INSTITUTE OF GEOGRAPHY AND SPATIAL ORGANIZATION
POLISH ACADEMY OF SCIENCES

[Conference Papers 2]

NATURAL ENVIRONMENT OF SUBURBAN AREAS AS A DEVELOPMENT FACTOR OF BIG CITIES

Papers from a scientific conference of the COMECON subject I. 3 "Evaluation and prognosis concerning the management of natural resources in the development of regions"
Jabłonna, Poland, 28 04 — 03 05 1986

WARSZAWA 1988

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Editors: Andrzej S. Kostrowicki, Marek Lityński

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ANDRZEJ SAMUEL KOSTROWICKI
Institute of Geography and Spatial Organization
Polish Academy of Sciences
Warsaw, Poland

INTRODUCTION

In the year 1972 an agreement had been signed by countries members of the COMECON concerning undertaking common studies related to the protection and transformation of the environment, entitled "Formulation of measures in the field of environment protection" /starting from the year 1976 - "General, expanded programme of countries members of the COMECON and Yugoslavia in the field of natural environment protection and a rational management of natural resources up to the year 2000"/. Within the framework of this programme, 14 subject groups have been established, which are concentrated on solving certain detailed problems of a research, technical, organizational character etc., and which gradually differentiated into units of a lower rank /subjects, problems/; they either grouped specialists from more narrow fields, or had a character of interdisciplinary syntheses. In the years 1975-1987, a total of 149 subjects have been realized. The results of the commonly conducted studies have been submitted to the Implementation Secretariat of the COMECON as so-called recommendations, and published as monographies or scientific elaborations in the COMECON publications, and of the cooperating countries.

Studies of a geographical character were concentrated mainly on two subjects: "Evaluation of economic and non-economic results of human influence on natural environment" /from the year 1985: "Evaluation and prognosis concerning the management of natural resources in the development of regions"/, and "Protection of ecosystems and landscapes". These subjects grouped specialists from many fields, such as ecologists, economists, planners etc., among which the main role has been played by geographers. It was them, or rather scientific geographical institutes which played coordinating functions for the whole studies. While the first of the two mentioned subjects is mainly of an utilizational character and concentrates mainly on learning the "man-environment" relations from the point of view of optimation in management of natural resources in regions of various types, then the main task of the second subject is learning the ecological mechanisms conditioning the stability of spatial patterns endangered by multi-directional pressures of human activity, as well as the definition of limits of an admissible interference of man into the existing ecosystems and landscapes, the exceeding of which causes a degradation of the studied systems.

The economic studies concerning the method of evaluation and prognosing of the condition and transformations of the environment as a factor of regional development are being carried out practically from the moment of establishing the first of the above mentioned subjects, i.e. from the year 1975. At the beginning they were of a theoretical and methodical character, as the task was to elaborate such assumptions and methods which would be possible to use both in various physical and geographical conditions, as well as in economic and social ones, and also in various approaches to the problems caused by different traditions of scientific research in various countries or scientific centres. This required above all a good learning of the specific features of the given area, understanding differences in the theoretical and methodical concepts used in different scientific centres which was, and still is, possibly only through common international and interdisciplinary field studies. Such studies have been conducted in all the participating countries, i.e. in Bulgaria, GDR, Czechoslovakia, Poland, USSR, Hungary and Yugoslavia. The results of these studies have been published in numerous separate monographies and in 15 volumes of the Information Bulletin of the COMECON subject I.3 issued by the Institute of Geography of the Czechoslovakian Academy of Sciences in Brno, and as achievements of various countries in own publications of scientific centres.

In the year 1985 within the subject "Evaluation and prognosis of the management of natural resources in the development of regions", a working group was established which was concerned mainly with the problems of environment as a factor stimulating or limiting the development of large towns. The selection of urban areas /to put it more precisely, suburban areas of developing towns, as it is in them that the specific interacting processes between the society, economy and nature take place, which are different from all the others/ as the subject of studies concerning the environment and the region was not accidental. It was a result of the understanding of the role played by towns, especially the big ones, as of one of the basic factors changing the natural environment, and simultaneously dependent from that environment in their development.

It is widely known that the social and economic development of any country or region may be measured by the level of urbanization. It is due to the fact that the town constituted, and to a certain degree still constitutes, a certain system in which both individuals and groups of humans of various ranks find the fullest possibilities of satisfying their material and spiritual needs. From the historical viewpoint, towns were established as the only means of a full satifaction of needs. This was due to the fact that towns ensured:

- increase in the feeling of safety /individual and group/,
- development of work division in the society, i.e. from the ecological point of view - creation of unit and population ecological niches and consequently of social stratification which is the main motor of species evolution,
- increasing the speed and facilitating the circulation of information in a wide sense, i.e. both of ideas and of goods, within the system, and between the system and the surroundings,
- limiting the creational role of the biological structure for the benefit of the social structure, and consequently placing the demographical and civilizational development on a wider basis.

Thus the town was to ensure for its inhabitants the obtaining at the lowest possible cost the biological, social, economic and intelectual success.

Already in the proto-urban era, the population established certain given mechanisms controlling the development of principles of group coexistence, the main task of which as the implementation of the above mentioned conditions. These mechanisms alienated human societies from their natural environment, created a new "human" world, in its character dangerous to nature. Gradually those mechanisms suffered a constantly increasing complication, and finally - which is a typical occurrence for animals in a social system - obtained independence, thus becoming a self-renewing, homeostatic and self-controlling system with an evident tendency for hypertrophy. At present the above mentioned creative conditions are of a secondary character, and are subordinated to the basic function of the town, which is its continuous growth. In other words, hitherto the town was necessary for man, and now man is necessary for the town.

When looking at urbanization from the point of view of ecology it is not only the expansion of the town itself, or a certain form of transformations in the conditions of functioning of nature and society, it is also the infiltration of an "urban" style of living, including the type of attitude towards nature in rural areas, in the area of the region. As a result of a diffusion of urbanization, four new types - or forms of coexistence of man with nature - were created: urban type, suburban type, rural type with urbanization pressure, and primary rural type.

A characteristic feature of towns is their irreversible development, which constitutes the basic danger for all natural processes. At the same time the character of the danger is not only due to the "metabolism" of the town, i.e.from production and disposal of various wastes, but from its mere presence and the spatial development. The town is an active megasystem, which in order to be able to function must introduce destruction into other systems, including natural ones. These systems either adapt themselves to the functioning of the town, or are destroyed. In this way a new quality is created - the natural environment of town, which differs from the nature of non-urban areas both in its structure, and in the mechanisms of functioning.

Presently studies of the natural environment of towns are advanced to such a degree which makes it possible for us to create town structures in such a way that substantial values of nature are protected against destruction and so that they may serve the inhabitants to the fullest extent. On the other hand, the situation is different in the aspect of the level of our knowledge about occurrences and processes taking place in the direct surroundings of towns, and in the whole zone of their influence on the natural environment out of their limits.

The suburban zone is characterized by a substantial instability of natural systems, a mosaic of ecosystems close to natural ones, and ecosystems which are totally "urban". The following are the distinguishing features of the natural environment in the surroundings of towns:

a/ a great spatial differentiation of ecological systems, which additionally are on different levels of inner organization, belonging to all the previously mentioned four types. These systems are usually structurally open, so that between them there is a free exchange of matter, energy and information. This differentiation may be confirmed by the fact that on a small study area of 400 hectares in the area of Warsaw, approximately 700 ecological and spatial units may be distinguished, while on an analogous area in the centre of Warsaw - 20 to 100, and in rural areas - 20 to 50;

b/ each of those ecological and spatial complexes is characterized by a big inner differentiation and a quick circulation of matter. As its consequence, a particular richness of flora and fauna may be observed. For example, in the previously mentioned study area,a spontaneous occurrence of over 600 species of vascular plants may be noted, i.e. almost one-fourth of the whole flora in Poland;

c/ the ecological structure of live organisms is much more diversified in the suburban zones than on rural areas, not taking into account the towns themselves. A principal features of these systems is the interchangeability of dominating species or a total lack of dominants;

d/ the stability of ecosystems of suburban areas is considerably big,much more substantial than in towns, but it does not reach values typical for natural ecosystems.

The discussed values indicate that the suburban zone creates a separate ecological system. It may be assumed, moreover, that it fulfills protection functions of a big importance for nature, thus "shielding" rural ecosystems from influence of towns. The range of suburban zones, understood as a separate natural system, is different and above all depends on the size of the town and its spatial structure.

In the case of Warsaw, this zone surrounds the town, and partially infiltrates it by the means of a ring of a width of 10 to 30 km. In small towns this type of ecological systems constitutes a dominant of the green areas inside them, and on the other hand in their surroundings occur only locally. Thus it may be assumed that from the point of view of nature, small towns with up to 20-30 thousand inhabitants are of a "suburban" rather than "urban" character.

x x

x

The scientific elaborations contained in this volume have been presented on the first inaugurational seminar of the working group, concerned mainly with the environment of towns and suburban areas, which took place in Jabłonna near Warsaw in the period of 28 April to 3 May 1986. The authors presented there their own still not uniform concepts that became a basis for the currently conducted studies. This results in the extensive thematical variety, different, frequently controversial ways of formulating and analyzing the studied social and economic, natural and spatial realities , such as towns and their surroundings. It seems that of the biggest interest to the reader may be that diversity of approaches to the ecological concept of town, which is due to both the different traditional of various research centres, and the specific distribution of pressure.

The first five elaborations present the selected problems concerning the suburban area of Warsaw, its character, development, both in the general concept and its selected fragments /e.g. the Łomianki Rural Commune/. From the remaining nine reports published in this volume, three have been elaborated by Czechoslovakian authors, two by authors from Hungary, two from the GDR and one each from the USSR and Bulgaria. Ideas presented in them and differences in the methodical approach enable an assumption that in the socialist countries there is a sufficient basis, both in manpower and the intellectual one, that may enable a further cooperation in the hitherto discussed field.

BOLESŁAW KRÓL
Warsaw Development Planning Office
Warsaw, Poland

PRINCIPLES OF SHAPING AND PROTECTING OF THE NATURAL ENVIRONMENT IN THE SUBURBAN ZONE OF WARSAW*

1. Existing conditions of the environment

The Warsaw Agglomeration constitutes the second largest agglomeration in the country. An analysis of the hitherto urbanization and industrialization processes indicates the occurence of considerable and dynamically increasing transformations of the natural environment on this area. Areas of the most substantial transformations and endangerment are practically identical to areas of the most intensive development and the highest population density.

In the spatial pattern the following zones of transformations may be determined:

- central zone with a wholly transformed natural environment and considerable air pollution, excessive noise, over-dense built up areas, high density of population and transformed local climate;
- transient zone, urbanized, with relatively big transformations but maintaining relatively correct standards of natural environment quality; endangerment and conflicts are here of an island or local character;
- external zone, with a rather unpolluted environment.

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* The paper embraces and describes the principles of shaping and protecting the natural environment by planning methods, however, it does not discuss means of a technical character.

Trends of changes particularly indicate the spatial expansion of the transient /middle/ zone. The most endangered areas are the centre of Warsaw, the western belt and the Wołomin belt, i.e. the north-eastern.

2. Basic elements of the system regulating the environment conditions in the Warsaw Agglomeration

The natural environment of the Warsaw Agglomeration is being formed by characteristic physiographical and large-scale natural features. From among them only those should be mentioned which are connected with the influence of green spaces and their open areas of the suburban zone on the regulation of climatic conditions in urbanized areas, underground water conditions and soils protection /Fig. 1/.

The analysis of anemometric relations and of the landscape indicates that the basic importance for ventilation of central areas of the Warsaw Agglomeration is ascribed to the complex of Kampinos Forest which is situated on the direction of prevailing winds in relation to Warsaw, and the belts of Otwock forests situated on the direction of gravitational wind run-offs in the Vistula valley. A similar role for urbanized belts of Pruszków and Wołomin is played by escarpments of the Rawa and Siedlce upland which are situated south of those lines, are gently sloped and in major part afforested. The main routes of gravitational run-offs of polluted air are the Vistula River valley below Warsaw, the Bródno-Nieporęt Valley and the Utrata Valley, as well as its tributaries on areas situated north of the Żyrardów line. In the regulation of underground water conditions of the Warsaw Voivodship, a major part is played by the Grójec watershed which feeds the underground water resources of the left side of the Vistula River, which is the most densely populated, and which has the best soils of the whole Warsaw Voivodship.

Due to a high share of poor quality soils, forests of the northern and eastern parts of the Warsaw Voivodship fulfill simultaneously very important functions of soil protection.

Thus in Warsaw there are generally favourable natural conditions and favourable assumptions for the creation of a system of regulating the environmental conditions. They result from the already discussed existing pattern of river valleys and the maintained setting of forest complexes surrounding Warsaw, and connected with the regional natural environmental system. These belts create a natural system of ecological protection of urbanized areas and decide about supplying these areas with clean air, rich with oxygen.

3. Perspective development assumptions

The perspective physical development plan, elaborated in the years 1976-1978 and approved by the decision of the City Council of Warsaw /29th May, 1978/ assumes that the natural environment on the area of the voivodship, constitutes a special amenity of particular value under permanent protection, and the utilization of natural resources cannot exceed the values which would disturb the environmental balance and conditions of its renewal. Transforming of the natural environment within the Voivodship should enable the improvement of housing conditions, recreation, work and health of its inhabitants.

The basic features of the physical functional and structural pattern of the Warsaw Voivodship, included in this plan, are being determined by /Fig. 2/:

1/ concentration of urban land uses in selected development directions,

2/ limited development of the central part /Warsaw/ and the belt pattern of urbanization in the suburban zone with a preference of the northern direction, on the right bank of the Vistula River,

3/ maintaining the proper relations between areas undergoing urbanization processes and green and open spaces, which fulfill such functions as: food production, recreation, protection and regulation of the environmental conditions.

According to the provisions of the plan it is assumed that a target figure of 42-47% of the Voivodship should be used for active areas, favourably creating those conditions which will be formed by:

- forests and afforestations	27-30%
- fields and meadows	10-11%
- arranged green areas	3-4%
- open water	2%

4. Forming of the protected areas system

In the approved model of the physical structure of the agglomeration, the pattern of green areas and open spaces of the highest values and natural potentials, has been formed as a large scale system of protected areas /Fig. 3/. The establishing of this system is aimed at protection against destroying or degrading those elements of the natural environment pattern, the maintaining of which is justified by important social, economic, or protection reasons. This pattern should:

- make more stable and enforce the existing system of ecological protection of Warsaw,
- protect natural features of special importance for shaping and regulating of human life conditions and for protection of agricultural lands,
- create conditions for intensified activity regulating the natural processes in respect of water and oxygen cycles, and soil protection,
- ensure a permanent natural basis for economic activity,
- counteract negative results of environment degradation,
- protect naturally valuable entities,
- ensure proper recreation and aesthetic landscape values /areas of scenic beauty/.

In relation to the perfomed analyses and on the basis of the assumed functions the following areas have been included into the above large-scale systems of protected areas:

- areas of the highest natural and ladscape values,
- areas of health resorts and of recreational functions,
- areas actively participating in the system of regulating environmental conditions such as forest complexes, green land use areas, water intakes and water retention areas, ventilation tunnels, forests protecting soils and water, etc.,
- complexes of poorer quality soils directly surrounding the above complexes,
- connections betwen natural features ensuring the physical and functional continuity of the given system.

From the protected areas urbanized areas in accordance with their perspective range, the majority of areas of favourable conditions for agriculture, animal farms industrial plants and municipal facilities of supra-local character were excluded.

The established system of protected areas surrounds in a semicircle the urbanized areas, from the south, east and north, penetrating into them with green spaces connected with the running of the river valleys. From the west this pattern goes into the urbanized areas of the Warsaw Agglomeration via wide belt of the Kampinos Forest and its surroundings. This belt ensures correct ventilating of districts lying in the central sector, and divides the urbanized areas of the northern sector from the highly productional complex of the Błonie lowland and the intensively urbanized western belt.

Interrelations between urbanized areas and the open suburban ladscape, and with suburban recreational areas included into a system of protected areas, ensure:

- in the centre of the agglomeration /Warsaw/ radial strips of green areas penetrating inside town and dividing various housing estates and industrial complexes,
- on urbanized areas of the inner zone, natural ladscape areas dividing various complexes and penetrating into them in the forms of belts with green areas, organized in a comb-like system.

Protected areas in the Warsaw Voivodship cover an area of approximately 2130 sq km which is 56.2% of the total area of the Voivodship, including 343 sq km /9.2%/ of the National Park in the Kampinos Forest. The structure of land use of the established system of protected land is as follows:

- forests	40%
- fields, meadows	16%
- open water	4.2%
- arable lands	32.4%
- others	7.4%

5. Principles of natural and landscape values protection, and provisions for economic activity on protected areas

In order to protect the natural values of this area, and to ensure protection of the natural environment in accordance with the requirements concerning its use, it is assumed that economic activity on protected areas should take into consideration the following principles*:

1. Maintaining the physical and functional continuity of the delimited system of protected areas;

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*Especially protected areas within the system of protected areas, such as reserves and national parks, are absolutely excluded from economic activity and their development is determined by separate regulations.

2. Using protected areas mainly for agricultural, forest, recreational and health purposes, in the scope and in forms applying a technology which would not conflict with the environment protection requirements, with a simultaneous excluding of those areas from intensive urbanization;

3. Intensified protection of natural resources, such as soils, woods, forests, open waters, small ponds, peat lands, swamps, turf lands, as well as the natural land configuration, especially characteristic for the surrounding of Warsaw: sand dunes, escarpment edges and scarps;

4. Subordinating settlement on the protected landscape areas to leading functions of this area;

5. Developing agriculture in the protected areas on the basis of ecological criteria i.e. on methods and means adjusted to requirements of environmental protection;

6. Expanding afforestations and forest areas through afforesting poor quality soils and unfavourable for agricultural purposes /including soils of class VI/;

7. Preference in using lands for establishing open recreation, universally accessible, before individual or group use;

8. Maintaining the existing water resources in the required purity class and of increasing water retention in every way /retention reservoirs, phytomelioration means - afforestations, etc./.

9. Recultivation of areas with lower natural values.

Thus, with determination of a system of protected areas in the Warsaw Agglomeration, a whole complex of assumptions and recommendations is connected with various aspects of economic activity, aiming at protecting this area, and of the natural functions performed by this area. These assumptions determine the principles of economic and physical planning and development. However, it sould be stressed that having protection as a target, they do not aim at decreasing the intensity of economy and lowering of production, but rather have as a goal attaining these aims in another way, by the aid of methods and means favourable to environmental protection.

The development of urbanized areas, correlated closely with the system of protected areas, assumes their shaping in belts and in directions adjacent to the determined system of protected areas.

In connection with the progressing endangerment to the environment, the determined system of protected areas takes care of physical structures having considerable importance for ensuring proper environmental conditions and maintaining the required living standards. Those structures and their influence should be considered in categories of activities aiding and supplementing the necessary current and future technical activity.

The technical influence assumes aiming at the reduction or neutralization of noxiousness, obtained by technological processes, and requires serious capital expenditures.

Influence of nature is based on the protection and dynamization of biotically active factors and on the creation and maintenance of suitable physical features. Those features should balance the activities and consequences of technical and economic activity by means of autogenous natural regulation processes.

In the existing conditions, the solving and moderating of a conflict which develops gradually between the processes of urbanization, industrialization and intensification of agricultural production on the one hand, and the requirements of environmental protection on the other, exceeds possibilities of natural environment self-renewal, and cannot be solved without the help of technology. However, the lack of investment funds and the sometimes insufficient technological means postpone into the future the possibility of appropriate control of this process by this way.

In such a situation, the creation of the physical order, connecting in the best possible way socio-economic development requirements with environment protection needs, becomes the only possible and accessible method currently enabling an effective constraining of the progressing environment degradation. In the future it should enable the full control of this process. The technological progress and the gradually obtained investment funds for purposes of environment protection, will with years enable an effective removal of noxiousness at its source.

An inappropriate physical disposition which disorganizes the functioning of the natural features is, as a rule, permanent and almost non-reversible loss. It destroys successive links in the system of natural balance and weakens permanently its effectiveness.

Nevertheless, in order to ensure an appropriate influence and functioning of the protected areas, it is necessary to:

- maintain the continuity of the system, and of its integration in various physical scales into one functionally and physically comprehensive system,
- maintain ecological differentiation in this system,
- protect against external factors negatively affecting the system,
- adjust the forms and technology of the economic and technical activity on these areas to the requirements of environment protection.

In this context the defined system of protected lands is not excluded from economic activity; it is, however, an area on which certain defined forms of economic activity should be introduced. The gist of the problem is that on these areas, with the exception of the specially protected ones, like reserves and national parks, land use for agriculture and forest purposes should be developed only by using certain defined technologies and methods, and should constitute - together with the development of recreational functions - an important factor of the social and economic activation of those areas.

Fig. 1 Functions of open spaces conditioned by specific features of environment in the Warsaw voivodship

1 - green and open spaces pattern, ensuring protection for ventilation and horizontal air exchange for the central areas of the agglomeration, 2 - the same pattern for urbanized areas and towns of the external zone, 3 - soil protecting forests maintaining dune areas, 4 - forests of water divides regulating water relations, 5 - areas of dusty soils, undergoing movements during dry seasons, which require the introduction of an afforested wind-protected zone, 6 - areas of health protection values, 7 - areas embraced by the steppe formation process, requiring appropriate phytomelioration processes, 8 - the Grójec water shed, 9 - the Wysoczyzna Rawska Foothill, 10 - the Błońska Plain, 11 - the Kampinos Forest, 12 - the Wysoczyzna Siedlecka Foothill, 13 - the Bródno-Nieporęt lowland

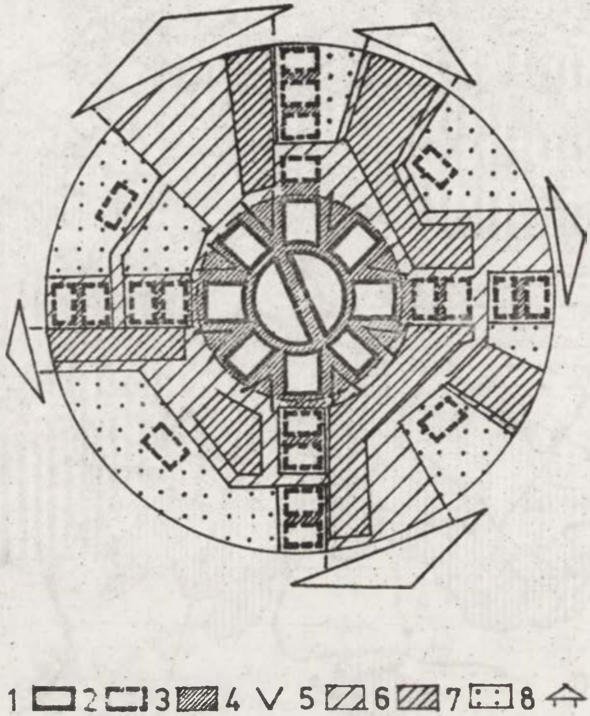

Fig. 2 Model of spatial structure of the Warsaw agglomeration

1 - complex of central districts; 2 - belts of external districts and dispersed patterns; 3 - green spaces; 4 - ventilation belts; 5 - system of areas within protected environment; 6 - recreational areas; 7 - agricultural production areas; 8 - connections between the system of protected areas with the regional pattern

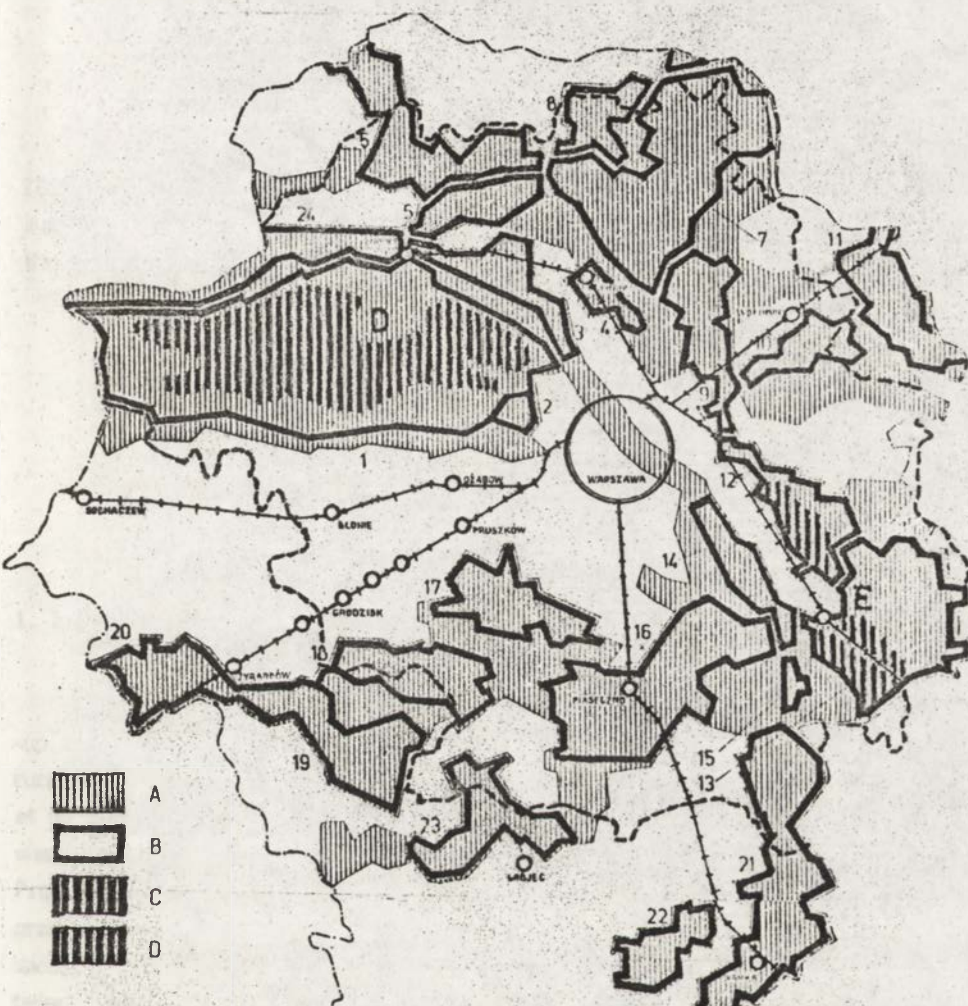

Fig. 3 Protected areas in the Warsaw voivodship

A - zone of protected landscape;

B - recreational and tourism zones /1-22/;

C - the Kampinos National Park;

D - the Mazovia Landscape Park

ZBIGNIEW CZERWIŃSKI
Warsaw Agricultural University
Warsaw, Poland

SOIL AND WATER RELATIONS IN SUBURBAN AREAS OF WARSAW

1. Introduction

Within each urban agglomeration, a central zone with dense, urban type built-up areas may be determined, as well as a suburban zone, of the rural housing type, rural/urban housing, or typically of agricultural character, with production directed at supplying urban population with agricultural and food stuffs. The extensive sale market stimulates the intensification and specialization of agricultural farms. Presently in the area of Warsaw the number of traditional multi-functional farms is gradually decreasing, while the number of orchards, vegetable farms or breeding of specific type of animals is increasing. Animal breeding or poultry farms are often being established in complete separation from plant production and from possession of appropriate cultivable lands for a rational utilization of the produced organic fertilizers and liquid manure. The necessary amounts of fodder are in such cases purchased, and liquid manure is being treated as an unnecessary waste by-product. Additionally, vegetable farms limit their cultivations to only a few or even to one type of plant /e.g. onions, gherkins, caulliflowers, etc./.

Apart from vegetable cultivations on farms, recently in the vicinity of Warsaw the production of vegetables and flowers in greenhouses is being developed. The areas near Żerań and Jabłonna only a little more than ten years ago were uncultivated and sparsely built-up, of sandy and dune type, and now constitute one big greenhouse production area, and each individual complex of greenhouses has its own heat production plant based on hard coal.

On suburban areas small service handicraft and production workshops are located, as well as several institutions with research and scientific centres, health centres, and even larger industrial plants.

The considerable splitting of farms and the progressing urban-type development as a consequence leads to the high density of population in suburban areas, often exceeding 400 persons per 1 sq. km /e.g. the Łomianki Rural Commune/.

The presented conditions indicate that substantial anthropogenic transformations may embrace not only the natural environment of the urbanized part of the town /Czerwiński 1978, Czerwiński and Pracz 1983, Dobrzański et al. 1977/, but also fundamental transformations may take place on adjacent areas.

The following internal factors are influencing soil proterties and water relations of suburban areas:

- the high level of mineral fertilizing of arable lands, mainly of vegetable and orchard farms;
- the excessive production - on certain areas - of liquid manure on farms of industrial type breeding of pigs and cattle, unproportional to the area of cultivable lands, on which this manure may be used as natural fertilizer;
- excessive amounts of domestic and industrial sewage in soils, as well as of various wastes, which as a consequence of the lack of sewerage system are being disposed of and utilized often in an uncontrolled way, which is contrary to the requirements of the protection of the natural environment;
- local emission to the atmosphere of burning products of hard coal which is the basic heating source in numerous farms and heat production plants in glasshouses.

Apart from local factors, which may occur in varied intensity depending on the way of land use, the suburban areas development is under the influence of external factors. Large industrial plants and heat and power generating plants which emit to the atmosphere large amounts of ash particles and gaseous elements, are being located at the peripheries of towns, and therefore suburban areas are constantly under the iunfluence of masses of polluted air. Additionally, suburban areas are being cut by exit transport routes from the town, with large traffic density, and which are a source of not only heavy metals emitted with automobile exhaust gases, but also of natrium chloride utilized in winter for disposing of snow on roads.

In this elaboration, changes in the soil environment of suburban areas will be presented, on the example of a rural commune located in the suburban area of Warsaw, i.e. Łomianki, as well as the chemical condition of open water of the following areas: Wilanów-Powsin, Okęcie-Służewiec-Pyry, Łomianki; groundwater in Białołęka Dworska and Łomianki, and well-water on the area of the Łomianki Rural Commune.

2. Soils of the Łomianki Rural Commune

2.1. Surface rocks

The area of the Łomianki Rural Commune is made of Quaternary period alluvia occuring in the forms of three main lithostratigraphic types - glacial alluvia, upper--Pleistocene alluvia of terrace levels together with after-glacial eolitic formations, and modern Holocene deposits of alluvial terraces.

The glacial deposits cover the south-eastern edge of the Commune /Dąbrowa Leśna, Buraków/, and are connected with the moraine high-land of mid-Polish glaciation. They are constituted by boulder loams with rocks covered by various types of sand, with a width of two to three metres.

Upper-Pleistocene formations of terrace levels occur in the western and middle parts of the Commune, creating a flat geomorphological formation called the Kampinos terrace. The range of their occurrence is constituted by a geomorphological boundary which simultaneously is an edge of the terrace, running along the line Łomianki-Dziekanów Polski. They are formed as a series of mutually inter--laying various sandy and gravel deposits situated over formations of clay and slime. In the surface areas mainly loose sands and loamy sands ones occur, and on areas between the settlements of Sadowa, Dziekanów Leśny and Dziekanów Polski, and on the area of Łomianki there are layered sand and gravel formations covered by coarse sandy loam, sandy loam or sandy clay loam. In the south-western part of the Commune, sandy formations of terrace levels have been in the period of dryas formed into a series of dune hills. The Holocene alluvial terraces, the higher non-flooded and the lower flood plains are made of silts, sandy silts and sands, and cover the northern and north-eastern area of the Commune.

2.2. Soils

Soils on forest and agricultural areas have maintained their natural morphological structure. In the southern part, on afforested sandy and dune areas, there are podsols, and in depressions between dunes, depending on the degree of soil humidity, podsolgley soils, mineral-mursh soils and peat soils. Proper alluvial soils constituting approximately one third of arable lands of the Commune, occur on the modern flood plain and non-flood plain terraces. Uniform surfaces of deep alluvial soils with the sait texture of silt, characteristic for the middle part of the Vistula River valley /Czerwiński 1971/, are located in the northern part of the Commune. In the eastern part a substantial spatial variety of the soil texture of surface layers takes place, and here alluvial soils occur with the soil texture of loose sands, loamy sands, coarse sandy loam, sandy clay loam silts.

Between the alluvial terrace and the southern forest part of the Commune, there is a majority of leached brown soils formed of sands and, however, a smaller area is taken by gley soils, among which locally may occur degraded meadow black earth soils and half bog soils.

For the total area of 1822 ha of arable lands, on the area of the Commune there are about 50% of light sandy soils of the V and VI class. Up to now the best soils were utilized for agriculture, while residential development is being implemented on least favourable areas from the point of view of soils.

The most intensive mechanical transformations may be noted in the case of soils on built-up areas with one-family housing estates, and on areas of ground works connected with the construction of flood banks and sand pits for construction purposes. Soils transformed mechanically with a destroyed of soil horizons, often without humus horizon, occur near Dąbrowa Leśna, Buraków and Łomianki, and on the flood plain terrace near Dziekanów Polski. Deteriorated areas, apart from residential development, are barren lands used as uncontrolled refuse dump site or for dumping of liquid manure, domestic sewage or even as industrial wastes disposal sites. The processes of mechanical transformation and creating of anthropogenic deposited soils are integrally connected with the urbanization of surface /Dobrzański et al. 1977/.

