POLISH ACADEMY OF SCIENCES • INSTITUTE OF ZOOLOGY
MEMORABILIA ZOOLOGICA

MEMORABILIA ZOOL.	34	13—31	1981

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PHYSIOGRAPHICAL CHARACTERISTICS OF WARSAW AND THE MAZOVIAN LOWLAND

ABSTRACT

The general physiography of Warsaw and the Mazovian Lowland is described, with special emphasis to geological structure, soils, climate, and plant cover. Detailed edaphic and phytosociological characteristics are given of urban and non-urban plots selected for the study on the effects of urban pressure on invertebrate fauna.

MAZOVIAN LOWLAND

GEOMORPHOLOGICAL CHARACTERISTICS

The Mazovian Lowland is located in the vast Central-European Plain (Fig. 1). It was formed during the central-Polish and Baltic glaciations. This is a flat area made up of fluvio-glacial and morainic deposits, including ground and terminal moraines. With respect to its configuration, it is subdivided into the Rawa upland (Rawa or South-Mazovian district), the Płock-Ciechanów upland (North-Mazovian district), and the Warsaw basin (Warsaw district) [11, 16, 25]. Following the Catalogue of the Fauna of Poland [10], also the so-called Międzyrzecze Łomżyńskie is included here to the Mazovian Lowland; other authors consider this area as belonging to the Podlasian region [25].

Vast upland areas reach an elevation of 200 m above sea level. They are surrounded by post-glacial plains formed as a result of erosion and deposition processes occurring at the time when these terrains were covered with the Vistula waters. At the time the Vistula flooded a large area, their waters being blocked by the head of the Scandinavian ice-sheet in the so-called Wkra sub-stage. In this relation the exposed fluvio-glacial or morainic deposits are strongly made, of sandy loam, rarely boulder clay. In the areas where deposition prevailed, on the surface there are exposed sandy, mud, and sild deposits (varved deposits) formed in marginal lakes, also peats and, in the valleys of the upper Wkra and Narew, sandy outwash plains. The Warsaw basin and many smaller ice-marginal valleys are mostly filled with well stratified sandy-gravel and silt deposits (alluvial soils). Sands and gravels

Fig. 1. Poland, Mazovian Lowland, Warsaw and non-urban study plots: 1 — Radziejowice near Mszczonów, 2 — Łomna-Las (boundaries of the Mazovian Lowland after the Catalogue of the Fauna of Poland [10]).

formed dune terraces, subsequently covered with wind-blown deposits (the Kampinos Forest) while the flood-marginal lake terraces were covered with alluvial deposits.

CLIMATE

The Mazovian, like the whole Poland, lies in the temperate zone. Its characteristic feature is a transitional character between the maritime and continental climate. In this relation six seasons can be distinguished in Poland, and the weather varies markedly from day to day and from year to year.

Since the Mazovian Lowland is largely deforested and not rich in natural water bodies, it has a very low annual sum of precipitation (less than 500 mm). It is, for example, 470 mm in Warsaw-Okęcie, 486 mm in Warsaw--Bielany [13], 448 mm in Legionowo [11]. Consequently, this area is largely

deficient in water. The number of days with ground frost varies from 100 to 110. Snow cover lasts for 50—80 days. The growing season covers a period of 210—220 days. As compared with the adjoining northern, eastern and southeastern regions (Masurian, Podlasian and Lublin), it is distinctly warmer, with a markedly longer growing season. It is cooler than southern regions (Łódź and Radom). The duration of the growing season, however, is similar. As it has already been noted, the basic difference between Mazovia and the surrounding regions is a very low precipitation in the former region.

Some climatic features of Mazovia are set up below after Kondracki [11]:

annual isotherm 7—8°C
January isotherm 3.5—4.5°C
July isotherm 18—19°C
degree of dryness (a difference between precipitation and potential evaporation) is −325 in Warsaw (the lowest minimum value in Poland).

SOILS

The character of soil formation processes depends on both the weathering of parent rock and the type of plant cover. As it has already been noted, the prevailing type of deposits on vast periglacial plains of the Mazovian Lowland are heavily eroded nonsorted materials of the ground moraine, such as washed coarse sandy soils and medium sand, rarely heavy boulder clay, as well as sands and silt loam (very fine sand) of other origin (eolian, deluvial, marginal-lake sediments, etc.). From these deposits under oak-hornbeam forest (p. 16) acid brown soils and podzolic-brown soils are developed. Of a little lesser importance are brown soils formed on more fertile sites (under rich oak-hornbeam forests on boulder clay, silt loam, and varved clay). Locally, e.g. near Błonie and Sochaczew, there are also fertile black earths developed out of transformed deposits of fens. The occurrence of podzolic soils in the Mazovian Lowland is limited to sandy dune terraces of the Vistula and Narew ice-marginal valleys. They can cover, however, large areas (the Kampinos Forest and southeastern part of the Warsaw basin). These are poor soils, generally derived from loose well-drained sands. They support mixed and pine forests. The other types of soil of the Mazovian Lowland are alluvial soils made up of fluvial deposits with different fractions (ranging from sands to clay) and marshy soils (hydrogenic).

Most of these soils are agriculturally utilized for hundreds of years, this leading to deep mechanical and structural transformations of the soil profile. They are partly used as urban areas (p. 20).

