
| *Circaeo-Alnetum* | 3 | 3 | 3 | 3 | 3 |
| *Ribo nigri-Alnetum* | 2 | 2 | 2 | 2 | 1 |
| *Tilio-Carpinetum*, fertile | 5 | – | 4 | – | 4 |
| *Tilio-Carpinetum*, poor | 5 | 5 | 4 | 4 | 4 |
| *Potentillo-Quercetum* | 1 | – | 3 | – | 2 |
| *Querco-Pinetum* | 3 | 3 | 3 | 3 | 4 |
| *Vacc. uliginosi-Pinetum* | – | – | 1 | – | – |
| *Leucobryo-Pinetum* | – | – | 2 | 2 | – |
| *Peucedano-Pinetum* | 1 | 2 | – | 2 | 2 |
| *Cladonio-Pinetum* | 1 | – | – | – | – |

Table 4. The number of substitute phytocoenoses and the average vegetation transformation degree in Warsaw Suburban Zone. (a) Conventional scale: 1 – less than 5 substitute phytocoenoses; 2 – from 5 to 10; 3 – from 11 to 15; 4 – from 16–20; 5 – more than 20 substitute phytocoenoses. (b) Conventional scale: 0 – natural vegetation; 10 – fully anthropogenic vegetation. In this case and in all other cases the degree of vegetation transformation (synanthropization) has been calculated using the method of KOSTROWICKI, PLIT, SOLON (1988).

| Habitats | number of substitute phytocoenoses[(a)] | average transformation[(b)] |
|---|---|---|
| *Oxycocco-Sphagnetea* | 1 | 1–2 |
| *Cladonio-Pinetum* | 1 | 1–2 |
| *Vaccinio uliginosi-Pinetum* | 2 | 1 |
| *Molinio-Pinetum* | 2 | 1–2 |
| *Peucedano-Pinetum* | 2 | 2–3 |
| *Leucobryo-Pinetum* | 2 | 2–3 |
| *Ribo nigri-Alnetum* | 3 | 2–4 |
| *Ciraco-Alnetum* | 3 | 4–7 |
| *Potentillo albae-Quercetum* | 3 | 3–7 |
| *Salici-Populetum* | 4 | 1–5 |
| *Ficario-Ulmetum chrysosplenietosum* | 4 | 6–9 |
| *Querco-Pinetum* | 5 | 5–8 |
| *Ficario-Ulmetum typicum* | 5 | 6–9 |
| *Tilio-Carpinetum* poor series | 5 | 6–10 |
| *Tilio-Carpinetum* fertile series | 5 | 6–10 |

in *Querco-Pinetum* and *Circaeo-Alnetum* habitats. The picture of vegetation synanthropisation obtained from very detailed studies of model areas is more or less the same as a picture got from survey studies of the whole suburban zone (Tab. 4).

Changes in vegetation landscapes were and are varied across different habitats and in separate regions. As a result an average degree of vegetation synanthropisation is spatially differentiated (Tab. 5).

Table 5. Changes in vegetation synanthropization over 160 years in different regions (according to PLIT, SOLON 1990a). Regions' numbers correspond to numbers on Fig. 1. Synanthropization level is described in conventional scale: 0 – natural vegetation; 10 – fully anthropogenic vegetation.

| Region | Synanthropisation degree in 1830 | Synanthropisation degree in 1990 |
|---|---|---|
| 1 | 3 | 7 |
| 3 | 5 | 5 |
| 3 | 3 | 4 |
| 4 | 4 | 5 |
| 5 | 3 | 5 |
| 6 | 2 | 4 |
| 7 | 3 | 4 |
| 8 | 8 | 8 |
| 9 | 6 | 7 |
| 10 | 6 | 8 |
| 11 | 4 | 8 |
| 12 | 5 | 5 |
| 13 | 3 | 5 |
| 14 | 4 | 6 |
| 15 | 2 | 6 |
| 16 | 4 | 7 |

Before 1830 the Warsaw agglomeration had developed rather slowly and there was no equivalent to a modern type of suburban zone. Attention should be drawn to the division at this time of the terrain into two distinct parts. The southern and south-western part, covered by fertile habitats, was characterised by a relatively high degree of synanthropisation (6–8). This related to a reasonably high population level, early deforestation and a relatively well developed agricultural economy.

