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Changes in the vascular flora of the city and suburban zone of Kielce (Central Poland) and present state

Bożena MACIEJCZAK and Edward BRÓŻ

1. INTRODUCTION

The studies on the city flora were started in Poland as early as the first half of the 19th century; however, they have developed on a greater scale as late as the sixties of the current century (SOWA and OLACZEK 1978).

The first floristic records from Kielce, given, inter alia, by Szubert, Jastrzebowski, Waga, and Berdau, date from the first half of the 19th century. These data were considered later in the synthetic studies by ROSTAFINSKI (1872, 1886) referring to the vascular flora of the Kingdom of Poland.

The most important nineteenth-century study on the flora of Kielce and the nearest neighbourhood (now located within the city limits) was the comprehensive work by DRYMMER (1890), containing an inventory of localities of about 570 species. In the first half of the 20th century several dozen new and rare taxa were recorded from the then suburban areas of Kielce (KAZNOWSKI 1922, 1927, 1928). The authors prepared a detailed inventory of vascular plants of all types of habitats occurring in the area of the city and in its suburban zone. The material collected from 1984 to 1988 is currently being studied. Therefore, the present paper is a preliminary evaluation of the floristic resources and changes in the city and suburban flora. Based on the occurrence of the protected, rare and threatened species in the Swietokrzyski region, an attempt was made to delimit the areas of high floristic values, which should be protected.

2. PHYSIOGRAPHIC CHARACTERISTIC

The area under study occupies 260 km^2, and about 50% of the area is located within the administrative limits of Kielce. It is characteristic of rich orography, diversified topoclimate and varied lithological and soil conditions (KONDRACKI 1978). Within the city and in its suburban areas banded relief (ridge-and-valley) typical of all the Gory Swietokrzyskie Mts. was observed (BROZ 1991). The main part of the city is located in a vast valley.

Kielce is a city with very diversified geological formation (JANKOWSKI and SADOWSKI 1983). The sediment rocks of all links of the Palaeozoic age (ZAREBA 1977) may be found in this area. Here occur mudstone, claystone and sandstone (Cambrian) and also grauwacke and graptolite shale (Sylurian). The greater part of the area is located on the Devonian dolomites, rocky and coral lime and on marl. Among the Mesozoic sediments, in small areas, there occurs mottled Triassic sandstone. The depression of the area and partially the mountain slopes are covered with the coat of Pleistocene formations (sand, clay, loess). In the river valleys the Holocene formations occur (sand, silt, organic aggregations and peats).

Kielce and its suburban zone are hydrographically located in the river basin of the Bobrza and Lubrzanka rivers. There are big water reservoirs and numerous ponds in place of exploited open pits. Climatic conditions of the area are favourable for the vegetation. Mean yearly values are as follow: air 7.3°C, precipitation 656 mm, length of vegetative season 210 days.

3. HISTORICAL OUTLINE

At the beginning of its existence (11th century) Kielce was a small market settlement located amidst the Swietokrzyski forest and swamps (DURCZAK 1975). The process of anthropopression intensified together with the development of the Old Polish Industrial Centre with its centre in Kielce in the 16th century (BROZ 1991). At that period intensive exploitation of natural resources of Kielce and environs started. Dynamic development of metallic mining and Swietokrzyskie smelting industry markedly influenced the development of the urban organism in the 16th and 17th centuries, and, at the same time, it triggered the occurrence of new types of habitats (synanthropic). Carriageable roads (16th century), and especially railway connections (1885) enabled penetration of many plant species, alien to the area. At the beginning of the 19th century the spatial development of the city was planned and a very intensive

economic and spatial development of Kielce has started. In the areas annexed to the city, new housing estates arise and the traffic increases. More and more areas are occupied by vegetation formed by man. In the suburban zone and in the outskirts occurs marked area of cultivated fields. At present, Kielce covers an area of 112 km^2, and the number of inhabitants is 200'000.
The economic and spatial development of the city aggravated the devastation of the natural environment. In the last 20 years, a special role in the degradation of the natural environment was played by the cement-lime industry of "White Industrial Centre", south of Kielce (CIESLINSKI and CZYZEWSKA 1991). This favours the development of anthropogenic communities, and simultaneously, causes rapid decrease in the resources of natural and semi-natural vegetation. In spite of this, fragments of various kinds of forests, grasslands, xerothermic thickets, patches of swamp, peat and meadow vegetation are fairly well preserved in the study area.