Soils utilized for agriculture which maintain the genetic horizons optically characteristic for the defined soil-forming process, also undergo far-reaching transformations. The intensive, one-sided mono-culture farms based mainly on mineral fertilizing without appropriate supplementing lime and organic fertilization leads in a very short time to heavy acidity of the cultivable layer of soils /Tab. 1/, intensive leaching by rainfall of lime and changeable magnesium /Tab. 2/, and makes the mineralization of humus much quicker, /Tab. 1/. This type of perceptible changes take place already after a three-year period of intensive mineral fertilization /Czerwiński and Pracz 1978/. The process of degradation of chemical properties of soils may also be caused by a frequent fertilization of soils by vast amounts of liquid manure. In such cases not only a high acidity of surface layers of soils take place, but also very unfavourable relations between the content of monovalent and bivalent cations in the soil sorption complex /Tab. 2/.

In non-productive places with a permanent surpluss manure dump sites which originate from farms of industrial animal breeding, a substantial hyper-nitrogen content of soils takes place, and the salt content of surface layers of soils increases with potassium-sodium compounds /Tab. 3/.

The E-81 road running through the suburban Łomianki Rural Commune, which in this part concentrates also the automobile traffic of the T-81, 107 and 114 roads, has an influence on the content of heavy metals in soils in the neighbouring areas, of a width of even 300 metres /Tab. 4/. The highest accumulation of heavy metals amounting to 452 ppm of Zn, 330 ppm of Pb, and 66.8 ppm of Cu takes place in the distance of 0.5 m from the edge of the road. The content of those metals in soils at the beginning decreases with the distance increase from the edge of the road, but after a 100 metres once more begins to increase. Those results are in conformity with the deducted mathematical function /Wheeler and Folfe 1979/, according to which bigger particles of exhaust gases flow down in a distance of up to 5 metres from the road, and small particles are carried by air farther away. The influence of exhaust fumes from automobiles on the content of lead and zinc on soils adjacent to the E-81 auto road has a bigger range, as already in a distance of 300 metres the amount of 78 ppm of Zn and 50 ppm of Pb have been found; those amounts exceed the natural ones for agricultural areas of middle Poland /Czarnowska 1977/.

One of the unsolved problems in suburban zones is the influence of burning of big amounts of hard coal in individual heat producing plants of various greenhouses as in the case of the occurrence of larger number of greenhouses on the given area, for example between Żerań and Jabłonna, in evenings during spring and autumn there is a uniform smoke cloud just above the surface of the ground.

3. Chemical properties of water in suburban zones

3.1. Surface water

Chemical properties of surface water on urbanized areas are clearly transformed and depend on numerous factors /Czerwiński and Pracz 1983/, among which the dominating role is played by time duration describing how long given areas have been built-up, and the character of the accumulated anthropogenic alluvial layer, the geochemical and hydrological properties of the natural ground, the amount of inflowing wastes and the way of utilization of ground within the town.

Lately also on areas which are typically agricultural,fundamental transformations of the chemical properties may be observed of surface water, which are connected with the intensification of plants production /Borowiec 1984, Taylor 1984/, and the change to a litter-less system of animal breeding /Maćkowiak 1984/.

In suburban areas the influence are being superimposed of neighbouring urbanized areas, industrial plants, residential development and agriculture; simultaneously the influences of various sources of surface water pollution may be of different intensiveness.

In order to make the picture of the chemical condition of surface water clearer three suburban areas have been selected with the following characteristics:

- Wilanów-Powsin is an area of typically agricultural character, isolated spatially from the dense metropolitan built-up areas, without industrial plants and with only a few small service centres. The basic agricultural production are field cultivations with a high share of vegetables. The animal production does not play a substantial role and is of a traditional character. A certain external influence may be fulfilled by the heat and power generating plant of Siekierki, located nearby, which is in operation for over ten years. The area is of a typical rural or dispersed one-family housing.
- Okęcie-Służewiec-Pyry is an area of agricultural character directly neighbouring with numerous industrial plants, high-rise blocks of flats, airport and horse race course.
- Łomianki Rural Commune - the studied surface water occurs on an alluvial terrace utilized solely for the purposes of agriculture, but they are fed by under-surface run-offs from areas of neighbourhoods and one-family housing estates of Buraków and Łomianki and from the southern agricultural lands.

Surface water of agricultural lands in suburban zones is characterized by a low degree of mineralization, not exceeding 500 mg/dm^3 /Tab. 3/. Despite a similar content of soluble salt, water of the Wilanów-Powsin and of the Łomianki Rural Commune areas is differentiated by the ions structure. In the positive ions part of soluble salt of surface water of the area of Wilanów-Powsin, Ca^{++} is dominating of which equivalently there is double the amount of the total sum of Mg^{++}, K^+ and Na^+. Similarly in the negative ions part, decidedly dominating is HCO_3^- over negative ions SO_4^{--} and Cl^-. Thus, generally surface water of this area is of a typical calcium-bicarbonate character and only to a slight extent the increased values of SO_4^{--} may indicate some influence from the nearby located heat generating plant. Water in ponds and of some ditches contains bigger amounts of $H_2PO_4^-$ and in one case only a substantial amount of NH_4^+ /Tab. 5/.

The hydrochemical character of the surface water of the agricultural area of the Łomianki Rural Commune indicates a stronger influence of domestic sewage permeating from areas of residential development. On average in the positive ions part of this water, equivalently dominating is Na^+, and the total amount of Mg^{++}, K^+ and Na^+ exceeds almost twice the amount of Ca^{++} /Tab. 5/. In the negative ions part of soluble salt, despite the dominance of HCO_3^-, an important role is played also by the Cl^- ions. In relation to surface water of the Wilanów-Powsin area, surface water in Łomianki contains less Ca^{++}, HCl_3^- and So_4^{--} and more of Na^+, K^+, Mg^{++} and Cl^-. From the hydrochemical point of view, they are sodium-calcium-bicarbonate-chloride water. Surface water of the area of Okęcie-Służewiec-Pyry is more highly mineralized with the total content of soluble salts up to 749 mg/dm^3 /Tab.5/. On average, apart from No_3^- and HCO_3^-, they contain more of all ions together with NH_4^- and $H_2PO_4^-$, the concentration of which may be up to 10.85 mg/dm^3. The influence of the adjacent urbanized lands and industrial plants is characterized by a considerable concentration of So_4^{--} and Cl^- ions. From the hydrochemical positive ions point of view, this is calcium-sodium-magnesium water, and in the negative ions structure bicarbonate-chloride-sulfate water.

3.2. Groundwater

Apart from agricultural sources of groundwater pollution on suburban areas of Warsaw, also transport routes may be considered as important sources of pollution, as well as local sewage pumping stations from industrial plants and emission to the atmosphere of sulfur compounds.

To agricultural sources substantially deforming the chemical properties of groundwater may belong the intensive mineral fertilization of certain cultivations, the utilization of liquid manure on light sandy soils with a shallow water table and disposing of surpluss of liquid manure on dung sites.

The most drastic influence on the chemical properties of groundwater are dung sites for liquid manure, the local sewage pumping station and the transport route /Tab. 6/. On disposal sites for liquid manure, the electric conductivity groundwater may exceed 7 $mS \cdot cm^{-1}$, and the total content of ions of soluble salts is up to 6210 mg/dm^3. When liquid manure is disposed of to marshy areas, the content of NK_4^+ in groundwater quickly increases, and a serious pollution by ions of K^+, Na^+, SO_4^{--}, $N_2PO_4^-$ and Cl^- takes place, while there is a relatively low content of Mg^{++} and NO_3^- ions in water. The hydrochemical character of water in such cases is in the positive ions structure of ammonium-sodium-potassium character, and in the negative ions structure - bicarbonate-chloride.

On surfaces with deeper table of groundwater, in places of permanent disposal of surpluss liquid manure and its longer contact with soil, ions of $H_2PO_4^-$ are absorption in soil, while NH_4^+ is nitrified, and from the remaining part of the liquid manure, during decomposition, large amounts of SO_4^{--} are being released. Then, ground waters in the negative ions part are of sulfate-nitrate character, and in the positive ions part there is an increase of Ca^{++} and Mg^{++}, and the amounts of Na^+ and K^+ decrease. Those changes are an effect of an interrelation between the sorption complex of soils and negative ions contained in liquid manure permeating the ground.

Sewage penetrating from the local pumping station increase the level of mineralization of groundwater, in a considerable distance from the pumping station. The main element permeating from sewage is sodium chloride, and certain amounts of sulfate compounds /Tab. 6/. Sodium-chloride water with the mineralization amounting to 2365 mg/dm^3 and electric conductivity of 4 $mS \cdot cm^{-1}$ also occur near the E-81 road. Surveys carried out from the point of view of dynamics, indicated that the changed chemical properties of groundwater in the zone of influence of the pumping station and near the transport route are a permanent phenomenon.

The vicinity of large power units influences the content of sulfates in groundwater. Groundwater in Białołęka Dworska is of a typical sulfate character, and the general level of mineralization may reach 1467 mg/dm^3 /Tab. 6/.

On agricultural lands which are beyond the range of influence of external factors, chemical properties of groundwater are determined by the level and type of fertilizers and the type of cultivated plants or method of land use. The cleanest water from the chemical point of view is on field and pasture areas fertilized by mineral fertilizers. However, a temporary pollution of water by nitrates takes place in the case of fields on areas of sandy soils with a high level of groundwater and fertilized by large amounts of liquid manure /Czerwiński et al.. in print/.

In case of field cultivations, the main compound influencing the quality of water is the nitrate nitrogen, and the content of nitrates in water increases in the direction: grains < root-crops < maize < vegetables < berry bushes.

In case of intensive mineral fertilization, groundwater may be of a nitrate character /Tab. 6/.

3.3. Well-water

A single analysis of water in 181 dug wells implemented on the area of the Łomianki Rural Commune in the year 1982 indicated a very high level of their pollution /Tab. 7 and 8/. The main ion limiting the suitability of water for drinking purposes was NO_3^- /Tab. 8/. Only in water of 26% of studied wells the concentration of NO_3^- was within the limits of standard defined by sanitary regulations /State legal gazette "Dziennik Ustaw", no. 18, 1977/, while in water of the remaining 74% of wells the concentration of NO_3^- exceeded the permissible level of 44.4 mg/dm^3; moreover, in as many as 50% of wells, water contained from 88.9 to 710.4 mg of NO_3^- /dm^3 /Tab. 8/. Apart from nitrates, water of 27% of studied wells contained an exceeded amount of NH_4^- /Tab. 1/, 14.4% of wells contained an exceeded level of SO_4^{--}, and in water of 41.1% of studied wells there was a concetration of $H_2PO_4^-$ exceeding the norm set for the I class of water purity /"Dziennik Ustaw" 1970/. In water of numerous wells also stated was a high concentration of positive ions of Mg^{++} and K^+, differing from natural concentrations occuring in groundwater /Czerwiński, Pracz 1983, 1984/.

The obtained results of single studied did not provide answers as to whether this chemical condition of water in wells is an accidentla phenomenon, or a permanent anthropogenic transformation. In order to receive an answer to this problem, in the year 1983 a selection was made of 14 dug wells with a varied degree of water pollution and four drilled wells obtaining water from deeper layers /8 to 12 metres/, and in those wells in the period from April 22 to October 13, water has been analysed in two-week period intervals.

The ranges of concentration changeability of NO_3^- obtained in studied well water /Tab. 9/, indicate a permanent pollution by nitrates if the dug well is situated within a yard in a bad sanitary condition. An identical situating of a well on a farm without animal breeding with a clean and soddy yard wholly protects water in wells, even in dug ones, from the penetration of nitrates. The pollution with nitrates takes place also in water of dug wells situated within dense built-up areas. The source of water pollution in those cases are domestic sewage and sanitation tanks.

The comparison of the nitrates content in water of dug wells /village of Sadówka 5 and Kępa Kiełpińska 23/ and in water of drilled wells indicates that higher pollution occurs in ground water of the upper layer of the first water-carrying level, while in deeper layers of this level, water - from the chemical point of view - indicates a high degree of purity and may be used as potable water /Kępa Kiełpińska 23a/.

Additionally, to water of dug wells situated within rural yeards in a poor sanitary condition penetrate also bigger amounts of such ions as K^+, Na^+ and Cl^-.

Summary

Soils in suburban areas may undergo mechanical deformations, which are a result of construction works, sand exploitation for construction purposes, and carrying out of various on-the-ground facilities construction. As a result of mechanical deformations, the natural vertical soil horizons is damaged, and soils often are deprived of humus levels.

Soils of agricultural lands with a natural morphology, under the influence of fertilization, undergo acidified and leaching from positive ions of calcium and magnesium. A frequent fertilization with liquid manure leads to the saturation of the sorption complex by the sodium ion, and dumping of liquid manure causes a serious hyper-nitrization process and a considerable increase of salt content.

Near by transport routes with big traffic density, an accumulation of zinc, lead and copper takes place. The range of accumulation of heavy metals may reach 300 metres from the edge of the road.

On suburban areas, open water /e.g. ponds, ditches, rivers/, and groundwater undergo a considerable chemical pollution, and the type and intensity of pollution depends on land utilization. The agricultural land use leads to a higher concentration of nitrates in water. An intensive development of farms of industrial animal breeding increases in water the content of K^+, Na^+, NH_4^+, SO_4^{--}, $H_2PO_4^-$, NO_3^- and Cl^-. Domestic sewage and industrial wastes as well as run-offs from transport routes are a source of NaCl in water. Groundwater and surface water of areas adjacent to power generating plants may be to a large degree sulfated.

A majority of water in dug wells in suburban areas is highly polluted by nitrates; however, water taken from deeper layers fulfill conditions required for drinking water.

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Table 1 Content of organic carbon, nitrogen and pH of soils

Type of land use	Depth in cm	pH in		%		C:N
		H_2O	1 M KCl	Organic carbon	Total nitrogen	
Barren land	0 - 20	6.5	5.7	1.55	0.15	10.3
liquid manure	20 - 70	6.2	5.9			
disposal site	70 - 100	6.1	5.9			
Arable land	0 - 28	4.9	4.0	0.53	0.07	7.6
fertilized by	28 - 48	7.7	7.2			
mineral fertilizers	48 - 90	8.0	7.5			
and liquid manure	90 - 110	8.0	7.5			
Meadow	0 - 5	5.5	4.9			
permanently ferti-	5 - 10	5.7	5.2			
lized by liquid	10 - 20	5.8	5.5			
manure	20 - 60	6.4	6.0			
	60 - 80	6.6	6.0			
	80 - 100	6.7	6.4			

Table 2 Sorption properties of soils

Type of land use	Depth in cm	Changeable cations meq/100 g of soil				
		Ca^{++}	Mg^{++}	K^{+}	Na^{+}	total
Barren land	0 - 20	3.16	0.40	0.40	0.34	4.30
liquid manure	20 - 70	0.16	0.01	0.05	0.03	0.25
disposal site	70 - 100	0.11	0.01	0.04	0.01	0.17
Arable land	0 - 23	1.54	0.54	0.20	0.05	2.33
fertilized by mine-	28 - 48	7.39	1.88	0.05	0.19	9.51
ral fertilizers	48 - 90	4.98	1.17	0.03	0.13	6.31
and liquid manure	90 - 100	0.69	0.18	0.04	0.06	0.97
Meadow	0 - 5	8.58	0.51	6.75	0.37	16.21
permanently ferti-	5 - 10	7.28	0.45	8.79	0.35	16.87
lized by liquid	10 - 20	8.03	0.45	6.19	0.35	15.02
manure	20 - 60	7.98	0.50	6.01	0.39	14.88
	60 - 80	5.17	0.51	0.59	0.24	6.51
	80 - 100	3.14	0.18	0.46	0.17	3.93

Table 3 Content of soluble ions and mineral forms of nitrogen in soils

Land use	Depth in cm	Content of soluble ions (mg/100 g of soil)								Mineral nitogen /mg/100 g of soil/	
		Ca^{++}	Mg^{++}	K^{+}	Na^{+}	SO_4^{--}	HCO_3^{-}	Cl^{-}	suma	NH_4^{+}	NO_3^{-}
Waste land	0 - 20	1.6	0.11	14.2	9.2	9.0	26.8	5.3	66.2	18.72	14.18
flooded by liquid	20 - 70	0.6	0.01	1.5	1.3	6.1	4.3	1.4	15.2	3.06	1.06
manure	70 - 100	0.6	0.02	1.8	1.6	9.0	3.1	1.4	17.5	4.22	0.97
Arable soil	0 - 28	1.1	0.21	2.1	0.6	2.4	3.7	0.2	10.3	1.97	2.04
fertilized by	28 - 48	5.9	1.09	0.3	1.5	4.0	23.2	0.4	36.4	1.29	1.95
mineral fertilizers	48 - 90	4.2	0.73	0.3	1.5	0.5	20.7	0.1	28.0	1.00	1.24
and liquid manure	90 - 100	2.0	0.29	0.4	0.4	2.0	7.9	0.1	13.1	0.87	1.24

Table 4 Content of heavy metals in soils

Distance from road in m	Depth in cm	ppm		
		Zn	Pb	Cu
0.5	0 - 5	452.0	330.0	66.8
	5 - 10	207.0	102.0	31.3
	10 - 20	133.3	67.5	22.0
	20 - 40	76.8	vest.	12.0
5	0 - 5	136.3	42.5	17.3
	5 - 10	117.7	40.0	17.0
	10 - 20	103.5	97.5	19.8
	20 - 40	83.0	62.5	16.0
25	0 - 20	66.0	37.5	16.0
	20 - 40	56.0	vest.	12.0
50	0 - 20	87.0	55.0	13.5
	20 - 40	83.0	50.0	11.5
100	0 - 20	107.8	107.5	23.0
	20 - 40	63.0	87.5	7.5
200	0 - 20	86.0	60.0	13.5
	20 - 40	26.8	50.0	9.8
300	0 - 20	78.0	50.0	16.5
	20 - 40	67.0	42.5	9.9

Table 5 Chemical properties of surface water

Water	Content of ions in water										
	meq /dm^3							mg/dm^3			
	Ca^{++}	Mg^{++}	K^+	Na^+	SO_4^{--}	HCO_3^-	NO_3^-	Cl^-	NH_4^+	$H_2PO_4^-$	Total ions
	1. Warsaw										
	1.1. Wilanów-Powsin										
Ponds	2.50	0.58	0.16	0.74	1.15	2.73	0.020	1.09	0.01	0.55	335
	2.32	0.65	0.26	0.95	1.61	2.67	0.040	1.06	0.06	0.37	369
Canals	2.97	0.44	0.09	0.44	1.25	4.19	0.020	0.67	5.15	1.17	425
	3.66	0.72	0.05	0.41	1.72	4.41	0.020	0.53	0.04	0.08	465
Rivers	2.80	0.61	0.13	0.90	1.11	3.93	0.023	0.75	0.0	0.05	411
	3.09	0.69	0.08	0.95	0.65	4.95	0.006	0.83	0.04	0.09	458
	1.2. Okęcie-Służewiec-Pyry										
Ponds	2.51	1.13	0.33	1.13	1.99	1.52	0.005	1.52	0.95	0.06	346
	4.59	2.54	0.99	2.70	2.81	.4.00	0.022	3.79	2.33	4.75	749
Canals	3.22	0.91	0.22	2.47	1.67	3.94	0.003	2.80	3.00	1.40	559
	3.23	1.09	0.91	3.43	1.50	5.64	0.013	3.12	3.80	10.85	735
	2. The Łomianki Rural Commune										
Ponds	1.14	0.94	0.04	1.24	0.46	1.08	0.006	1.06	0.51	0.03	191
	1.88	1.17	0.98	1.87	0.60	2.56	0.022	1.70	0.82	0.05	381
Canals	1.79	0.67	0.19	1.32	0.37	1.76	0.021	1.26	0.75	0.03	254
	1.68	0.76	0.19	2.55	0.96	3.12	0.014	1.78	0.52	0.11	410

Table 6 Physical and chemical properties of groundwater

Land use	pH	Electrical conductivity mS. cm^{-1} with 25°C	Content of soluble salt mg/dm^3	Content of ions mg/dm^3	
				NH_4^+	$H_2PO_4^-$
1. The Łomianki Rural Commune					
Forest	3.9	0.25	41	0.61	0.24
Liquid manure dungsites a.	8.4	7.65	6210	713.7	156.0
b.	7.2	6.14	4153	0.84	0.46
Highway E-81	7.7	4.00	2365	0.74	no description
Meadow near sewage pumping station	8.2	11.16	8637	0.30	0.06
Meadows and pastures	7.2	0.31	154	1.15	0.064
Grains	7.0	0.45	174	3.66	0.28
Maize: a/ mineral fertilizers	8.1	1.37	931	0.22	1.10
b/ liquid manure	7.3	0.47	338	8.44	0.05
Vegetables	7,8	0.50	240	0.89	0.02
Berry bushes	6.0	0.67	414	0.04	0.06
2. Białołęka Dworska					
Meadow: 1977 04 15	4.6	no description	697	3.11	0.0
1977 08 05	3.0	"	1467	2.63	0.1
1977 10 07	3.9	"	631	9.80	0.02

Table 6 cntd. Physical and chemical properties of groundwater

Land use	Content of ions meq/dm^3							
	Ca^+	Mg^+	K^+	Na^+	SO_4^{--}	HCO_3^-	NO_3^-	Cl^-
1. The Łomianki Rural Commune								
Forest	0.22	0.15	0.02	0.13	0.17	traces	0.007	0.60
Liquid manure dung site a.	2.62	1.39	12.79	17.50	3.23	55.0	0.334	23.61
b.	5.77	5.39	6.45	11.45	29.06	4.08	27.0	4.39
E-81 transport route	7.07	4.67	1.02	27.83	2.75	4.31	0.085	30.58
Meadow near sewage pumping station	4.91	4.41	0.09	127.00	38.12	30.0	0.061	52.59
Meadows and pastures	1.32	0.32	0.07	0.51	0.79	0.91	0.082	0.26
Grains	1.41	0.53	0.16	0.97	1.26	0.25	0.153	0.60
Maize: a/ mineral fertilizers	3.66	2.93	0.34	5.04	0.42	8.74	0.55	2.96
b/ liquid manure	1.55	0.50	0.58	0.73	0.75	13.14	1.89	0.54
Vegetables	1.92	0.83	0.01	0.57	0.58	0.84	1.15	0.79
Berry bushes	2.77	1.36	0.07	0.52	2.08	0.06	3.32	0.48
2. Białołęka Dworska								
Meadow: 1977 04 15	5.23	0.29	0.10	0.94	10.87	90.00	0.169	0.79
1977 08 05	6.99	3.04	0.13	1.36	23.62	1.42	0.071	0.83
1977 10 07	5.63	0.09	0.22	0.87	9.62	0.00	0.006	0.46

Table 7 Concentration of cations of soluble salt in water 181 dug wells in the Łomianki Rural Commune

Cation	Permissible concentration mg/dm^3	Range of concentration mg/dm^3	% of wells
Ca^{++}	not limited	< 50	34.4
		51 - 100	57.4
		101 - 150	8.2
Mg^{++}	not limited	< 10	22.1
		10.1 - 20	50.8
		20.1 - 30	20.4
		30.1 - 40	6.1
		40.1 - 50	0.6
K^+	not limited	< 25	67.4
		25.1 - 50	18.8
		50.1 - 100	13.2
		101.1 - 150	0.6
Na^+	not limited	< 100	91.7
		101.1 - 150	8.3
NH_4^+	to 0.65	< 0.65	72.9
		0.66 - 1.30	17.7
		1.31 - 2.60	5.0
		2.61 - 5.20	2.7
		5.21 - 10.40	0.0
		10.41 - 20.80	0.6
		20.81 - 41.60	1.1

Table 8 Concentration of anions of soluble salts in water
181 dug wells in the Łomianki Rural Commune

Anion	Permissible concentration mg/dm^3	Range of concentration mg/dm^3	% of wells
SO_4^{--}	to 200	< 200	85.6
		201 - 400	13.8
		401 - 400	0.6
$H_2PO_4^-$	I[x/] 0.204	< 0.204	58.6
	II 0.205 - 0.51	0.205 - 0.51	19.9
	III 0.51 - 1.02	0.51 - 1.02	8.3
		1.03 - 2.04	3.8
		2.05 - 4.08	5.0
		4.09 - 8.16	1.6
		8.17 - 16.32	2.8
NO_3^-	to 44.4	< 44.4	26.0
		44.5 - 88.8	24.3
		88.9 - 177.6	29.8
		177.7 - 355.2	16.6
		355.3 - 710.4	3.3
Cl^-	to 300	300	100.0

[x] Class of water purity.

Table 9 Scopes of changes of soluble salt ions /mg/dm^3/ in water of wells in the Łomianki Rural Commune in the period April 22 to October 13, 1983

Ion	Shallow dug wells			Drilled wells	
	Sadówka Village nr 5	Kępa Kiełpińska Village nr 23	Łomianki ul. A.Poznań nr 21	Sadówka Village nr 3	Kępa Kiełpińska Village nr 23a
Ca^{++}	20.6 - 76.0	94.4 - 134.8	47.2 - 74.8	19.4 - 32.0	62.0 - 91.6
Mg^{++}	5.6 - 18.0	36.4 - 71.0	12.0 - 15.2	0.8 - 2.4	14.2 - 18.4
K^{+}	15.8 - 36.6	102.8 - 240.0	8.0 - 11.6	0.4 - 11.8	0.9 - 2.0
Na^{+}	34.4 - 103.2	74.4 - 168.0	30.9 - 61.6	1.7 - 5.6	11.2 - 16.0
NH_4^{+}	0.25 - 1.46	0.05 - 0.11	0.22 - 5.82	0.21 - 0.93	0.09 - 2.42
SO_4^{--}	69.0 - 119.0	179.0 - 288.0	87.0 - 185.0	13.0 - 47.0	27.0 - 58.0
$H_2PO_4^{-}$	0.05 - 0.67	0.16 - 0.53	0.0 - 0.40	0.09 - 0.22	0.0 - 0.27
NO_3^{-}	146.9 - 269.6	120.6 - 311.3	145.9 - 198.4	0.01 - 0.4	0.2 - 4.2
Cl^{-}	42.6 - 129.2	79.2 - 146.3	34.8 - 65.3	2.8 - 15.6	19.9 - 41.2

EWA ROO-ZIELIŃSKA, JERZY SOLON
Institute of Geography and Spatial Organization
Polish Academy of Sciences
Warsaw, Poland

GEO-ECOLOGICAL CHARACTERISTICS OF THE SUBURBAN AREA OF WARSAW - GENERAL DESCRIPTION AND THE STUDIES OF MODEL AREAS

1. Introduction

One of the most important problems of modern geo-ecology is the study and comprehension of the nature of changes taking place in the natural environment under the influence of human activities which are multidirectional and varied in their intensification. One of the best models for such studies are suburban areas of large towns. This is due to the fact that suburban areas, unlike urban or clearly rural areas, perform many varied, often conflicting functions, and are under differentiated pressures, directed at attaining divergent goals.

For several years now in the Laboratory for Environmental Management IGSO of the Polish Academy of Sciences, studies are being carried out concerning the relation "man-environment" in suburban areas of Warsaw.

The main task of these studies is to obtain the knowledge of the geo-ecological essence of the suburban areas, i.e. of the space of direct contact between the large town and adjacent rural areas. One of the methods enabling a universal study of the structure and functioning of suburban natural and technical systems is based on assumptions of ecological bioindication, especially of phytoindication. An analysis of the existing conditions of vegetation requires the undertaking of approaches and methods from various geographical and biological disciplines, the most important of which are: phytosociology, autecology and landscape science. Empirical studies have often indicated that vegetation is characterized by specific properties, i.e. the so-called hyperinformativity that enables the description of variables of all those systems with which it is connected. This means that knowing the structure of vegetation mantle, its spatial differentiation, the vitality of various plant species etc., enables not only the determination of the existing conditions, but also the processes taking place in those components of the environment which are ecologically substantial for the life of plants.

Examples of applying certain methods and approaches will be presented further in this paper. on the basis of two areas which have been studied geobotanically in detail, and which constitute representative model areas, namely Białołęka Dworska and Łomianki, situated in the northern part of the suburban area of Warsaw.

It should be stressed here that in the case of Białołęka Dworska a full geobotanic analysis has been carried out, while for Łomianki only a map of potential and actual vegetation has been elaborated, and an analysis was made of the differentiation of certain features of the habitat.

2. General characteristics of vegetation cover in the suburban areas

The vegetation cover existing on this area is a result of interaction of various often opposing influences, which very generally may be divided into natural features i.e. climate, hydrography, geological structure, flora, fauna etc., and anthropogenic features, directly influencing the vegetation, or indirectly, through influencing the features of the first group.

The carrying out of a full analysis of various forms of anthropopressure taking place within suburban areas is not possible in this paper. Attention has been drawn only to three main complexes of anthropopressure forms which are - according to the authors - responsible for the existing structure and functioning of the vegetation i.e. agriculture, urbanization process with small-scale industry development, and recreation.

From the biological point of view, agricultural activity is limited to creation of new biological systems, with simplified trophic chains and a considerable limitation of consumers in order to achieve a maximalization of the given production effects.

The process of urbanization and industrialization causes, on the one hand, the decreasing of areas available for vegetation, and on the other - the creation of new, hitherto non-existing habitats, or a fundamental transformation of the existing ones, with some changes in local climate conditions.

The use of the suburban zone as a recreational area is connected with conscious activity aimed at the maintenance or enrichment of aesthetic, health or functional values, which is closely related to the protection of the existing elements of natural vegetation. It also causes, similarly to urbanization, the mechanical destruction of vegetation; however, unlike in the case of urbanization, this destruction is selective in varying grade concerning particular species or populations.

The coexistence and close interlacing of various forms of pressure on vegetation causes its rapid synanthropization, understood as a process of adaptation to new conditions created in the given place and time by the main influencing factor, which is human activity /Kostrowicki 1982/. According to Faliński /1972/ in the process of synanthropization the biggest part is played by eurytopization, i.e. replacing stenotopic components by eurytopic ones; the cosmopolitation, i.e. replacing of certain own components by cosmopolitan ones, and allochtonization, i.e. replacing own elements by incoming ones.

These processes may be clearly determined during the analysis of vegetation cover in suburban areas.

In the case of vegetation, a considerable decreasing process of plant species variety may be observed, with narrow habitat spectra. An effect of this is a relatively high percentage of rare species or very rare ones in the given local floras. Nowak /1983/ who has been studying the flora of the western part of the suburban area of Warsaw states that as much as 32 % of species has less than 20 stands, and the next 30 % - less than 50 stands. The replacing of local by cosmopolitan elements is visible in the increase of species variety, which are not closer connected with any vegetation types; while maintaining a relative stability of the number of these species, i.e. approximately 20 % of the given flora, which is only relatively more than in comparison to the average in the country /approximately 15 %/.

An effect of the allochtonization of the vegetation is an increased share of anthropophytes. In the Polish vegetation, anthropophytes constitute only 11-13 % of species, in Białołęka Dworska 23 %, and in the previous Pruszków district 30 % /Nowak 1983/. The spatial distribution of anthropophytes is of course differentiated. In Białołęka Dworska about 25 % of the area is taken by a vegetation cover in which anthropophytes constitute less than 20 % of the total population. On the other hand, approximately in 20% of the area there are communities which in 90--100 % consist of anthropophytes /which equals to about a 50 % share of anthropophytes in the species structure/. Such a considerable differentiation is not directly connected with the phytosociological type of communities, but is a result of the intensiveness of land use, since among vegetation with the highest share of anthropophytes the biggest role is played not only by segetal communities which, in the Mazovian area considered as an entity, are also characterized by an approximately 50 % share of anthropophytes as a species /Wójcik 1968/, but also communities from other phytosociological classes.

In spite of these phenomena connected with synanthropization, the vegetation of the suburban areas may be characterized by a considerable richness and differentiation.

On the area of Białołęka Dworska covering 400 hectares, the spontaneous occurence of 582 species of vascular plants was assessed, which constitute over 20 % of the total vascular flora of Poland /Roo-Zielińska 1982/. On a considerably larger area of the Pruszków administrative district covering 623 sq. km, there are approximately 1280 species /Nowak 1983/. In the Łomianki Rural Commune no detailed study of vegetation has been carried out, but cautious assumptions allow the conclusion that on its area covering 3,000 ha there are at least 500 species of vascular plants.

This vegetation is considered as very rich, particularly if we realize that such big complexes as the Kampinos or the Białowieża Forests, i.e. areas with a well maintained vegetation and substantially varied habitat conditions, are characterized by floras amounting to not much more than 1000 species /Sowa, Olaczek 1978/.

Vegetation of suburban areas is also characterized by a considerable differentiation from the point of view of connections with the defined big phytosociological units. In the Pruszków administrative district, species of a syntaxonomical importance represent 33 classes /Nowak 1983/. In the Łomianki Rural Commune - 24 classes,and in Białołęka Dworska - 22. This differentiation of phytocenotical elements is, above all, connected with varied land use and not with the number of habitats, as their numbers are similar and constitute respectively: 7, 10 and 7.

