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INSTITUTE OF GEOGRAPHY AND SPATIAL ORGANIZATION

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SPATIAL ORGANIZATION IN THE PROCESS OF TRANSITION FROM A CENTRALLY PLANNED TO A MARKET ECONOMY

RYSZARD DOMAŃSKI

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ABSTRACT: The main topic discussed is the change of spatial organization during the period of transition from a centrally planned to a market economic system. The economic reforms start, cause some temporal perturbations and conflicts then effect changes in the location and linkage patterns, hierarchical transformations and shifts in the spatial structure of the economy.

KEY WORDS: Economic transformations, self-organization theory, self-government, local initiatives, privatization of the former state-owned enterprises, infrastructural barriers.

The present article is an attempt at an anticipation of the transformations in the spatial organization of the economy that accompany the transition from a centrally planned to a market system. The anticipation rests on an analysis and a preliminary generalization of changes observed in the first years of the transition. The research procedure employed is one inspired by, a self-organization theory and its geographical adaptation, the theory of spatial self-organization*. The concept of spatial self-organization fits the nature of the process of transition from a centralized to a market sysem well. Its notional apparatus makes it possible to trace the spatial consequences of both radical systemic changes as well as minor economic and demographic ones occurring at the levels of enterprises, households, and localities. The reasoning proceeds from the beginning reforms, through the perturbations and fluctuations caused by them, the reinforcement and the damping of the fluctuations, deterministic and stochastic processes, the multiple objectives and conflicts, to the changes in the location and linkage patterns, hierarchical transformations, and macroscopic changes in the spatial structure of the economy.

* Cf. 1) R. Domański, A. P. Wierzbicki, Self-organization in dynamic settlement systems, *Papers of the Regional Science Association*, vol. LI, 1983, pp. 141-160; and
2) R. Domański, Przestrzenna organizacja rozwoju regionalnego (Spatial organization of regional development); Komitet Przestrzennego Zagospodarowania Kraju PAN, *Studia*, vol. 93, Warszawa: Państwowe Wydawnictwo Ekonomiczne 1987, pp. 159.

ASSUMPTIONS

When formulating hypotheses about the evolution of spatial organization in the process of the transformation of the sociopolitical and economic systems, we make the following assumptions:

1. The changes in the spatial organization of the economy are produced by three specific processes, apart from natural demographic and socio-economic ones: a) the spontaneous development of the private sector of the economy, especially small and medium-sized enterprises, b) the changing role of the state, both as a regulator of socio-political life and as an owner of enterprises (the process of privatisation of state-owned enterprises), and c) the reconstruction of territorial self-government, which, after it has separated from government structures, sets itself different aims and employs different modes of action.
2. Changes in the system of ownership produce an enormous growth in the number of economic agents, whose appearance, liquidation and operation shape spatial organisation.
3. Under the altered systemic conditions economic agents evaluate geographical space differently, and behave differently in it.
4. Domestic capital resources are modest, and so is the inflow of foreign capital. Nevertheless, the economy is opening fairly wide to foreign markets.
5. The poor market infrastructure hinders the development of enerprise and international exchange.
6. The population's real earnings go down temporarily, demand declines, unemployment rises, and differences in the level of affluence of the particular population groups widen.

THE MECHANISM OF TRANSFORMATION

In the conditions defined by the above assumptions, there appear changes in the spatial organization of the economy. In this article we seek to recognise the mechanism of these transformations and the emerging new features of the economic landscape. The following elements make up the mechanism of changes:

1. Rapid fluctuations in the number of economic agents and considerable deviations of this number from the initial and then the average state (big amplitudes). At present, it is hard to detect any regularities in the appearance of these agents (usually small and medium-sized enterprises, especially commercial ones). It may be largely a random process. There are many unsuccessful economic initiatives which the market eliminates quickly. It also eliminates some previously existing enterprises which have proved unable to adapt to the rules of a market economy. The number, branch structure and regional structure of small and medium-sized businesses keep fluctuating. Hence, the economic landscape is likewise variable.
2. Changes in the functioning of the local economy as a result of the

reconstitution of territorial self-government. Self-governments are generally more effective than the government administration in making use of local resources. Also their allocation is changing. Inter-sectoral shifts may be expected in local budgets. Self-governments will probably want to earmark more funds for the development of the local technical and social infrastructure, services, housing and environmental protection. Soon they will face the dilemma of whether to satisfy current needs of the local community, or to improve the utility of places (communes) with a view to long-term interests and competitiveness with other territorial units. Facing the accumulation of unmet needs, self-government organs will be hard put to resist their pressure. A shift in focus to the other disjunct can take place with the gathering of experience and learning to operate in the conditions of competition. Competition forces the use of new management methods. One of the means of improving the economic efficiency of these methods is the so-called city marketing.

3. Non-linear relations, differentiated dynamics. In the period of transition from a centralized economy to a market one many enterprises go bankrupt, but also many larger or smaller fortunes grow rapidly. Invested capital brings highly diversified losses or profits. The relations between capital and revenues assume the form of non-linear functions. There are also widening differences in the effectivenesss of ulitisation of resources, and, in consequence, in the revenues of particular towns and communes. Differences in the effectiveness of activity bring about differences in the development dynamics of particular firms as well as towns and communes. The diversification is greater than it was under the central regulation of economic development. It triggers new cumulative processes, both at the scale of enterprises and territorial units.