4. METHODICAL REMARKS

The inventory of the flora was made after the cartogram method, by dividing the study area into a net of 260 plots of 1 km^2 (Fig. 1). For each square a list of species as complete as possible was provided. Plants of all types of habitats were included in the studies. The total number of thus achieved records was about 87'000.
The substantial field studies, preceded by a several-year introductory examination, were carried out from 1984 through 1988.

5. RESULTS

5.1. GENERAL CHARACTERISTIC OF THE FLORA

The first list of vascular plants, based on the authors' own studies and on literature data, includes 1240 species. At present the occurrence of 1190 species from 103 families has been confirmed. Taking into consideration the fact that the study area is relatively small, its flora should be regarded as exceptionally rich.
The degree of floristic diversity, understood as the number of the taxa on 1 km^2, exhibits marked differentiation in particular squares (Fig. 2). On average 335 species per 1 km^2, and in extreme cases the number of species per 1 km^2 is from 158 (9A) to 625 (3I).

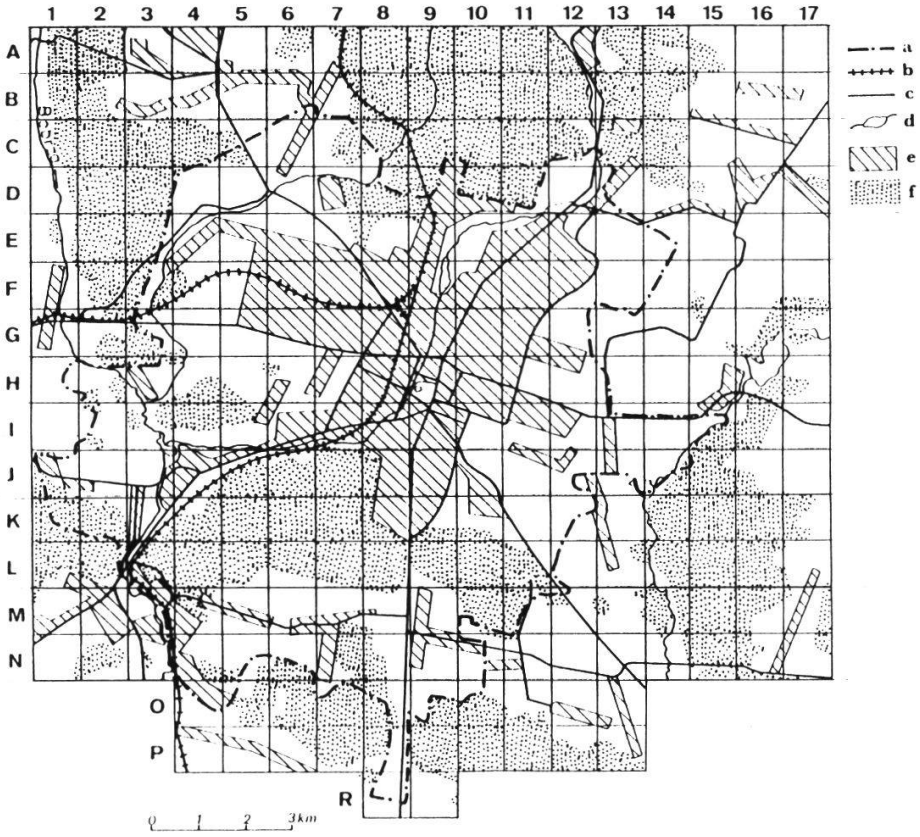

Fig. 1. Spatial division of the city area and suburbs of Kielce and the net of 1 km^2 plots. a - administrative limits of the city, b - railways, c - road and main streets, d - rivers, e - settlements, f - forests.

About 875 (74%) of native species occur in the present composition of the flora. A greater part (c. 420) is exclusively or almost exclusively connected with the ecosystems of natural or semi-natural character; further 370 species, apophytes, are included in the composition of synanthropic vegetation. About 400 taxa (85 apophytes and 315 anthropophytes) solely occur in synanthropic habitats and constitute 33% of the flora.