Certainly the differentiation of flora is considerably sharper than the differentiation of classess. In the Łomianki Rural Commune - similarly as in Białołęka Dworska - all plant communities may be qualified into 14 classes. The number of phytosociological classes does not reflect fully the syntaxonomical richness and variety of vegetation in the suburban areas. A much better index is the general number of types of phytocoenoses which for example in Łomianki equals to 81 and is substantially higher than on rural or urban areas of comparable size. Still better the vegetation differentiation may be characterized by its informative richness /Kostrowicki 1982/. As a result of various forms of anthropopressure, communities belonging to the same class differ seriously by vertical structure, richness and variety of species, as well as by development degree. All this results in the fact that within given classes, there are vegetation complexes with completely different informative indexes. For example, on the area of Białołęka Dworska, within communties of the class of sandy grasslands there are both stands with an index of 106, and of 1830, with the most usual variety in the span of 300-700.

As a result of the process of synanthropization, the number of fully developed phytocoenoses substantially decreases, while the area of impoverished vegetation increase; they are lacking their characteristic and distinguishing species. This phenomenon is wide known and common; but especially on suburban areas it becomes rather intensive. Also, synanthropic segetal and ruderal vegetation playing a great role in suburban areas are not free from the phenomenon of the flora impoverishment. Sowa and Olaczek /1978/ indicate that in towns the number of types of synanthropic communities varies from 11 to 30, and the maximum values occur only in the largest towns. On rural areas the number of communities of this type is similar and, for example near the Wigry lake, amounts to 17, which is about 17 % of all local vegetation types /Solon, in print/. On the other hand, vegetation in suburban zones is characterized by a more substantial richness of synanthropical communities. In the Łomianki Rural Commune it covers over 31 local phytocenoses types, which constitutes almost 40 % of all vegetation types.

The role of synanthropical vegetation is even more distinct when areas taken by various communities are considered. In the Łomianki Rural Commune they constitute 61 % of the total area; and in Białołęka Dworska - 69 %, and in both cases areas taken by ruderal and segetal vegetation are similar. This is a characteristic feature for suburban areas, as both in the rural and urban landscapes synanthropical vegetation may cover similar or even larger areas, but in the first case segetal communities are dominating, and in the latter - ruderal ones.

In the case of synanthropical vegetation, the loosening of relations may be observed between the actual vegetation and the habitat, characterized by potential vegetation. Often the same combinations of species occur in various habitats. This constitutes an indirect but important evidence that the occurence of determined synanthropical communities is conditioned by dynamic interrelations within the vegetation itself, and by quickly changing synanthropical factors.

The phenomena and processes described above determine the specific spatial pattern of vegetation in suburban areas. The most characteristic feature of this process is the splitting of vegetation areas. On a comparable area unit in the suburban zone there are on average 5-10 times more of various phytocoenoses than in rural areas, and approximately 4-25 times more than in the central part of Warsaw situated on the right bank of the river. Similarly, the dynamic groups of substitute communities are richer by 20 to 50 %, at least in relation to habitats of oak-hornbeam forests, coniferous and mixed forests, and partly also to alder woods.

The spatial diversity of vegetation in the suburban area, which is constituted by a large number of small-size vegetation mantles representing numerous types of plant communities, depends only to a small degree on the habitat differentiation. For example, the diversity index of Shanon-Weaver /1963/ in the form $H = -\sum p_i \log_2 p_i$ counted for the total habitat-vegetation variety /with vegetation considered as phytosociological classes/ amounts to 3.78 in Białołęka Dworska, and 4.71 in Łomianki with the habitat diversity of respectively 1.73 and 2.51. With such big spans of total and habitat diversity considerably small differences result from a comparison of vegetation diversity indices, which in Białołęka Dworska equals to 2.73 and in Łomianki to 3.03. The similarity of spatial structure is clearly indicated by the diversity index reflecting an average differentiation of vegetation within various given habitats, evaluated as a difference between the total diversity and the habitat diversity. This index amounts to 2.06 in the case of Białołęka Dworska, and 2,20 for Łomianki.

The spatial diversity of vegetation within suburban areas shows certain regularities. It is easy to distinguish repetitious and relatively stable vegetation complexes connected with various forms of anthropopressure within defined habitats. Phytocoenoses creating a given complex cover defined and more or less stable areas and are characterized by clearly determined spatial relations, such as the type of occurence /space, belt or spot/; or neighbouring with other defined types of vegetation. A characteristic trait of such complexes within suburban areas is the coexistence within one complex of phytocoenoses being in different phases of transformations of ecological mechanisms*. An example of such a complex occuring in Łomianki may be the vegetational pattern on oak-hornbeam forests habitat and constituted by assotiations of weeds of grain crops, and weeds of root crops /both occur in space forms, and each encompasses about 40 % of the area/, two ruderal communities related with baulks, encompassing each about 1% of the area and occuring in a belt pattern, fresh meadows and tramplings also occuring in a belt pattern and each embracing about 7% of the area, and small spots dispersed on the whole area of complexes covered by accidental plant species aggregations. In such a complex, the four first vegetation types are in the third phase of transformations. This phase is characterized by the domination of purposeful /meadows/ or purposeless /baulks/ anthropogenic influences on the structure and functions of phytocenoses with a hidden and limited functioning of natural mechanisms.

The two successive communities are in the second phase, characterized by the coexistence and balance of natural and anthropogenic mechanisms stabilizing the structure. The remaining vegetation is in the fourth phase, which lacks any ecological mechanisms.

Summing up the above assumptions one may come to the conclusion that the process of synanthropization of the vegetation cover in suburban areas takes place in a specific way. The fact that suburban areas are a separate ecological system as compared to areas of definitely urban or rural character may be confirmed by the following features:

- on the flora level: vegetational richness, a considerable share of rare species, a high share of anthropophytes, the highest diversity of phytocenotic elements in relation to habitat types;
- on the populations level: the highest number of local phytocenoses types in relation to number of habitats and area size, a high diversity of vertical structure richness of species and their high number within phytocenoses of the same type, the highest number of synanthropic communities with a relatively changing share

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* Kostrowicki /1979/ defines four phases of transformations of ecological mechanisms differing between each other by the coexistence and intensiveness of natural and anthropogenic mechanisms stabilizing the structure and function of phytocenosis.

of areas, loosening ties between synanthropical vegetation and habitats of potential vegetation;

- on the level of vegetation landscape: the biggest area subdivision on the majority of habitats, existence of repetitive complexes of phytocoenoses in different phases of transformations of ecological mechanisms, characterized by a different origin, dynamics, vertical structure, resistence to anthropopressure and phytosociological relations.

From the above facts it may be assumed that suburban areas are a separate ecological system requiring an appropriate selection of methods and a very careful and critical assuming of results attained during studies of both rural and urban areas.

3. Model areas and methods of their surveys

Depending on the assumed main goal, the surveys of vegetational cover in suburban areas may be directed at the following tasks:

- survey of the existing flora and vegetation,
- description of the vertical and species structure of the vegetation,
- learning the phytosociological structure of the existing vegetation occuring spontaneously in relation to habitats determined on the basis of potential natural vegetation,
- detailed analysis of vegetation and flora from the point of view of:
  a/ phytogeographical differentiation,
  b/ ecological origin,
  c/ anthropization level,
- checking and/or using the index potentials of plant species and populations as indicators of the existing conditions and transformations on studied areas,
- determination of influence of various forms of anthropopressure on the structure and functioning of plant communities,
- analysis of the repetitive mosaic vegetation patterns, their typology and functioning,
- evaluation of the vegetation from the point of view of their potential use.

As plants do not loose their indicating properties even in the case of their partial destruction, geobotanical methods are very useful in studying areas which are being dynamically and intensively transformed. One of such areas is definitely the suburban area.

The indicational geobotany uses indicational features of various species and populations of vegetation for a quick and cheap determination of numerous parameters of the natural environment.

The elaborated and verified complex of methods on model areas has been selected in such a way that with its help the evaluation may be made of the existing conditions and transformations taking place in the vegetation itself, which are immanently connected with the structure of plant communities and in the ecological environment, and particularly in a habitat. This role is fulfilled by synthetical and phytoindicational analytical methods.

An example of geobotanic and synthetic elaboration may be the map of potential natural vegetation. It presents the existing biotic potential of habitats - and it takes into consideration all irreversible changes which have been introduced into the habitat by man, and does not take into account the reversible ones. From the map of potential natural vegetation, the following may be assumed:

- direction and intensity of the currently dominating soil process,
- resources of some nutrient elements of soils and their bioavailability,
- water conditions,
- soil acidity,
- general fertility and productivity of soils,
- flexibility of habitats and possibilities of transformations of its use forms /taking into consideration groups of substitute populations/ - see Fig. 1.

And thus on the basis of the map of potential natural vegetation, the directions of transformations in vegetation cover and habitats may be evaluated.

From the point of view of habitat differentiation, both model areas are very similar. Decidedly dominating are habitats of mixed coniferous and oak-hornbeam forests, but habitats of pine forests, ash-elm alder forest and rich oak woods, occur on considerably smaller areas. On the area of the Łomianki Rural Commune, a certain role is also played by the habitat of ash-alder and poplar-willow woods on water-logged soil.

Such pattern, and areas for various categories of habitats are typical for the majority of suburban zones of Warsaw /see Matuszkiewicz J.M. 1981; Matuszkiewicz W. 1966/. Substantial differences between the geobotanically determined types of habitat and the existing vegetation created within this type are also characteristic for suburban areas.

Another phytoindicating factor is the informative richness of phytocenoses of A.S. Kostrowicki /Fig. 2/. The use of this index makes it considerably easier to classify vegetation mantles into various phytosociological units, the definition of the role of ecological and phytogeographical groups within those geobotanical and spatial units. This index describes the degree of complication of phytocenoses structure, and thus enables a numerical description of floristic, phytogeographic and ecological differentiation of the surveyed areas. The use of the informative richness index had moreover additional values, such as:

1. indirect indication of relative differences in natural productivity taking place between phytocenoses creating the given physical unit,
2. quantitative description of the transformation degree of plant populations by man.

One of the main uses of the index of informative richness is the evaluation of the anthropization degree. For example the area of Białołęka Dworska may be divided into two parts: one is characterized by an extremely low /0-10%/, and the second by a very high /90-100%/ pattern of anthropophytes. A very interesting phenomenon is a relatively small share of phytocenoses of an transient character. It may be assumed that it is a characteristical phenomenon of a mosaic spatial selection which is conditioned by the type and intensity of pressure by human society.

Another example of use for the index of informative richness is the analysis of ecological structure of species creating the various vegetation units. Phytocenoses with the majority of species of a forest origin and grasslands, within which the psammophylic species cover in the Białołęka Dworska nearly a half of the territory. Considerable areas are covered by vegetation with the majority of ruderal and segetal species.

The share of steppe, marshy and water species is sporadic. Thus it may be stated that the presently highly differentiated vegetation was created from the forest and psammophyles substrates with a high share of anthropophytes as an expression of the specific ecological selection.

A phytogeographical analysis of vegetation is one of the most important methods enabling making deductions concerning the direction of changes which in the environment are caused by human activity. The determination of the species pattern in accordance with the range type enable forming assumptions about the origins of the studied flora. As an example, in Białołęka Dworska it is very differentiated. This is due to the fact that within it, elements of a cosmopolitan, Eurasian, European and boreal character have been determined:

As it already has been mentioned above, apart from synthetic methods of vegetation bioindication /index of informative richness, idea of potential natural vegetation/, there are analytical methods of phytoindication. They make use of indicational properties of plant species for the evaluation of conditions of climate and habitat on the one hand and habitat and edaphics on the other.

And thus on the two model areas, in Białołęka Dworska and in Łomianki, the phytoindicational analytical method of Ellenberg /1974/ has been applied. In Białołęka Dworska an evaluation of climatic and edaphic conditions haven been carried out; while in Łomianki only of the edaphic conditions.

Climatic parameters have been estimated on the basis of the domination of species with occurence optima in the given climatic and vegetational zone, or in vertical zones /the "T" temperature index/. The "T" index describes the relation between plants and the average temperature of the vegetational season, as well as the thermal optimum of various species, and thus the problems of the duration of day, pattern of temperatures, precipitation, etc.

The "T" index differentiates Białołęka Dworska only very slightly, which is understandable when the small area and the slight hypsometric differences are taken into consideration. It should be stressed that there is a definite majority of areas with the dominance of species having their thermal optimum in foothill mid--European areas. This fact indicates the specific climate conditions of Białołęka Dworska, close to those characteristic among others to the foothills of Karpaty and Sudety mountains. It may be assumed that this is a result of the peripherial, north-eastern situation of Warsaw in relation to the proper middle European climatic and vegetational zone on the one hand, and the specific influence of the large city on the other.

The "K" degree of continentalism determines the resistance of species in relation to the frequency and length of dry seasons and sensivity to frosts and low temperatures in winter. The "K" index supplements the "T" index. The "T" index is a synthetic factor of the climatic optimum of species, while the "K" index determines the limits of thermal amplitude - indicates the severity of winter, occurence of frosts and in summer dry periods.

In Białołęka Dworska the vegetation stands have been determined as to be with the dominance of the following species:

- oceanic and suboceanic character,
- subcontinental and continental character.

The reasons for the spatial dominance of suboceanic species are to be found, among others, in the moderating influence of the town. The direct vicinity of Warsaw created in the suburban areas climatic conditions considerably different from those in the Mazovia Region, with the exception of several towns; these conditions are similar to those existing in rural areas of the south-western parts of Poland. It would be extremely interesting to carry out analogical studies in suburban areas of other towns. Only then would it be possible to determine the fact whether the observed phenomenon of eco-climatic translocation is of a stable character, and what size of town does is concern.

The phytoindication of habitat and edaphic conditions of Ellenberg concern above all the evaluation of humidity of the ground, its acidity and the content of assimilative nitrogen.

The "F" index of humidity determines the ecological reaction of species in relation to the ground humidity in the vegetational seasons, and enables the definition of the total demand of plants in relation to this feature /Fig. 3/.

In Białołęka Dworska the range of the "F" index varies between F2 and F8, and thus within the scope of dry, fresh to humid surfaces. In Łomianki, due to its larger area, and also due to a considerable differentiation of habitats, the range of the "F" index is much wider - from a dry surface, through fresh and humid soils to wet ones. On both model areas, fresh soils are dominating.

The aim of elaborating a map of soil acidity /the "R" index/ is the biological determination of the acidity of the ground on the basis of bio-indicational properties of vegetation species.

In Białołęka Dworska the range of acidity is very wide, from soils indicated by plants as extremely acid, to slightly alkaline ones. In Łomianki this range is a little more limited, reaching to neutral soils.

The evaluation of habitats from the point of view of nitrogen content /the "N" index/ on both model areas indicates the majority of soils rich in nitrogen. There are some habitats with a poor and moderate content of nitrogen, but they embrace a much smaller area. Information received through vegetation concerning the content of nitrogen in habitats allows us to find clear corelations with the content and structure of plant communities.

And thus as intensive fertilization with artificial fertilizers of agricultural cultivations and market gardens finds its reflection in the structure and content of spontaneous vegetation /populations of weeds on grain and root cultivations/. In habitats with a moderate content of nitrogen there are mixed coniferous and leafy forests. On the other hand, a substantially low content of nitrogen is characteristic for poor and dry coniferous forests.

In Łomianki a comparative picture of the spatial changeability of the existing vegetation and such habitat features, as for example humidity, acidity and nitrogen content, was obtained through a phytoindicational analysis. This picture enabled the determination of six ecological and habitat units:

- pine and mixed forests on dry acid soils with a low and moderate nitrogen content,
- oak-hornbeam on forests fresh, slightly acid soils with a moderate nitrogen content,
- root and grain cultivations on fresh soils, differing in the acidity and nitrogen content;the first complex, predominating on larger areas, occurs on slightly acid soils with a very high and high nitrogen content. The second, in the vicinity of afforested areas, is connected with an acid soil with a moderate nitrogen content,
- poplar and willow woods in various development stages on humid, slightly acid and neutral soils with a very high nitrogen content,
- half-natural and anthropogenic meadow and pasture complexes on fresh soils, more seldom on humid, slightly acid and neutral ones with a high nitrogen content,
- populations of alder trees and reeds on wet soils.

On the basis of a rich material obtained during studies in Białołęka Dworska, a division into two different habitat and ecological units of the total area may be determined:

- On habitats of potential mixed coniferous forests there are sandy grasslands and healths, as well as grasslands with Nardus stricta, the forest species are dominating, and simultaneously the share of anthropophytes is very small. Boreal species are dominating there. The ground is highly acid, dry or fresh with a small nitrogen content.
- On habitats of potential oak-hornbeam forests, predominating are meadow communities with a high share of synanthropic species of a European and Eurasian range type. Predominating are slightly acid, moderately humid habitats, with a high nitrogen content.

It should be stressed that for the majority of areas of not exclusively the suburban zones, a typical phenomenon may be observed of habitat transformations. And thus extreme habitats /e.g. very dry or very wet ones/ often undergo unconscious, and at the same time indirect, influences /e.g. the increase or decrease of the underground water level/. They may be characterized by the lowest flexibility. The pressure of man may thus destroy them in an irreversible way.

Of the highest flexibility are intermediate habitats - fertible and poor forests, which are as a rule being transformed as a result of conscious anthropopressure into more or less stable ecological structures, as for example root and grain cultivations.

A summary and a synthesis of the hitherto discussed types of analyses may be constituted by the map of geobotanical evaluation of the area. It is of a considerable importance that the evaluation of geobotanical and habitat conditions should be carried out taking into account the flora and the vegetation. While elaborating a map of geobotanical evaluation of the Białołęka Dworska area, the following criteria were taken into consideration:

1. The degree of complication of the vegetational structure - the highest degree of complication in the vegetational structure is characteristic for all well maintained afforested areas /birch woods, pine forests, mixed forests, parts of oak-hornbeam forests/ as well as fertile sand grasslands remaining with the above mentioned in a mosaic pattern;

2. Health properties - health values may be characterized in accordance with Wehmer /1935/ on the basis of a complex of species characteristic for the given community emitting directly or indirectly via soils chemical substances with given phyto-terapeutic or phyto-toxic properties. The producing for example by vegetation of birch forests of such volatile substances, as the following oils: essential betul, camphor, betul, quercitine, phurphor, chrysophanol, butyl, as well as esters, and acids: elag, franguline, apple, citric, fumaric etc., influences extremely favourably the phyto-terapeutic values of these forests;
3. Flexibility of habitats, i.e. ability for transformations; this value is defined on the basis of the number of substitute communities of the given potential vegetation.

The map of geobotanic evaluation seems to be highly valuable as one of the methods of estimating given areas which takes into consideration the botanic and ecological criteria. It should be considered if it would not be favourable to include in suburban areas such important factors, as for example the recreational features, aesthetic values, oxygen production etc.

The type of ecological evaluation of landscape discussed above is the most useful for the preparation of designs for physical development of suburban areas. For other purposes, the ecological evaluation of the area may be using totally different criteria and provide answers to completely different questions.

4. Evaluation and utility of applied methods

As a basis of methods of evaluation of natural conditions with the help of vegetational indexes, a great number of detailed studies was carried out, by biochemists, physiologists, ecologists, and phytosociologists. Of a substantial importance for the development of bioindication were the achievements in ecology and phytosociology. They enabled the collecting of all dispersed detailed information into one logical system, and thus created a basis for using the obtained knowledge in practice.

Today it has already become obvious that each plant or population of plants represent a perfect reflection of these conditions, in which it exists /Clements F. 1928/, and thus it has hyperinformative features. This assumptions has direct practical implications, as it allows the definition of natural conditions through an analysis of flora structure. Taking into account the present knowledge, biological tests enable learning a given element of the environment in a much more detailed way than by the help of even the best instruments. They enable studying the condition of not only the factor itself, but also of processes it undergoes in time.

The favourable feature of the phytoindicational methods, apart from their precision, is also their low cost. They do not require any complicated equipment or instruments, or any initial studies, which for example are necessary in soil research. Apart from its advantages, this method has several limitations both of the objective and subjective character. This is due to the fact that plants may be indicators only of these elements of the environment, which are important for them. Many features of the natural environment,for example the origin of land relief, forms or soils, depth of underground water, etc., cannot be indicated by plants. It should also be added that the degree of learning of the usability of plants as indicators of various environmental elements is not uniform. Thus, for example, methods of bioindication of water relations or soil relations are fully elaborated, while the determination of a microclimate or geomorphological processes are still begin studied.

On the other hand, it is a very important feature that vegetation even in the case of its partial destruction does not loose its indicating properties. Consequently the fact that geo-botanical and habitat methods are particularly useful in studies of deteriorated, dynamically transforming areas. Therefore, they should be used in suburban areas of large towns.

5. Summary

1. The suburban areas create separate ecological patterns.

2. Those areas require a special series of methods and research techniques.

3. The high hyperinformativity of the vegetation cover is of a particular importance for the evaluation of other elements of the geographical environment of suburban areas.

4. Of particular usefulness in this case are the phytoindicational methods.

5. The suggested series of phytoindicational methods is based on a universal characterization of various species and knowledge of the floral structure of the studied vegetation cover.

6. The applied complex of methods has been verified many times on model areas of suburban zones. It enabled the implementation of the assumed research goals, among others it enabled the determination of the character of suburban areas.
7. The discussed methods, due to their relatively low cost and short time on obtaining results, should be used in studies of suburban areas of other large towns.

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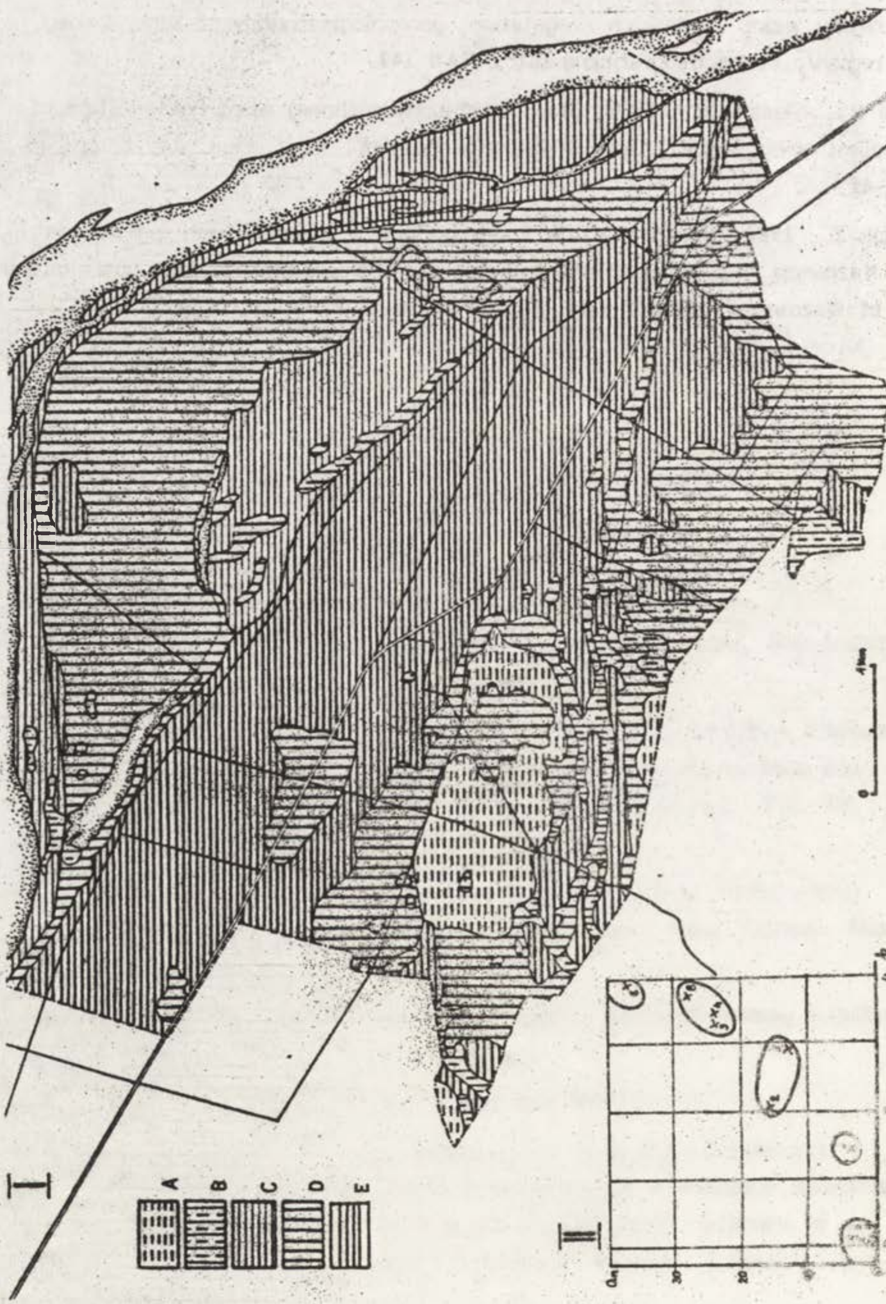
I
A
B
C
D
E
II

Fig. 1 Flexibility of habitats in the Łomianki Rural Commune

I A - habitats of a particulary low flexibility,
B - habitats of low flexibility,
C - habitats of medium flexibility,
D - habitats of a high flexibility,
E - habitats of an extremely high flexibility

II Division of habitats into classes of flexibility

a - number of substitute communities for the given habitat,
b - value of the spatial diversity index of phytocenoses in the given habitat

1: Carici-Alnetum, 2: Salici-Populetum, 3: Circaeo-Alnetum, 4: Ficario-Ulmetum, 5: Tilio-Carpinetum poor form, 6: Tilio-Carpinetum rich form, 7: Potentillo albae-Quercetum, 8: Pino-Quercetum, 9: Peucedano-Pinetum, 10: Cladonio-Pinetum

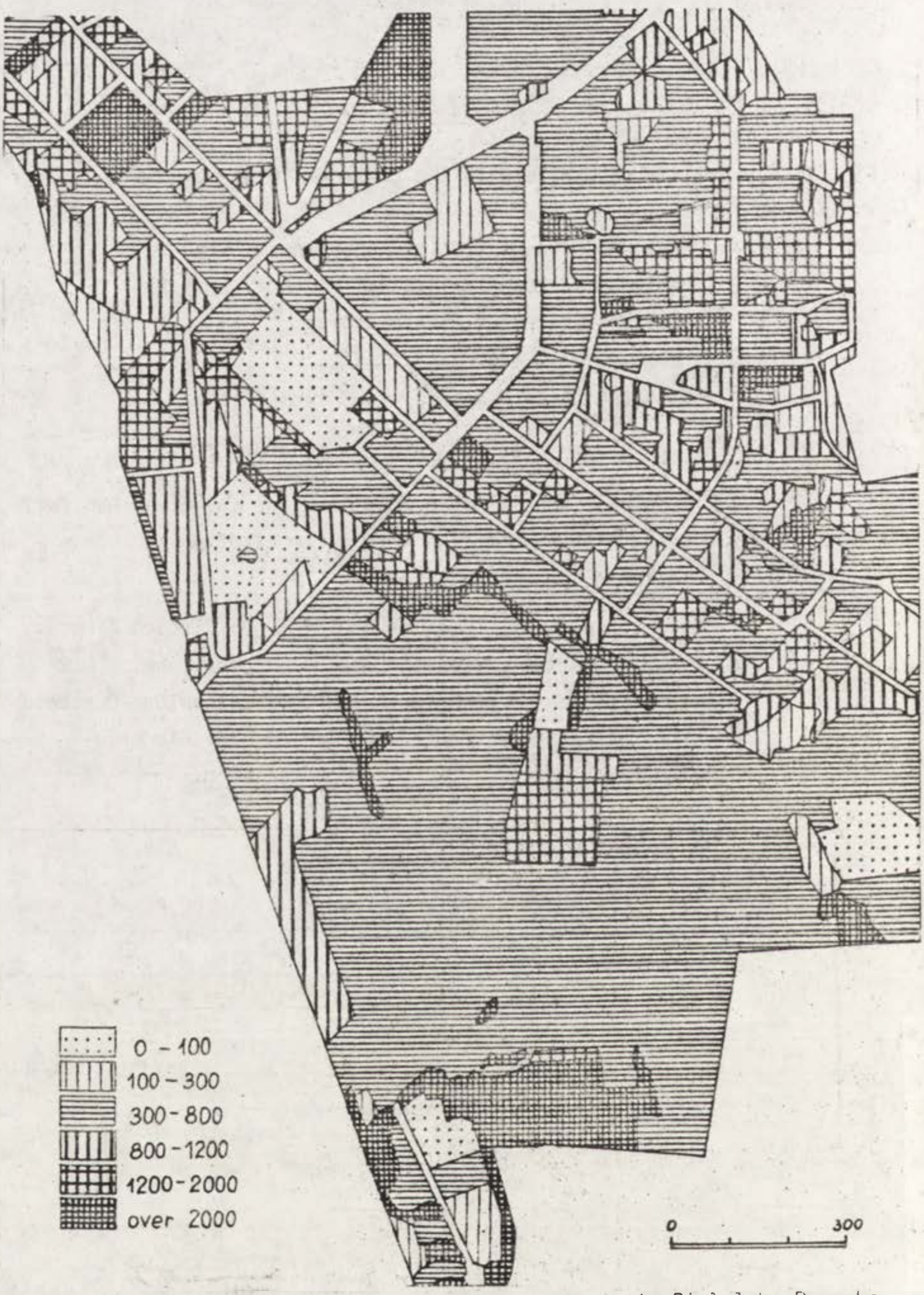

Fig. 2 General informative richness of phytocenoses in Białołęka Dworska /according to the index of informative richness of A.S. Kostrowicki/

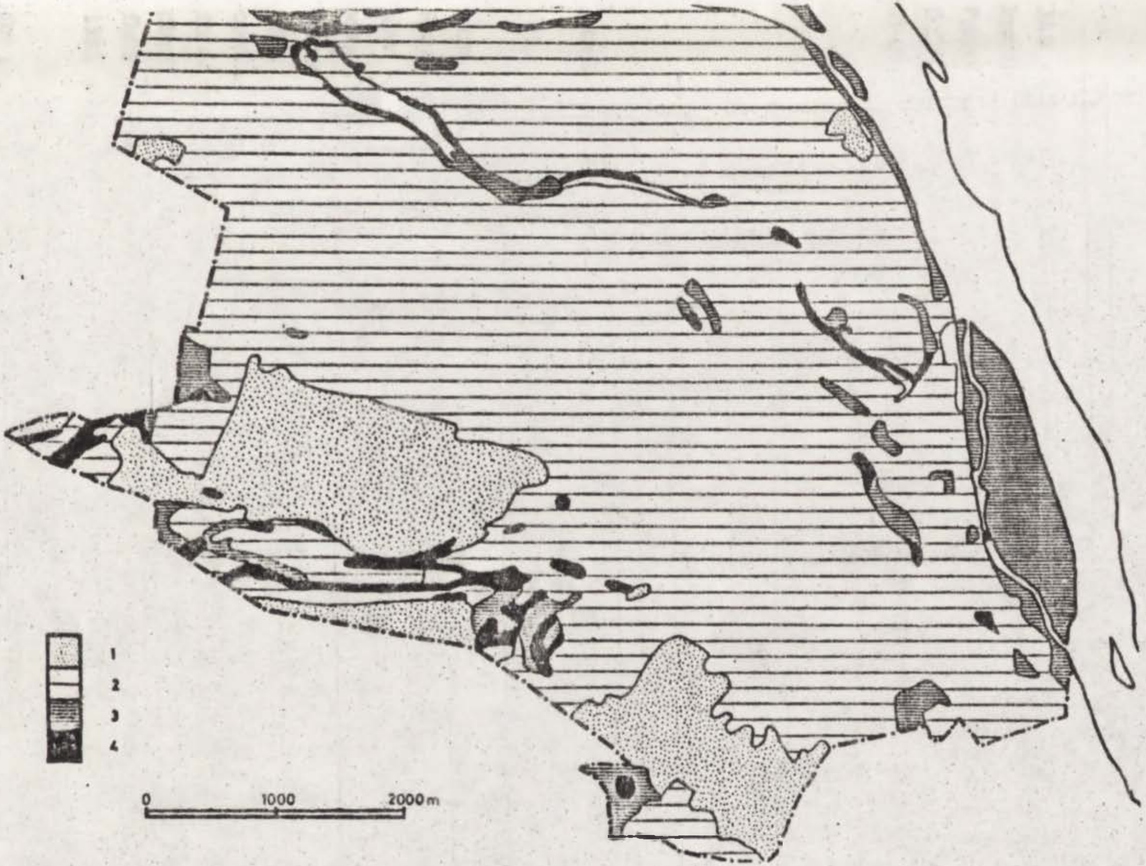

Fig. 3 Evaluation of soil humidity in the Łomianki Rural Commune

1 - dry soils, 2 - fresh soils, 3 - humid soils, 4 - wet soils

JAN PINOWSKI
Institute of Ecology
Polish Academy of Sciences
Dziekanów Leśny
05-092 Łomianki, Poland

ECOLOGICAL STUDIES OF THE SUBURBAN AREA OF WARSAW /THE ŁOMIANKI RURAL COMMUNE/

Introduction

The suburban areas in Poland, similarly to those in other countries, are rapidly increasing in size and may be characterized by a growing economic importance. Simultaneously, those areas are fulfilling various functions, and that is why it is also very difficult to carry out a reasonable development there from the point of view of environment protection. Suburban areas embrace both cultivated lands connected with the natural cycle of seasons, as well as areas of human development, urban and industrial, which are independent from the natural cycles. Serious conflicts have been created due to the mixing up of production and settlement forms on the one hand and mixing up of economic forms on the other. An industrial plant polluting water is situated near recreational areas, and farms near blocks of flats /Andrzejewski 1975, Pisarski and Trojan 1976, Karolewski 1981, Ryszkowski 1983 and others/.