4. Keeping the transformation process going by exchange with the European and world environments. The countries changing their economic systems make use of the experience and help of those with modern and stable market economies. This assumes a variety of forms: the assistance of economic and financial experts, credits for maintaining the convertibility of domestic currency, or credits for the reconstruction of selected sectors of the economy important for the trasformation process. Treaties are negotiated which are designed to draw East-Central European states closer to the European Union, the International Monetary Fund, the World Bank, or the European Bank for Reconstruction and Development. Limitations in the flow of goods, persons and technologies are removed. The opening has taken place not only at the level of the country as a whole, but also at the regional and local levels. Particular towns and regions enter into partnerships with West European and American ones. This opens up new perspectives for the development of towns and regions engaged in the transformation, but the use they make of these possibilities is not the same everywhere. It is one of the factors accounting for the differences in the development of towns and regions in the period of transformation.

5. Barriers to and damping of transformation. The transformation process encounters barriers and is held back. The barriers are diverse: infrastructural

and institutional, social, political and international. The states undergoing transformation have as a rule deficient telecommunications, banking systems, stock exchanges, insurance companies. The so-called shock therapy which has so far produced the best results (lessening the economic disequilibrium, reducing the inflation rate, availability of goods and services) has also created serious social problems (a drop in the population's real earnings, unemployment, or the widening differences in the affluence level of particular groups of people which draw protests from the impoverished side). The high social costs of the transformations undermine the reformatory determination of political parties, parliaments and governments. Differences in the opinions on the rate and scope of the transformations, especially on the questions of privatisation and state interventionism, hinder the formation of coalitions in a pluralist parliament and government. It is one of the factors of political instability which has many adverse consequences. Foreign aid is estimated as unsatisfactory. West-European countries employ protectionist action in trade to obstruct the access of East-Central European goods to their markets. What arouses criticism is the fact that Western Europe seems to underrate the impact of the possible failure of reforms in East-Central Europe on the process of European unification.

The barriers to and damping of the transformations are diversified spatially. They are stronger in poorer and less dynamic regions. These are regions which have lost their markets, which have deficient infrastructure and depreciated production assets, high unemployment rates, loose contacts with foreign countries, and which are unattractive to domestic and foreign investors.

In the period of transformation the already existing spatial and environmental limitations on socio-economic development become stricter. Self-governments show more determination in enforcing the environmental protection act, while, the market prices of land exact its more economical management. Investors must consider various location sites more carefully.

The many spatial and environmental limitations will restrict the freedom of choice of new locations. Particular towns and communes can impose partial limitations to block specific kinds of investment and activity, while remaining open to other kinds. There are few towns and communes, imposing no limitations that would require considerable investments to overcome. Hence, the utility of places and their locational advantages will grow in price as scarce goods. The scarcity especially concerns the highly industrialized and urbanized areas.

A further limitation in the choice of location is the scarcity of foot-loose investments means. This concerns investments which are financed or partly financed by the government. In the state sector the investment involvement is still fairly high. The completion of economic objects and putting them to use will require big outlays. It will, however, discourage new investments from places unconnected with earlier ones. Together with the spatial and environmental limitations, the deficiency of foot-loose investments means will restrain macroscopic transformations of the spatial organization of the economy.

NEW PROPERTIES OF SPATIAL ORGANIZATION

In the initial period of transition, mass changes occur in the economic landscape, but usually at the microscale. Small trading businesses proliferate, taking advantage of the opening of the economy and the importing of goods which formerly merely trickled from Western Europe, ofen illegally or via so-called hawking tourism. The use of shop and office premises changes. New functions are introduced for those which were previously used ineffectively. This is an occasion for the renovation of buildings, which enhances their aesthetic value. Very often their owners leave their less well-paing jobs and become entrepreneurs. State enterprises and institutions, which have found themselves in financial difficulties, lease out their spacious rooms to reduce the maintenance costs of the premises and gain an additional income. There emerge new consulting agencies, new notarial offices, various organizations of economic self-government. The banking sector becomes very expansive, but still it cannot meet all the needs of the rapidly transforming economy.

Up to a point, the microscale changes can be absorbed by the existing spatial organization thanks to its adaptive abilities. It maintains its dynamic equilibrium and does not undergo any qualitative alterations.

Enerprises, households, self-government and government organizations make use of diversified space and spatial organization, but through their activity they produce a new diversity and a new organization. These agents influence spatial organization unintentionally through their decisions and activities, but if the organization assumes a specific form, they make use of it, and at times try to improve some of its properties.

Adaptive processes are hardly a result of the optimum behaviour of individual firms in space and their environment. Rather, they are processes of learning that big populations of existing and newly created enterprises have to go through. Since they occur in the conditions of a wider opening of the economy to the outside world, there is a tendency to take over the patterns that have proved successful in the countries with advanced market economies. The rate of adaptation varies with the sector and region. It is faster in sectors requiring lower investment outlays and in wealthier regions in which the tradition of a market economy has survived in better shape and in which enclaves of new entrepreneurial activity have developed.

The soft and hard elements of spatial organization change with different speeds. The soft elements (economic activity) change faster, the hard ones (infrastructure, production means) slower. Changes in the spatial organization of economic activity trigger changes in the spatial development of towns, regions, and the country.