In regions to the north and north-east of Warsaw vegetation had been less altered (synanthropisation level from 2 to 4). Large forests and marshes covered most of the land here. The very low level of changes in the vicinity of the right-bank part of Warsaw is surprising. This may be explained, on the one hand, by a relatively small population in this area, or, on the other, by the barrier to transport which the river forms.

An intermediate degree of vegetation synanthropisation was characteristic for the Vistula river valley, which had been under constant pressure since the Middle Ages, but continuous changes of the river bed made it impossible to create permanent man-made structures.

The present state of vegetation transformation is very different. Regions to the east and north-east of Warsaw have undergone a considerable change (even by 4 units). This is a consequence of changes to the vegetation due to large-scale deforestation and the building of new settlements, particularly along new railway lines, as well as to major habitat changes connected with amelioration and changes to water courses. In areas to the west of Warsaw the index of vegetation synanthropisation increased by just over 1 unit. On the other hand, the Vistula river valley underwent hardly any changes.

## DIVERSITY OF ACTUAL VEGETATION AND SOME OF ITS CONDITIONS

Today's typological and spatial diversity and actual vegetation in the suburban zone of Warsaw is the result of influence of many factors. The most important ones include:

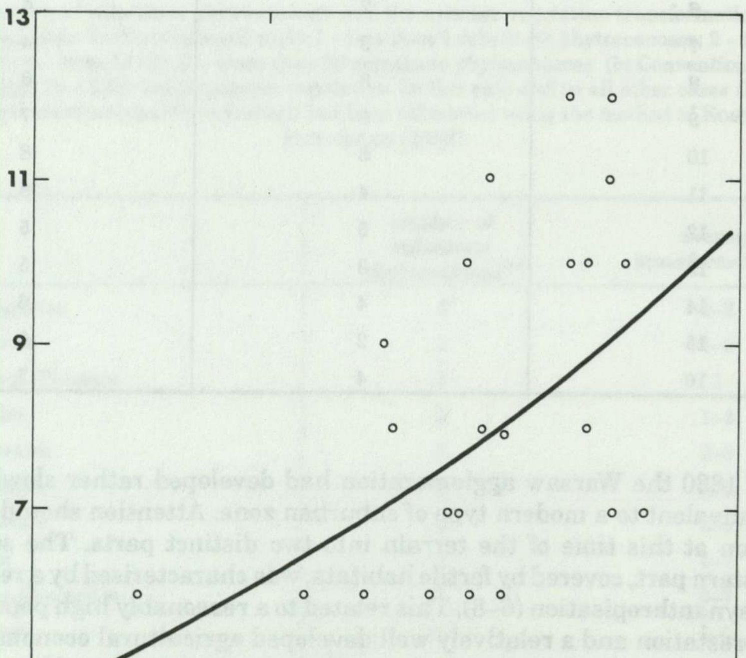


Fig. 2. Relationship between the level of anthropogenic transformation of vegetation (x axis) and the number of phytocoenoses within vegetation complexes (Y axis) in Łomianki commune. Y=EXP(a+bX); a=1.014; b=0.134; correlation coefficient=0.52.

a. character and distribution of various forms of land use, which as a consequence defines the level of anthropogenic deviation of vegetational cover;

b. the influence of settlements, which, although destroying the natural vegetation cover, creates in its place new habitats enabling – at least potentially – new communities to spread;

c. durability of the type of anthropogenic influence, which leads to the stabilisation of vegetation character.