A considerable percentage of suburban areas is destined for using solar energy for producing a vegetational biomass as food for inhabitants and livestock, in gardens near houses, vegetable gardens, allotment gardens, in plastic sheet tunnels and glasshouses, on farms. Organic wastes, both liquid and solid, to a large degree remain on the site. These wastes are utilized later as manure and neutralized through soils, or they infiltrate to potable water resources from leaking septic tanks and to dung dump sites and dunghills in inappropriate places. The main inflow of energy and matter from outside to suburban areas are constituted by energy and matter in the forms of: electric energy, gas, furnace fuels, food products, raw materials for the local industry, fertilizers and plant protection means.

Simultaneously with the development of urbanization in suburban areas /built-up areas, increasing population density/, the circulation of matter begins to be less and less closed. Increasing amounts of matter in the forms of food products, furnace fuels, raw minerals and often also wastes from the metropolis reach suburban areas. The amounts of fecal matter, domestic sewage and industrial wastes also considerably increase. Additionally, into consideration should be taken large amounts of fertilizers used on the remaining land enclaves for cultivations and farms, as well as liquid manure from litterless pig breeding. In effect this leads to the collection in soils and ground water resources of such amounts of nutrients that the vegetation mantle is unable to utilize them, and as a result they infiltrate to potable water.

In suburban areas with no sewerage systems, contrary to the situation in towns, about 50% of wastes, excluding water which has evaporated directly or by means of plants, are replenishing local water resources /Brechtal 1982/. However, land draining connected with construction, and water intaking from local sources lowered the level of potable water resources to such an extent that supplying the inhabitants with healthy water in suburban areas, which have been provided with no water supply and sewerage systems, becomes a problem of absolute priority.

The complex problems of suburban areas in Poland have been discussed during various conferences, which were mainly concerned with landscape shaping. The domestic and foreign literature discussing many problems of suburban areas embraces numerous publications /see Król, Majdecki and Wolski 1983/. However, there is a lack of complex and detailed ecological research of this area, which would provide a basis for a reasonable economic activity from the point of view of environment protection, as well as protection of health of the inhabitants.

Comprehensive studies of a relatively small part of the suburban area in Białołęka Dworska near Warsaw have been carried out from the point of view of demands of urban-type settlements construction /Andrzejewski 1982, Stala 1982, Trojan 1982 and others/.

The aim of the here presented studies was to obtain the knowledge of transformations taking place in suburban areas during the development of the urbanization process, of intensification of various kinds of pollution, and particularly acquiring information concerning the role of water as a carrier of pollution. The studies concerned suburban areas deprived of sewerage and water supply systems, and thus the main question was planning the most effective use of environment by man in order to ensure healthy potable water from local intakes for the inhabitants.

In studies coordinated by the Department of Vertebrate Ecology of the Institute of Ecology in the Polish Academy of Sciences, carried out as subject no. 01.03 "Elements of eco-systems functioning in suburban areas" of the problem scope "Ecological foundations for environment management" M.R.II/15, the following institutions participated:

- Institute of Physical and Geographical Sciences of the Warsaw University,
- Institute of Environmental Engineering of the Warsaw Politechnic High School,
- Department of Pedology of the Warsaw Agricultural Academy,
- Department of Environment Management and Department of Climatology of the Institute of Geography and Spatial Organization of the Polish Academy of Sciences,
- Research Centre for Railway Health Service,
- following departments of the Institute of Ecology in the Polish Academy of Sciences: Agroecology, Plant Ecology, General Ecology and Vertebrate Ecology.

Study area

As the study area, the rural commune of Łomianki has been selected, embracing the western part of the northern suburban area of Warsaw, limited by natural borders - from the east by the Vistula River, from the west by the forest complex of the Kampinos National Park. From the south, i.e. from Warsaw, to the north there is a clearly defined decrease of the urbanization level of the studied suburban area.

The studied area of the Łomianki rural commune embraces 3810 hectares. Often before, studies embraced much larger areas, for example hydrological, geochemical and zoological studies, as this was strictly required in order to comprehend processes taking place in the area of the Commune. The area of the Commune has a clearly determinable cascade structure. Three morphological units may be distinguished: the highest situated glacier highland, the complex of upper Pleistocene accumulative terraces, and the low situated Holocene valley of the Vistula River. The glacier highland penetrated the area of the Commune from the south near the villages: Pancerz, Buraków and Dąbrowa, and the height of the area does not exceed there 85 m. The upper parts of this level are made of boulder clay, gravel with stones and fine sands with some gravel. Sandy upper Pleistocene alluvia of the terrace levels cover the greater part of the Commune area. The morphological boundaries have been erased there by later after-glacial, eolian and fluvial processes, partly of Holocene origin. The Holocene valley of the Vistula River is covered by an over 4-metre layer of young alluvia deposits, mainly fine sands and dusty mud from rivers /Wicik 1987, Chmielewski 1988/. The eastern and northern parts of the Łomianki rural commune are a part of the Vistula River catchment area,to which the Dziekanowska Struga /brook/ is drained directly or indirectly through a streamlet. The southern part of the studied area belong to the catchment area of the Bzura River, to which it is drained via the tributaries of the Łasica River /Bajkiewicz-Grabowska 1987/.

Scope of studies

Studies embraced ground to the depth of 5 metres, and the basic geochemical landscapes have been determined. A hydrographical division has been carried out and directions for drainage by surface and underground were discussed. Ways of supplying the main water carrying horizon have been pointed out, as well as directions for the outflow of surface water.The chemistry of underground water resources has been studied on meadows, pastures, arable lands, barren lands fertilized in various ways. Also analyzed was the chemistry of water flowing to the surface of the ground, springs catching ground water from agricultural lands and built-up areas of the suburban areas /Bajkiewicz-Grabowska 1987, Czerwiński et al. 1987a, 1987b, Wicik 1987/.

Detailed studies have been carried out concerning the sources of contamination both liquid and solid, in the time and space aspect on the whole studied area, as well as the influence of these pollutions on the quality of underground water resources with intakes in the form of dug and drilled wells /Żabowski et al. 1987, Szperliński et al. 1987, Czerwiński and Pracz 1987, Szperliński 1987/.

The main pollution sources are leaking septic tanks, improperly neutralized liquid manure and fertilizers. Particularly much attention has been paid in numerous studies to the influence of pouring liquid manure to underground and ground water resources to soils, vegetation cover and selected groups of animals living in the soil or on the ground.

A presentation was made of the distribution of potential and actual vegetation and a study was carried out of the natural and half-natural complexes of waterlogged plant populations, as well as of forests and bushes, segetal and ruderal populations. The influence of the suburban environment has been studied on small mammals and birds, and also the role of rodents and cats in carrying mycoses pathogenic for man.

Within the scope of the geographical environment transformations in the Łomianki rural commune, resulting from the socio-economic development of the suburban area, an analysis was made of historical transformations of the environment in the suburban area: population, settlement, built-up areas, agriculture, branch and spatial structure of handictafts. A synthesis was made of anthropogenic influences on environment in the suburban areas.

The introduction of obtained results will intensity environment protection in suburban areas, and at the same time will improve the sanitary conditions of life for the inhabitants.

It has been assessed that about 9% of dug wells are characterized by unpolluted water,18% by potable water, 22% by periodically potable water, 43% by permanently polluter water, and 10% by water unsuitable for domestic purposes. In drilled wells the above shares constitute respectively: 46%, 28%, 19% and 7%.

The main toxicant limiting the possibility of the use of water destined for drinking are nitrates. The role of water as a carrier of toxic substances was also studied. The level of pollution in water was so high that the Łomianki Authorities decided to continue studies on their cost; they are still being carried out by the Institute of Environmental Engineering. As the intensive contamination of water by nitrates causes the danger of methamoglobinemy, that is particularly harmful to infants which are in the transient period from breast to bottle feeding the results of studies have been applied immediately. The Institute of Environmental Engineering is in permanent contact with the Health Centre in order to be able to study water intakes destined for the use by future mothers and their infants.

The Health Centre also informs currently about places of intake of healthy water.

Simultaneously under the pressure of facts supplied by our studies concerning the problems of pollution of potable water, The Commune Peoples Council obliged the head of the local authority to build public intakes of healthy potable water. In connection with the lack on the area of the Commune of a municipal enterprise disposing of solid and fluid wastes, the head of the local authority has been also obliged to establish such an enterprise.

A big problem for the Commune are liquid manure and municipal sewage. It is planned that a communal composting site is to be organized, where sawdust from the local plant would be utilized, as well as straw and other organic wastes with liquid manure and municipal sewage, which would help eliminate polluting the Commune with those wastes.

Results of the carried out studies helped to create a natural reserve which protects the relatively unchanged old valley of the Vistula River. It also helped to protect by law 23 trees as natural monuments, mainly oaks and poplars growing near the Vistula River. Also the proper sanitary protection of the existing water intakes is introduced with the help of legal regulations.

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MAREK LITYŃSKI
Institute of Geography and Spatial Organization
Polish Academy of Sciences
Warsaw, Poland

SOCIO-ECONOMIC DEVELOPMENT OF THE SUBURBAN ZONE OF WARSAW AFTER THE SECOND WORLD WAR - ON THE EXAMPLE OF THE ŁOMIANKI RURAL COMMUNE*

Suburban zones of big towns constitute specific ecological units. They may be characterized by their varied functions and a considerable physical differentiation. In those units all processes take place in an exceptionally dynamic way, and changes caused by various forms of anthropo-pressure often result in an obvious degradation and even a disfunction of ecosystems. Areas belonging to the suburban zones of towns have only conventional boundaries, which usually differ from the administrative ones, and they usually change simultaneously with the change of town size. The size of suburban areas is defined in geographical studies on the basis of territorial range of certain characteristic phenomena and processes which are different from those in towns or rural areas. They may be similar, but of a different intensity /density of population, employment structure, commuting to work, scope of urbanization, land use etc./.

The problem of delimitation of the suburban zone for the capital of Poland will not be discussed in this paper. It can be stated, however, that generally it complies

*In this article use has been made of information contained in a collectively elaborated paper "Transformations of the geographical environment of the Łomianki Rural Community near Warsaw as a result of socio-economic development of the suburban zone", Polish Ecological Studies, in print.

with the Warsaw Voivodship established in 1975, which encompasses 27 towns and 32 rural communes /Fig. 1/. In many of those administrative units in the last 40 years the increase in population has been considerable,especially in towns, half of which obtained town rights already after the war. Thus the range of urbanized lands, which currently encompass 26.5% of the total area of the Warsaw Voivodship increased in 1950-1984 almost three-fold, and the population number increased in the same time by over two times; the percentage of town inhabitants reached in the year 1984 88.5% of the total population of the Warsaw Voivodship.

The development of towns and settlements in the vicinity of Warsaw was connected with the construction, and later with the electrification of its railway lines, and with the development of industry and commerce, and took place in the 20th century in five main directions, mostly on the east-west axis. Exhaustion of vacant land within the present development belts of the agglomeration, considerable extension of transport distances, laws limiting in-migration in the sixties, and the development of car ownership index in the seventies, caused the intensification of development of areas located far away from railway lines, which up to now have been rather unattractive. One of such areas was a belt of old settlements, along the left side of the river Wisła through Łomianki and Czosnów. The development of this belt was additionally limited by unfavourable natural conditions /forests, flooded areas/, and by the location in the 19th century of Russian fortifications, and after the Second World War of the "Huta Warszawa" Steel Works. Therefore, it was only recently that the process of socio-economic development of areas situated between Vistula and the Kampinos Forest became intensive, and the border running between rural and urban areas quite distinct in the period between wars, begun slowly to disappear - and thus specific suburban areas were created.

The after-war changes in population density of the five administrative units /two districts of Warsaw and two adjacent rural communes/, situated in the distance of up to 30 km from the city centre, have been presented on Fig. 2. The diagram shows shifting of the in-migration flow to areas situated farther away, and while the process of population increase in the Warsaw district of Żoliborz has practically ended, the influx of people to rural areas closest to the town still continues. In the next rural commune, after a temporary increase, a tendency is observed for ceasing of population growth due to population out-flow.

The rural commune of Łomianki has been selected as a model area for detailed research of socio-economic development because of its situation, the existence distinct natural and functional boundaries, as well as of the concentration on a relatively small area of basic functions connected with the socio-economic development, such as: housing, production, services and recreation. For some time now there has been a competition on this area between the above mentioned forms of human activity, and also their distinct conflict with the natural environment. All this leads to believe that the obtained result can be used for other similar suburban areas on a similar stage of development. It should be stressed that for this sector of the suburban area of Warsaw it is extraordinarily important that the present physical development fully complies with local potentials of the natural environment, otherwise this area may become ecologically endangered even in the nearest future.

The rural commune of Łomianki lies on the border of Warsaw, which enables us to define it as a direct suburban area of our capital /Fig. 1/. It has clearly determined borders: the left side of the Vistula River, the edge of the Kampinos Forest /boundary of the Kampinos National Park/, and the edge of the Młociny Forest /from the side of Warsaw/. Taking into account its size, i.e. 38.1 sq. km it is one of the smallest rural communes within the Warsaw voivodship, and from the point of view of the number of inhabitants, i.e. 13,236 persons, and almost 350 persons per sq. km in the year 1984, it belongs to one of the most densely populated, not only in the Warsaw voivodship, but also in the whole country.

The area of the commune belongs to the mid-Mazovian Lowland /Nizina Środkowomazowiecka/ of the mesoregion of the Warsaw Basin. It sloped north-west with the highest point of 88 m a.s.l. in the southern area, and the lowest point of approximately 74 m a.s.l. in the vicinity of the Vistula River. Taking into account the lithological and geomorphological features, it constitutes a polygenetic unit. Three geomorphological units may be defined here: glacier upland, upper Pleistocene alluvia of two terraces, flooded and non-flooded, and the Holocene Vistula river valley.

The settlement basis of this part of Mazovia has been created in the 11th and 12th centuries on the axis of an ancient tract connecting the first capitals of this historical part of Poland - Czersk and Płock. This route ran at first on the high bank of the Vistula pradolina, later on the edge of the above mentioned terraces, and led through the oldest settlements of the area - Łomna and Cząstków. On its both sides in the 14-15th centuries Dziekanów, Kiełpin, Łomianki and Buraków were created. Considerably later - at the end of the 17th century - settlements on the boundary of arable lands and the Kampinos Forest were established - Sadowa and Dziekanów Niemiecki, and next the colony villages of the flooded terrace of the Vistula River - Kępa Kiełpińska and Łomianki Dolne /turn of the 18th and 19th centuries/.

The 19th century was a beginning of the influence of an external factor - the urban area of Warsaw - which soon changed the type of development on those areas. The era has ended of rural housing, where the aim was to gain the easiest possible accessibility both to arable lands and to meadows and pastures. On the areas of forest parcellation on the edge of the Kampinos Forest at the end of the 19th century, the last settlement is established of the modern settlement system - the rural commune of Dąbrowa - as a result of a new tendency - suburban settlement /see Fig. 3/.

The most important natural barriers for the development of settlement of this area were, on the one hand, the escarpment between flooded terraces and the unflooded ones /or temporarily flooded/, and on the other hand the edge of the Kampinos Forest. Thus created settlement belt of a meximum width of 2-3 km, which has consumed the most favourable arable soils of this area remains until today, additionally stabilized in 1958 by a permanent boundary of the Kampinos National Park. The population density of this belt /for the area of the rural commune/ increased from 20-30 persons per sq. km in 1790, to 60-80 persons per sq. km in 1913, 150 in 1950, up to 250 persons per sq. km in 1970, and to 348 persons per sq. km in 1984.

The population density in the commune /without forest lands of the Kampinos National Park/ is very differentiated - from 39 persons per sq. km on Kępa Kiełpińska to 1020 persons per sq. km in Łomianki. Thus for 60% of the area this index exceeded 150 persons per sq. km, which for Polish conditions is considered as characteristic for areas with intensive urbanization processes /Fig. 4/. Łomianki Buraków and Dziekanów Leśny have in their boundaries such a density of population which is characteristic for urbanized areas, i.e. 600-1000 persons per sq. km. Less dense population concerns settlements situated farther away, with more difficult accessibility to mass transport systems, operated on this area by two suburban bus lines.

The number of inhabitants of various settlements of the commune did not increase uniformly, which can be illustrated by data in Tab. 1. Attention is drawn to a considerable population increase in Buraków, Łomianki and Dąbrowa, which led to their merging into one urban entity. Here presently the basic population po[illegible] tial of the rural commune is concentrated, i.e. almost 80%. Only in 1973-1984 the total population increase amounted to 29.4% which gives an annual growth rate of 2.57%. Should this rate be maintained, then in the next 10 years the area will be inhabited by almost 17,000 persons, which may be the upper limit enabling the further good functioning of the natural environment.

The population increase consists mostly, i.e. at almost 60%, of in-migrants, despite the natural increase rate being higher than the average /in-migration of young and middle-aged groups/. Presently over 50% of the inhabitants of the rural commune have been born away from their current place of living: for many of them it is only a phase, before moving to the capital. Another demographic feature of the population of the commune, pointing to the evident process of urbanization of these areas, is the majority of people in the productive age groups in the age structure, as well as a high share of females, i.e. 111 females per 100 males. This last phenomenon is closely connected with a bigger in-migration of women from villages, for whom it is much easier than for men to find employment in urban services, and because of registration restrictions or financial reasons they find it easier to obtain accommodation near Warsaw than in the city itself.

From the beginning of the seventies, over 90% of the inhabitants of the commune earn their living in services not connected with agriculture. Less than 10% of inhabitants earn their living in agriculture, including a large number of older people, over 65 years of age. In 1984 there were almost 2100 persons employed in the non-private sector, concentrated in 80% in four places of a supra-regional range. At the same time in the private sector 1900 persons were employed. Whereas the non-private sector recently shows a stabilized level of employment, then privately employed craftsmen /and lately also employees of Polish-Polonian enterprises/ note a constant increase and shortly will be dominant. It is difficult to define what share in both groups is of people commuting to work from outside of the commune, and what is the share of people living in the commune itself - especially where work in private enterprises is concerned. However, a decrease in the number of people commuting to work outside of the commune by over 1100 persons in 1983 as compared to 1978 in the national sector indicates that local employment market is continually more attractive /Fig. 5/.

The private sector is particularly active in the commune. In 1984 there were 776 crafts workshops, which in relation to over 33 thousand units operating in the Warsaw voivodship, constituted almost 2.5%. In 1979-1984 their number has been doubled, and recently almost 100 new enterprises are established per year. Since

1982, in the commune 15 Polish-Polonian companies have been established. The private enterprises are being established mostly in Łomianki, Buraków and Dąbrowa i.e. close to Warsaw. Generally speaking employment in private enterprises is undertaken mostly by younger people. It not only takes over the hitherto traditional work in industry by the bi-professionals /working on their own farms, and simultaneously employed in industry/ but also lately causes shifting over from the lower paid jobs in the state sector.

The presented increase in the number of inhabitants, socio-economic changes and the development of economic activity, caused specific spatial consequences in the area of the commune. During the last 30 years considerable transformations took place in land use, embracing both new forms of land use, and changes in proportion between the traditional forms, often creating conflicts. This situation concerns, first of all, residential areas and is mainly connected with the dynamic expansion of individual non-rural housing.

Thus, although the general census of 1921 indicated that on an area the size of the present commune, there were 469 buildings /already then Łomianki was clearly distinguishable by its industrial settlement and its small commercial centre/, then the 1978 census names 2258 buildings, mostly constructed after the war. Only during the last 15 years the built-up area increased almost two-fold, and according to the assumptions of the local physical development plan this number is to double up to 1995, and will embrace 17.3% of the total area of the commune. Akready in 1984 the housing, municipal and transport infrastructure facilities embraced 20--25% of the area of Łomianki, Buraków and Dąbrowa. Annually approximately 150 buildings permits are being issued, in 90% for private developers. A new phenomenon is the construction of cooperative housing in the commune by cooperatives from Warsaw for their members, who, after already having taken residence, are still directly connected with Warsaw /work, family, friends, entertainment/, and the new dwelling is for them only a dormitory.

Cultivated lands still constitute over 60% of the area of the commune, which equals the average for the country. This share obviously decreases each year in favour of the above mentioned technical facilities, and also undergoes internal transformations. This especially concerns the area of permanent fields and pastures of the flood terrace, where in the sixties large orchards have been established, and since the seventies allotment gardens are being organized. In the same period pig breeding has been seriously developed /mainly in the litterless method in special fattening houses/, the population of which per 100 hectares is presently the highest in the voivodship, and exceeds a couple of times the average of the country. The influence of this type of economy on the natural environment of the commune has recently become significant due to uncontrolled liquid manure flooding. In Łomianki and Dąbrowa several big green houses have been constructed, also the sight of plastic sheet tunnels for accelerated vegetable production is rather common in spring.

It is very characteristic that during the last 150 years the pattern of cultivated lands in the area of the commune has not undergone more serious transformations. Agriculture developed for years on better soils of the flooded terraces, while meadows and pastures were concentrated near the river and the Kampinos Forest. The ownership pattern also remained unchanged, as individual farms constitute 93% of agricultural lands, i.e. 11% more than the average of the country, and are characterized by their small size /over 60% of farms are under 2 hectares/. This is a result of the land subdivision which took place at the end of the 19th century. A considerable number of the smallest farms with an area of below 0.5 hectare have been established in the period between wars, and after World War II. This was the consequence of emerging of a group of biprofessionals. Presently there is a tendency of treating these small plots of land as recreational areas /especially on the escarpment between terraces near both lakes/, on which often summer houses appear.

The relations between the commune area and its surroundings /commuting to work, market for agricultural goods and artisan products, supply of production means etc./ are determined by the transport and the communication system, in which the most important role is played by the road pattern. The most significant road connection of the commune has an identical, unchanged direction for the last 1000 years, and it is of supraregional character. Its functions are currently being realized by a two-lane part of the Warsaw-Gdańsk route; almost parallel to it, two paved roads run additionally to the capital and to the neighbouring commune. Roads connecting them are usually unpaved, especially those situated farther from Łomianki and are often of poor access. Public transport is ensured by bus lines between towns /8 lines/, and one line each for the town and for the suburbs /Fig. 3/. In relation with this we can see here a reflection of a rule that the scope of economic activity depends on good road accessibility, determined here by road quality and public transport. Settlements situated farther away from Warsaw, such as Kępa Kiełpińska, Dziekanów Polski, Dziekanów Nowy, and Sadowa, are unattractive for the location of handicrafts, are unfavourable for construction of green houses, are devoid of services, and there are still a lot of old houses there, often of wood, sometimes thatched by straw.

In order to characterize the spatial differentiation of the socio-economic development and its influence on the landscape, eight selected indices of this development have been analysed. They represent population increase, technical and agricultural land use, handicrafts and commerce within the twelve settlements of the commune. Various units of measure were brought to the common denominator with the help of point evaluation, in which part indices were presented as well. Then each of them have been endowed with appropriate rank for the given settlement, and the results were analyzed in order to obtain a synthetical index. The higher its value, the more intensive the development of the given settlement. Next, the obtained results were grouped into classes and they have been presented in a cartographic way /Fig. 5/. In this way six areas were determined, each in a different stage of development:

A. Buraków, Dąbrowa, Łomianki Górne create an urbanized unit with a small--town structure, which embraces 38% of the total area and 79% of urbanized areas; it is inhabited by 69% of the population using 75% of the housing in the Commune. Here are also located: the administrative, commercial and economic centre, and a neighbourhood of urban character. Good transport links enable its inhabitants to reach the centre of Warsaw in about one hour. It is planned that up to 1995 this area is to be totally filled with housing and several services of a regional character will be developed here.

B. Dziekanów Leśny may be called a "developing" settlement, where owing to good transport links and to a large number of new sites for buildings, mainly the housing, private production and vegetable production are being developed. Landscape has been transformed only slightly, roads are still unpaved. However much points to the fact that in the next ten years considerable anthropogenic changes will take place here.

C. Łomianki Dolne and Kiełpin - the further development of the first one is directly connected with Łomianki as an area of ancillary functions for the "centre" /lack of possibilities of extending built-up areas/. Kiełpin, on the other hand, gradually becomes a centre of intensive agricultural production of market gardening type. Transformations in land use which take place on this area usually occur without conflicts: cultivated lands are being gradually transformed into vegetable gardens, and meadows into allotment gardens.

The landscape is still cultural, but of an often modern physiognomy

D. Sadowa, Dziekanów Nowy, Dziekanów Polski, Kiełpin Poduchowny. The later constitutes - together with Kiełpin - a transient area to the zone of extensive agricultural economy, represented by the first three units. The lack of stronger external influences helped to maintain the historical cultural landscape - a dense settlement unit with a chequer of fields.

E. Kępa Kiełpińska - as the only one it shows a regress of the settlement functions after 1945, with simultaneous considerable transformations in favour of intensive forms of agricultural land use.

F. Forest areas under the administration of the Kampinos National Park.

The dynamic socio-economic development, which during the last 40 years caused the urbanization of over half of the hitherto agricultural parts of the commune, also caused considerable changes in the natural environment. Pollution of water, air and soils, as well as pressure of population are factors causing a degradation or even a disfunction of the natural ecosystems. Especially endangered were the biosphere and the pedosphere, as well as the underground water resources, which are the basic local sources of potable water for domestic purposes.

The evaluation of the condition and of the scope of environment transformation in the Łomianki commune under the influence from various anthropogenic factors, has been carried out with the use of three research approaches. The first research method is based on evaluating the degree of structural distortion of the present vegetation cover from the hypothetical original condition, taking into account the influence of pollution and anthropogenic pressure /evaluated on the basis of the population number/ within defined, to a certain extent uniform, landscape units. The second method makes use of an index of spatial differentiation of the vegetation, and its results are presented in the limits of the settlement units. In the third method the type of land use and the civilization artefacts have been taken into consideration, and the results of studies were presented in the form of a network of squares, each representing a defined value in percents of the synthetic anthropization index. This method is shown as an example - on Fig. 6.

The details of obtained results for the area of the Łomianki commune will not be discussed here. All readers interested in methods and results of studies should consult the collectively elaborated paper, mentioned in the introduction. It should be stressed,however, that the applied methods enable a general evaluation of the transformation scope of the natural environment in the given spatial unit under a great urbanization pressure. Their universal value may be defined by the fact that they can be used at any given time and on any area, and thus they are suitable both for current and perspective physical planning. The informative result obtained on the area of the Łomianki commune in the form of changes of the natural environment under the influence of an intensive activity of man, may be considered as representative for those areas of the suburban zone, which are characterized by a similar development in time and by a similar physical pattern.

The economic activity intensified in the last years left a permanent trace on the landscape of the discussed area. Natural fragments are practically unique, and therefore we may speak of only the degree of anthropogenic modification of fields, meadows, forests or even built-up areas. Each of the above mentioned forms of land use have been influenced by anthropogenic factors in a different, sometimes changing /in direction and intensity/ way, which caused a varied degree of advancement of those processes in different places.

The basic anthropogenic factor which will continue to modify the environment of the commune is housing with ancillary buildings, and the connected road network with a paved surface. With time the number of smaller building sites increases, houses stand closer to each other, the road network becomes denser, the same with regard to urban roads /carriageway plus footways/. In these conditions the anthropized landscape will gradually embrace bigger areas of the commune, especially those situated closer to Warsaw /Łomianki, Buraków, Dąbrowa/. This process also concerns Dziekanów Leśny, which is situated a bit farther away, at present it is less intense and basically has just begun. It is to be assumed that the pressure upon the environment will, in connection with the above, increase in those places, since during the nearest future there will be no change in conditions of the hitherto development: lack of sewage system, dumping of sludge and refuse on unprepared sites, emission of dust and gases from several local heat sources, exhaust gases from cars, car noise which is rather excessive on main transport routes.

A reflection may be noted here that the more intense socio-economic development, connected with the progress in everyday life required by the local population, the higher dynamic uncontrolled changes in the natural environment, and their negative influence on the health of the inhabitants.

It may be assumed that the further harmonic socio-economic development both of this area and of similar areas will mainly depend on:

- solving the conflict between settlement and agriculture,
- regulating the water and sewerage systems relations,
- introducing controlled dumping of refuse,
- providing an efficient public utility systems,
- carrying out a specially strict sanitary control of the whole cycle of pig breeding,
- prohibiting the site allocation for production and services harmful to the environment,
- developing the local commercial and service networks,
- channelizing of outer pressures /recreation, allotment gardens, supraregional investments/,
- limiting of uncontrolled influx of new inhabitants until all the above problems are solved.

At the end, the presently implemented project should be mentioned which for local authorities of the commune and for planning authorities may constitute a considerable help in solving the discussed problems. As a combined effort of the employees of the Institute of Ecology and of the Institute of Geography and Spatial Organization of the Polish Academy of Sciences, a synthetic cartographic elaboration is being carried out, entitled "Atlas of Environment of the Łomianki commune". It will present the condition of the natural landscape and developed spaces of the commune, based on complex ecological and geographic studies, carried out in 1981--1985 /a fragment of it has been presented in this paper/.

The cartographic side of this publication embraces 34 two-side printed sheets - on the observe a multi-colour basic map and on the reverse a black and white additional information in the form of diagrams, tables and descriptions, explaining the cartographic picture. Each of the above mentioned figures of the A3 format will contain a single map at the scale 1:25,000 or two to four maps in the scale 1:50,000 /Tab. 2/. A series of basic maps is supplemented by two reconnaissance maps and a certain number of maps at various scales. In such a way the area of the commune shown is large enough to present detailed problems taking into account the precise situation of the given phenomenon. This is made additionally easy by two transparent cover sheets in the main scales, presenting the area of the commune within administrative boundaries of 12 settlements and the simplified basic content. The whole will be preceded by an introduction in the form of a monogramic elaboration of an analytical and descriptive character, richly illustrated by pictures and photographs.

Table 1. Population of the Łomianki rural commune in selected periods.