Gradually, some areas, especially those which have qualities facilitating economic activity in the conditions of transformation, or those which cannot reorientate quickly and adjust to the new market conditions, show signs of deepening instability and disequilibrium in spatial organization. Some of its segments cannot absorb the expansive economic activity any longer, other lose

their economic functions and undergo degradation. These are processes bringing the particular segments of spatial organization to a point where structural transformations must be made in order to reach a new state of equilibrium. These processes can be described by bifurcation and catastrophe theory. Disturbances are more serious and transformations of spatial organization more radical when they are caused not by small economic and demographic changes, but by daring innovations in the political-economic system and large-scale investments (e.g. the construction of a new airport, modern border crossings, duty-free zones, motorways, etc.). Although they are restricted to relatively small areas, they can affect, to a greater or lesser extent, the whole of the country.

In what spatial shape can the economy emerge from the period of transition from a centralized to a market system? Several trajectories of the economic development of regions are possible, each leading to a different state of equilibrium, depending on their history, current state and the impact of external factors. The most probable is asymmetry between the expected revival of the economy and the recession that hit it in the period of crisis and the introduction of reforms. In other words, the path of initial growth, the path of decline, and the path of renewed growth will take different courses, will not repeat themselves. Asymmetry will be more pronounced in economic activity, its structure and technology, than in the built-up patterns of towns and regions. The new spatial shape will be modelled by a variety of processes. First, the regions that will be more successful in attracting new enterprises or new branches of existing ones will be those with less spatial and environmental limitations. It will be regions with moderately advanced urban-industrial agglomerations, offering considerable external economies and only moderate limitations. Economic revival can also embrace many small towns offering favourable conditions for the development of small and medium-sized enterprises. Secondly, although the share of transport in production costs generally tends to decline, making the transport tariff more realistic after the years of artificially low prices imposed by the centrally planned economy, will force enterprises to rationalize their freight traffic, e.g. by shortening the distances travelled. This may contribute to a higher closure of a regional economy. Thirdly, in the group of regions with fewer limitations and better chances the differences in the pace of development will widen. This will be so because in the period of transition enterprises will tend to respond to differences in infrastructure, production, services, labour market, research and development opportunities, and environmental conditions stronger than they used to do under the centrally planned economy.

The processes of the first and second kinds will work towards reducing regional variations in the level of socio-economic development, while those of the third kind will tend to reinforce them. In a reasoning anticipating the spatial shape of the reforming economy, the transition to the market economy, especially in its initial phase, may be an argument for accentuating regional differences. However, what speaks against this argument is the fact that the

restoration of this economic system is taking place under conditions dissimilar to those in which it developed originally. The dissimilarity consists e.g. in the mentioned limitations constraining agglomeration tendencies in traditional industrialized and urbanized areas, in the possibilities of the successful development of small and medium-sized businesses which find favourable operating conditions also far from traditional agglomerations, and in the formation of new-generation agglomerations.

Actual spatial tendencies could be possibly distinguished on the basis of empirical observations of the multifarious and multidirectional changes in the behaviour of enterprises, households, local governments and state authorities, and in the functioning of market mechanisms and institutions. It is already possible to notice certain patterns auguring new spatial tendencies. In particular, we can distinguish a group of regions with stagnating or declining tendencies, and a group of those which, having recuperated after the shock therapy, are entering the path of development. The first group includes: mining districts with traditional industries (steel and iron, metallurgy, chemistry), especially regions with depreciated infrastructure and production goods and a degraded natural environment, industrial centres until recently supplying the countries of the now dissolved COMECON, and centres of the armaments industry which have lost their markets with the dissolution of the Warsaw Pact. The transformation process has turned out to be particularly painful for agricultural regions with a high proportion of state farms. Those regions which are sparsely populated have found themselves in the worst situation. There are few farmers there ready to buy land from the government and the farmhands who have lost their jobs and can not find new ones because of the overemployment in the existing agricultural sector and the retarded industry and deficient services. This brings about several negative consequences, not only economic but also social and cultural. The other group embraces regions in which the class of businessmen and their network of economic (including foreign) contacts have formed earlier. As a rule, these are regions in which more advanced industries have developed, thanks to which they are more open to technological and organizational innovations. In some of them the natural and socio-economic environments are good enough to encourage people to settle and invest there. Such regions attract both domestic and foreign investors, and thus are able to take an advantageous position in the national and international economic networks. This may reinforce positive feedback and promote the development of positive cumulative processes. So far, the differences between the two groups of regions tend to widen.

There are also increasing differences at the lower, viz. local level of spatial organization. The factors that contribute to them include: 1) existing differences in local potentials and their attractiveness to investors, 2) unequal access to regional and national potentials, and 3) varying efficiency of local governments owing to differences in experience and qualifications of self-government personnel, and in their ability to integrate local communities around communal projects and to attract investors from the outside.