GEOBOTANICAL CHARACTERISTICS

To the geobotanical characteristic features of Mazovia belong the lack of the beech, fir, sycamore, and wild service tree, "insular" occurrence of the Polish larch and spruce (in the spruceless zone), disappearance of Pontic

elements from the xerothermal flora, disappearance of Atlantic elements, and the occurrence of plants associated with moors, as well as psammophilous plants [25]. Since this is a largely deforested area, the landscape of this region has been markedly transpormed. Woodland covered only 20.1% of this area in 1970, this being the lowest figure in Poland [22]. The surface occupied by woodlands in the Warsaw district is still lower, reaching merely 16% (11% without the Kampinos Forest) [19]. And originally this was a wooded and marshy terrain. The present tree stands are mainly represented by pine monocultures, rarely by oak-pine stands, and they grow on more or less degraded sites.

A detailed study on the potential vegetation of the Warsaw basin carried out by W. Matuszkiewicz [19] shows, in spite of a common view that this is a natural habitat of pine forests, that most of its area was covered with lime-oak-hornbeam forests (*Tilio-Carpinetum*). This author distinguished there three major types of natural plant landscapes:

— a lime-oak-hornbeam forest landscape of the alliance *Carpinion* on periglacial denuded plains, made up of subcontinental lime-oak-hornbeam forests (*Tilio-Carpinetum*) and xerothermal oak forests (*Potentillo albae-Quercetum*); a small proportion of continental mixed forests (*Pino-Quercetum*) was found there.

— a coniferous forest landscape of the alliance *Dicrano-Pinion* on dune terraces within the area of fluvial deposits. It includes continental mixed forests (*Pino-Quercetum*) and the "Sarmatian" variety of the continental pine forest (*Peucedano-Pinetum*); the occurrence of the two types of forests in the Warsaw basin is almost completely restricted to the Kampinos Forest and dunes located on the right bank of the Vistula. Moreover, in depressions on the dune-terraces there are alder swamps (*Carici elongatae-Alnetum*), ash-alder carrs (*Circaeo-Alnetum*), and locally small patches of the bog pine wood (*Vaccinio uliginosi-Pinetum*) and subatlantic pine forest in its impoverished wet form (*Leucobryo-Pinetum molinietosum*).

— a carr landscape of the alliance *Salicion-Alno-Padion* in flood plains. It is made up of willow-poplar carrs (*Salicetum albo-fragilis*), ash-elm carrs (*Fraxineto-Ulmetum*), and ash-alder carrs (*Circaeo-Alnetum*). Locally in oxbows and water effusions there are alder swamps (*Carici elongatae-Alnetum*).

In the paper already quoted [19], a high consistency is found between the natural landscapes listed above and physiographical units distinguished; also the main secondary communities such as crop fields, meadows, and forests are discussed. As no similar data exist in relation to other areas of the Mazovian Lowland, it is impossible to present their phytosociological characteristics now. It may be suggested, however, that most of their primeval plant cover also consisted of lime-oak-hornbeam forests (*Tilio-Carpinetum*). The studies carried out by Sokołowski on forest communities of the southern part of the Mazovian Lowland [25] show similar geobotanical relations.

The so-called Łomża Międzyrzecze, considered here as a part of Mazovia, is a transitional zone between the northern geobotanical unit and the true Podlasian region [25]. The most important features it shares with the Mazovian Lowland are the lack of spruce, beech, and fir.

CHARACTERISTICS OF THE STUDY PLOTS IN MAZOVIA

The study on changes in the fauna subjected to the pressure of urbanization was conducted on the Rawa upland and in the Warsaw district in the Kampinos Forest (Fig. 1). This study was continued in a period of 1976—1978. The study plots are characterized below.

RAWA UPLAND

Radziejowice near Mszczonów (Fig. 1)

1. A lime-oak hornbeam forest (*Tilio-Carpinetum*). Depending on the depth of water table it supports either a typical lime-oak-hornbeam forest (*Tilio-Carpinetum typicum*) or its wet variety (*Tilio-Carpinetum stachietosum*). The tree stand of this community is a little modified, mainly because oaks and in places pines and spruces were introduced. They grow on brown or pseudogley soils derived from sandy loams of morainic origin.

2. An ash-alder carr (*Circaeo-Alnetum*) located in the bottom of the Pisia Gągolina valley. In this valley there are also wet oxbows covered with alder swamps (*Carici elongatae-Alnetum*). The tree stand, in part of the offshot character, is dominated by the alder (*Alnus glutinosa*). It grows on hydrogenic soils mainly of the type of mud-earth or alluvial soils.

3. A meadow on the site of a carr, located in a forest clearing. A transitional community between wet meadows (of the order *Molinietalia*) and moist meadows (of the order *Arrhenatheretalia*); in the southeastern corner there is a drying marsh (with *Carex gracilis*) and patches of the meadow with tall perennial forbs and marsh marigolds (of the order *Molinietalia*).

4. A rural park surrounding the palace in Radziejowice. It is located on the site of lime-oak-hornbeam forests. The tree stand is dominated by native species such as oaks, alders and hornbeams, and by some foreign species (mainly the horse-chestnut).

WARSAW DISTRICT, THE KAMPINOS FOREST (EASTERN PART)

Łomna-Las (Fig. 1)

5. A moist coniferous forest (*Pineto-Vaccinietum myrtilli*) covering a dune; podzolic soils on loose sands.

6. Moist mixed forest (*Pino-Quercetum*) on an acid brown soil derived from coarse sandy soils.

WARSAW

GEOMORPHOLOGICAL UNITS. GEOLOGICAL STRUCTURE

Warsaw is located in the centre of the Warsaw basin (Fig. 1) which is a deep Tertiary syncline filled with the Quaternary deposits of glacial and post-glacial (Holocene) origin. In Warsaw and surroundings older deposits than those from the period of central Polish glaciation are generally not exposed (except for the Warsaw escarpment). Surface layers form a large periglacial plain dissected by the ice-marginal valleys of the Vistula and Narew with their accumulative terraces [17, 18, 20, 24].