Name of settlement	Number of inhabitants in the year			
	1827	1921	1978	1984
Buraków	138	365	1490	1654
Dąbrowa	.	320	2351	2568
Dziekanów Leśny /Niemiecki/	108	167	948	984
Dziekanów Nowy	.	52	275	304
Dziekanów Polski	268	443	416	540
Kępa Kiełpińska	39	166	74	81
Kiełpin	.	292	476	510
Kiełpin Poduchowny	75	106	235	209
Łomianki	250	798	2429	3581
Łomianki Górne	.	156	1267	1535
Łomianki Dolne	.	315	995	1087
Sadowa	115	229	452	442
TOTAL	993	3417	11408	13236

Note: '.' indicates lack of information

Source: Own data from various sources

Table 2. Thematic scope of environmental atlas for the Łomianki commune

Title of Figure /in parentheses no of maps/	Scale of basic map
1. Review map	1:250 000
2. Administrative map	1:250 000
3. Picture from Landsat	-
4. Prehistory /archeology/	1:25 000
5. Historical maps /6/	1:50 000
6. Dynamics of environmental changes /4/	1:50 000
7. Orthophotomap	1:35 000
8. Topographical map	1:25 000
9. Elements of geochemical landscape	1:25 000
10. Local climate	1:50 000
11. Local bioclimate	1:25 000
12. Hydrography /4/	1:50 000
13. Soils	1:25 000
14. Geobotanic evaluation of environment /4/	1:50 000
15. Existing vegetation	1:25 000
16. Animal life /4/	1:50 000
17. Environment protection	1:25 000
18. Types of geocomplexes	1:25 000
19. Soil and agricultural complexes	1:25 000
20. Land use	1:25 000
21. Agriculture /4/	1:50 000
22. Population I /distribution/	1:25 000
23. Population II /other problems/	1:50 000
24. Increase of built-up areas	1:25 000
25. Modern types of development	1:25 000
26. Industry and handicrafts	1:25 000
27. Non-material services	1:25 000
28. Transport and communications	1:50 000
29. General economic map	1:25 000
30. Environment pollution /4/	1:50 000
31. Recreation and tourism	1:25 000
32. Environmental anthropization /4/	1:50 000
33. Directions of perspective development of commune	1:25 000
34. Commune in the north-west part of the Warsaw Agglomeration.	1:100 000

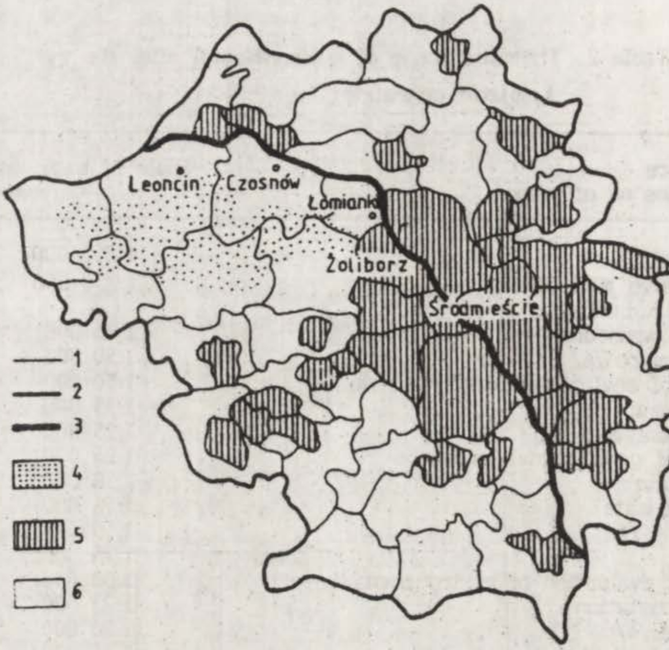

Fig. 1 Administrative division of the Warsaw voivodship

1 - boundaries of administrative units, 2 - boundaries of the Warsaw voivodship, 3 - the river of Vistula, 4 - The Kampinos National Park, 5 - urban areas, 6 - rural areas / commune/

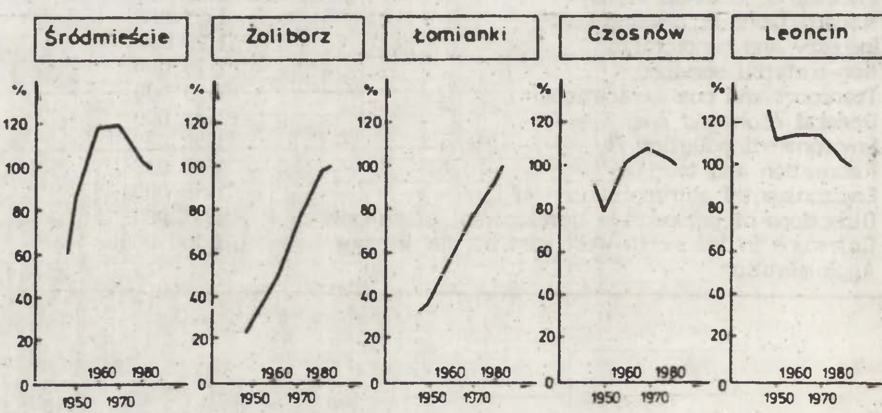

Fig. 2 Changes in the population density of five administrative units situated along the left Vistula bank in 1946-1984 /1984 = 100/

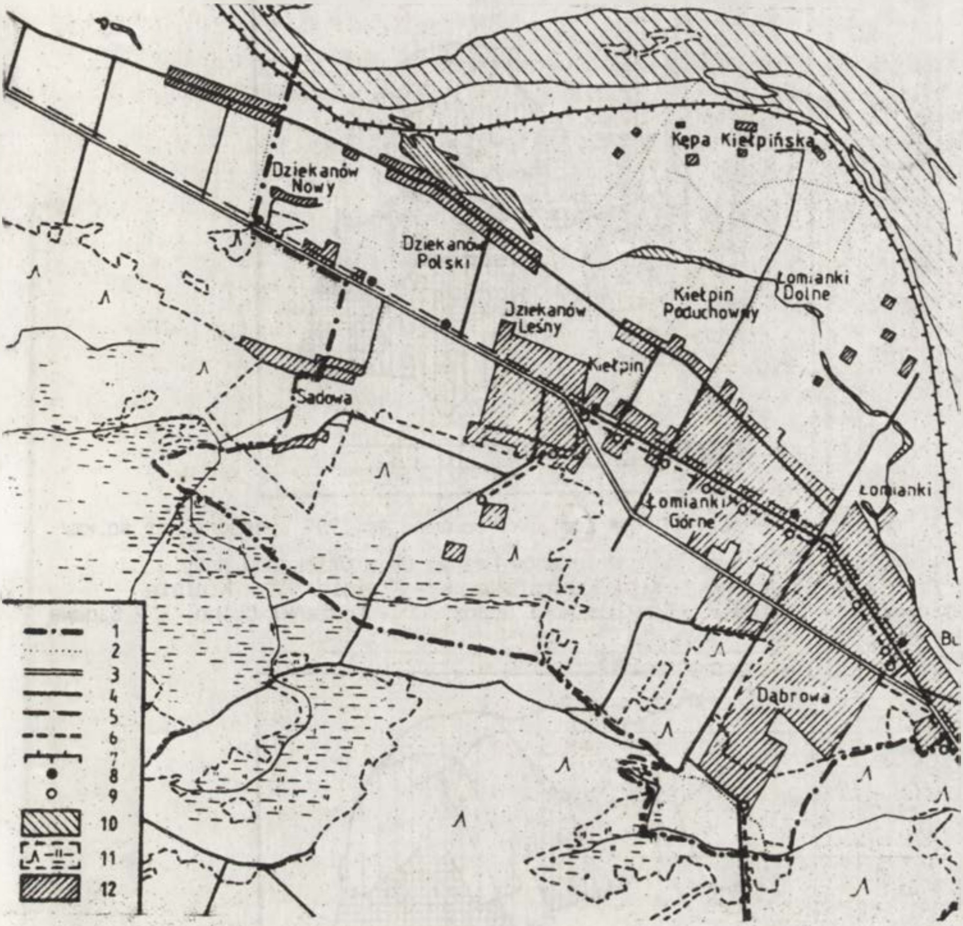

Fig. 3 Administrative and transport situation of the Łomianki commune against the modern range of built-up areas

1 - boundaries of the commune, 2 - boundaries of the settlements, 3 - highway /supraregional/, 4 - main roads of the commune, 5 - long-distance bus lines, 6 - suburban bus lines, 7 - anti-flood dyke, 8 - bus stops of long distance lines, 9 - bus stops of suburban lines, 10 - waters, 11 - forests and wet meadows, 12 - built-up areas

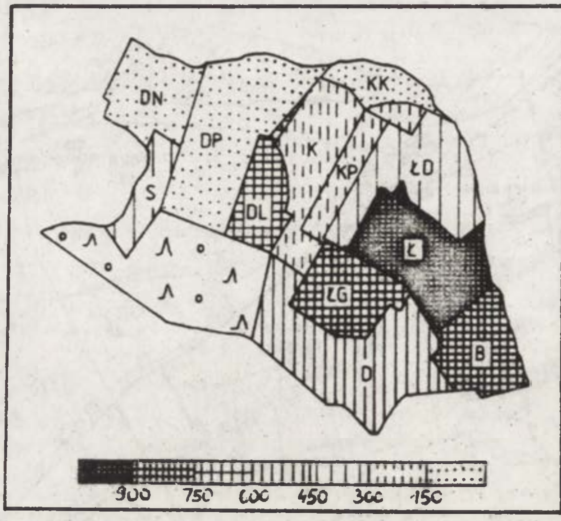

Fig.4 Population density of the Łomianki commune in 1984 /persons per sq.km/

B - Buraków, D - Dąbrowa, DL - Dziekanów Leśny, DN - Dziekanów Nowy, DP - Dziekanów Polski, KK - Kępa Kiełpińska, K - Kiełpin, KP - Kiełpin Poduchowny, Ł - Łomianki, ŁG - Łomianki Górne, ŁD - Łomianki Dolne, S - Sadowa

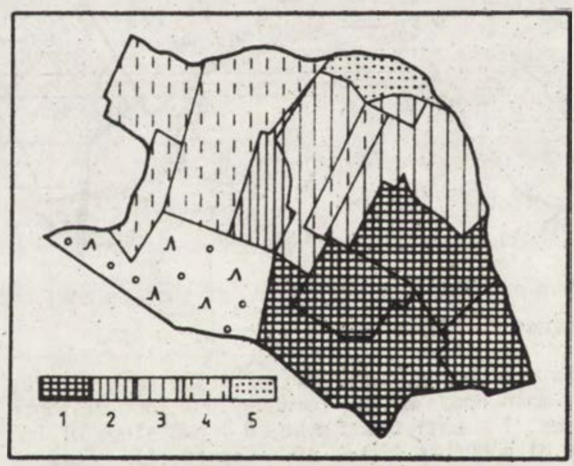

Fig. 5 Socio-economic development of the Łomianki commune in 1984 in accordance with selected indices

1 - Łomianki, Łomianki Górne, Buraków, Dąbrowa, 2 - Dziekanów Leśny, 3 - Kiełpin, Łomianki Dolne, 4 - Dziekanów Polski, Dziekanów Nowy, Sadowa, Kiełpin Poduchowny, 5 - Kępa Kiełpińska

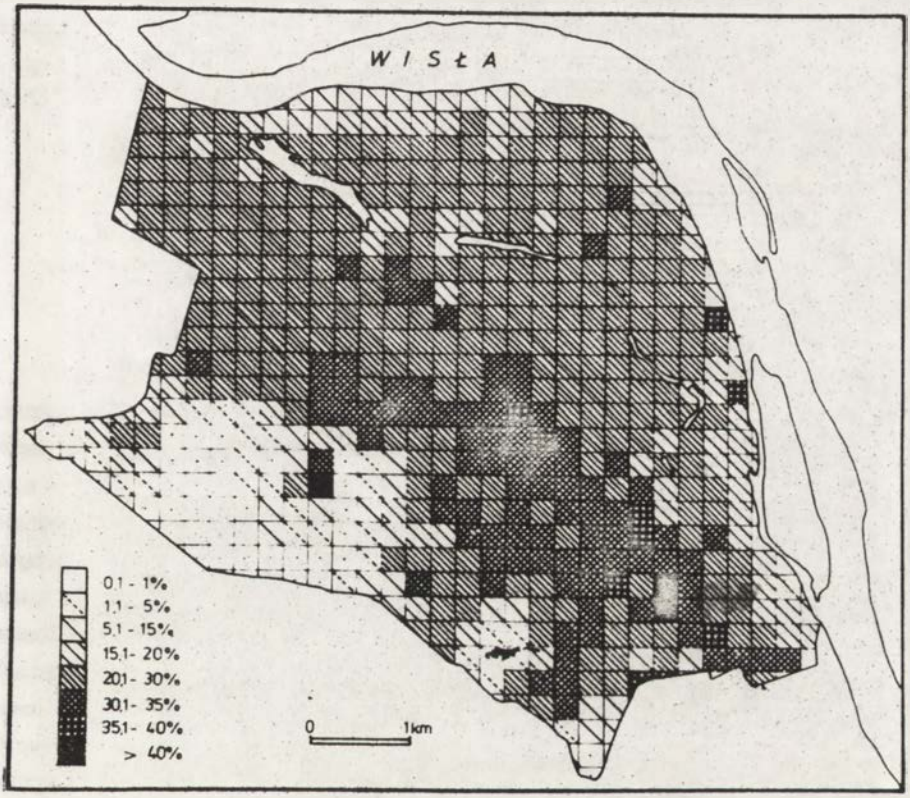

Fig. 6 Intensity of anthropogenic factors in the Łomianki commune

STEPHAN VELEV
Institute of Geography
Bulgarian Academy of Sciences
Sofia, Bulgaria

THE CLIMATE OF SOFIA

The climate of big towns differs considerably from the climate of their neighbouring regions. The differences result from the heavy anthropogenic impact on most of the climatic elements. It was at the beginning of the 19 century that climatologists reported perceptible changes in some elements of weather and climate caused by the big town. There is a great variety of views about the type and degree of these changes. The long-term observations in certain capitals of Europe make it possible to assess accurately transformations of the climatic elements. All scientists without exception point to the size of the population as the basic factor for the degree of these changes. In order to estimate them, models have been suggested /Landsberg 1983/. In spite of this fact, the long-term observations /covering a period of 100, 200 or even more years/ remain the most reliable source for specifying the man-induced climatic changes in big towns.

In Sofia the observations on weather started almost a century ago /in 1887/ in the Botanical Gardens station in the city centre. The station of the former Department of Agronomy, next to the Radio Sofia Building, and that of the Central Bureau of Hydrology and Meteorology have data referring to considerably shorter periods - respectively from 1938 to 1963 and from 1951 onward. There is a network of 16 rainfall stations within the city limits, each one providing recors of different duration. Although the observation periods are twice or thrice shorter as compared to those in the big European towns, the stations in Sofia gave also registered changes in the value of many climatic elements, due to the harmful urban influence during the last two or three decades. Further on, the paper will focus its attention mainly on the man-induced transformations of climate.

From the viewpoint of its morphological structure, West Central Bulgaria is a basin, which is an important orographic climatogenic factor, affecting the global climatic factors. The temperate climate of the basin is represented by its usual characteristics: relatively cold winter, hot summer, precipitation maximum in May and June and precipitation minimum in February.

The mean duration of solar radiation /2065 hours a year/ is a constant element varying within the range of ± 200 hours and is poorly affected by the built-up urban area, as it is associated primarily with the density and type of clouds. Its maximum is in August and its minimum - in December and January. The same clearly expressed annual cycle refers to the total direct solar radiation, but the greatest is the amplitude of the annual cycle of the total incoming solar radiation. The radiation balance has minimum values /usually negative/ in December and January and maximum ones - in summer, particularly in June and July /Lingova 1981/. If the town has an almost insignificant effect on the solar radiation duration /the latter is by 60 hours shorter in the station of the Department of Agronomy than that in the station at the Central Bureau of Hydrology and Meteorology/, it is exactly in the town where the intensity of the total solar radiation in January is by 20% lower. Generally speaking, the urban territory disturbs solar radiation only in winter, while in summer it heavily influences the albedo. In the city the albedo is almost as small as of the water surface, i.e. not more than 15% or 20% of the total solar radiation is reflected. On space photography, taken at the height of 200 km in the visible electromagnetic spectrum, the built-up area of Sofia is distinctly outlined against the background of the adjacent territory, and by its colour looks like the Iskar reservoir.

The mean annual temperature for a one hundred year period /1887-1980/ according to the records of the Botanical Gardens station is + 10.3°C, the mean temperature in January - -1.8°C and the mean temperature in July - +21.0°C. The winter temperatures vary within a wider range than the summer ones. In 1893 the mean temperature in January was -10.4°C and in 1948 - +4.4°C /Climat .... 1983; Hristov and others, 1978/. In comparison with them, summer temperatures are much more steady and the yearly deviations from their standard value do not exceed 3°-4°C. Spring in Sofia is by 1°C colder than autumn. The absolute maximum and minimum temperatures are respectively lower and higher than those in many other plains and hilly regions of the country. The Botanical Gardens station has registered temperature below -30°C only once /in 1893/ and temperature above +38°C - again just once /in 1916/ - /Climat .... 1983/. The extreme amplitude for this station is 70°C.

A very common phenomenon in the atmospheric stratification over Sofia are the surface and upper temperature inversions. For the last 25-year period, the average annual number of days with surface temperature inversions, observed at 2.00 a.m. has grown up from 174 to 209 /Hristov 1978; Sabev 1978/ and vertically the inversions reach 230-380 m above the station at the Central Bureau of Hydrology and Meteorology /587 m altitude/. Of all 209 days, 94 maintain their inversion until the morning observation at 8.00 a.m. Most of these days belong to the cold half-year period /October-March/ which means that steady surface temperature inversions, continuing for 10-12 hours, occur each two or three days during these months. Then the inversion upper boundary can stretch even up to 500-600 m above the station. Although they are seldom /approximately 10 days a year/, inversions have been recorded during the observations at noon, but their height and temperature gradient are negligible.

Very often /in about 150 days per year/ together with the surface temperature inversions or independently, other inversions occur in the free atmosphere, called "upper inversions". Usually, they originate from the surface ones, when the underlying surface warms up in the morning and destroys them from below. The greatest is the inversion layer thickness in winter /from 370 m to 500 m/, while in the other three seasons it is about 300 m. Upper inversions are most frequently observed in the morning but sometimes, especially in winter, they can exist until 2.00 p.m. /with 3 or 4 cases in December/.

All the aforesaid data refer to the non-built-up spaces of the basin bottom, leaving out its built-up urban area /Climat .... 1983/. Due to the greater heat conductivity of building materials, as well as to the formation of a "heat island" in the city centre, upper inversions over the town are far more frequent than the ground and upper ones over that part of the basin which is free of buildings. This is confirmed by the abrupt decrease of the number of foggy days, having been recorded at the Botanical Gardens station during the last decade.

The urban influence on the mean monthly and annual temperatures becomes obvious when data, taken for the city centre, are compared with data for fields far away from the built-up area. The differences are 0.5°-1.0°C, and they prove that the city centre has higher temperatures. In literature this phenomenon is known as "heat island" /Landsberg 1983/ which is established for each big town all over the world. The city temperature changes are well discernible in the process of comparing data, obtained by the Botanical Gardens station throughout the observation period with those of the same station, but related only to the last 20 or 30 years. The mean annual temperature for the period of 1962-1981 is +10.7^{o}C i.e. by 0.4^{o}-0.5^{o}C higher than the average temperature for 1887-1981. The differences are great especially in January /the last 20 years have seen a warming up by 1^{o}C/, and this trend can be explained by accelerated rates of population growth and by the expansion of the built-up urban area.

Strangely enough, the same trend develops in territories entirely saved from urban impact, like that of the peak of Moussala with its station, where the temperature in January also rises but more slowly. The trend line equations for both stations, based on one and the same observation period /1950-1980/, are as follows:

the peak of Moussala - $y = -11.2^{o} + 0.02^{o}\,x$;

The city of Sofia - $y = -1.6^{o} + 0.05^{o}\,x$,

i.e. if on the peak of Moussala every year the mean temperature in January rises by 0.02^{o}C, in Sofia this temperature rise is 2.5 times higher - 0.05^{o}C. The temperatures in Sofia have turned to be the highest as compared with those recorded by 20 other stations in the country, covering a long observation period.

Undoubtedly, the facts speak in favour of the "heat island" so characteristic for our capital with its 1,000,000 population. In spite of the low albedo in summer, throughout the 30-year observation period, summer temperatures decrease gradually - a tendency which differentiates Sofia from the large towns in Europe and North America and shows that urban influence cannot balance the heavy oceanic effect on climate in the European continent over the last 2 or 3 decades.

More distinct are the differences between the extreme winter temperatures. If the stations of Bozhurishte and Sofia airport are compared with the Botanical Gardens station, the latter provides data about the average temperature which are by 3.0^{o}-4.5^{o}C higher and the absolute minimum temperature, which are by 5^{o}-7^{o}C higher. These differences hold only for the city centre as the extreme temperatures in the housing complexes near the Vitosha and the Liulin mountains are approximate to those in the non-built-up area of the basin. The tendencies towards raising the absolute minimum temperatures are valid for all plains and hilly regions in the country during the last 30-50 years, which is probably due to the oceanic characteristics assumed by the climate of Europe. The temperature rise has an almost equal quantitative expression for the period 1935-1979 as can be seen from the examples below:

the station of Panagiurishte - $y = -21.0 + 0.14\ x$;
the station of Bouzhurishte - $y = -22.4 + 0.12\ x$;
the station of Gorni Lozen - $y = -24.5 + 0.15\ x$;
the station of Sofia - $y = -18.9 + 0.17\ x$.

Although there are deviations in the mean temperature values, the rates of temperature rise are almost the same. However, an analysis of a shorter observation period /1945-1979/ gives evidence that the station of Sofia has recorded rates of temperature rise /$y=-18.1^{o}+0.21^{o}\ x$/ twice as high as those in the station of Bouzhurishte /$y=-20.8^{o}+0.10^{o}\ x$/ and in the station of Panagiurishte /$y=-19.5^{o}+$ $+0.13^{o}\ x$/. Hence, it can be concluded that in the first four or five decades of the whole 93-year observation period /1887-1979/, it was the average long-term values of the absolute minimum temperatures in the town of Sofia that were affected, while during the last 2 or 3 decades the town had its impact on their growth rates in contrast to the ones beyond the range of urban influence, which remained unchanged.

All the facts mentioned so far prove the existence of a "heat island" in the centre of Sofia which perhaps stretches up to 200-300 m above surface, and which is best shaped in winter and by night. In other big towns it isn´t so high but the physiographic situation of Sofia lets it go up to that height at which temperature inversions occur most often. It goes without saying that the formation of such a "heat island" is possible only in calm weather. In days with wind velocity exceeding 8-10 m/s the island cannot be formed at all. The climatic conditions in the basin guarantee 229 days yearly with a gentle wind or no wind at all, i.e. they favour the emergence of a "heat island" in winter.

Quite heavy is the urban influence on the frost-free period duration, too. In the densely built-up city centre this period is by 15-20 days longer than in the outskirts at the foot of the Vitosha mountain and in the marginal parts of the basin.

All changes in the air temperatures, caused by the town, approach in value the average changes, having been calculated for most of the big towns in the world /Landsberg 1983/. In the Botanical Gardens station the rate of the mean annual temperature growth is also close to the global average one throughout the 93-year observation period /1887-1979/. The equation of regression line is $y=+9.8^{o}+ +0.01^{o}$ x, but according to Dronia, 1967 /cited by Landsberg 1983/, the mean coefficient for the world's large towns is $+0.008^{o}C$ annually during 1871-1960. This tendency of raising the mean annual, and of especially the mean winter temperatures, is supposed to continue in the following two decades as well, but at lower rates because of the reduction of population growth, and of the city territorial expansion in the future. Taking into consideration these developments we may conclude that at the end of the present century and at the turn of the next one /i.e. 1980-2010/, the mean temperature in January in the Botanical Gardens station will be $-0.5^{o} \pm 0.2^{o}C$, and the mean annual t^{o} - $+10.8^{o} \pm 0.1^{o}C$. A comparison with 1887-1961 data, which are respectively $-2.0^{o}C$ and $+10.2^{o}C$ /Hristov and others 1978/, shows that the most significant is the winter temperature increase.

The wind velocity of the Sofia basin has its maximum value at the end of winter and at the beginning of spring /from 3.5 to 4.5 m/s on the average in Fenruary, March and April/ and its minimum - in August and September. In this respect the bottom of the basin is similar to all plains and hilly regions of the country. During most of the year the basin is dominated by western, eastern and north-western winds. Only in autumn it is the eastern winds that are prevailing. The reason for such an orientiation of winds is the long axis of the basin, in western-northwestern-eastern-south-eastern direction. In summer, at the foot of the Vitosha, there a mountain breeze can be felt which during the day comes from the north and during the night - from the south.

The foehn is considered to be a very important element in the wind regime. Its nature makes it quite difficult to reveal its characteristics within the city limits. Added to this is the insufficient number of meteorological stations. The Sofia airport station and the station at the Central Bureau of Hydrology and Meteorology have recorded that the frequency of wind velocity of over 15 m/s is several times greater than in the Botanical gardens station. As for the remaining city regions, the availahle data are inadequate.

In the central part of the city /at the Botanical Gardens station/ the annual mean wind velocity steadily weakens. For the period of 1901-1963 it is 2.0 m/s, for 1952-1963 - 1.8 m/s /Hristov and others 1978/ and for 1965-1977 - 1.0 m/s. /Climat .... 1983/. During the same periods, the mean wind velocity at the

Sofia airport station has not changed its value, which amounts to approximately 3.5 m/s. The cases of calm weather with wind velocity up to 1 m/s have increased from 58% to 70% of all the observations carried out, and those with wind velocity between 2 and 5 m/s have decreased from 32% to 22%. The cases in which wind velocity exceeds 5 m/s constitute 8-9% of the observations.

If we sum up the empirical results, achieved on the basis of data given by Oke and Hannell /1970/, a correlation can be drawn between urban population and wind velocity /the latter destroying the "heat island"/, which is expressed by the following equation:

$$U_{lfm} = 3.4 \log P - 11.6$$

where P is the urban population, U_{lfm} - the critical wind velocity. In the town of Sofia with its population of 1,000,000 inhabitants this velocity is about 9 m/s /Climat .... 1983; Blaskova and others 1979/. The probability occurrence of such wind velocity in the Botanical Gardens station during 1901-1963 was 1.0-1.5% and during 1965-1977 - just 0.3%. It is evident from the aforesaid data that in the city centre the wind velocity has almost no contribution to the air purification from anthropogenic pollutants.

Air humidity in the city has its maximum value in December and its minimum - in August, while humidity deficit is at its minimum in December and at its maximum - in August. The greatest is the humidity in the morning, and the smallest - at noon. Its day and night cycle is best illustrated in summer. Because of the higher temperature in the city, and because of no evaporation from the stone and asphalt roads, the relative humidity in the city centre drops and the humidity deficit goes up.

The mean annual precipitation amount is 621 mm /the Botanical Gardens station/, i.e. slightly below the average for the country /680 mm/. Some months remain without any precipitation at all /e.g. September 1923/ and the greatest precipitation amount was recorded in August, 1900 - 226 mm. The mean square deviation from the annual precipitation is 121 mm. There were only three years with a precipitation bigger than double the amount of the mean square deviation /above 870 mm/ - 1892, 1897 and 1937. At the same time only the year of 1945 is with precipitations lower than the doubled mean square deviation /below 390 mm/. So, obviously the available data suggest that deviations of the total annual precipitation, measured in the station for a period almost a century long, are insignificant. The number of days with a precipitation $>$ 0.1 mm is 125, and that with precipitation >1.0 mm - about 90. Precipitations greater than 10 mm in a 24-hour period take place only 19 days a year and those estimated at >25.0 mm just 3 days yearly. In the afternoon and in the evening the precipitation is heavier than that in the morning and night. Shower-type precipitations /with intensity above 30 l/s/ha/ fall most often in May, June and July. In the cold half-year period such precipitations cannot be observed. The average number of days under snow cover is about 50, but there are years with no snow cover.

The territorial distribution of precipitations in Sofia is dependent on certain physiographic factors, such as the vicinity of Vitosha and the locking up of basin from the south and north. No data are available to confirm any differences between the town's regions as a consequence of anthropogenic influence. The conclusions drawn by Dimitrov and others /1966/ in favour of such differences probably result from the short duration of observation period covering only 9 years. The basin surface, adjoining the city's northern and northeastern parts together with the urban core, have approximately 600 mm of annual precipitation. Moving southward, the precipitations near the mountains increase to 700 mm /Juzinata Hydroelectric plant station and Bankya station/, while at the foot of Vitosha and Liulin they reach 800 mm /the stations of Gorna Banya and Boyana/. On the northern slopes of Vitosha the precipitations increase to 1100 mm at an altitude of 1400 m, but higher up to the Cherni Vrah peak they almost do not change in their quantity /the instrumental error correction is not taken into account/.

Closely associated with the total annual amounts are the days with precipitation above 10 mm. There are about 20 of such days for the basin bottom, at the foot of the mountain - 22, in the regions of Boyana and Gorna Banya - 30 and at an altitude of 1400 m - 40 yearly. As it can be seen from the aforementioned data, there is a common tendency to an increase of precipitation from north--east to the soutwest /the Sofia airport station - 530 mm, Boyana station - 820 mm/.

Still unsettled remains the problem of the anthropogenic effects on precipitation amount, as well as on the changes it undergoes during the last one hundred years. D.Dimitrov and G.Stankov /1965/ have not discovered deviations in the annual precipitations while comparing them with those recorded in the Bouzhurishte station. The same result was obtained by studying changes which have occurred during the last century in the Botanical Gardens station. The amount precipitation has not altered considerably since the beginning of the period up to the present days. The regression equation of the total annual precipitation is of the following:

$$y = 637 - 0.37\,x$$

which points at a very slow rate of deminishing, by 1 mm every three years.

Most of cases with foggy weather in the city belong to the cold half-year and their main factor is radiation. Almost always they occur together with temperature inversions; this is evident from the fact that 85% of them begin their existence somewhere between midnight and 9.00 a.m. The average number of foggy days in the lower northern and eastern parts of the city is about 30 per year and in its high southern and western parts it is 10-15. In the Botanical Gardens station and the Bouzhurishte station the number of foggy days decreases quickly during the last years, i.e. respectively 10 and 23 annually. The reason for this can on the one hand be explained with the smaller quantities of solid fuel used, and on the other - by the "heat island".

Comparing the climatic elements transformations caused by the town of Sofia, with those published by Landsberg /1983/ who has generalized the world findings in this respect, it becomes obvious that Sofia has the same effect on air temperature air humidity and wind velocity as the metropolitan areas in North America and Europe. True enough, this has been quite unexpected because most of the large towns, given as an example by Landsberg, are situated in plains unlike Sofia which lies in a basin. Many quantitative indicators, used by him, are confirmed by those recorded for Sofia and what is more, in some cases the changes in our capital are even greater. Thus, wind velocity in the centre of Sofia weakens by 50% as compared to that observed in the out-of-town stations while according to Landsberg this amount equals to 20-30%. However, the data provided for Sofia suggest that there is no anthropogenic impact on cloudiness and precipitation. On the contrary, Landsberg has established differences amounting to 5-10% for these two climatic elements.

Due to the joint effect of land relief and man's activities, the authors of the monograph "Climate and Microclimate of Sofia" /1983/ maintain that urban territory can be devided into 4 mesoregions. In addition to their views and supporting them, this paper outlines the boundaries of the regions they have distinguished and gives for each one the basic climatic characteristics:

1/ City centre. The highest temperature here is in winter /mean temperature in January 0.9^{o}C which is by 0.5^{o}-0.8^{o} C higher than in the other built-up urban areas/. Fogs occur most seldom and wind velocity and air humidity are at their lowest values.

2/ City margin. It looks like a ring around the city centre. The winter temperatures in it are by 0.5^{o}C lower than in the town central parts, the absolute minimum - by 2^{o}-3^{o}C lower and the wind velocity - by 1 m/s greater.

3/ Basin bottom. It embraces all housing complexes belonging to the 7th administrative region in the northern and north-eastern parts of the city. The basin bottom is remarkable for its colder winter than that in the above mentioned two regions, for its shorter frostless period, for the greater number of foggy days owing to the anthropogenic activities and for the smallest total amounts of annual precipitation.

4/ Foothills. They include all housing estates to the south and west from the ring--road. This region considerably differs from the remaining three regions in terms of its microclimatic characteristics. The mean wind velocity is higher /2.5-3.5 m/s/ the summer temperatures are lower, the number of foggy days is reduced, the total precipitations much greater /750-820 mm/. As compared with the whole urban area, the climatic conditions there are most favourable for living and recreation.

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VLADIMIR VORACEK
Institute of Philosophy and Sociology
Czechoslovak Academy of Sciences
Prague, CSSR

LUDMILA OLIVERIUSOVA
Department of Environment and Landscape Ecology
Faculty of Natural Sciences, Charles University
Prague, CSSR

ENVIRONMENTAL PROBLEMS IN THE PRAGUE SUBURBAN ZONE

The general development of Prague, the formulation of goals of its future development and, consequently, the quality of environment are strongly influenced by the present state of the capital city with its spatial organization, planning and distribution of building stock, as well as by its remarkable cultural and material values and many problems and shortcomings whose solution is difficult and expensive.

The entire urban structure exhibits evident traces of the concentric growth of the city at different stages of its evolution. The Prague historical core still represents the centre of gravity of the capital and constitutes the main part of its centre. It was proclaimed, as a whole, the state monument reservation in 1971. A considerable part of non-residential buildings is utilized for various purposes /administration, trade, services, hotels, social facilities, storage, production/. The quality of dwelling stock in the centre is low owing to the neglected technical conditions of houses and insufficient utilities.

In the last century, urban development got over the fortification system of the historical city. Behind the city gates new districts began to form compact built-up areas incorporating old communities situated on the then outskirts of the city. They gradually intergrated into a closed ring of the inner city around the medieval core. The quality of individual districts is differentiated ranging from the worst working - class districts of Zizkov, Smichov and Liben to former middle-class districts of Dejvice, Letna and Bubenec. An important shortcoming, considerably affecting the quality of environment, is constituted by various industrial plants embedded in the residential districts.

In the last decade, a number of important public buildings was constructed. They took a weight off the functionally overburdened centre and, at the same time, they enriched the inner city by new values, enhancing its importance and social attractiveness.

Since 1945 the city has been expanding and behing the compact ring of the inner city there arose an outer urban zone formed by a loose pattern of residential estates, industrial districts, technical facilities and open landscape with greenery and recreational facilities.

Large new settlements on the outskirts determine the specific nature of the urban periphery. They represent the strongest functional component in the urban structure and affect the fundamental links with the region behind the urban boundaries. The industrial areas also play a great role. The city is, to a certain extent, encumbered excentrically by a gradually formed industrial zone of the eastern fringe. No analogues zone appears in the western part with fewer industrial plants. Nevertheless, this situation aggravates the transport conditions and complicates the relationship between residence and place of work.

Independent communities on the fringe are predominantly of rural character and have underdeveloped technical infrastructure facilities. However, the fringe territory still offers the space necessary for urban development. This activity is limited due to stricter measures of protecting high-quality agricultural land which is found on almost the entire periphery. The above-mentioned urban characteristic constitutes one of the unchangeable facts of the present time and it exerts substantial influence upon the quality of environment not only in the centre, but also in the suburban zone.

One of the natural conditions, essential for development, is the urban relief with the preserved greenery. It influences the kind of building stock, land-use pattern, as well as layout of and technical networks. The quality of agricultural land puts constraints upon the possibility of further development especially in fringe zones.

The physical configuration of the city is determined by the formation of relief with the river Vltava and its affluents. The Vltava with its deep valley forms the physical backbone of the Prague basin in the direction North-South. The altitude difference between the Vltava and the plateaux and terraces is over 200 m. The highest point is Kopanina /390 m above sea level/, Tocna /385 m a.s.l./, Bila Hora /380 m a.s.l./. The lowest point is on the Vltava bank near Podbaba at 176 m a.s.l.