The influence of the degree of synanthropisation of discrete vegetation units on the number of various types of plant communities has been analysed at two different levels of accuracy, i.e. within local complexes of phytocenoses in the Łomianki commune (Fig. 2) and – at the review scale – in relation to different types of habitats on four model zones (Fig. 3). In both cases there is a statistically significant correlation between the increase in the general degree of vegetation synanthropisation and the increase in the number of types of plant communities. At the same time it is also important to note that the increase in the number of phytocenoses is relatively more rapid in the case of the higher values of the synanthropisation index.

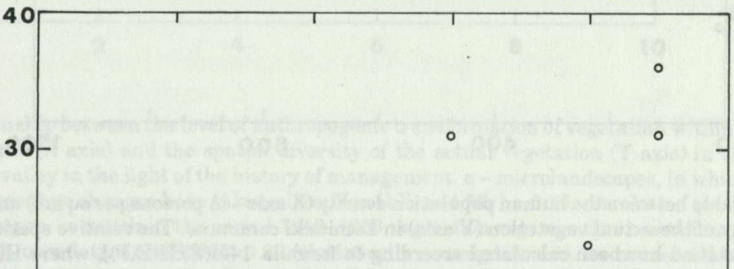


Fig. 3. Relationship between the level of anthropogenic transformation of vegetation (x axis) and the number of phytocoenones on different habitats (Y axis) in four model areas (Łomianki, Konstancin-Jeziorna, Nieporęt and Komorów). Y=EXP(a+bX); a=0.69; b=0.24; correlation coefficient=0.68.

Slightly different dependencies may be observed in an analysis of the influence exerted by the degree of urbanisation of a given area (measured by population density) on the relative diversity of actual vegetation (Fig. 4). Also in this case there is a statistically significant correlation between the increase in the population number and vegetation diversity, but the most rapid changes in vegetation take place at low values in the population density index.

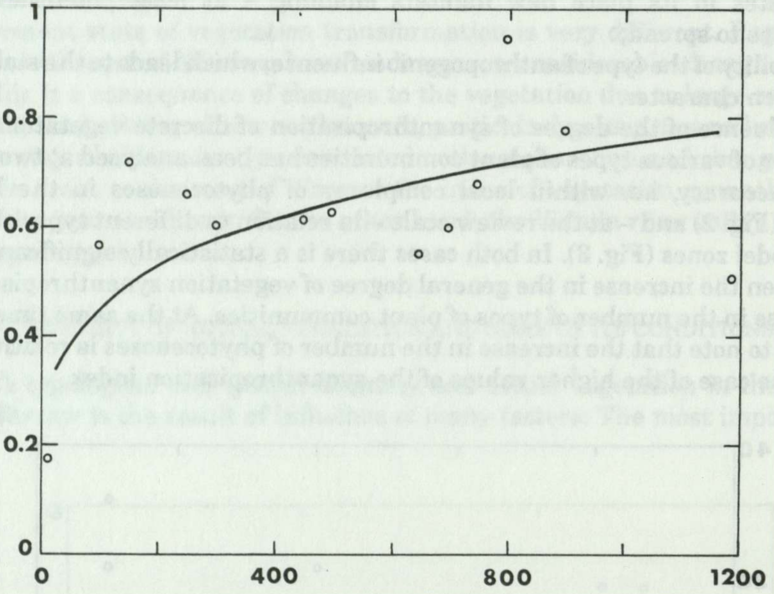


Fig. 4. Relationship between the human population density (X axis – in persons per sq km) and the relative spatial diversity of the actual vegetation (Y axis) in Łomianki commune. The relative spatial diversity of the actual vegetation has been calculated according to formula 1-[H(E):H(E,P)], where H(E) stands for diversity of the potential vegetation, H(E,P) stands for total diversity of actual and potential vegetation. Diversity index has been calculated according to formula $H=\Sigma \log 2p$. $Y=a*X^b$; loga=-1.77; b=0.215; correlation coefficient =0.81.