The relief of this area was sculptured by the so-called Warsaw marginal lake formed as a result of blocking the Vistula waters at the period when the head of the ice cap stopped at the Nasielsk — Serock line (the Wkra sub-stage). In the bottom of this lake the processes of erosion and sedimentation occurred. The southern and northern uplands and the Warsaw Kępa (hillock) (115 m above sea level), where the oldest part of Warsaw is located — the Old Town, were not flooded. The retreat of the ice sheet head was followed by running off post-glacial waters and carving the erosive escarpments of the ice-marginal valleys of the Vistula and the Narew, as well as by the formation of new river terraces. These terraces were flooded and eroded during the Baltic glaciation. When the blocked waters ran off, the rivers returned to their channels, continuing their erosive-depositing activity. In this way three erosive-accumulative terraces were formed:

1. The lower accumulative terrace of the Vistula, called the flood terrace, is made up of alluvial deposits. This terrace is well developed along the right bank of the Vistula, while on the left bank it is marked only to the south of Siekierki and to the northwest of Bielany (Fig. 2).

2. The intermediate accumulative terrace, called the Praga terrace (82—87 m above sea level). It is made up of alluvial deposits, mainly gravels and sands, as well as of peat and muds in depressions of the ground. This terrace was subsequently covered by wind-blown materials (dune terrace — Kampinos Forest, Jabłonna-Praga).

3. The upper erosive terrace, called the Warsaw terrace (along the right Vistula bank it has a character of the accumulative terrace). As a result of down-cutting erosion by waters of the Warsaw marginal lake, the glacial deposits (ground moraine and overlaying fluvio-glacial deposits) have been destroyed. Thus, the terrace is covered with sandy loam and medium sand (moraine made sandy by erosion), as well as clay, muds, and wind-blown sands. In the region of Warsaw this terrace is overlooked by the so-called Warsaw Kępa.

CLIMATIC CONDITIONS IN THE TOWN

An artificial character of the urban landscape has a direct effect on the climate. The agglomeration of buildings of various sizes, constructed

of materials with different thermal properties (multiplication of the active vertical surface), replacement of the soil and vegetation by asphalt and concrete, and draining off the major part of rain waters through the sewage system, all this is followed by specific changes in climatic conditions as compared with those in suburban and non-urban areas. The urban climate can be characterized as follows:

— an increase in temperature. An increase in the mean annual temperature of Warsaw is 1°C [4, 11—15] and only occasionally it reaches 3°C. At very low temperatures (below −20°C) and at some warm nights, the difference can rise up to 7°C. The town is particularly overheated in summer (radiation of the heat accumulated during the day from surfaces of different types). The increase in temperature is mostly due to the multiplication of the active accumulating surface of the town, thermal properties of building materials and those used for street surfaces, reduction of green areas (reduction of losses related to water evaporation from soil and plant transpiration) and insulating properties of the polluted air (greenhouse effect), although the input of solar energy is reduced markedly. The heat of the so-called artificial sources like means of transportation, industrial plants, sewage system, and heating system are of lesser importance, nonetheless they account for about 1/4—1/3 of the energy available in winter.

— a lower input of solar energy, an increase in cloudiness and amount of precipitation. All these phenomena are a direct effect of heavy air pollution. The mean annual sum of precipitation is 500—550 mm in Warsaw (e.g. the Astronomical Observatory 566 mm) [11], while less than 500 mm in the suburbs. Precipitation mostly runs off through the sewage system.

— a decrease in the relative air humidity, i.e., the drying of urban air. The mean annual humidity is 78%, with the lowest values in May and June (54—69%), and the highest ones in November-February (86—88%). The air in the town is generally drier by 2—4% than in the suburbs and in some summer evenings even by 10—12%. There are, however, differences between various places, depending on their location and surroundings (green areas, built-up areas, etc.). It has been found that urban green areas have a positive effect on humidity when they cover at least a threshold surface of 1000 m^2 [21].

Due to the increased temperature in the town, as compared with non-urban areas, the first ground frosts and snow occur later in the town and they disappear earlier in the spring.

A specific feature of the urban climate is a large thermal inertia of built-up areas, both decreases and increases in temperature being markedly less pronounced in the town as compared with suburban areas [13].

SOILS

In Warsaw mostly ground morainic deposits of the central-Polish glaciation of the Warsaw terrace are exposed. They are largely transformed by erosion. They mainly involve sandy loam, medium sand, rarely moist boulder clay. Also silt loam and sands of other origin can frequently be met there [24]. On these deposits, under the broad-leaved forests, acid brown and brown soils are developed. In the part of Warsaw lying on the right bank of the Vistula where a sandy dune terrace stretches, podzolic and acid brown soils are most frequent. The lower, flood terrace of the Vistula has alluvial and muck soils.

This soil is largely modified by human activity. In the centre of Warsaw there are no natural but man-made deposits involving the substrate moved during earthworks, litter, crushed brick, and earth. These deposits, called heaps, reach a depth of 3—6 m, occasionally forming a layer more than 20 m deep [24]. Small fragments of natural deposits were found only at the peripheries of the town [24] and in some places in the centre, e.g. on the lower terrace of the Łazienki park [6].

Because heaps are a characteristic feature of the geological structure of Warsaw, a modified classification of soils should be applied. Two categories of soils can be distinguished there:

— natural soils — only in the suburbs and in non-urban areas,

— anthropogenic soils — in built-up areas.