The relief has strongly influenced the direction of urban development and formation of natural urban zones. The Strahov divide on the left-hand bank of the Vltava forms a natural dividing element between the north-western and south-western urban sectors. On the right-hand riverside the divide is formed by a ridge extending from Vitkov over Balkan towards Smetanka and Tabor. This ridge, in turn, separates the northern and western urban sectors. Another dividing function is performed by deep valley cuttings. The natural divides break up the compact mass of the urban development. Owing to the greenery, preserved on their surfaces they play great compositional and environmental role. Prague has 4,900 ha of park forests, i.e. 41 sq.m /inh, and 1,160 ha of public parks, which is less than 10 sq.m/inh.

In consequence of complicated geological, tectonic and geodynamical evolution, the technical and geological conditions are very heterogeneous. These conditions are reflected in the built-up spaces and especially in the pattern of road network.

According to its technical and geological properties, soils are divided, horizontally and vertically, into 10 zones. They are characterized by occurrence of rocks with approximately identical properties and with similar geological and geomorphological evolution.

There are considerable climatic differences between the city centre and the peripheral zones. For instance, minimum temperatures in the centre are by 6 to 7°C higher than temperatures on the outskirts at a distance of about 25 km. Differences in wind velocity also exist: on the periphery they are about 4 to 5 m/s while in the centre they reach only 1.5 to 2.5 m/s. Annual number of sunshine hours decreases by one hour in 10 years owing to atmospheric pollution.

In the Prague territory there are 94 nature-protected areas.

Prague covers an area of 496.44 sq.km with 1,193,513 inhabitants /as of January 1, 1986/, i.e. 7.7% inhabitants of the CSSR*. Population density is 2,382 inh/sq.km. Average age is 38.6 years; 653,984 inhabitants are in productive age; 634,800 persons, i.e. 53.7% of the total population, are economically active. In the class structure the working class represents 42.4%. 173,646 inhabitants, i.e. 26.3% of the total number of employed persons, work in industry and they produce 11.9% of the industrial output of the CSR /i.e. 8.3% of that of the CSSR/. Job commuting from the CSR involves 125,171 persons. 39,808 students commute to schools.

In Prague there are 77,827 buildings. During the past ten years their number increased by 3,148. One families houses represent more than 38% of the housing stock, namely:

blocks of flats	44,270	58.4%
cooperative residential houses	3,457	4.6%
other residential houses	26,610	33.8%
other buildings	2,457	3.2%
total	75,794	100.0%

Average age of permanently occupied houses is 43.5 years. Total number of dwellings is 461,984, of which 448,741 /97.1%/ dwellings are occupied permanently.

In the field of civic amenities the statistics report 83 cinemas, 20 theatres, 14 museums, 35 galleries and 82 libraries of all kinds. 43,623 students study in colleges and at universities. Kindergartens have 46,182 places. There are 131,550 pupils in primary schools, 11,471 in secondary /comprehensive/ schools, 16,485 in vocational schools and 27,340 in training centres. Tourism is catered for by 71 facilities with 9,519 beds. In public catering there are 91 places at table per 1000 inhabitants. Shops have 263 sq.m/1000 inh.

Transport is characterized by the following data: number of passengers per year is 1,145,975. Length of traffic routes is 1,998 km. Total number of motor vehicles is 364,449. Car ownership is 1:4.25; vehicle ownership is 1:3.27. Length

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* For comparison: the Central Bohemian Region occupies an area of 10,994 sq.km and has 1,139,116 inhabitants.

of roads is 2,389 km, of which 478 km are classified as highways and 1,911 km as parish roads. Density of roads is 4.78 sq.km.

Water supply pipelines are 2,599 km long. Average water consumption amounts to 550,000 m^3/day, specific consumption is 485 l/inh/day.

Gas supply lines are 1,796 km long. Gas /gas and natural gas/ consumption amounts to 696 million m^3/year.

The general position of Prague in the economy of the CSSR can be seen from its percentual shares in the following indicators:

	CSR	CSSR
population	11.5	7.7
employed persons	14.4	10.1
fixed assets	17.1	12.1
investments	16.7	10.9
construction investments	16.5	10.6
value of industrial output	7.9	5.6
value of agricultural output	0.7	0.5
value of building industry output	20.0	13.1
retail turnover	15.1	10.5
money income	15.7	10.9

The total value of fixed assets is 304 milliard Kcs, but their efficiency in the production process is evaluated as below-average.

One of the basic indicators for identifying the environmental problems is the distribution of land uses /in %/:

	Prague in 1980	Prague in 2000
residential areas	40	48
- dwelling	30	32
- civic amenities	6	7
- green spaces	4	9
- inh/ha	97	77
remaining urbanized area	60	52
- industry and storage	8	7
- transport	13	14
- open spaces	36	28
- water	3	3

In planning the development of Prague the following alternatives were elaborated:

Alternative 1

Reaching the maximum number of approximately 1 million inhabitants within the old boundaries; at the same time developing three satellite towns /Kladno, Brandys, Ricany/.

Alternative 2

Acquiring new space both for industry and housing by annexing 29 cadastres of peripheral communities; localizing industrial zones and plants in the eastern part of Prague; building settlements provided with social infrastructure of various categories around the outskirts of Prague.

Alternative 3

Aiming the further development of Prague at demolition of inadequate built-up areas and controlling the physical development with regard to the high-quality agricultural land in the fringe zones of Prague.

At present the quality of environment in Prague is highly unsatisfactory. It can be compared with that of the North Bohemian Brown Coal Region or with that of other industrial agglomerations. The suburban zones are subject also to the harmful influence of economic activity. Consequently, this fact restricts their prospective compensating function in controlling the quality of environment in the whole territory of the Prague agglomeration.

The continued development of Prague should gradually be transferred into smaller settlements in the suburban zone. This is necessary not only in respect of reserves of land and resources but also because the hitherto development of Prague has brought about a stagnation in the overall development of the suburban zone. Nevertheless, the areas of intensive agricultural use in the northern part of the suburban zone constitute a certain barrier. These areas can accomodate certain kinds of industrical production, food industries, centralized services, etc. Natural and economic conditions, best suited for the high quality of environment, are found in the south-eastern and southern parts of the suburban zone. The danger of infavourable influences is imminent even in these parts but it results from the dense settlement structure. At present, these settlements perform recreational and residential functions.

MIROSLAV HAVRLANT
Faculty of Pedagogy
Ostrava, CSSR

FUNCTION OF BOUNDARY REGIONS IN THE DEVELOPMENT OF AREAS

Evaluation of boundary regions is based on them being a historical category /namely Czechoslovakia-Poland relation/ because boundaries between states changed often in the past but the territory has had some common features, functions and problems. Between the boundary regions some historical relations still exist due to similar economy, ecological problems, social structure and family relations, etc.

The socio-economic development of regions is always accompanied by production of waste, the transport of which /air, water/ is not restricted to the state boundaries. Consequently, mutual affecting of areas on both sides of the state frontier takes place. Cooperation of both countries in protection and study of the environment is required, as well as a close cooperation necessary because of the needs of development of the boundary regions which are often allied by economy /e.g. we are going to pay attention to the example of Polish Upper Silesia and Ostrava industrial region in Czechoslovakia/. If the nations of both countries, and namely people living in the boundary territories, are to maintain good relations, it is necessary to get mutually acquainted.

Although Upper Silesia was divided among three countries, the economical and social development of Upper Silesian and Ostrava industrial areas before the 1st World War were identical. The postwar arrangement of Europe which revived the Czechoslovak and Polish independence, has not considerably affected this situation. Natural conditions of both areas are very similar, including mountainous hinterland of the Beskydy Mts. The present state of coal-mining is due to the distribution of coal mines on both sides of the frontier. Long-distance transfer of emission is reversible, nevertheless undesirable. In the boundary agricultural areas a very close cooperation develops in utilization of agricultural products. It is tourism in the boundary areas, and namely mountainous ones /including the Beskydy Mts./ that requires the mutual utilization of the territory. Numerous international transit routes should be also taken into consideration. Let us assume that there is a number of serious reasons for which a very close cooperation in practice, science and research is needed.

Evaluation of areas for the needs of their development is affecting the rational exploitation of natural resources and geographical potential. It requires a specific geographical system approach applying structural, factor, statistic and cartographic analyses together with a final geographical synthesis. That is why the contribution of the Ostrava geography is involved, including a general view of research works on problems of the environment in the Ostrava industrial region.

In 1975, our first significant studies appeared referring to the needs of international COMECON cooperation.

It was a collection of basic materials and statistical data, implemented in the period of 1975-1980. Analyses were directed at gaining a profound knowledge of environment quality in separate components of the natural subsystem, and degradation effects on the socio-economic sphere. Our geographical research had a form of individual partial tasks at the level of basic research with analytical outputs. Apart from the employees of the Department of Geography, it also included biologists and chemists who participated in these works, namely in analysing study areas which were of use for a comparative analysis of the selected sites in places near to, or further from, heavy industry key factories in the Ostrava region. The following factors were evaluated: soil chemism, determination of adsorption capability of floating dust at the selected wood species, and composition of dust component in emissions.

Special attention of the geographical studies was paid to float timber in the Beskydy streams dependent from anthropogenic effects, and to the recreational hinterland of the Ostrava industrial region population, as well as to the recreational needs in a particular environment. This is closely connected with evaluation of anthropogenic terrain forms and their possible utilisation for everyday and short-term recreation. This orientation resulted from the first joint control of evaluation of the Ostrava model region environment. These studies were of use for the Research Institute on Tourism in Bratislava.

The aims and contents of research works of the past five-year plan were increased to a higher level in order to work out a final geographical synthesis. Work was devided into four basic fields. The bioecological field investigated possibilities of bioindication in evaluating ecological changes or even quality of the environment. These changes were indicated by selected groups of insects /beetles and spiders/ in the compared areas from contaminated and relatively non-degraded territories. Simultoneously, occurrence of some metals as components in food chains was determined.

Furthermore, floating dust adsorption capability of grass was investigated with relation to its effects on the decrease in negative impact of dustiness. Of a considerable importance for recultivation were studies concerning successive changes and phytocenoses development which are taking place in sanitary protection zones around metallurgical factories in Ostrava. An attack of SO_2 on the Beskydy forest resulted in large-scale removing of the gradually dying out vegetation which had numerous consequences in this mountainous region. Changes in functions of the Beskydy Mts. forest were involved in the research, too.

The aim of chemical analyses was unique - to find changes in plant pigments affected by SO_2, namely the degradation of chlorophyll and its consequences. Besides this, the chemists worked on an analysis of emissions of the Ostrava metallurgic factories.

A new geographical phenomenon of the Ostrava industrial area atmosphere was discovered - "island of heat" and its movement in the Ostrava basin surrounded by the Beskydy Mts. and the Jeseniky Mts., as well as the impact of polluted air on the Beskydy zone. Furthermore, attention was paid to float timber in the mountain streams of the Beskydy Mts.; simultaneously, the impact of timber cutting on erosional activity and its intensity was evaluated. The socio-economic field had rather a general character. Some difficulties appeared because of some extra changes in administration followed by a great fusion of communities. It was field work that was of biggest importance in this sphere. In the analytical studies on geography of recreation, evaluated were effects of deforestation of mountain slopes and ridges on recreation and development of the tertiary sektor with regard to recreational utilization.

These works were aimed at problems that had not been studied before, which contributed to a better knowledge of particular territorial structures of the Ostrava region.

A new stage of the Ostrava geography has begun in 1986. Our three research program tendencies have appeared to be, nevertheless, thematically interrelated.

The first tendency follows the previous period, i.e. we are reinvolved in the state plan of basic research with relation to the COMECON research task I-3. A group of twenty people of the Pedagogical Faculty of Ostrava is working on tasks concerning again the following four streams of research: bioecological, chemical, physical /atmosphere/ and geographical. The research is directed at prognosis of development of the Ostrava industrial region and requirements for structural changes, mainly in industry.

The second tendency is conditioned by the needs of state administration. The international commitments of Czechoslovakia aim to decrease the degradation effects of emissions. Even the conclusions of the 17th Congress of the Communist Party of Czechoslovakia, dealing also with the environmental problems, set the task to the Peoples´ administration authorities to elaborate a concept of protecting and creating of better environment. The Department of Geography of the Pedagogical Faculty has been invited to participate in this work which is directed by the Commissions of the Regional National Committee and National Committee of Ostrava. Our task is to evaluate the geographical environment in relation to processes concerning the environment itself, e.g. influence of a certain relief, typical climatic conditions, phytocenoses etc., on degradation effects of particular components of the socio-economic sphere. Let us assume that we are going to apply results of our former research works here. We participate in solving tasks settled by the Czech Planning Commission. The solution of these tasks is directed by the Research Institute of Development of Regions, Towns and Cities. Our main field of study is the elaboration of a methodology suitable for evaluating the quality of environmental social processes, including mainly development and structures of education in our region and developmental tendencies in the economic sphere. Once again we are going to make use of our previous results, as well as of results of the mutual international cooperation.

The third tendency is caused by the present aims of cooperation of geographers within the framework of COMECON, directed at the environmental problems in the boundary regions. Already in autumn of 1985, we organized the Czechoslovak-

-Polish Conference on this subject. The geographers from Ostrava and those from Katovice, Krakov, Opole informed each other about their results, judged possibilities of cooperation on problems of the closely interrelated Ostrava region and that of Upper Silesia. Another conference is to take place in Poland in 1987. Relatively good conditions for cooperation are provided by the agreements between the Pedagogical Faculty Ostrava and Silesian University Katovice, including concrete scientific and research tasks.

As regards the survey mentioned above, more intensive and more effective research activities may be expected in the field of the environment. Our share in cooperation within the COMECON I-3 theme is going to increase.

VLADIMIR LUDVIK
Regional Organization for the Development of Technology
Hradec Kralove, CSSR

THE DEVELOPMENT OF ENVIRONMENT IN HRADEC KRALOVE

In the CSSR, in East Bohemia, in the middle part of the river Elbe, a prospective agglomeration is situated. At present, the territory is used intensively for industrial and agricultural production, and Hradec Kralove occupies an important place there. It is, at the same time, the regional city of the East Bohemian Region. Hradec Kralove ranks among the oldest towns in Bohemia. Nowadays it has more than 99 thous. inhabitants and serves as an important transport and industrial centre and seat of educational facilities and institutions of national importance. Because of its traditions, beautiful natural environment, historical monuments and proximity of Giant Mountains and Orlicke Mountains, the city is a popular tourist centre for domestic and foreign visitors.

The Polabska flatland with a plateau on the confluence of the rivers Elbe and Orlice afforded favourable conditions for permanent settlement as soon as at the beginning of our history. A protected settlement point situated on an important commercial transport route linking the Baltic Sea with southern countries and Prague became the centre of the region in the 11th and 12th centuries. In 1225, in the reign of Premysl Otakar I it became a free town.

On the plateau, in the vicinity of the newly built Gothic castle, the fortified town itself grew gradually and in the surrounding flatland the Prazske and Mytske suburbs expanded. Their territory consisted of a rich network of 15 islands between the branches on the two rivers, connected by 18 bridges. In 1298 both suburbs were donated to Hradec Kralove by King Vaclav II, so that at that time the city arose as a united economic and administrative entity.

Till the middle of the 18th century, Hradec Kralove had developed with many fluctuations, similarly to a number of other towns. Its further development was influenced by the fateful decision of Joseph II to change the city - with regard to its strategic position - into a fortress. The construction of the fortress was started in 1766 and extensive suburbs were demolished. The rivers Elbe and Orlice were diverted directly under the ramparts into new beds and numerous branches of the two rivers were filled in. The surrounding terrain was lowered and by means of an ingenious system of sluices and ditches it could be - in case of war danger - inundated up to a distance to 500 m from the fortress. In such case the area was denuded.

The fortress was closed definitely in 1884. In that year the demolition of the ramparts has been started as well. Before starting new construction, an international competition for the first development plan of the city was organized by the city administration. The development plan, set up on the basis of the results of this competition, has been modified several times. The development plans respected, for instance, the previously planted alleys along which communications were proposed. At that time also extensive recreational parks were founded.

An important change occurred in 1928 when a new development plan by Architect Joseph Gocar was approved. This plan still remains in force and is an inspiration. The old city is surrounded by a green belt or water, new districts are divided into five sectors separated by radial green belts. They are connected with the old city by one radial communication. The proposal abandons closed blocks and in new districts half-open blocks are proposed with inner parks. Gocar was first to create a system of green areas which he employs in urban composition.

Another important development plan was proposed by Prof. Bode of the Technical University in Wrocław. This was the first plan dealing with the suburban landscape. It included an important, but not realized proposal to link up the existing forests in the vicinity of the city by means of broad belts of vegetation, i.e. breakwinds, which should improve the urban climate.

After World War II the previous proposals were further elaborated. A green zone along the water flows was proposed, the whole area of the confluency of the two rivers is constituted by a park. At present green areas in the settlements are realized with mixed success, a forest park and a botanic garden are arranged. The suburban forest should gradually be equipped with facilities for short-time recreation.

In the vicinity of Hradec Kralove 12 suburban recreational forests were demarcated. Accessible directly by public transport or on bicycle /10 minutes/, they extend mainly in areas in the eastward, southeastward and southward directions from the city. After building up the recreational facilities /pedestrian paths, cyclist paths, children playgrounds, etc./ these forests will provide both short-term and daily recreation of high quality for all inhabitants. The same role should be played by a number of water basins resulting from industrial extraction of gravel sand. These water basins constitute a suitable recreational environment of sufficient capacity. The main objective is to create a good and easily accessible environment for recreation at a distance of 3 to 5 km from the city; this will help to reduce more distant trips for recreational purposes.

The development of the entire city is aimed at a certain harmony in the relationship between the economic and social conditions and the natural environment. Success in this field is a result of the more than hundred years old tradition of town and country planning /unique in Czechoslovakia/, and also the most distinguished development plan by Architect Gocar. As early as 60 years ago it provided an essential basis for the present image of the city and created the prerequisites for its further development.

suburban forest should gradually be equipped with facilities for short-time recreation.

In the vicinity of Kraków Kraków 12 suburban recreational forests were demarcated. Accessible directly by public transport or on bicycle /30 minutes/, they extend mainly in areas in the northwardly, southeastward and southward directions from the city. After building up the recreational facilities /footpaths, cyclist paths, children playgrounds, etc./ these forests will provide both short-term and daily recreation of high quality for all inhabitants. The same role should be played by a number of water basins resulting from industrial extraction of gravel sand. These water basins, situated in a suitable recreational environment of sufficient capacity. The main objective is to ensure a good and easily accessible green areas for recreation at a distance of 3 to 5 km from the city. This will help to reduce also distant trips for recreational purposes.

The development of the entire city is aimed at a certain harmony in the relationship between the economic and social conditions and the natural environment. Success in this field is a result of the more than hundred years old tradition of town and country planning /origin in the nineteenth century/, but also the most modern-minded development plan by Architect Tomaszewski as early as 20 years ago it provided all essential bases for the present image of the city and created the preconditions for its further development.

HELMUT HERRMANN, FRIEDER LEISTNER
Institute of Geography and Geoecology AS GDR
Leipzig, GDR

ANALYSIS OF CHANGES IN THE LAND USE OF METROPOLITAN AREAS AND CONSEQUENCES FOR REGIONAL DEVELOPMENT PLANNING

1. Background of the problem

In an article in Izvestija, Serija geografija in 1973, MINC and PETRJAKOVA /1/ wrote on the utilization of territory as a geographical problem, and demonstrated convincingly the great significance of geographical investigations into these problems for the management and optimization of spatial organization of the production.

Such investigations are of special importance in densely populated and highly industrialized areas, as for instance the metropolitan areas of the GDR situated mainly in agglomeration areas. They are characterized by a high dynamics of economy since they are influenced by the scientific-technical progress. They are centres of investment, significant for the improvement of working and living conditions. Here overlapping functions accumulate, ecological problems arise, and the area becomes a limiting factor of regional development. Often the space demands for housing construction, industrial development, recreation and environmental improvement, agriculture or even mining, conflict with one another so that urgently needed are scientifically founded decisions in the interest of the whole society.

In 1982 these problems were also dealt with by SAVCHENKO /2/. On the example of land-use changes in Moscow from 1920 until 1980, he developed the idea of a conceptional model of evolution for analysing of the influence of driving forces the handling of which requires an automatic system of calculated planning for the area utilization.

This is an interesting and bold project which will be realized probably only step by step and on a long-term basis. Effective results can be achieved surely by a more simple approach, as pointed out in short in the following paper.

It deals with land-use studies in the metropolitan area of Leipzig, with the following tasks to be accomplished as a start:

- Definition of major area-related problems with regard to their content;
- Elaboration of a methodical basis for data acquisition, storage and processing;
- Finding out the most suitable forms for a better inclusion of land use in the national economic planning system.

In doing this, problems of territorial economy, town planning, urban ecology, and geography should be combined in a suitable way with problems of branches and sections.

1.1. The problems and their definition of content

In order to be able to investigate the general development problems of a metropolitan area as a special type of region with regard to its space requirement and physical structure, the following is necessary:

1/ delimitation of area and spatial structure;

2/ determination of major social functions related to area consumption in the past, present and future;

3/ survey of land-use changes of the past, assessing of the present state and of future development trends /of demands by society/;

4/ elaboration of a practical assessment concept for the creation of rational land--use structures in metropolitan areas.

In investigating of the concrete problems of the metropolitan region of Leipzig the above-mentioned four tasks have been treated so far with differing intensity.

Some problems shall be examined more closely, concerning data colleting and processing which are an important prerequite for the analysis of land-use changes, and in the long run for a better consideration of land use in the national economic planning system, particularly for territorial planning. This requires taking into consideration the above-mentioned spatial delimitation of the metropolitan region, essential social functions, and land-use changes in the past.

2. Survey of land-use changes - methodological approaches and model studies in the metropolitan region of Leipzig.

Maps are a data basis of paramount importance in the investigation of land-use structures and their changes in particular topographic maps, but also certain thematic maps. The role of maps is emphasized by the fact that any planning decision relating to an area as a resource must be based on functionally and physically differentiated characteristics of land-use structure and its development.

For the collection and processing of land-use data the grid method was selected. All data registered refer to the same part of the area. As to form, squares are most suitable for data acquisition. They can be divided into equal parts or combined with neighbouring squares. The size of the squares is dependent upon the degree of sophistication of the geographical phenomena and objects involved,as well as of the form of data storage used. Particularly when recording changes and dynamics of land-use structures, the grid method is of great methodical advantage compared with data collection by definite areas:

- Better possibilities for the quantification of land-use structures and general and specific changes of land use.
- Various possibilities of data analysis, interpretation and synthesis.
- Good possibilities for the application of computer-aided processing and interpretation procedures, i.e. collection and storage of large amounts of data, quick detection of land-use development trends by repeated comparing.

For the determination of land-use changes in the metropolitan region of Leipzig four periods were chosen /1910, 1930, 1960, 1978/ which resulted mainly from certain phases of regional development but also from the availability of maps. Topographical maps on the scales of 1 : 25,000 and 1 : 50,000, partly also 1 : 10,000, were taken as a basis for the survey of land-use structures, in particular in the analysis of built-up inner-city areas. For the functional assignment of areas, legend units were defined on the basis of the functions of living, industrial production, agriculture, forestry, recreation, waste disposal, transport. These functions were registered in squares of 250 x 250 m, using the principle of prevailing utilization, and stored in four different land-use data files.

Available are first analytical findings on the development of land-use structure in the metropolitan region of Leipzig in the period between 1910 and 1980. They confirm major basic trends found also in other industrial agglomerations, and documented in international literature.

In a greatly simplified form, the metropolitan region of Leipzig comprises the administrative areas of Leipzig city and Leipzig country covering 588 sq.km and 700,000 inhabitants.

The following changes are prominent:

1. A distinct decrease in farmland from 76 per cent to 54 per cent of the whole metropolitan region in favour of housing, industrial and recreation areas, as well as by the development of brown-coal mining chiefly in the past 20 to 30 years;
2. As a consequence of this, a distinct increase in housing, industrial and traffic areas, the share of which doubled between 1910 and 1980; it is an expression of the increasing urbanization of the hinterland of /the town of/ Leipzig;
3. An overproportional increase in mining areas chiefly since 1960 in connection with the development of brown-coal mining /from 1.4 per cent to 4.8 per cent of the entire area/ to the disadvantage of farmland and forest areas. It is a specific feature of the metropolitan region of Leipzig that open-pit mines extend immediately up to the built-up fringe of the town;
4. A double increase in recreation areas /parks, allotment gardens, sports grounds/ in the period from 1910 to 1930; these areas decreased until 1960 and has shown a slight downward tendency since then. In this connection there has been a strong trend of transformating the recreation areas into housing areas /about 25 percent/ which, however, war more than compensated by the transformation of farmland into recreation areas;
5. A strong development of horticultural areas chiefly on the fringe of the town.
6. A decrease in forest areas caused mainly by brown-coal mining.
7. A distinct increase in water bodies and other areas /wasteland, barren land/ also in close connection with the development of mining areas.
8. An increase in areas of agricultural cultivation /chiefly fodder crops for animal production/ between 1960 and 1980 as a result of the use of industrial methods of production in agriculture.

Tables 1 and 2 give a survey of the total development of the land-use structure of the metropolitan region of Leipzig. But all this is only a retrospective view of things. The following are the more important problems:

- A survey of actual land-use change by the help of a coordinated system of data collection through remote sensing /if possible with automatic image processing/, the land register of the real-estate agency as well as other special information in order to be able to monitor all land-use processes going on in a territory, and
- Monitoring and evaluation of current development as a basis for the control of undesired negative developments and a constant improvement of the land-use structure of a territory. /In this sense changes already ascertained are assessed chiefly by qualitative characteristics/.

3. Ideas for a better consideration of land use in regional development planning.

In the GDR at present the control of utilization and protection of areas is shared by several authorities, and with regard to area consumption such control is incomplete. Furthermore, the principles and aims of the present statistical registration and documentation of land use is little suited for our task. Official statistics record mainly land use by agriculture and forestry, whereas built-up and other areas can hardly be differentiated. Cartographic documention of land-use in territorial planning are incomplete and are done largely by traditional technologies and techniques. This makes it more difficult to register land-use changes and to store and process respective data by computer. Therefore, in the development of methodological foundations for the analysis of land use changes, it is important to find possibilities for the development of planning instruments and for the computer-aided collection and processing of land-use data.

Here the grid method could be an important link in the development of a computer-aided-multi-stage land register for planning purposes, with the documentation of land use as an integral part of it. At the same time this method helps to improve the management and coordination of the application of maps in territorial planning.

Together with the computer-aided land-register, surveys of land-use areas /including overlapping functions/ are regarded an essential planning instrument for controlling the utilization of territory chiefly in a quantitative way through five-year-plans and one-year plans.

The qualitative side, however, will have to be considered more through the long- and medium-term management of the land-use structure, i.e. through land--use maps incorporated in confirmed regional development conceptions /usually for administrative districts/ and general development plans for towns.

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Table 1. Survey of development of the land-use structure in the metropolitan region of Leipzig /in sq.km/

	1910	1930	1960	1978
Farmland	447,44 /76,1%/	404,76 /68,8%/	355,70 /60,4%/	319,06 /54,3%/
Housing area /incl. mixed areas/	51,00 /8,7%/	62,87 /10,7%/	92,93 /15,8%/	97,69 /16,6%/
Recreation area /incl. allotment gardens but without forests/	21,26 /3,6%/	45,69 /7,8%/	51,57 /8,8%/	47,75 /8,1%/
Forests	40,56 /6,9%/	38,88 /6,6%/	37,44 /6,4%/	34,26 /5,8%/
Mining area	4,94 /0,85%/	2,44 /0,4%/	8,32 /1,4%/	28,12 /4,8%/
Industrial area	11,38 /1,9%/	15,63 /2,7%/	18,89 /3,2%/	22,88 /3,9%/
Traffic area	4,94 /0,85%/	7,06 /1,2%/	6,94 /1,2%/	10,63 /1,8%/
Market gardens	2,31 /0,4%/	4,00 /0,7%/	6,88 /1,2%/	9,88 /1,7%/
Water bodies	0,94 /0,7%/	3,00 /0,5%/	2,88 /0,5%/	4,63 /0,8%/
Agricultural production plants	0,13 /0%/	0,19 /0,%/	1,38 /0,2%/	4,38 /0,7%/
Other areas	3,10 /0,5%/	3,48 /0,6%/	5,07 /0,9%/	8,72 /1,5%/
	588,0	588,0	588,0	588,0

Table 2. Changes of land-use structure in the metropolitan region of Leipzig /in sq.km/

	1910	1930	1960	1978
Housing area	51,00	62,87	92,93	97,69
	+ 7,75 farmland + 2,87 recreation area + 0,75 industrial area	+ 18,45 farmland + 10,94 recreation area + 0,63 industrial area	+ 4,25 recreation area + 2,06 farmland - 1,50 mining area	
Industrial area	11,38	15,63	18,89	22,88
	+ 5,50 farmland - 0,75 housing area	+ 2,62 farmland + 1,19 recreation area - 0,63 housing area	+ 2,94 farmland + 0,81 recreation area	
Forests	40,56	38,88	37,44	34,26
	+ 1,19 farmland - 1,25 farmland - 1,06 recreation area	+ 2,82 farmland - 2,00 mining area - 1,94 farmland	+ 1,00 farmland - 2,25 mining area - 1,44 farmland	
Recreation area	21,26	45,69	51,57	47,75
	+ 24,81 farmland + 1,06 forests + 0,75 mining area - 2,87 housing area	+ 17,25 farmland - 10,94 housing area - 1,19 industrial area	+ 2,19 farmland - 4,25 housing area - 0,81 industrial area - 0,56 mining area	
Farmland	447,44	404,76	355,70	319,06
	+ 1,25 mining area + 1,25 forests + 0,57 other areas - 24,94 recreation area - 7.75 housing area - 5,44 industrial area - 2,06 market gardens	+ 1,94 forests + 1,44 recreation area + 1,13 other areas - 18,68 recreation area - 18,44 housing area - 4,68 mining area - 2,62 forests	+ 1,62 mining area + 1,44 forests + 1,37 housing area + 0,81 recreation area - 19,32 mining area - 3,75 traffic area - 3,44 housing area	

Table 2, contd.

	- 1,50 water bodies - 1,75 traffic area - 1,19 forests - 1,19 mining area	- 2,56 market gardens - 2,56 industrial area - 2,06 other areas - 1,06 agricultural areas - 0,38 traffic area - 0,25 water bodies	- 3,00 market gardens - 3,00 recreation area - 2,94 industrial area - 2,82 agricultural areas - 2,06 other areas - 1,00 forests - 0,56 water bodies	
Market gardens	2,31	4.00	6,88	9,88
	+ 2,31 farmland - 0,31 recreation area - 0,25 farmland	+ 3,06 farmland + 0,63 recreation area - 0,50 farmland - 0,50 recreation area	+ 3,44 farmland - 0,44 farmland	
Traffic area	4,94	7,06	6,94	10,63
	+ 1,75 farmland + 0,25 industrial area	+ 0,31 farmland - 0,25 industrial area - 0,13 housing area	+ 3,75 farmland	
Mining area	4,94	2,44	8,32	28,12
	+ 1,19 farmland - 1,31 other areas - 1,25 farmland - 0,75 recreation area	+ 4,68 farmland + 2,00 forests - 0,63 other areas	+ 19,32 farmland + 1,50 housing area + 2,88 forests + 0,94 recreation area - 2,00 other areas - 1,63 farmland - 1,38 water bodies	
Water bodies	0,94	3,00	2,88	4,63
	+ 1,50 farmland + 0,25 forests + 0,19 mining area	+ 0,31 farmland - 0,38 forests	+ 1,38 mining area + 0,57 farmland - 0,31 mining area	

Table 2, contd

Agricultural areas	013	0,19	1,38	4,38
	+ 0,06 recreation area	+ 1,06 farmland + 0,13 housing area	+ 2,82 farmland + 0,13 recreation area	
Other areas	3,13	3,50	5,06	8,75
	+ 1,31 mining area + 0,88 farmland - 1,44 farmland - 0,37 recreation area	+ 2,06 farmland + 0,62 mining area + 0,25 housing area - 1,13 farmland - 0,44 recreation area	+ 2,06 farmland + 2,00 mining area + 0,62 forests - 0,50 farmland - 0,50 mining area	

JÜRGEN BREUSTE
Martin-Luther-University of Halle
Section of Geography
Halle /Salle/, GDR

PROBLEMS OF INVESTIGATION AND EVALUATION OF THE URBAN LANDSCAPE STRUCTURE

I. Introduction

In the highly developed industrial countries, towns are considered to be the best organized and most effective kinds of settlement, built up by people for their continuous reproduction /Bönisch et al. 1976, p. 239/. The worldwide growth of towns, the recently increasing process of urbanization and considerable transformations of natural conditions in towns, causing a lot of new problems for their inhabitants, let towns become a subject of investigation also in natural science. The investigations in different disciplines, from different theoretical and methodical positions, all have the same target of improving towns as landscape, ecosystem and habitat of people, or of creating preconditions for it. The conditions of socialist production allows the effective control of this process; however, at present it is still not without some contradictions.

The current development of large urban agglomerations, the world-wide spread of urban forms of life, new environment-influencing technologies with important, far-reaching effects, have varied and formed natural conditions in the city as never before /Detwyler, Markus 1972/. Nowadays, under such qualitatively new environmental conditions, a lot of people are living in large towns, not only in highly developed industrial states.