According to geographic and historic classification of synanthropic plants (KORNAS and MEDWECKA-KORNAS 1986) the composition of adventive flora was characteristic of the following groups: archeophytes (32%), epoecophytes (13%), agriphytes (10%), ephemerophytes (6%) and ergasiophygophytes (39%). The proportion of particular groups of anthropophytes is similar to that in other cities of Poland (MACIEJCZAK 1988, SOWA and WARCHOLINSKA 1984, TRZCINSKA-TACIK 1979).

Apart from typical synanthropic plants, another ecological group of 290 taxa

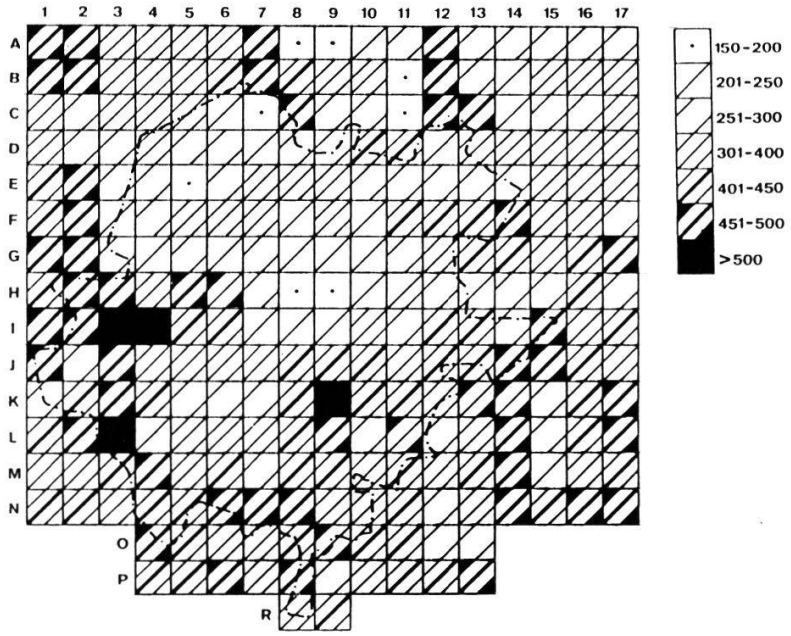

Fig. 2. Number of species in subsequent squares of the city and suburban zone of Kielce.

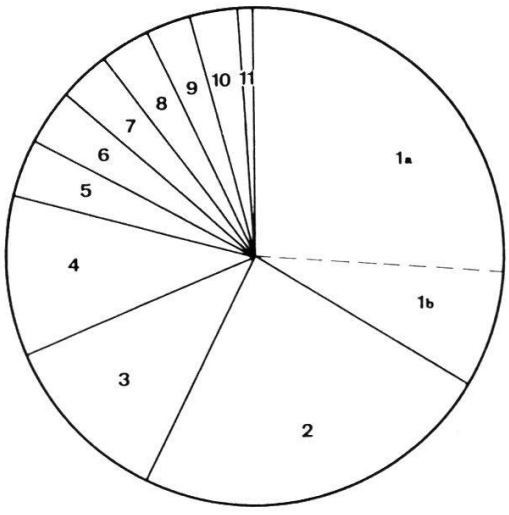

Fig. 3. Percentage proportion of species from different habitats in the city area and suburban zone of Kielce.
1 - species occurring solely in synanthropic habitats (a - anthropophytes, b- apophytes), 2 - forest or scrub species, 3 - meadow and heather species, 4 - xerothermic grasslands and thermophilous scrub species, 5 - sandy grasslands species, 6 - peat-bog species, 7 - swamp species, 8 - species of muddy places and temporarily dry water reservoirs, 9 - water species, 10 - species of rock crevices and scree, 11 - species of other habitats