Dobrzański and co-workers [8] have proposed the following classification of anthropogenic soils:

1. mechanically transformed soils,

2. strewed soils, including rubble soil, humus soil, and carbonate soil.

Within the two categories there are solonchak and solonetz soils along streetsides (up to 6 m from the edge of the street margin), formed as a result of the application of salt in winter. Anthropogenic soils can differ in their mechanical composition, according to the type of strewed material and to the substratum. The soils of Warsaw have an alkaline or neutral pH, a high content of salt and heavy metals, mainly lead [2, 7, 8] and a low humus content, mostly (more than 80%) in the form of unsaturated hydrocarbons [3].

PHYTOSOCIOLOGICAL CHARACTERISTICS

W. Matuszkiewicz, who studied potential vegetation of the Warsaw basin [19], thus also of the areas where Warsaw is located now, has found that the town lies on the site of poor subcontinental lime-oak-hornbeam forests (*Tilio-Carpinetum*) (Fig. 2). The northern part of Warsaw on the left bank of the Vistula, where now are Marymont and Żoliborz quarters was covered with a large stand of the xerothermal oak forest (*Potentillo albae-Quercetum*), while the southern part (Ochota and Mokotów quaters) was occupied by the Mazovian variety of the rich subcontinental lime-oak-horn-

beam forest (*Tilio-Carpinetum*). A narrow stretch of the site of this forest reached the present Łazienki park on the Warsaw terrace. In the left-bank Warsaw there are no natural sites of alder swamps and coniferous forests. The continental mixed forest (*Pino-Quercetum*) covered a large area on the right bank of the Vistula (Żerań, Praga-Południe). The occurrence of the continental pine forest is, as noted above (p. 16), restricted to the Kampinos Forest: consequently, this site occurs only at the northern edge of Warsaw.

Along the Vistula valley, particularly in its southern section below the Łazienki park (Siekierki, Wilanów, Marysin) and in the northern section, there are ash-elm carrs (*Fraxino-Ulmetum*) and riverine willow-poplar carrs (*Salicetum albo-fragilis*). On the right bank, locally, alder swamps (*Carici elongatae-Alnetum*) (Fig. 2).

As the urbanization advanced, the primeval plant cover of this area was being destroyed. Only small fragments of woodlands persisted, forming now the so-called urban woods. Most important are the Młociny wood, Bielany wood [1], Wawer wood (a nature reserve named after Sobieski), Koło wood, and Kabacki wood. Relatively little transformed tree stands were also found in the Wilanów and Natolin parks [19], while among urban parks the smallest transformations, at least at the level of soil, were found in the Łazienki park [6]. This park was established on the area occupied by fragments of the primeval forest in Jazdów (p. 24, 25).

At present there is no uniform phytosociological classification of secondary communities covering urban green areas on the natural sites listed above. The urban lawns are sown with a mixture of six grasses, including *Poa pratensis, Lolium perenne, Agrostis vulgaris,* and *Festuca rubra.* The are frequently mown at a low level. Soil is heavily polluted with various toxic substances, including heavy metals. All these factors, in addition to natural site conditions, and first of all a strewed character of urban soils, account for the development of xerothermal grasslands there. The study carried out at the Institute of Environmental Protection of the Agricultural University of Warsaw in 1972—1976 show that the turf of the lawns is formed by 60 species of vascular plants, the most frequent being *Poa pratensis, Lolium perenne, Agrostis tenuis, Trifolium repens, Achillea millefolium, Taraxacum officinale,* and *Medicago lupulina.* Phytosociological analysis of these lawns shows that they are similar to pastures (*Lolio-Cynosuretum*) of the alliance *Cynosurion,* order *Arrhenatheretalia* [26]. On the lower terrace of the Łazienki park there are also communities similar to moist meadows of the alliance *Arrhenatherion,* order *Arrhenatheretalia.* The most overdried, streetside lawns, also containing more salt than park lawns, have a poorer plant cover. They support 8—10 species of vascular plants (5—6 grass species), while the lawns in parks support 20—25 species (7—10 grass species). The plant communities of the margins of streetside lawns are often similar to xerothermal communities of the class of sandy grasslands *Sedo-Sclerantea.* In this zone also mesohalophytes were recorded.