Such attractive slogans used in the West European literature as "The city in the ecocrisis" /Miess 1975/, or even the comparison of a town with the uncontrolled growth of a "carcinoma with its metastases" /Jonas 1962, p. 15/ show that there are alarmingly many open environmental problems, and that they are also an expression of resign to the apparently uncontrollable phenomenon "of town".

In the last years special research programmes have been elaborated, and institutes and teams began to work all over the world in order to investigate these special problems and to draw conclusions from the results for planning and forming of towns. In spite of the expanding knowledge and experience, till now scientific knowledge can hardly be applied to practical investigations and to town planning. Our country is here no exception.

2. Urban ecology - a complex of special efforts

"Ecological" concepts arising recently all over the world brought about such terms as "settlement ecology", "village ecology" and "town ecology", which have not always been applied sensibly. Often traditional concepts of investigation as, for instance, the settlement or town planning hygiene /Petzoldt, Rostock 1980/ or the town climate research /Kratzer 1966/ are summed up in town ecology. Thus it turns out that the term "ecology" is rather worn out /Müller 1978/.

The whole range of contents of "town ecology" reaches from the description of social and physical structures of town, natural scientific investigations from different points of view, common man-environment problems on example of the town, up to the "town-ecological" explanation of the social bahaviour, for instance, criminality of its inhabitants. The term "town ecology" came into use since the study of Park, Burgess and McKenzie /1925/, above all in Anglo-American countries used synonymously with "social ecology". Another common characteristic of town ecology is the application of ecological rules and methods to special conditions of the urban habitat /Klausnotzer 1981/. Accordingly, town ecology is the "ecology of organisms, populations and ecosystems in towns and agglomerations, i.e. the science of town as a great dependent ecosystem" /Schaefer, Tischler 1983, p. 254/. Therefore, town ecology is not an "ecology of man" and cannot be only oriented to the "ecophysiology", i.e. to man.

Town ecology is an interdisciplinary subject. Biology, physical geography /biological and climatic geography, landscape ecology, geomorphology/, geology, meteorology, hydrology, pedology, chemistry geomedicine, science of engineering and landscape cultivation can make some contributions /Eriksen 1983, 1984; Adam 1985/. Themes worked out by town-ecological branches are quite different. Nowadays, town ecology investigates a wide range of problems reaching from the basic bio-ecological research, for instance, surveys on the behaviour, occurence, loading and maximum stress of special species and communities in urban environment over the researches on material and energetical inter-relations in urban ecosystems, the social and natural relations in urban ecosystems, the social and natural relations between man and environment, up to landscape ecology /applied landscape research/.

3. Contents, tasks and aims of urban landscape ecology

Landscapes can be regarded as a chronologically orientated system of the earth surface determined by a characteristic relation of natural features, and its historical and actual integration into the social process of reproduction. That is why landscape is not ending on the edge of settlements. The special characteristics of the town landscape, however, are that here man most intensively plans and forms the natural conditions and features, including the newly built technical plants for use in a special way. The anthropogenous influence concerns all landscape components in their material and territorial structure. The landscape ecology, comprehensively investigating and evaluating the natural structure of characteristics, the territorial peculiarities and processes of landscapes, is in the town unrelated to unused natural features, but to completely new material and territorial structures. Here its task is to investigate the structure of characteristics and territory, arising from inter-relations between natural landscape and social reproduction, and to investigate the secondary processes connected with them, which determine the development of structure on the given area and its components. Thus, on the one hand, traditional working instruments of the non-urban landscape ecology can be applied, but on the other hand new experience with important landscape characteristics, processes and territorial structures in towns must be attained. Therefore, basic research are needed on single landscape components and their relationships, as well as on the territorial classification of landscape and of the structure.

Investigating the territorial structure of ecological functions on different levels of hierarchy is the main task of landscape ecological research in the town /Richter 1984, Kaerkes 1985/. This research should be perfomed with regard to landscape planning and town planning. Its main tasks are:

1/ territorial registration of natural anthropogenic changes and technical components,
2/ classification of urban landscapes and their structural and territorial characterization,
3/ evaluation of characteristics and territorial structures regarding the anthropogenic modification of elements and processes in the town landscape, or special planning problems,
4/ elaboration of recommendations for the land cultural shaping in regional units, or structures of town relevant to planning, on the basis of the obtained data and values.

4. Analysis of urban landscape structure

4.1. Theoretical and methodical foundations

The dynamic influence of man on urban landscape brings about a special state of landscape. Similarly, the uninfluenced landscape is characterized by some peculiarities and a natural succession of vegetational structures, i.e. the condition of urban landscape is the result of original and historically developed natural conditions, and of the recent processes of the landscape use for social reproduction. This process is often called land use or "Flächennutzung" /Kröhnert et. al., 1985, p.12/. Thus including landscape in the social process of reproduction, a discrimination should be made between the result of anthropogeneous effects, the existing conditions of the landscape on the one hand, and the social functions fulfilled by certain landscape sectors on the other. While the structure is of a more static nature, the function is of a more dynamic character, but both form a dialectic unit /Walossek 1980/; however, that does not mean that areas of equal function /utilization/ have also an equal structure.

The territorial organization of the process of social reproduction divides landscape into areas with equal social functions. The existing condition of landscape can be regarded as the totality of landscape objects and their natural and technical territorial structure /Richter 1984/. Such territorial objects in the town are urban landscape /structure/ elements /see tab. 1/. They are mostly represented by their plan area and defined by their characteristics. For the typification such characteristics should be selected, which are of certain importance for the regional, i.e. ecological, hydrological, climatic, etc., functions of the landscape; for the type, intensity and duration of anthropogenic influence; and for the structure of landscape

/see also Niemann 1982/. The specialist who chooses those characteristics determining the condition of the landscape or its regional elements has a great subjective influence on this choice. Observing and determining the infinite diversity of characteristics cannot be the aim of landscape research; on the contrary, what matters is whether you are able to choose characteristics typical for the given landscape structure and its landscape functions.

Urban landscape elements as structural basic units of town landscape /Haase, Richter 1980/ can be defined above all by characteristics of vegetational structure, technically formed soil surfaces and buildings. Soil structures and their characteristics seem to be relatively independent from those units. They are heavily influenced by people, and that is why they cannot always affect decisively the above-mentioned structures.

4.2. Definition of characteristics

4.2.1. Urban landscape elements

After working out a catalogue of characteristics and types, a large-scale /1:1 000/1:2 000/ cartographical registration of the urban landscape elements or a quantitative documentation of characteristics determining them /i.e. area units/ ought to be carried out, in order to evaluate the landscape or to recommend its planning.

One of the most important characteristics of buildings is their height being of special importance for the structuralization and shading of the neighbouring free spaces. The analysis of free spaces dominating nearly everywhere, even on the built-up areas in towns, is of great meaning, too. There are surfaces covered by plants, and paved or unpaved surfaces without any vegetation, which can be distinguished by the type of surface and its permeability.

As one of the urgent aims of town landscape planning is the long-term planning and widening of the given vegetational areas and forests fulfilling important ecological and environmental functions; it becomes especially necessary to registrate them. The typification of vegetational structures is based on characteristics of the vegetation layers, of human influence, utilization of the natural landscape and typical habitat conditions.

Counting trees outside forests and the classification of these areas by means of structural characteristics is a further task for urban landscape and ecological research. Trees in towns are not only considered to be the most aesthetic part of urban vegetation, but also the most important elements of landscape architecture. The protection and enlargement of the afforested areas is one of the main tasks of ecological and landscape town planning. Understanding the great meaning of trees in towns, many town councils have issued tree protection decrees /as, for instance in 1983 the "three protection decree in the G.D.R." or the "tree protection decree" in Halle/. However, they can be consequently put into effect only then when one has a wide knowledge about trees. From that results the urgent task of counting all trees in a town, for they represent an important part of urban landscape and vegetation.

Apart from information about species and habitat, scientists gather dendrometric data /diameter of the trunk at the height of breast, height of the tree, diameter of its crown/. These data help to estimate the ecological function and the age of trees. Determining these data is expensive, but just as necessary as calculating the surface of areas covered with vegetation.

Another characteristic already based on evalution should be the vitality /degree of damage/ of trees determined by the visual damage picture /Heinrich, Klotz 1980; Kenneweg 1973/.

4.2.2. Soils

Because of the manifold ecological and other functions of soils, a lot of information about urban soil conditions is required in order to carry out landscape and ecological analysee and planning. With the exception of foundation-soil maps, hardly any soil maps of urban areas have been made.

It has turned out to be very profitable for mapping urban soils to classify soil and to name them after the soil types and the typical properties and layers of their substrate /Blume 1982/. Neighbouring soils, which form a functional unit, can be integrated to certain soil groups, which can be specified after the given soils /Böcker et al., 1985/. Mostly the original soils have been substituted by completly new ones, which, however, can still include natural soils, as a result of former and present land use.

It seems to be important to distinguish between natural soils, i.e. soils of a natural pedo- and lithogenesis and anthropogenic soils /so-called cultosoles/. The latter are soils of morphological character, differing from those of natural soils as a result of anthropogenic influences, modified pedogenesis /Runge 1975; Billwitz, Breuste 1980/.

Among the anthropogenic soils the following classes may be distinguished:

1/ anthropogenic soils with a modified soil structure - anthropogenic pedogenesis /for instance regosoles, hortisoles etc./,

2/ anthropogenic soils on anthropogenic covers of natural accumulation substrates - accumulation soils, anthropogenic pedo- and lithogenesis

a. loose sandy, slack, gravel or stone material

b. loose loam material,

3/ anthropogenic soils on anthropogenic covers with several natural and artificial substrates /"loose anthropogenic stones"/ with a big part of skeleton - "ruderal soils" both as accumulation and in situ with an anthropogenic pedo- and lithogenesis.

The above classification of soils reflects the degree of sealing of the soil surface,the type of dominant and typical utilization of soils, and concrete local transformations in the soil structure.

4.2.3. Landscape and ecological structure of the town

The qualitative and quantitative definition of landscape ecosystems of the town, as well as the recognition, description and evaluation of the territorial distribution patterns of ecological data, are the main tasks of the landscape and ecological research in towns.

The landscape and ecological conditions of the town which greatly differ from the surroundings, are generally determined by the type of land use. Characteristics of land use overlay and modify the natural conditions /soil, climate, vegetation/. On the other hand, the real conditions of land use determine all the measures of protection development and management.

The landscape and ecological structure of the town on a medium level of hierarchic arrangement makes the connection between function and structure evident. Areas with a certain function such as, for instance, industrial areas, are clearly differing from other functional areas, like, for example, residential areas, with respect to their landscape and ecological structure /i.e. their urban landscape elements/. Here different functions cause different structures. However, this correlation is not so close that one could a priori refer the real structure of landscape elements from the function of land use. Nevertheless, certain functional areas are characterized by typical urban elements. This makes it possible to determine the landscape and ecological structure by functions of the land used in its widest sense. Therefore, both combinations of functionally similar areas and a strong differentiation of functionally homogeneous areas of the land use are needed, especially as for the structure, age etc. of the built-up areas. Above all, structures of built-up areas often have typical landscape and ecological features.

That means that landscape and ecological units of the town are obviously intensely influenced by man /for instance, built-up/. This concerns both the content of the characteristics and their differentiation /Schulte 1985/. They may be regarded from a functional point of view, as used land complexes, or from the landscape-ecological and structural point of view, as a complex of urban landscape /structure/ elements /see fig.1/. This should be also remembered if a name based on the function of the area complex is to be used /Klotz et. al., 1984; Breuste 1985/. On the town outskirts, which are less influenced by man, other characteristics of natural conditions become more important as distinctive marks of the regional landscape and ecological units, for instance: land relief, vegetational structure /Schanda 1983/.

Unlike in the landscape structure outside of the town, in the city a total homogeneity of all the ecological features of the landscape and ecological unites cannot be expected. The human influence connected with urban functions typical for settlements cause a greater inner heterogeneity of the landscape elements than in comparable regional units outside of the town /Richter 1984/.

4.2.4. Documentation of urban landscape characteristics

The documentation of landscape characteristics is important not only for large-scale detailed maps, but also for certain medium-scaled map complexes of towns. Therefore, scientists have already drawn up complete thematical maps of the landscape-ecological structure of towns /Böcker et. al., 1985/ and maps of single landscape factors /for instance soils - Blume 1982 , see also Schönfelder 1986/.

If large-scale landscape data are to be useful for balancing, calculating parameters of areas and for evaluating area of whole towns in a sufficient quantification, then large-scale mapping is not sufficiant anymore. Computerized information systems have already become research, documentation and planning instruments for controlling and making prognoses of the development of given areas and the condition of their environment. In connection with research performed in 1986 on district and country towns of the GDR , the "Investigation for Cartographical support of the computerized information systems /CIS/ of the City of Dresden ...." /Fiedler 1986/ has been carried out by the Section of Geodesy and Cartography at the Technical University of Dresden.

In order to create comprehensive town information systems, more and more data files are being compiled, containing information about open spaces and green plots, ecological information and landscape data. These data files are often forming autonomous information systems. Urban data files are becoming of increasing importance, too, for geographical research, landscape ecological analysis and evaluation. This is above all a consequence of extensive urban-ecological research and data collection in several disciplines. Because of their great vividness beside lists and tables, particularly graphas, printer and plotter maps are in use. Many of the maps allow the processing of a lot of data, tying them together and modelling them cartographically. These advantages can be used only with the help of electronic data-processing and automatical output of area cartogrammes.

5. Ecological evaluation of urban landscape structure

5.1. Structural indices and their evaluation

Demands for quantitative ecological data of town areas can at present be fulfilled only unsufficiently. Cartographical registration and computerized storage of town landscape characteristics open up manifold possibilities of quantification, calculation and polyfunctional evaluation of statistical data according to the needs, for instance, of planning. Statistical data and values may be defined for different areas and processed by electronic data-processing devices, if the data needed are stored, for instance, by rasters. Statistical data can be such typical indication of areas as, for instance, the share of

a. vegetation areas
b. unsealed vegetationless soil surfaces
c. sealed open spaces
d. built-up areas
e. /= c + d/ sealed areas
f. /= a + b + c/ open spaces

in the total area or the open spaces of a given reference unit. They can be exactly defined and - if necessary - classified with the help of landscape characteristics. Urban landscape research has not only to find such structure indices, but also to evaluate the landscape functions. This helps to make decisions on special measures of planning, care and development. Collecting landscape and environmental data and their statistical processing are not sufficient to make statements for planning and practical work /Billwitz 1979/. The evaluation of the given conditions and possible effects of a modification of these conditions play a very important part in the process of planning and decision making.

While evaluating the urban landscape or environment, above all the following features should be distinguished:

1. The evaluation of functions within the process of social reproduction and of their effects /on people, on other functions/.
2. The evaluation of landscape structures with respect to landscape processes and investigated functions.
3. The evaluation of the situation, dimension, equipment and neighbourhood of partial regions, in order to recommend or interdict some special measures.

Similar ecological characteristics must be evaluated very differently, dependening on the given conditions.

The main criteria of evaluation in urban regions may be as follows:

1. Loads or irreversible changes in the environment must be avoided.
2. The multiform landscape ecosystems must be protected in order to preserve their ability of regeneration and selfregulation.

In order to register and evaluate elements and processes of urban landscape ecosystems in the easiest possible way, one must especially intensively study the indices. There are many function-oriented possibilities depending on the given area indices /as, for instance, ecological functions, hydrological functions, urban sanitary functions, social and recreation functions, etc/.

The hemerobic scale for determining the degree of anthropogenic influence has proved to be a well-fit methodical aid of bioindication for characterizing the degree of human influence on landscape /Klotz 1985/. The hemerobic concept has been applied on urban areas, too. On the one hand, it helps to evaluate the types of utilization complexes /Luder 1980, Kunick 1982 , see tab. 2/; on the other hand different urban landscape elements can be related to some hemerobic values, too

/Bornkamm 1980/.

By comparing the hemerobic values with the share of their area to a randomly selected reference unit, the Index of Ecological Value /IEV/ can be calculated after Buckley Forbes 1979 and Klotz 1985, being an exact ecological standard of assessment:

$$IEV = \sum_{i=1}^{n} W_n \cdot E_n ;$$

where:

W = the degree of hemeroby /unhemerobical = 7 .....,
metahemerobical = 1/

E = the territorial share of the single degree of hemeroby in the total area of the given reference unit /1 = 100 per cent/.

The cartographical illustration can be performed both by grids of square rasters, and by landscape and ecological units or other reference areas.

After Witting and Schreiber 1983, Mohrmann et al. 1984 and Schulte and Marks 1985, urban landscape units can be classified by their bioecological features and structure with respect to the habitat value, to the necessity of protection corresponding with a given urban nature protection plan, and to its value within a vegetation area net system. In order to calculate the values of the single unit characteristics, ecological interweaving matrices of the given single value classes can be applied. Equal-ranged classification criteria, i.e. intensity of utilization and care, size of vegetation areas, degree of their isolation, can be aggregated, and their total value can be represented for planning needs /see tab. 3/.

Summary

With the constantly progressing urbanization of towns and the great changes taking place in natural structure and processes, urban ecology became a field of scientific and social research. The landscape ecology of towns, if it is oriented into territorial registration of landscape characteristics, their regional structure and classification after the different functions and aspects, cannot only be a subject of basic research, but also take part in working out recommendations for a planned shaping of the urban landscape. The great number of data needed for large scale maps of the landscape condition and structure, i.e. urban elements, may be analyzed, and the urban landscape can be mapped thematically or

documented in a computerized information system /CIS/, thus connecting and classifying them thematically and regionally and making them available to planning in the town.

The calculation of landscape-structural parameters and the special classification of landscape data with respect to the manifold natural environment are of great meaning for the protection of plants and animals and their habitats also in the town. The application of landscape-ecological knowledge and right planning decisions can be expected only then, if the actual problems are recognized and if the landscape and ecological research investigates the town from many points of view and delivers results ready for application. Thus scientific research is often in a promising way connected with practice.

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Table 1. Landscape elements as urban structural units /Breuste 1987/

Types:

1. Vegetation covers

1.1. grass- and shrubland

zR	lawn, intensively cultivated, without trampling
R	lawn, intensively used, trampling
aR	grassland with fruit trees
oR	trampling grassland, vegetation cover destroyed, with gaps
bR	ruderal grassland with fruit-trees
rR	ruderal grass- and shrub-areas with complete ground covering
lR	ruderal grass- and shrub-areas with incomplete ground covering
nR	wetland
wR	meadows and pastures
xR	xerothermic and semixerothermic grassland

1.2. Bushland

kS	small bushes with complete ground covering
gS/sS	horticultural well-kept bushland
rS/vS	neglected and spontaneous ruderal bushland
nS/gS	river-bank- and shore-bushland
fS/uS	wetland-bushes

1.3. Small woods /more than 40% shadowed, more than 10 cm stem diameter in breast height, minimum area 200 m^2/

sB	with horticultural well-kept underwood
bB	of cemeteries
rB	with spontaneous respectively ruderalized underwood or afforestation
gB	with lawn in the bottom
kB	with ruderal herbs
vB	with compact covered soil surface

1.4. Woods and forest grounds

aW	riverside woods
xW	woods outside of riversides
fW	forests in natural sites
sW	forests in special sites

1.5. Horticultural well-kept grounds

zG	with ornamental plants
nG/oG	with useful plants/with useful plants with fruit-trees
hG/bG	allotments near the house / with fruit-trees
fG	of cemeteries
kG/sG	allotments/ with old fruit-trees

1.6. Farmland, fields, arable land /L/

c.d. table 1

2. Open spaces without vegetation or with strong disturbed vegetation

bF covered with crushed rock or shippings
sF covered with dust
vF uncovered compressed soil-surfaces
lF rocks

3. Covered areas

A asphalt
B concrete
P pavement with stones

4. Built-up areas /hight in m/

1 under 2 m
2 2 - 5 m
3 5 - 10 m
4 10 - 15 m
5 15 - 20 m
6 20 - 40 m
7 over 40 m

U Areas with changing land use form

Table 2. Intensity of anthropogeneous influence on urban landscape /hemerobic concept/ /after Bornkamm 1980, Luder 1980, Kunick 1982, Breuste 1987/ - examples.

Hemerobic degree	Urban landscape units	Urban landscape elements
metahemerobic	closed built-up residential areas, industrial areas, traffic areas	covered with asphalt and concrete areas, ground areas of buildings
polyhemerobic	half-open built-up residential areas, railway lines, single houses areas, waste areas	compressed soil surfaces without vegetation
- euhemerobic	fields, arable land, gardens, graveyards	young ruderal grass- and shrub-areas
- euhemerobic	parks and green spaces	meadows, pastures, elder ruderal grassland

Table 3. Habitat evaluation of types of urban landscape units /examples of residential areas/ /see also Mohrmann et al. 1984, Schulte and Marks 1985/.

	Closed built-up areas before 1918	Blocks of flats constructed between 1918 and 1940 with park trees
/steps: 1=less, 2=more, 3=much/		
A intensity of use and human impact	3	2
B sealed-up degree	3	2
C biotic structural differences	1	2
D habitat potential	1	2

method of increasing the degree of habitat potential /D/

		A 1	2	3
B	1	1	2	3
	2	2	2	3
	3	3	3	3

	D	A/B 1	2	3
C	1	1	2	3
	2	2	2	3
	3	3	3	3

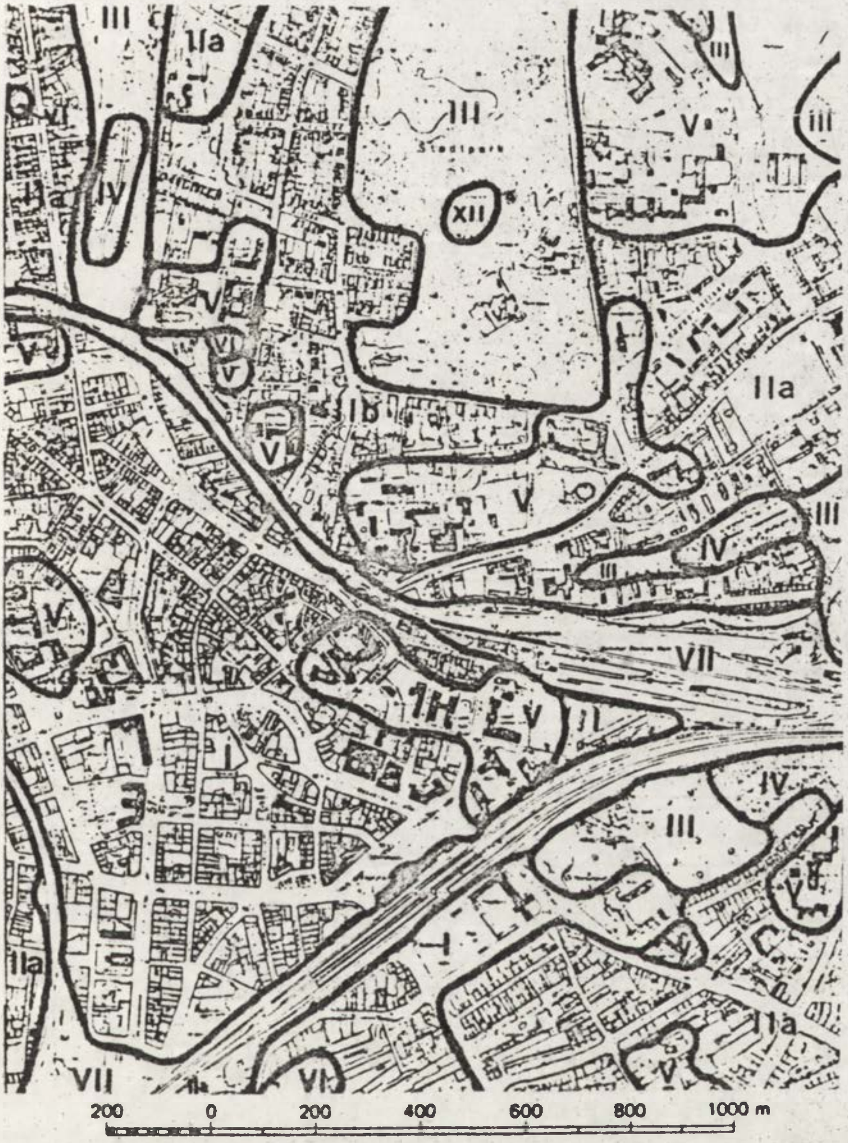

Fig. 1 Examples of possible urban landscape units in the city of Bochum /FRG/ /Schulte 1985/
I - closed built-up inner city, IIa - mixed built-up areas / different types/, IIb - one-family housing, III - parks and green spaces, IV - gardens, V - special areas of different types: hospitals, public buildings and their free spaces, VI - vacant land, VII - railway lines, VIII - industrial areas, IX - villages, X - fields, XI - abandoned former railway lines, XII - natural amenities, XIII - humid habitats

ISTVÁN FODOR
MTA Dunántúli Tudományos
Kutatóintézete
Pécs, Hungary

SOME PROBLEMS OF SETTLEMENT ECOLOGY

Researchers have studied the economic, social and technical aspects of laws governing settlements development for quite a long time.

When the crisis of the environment became noticeable all over the world, questions related to the ecology of settlements gradually came into the focus of scientific studies in various ways. As a natural consequence of this situation the ecological aspects of urban development have to be studied with respect both to the general relationship between ecology and settlement, and the specific problems that may arise.

This kind of research is particularly important if we consider that the growth, extension of settlements as a result of social development and spatial extension, i.e. the development of our settlement network, is an important factor that contributes to the increasing load our natural environment has to bear. There is a serious contradiction related to this problem that we have to realize: while the concepts and plans elaborated for the development of our settlement network are supposed to improve the quality of life, what we have achieved - even in recent years - is the deterioration of the environment of our settlements and thus the natural conditions of human life by increasing the load on the natural environment, often destroying it beyond repair. Securing good ecological background for the settlements means protecting the ecological conditions of human life because the environment of human life in settlements is characterized by various natural and anthropogenic, technical ecosystems. The integrated forms of these diverse systems developed most intensively in urban settlements and in their totality, function as a natural - social complex. This is the main reason why it is important to explore the ways in which the interaction between the development of settlements /or settlement groups/ and the natural environment changes in the course of the complex processes of socio-economic development.

The complexity of the problem is further increased by the need to analyse in a complex way both the long and short term interrelationships of the natural or anthropogenic, favourable and unfavourable, local and regional, as well as the technical, physical, chemical, biological, ecological, social and economic effects that vary in their character and importance. The changes observed must also be assessed from similar viewpoints. On the one hand, we must examine how the natural environment can promote development and, on the other hand, we must see clearly how the same environment, in its degraded condition, hinders development.

In the course of its historic development, the settlement network has embedded all those natural characteristics that were determined by favourable geographical conditions /e.g. features of the ground, soil, climate, etc ..../. However, in the middle of the 20th century most of the socialist countries - including Hungary - experienced a strong extensive industrialization which considerably disturbed this balance. The great ecological crises of the 1960s and 1970s drew attention to the pollution of environment by the industry. By degrading the environment, this process started a chain of reactions that increased the role which the ecological crisis played in slowing down or hindering the development of settlements. Hungary is a good example for illustrating this situation. Here industry was located along a so-called "industrial axis" determined partly by the natural conditions and partly by the historic, social and economic relations that prevailed at the time of industrialization. The main industrial regions along the axis are found in Borsod, Nógrád countries, the metropolitan region of Budapest, North and Central Transdanubia. The concentration of air - pollutants is the highest here, creating an extended region of dangerous air pollution, that spreads along the north-east /south-west industrial axis. The reason why this situation is particularly aggravating is that about 38 % of the population lives on this relatively small area /hardly more than 7 % of the territory of the country/.

The concentration of sulphur and soot which strongly affects the quality of air stopped increasing between 1958-1960, and decreased between 1960-1964, when the process of extensive industrialization ended in Hungary. Figure 1 shows the location of strong sulphur dioxide pollution. Its pattern of nearly adjoining areas covers the north/east - south/west axis. It is interesting to compare Figure 1 with Figure 2, the latter showing changes in sulphur dioxide emission and indicating that sulphur dioxide emission decreased around Budapest, in Komarom, Fejér and Heves counties between 1981-1985, while air quality deteriorated in Veszprém, Nógrád and Borsod counties due to the increase in sulphur dioxide emission.

Figure 3 shows areas heavily polluted with nitrogen dioxide. Their location is similar to those polluted with sulphur dioxide, and moreover it is also worth noticing that besides areas along the industrial axis, the agglomerations of Győr in North--Transdanubia and of Pecs in South-Transdanubia are also affected. The analysis of the regional arrangement shows that pollution decreased in the Budapest and Borsod areas but worsened around Komárom and Pécs.

Besides the degradation of the environment due to industrial pollution, more and more attention should be paid to the contradictions inherent in infrastructural development, which, in spite of improving living conditions, gives rise to unfavourable tendencies in the set of man-society-environment relationships. Towns expanding in urban areas, the construction of newly established industrial plants use more and more land not only for building homes, factories and public buildings, but also for the development of road, water and gas network, recreational areas, etc. In the rapidly industrializing areas we have to witness the constant reduction of agricultural land despite legal protection.

Such a loss of land, even if it is used inevitably for the development of infrastructure, has led to remarkable changes in agricultural production in the agglomeration of Pécs. In just one decade, between 1971 and 1981, about 3 000 hectares were withdrawn from agricultural production in this region. The loss of land stopped increasing in only 6 of the 55 settlements. The example of Pécs proves beyond doubt that the changes made at the expense of fruit and grape production were primarily brought about by the development of the infrastructure. The southern slopes of the Mecsek mountain have a most favourable mezo-climate - creating a special plant life between the forest zone and the town which constitutes the historical wine-growing region in Pécs and its equally historical orchards. The town began to expand northward up the hills thus exposing the region to various forms of intervention. This process damages the erosion-sensitive soil, the balance of the eco-system, replacing the green belt with a densely constructed residential area. While recognizing the need to develop infrastructure, we wish to emphasize that such interventions may lead to an irreversible destruction of favourable natural conditions. This in itself justifies the requirement that due consideration be given to the natural conditions and potentials before decisions are made on the development of settlements in the urban regions. A host of similar problems arose when we analyzed emmission values of air pollution in South--Transdanubia. Pécs proved to be an excellent example of how markedly can concentrated pollution influence or modify the various elements of the climate,such as irradiation, air temperature, etc .... This recognition is particularly important because air pollution in South-Transdanubia is rather of local than of regional extent and greatly depends on settlement size, at least for the time being.

Our research is aimed at exploring the ecological background of the immediate and broader environment of the settlements where the town and its gravity zone are to function. The operation and development of the model should include the measures that ensure a dynamic ecological equilibrium between town and its environment. The spatial delimitation of this dynamic ecological equilibrium is important because this will enable us to develop our towns in harmony with their natural environment.

The development of settlements has produced several examples which can prove the objective fact that a down can develop even if the quality of the environment is damaged or the ecological equilibrium disturbed. There is a high number of towns or metropolitan areas that have grown beyond their natural environment, completely destroying it. The dangers of this type of development are quite well-known. For our further research another important factor to be considered is the fact that pollutants originating in the third sector take an increasing part in disturbances of the dynamic ecological equilibrium, and their amount equals or exceeds the amount of industrial or agricultural pollution,already damaging the natural environment or ecological background of a given settlement.

An important criterion of scientific, well-planned settlement development is that towns should not destroy their natural environment but make efforts to preserve its qualities as an important element of the quality of life. It means that the optimal proportion of the socio-economic and ecological factors reflecting continuity and change, as well as the interrelations between natural and social environments should be analyzed simultaneously in the process of planning. In other words, at the level of principles there is no antagonistic contradiction between the natural and man-made environment of the towns; on the contrary, it is a basic requirement that towns should develop harmoniously as a complex ecological and socio-economic system. To achieve this is our responsibility in the interest of future generations.