is represented by the plants connected with various groups of forest communities. Their phytocenotic structure (Fig. 3) with decisive domination of deciduous forest elements (from the class *Querco-Fagetea*) and the "forest-wide" species is observed.
In the ecological spectrum of the flora a marked proportion is represented by plants of meadows and peat-bogs (c. 140 taxa), xerothermic grasslands and thermophilous thickets (c. 120 taxa). A very inconspicuous percentage (3-4%) is represented by water and swamp plants.
The flora of Kielce and environs does not widely differ from the Polish flora (cf. PAWLOWSKA 1972). Its main core is constituted by the Holarctic element. The marked proportion of the representatives of the Pontic subelement and Mediterranean species (e.g. *Achillea pannonica, Asperula cynanchica, Aster amellus, Campanula bononiensis, C. sibirica, Cirsium canum, Inula ensifolia, I. hirta, Malva alcea, Orchis ustulata, Peucedanum cervaria, Prunus fruticosa, Rosa gallica, Scorzonera purpurea, Tunica prolifera*), attached to warm and dry lime hills, is especially interesting.
The relatively abundant occurrence in shady and damp forests of numerous plants (more than 50 taxa), included in the so-called "mountain element" (SZAFER 1930, 1972), should be stressed here. This is connected with the upland character of the Swietokrzyski region with habitats of a specific "mountain" topoclimate, the history of its flora and vegetation, and the rich relief. Quantitatively, the most important group are the montane species (e.g. *Abies alba, Acer pseudoplatanus, Fagus sylvatica, Aruncus dioicus, Galium rotundifolium, Euphorbia amygdaloides, Polygonatum verticillatum, Sambucus racemosa, Veronica montana*), and in the second place the mountain-wide element (e.g. *Alchemilla glabra, Calamagrostis villosa, Cotoneaster integerrimus, Valeriana officinalis* ssp. *sambucifolia*).

5.2. CHANGES IN THE COMPOSITION OF THE FLORA

Reliable and detailed evaluation of the changes in the composition of the flora of Kielce has been hampered by the inefficient studies in the past. In the studies published in the 19th century and in the first half of the 20th century, about 600 species were considered, except for one fairly comprehensive study by DRYMMER (1890) including a list of 570 species (referring also to the records by the former authors), the remainder were only inconspicuous contributions. In this paper, however, the authors only concentrate on the presentation of the losses in the composition of the flora, which have occurred from

the beginning of the studies and on short information on the present tendencies.

The comparison of literature data with the present condition of the flora points out a loss of 50 species during 150 years (c. 4% of the flora). Thus the percentage of the extinct taxa, compared with other agglomerations, is relatively low (SUDNIK-WOJCIKOWSKA 1987). However, taking into account the high values of the extinct plants, the losses should be regarded as very serious. The majority of the extinct plants were protected by law (9 taxa), rare and threatened in the Swietokrzyski region and representing interesting geographical elements, e.g. *Adonis vernalis, Ajuga chamaepytis, Arnica montana, Blechnum spicant, Botrychium multifidium, Carex praecox, Catabrosa aquatica, Dactylorhiza sambucina, Dentaria glandulosa, Epipogium aphyllum, Gymnadenia conopsea, Gypsophila repens, Hieracium cymosum, Lepidotis inundata, Lithospermum officinale, Ophioglossum azoricum, Pleurospermum austriacum, Potentilla rupestris, Prunella laciniata, Teucrium chamaedrys, T. scordium, Trifolium lupinaster, Veratrum nigrum.* At present some synanthropic plants, very rare otherwise, are absent, *e.g. Adonis flammaea, Euphorbia platyphyllos, Pulicaria vulgaris, Orchis militaris, Valerianella olitoria, Xanthium spinosum.* Many of the species currently occurring in the study area have lost part of their former localities, e.g. *Androsacae septentrionalis, Botrychium lunaria, Cypripedium calceolus, Diphasium complanatum, Gentianella germanica, Huperzia selago, Ophioglossum vulgatum, Polystichum aculeatum, P. lonchitis.* Fragmentary and dying out populations are as follows: *Aconitum variegatum, Adenophora liliifolia, Allium ursinum, Botrychium matricariaefolium, Corydalis solida, Dentaria enneaphyllos, Iris sibirica, Matteucia struthiopteris, Pulsatilla patens, P. vernalis, Trollius europaeus, Veratrum album* ssp. *lobelianum*, and some formerly widespread anthropophytes, e.g. *Caucalis daucoides, Fumaria vailantii, Hyoscyamus niger, Ranunculus arvensis, Scandix pecten-veneris.*

6. PRELIMINARY ASSESSMENT OF FLORISTIC VALUES AND PROTECTION POSTULATES

The extension of the city and its suburbs, new housing estates, development of infrastructure and transport routes, mine querries of rock resources and cement-lime industry markedly changed the vegetation. The effect of the continuous urbanization is the permanent ruderalization and degradation of the floristic values of the city areas.