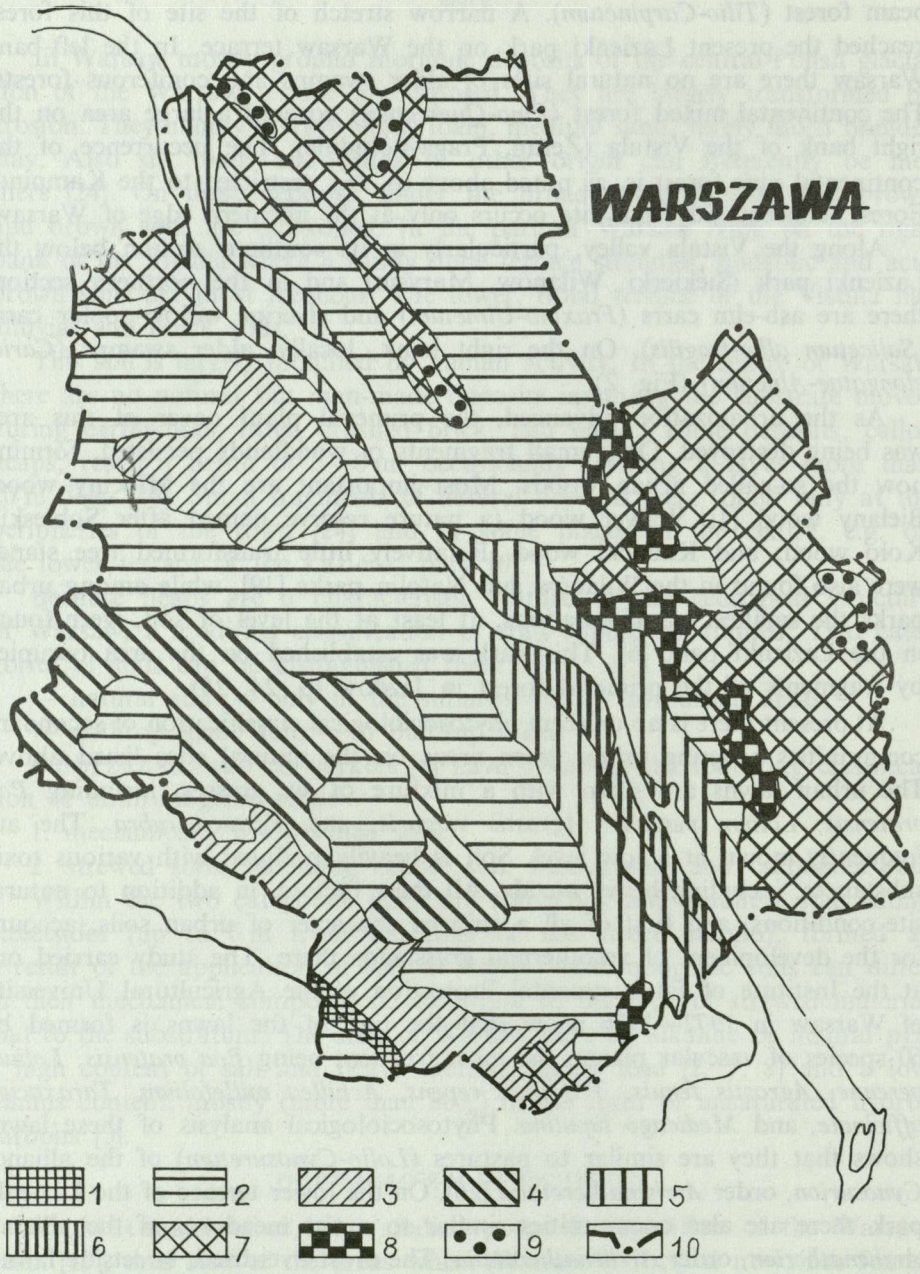

Fig. 2. Potential vegetation of Warsaw (after W. Matuszkiewicz [19]): 1 — riverine alder-ash carrs (*Circaeo-Alnetum*), 2 — subcontinental lime-oak-hornbeam forests (*Tilio-Carpinetum*), Mazovian variety, poor form, 3 — xerothermal oak forest (*Potentillo albae-Quercetum*), 4 — subcontinental lime-oak-hornbeam forests (*Tilio-Carpinetum*), Mazovian variety, rich form, 5 — ash-elm carrs (*Fraxino-Ulmetum*), 6 — riverine willow-poplar carrs (*Salicetum albo-fragilis*), 7 — continental mixed forest (*Pino-Quercetum*), 8 — alder swamps (*Carici elongatae-Alnetum*), 9 — continental pine forest (*Peucedano-Pinetum*), 10 — administrative boundaries of Warsaw.

Beyond the managed green areas there are in Warsaw nitrophilous ruderal communities of the order *Onopordetalia* [25]. They develop mainly in new housing estates, in the suburbs, and in wasteland of different types (e.g. Pole Mokotowskie, not existing now).

The managed green areas have a specific structure. Lawns occupy 60—70% of the urban green areas, trees and shrubs occupy the remaining area. Three major types of urban green areas can be distinguished: urban parks, green areas of housing estates and green of the centre of the town. They are characterized below.

1. Urban parks. Since the proportion of trees and shrubs is high in parks, their vertical structure is similar to that in natural forests. The soils of park lawns are relatively little polluted with heavy metals, toxic substances, and salt. These are soils mechanically transformed or strewed soils, occasionally (in the Łazienki park) the soil profile is natural. They support a rich plant cover of the moist pasture community of the alliance *Cynosurion*, and in places moist meadows of the alliance *Arrhenatherion*. Urban parks are large complexes of verdure with a surface area exceeding 16 ha (the Saxon Garden), thus they have an effect on urban microclimate. The Łazienki park covers the greatest area (86 ha). Also old cemeteries (Powązki, (Bródno) can be included in this category of urban green areas.

2. Green areas of housing estates. In green areas of this type there are few trees and shrubs (young, singly growing trees). Soils are generally strewed (moved, mixed substratum, often with carried upper layer). The open lawns, a predominating feature of the structure of these green areas, are large (more than 1000 m^2 in surface area), thus they have a significant effect on microclimate. The layer of herbaceous plants forms a community similar to moist pastures of the alliance *Cynosurion*. Unmanaged, unmown parts can be covered with ruderal communities of the order *Onopordetalia*.

3. Green of the centre of the town. It includes courtyard verdure in closely built-up areas and lawns along street verges or between lanes, and single streetside trees. Soils are strewed, mostly rubble. These lawns are small, about 250—500 m^2 in surface area, thus they do not influence the microclimate. They are dominated by a poor pasture community of the alliance *Cynosurion*. At the margins of streetside and interlane lawns, on heavily polluted solonchak and solonetz soils, xerothermal communities similar to sandy xerothermal grasslands (*Sedo-Sclerantea*) can be developed. They include mesohalophytes.