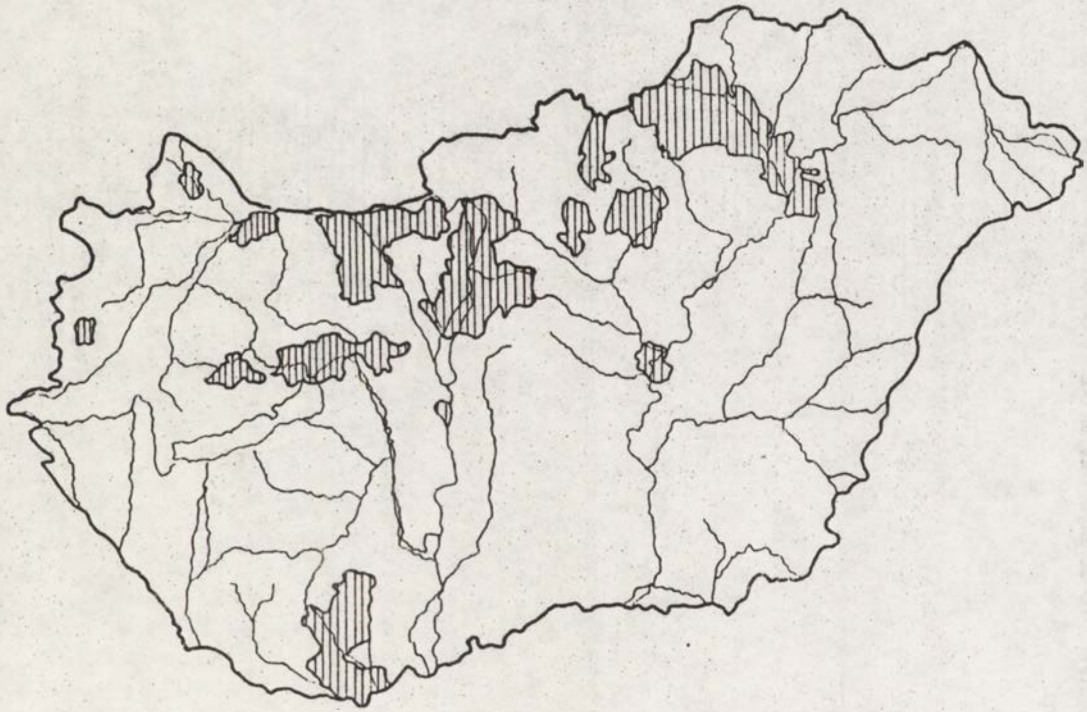

Fig. 1 Areas of heavy sulphur dioxide pollution in Hungary, as recorded in 1985

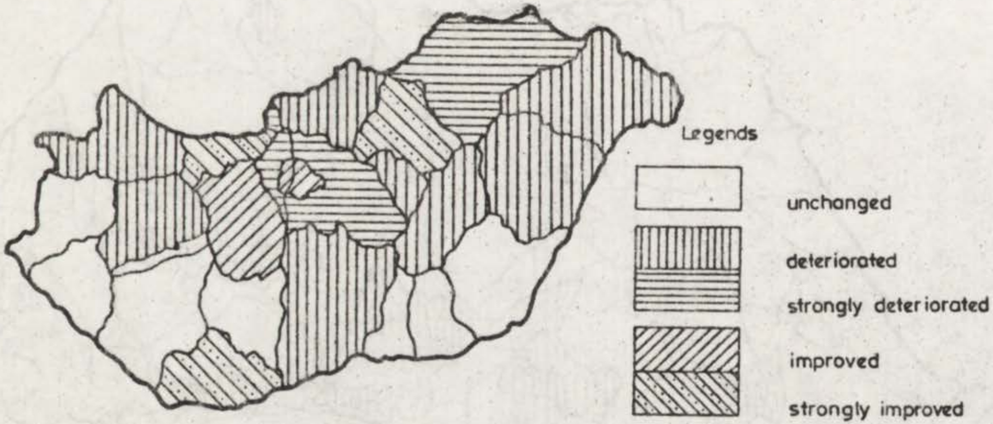

Fig. 2 Changes in sulphur dioxide emission in Hungary between 1981-1985
/sources: industrial points/

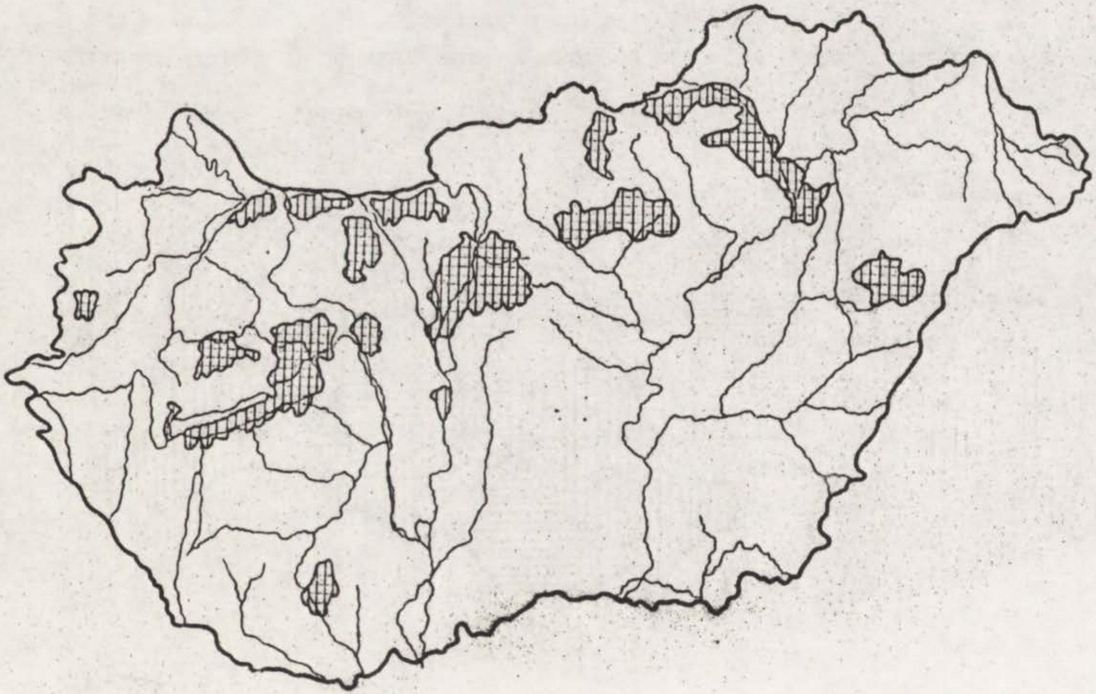

Fig. 3 Areas strongly polluted with nitrogen dioxide in Hungary
/as recorded in 1985/

TAMAS T. SIKOS
Research Center for Regional Studies
Pécs, Hungary

INVESTIGATIONS IN THE BUDAPEST AGGLOMERATION

In Hungary, a new regional- and settlement development policy has been elaborated recently. The principles of this policy were adopted by the Parliament in spring 1986. These principles, however, do not include the trends and plans of the settlement development, therefore it is of utmost importance to carry out research on the settlement network in regions of complex spatial structure as, e.g. in the Budapest agglomeration. Investigations in the Budapest agglomeration are all the more important because until now just a few problems have been discussed and the region has not been profoundly analysed yet. In addition, new processes have appeared in the transformation of the agglomeration area.

We do not have wide knowledge on the nature, trends and extent of these new processes, or on the modification of earlier, more or less known. In the present stage of socio-economic changes the trends, dynamism, and nature of the social and physical transformations seem to be undoubtedly modified, parallel with the emergence and strengthening of new processes. Obviously, a few changes on the macro-level traced by traditional statistical methods, tend either to disappear or to slow down, including the occupational re-stratification of population, the increasing rate of population migration in the agglomeration area. At the same time, settlement system and settlement environment are expected to met the requirements of local communities, which means that the significance of local circumstances keeps growing.

Statistically unobserved factors based on alternative decisions made by individuals and families are supposed to become dominant in spatial /social/ processes, including the modification of appropriately planned and possible way of life for children differing at the same time in social strata, and in regional units. The differences among the settlements of the agglomeration /among local societes of settlements/ will probably increase; desurbanization may have a large share in this process.

Totally diverse groups of settlements have developed, thus uniform development plans cannot be applied at all. We have only vague ideas about the size, structure and processes shaping the settlement development in these regional units. The occasionally intensifying development could offer a solution to a part of disorders and shortage-situations /e.g. the conditions of housing have improved, the primary institution network has widened etc./, but new tensions seem also to be generated /e.g. relationships between labour market and residence are re-evaluated by the rising generation, the importance of the "environment" keeps frowing, etc./.

Difficulties will probably accumulate as spontaneous processes not directed by urban planning, have impact on the development of settlement pattern in the metropolitan area. In numerous cases we are witnessing a contradiction of interests between the "nationwide" regulation and local, special concerns /e.g. between land protection and the demand for building sites; this resulted in an urban sprawl in the agglomeration due to scarcity of construction sites.

The purpose and subject of investigations

The Regional Science Department of the Centre for Regional Studies, Hungarian Academy of Sciences, can undertake to reveal imbalances occuring in the settlement system and settlement environment, in local societies and their relationships in the agglomeration area. The Department can aim at describing and localizing processes which lead to imbalances, and at making proposals for means and ways /belonging, first of all, to the scope of regional and settlement development/ of solving conflicts and shortage-situations. The Department does not intend to make monographic investigations in the Budapest agglomeration due to the composition of its staff only representing the following disciplines: economics, geography, history and sociology.

The task of the Department is to discuss some burning issues of the Budapest agglomeration, e.g. conflicts, shortage-situations, processes shaping settlement network etc., by giving answer to a few questions thought to be fundamental. The

Department has no possibility of carrying out research in the whole agglomeration area. Therefore, it should be decided whether just a certain group of settlements are to be investigated or the results of earlier investigations are to be taken into consideration and included into the research.

The concept proposal has been outlined roughly, its possible new version would require a detailed description of conflicts /especially in case of local societies/, the definition and interpretation of the most important concepts. Investigations in the agglomeration area are in an initial stage of the short-term planning period from 1986 to 1990. The financial background of the research has not been made clear yet.

A draft concept will be presented below on how the settlements of the agglomeration can co-exist efficiently with the city of Budapest. Above all, a better understanding of the agglomeration process, special interrelationships among Budapest and its environs typical to agglomerations, is one of the aims of the Department.

I. The concept, formation and international tendencies of the agglomeration

The results of investigations in the agglomeration achieved in Hungary and abroad so far:

1. The emergence of agglomeration is a special stage of urban development /its historical background/.
2. The definition, delimitation of the agglomeration: description of interrelationships characteristic of agglomeration.

II. Spontaneous processes in the formation of the Budapest agglomeration

1. Concentration of economic activities in the capital's agglomeration ring /the emergence of an area which offers agricultural supply and has a special industrial structure to meet the needs of Budapest.
2. The agglomeration area used to provide the economy of Budapest with work force /partly with work force engaged in the economic activities of the agglomeration, partly with vast numbers of migrants/.

3. New forms of economic relations:
   - spatial and organizational changes:
     launching branch-plants and affiliated industrial projects by industrial enterprises in the agglomeration having their headquarters in Budapest,
   - other types of possibilities of cooperation,
   - significance of Budapest in the economic supply of the agglomeration area.
4. Non-economic physical connections /based on the needs of Budapest/
   - the agglomeration area serves for recreation purposes for the inhabitants of Budapest,
   - it is an area of residential development, and
   - an area of week-end recreation, as well as of agricultural use, etc.

In our view, the reason why the Budapest agglomeration could further develop is that it has been fulfilling functions of supply, which, however, have changed by time. It means that this area -the agglomeration ring- is closely connected with Budapest and promotes the development of the capital city. The parallel development of the agglomeration and the city of Budapest should be of primary importance, thus the earlier spontaneous connections and processes should be replaced by planned management. Consequently, the same conditions would have to be established for the development of the agglomeration as for the capital city. Currantly, the pace of urban development in the agglomeration area is much slower than in the capital and there is an increasing gap in the living conditions between the settlements in the agglomeration and Budapest, or even other regions of the country which all prove that Budapest makes use of the supplying activity of the agglomeration and absorbs its economy without adequate compensation.

III. Comparison of living conditions in Budapest to those in the agglomeration area.

1. Demographic situation
2. Income relations
3. Infrastructural supply /health care, trade, culture, transport etc./
4. Proportions and mechanisms of distribution of development resources in the past decades.

IV. Planned processes of coexistence of Budapest with settlements of the agglomeration ring

1. The development and proper functioning of infrastructural supplying networks of Budapest /e.g. the extension of transportation networks, strengthening of central functions of the capital in settlements of the agglomeration etc./
2. The significance of the labour division between Budapest and the towns of the agglomeration area in supplying population of the agglomeration.
3. Integrated /complex/ management of the agglomeration
   - efforts
   - failures
   - possibilities
   - necessities

An approach to investigations; methods and procedures

1. Our investigations will be carried out in the field of social sciences, the examination of iterrelationships between settlement environment /technical system/ and society can represent a special field of the Department´s research.

2. Within society-centered approach our investigations are of geographical-regional nature, with the primary aim of localization of processes, exploration of physical structure of the agglomeration /the Department´s investigations differ from those of sociology in this point./ In the agglomeration area characteristic regional differences arise both in the urban environment, functions, and in the nature, distribution and organization of local societies. There are settlements acting as resorts, residences for pensioneers, migrants along the Northern band of the Danube river. A semicircular subrural zone spreads as far as the Great Plain. Industrial settlements, like Százhalombatta, Szigethalom, Szigetszentmiklós, etc., are connected with the southern borders of the capital.

Obviously, the reasons for the insatisfactory planning work carried out so far can be found in ignoring of regional differences and regionally undifferentiated goals.

2.1. Investigations concerning the situation of settlements, as well as the processes shaping settlement pattern have to be closed by the determination of regional types and their regional distribution. When localizing, or just making investigations, the administrative boundaries of designated regional units are inadequate to observe, and consequently, another kind of breaking down of settlements should be applied, e.g. regional units based on census regions or "homogeneous" parts of settlements etc.

2.2. The investigations of the Department will exceed delimitations of the officially established agglomeration area.

3. The goals outlined do not make it possible for us
- to make investigations exclusively on the basis of data published or collected regularly;
- to perform data collection or field surveys in the same specified way in all settlements of the agglomeration.

As a result in a definite group of settlements of the agglomeration a deep and intensive investigation is needed, including data collection made by questionnaires and interviews, use of registered but unpublished data concerning prices and turnover of land, population registration, migrations and mapping, field works etc., where particular attention could be paid to processes influencing the development of settlements. The methods for generalization and localization of given results need to be elaborated.

4. Individuals or families /households/ could be units of information collection or observation of information, while data processing level can be either a settlement or a determined part of a settlement.

When individuals are observed, we need information concerning:
- indices of life, lifestyle of local societies /e.g. regional incidence of deviating behaviours/,
- reasons for significant regional interactions, and the change of settlement environment, in a part or of the whole settlement, /we mean interrelationships of social and regional mobilization, changing social status of a settlement or a part of it etc./.

5. Investigations of the Department are of basic research nature which, however, does not preclude the possibility of broadening our investigations by practical aspects, should such requirements occur.

6. The possibilities of the Department allow us to pay special attention to international comparison.

GRIGORIJ W. IOFFE
Institute of Geography AN USSR
Moscow, USSR

THE POLARIZATION OF RURAL SPACE AND ITS CONSEQUENCES

The process of formation of concentric zones around a central place reflecting differences in farm production, has been thoroughly investigated. It has drawn attention of economic geographers over the last 150 years. Contemporary urbanization has endowed this process with an even greater geographic content, and imbued it with some new aspects. In contrast to the past, when the annular spatial structure was shaped by the impact of differential rent in terms of location, reflecting potential differences in the cost of transportation of goods, at the present time the leading role is being played increasingly by transport accessibility of the central place from the perspective of the surrounding population.

Without necessarily exhausting the concept of economic and geographical situation of a rural place, the sum of these two factors does apparently represent the most significant aspect of its present-day content /Fig. 1/.

Relationship /factor/	Differential rent	Accessibility of a central place
Subject of relationship	Goods	Population

Fig. 1. Model of the economic and geographic situation of a rural area

The two factors, which together constitute the economic and geographical situation of a rural place, differ greatly in their mode of operation. In the final analysis, both the transport of goods and the transportation of people to the centre of production and services, reflect the needs of the population. But while rent is associated with human needs through the intermediary of the economic process of reproduction, the accessibility of a central place is associated directly with the realization of a whole series of needs, especially the need for services and for social contact.

When the rural population, after having consciously selected its place of residence, gains in mobility, the role of the second, purely geographical factor of territory differentiation gravitating toward the town increases its significance. This becomes evident in physical differences in the dynamics of the rural population which tends to have an inertial impact on the spatial structure of the economy. The geographical character of that impact, in our view, lies in the fact that it is based on a locational inequality, i.e. in this particular case, on inequality of accessibility of the central place.

We shall try to analyze physical transformations connected with rural population of the Non-Chernosem zone of the Russian Federation over the period of 1959-1979. This zone consists of 29 administrative Oblasts and ASSR's /autonomic republics/.

The rural population of the region decreased by 36% during the study period, with its share in the total regional population dropping from 41.7% to 23.8%. This decline has been a part of a longer-term trend. It might be recalled that nearly 80% of the regional population was rural at the time of the 1926 census. The decline has been associated with the fact that the work force in agriculture has been sharply reduced by the migration to cities, decreasing by 20% from 1959 to 1970, and again by 20% from 1970 to 1979.

Multidimensional statistical analysis of differences among oblasts helped us to identify the principal factors. In the course of the analysis we successively eliminated factors of little significance, and tested several types of relationships /linear, linear-logarithmic, hyperbolic./ The statistically insignificant factors included the mean population size of rural places, the density of given areas and employment in services. Only two factors confirmed their effect on rural population changes in oblasts from 1959 to 1979: population trends during the preceding intercensal period /1926-59/, and the share of the total population in towns of 100,000 inhabitants or more. It turned out that the greater the mobility of rural population in the preceding period, the greater were population losses during the study period. On the other hand, the greater the population share of large cities, the more stable was the rural population.

Of particular interest is the fact that a similar relationship was identified for employment in agriculture, with the impact of preceding trends even stronger than in the case of rural population as a whole. Here one would have to consider that employment of rural population falls into three categories: employment in agriculture in rural nonfarm activities, and in the cities. Changes in investment, both spatial and through time, have affected the nonfarm activity in rural areas and in cities while employment in agriculture has remained more stable. It is therefore in agriculture that historical trends have been leaving their strongest imprint on social processes.

In short, the results we have obtained tend to be somewhat ambiguous. They suggest, first of all, a tremendous force of inertia in rural population change; second, the increasing concentration of rural population in highly urbanized areas; third, weak relationships between rural population change and structural characteristics of settlement.

The question that arises is, why is there a weak relationship between rural population change and one of the main components of the rural environment. There may be two alternative explanations. One is that while the characteristics of the rural environment to affect rural population changes, the effect is modified by the presence of large cities and manifests itself in pure form only if there are no such cities. The other possible explanation is that the characteristics of the rural environment do not affect rural population changes, and that the overall lag in rural infrastructure development tends to overshadow spatial differentiation. As a result, the decisive factor in stabilization of rural population would be the proximity to a large city, which would provide special benefits that the rural residents lack at home. It should be noted that the oblast level of analysis does not cast doubt on either of these two hypotheses. We will come back to this issue in the context of the local level of analysis.

Intra-Oblast Redistribution. The preceding conclusion suggests that the best way to test intra-oblast changes in rural population distribution is in terms of accessibility to a large city. An example of such an analysis was provided by Lola and Savina /8/.

We had information regarding accessibility to large towns only for three oblasts. The analysis suggested that there were pronounced centripetal shifts in the distribution of rural population /Table 1/.

Since we wanted to cover most of the oblasts of the Non-Chernozem zone we returned for reference to the Handbook for Partitioning a Territory for Regional Planning Purposes /12/, which Ye.Ye.Leyzerovich, the complier, had already used to measure changes in population distribution /7/ in 1959-73. This particular regionalization breaks oblasts down into economic microregions, each of which comprises a number of rayons /usually three to six/.

Even though this particular regionaiization does not reveal very pronounced contrasts in population change /Table 1/, it did show that the rural population of the central economic microregion was fairly stable in 17 of the 29 oblasts and ASSR´s. On the one hand, in the Far North and in Sverdlovsk and Perm´oblasts of the Urals, relative stabilization of rural population was evident in areas throughout the oblast, mainly in conjunction with rural nonfarm activities. In six other oblasts and ASSR´s, secondary, noncentral poles of stabilization were associated with a favourable transport situation, for example, the Rostov microregion in Yaroslavl´Oblast and the Kanash microregion in Chuvash ASSR.

In 15 of 26 oblast-level /outside the Far North/, the overall population increase was evident only in the central economic microregions /which are the ones centered on oblast capitals/. The Leningrad Oblast and the Karelian ASSR had only one depressed microregion each. The Moscow Oblast had no depressed microregions at all. Nine oblasts showed population growth in at least one additional microregion /aside from the central microregion/.

Even if the population increase in these microregions results entirely from the growth of urban population, it is nevertheless an important factor in stabilizing rural population levels. In microregions where urban growth more then compensated for rural decrease during the period of 1959-79, the rural decrease itself was much smaller than in the Non-Chernozem zone as a whole. Compared with an average rural population, decrease of 38% in the zone as a whole /not counting the Far North/; the rural decrease in these microregions was only 23%. The significance of these nodes of stabilization of rural population is extected in increase over the longer term.

Information about the outlying microregions sheds additional light on the issue of why rural population changes in the Non-Chernozem zone are so weakly related to the characteristics of the rural environment.

One could assume that the high proportion of outlying microrayons with decreasing population number /within the oblast's limits/ would be evidence that there is a weak relationship between rural decline and distance from cities. Actually only the distance to the oblast capital is supposed to be a significant factor accounting for rural population changes. But since the radius of regular cultural and shopping trips to the oblast capital tends to be limited, any decrease in rural population beyond that radius would have to be accounted for by other factors, for example local differences in the level of rural services. On the other hand, local differences in the level of rural services tend to become equalized in oblasts and large growing cities since any shortcomings in rural services are compensated for by services provided by the rapidly growing city.

We tested this assumption with respect to two oblasts with different urban population characteristics /Table 2/. For each of two oblasts we identified variables that would explain the largest possible percentage of intra-oblast differences in rural population change. We used a total of 11 variables. After excluding the less significant ones, we found that the level of urban population in a rayon, and the distance from the oblast capital are of roughly equal significance in Yaroslavl' Oblast in accounting for the stabilization of rural population; in the case of Ryazan' Oblast, the largest percentage of variation is accounted for by the availability of rural services,, the proximity to the oblast capital and the development of rural commuting to work. Moreover, in Ryazan' Oblast, employment in rural services was found to increase with distance from the oblast capital.

We thus established that the hypotheses we formulated regarding the causes of the weak relationships between rural population change /in the Non-Chernozem zone as a whole/ and the characteristics of the rural environment are not alternative, and that the degree of confirmation for each of the hypotheses depends on local parameters of urban network. This empirical confirmation is in keeping with the basic finding that distance from a large city is the main factor accounting for differences in population change in the Non-Chernozem oblasts. Obviously the end result of this differentiation would be gradual concentration of rural population in the zones of influence of large cities, which in the Non-Chernozem zone also happen to fulfill the role of oblast capitals.

A separate question again is to what extent this regularity also applies to farm employment. On that score, we only have selective data for 10 oblasts and ASSR's.

Our analysis suggests that three stages can be distinguished in the process of population concentration around large cities. In Stage I, which has apparently already been achieved by most of the oblasts in the Non-Chernozem zone, the process involves mainly stabilization and increase of nonfarm population. The farm population at this stage tends to decrease at similar rates both in the central rayons and in the peripheral rayons. In Stage II /reached by most oblasts in the mid--1970s/, the farm population starts to stabilize in the suburban zone of the oblast capital, while continuing to decrease in external areas. In Stage III, farm employment begins to increase in the suburban zone. Most of the oblasts now seem to be in Stage II. However, the first indications of Stage III are already evident in the oblasts of Moscow, Leningrad, Sverdlovsk and Gor'kiy, where farm employment in the suburban zones has been increasing in recent years.

The sequence of stages is one of the characteristic features of the process of population concentration progressing, as a result of its unequal distribution, from place to place. We did not try to analyze the elements of this unequal distribution. However, the oblast data suggest that the share of older age groups in rural population is higher in peripheral rayons than in centrally situated rayons, so that the natural decrease of population is greatest in the suburban areas. In recent years there has been an increase in rural-rural and urban-rural migration. An analysis of these migration streams in Vologda Oblast showed that they are directed mainly toward suburban farms /2/. Thus, there are grounds for assuming that the spatial concentration of population is being fostered both by natural increase and by migration.

Specific features distinguish the redistribution of farm population in the Moscow Oblast and adjoining areas. A personnel analysis in outlying farms of the Moscow Oblast suggests that a substantial percentage stems from adjoining oblasts and, in some cases, more distant oblasts /usually within the Non-Chernozem zone/. In Serpukhov rayon /extreme South of the Moscow Oblast/ for example, only 15% of the state farm workers are natives of the rayon. Closer to Moscow, farm workers include both natives of other oblasts and natives of outlying rayons of the Moscow Oblast.

The Redistribution Within Rayons. The nature of the population redistribution within a rayon will depend on its position in relation to a large city. If the rayon-

-shaving significance of a local administrative center is overshadowed by the proximity of a large city that "intercepts" commuter streams, the spatial redistribution of stable population within the rayon will be affected accordingly.

In this case, linear concentration /along transport channels/ will exceed clustering around the rayon seat, and the linear forms of concentration will in turn be a part of a wider star-shaped nodal pattern around the large city. Such a pattern is maintained in particular, for the two-hour travel zone around Moscow.

Beyond that zone, the rayon-shaping significance of small urban places greatly increases in importance; linear and nodal concentration of population occur simultaneously within the framework of structures of a particular taxonomic rank. It is, therefore, of particular importance to examine the evolution of the settlement network in outlying monocentric rayons headed by small urban places. Such rayons do not display the complex pattern of the zones of influence of nearby large cities and of transport channels, which, though not affecting the essence of settlement processes, do complicate their external forms. An outlying rayon can thus be regarded as a kind of model in which the process of spatial concentration of population can be traced in its purest forms.

For our analysis we selected the Uglich Rayon of Yaroslavl´Oblast and Mikhaylov Rayon of Ryazan´Oblast, two fairly representative outlying rayons in two parts of the Non-Chernozem zone that offer pronounced constrasts in their settlement patterns. The present differences in rural settlement in these two parts of the Non-Chernozem zone have been historically inherited. While the Ryazan´ Oblast lies in the belt of continuous agriculture, with its typically large plots of cropland,the Yaroslavl´Oblast is situated in the belt of selective agricultural development with a predominance of tiny villages within small, densely populated areas.

We analyzed spatial differences in the rates of population decrease in terms of travel distance from the rayon seat. We established the travel-time zones by determining the time it takes to travel from every place in the two study rayons to the rayon seat. The basic transport mode for rural residents of the two study rayons is the bus. Walking time to bus stops was determined by map measurement along foot paths. Trip duration was taken from bus schedules /4/. As shown in table 3, the share of the central travel zones in total rural population has been growing during the period 1959-79.

The fact that this picture applies to most of the rayons in the Non-Chernozem zone is supported by similar evidence for the rayons of Novgorod Oblast /9/, Kalinin Oblast /1/ and Udmurt ASSR /6/. Particularly interesting data on the linear concentration of rural population are provided in /1, 14/.

What forms does this spatial concentration take at the level of local groups of places ? This question is in itself of interest.

We used regression analysis for each of the travel-time zones around outlying rayon seats and for the rayons as a whole to identify the factors that contribute most to the stabilization of population.

The problem was handled through a successive elimination of factors of smaller significance. Aside from statistical criteria of significance, we also relied on visual assessment of the configuration of the potentially stable network of places.

As it turned out, viable settlement structures, which take shape especially at the stage of selective out-migration, assume a variety of forms: concentric settlement within the central zone /less than 60 minutes travel time from the rayon seat/; linear settlement in the intermediate travel zone /60 to 120 minutes/, and disseminated settlement in the peripheral zone /over 120 minutes from the rayon seat/. The characteristic feature of linear settlement is that the road net forms the axes of development. Since the mean distance to surfaced roads within the intermediate travel zone is two to three times greater than in the central zone, the presence of these "lines of force" within the field of settlement becomes particularly pronounced and graphic. In disseminated settlement, the stable places tend to be isolated and so far apart as to hamper regular interaction.

The process of polarization of rural areas has become apparent not only in Non-Chernozem zone. In the European Part of the USSR it also takes place in Byelorussia, throughout the major part of the Ukraine, within the Baltic republics it is Latwia that is mostly affected by this process.

There are two alternative standpoints in Soviet geography and regional science regarding the polarization. According to the first one /up to now the dominating one/ it is the outcome of mistakes and omission in planning, manifested in insufficient attention to rural context /10/. Consequently, the correction of those mistakes should turn the process backwards in favour of farming needs. According to the second standpoint /shared by the author/ the polarization of rural space is the inherent phase of rural settlement evolution, regardless of the ammount of attention paid by central authorities. The latter may only raise the overall level of rural infrastructure and well-being, not the spatial distinction in population dynamics. The real mistakes and ommission consist in the fact that the mechanization, specialization and spatial division of labour in agriculture had not been brought into accord with the inevitable change in rural settlement /3, 5/.

What are the main consequences of rural areas polarization? There are several ones.

Firstly, it is the sufficient reduction of the amount of villages. The total number of rural places in the Non-Chernozem zone decreased from 180,000 in 1959 to 118,000 in 1979. Although some of this reduction resulted from administrative changes, most of it was undoubtedly due to the exhaustion of demographic resources of small places, as a result of outmigration and of natural decrease of the population. Meanwhile the stock of agricultural land was reduced by 4 million hectars. In some oblasts, particularly in the North-West of the zone, areas used by farming decreased more than twice during the post-war period due to the abandonment of land /13/. The deserted land is being overgrown by bushes and scrubs.

Another consequence of rural areas polarization is the increase of so-called centrifugal gradients in productivity of arable land, manifested in the distinction in crop capacity and cattle-breeding results per hectare and per unit of live-stock. The majority of deficient collective farms receiving subsidies in the form of supplement to state purchase prices is situated in outlying rayons. On the other hand, the prevailing number of profitable farms is in the suburbs /5/.

The agricultural consequences of rural areas polarization are accompanied by the spread of recreation function of peripheral villages. The first research attempts in this field show the direct proportionality between recreation specialization of place and the level of its agricultural depopulation. There are many peripheral rayons in the Non-Chernozem Zone with seasonal population exceeding constant one. The summer residents of the villages are mainly relatives of native people including the successors of private homes. The process of spontaneous recreation development in depopulated rural places create some complicated problems of legal character.

Implication

Spatial concentration thus turns out to be the main tendency distinguishing shifts in rural population of the Non-Chernozem zone at all taxonomic levels. Another matter is the question of the causes of this latent process, its economic and ecological consequences, and possible controlling mechanisms. The need for investigating these aspects arises from the fact that economic plans and investment programs always require a specific spatial breakdown within every oblast and every rayon. The strategy of such a spatial breakdown cannot be determined once and for all. It tends to vary, just as the objective conditions of development vary.

"Available investment resources should not be spread around on an even basis. An effort should be made in the new five-year plan /1986-90/ to focus investment on projects that promise the greatest and most immediate return. This applies, in particular, to agrobusiness complexes where the level of investment has reached an optimal size, but the return on investment is still inadequate". /Gorbachow M.S., Pravda, 14 09 1985/.

The realization of this guideline confronts investigators with a number of tasks. One issue in particular, is how useful and effective are efforts to counteract the proceding spatial concentration of rural population ? Does this process embody any positive aspects at all ? How does it relate to the issue of converting agriculture to an intensive path of development ?

In the author´s opinion the positive consequences of rural areas polarization are underestimated. Firstly, it is one of the strongest supplement incentives of farming land use intensification.Secondly, separating areas of high and low density o. human activity, ensures the spatial integrity of landscape cover. It is one of the well-known principles of nature protection. Thirdly, the future of agriculture in the light of the depicted situation seems to be as follows. The continuous intensification in suburbs, the increase of greenhouses, multistory plantation,poultry farms; plant-growing on shelves up to hydro- and airponics; the conversion of agriculture into a kind of industry ensuring mass line production of small variety of standart and relatively cheap food articles. On the other hand - the so-called policulturization of plant-growing and cattle-breeding, the cultivation of half-wild animals in multispecial herds, the return to gathering /picking-up/ on a scientific base, rationalization of hunting and fishery, the rapprochement between cattle-breeding and hunting and between horticulture and forestry. This second side of potential agriculture can supply us with more expensive but more diverse, delicious and vitamin-rich food articles /11/.

Side by side with recreation development, this way of agricultural transformation in outlying regions should fill the rural space polarization with valuable content.

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Table 1. Rural Population Shifts within Oblasts
/1979 rural population in percent of 1959 level/

Oblast	Oblast as a whole	Whithin 2-hour travel of oblast capital	In the central economic microregion
Novgorod	56.0	74.4 /3.6/*	65.4 /30.8/
Kostroma	52.4	80.9 /3.3/	62.3 /30.5/
Kalinin	54.0	75.6 /2.4/	66.2 /24.6/

* Figures in parentheses show the percentage that the given areal entity occupies in the total area of oblast.

Source: /5/

Table 2. Some Characteristics of Urban Settlement in Ryazan´ and Yaroslavl´ Oblasts

Characteristics	Ryazan´ Oblast	Yaroslavl´ Oblast
Urban population share in 1979, in %	60	78
Urban population density in 1979 /per km^2/	9.2	13.9
Share of population in urban places that grew during the 1959-1979 period, in % of 1979 urban population	85	93
Percentage of microregions with a growing total population within each oblast	14	60

Source: /5/

Table 3. Settlement Pattern /as of 1979/ and Population Change /1959/79/ by Travel-Time zones from the Administrative Seats of Rayons

Travel time minutes	Percentage in area	Percentage in population	Percentage in overall number of settlements	Population density	Mean population size of places	Index of population decrease
			Uglich rayon /Yaroslavl´Oblast/			
0-60	11.7	31.4	22.3	48.5	55	0.84
60-120	26.9	28.1	28.7	8.7	38	0.56
120	61.4	40.5	49.0	5.5	32	0.36
Rayon as a whole	100.0	100.0	100.0	8.3	39	0.53
			Mikhaylov rayon /Ryazan´Oblast/			
0-60	25.1	55.7	29.3	36.4	293	0.61
60-120	31.3	19.7	27.2	10.3	112	0.49
120	43.6	24.6	43.5	7.1	87	0.44
Rayon as a whole	100.0	100.0	100.0	16.4	154	0.54

Source: /4/

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