Conditioned by natural factors the directions of spatial development of the city favour the maintenance, especially in the suburban zone, of vast enclaves of natural and semi-natural vegetation (with the domination of forests, meadows, grasslands and xerothermic scrub). The mosaic pattern of typical synanthropic, natural and semi-natural vegetation patches finds reflection in the present condition of the flora of Kielce. In the background of other cities of similar size it is conspicuous for its floristic richness, high percentage of native species, high degree of diversity and abundance of protected, rare and endangered species on national and regional scale.

In order to bring into prominence the floristic values of the study area the list of species under total protection was compiled (Table 1) and enclosed in the "red lists" of the country (JASIEWICZ 1981, ZARZYCKI 1986) and region (BROZ 1989) range.

Among the presently recorded 69 protected species, 54 are totally protected, the remainder are partially protected. The most frequently recorded species are *Daphne mezereum* (77 localities), *Hedera helix* (72 localities), *Chimaphila umbellata* (70 localities), *Dactylorhiza majalis* (69 localities), *Lilium martagon* (55 localities), *Epipactis latifolia* (49 localities), *Gentiana pneumonanthe* (47 localities) and *Lycopodium clavatum* (43 localities). The degree of distribution density of the totally protected species in consecutive sectors is very irregular (Fig. 4). The maximum number was found in the squares

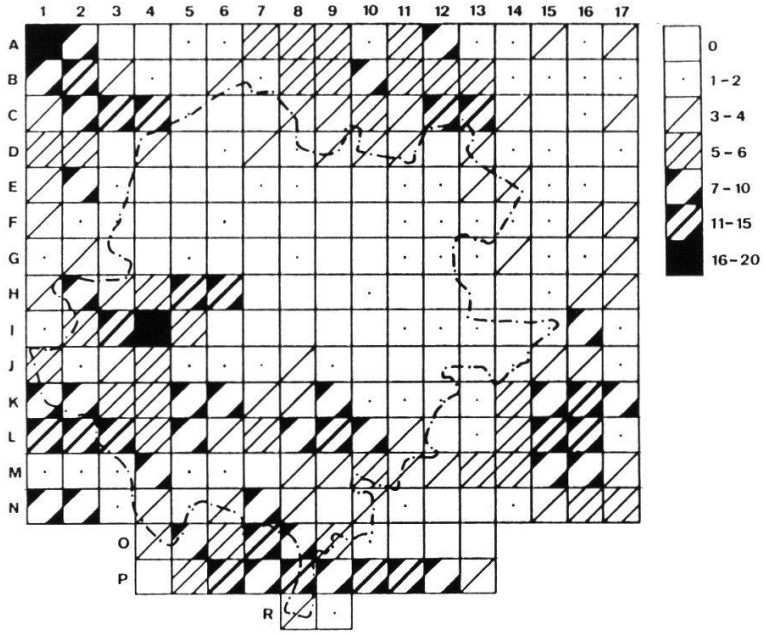

Fig. 4. Density of endangered species under total protection both in the city of Kielce and its suburbs.

Table 1. Vascular plants of the city and suburbs of Kielce under total protection (C), included in the national "red lists" (X), and rare and endangered in the region (E - endangered V - vulnerable, R - rare, I - indeterminate, K - taxon included in national "red lists" but not rare or endangered in the region, numbers - number of localities).