The other types of urban verdure are represented by allotments and ruderal communities of the alliance *Onopordetalia*, occurring mostly at the peripheries of the town. Urban cemeteries have a character of parks (type of tree stands, high proportion of herbaceous plants) thus they are classified as parks in the present study.

HISTORY OF THE DEVELOPMENT OF WARSAW

Warsaw became an urban and administrative centre in the tenth century. In the 10th and 11th centuries there was a small stronghold on the right bank of the Vistula, in the region of the old Bródno quarter. A similar stronghold was established on the left bank of the Vistula, in the region of Jazdów. But a true development of the town started in the 13th century on the area of the village of Warszowa, located on the so-called Warsaw Kępa (hillock). Here an urban defensive system was established to defend the Vistula ford. In the 14th through the 15th and 16th centuries the town developed southerly and northerly within the boundaries of the Old and New Town (Stare and Nowe Miasto). Due to the location of the town in central Poland, king Sigismund III Vasa moved here the capital of Poland from Kraków in 1611. It should be noted that at that time the surroundings of Warsaw were completely deforested, except for Jazdów. In the 17th and 18th centuries the boundaries of the town were not extended but many magnate residences were built in the peripheral zone, and housing estates grew around them, being the framework of the present quarters of Warsaw. Within Warsaw there were rebuilt and traced new arteries (Marszałkowska street, "Saxon Axis", Zbawiciela square — Unii Lubelskiej square, etc.). In the period of partitions (1795—1917), the town developed rapidly, though its territory was not extended much (Tab. 1). Since 1917 the territory of Warsaw increased almost four times. In 1918—1939 the quarters Ochota, Koło, Żoliborz, Mokotów, Grochów, and Saska Kępa were largely extended. During World War II Warsaw was heavily destroyed. More than 84% of its building were damaged. After the war the town has been rapidly rebuilt and enlarged. The centre of the town has been rebuilt with great effort. New housing estates were constructed within the central zone (Za Żelazną Bramą, Wierzbno, Sady Żoliborskie, and others), and outside it, in the areas that were not closely built-up before the war (Rakowiec, Bródno, Służewiec Przemysłowy, Piaski, Wawrzyszew, Marymont-Rudka, "Ostrobramska", Gocław, Jelonki, Ursynów, and others). Also such localities as Rembertów, Włochy, and recently Ursus have been included into Warsaw. In this way in 1978 the surface of the town was four times as large as in 1944, reaching 469.6 km^2 (according to the state from the end of 1978) (Tab. 1).

Tab. 1. Territorial development of Warsaw

Year	Surface area (in km^2)
1826	21.54
1913	32.73
1917	114.83
1937	118.07
1951	411.73
1978	469.60

STUDY PLOTS IN WARSAW

The fauna of urban green areas in Warsaw was studied in the years 1974—1978. The major purpose of this study was to determine the effect of urban pressure on the development of urbicoenoses, first of all, in managed green areas. Thus allotments and ruderal plant communities of the suburbs were not examined.

The study plots were located in the suburbs and in particular types of urban green areas (Fig. 3). They are briefly characterized below.

SUBURBAN AREAS:

1. Bielany. An urban wood (now a nature reserve), with a surface area of 130.4 ha, covers the two Vistula terraces [1]. The Warsaw terrace is dominated by a lime-oak-hornbeam forest (*Tilio-Carpinetum*), in places modified towards a secondary mixed forest (*Pino-Quercetum*). Also a xerothermal oak forest (*Potentillo albae-Quercetum*) grows there. The lower terrace (Praga and flood terraces) supports and oak-hornbeam forest (*Querco-Carpinetum alnetosum*) and an ash-elm carr (*Fraxineto-Ulmetum*). This area was under study in 1976—1977. Moreover, it has permanently been visited by Warsaw entomologists.

2. Ursynów. A park surrounding a manor-house, located in southern part of the town, on the upper, Warsaw terrace of the Vistula. The manor-house is one of the seats of the Agricultural University of Warsaw. Loam soils, plant community similar to moist pastures of the alliance *Cynosurion*. This plot was least polluted with lead of all the study plots in Warsaw. The study was carried out in 1974—1975.

3. Białołęka Dworska. The area of a future housing estate in the projected Northern Housing Estate. Now it is loosely built with low houses. Soils mostly agriculturally used (meadows and pastures); in western part, on the dune terrace, degraded pine monocultures. More detailed characteristics of the study plots are given by Roo-Zielińska [23].

URBAN GREEN AREAS

Urban parks. The study was carried out in 1974—1976, except for the Cemetery of Soviet Soldiers where it was continued also in 1978.

4. The Łazienki park. It covers an area of 86 ha and is the largest park of Warsaw. It was established on the area of a preserved forest, firstly as a prince's park where various animals were kept. In 1784 it was rebuilt by J. Ch. Schuch as a landscape park in the French style. Loam and sandy loam soils, in places also muck soils, all of them mechanically transformed and rarely strewed [6, 7]. The communities of herbaceous plants similar to moist meadows of the alliance *Arrhenatherion*.

5. The Saxon Garden. The oldest public park in Warsaw. Established in 1713 at the palace of king Augustus II and opened to the public since 1727. It covers an area of 16 ha. Largely destructed during the siege of

Fig. 3. Location of the study plots in Warsaw; suburban areas: 1 — Bielany, 2 — Ursynów, 3 — Białołęka Dworska; urban green areas; 4 — Łazienki park, 5 — Saxon Garden, 6 — Cemetery of Soviet Soldiers, 7 — Praga park, 8 — housing estate Wierzbno, 9 — Institute of Zoology PAS, 10 — MDM, 11 – Niepodległości avenue, 12 — intersection of Poznańska and Hoża streets.