In the period of transition there will be many factors at work deforming spatial processes specific to a market economy. The most important are: a high level of monopolization of the economy, difficulties occuring when reviving private initiative, under-development of institutions favourable to the operation of a market economy (banks, stock exchanges, insurance companies, employment agencies), lack of reserves of construction sites and housing, a shortage of managerial staff experienced in the implementation regional policy under market conditions, revaluation of goals and change in the behavioural patterns of social groups, and finally, conflicts arising out of these revaluations and changes. For instance, the big-industry working class which initiated the radical political transformations has now assumed an ambivalent position on the privatization of state property (perceiving in it the threat of self--liquidation), while the country, which under the centralized economy demanded market freedom, now insists on more state interventionism. The action of these factors deforms the spatial processes typical of a market economy by reducing the spatial mobility of labour and capital, hampering the restructuring of regional economies, weakening the inclination to take business risks, and stifling the ability to initiate a new phase in regional development.

Another thing that changes in the period of transformation is the hierarchical relations in the spatial organization of the economy. In East--Central Europe the processes of disintegration of the lower hierarchical levels that are commonly taking place in European countries overlap with, the processes resulting from the rebirth of territorial self-government and the formation of interdependent though non-hierarchical territorial self-governments — central government system. The rebirth of territorial self-government integrates the local community, stimulates local initiatives and, in many cases, leads to the reconstruction or expansion of the economic base of small towns and communes constituting the lower rungs of the hierarchy. This holds back the progress of disintegration of this level of spatial organization.

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THE PLACE OF GEOGRAPHY IN THE STUDIES ON THE MAN AND THE EARTH SYSTEM

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ABSTRACT: The author discusses the place of geographical sciences in studies of the system "Man and the Earth". Nowadays this system is investigated by various disciplines starting from the earth and biological sciences upto physics, chemistry, economic, social, agricultural and technical sciences.

The geographical sciences should try to keep their central position due to their wide perspectives, both spatial (regional) and historical (genetic).

KEY WORDS: Man and Earth, environment, geography, ecosystem studies.

Geography as a science is concentrated on a knowledge of the origin and course in time of the phenomena occurring on the surface of the Earth. Their effects are multiscale spatial structures. Geography, or to put it more precisely, the specialized sciences derived from geography deal, or should deal, with the interrelations appearing in the Man and the Earth system as a whole.

THE MAN AND THE EARTH SYSTEM

Due to the definite chemical composition and the radiation balance, the surrounding lithosphere, hydrosphere, atmosphere and biosphere create on the Earth the unrepeated and priviledged conditions for the appearance of life. The exchange of energy and the circulation of matter between the oceans, continents and atmosphere in diurnal and annual cycles guarantee the maintenance of equilibrium in the environment, and the existence of the zonal pattern of all the components between the equator and the two poles. However, the changing external and internal forces in the system cause or provoke the formation of deviations and oscillations, mainly of a rhytmic character. Among them there are the 11 years solar spot cycles, precession cycles, up to the glacial and orogenic epochs. These rhytmic changes, as well as the catastrophic events passing the thresholds of the metaequlibrium systems, are the promoters of

the long-term transformations of both the physical and the biotic components of the environment.

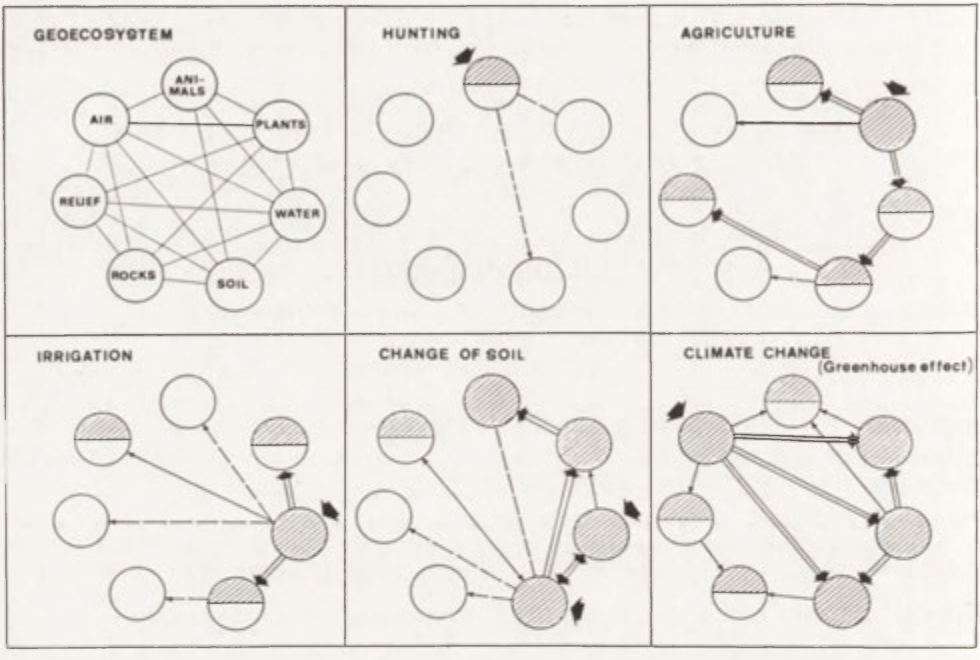

Fig. 1. Interrelations of various elements of the geoecosystems and types of human activity from paleolithic hunter to the global warming conneced with the greenhouse effect (after Starkel 1993b). The width of arrows indicates the intensity of impact. Full or half-shaded circles indicate the degree of degradation or pollution due to human intervention