Vegetation diversity (measured in any desired way) is not always so clearly correlated with anthropogenic influences as it is in the examples given above. As has already been mentioned, land-use history plays a big part. An excellent example of those dependencies is given by the Vistula river valley within the Konstancin-Jeziorna commune. By comparing detailed maps of vegetation made in 1948 and 1988, several landscape units were delimited, differing in the direction and intensity of vegetation transformations (PLIT, SOLON 1990b, 1991). It turned out that in microlandscapes, in which a regeneration of vegetation took place, there is a weak positive correlation between the present degree of synanthropisation and diversification of the vegetation. On the other hand, in microlandscapes, in which either degeneration took place, or dynamic contrasting of vegetation, or no changes at all, there is a statistically significant dependence with an opposing character, i.e. higher values in the synanthropisation index are accompanied by a lower level of diversity in actual vegetation (Fig. 5).

A separate problem is the change of physiognomic diversity of various parts of the suburban zone. It may be described in an indirect way on the basis of changes in the length of forest-field and forest-meadow edges. Three basic types of changes, charac-

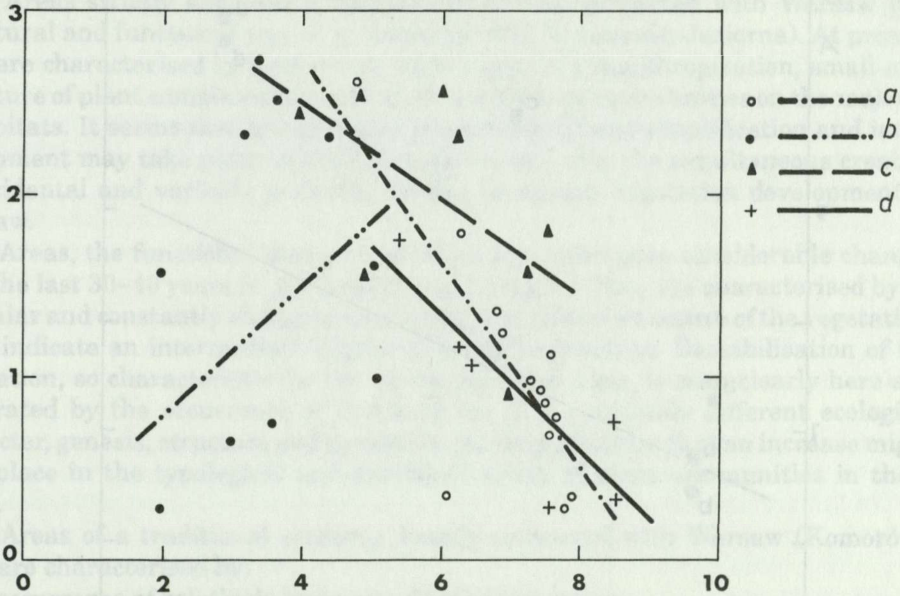


Fig. 5. Relationship between the level of anthropogenic transformation of vegetation within the vegetation microlandscapes (X axis) and the spatial diversity of the actual vegetation (Y axis) in the fragment of Vistula River valley in the light of the history of management. a – microlandscapes, in which in the period 1948–1988 almost no changes have taken place; Y=a+bX; a=4.95; b=-0.55, correlation coefficient=-0.76. b – microlandscapes, in which in the period 1948–1988 vegetation regeneration has taken place; Y=a+bX; a=0.94; b=0.18, correlation coefficient=0.22 (statistically non-significant). c – microlandscapes, in which in the period 1948–1988 vegetation degeneration has taken place; Y=a+bX; a=3.56; b=-0.27, correlation coefficient=-0.58. d – microlandscapes, in which in the period 1948–1988 both regeneration and degeneration of vegetation have taken place; Y=a+bX; a=3.55; b=-0.37, correlation coefficient=-0.87.

teristic of various areas of the suburban zone of Warsaw are shown in Fig. 6. The first is connected with areas on which relatively large and dense forest complexes occur and on which in recent years no major changes have taken place in land use (e. g. the model region in Komorów). In such cases changes in forest area and the length of various types of edges have not undergone major changes, although one may observe a slight tendency towards a decrease in the forest-field edge.