Warsaw in 1939 and during the Warsaw uprising in 1944, reconstructed after the war. Soils mostly strewed with a large proportion of rubble, and heavily polluted with lead [8].

6. Cemetery of Soviet Soldiers. It was established in 1949—1950 on former croplands and covers 20.5 ha. Very-fine sandy soils and loam soils. Herbaceous plants form a community similar to moist pastures of the alliance *Cynosurion;* also the primary productivity of lawns was studied there [26].

7. The Praga park. Established in 1865 on the place of a demolished harbour of Napoleon, built in 1808. Since 1928 it has formed one complex with the Zoological Garden. This is the only study plot in the right-bank part of Warsaw. The western part of the park with preserved old tree stands occupies a carr site. The eastern part, managed from 1948, probably occupies the site of a mixed forest. Mostly strewed soils [24].

GREEN AREAS OF LOOSELY BUILT HOUSING ESTATES

Urban green areas of this type were represented by the plots located in

8. the housing estate Wierzbno (Mokotów). This estate was built in 1960—1965, thus the tree stand was 10—15 years old during the study. Tree crowns were largely spaced. Lawns were sown on loam, anthropogenic soils (no more detailed characteristics are available). Herbaceous plants form a community similar to a moist pasture of the alliance *Cynosurion.*

GREEN AREAS IN THE CENTRE OF THE TOWN

Isolated courtyard green

Lawns generally do not exceed 250 m^2 in surface area. They occupy strewed soils watered with various intensities. The following plots were under study:

a. An inner courtyard of the Institute of Zoology PAS in Wilcza street, (9).

b. An inner courtyard in Piękna street, MDM, (10).

c. A lawn at the intersection of Poznańska and Hoża streets, see Fig. 3, (12).

Streetside and interlane verdure

Belts of lawns along streets, on strewed mostly rubble soils.

a. An interlane lawn at the intersection of Królewska and Marszałkowska streets at the Saxon Garden [8], (5),

b. An interlane lawn at the tram-line along Niepodległości avenue [5], (11).

c. An interlane lawn along Żwirki i Wigury avenue at the Cemetery of Soviet Soldiers, (6).

To this group are also included streetside plots adjoining the Łazienki park (4), Cemetery of Soviet Soldiers (6), Praga park (7), and housing estate Wierzbno (8) along Woronicza street (Fig. 3).

ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr. Z. Czerwiński, Dr. J. M. Matuszkiewicz and Dr. C. Wysocki for their valuable suggestions and discussions on the manuscript.

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CHARAKTERYSTYKA FIZJOGRAFICZNA OBSZARU WARSZAWY I MAZOWSZA

STRESZCZENIE

Nizina Mazowiecka położona jest w pasie Wielkich Dolin. Ukształtowana została w czwartorzędzie — w okresie zlodowacenia środkowopolskiego i bałtyckiego. Jest to płaska równina zbudowana z osadów fluwioglacjalnych i morenowych (glin zwałowych), silnie przemytych na obszarze rozległych równin peryglacjalnych oraz z osadów zastoiskowych (piaszczystych, mulistych, ilastych i organogenicznych) na obszarach akumulacji wodnej, natomiast szerokie pradoliny rzeczne wypełnione są osadami piaszczysto-żwirowymi i ilastymi, gdzieniegdzie nadbudowanymi eolicznie w tarasy wydmowe. Klimat Niziny Mazowieckiej cechuje przejściowość i duża zmienność stanów pogodowych z dnia na dzień. Jest to rejon o najmniejszym w Polsce opadzie rocznym (poniżej 500 mm), chłodniejszy w stosunku do sąsiednich dzielnic zachodnich i południowych. Przeważającą część gleb stanowią gleby skrytobielicowe i bielicowo-brunatne, mniejsze znaczenie mają gleby brunatne, wytworzone na siedliskach żyźniejszych (glinach zwałowych, pyłach i iłach warwowych), lokalnie występują także bardzo żyzne, pobagienne czarne ziemie. Występowanie właściwych gleb bielicowych na Mazowszu ograniczone jest do obszaru tarasów wydmowych. Pod względem botanicznym region ten charakteryzuje się zanikiem elementów atlantyckich, rozpowszechnieniem roślinności torfowiskowej (torfowisk niskich) i psammofilnej, brakiem buka, jodły, jaworu i brekini oraz wyspowym występowaniem modrzewia i świerka (pas bezświerkowy). Pierwotnie był to krajobraz lesisty i bagnisty, dominował krajobraz grądowy typu *Carpinion*. W obszarze tarasowo-wydmowym równin akumulacji rzecznej występował krajobraz borowy typu *Dicrano-Pinion*, w obszarze zalewowym dolin rzecznych krajobraz łęgowy typu *Salicion-Alno-Padion*. Obecnie jest to region w znacznym stopniu odlesiony, procent powierzchni leśnej należał do najniższych w Polsce i wynosił w roku 1970 20,1%. Istniejące obecnie drzewostany zagospodarowane są przeważnie jako monokultury sosnowe, rzadziej dębowo-sosnowe.