At first, the appearance of *Homo sapiens* did not cause any substancial changes in the natural system. The pre-Neolithic tribes formed an integral part of the geoecosystems. The introduction of agriculture, soil cultivation and grazing, combined with the degradation of the natural habitats, caused an acceleration in the exchange of energy and matter, first on a local and next on a regional scale (Fig. 1). The industrial revolution disturbed the energetic balance of the Earth by introducing new energies and matter into the cycle. Man of the present-day era of atomic energy and biochemical revolution has begun to act as one of the main factors of global change. Therefore, we may speak of the Man and the Earth system. In this system there exist connections and feed-backs not only between the natural components (elements of the ecosystems, land-ocean interrelations), but also between the natural structures and the defined human activities (agriculture, settlement, industry, mining, etc.). The initial influences, acting on a local or regional scale, have been changed at present into a chain of cause and effect on global scale, leading to an increase of gases, manifested in the rise of the greenhouse effect, to the ozone hole, as well as to the expansion of the arid zone and the shift of other ecotones.

THE EVOLUTION OF KNOWLEDGE OF THE MAN AND THE EARTH SYSTEM

Traditional geography rooted in antiquity all the natural features and events appearing on the Earth, as well as various products of human activity. The geography of the industrial epoch started to explain the causes, to characterise the areal pattern and put all the observed features in an evolutional chain.

In the recent centuries it is even more difficult for a single researcher to embrace the whole complexity of all physical, chemical, biological and anthropogenic phenomena. For that reason, a general geographical, or even a general environmental knowledge was not sufficient. From the united geography specialised disciplines, such as geomorphology, hydrology, soil science etc, were separated. In the middle of the present century the role of the leading research workers of the whole Man and the Earth system was overtaken by other earth and biological sciences. Ecology originated and knowledge of the physical and chemical nature of events and features was possible only due to the introduction of such sciences as physics and chemistry (cf. IGBP 1990). The shrinking of natural resources required their rational management, especially of those that are unrenewable (Clark et al. 1987, Kozłowski 1991). At the same time the agricultural, economic and technical sciences joined the research of the Man and the Earth system (Boer and de Groot 1990). The challenge of the education of individuals and societies who would protect nature and manage the natural resources scientifically caused the interest and inclusion in this environmental orbit, of the social sciences such as sociology, history, spacial planning, and even ethics and theology (cf. Surprising future 1987). The study of the Man and the Earth system and the taking of steps to rescue the disturbed equilibrium of the environment has begun to be the leading goal uniting the diverse sciences (Fig. 2).

THE PRESENT POSITION OF GEOGRAPHY IN CENTRAL-EASTERN EUROPE

Which place should geography and geographical sciences (still incorporated in geographic departments) occupy in the investigations and explanation of the great diversity of the Earth and Man system in space and time?

The strong side of the Polish and neighbouring geographies in Central--Eastern Europe is a spatial look at this phenomenon and a regional approach. On the contrary, the genetic and historical approach of the contemporary human and physical geographers is rather weak. I do not think on specialists in hydrology, climatology and geomorphology. Especially in the geomorphology and soil science there are very distinct connections with the past epochs, from which many relief and soil features, still preserved in the existing geo-ecosystem have been inherited (Starkel 1992, 1993b).

Other weak points of our geography are the lack of relations between the investigations carried out on a global scale and the avoidance of prognostic

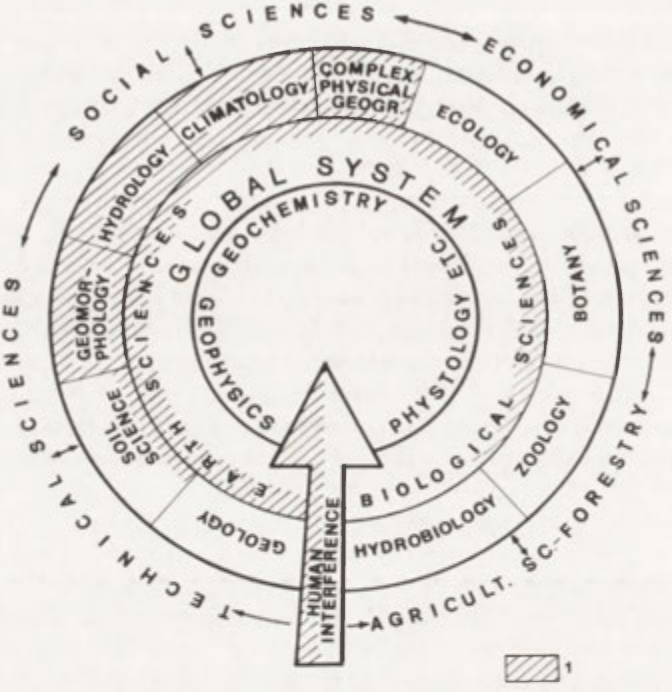

Fig. 2. Place of geographical sciences in studies of the Man and the Earth system
1 — the area of studies controlled by geography departments in Poland

problems. There are several theoretical approaches of individual scientists (A. S. Kostrowicki 1992), but these directions are still not present in the dissertations and team studies of our geographers. This situation is slowly changing, of course. A much better situation exists in this field in several western countries such as Great Britain (Goudie 1977, Gregory and Walling 1987, Clark et al. 1987). In fact, our knowledge in the field of the related sciences (even geographical ones!) is very poor and, therefore, frequently we put very superficial questions and we are not able to follow the teams from the geophysical and biological sciences.