The second type of change is connected with insignificant growth in or losses of the forest area, which is accompanied by an increase in the length of the forest-meadow edge and a decrease in the length of the forest-field edge length. Such types of changes, characteristic among others for the model regions of Łomianki and Nieporęt are primarily the result of a change in the spatial structure of arable lands, and in particularly to a decrease in the area occupied by cultivated land.

The third type of change, seen for example in the valley of the Vistula river, is connected with a slow renaturalisation of the environment. It is characterised by the creation of new afforested areas, mainly very elongated in shape. This leads as a consequence to a marked increase in the length of forest-field and forest-meadow

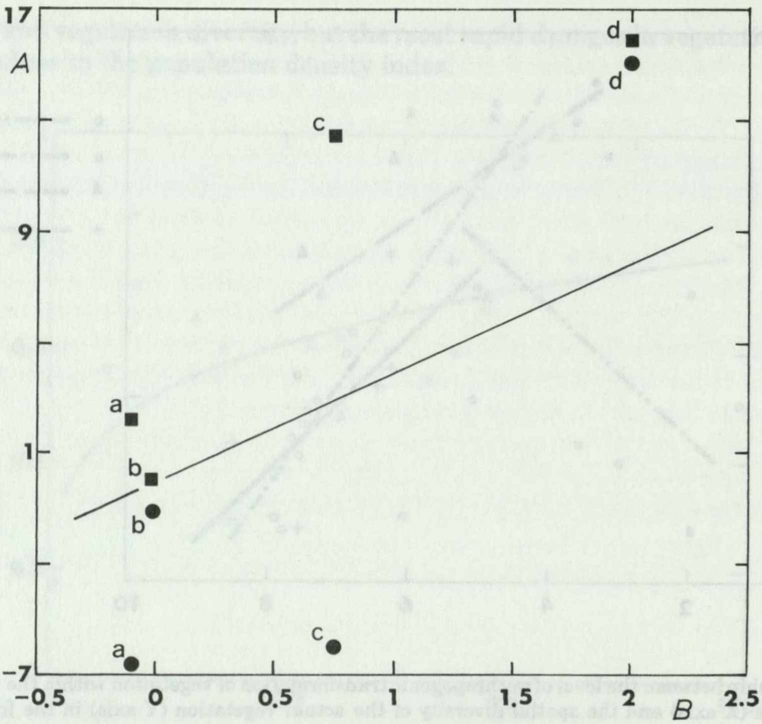


Fig. 6. Relationship between changes in afforested area (B axis – in sq km) and changes of the length of forest-field edge and forest-meadow edge in four model areas (a – Nieporęt, years 1960–1988; b – Komorów, years 1956–1988; c – Łomianki, years 1933–1983; d – Vistula River valley in Konstancin-Jeziorna commune, years 1948–1988). Circles – forest-field border; rectangles – forest-meadow border. The line on figure describes situation in which one rectangular forest complex is added (or subtracted) in the centre of one type of ground cover (field or meadow).

edges in which the increase in the length of the forest-meadow edge is slightly greater.

These examples illustrate several general trends in the suburban zone of Warsaw. In the first place, changes in the type and increases to the intensity of anthropogenic influences are accompanied by an increase in typological diversification of vegetation, while longer periods of unchanged land-use cause a decrease in the phytocenone number. Secondly, the physiognomical structure of vegetation undergoes changes, which is accompanied by a change in the length of forest-field and forest-meadow edges.