Aconitum variegatum: C, X, V-5
Adenophora lilifolia: X, R, -3
Allium scorodoprasum: R-2
Allium ursinum: V-1
Anemone sylvestris: C-22
Aquilegia vulgaris: C-31
Aruncus dioicus: C, X, K-23
Asparagus officinalis: R-6
Avenula planiculmis: X, K-1
Botriochloa ischaemum: R-1
Botrychium lunaria: X, V-2
Botrychium matricariifolium: X, R-1
Bupleurum longifolium: X, V-3
Carex davalliana: X, V-22
Carex limosa: X, V-3
Carex umbrosa: R-3
Carlina acaulis: C, V-4
Centaurea oxylepis: R-8
Cephalanthera damasonium: C, V-2
Cephalanthera longifolia: C-16
Cephalanthera rubra: C, X, V-1
Chimaphila umbellata: C-70
Cimicifuga europaea: C, X, K-11
Corallorhiza trifida: C, R-2
Corydalis solida: X, K-3
Cystopteris fragilis: X, K-8
Cotoneaster niger: R-3
Crepis mollis: R-4
Cypripedium calceolus: C, X, E-1
Dactylorhiza maculata: C, X, V-33
Dactylorhiza majalis: C-69
Daphne mezereum: C-77
Dentaria enneaphyllos: V-1
Digitalis grandiflora: C-29
Diphasium complanatum: C, V-2
Drosera anglica: C, X, V-2
Drosera rotundifolia: C-25
Dryopteris cristata: X, V-14
Eleocharis ovata: X, R-2
Epilobium dodonaei: R-4
Epipactis latifolia: C-49
Epipactis rubiginosa: C-22
Epipactis palustis: C, X, V-29
Equisetum variegatum: R-3
Festuca heterophylla: I-2
Galium rotundifolium: V-10
Gentiana cruciata: C, R-3
Gentiana pneumonanthe: C, X, V-47
Gentianella ciliata: C, V-17
Gentianella germanica: C, V-5
Gladiolus imbricatus: C, V-12
Glyceria declinata: X, I-1
Goodyera repens: C-2
Gymnocarpium robertianum: R-1
Hedera helix: C-72
Huperzia selago: C, X, V-3
Inula ensifolia: V-1
Inula hirta: R-1
Iris sibirica: C, X, V-1
Juncus atratus: X, R-1
Laserpitium latifolium: X, K-8
Lathyrus pisiformis: X, V-2
Lemna gibba: R-1
Lilium martagon: C-55
Listera ovata: C-8
Lycopodium annotinum: C-39
Lycopodium clavatum: C-43
Matteucia struthiopteris: C, X, V-2
Melica uniflora: R-1
Microstylis monophyllos: C, X, R-4
Neottia nidus-avis: C-13
Nuphar luteum: C-15
Nymphaea candida: I-1
Ophioglossum vulgatum: V-10
Orchis ustulata: C, X, V-6
Orobanche lutea: X, R-4
Pedicularis sylvatica: C-2
Petasites albus: R-1
Pinguicula vulgaris: V-1
Platanthera bifolia: C-37
Platanthera chlorantha: C, V-2
Polygonatum verticillatum: X, K-68
Polystichum aculeatum: X, V-2
Polystichum lonchitis: E-1
Potamogeton alpinus: R-4
Potentilla recta: R-4
Potentilla tabernaemontani: R-7
Prunus fruticosa: C, V-5
Pulsatilla patens: C, X, V-6
Pulsatilla pratensis: C-17
Pulsatilla vernalis: C, X, V-2
Rosa sherardii: V-14
Salix myrtilloides: C, X, R-2
Scirpus radicans: X, I-3
Scirpus setaceus: R-3
Scorzonera purpurea: C, X, R-1
Senecio nemorensis ssp. *nemorensis*: V-7
Sempervivum soboliferum: C-3
Sesleria caerulea: V-9
Sparganium minimum: I-2
Stachys germanica: R-3
Taxus baccata: C, X, E-1
Trifolium ochroleucum: R-1
Trollius europaeus: C, V-2
Utricularia minor: I-1
Veratrum album ssp. *lobelianum*: V-9
Veronica montana: V-6
Veronica teucrium: R-5
Vicia dumetorum: R-3
Vicia pisiformis: R-7
Vinca minor: C-25
Zannichellia pedicellata: X-1

4J (19 taxa), 1A (17 taxa) and 5H and 2L (15 taxa each).

The rare and endangered plants of Poland are represented in the flora of Kielce by 44 species. Even more frequent are the plants included in the regional "red list" (BROZ 1989). Among the 89 taxa recorded there and regarded as endangered and dying out in the Swietokrzyski Region, 3 represent category E, 39 category V, 35 category R, 6 category I, and 6 category K. They exhibit distribution similar to that of protected species, and their number in the richest sectors reaches 17 taxa (5H) and 20 taxa (4I).

The diagrams presenting the degree of floristic diversity (Fig. 2), density of protected plants (Fig. 4), and of the rare species and these threatened with extinction (Fig. 5), may be the basis for the delimitation of the areas characteristic of outstanding floristic values (Fig. 6). According to the rules of spatial planning and management of natural resources in suburban zones (BIERNACKI 1983, KASSENBERG and MAREK 1986), and also with the assumptions of the world strategy of nature protection, these areas should perform protective functions. The most precious fragments of natural vegetation of Kielce (Fig. 6) are qualified to be included in the reserve protection and their part should be included in the system of protected areas of the Gory Swietokrzyskie Mts. Maintenance of floristic values is only possible if the actual ecological conflicts are diminished or eliminated.