Parallel to that we have observed for decades a disintegrational tendency and specialization (an expert on the suspended load, on railway transport, etc.). The widest research fields: the study of the Man and the Earth system and the evaluation of natural resources has been left for others (Boer and de Groot 1990).

The representatives of physical geography are experts in typological classifications (Richling 1992), but they investigate mainly, small fragments of the natural environment in detail, sometimes including human intervention. Preserving the historical and genetic approach, they may be able to join the studies on global environmental structures, but, only after a modernization of research methods (Gregory, Walling 1987, Clark et al. 1987).

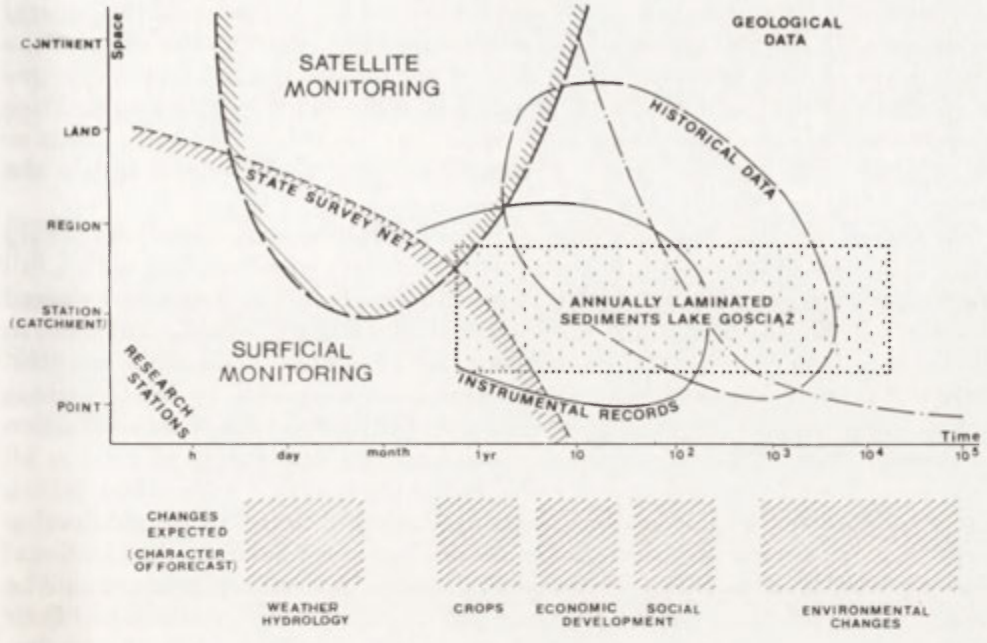

Fig. 3. Monitoring of environmental parameters in different time and spatial scales. Use of various time scales for forecastings of environmental, economic and social changes

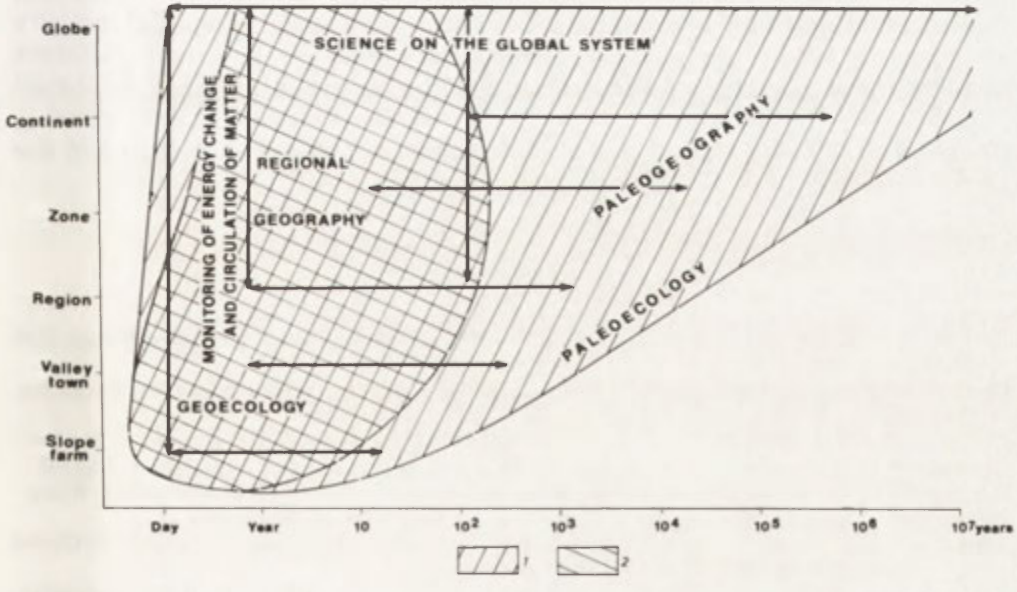

Fig. 4. Scales of research and correlations in the geographical sciences
1 — area of physico-geographical studies; 2 — area of socio-economic geographical studies

Our social geographers investigate the social and economical phenomena in a relatively short perspective of time, mainly without relation to the natural environment. The initiatives of S. Leszczycki (1974) such as the atlas of the degradation of natural resources in Poland or exensive studies on the changes in landuse by J. Kostrowicki (1986) do not have many continuators. More frequently these are repetitions of the problems undertaken by economists or sociologists with one exception: geographical studies introduce widely the "geographical method" of spatial differenciation.