Warszawa położona jest centralnie w Kotlinie Warszawskiej, wypełnionej osadami lodowcowymi i osadami akumulacji rzecznej i eolicznej. W rzeźbie geomorfologicznej terenu zaznaczają się trzy tarasy rzeczne — najniższy taras akumulacyjny Wisły (taras zalewowy), średni taras akumulacyjny (taras praski), zbudowany z osadów rzecznych i w rejonie Puszczy Kampinoskiej i na prawym brzegu (Jabłonna — Praga) nadbudowany następnie eolicznie w taras wydmowy oraz najwyższy taras (taras warszawski), stanowiący rozległą równinę peryglacjalną. Na lewym brzegu Wisły taras ten ukształtowany jest wskutek zjawisk erozji i akumulacji,

na prawym ma charakter akumulacyjny. Odsłonięte na lewym brzegu osady to przeważnie spiaszczone gliny oraz osady zastoiskowe (muły, iły i torfy), na prawym brzegu przeważają osady piaszczyste. W granicach aglomeracji warszawskioj wskutek długotrwałej działalności ludzkiej odsłonięte na powierzchni są nie osady pochodzenia naturalnego, lecz osady o charakterze nasypowym z poruszonego podłoża, zwiezionych śmieci, gruzu i ziemi. Nasypy osiągają miąższość 3—6 m, niekiedy przekraczając 20 m. W związku z przewagą nasypów w budowie geologicznej aglomeracji warszawskiej występujące na tym obszarze gleby ujmuje się w dwie kategorie — gleby naturalne, i w obszarze zabudowanym — gleby antropogeniczne, mechanicznie przekształcone lub nasypowe. Wskutek solenia jezdni w okresie zimowym w rejonach przyulicznych tworzą się w ramach gleb antropogenicznych gleby sołońcowate i sołończakowate. Wskutek sztucznego charakteru krajobrazu miejskiego klimat miasta cechuje w stosunku do obszarów zamiejskich wzrost temperatury (średniej temperatury rocznej o 1°C), osłabiony dopływ promieniowania słonecznego, wzrost zachmurzenia i ilości opadów (500—550 m), obniżenie wilgotności względnej powietrza i silne przegrzanie środowiska miejskiego, zwłaszcza w miesiących letnich. Znaczna część wód opadowych odprowadzana jest jednak siecią kanalizacji miejskiej. Cechą szczególną klimatu miejskiego jest duża bezwładność termiczna. Analiza roślinności potencjalnej na obszarze miejskiej aglomeracji warszawskiej wskazuje, że na tarasie warszawskim, zwłaszcza w części lewobrzeżnej, występowały jedynie siedliska grądowe (*Tilio-Carpinetum*) w odmianie mazowieckiej, z niewielkimi płatami świetlistej dąbrowy (*Potentillo albae-Quercetum*). Znaczną część obszaru na prawym brzegu Wisły zajmował kontynentalny bór mieszany (*Pino-Quercetum*) i lokalnie olsy (*Carici elongatae-Alnetum*). Wzdłuż doliny Wisły na tarasie zalewowym występują łęgi jesionowo-wiązowe (*Fraxino-Ulmetum*) i nadrzeczne łęgi wierzbowo-topolowe (*Salicetum albo-fragilis*). Występowanie kontynentalnego boru sosnowego jest ograniczone jedynie do najbardziej północnego obszaru aglomeracji warszawskiej. W trakcie procesu urbanizacji pierwotna szata roślinna została całkowicie zniszczona. Głównym procesem wpływającym na kształtowanie się zbiorowisk darniowych zieleni miejskiej, poza silnym zanieczyszczeniem gleb metalami ciężkimi i innymi związkami toksycznymi, jest podsiewanie trawników miejskich mieszanką nasion 6 gatunków roślin. Analiza fitosocjologiczna składu badanych trawników wykazała zbliżony charakter tych układów do zespołów ze związku *Cynosurion*, w niektórych punktach parku Łazienkowskiego występować mogą także zespoły zbliżone do łąk świeżych ze związku *Arrhenatherion*. Strefy brzeżne trawników przyjezdniowych, charakteryzujących się silnym przesuszeniem i znacznym stopniem zasolenia i zanieczyszczenia metalami ciężkimi, zbliżają się składem fitosocjologicznym do roślinności kserotermicznej z klasy muraw piaskowych (*Sedo-Sclerantea*). Zagospodarowana zieleń miejska ma swoją określoną strukturę — przyjmuje się, że trawniki stanowią 60—70% powierzchni zielonej, pozostałą część zajmuje piętro drzew i krzewów. W pracy wyróżniono trzy typy zieleni miejskiej — zieleń parkową (o strukturze pionowej zbliżonej do warunków naturalnych, na glebach mechanicznie przekształconych, rzadziej nasypowych), zieleń osiedlową (przeważnie w postaci odsłoniętych dużych trawników na glebach nasypowych) oraz zieleń w centrum miasta, w postaci niedużych izolowanych trawników na glebach antropogenicznych nasypowych, przeważnie gruzowych.

W części szczegółowej pracy podano charakterystykę powierzchni badawczych w zieleni miejskiej i homologicznych środowiskach naturalnych w obszarze zamiejskim.

ФИЗИОГРАФИЧЕСКАЯ ХАРАКТЕРИСТИКА ТЕРРИТОРИИ МАЗОВИИ И ВАРШАВЫ

РЕЗЮМЕ

В статье обсуждены общие особенности физиографии территории Мазовецкой низменности и варшавской агломерации, с особенным учётом геологического строения,

почв, климата и растительного покрова. Далее приводится характеристика почв и фитосоциологическая характеристика городских и внегородских пробных площадок, выбранных для исследований по влиянию урбанизационного пресса на фауну, которые находились вне территории города, в пригородах в административных границах варшавской агломерации и в благоустроенной городской зелени.