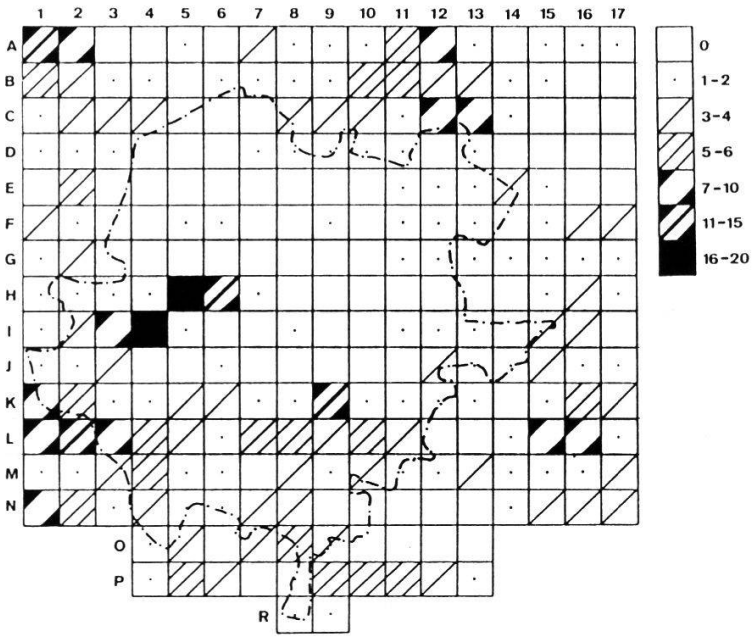

Fig. 5. The density of endangered species and dying out in the Swietokrzyski Region and suburban zone of Kielce.

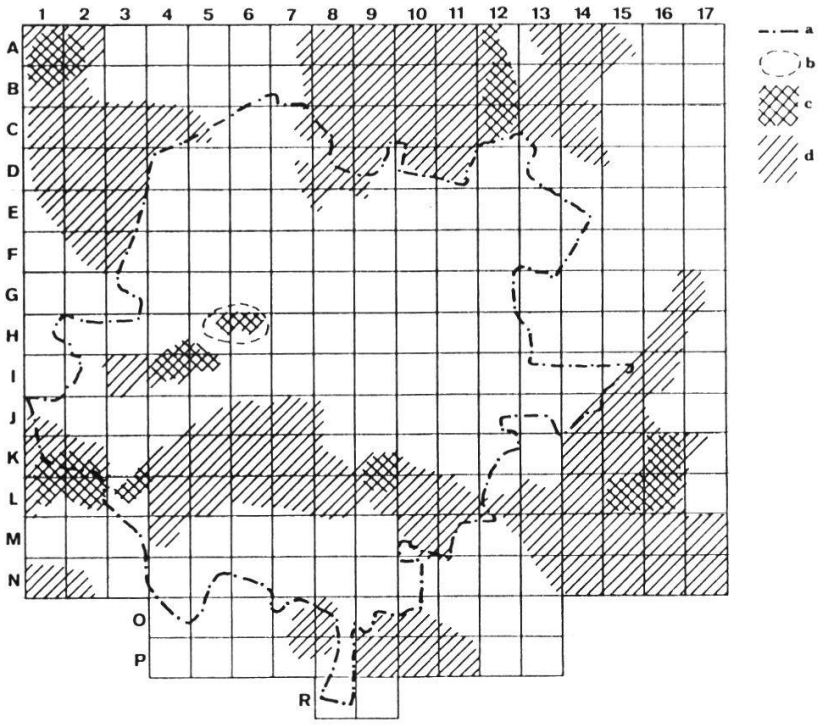

Fig. 6. Areas of outstanding floristic values in the city of Kielce and its suburbs suggested for the protection.
a - administrative limits of the city, b - limits of the planned botanical garden, c - areas proposed for the reserve protection, d - areas qualified to be included in the system of protected areas of the Gory Swietokrzyskie Mts.

SUMMARY

The results on the inventory of the flora of the city of Kielce and its suburban zones (260 km^2) made by the cartogram method for all types of the habitats is presented. From about 1200 vascular plant species, 74% represent native species, including more than 50 mountain species, and 26% represent anthropophytes. The flora of the area is rather diversified with many rare, endangered and protected plant species.

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