What will be the future of geographic research in our countries? We should enter much more strongly into the interdisciplinary problems but with a full conscience that we will never prevail in this research. The programs steered by UNESCO (Man and Biosphere), UNEP, ICSU (IGBP-Global Change) are in the hands of the representatives of biological, geophysical and other sciences. Only the Human Dimension Programme (HDP), supported by ISSC, creates full possibilities for human geographers to enter the first stages of realisation (Jacobson, Price 1990). Nevertheless, our geographical points of view in all investigations on the environment and man may insure a wide scope, taking into consideration all the interrelations in space and time. We should develop a global point of view on the environment also in our didactic and educational activity in relation to various branches of society. Special attention should be paid to the development of geographical studies of natural resources and their management by an extension of the methods of complex monitoring, undertaken by multidisciplinary teams. The monitoring should cover various scales in space and time (Fig. 3). Another area open for geographical research may be the correlation of the data compiled on various scales (both in space and time), including the geographical information system (GIS), spatial imagery and superficial stationary measurements, as well as those stored in different historical and geological records (Fig. 4). The geographical sciences should participate in the construction of prognostic model (Domański 1993), covering the relations between processes and phenomena, active in the Man and the Earth system.

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ON A NEW APPROACH TO THE THEORY OF SETTLEMENT SYSTEMS

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ABSTRACT: The present discourse demonstrates the thoughts related to the possibilities and consequences of an adaptation for the geographic settlement systems research of the methodological approaches and concepts taken from natural sciences, especially the concept of deterministic chaos along with the concept and measures of entropy.

KEY WORDS: settlement system dynamics, supra-national urban system.

Reading the literature on modern methodological and conceptual approaches in mathematics, physics, cosmology, biology and philosophy of sciences, it is easy to observe that such approaches may be transferred with some success usufully to studies in geography and spatial economy. This is especially evident in the field of settlement systems as well as of urban ones.

In geography the Einsteinian concept of "timespace" is already widely used. Bertrand Russell, in a short book published in the early twenties to popularize the Einsteinian theories, stated that, the full application of the timespace concept involves replacing the term "element" with a different one of "event". Russell incidentally considered the introduction of the timespace concept to be the greatest scientific achievement of Albert Einstein. In geography we should speak now of settlements, cities or regions not as elements but as events. They begin, grow and develop, dissolve or vanish. Such a replacement in terms will make the application of another important concept — one of a "process" easier and more effective.

Still another concept which — thus far it seems to me — has not been transferred to geographical reasearch is that of a "deterministic chaos". Physicists, as well as cosmologists, introduced it when they had to face the problem of uncertainty developing in mechanistic models used for the description of real phenomena and events. To overcome such difficulties they turned to probabilistic calculus and analysis.

Returning to the interpretation of geographical events, it is easy to assume that often they develop in conditions of a deterministic chaos. However such

an assumption does involve some changes in the construction of the systemic models. So far in geography the construction of such models has been based on reductionist assumptions. Starting with an identification of single phenomena — elements or events — these were connected by observed relations and then larger units were established and finally the whole model was constructed. On the other hand, the introduction of a new concept of deterministic chaos demands an holistic approach. It is necessary to consider first the whole system as given and then to identify within the events and structures together with their mutual relations. At the same time, we assume "a priori" that we shall not be able to identify (and count) all such events, structures and relations. As a result in the whole system there exists a characteristic lack of full determination. There exists at least a partial chaos or, in other words, a deterministic chaos.

Now we have to face the question, as to whether it is possible to identify and to measure the dimension of such chaos? To answer this involves, however, the introduction of still another concept (term) of "entropy" into the system. This opens still further questions: how to define and measure its size? what indices should be used and, finally, when the system is in full entropy (which would imply its dissolution or death).

An effort to answer those questions shall be limited here to the field of settlement sysems only. Problems of entropy in the theory of settlement systems is not really new. Already, in the sixties and seventies, the concept was used for the interpretation of observed regularities in the distributions of urban communities in specific regions or countries when ordered according to their size (the so-called "rank and size" rule). A thesis was then formulated that such distributions reflect the relative entropy of a stabilized settlement (urban) system. With such a statement — questioned by some scientists — the relative entropy would be measure of the stability of a system. Therefore, each stabilized system would possess its own characteristic relative entropy. The critics of such proposals considered, however, that the stability in structure and modelling of a system reflects rather the degree of selforganization in such a system.

When we assume the existence within the settlement system of a deterministic chaos, logic leads us to consider the size of entropy as a measure of the size of chaotic conditions within the system. Then the measure of the entropy itself may be found in the proportion between the chaotic parts and the parts with identified structures within the whole system or the corresponding percentages.

Theoretically the state of full entropy would be reached in a settlement system with a total and even distribution of population and settelements throughout the territory of the system. On the other hand, the full concentration of the population in one point (one city) would imply the lack of any entropy.

On the basis of such assumptions and observations, an increase or decrease in entropy should be connected with the growth or fall in the number and size of settlement units or, in other words, in the settlement structures. Such conclusions imply that there are possibiblities for different definitions of measures for entropy in the settlement systems.