## DYNAMIC DIFFERENTIATUON OF THE SUBURBAN ZONE OF WARSAW

The suburban zone of Warsaw (within the voivodeship boundary) has had a varied history of development. It comprises areas of at least three types:

1. Areas strictly and over a long period of time connected with Warsaw in a structural and functional way (e. g. Łomianki and Konstancin-Jeziorna). At present they are characterised by a relatively high degree of synanthropisation, small-area structure of plant complexes and a rich set of substitute communities on the majority of habitats. It seems that in successive years a significant simplification and impoverishment may take place to the vegetation cover, with the simultaneous creation of accidental and variable patterns, similar to current vegetation development in Warsaw.

2. Areas, the functional character of which has undergone considerable changes over the last 30–40 years (e. g. Nieporęt and Karczew). They are characterised by an irregular and constantly changing typological and spatial structure of the vegetation. They indicate an intermediate degree of synanthropisation. Destabilisation of the vegetation, so characteristic for the whole suburban zone, is seen clearly here and illustrated by the occurrence of communities of a completely different ecological character, genesis, structure and dynamics. It seems in future that an increase might take place in the typological and spatial diversity of plant communities in these areas.

3. Areas of a traditional economy, loosely connected with Warsaw (Komorów). They are characterised by:

a. occurrence of relatively large stands of communities;
b. their marked stability;
c. maturity of numerous communities;
d. relatively low synanthropisation of vegetation (although changes in agro- and pratotechnology might as a consequence cause a rapid increase in the proportion of ruderal species and changes to the floristic structure of many communties);
e. less versatile use and development of habitats.

It seems that if the traditional method of use is preserved, the further development of the vegetation landscape might be based on changes of the typological diversity while the present spatial structure is maintained.

Despite indubitable differences numerous attributes of the vegetation exist, common on the areas analysed, and characteristic for the suburban zone. One should mention here among others the evident mosaic type of spatial structure, high ecological physiognomical and syntaxonomical contrastive effect of the vegetation landscape and index of synanthropisation, which is higher than in the case of areas of a clearly rural character.

The changes to the vegetation discussed above represent a certain more general synanthropisation trend in the vegetation cover. In accordance with FALIŃSKI (1972) the synanthropisation process comprises above all:

a. eurytopisation – i.e. substituting of local stenothopic components by eurythopic ones;

b. cosmopolitisation – i.e. the substitution of cosmopolitan components for local and specific ones;

c. allochtonisation – i.e. substituting allochtonic components for autochtonic ones;

d. differentiation and complication – i.e. substituting more complicated patterns for simple ones, but not ones homogenous from the genetical, dynamical, as well as historical and geographical point of view.

These phenomena may be observed at various levels of vegetation cover organisation. At plant community level and that of the vegetation landscape of suburban zones, an effect of eurythopisation is a decrease in the number of and area covered by xero- and hygrophilous communities and the replacement of them by mesophilous ones. Further, the ties between the actual and potential vegetation are loosened, which is particularly clear in the case of ruderal communities, which occur on numerous different habitats.

An effect of cosmopolitisation and allochtonisation of vegetation is the reduction and loss of ranges of autogenic communities and the increase in area and number of anthropogenic ones. In the suburban zone anthropogenic communities frequently account for more than 40% of types (ROO-ZIELIŃSKA, SOLON 1988). They occupy on average about 70% of the whole area, which is more or less evenly divided between ruderal and segetal communities. This is a characteristic phenomenon for the suburban zone, as both in the urban landscape and in the rural landscape the synanthropic vegetation may occupy a similar or even larger area. But in the first case ruderal communities dominate, and in the second segetal ones.

The differentiation and complication of the vegetation landscape cause several mutually connected phenomena, namely:

1. Occurrence of communities respresenting the same syntaxonomical unit, but in various stages of degeneration and differing in their vertical structure, richness and species variety. This causes the existence of stands with various values of the informative richness index (KOSTROWICKI 1982). For example in the area of Białołęka Dworska, within communities of the *Festuco-Sedetalia* order there are stands for which this index reaches the value of 106, and others with a value of 1830, although in most cases values remain in the range 300–700 (ROO-ZIELIŃSKA 1982);

2. Considerable fragmentation of the terrain: per unit area in the suburban zone there is on average 5–10 times more variety in communities than in the agricultural landscape, and about 4–20 times more in comparison with the town centre;

3. Significant increase in the number of local phytocoenones and enrichment of the dynamic series of substitute communities by about 20–50% (at least on habitats of *Tilio-Carpinetum* and *Querco-Pinetum*) in relation to the agricultural and urban landscape;

4. Decrease in the average area of any single phytocoenosis;

5. Change from the predominantly belt-island spatial pattern of communities into a mosaic pattern;

6. Creation of repeatable spatial complexes of vegetation, which embrace communities of different ecological character, differing in origin and in patterns of succession.

## REFERENCES

FALIŃSKI J. B. 1972. Synantropizacja szaty roślinnej – próba określenia istoty procesu i głównych kierunków badań. Phytocoenosis, 1: 157–170.

KOSTROWICKI A. S. 1982. Synanthropization as a result of environmental transformations. Memorabilia zool., 37: 3–10.

KOSTROWICKI A. S. (ed.) 1990. Kształtowanie układów ekologicznych w strefie podmiejskiej Warszawy. Wyd. SGGW-AR, Warszawa, pp. 207.

KOSTROWICKI A. S., PLIT J., SOLON J. 1988. Przekształcenie środowiska geograficznego. Pr. geogr. IGiPZ PAN, **147**: 108–115.

PLIT J. 1990. Charakterystyka siedliskowo-ekologiczna strefy podmiejskiej Warszawy. In: A. S. KOSTROWICKI (ed.). Kształtowanie układów ekologicznych w strefie podmiejskiej Warszawy. Wyd. SGGW-AR, Warszawa, pp. 12–22.

PLIT J., SOLON J. 1990a. Selected developmental problems in the suburban zone of Warsaw. Geogr. slov., **21**: 109–132.

PLIT J., SOLON J. 1990b. Evaluation of the Natural Environment on the basis of vegetation (selected examples from the suburban area of Warsaw). Geogr. slov., **21**: 89–108.

PLIT J., SOLON J. 1991. Long-term vegetation changes – an attempt of cartographic presentation of vegetation dynamics. Phytocoenosis 3 (N.S.), Suppl. Carthographiae Geobotanicae, **2**: 145–157.

ROO-ZIELIŃSKA E. 1982. Struktura geobotaniczna i jej ekologiczno-siedliskowe uwarunkowania terenu przyszłych osiedli mieszkaniowych w Białołęce Dworskiej w Warszawie. Czlow. i Środ., **6**: 403–422.

ROO-ZIELIŃSKA E., SOLON J. 1988. Geo-ecological characteristics of the suburban area of Warsaw – general description and the studies of model areas. Proc. COMECON Conf., Jabłonna, IGiPZ PAN, pp. 45–67.

ROO-ZIELIŃSKA E., SOLON J. 1989. Natural versus anthropogenic changes in vegetation within one of Warsaw's suburbs – the Łomianki commune. Braun-Blanquetia, **3**: 159–164.

RYKIEL Z. 1977. Urbanizacja – ujęcia teoretyczne oraz aspekty procesu. Przegl. geogr., **49**: 27–40.

SOLON J. 1988. A general characteristic of vegetation in Łomianki commune. Pol. ecol. Stud., **14**: 7–21.

SOLON J. 1990. Typologiczne i przestrzenne zróżnicowanie roślinności rzeczywistej. In: A. S. KOSTROWICKI (ed.). Kształtowanie układów ekologicznych w strefie podmiejskiej Warszawy. Wyd. SGGW-AR, Warszawa, pp. 23–33.

ZAWADZKI L. 1979. Strefa podmiejska – wybrane problemy zagospodarowania przestrzennego. Przegl. geogr., **51**: 271–279.

Institute of Geography
and Spatial Organisation Polish Acad. of Sc.
ul. Krakowskie Przedmieście 30
00-927 Warsaw, POLAND