For instance: one of the simplest among many possible measures would be the percentages of population living (settled) outside the administrative boundaries of cities, i.e. of rural population. Similar measures would be percentages in the dispersed rural settlements of population living in settlements below some specific number of inhabitants. In other words, as measures of entropy may serve all indices related to some specific degree of concentration.

The indices of surpluses or deficits in number of population in relation to the actual potential of functions and functional structures of cities would be a more involed measure. Here an index of unempolyment may be also included.

Different but dynamic measures of entropy may be found in analysis of migrational movements. But for such purpose a more advanced classification and typology of such movements is necessary. There are various migratory movements: temporary, seasonal and permanent, one-way and return, also repeated ones. Not all migrations reflect a changing entropy within the settlement system. The strongest changes are due to permanent, one-way ones (including ones spread over a short period of time i.e., over few years). On the other hand, migrations taking place constantly in time usually reflect specific structural characteristics in the settlement system. Then only sudden larger changes in their intensity will be connected with a permanent change in entropy. All these remarks pertain both to the in- and outflows of population.

Among the one-way migrations, disturbing or radically changing the entropy in a settlement system a special role and significance is played by the foreign migrations. They are important in both directions i.e. immigration and emigration, to or from abroad. In cases of great intensity, they destroy completely and for long years the internal stability of the whole settlement system leading to large increase or decrease in entropy. They change, or even transform completely, the structure of the whole system.

A single, integrated and complex index of entropy could be constructed with help of probabilistic calculus and computers but the full information on the characteristic (dimensions) for all (or at least a majority) of elements and events in the system which would be needed is at present unavailable. Gathering, this would involve a major effort in organization and research.

By the measurement of entropy and its changes, it is possible to study the disturbances and eventually the dissolution, partial or total, of the settlement system. On the other hand, the opportunities for observation of formation, growth and development of settlement structures and systems are limited. Such events may be defined as a phenomenon of so-called "negentropy" but the application of this new concept (formed by negation from "entropy") does not lead yet into the identification of the causes of such phenomena.

Here a weak theoretical construction may be based on processes of concentration both of population and in settlement. A weak one because it does not identify conditions and ways for the emergence of the concentration itself. Here additional analyses — geographical and historical, sociological and economical — are needed.

Stronger theories may be constructed with use of an idea that specific superstructures do arise in conditions of deterministic chaos by way of selforganization. An increase of chaos in settlement system, in the form of the disintegration and fall of earlier developed structures and smaller systems, leads quite often in specific situations to the development of additional superstructures. Within these the former decaying structures and settlements may be redeemed with new functions and renewed vitality.

These speculative statements may be relatively well illustrated by contemporary changes in settlement structures and systems. In Poland, even without an identification of the causes, it is possible to observe the disintegration of an historically developed network of central places on one hand and of older industrial patterns of settlement on the other. We are facing, in fact, an increase of deterministic chaos within the settlement system. At the same time, the metropolitean areas and industrial conurbations are spreading. This implies the birth of some new superstructure. Moreover, at the higher level of settlement pattern there is a significant decrease in importance for national settlement systems (with their capitals and main urban centers) and, sign of the growth of a new superstructure which may be called "supranational urban system". From this point of view, it is interesting to observe the formation of capital urban system for the newly established European Union (Brussels, Luxembourg, Strasbourg, London, Amsterdam, lakely Frankfurt am Main, but so far leaving aside such important historical capitals like Paris, Berlin, Rome or Madrid). The network of centers connected with functioning of the United Nations Organization (with such centers like New York, Geneva, Paris, Rome, Vienna, Addis Abeba and Rio de Janeiro) seems here to be of smaller importance as limited basically to political functions only.

Now a curious reversal of the original assumptions should be noticed. In the beginning it was stared that in a settlement system there may develop some kind of deterministic chaos — now we are discussing how, in a given system, characterized by a state of widely spread chaos there arise new relations and structures. In such an analysis, the boundaries of a system have to be assumed "a priori". They may be connected either with natural or formed by human frontiers. Usually in the geography of settlement they are identified with some administrative boundaries, whether of states or other regions. They may be assumed also, more or less, at will. But in such cases they have to be verified during the course of research. However, it is necessary to have some reason for such assumption because, even in very highly chaotic systems, they have to be closed in some respects.

Another paradoxical characteristic of the new theoretical approach lies in possibility of discussing the settlement system without use of such concepts as "city" or "settlement". They may be abandoned in favour of such as "point" or "area" of concentration. However, when we turn to an area of concentration as a separate system the return to traditional terminology becomes useful or even unavoidable.

In this extremely short presentation, the possibilities of a new approach to the theory of settlement systems were explained. They seem to be interesting as they open new perspectives for research and make way for more ambitious programmes of future studies.

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RETAILING AND URBAN MANAGERIALISM: PROCESS AND PATTERN IN ŁÓDŹ, POLAND

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ABSTRACT: It is argued that positive explanations of retail location in Polish cities have simply described spatial patterns and have inadequately explored causative processes. Central to the latter is the concept of urban managerialism. The paper focuses on the Łódź managers, or gatekeepers, who have laid down the rules for privatisation, drawn up minimum bid-rents for different zones, and have discriminated in favour of certain types of shop. Recent retail changes in the main shopping street, Piotrkowska, are analysed, and an assessment made of the role of the urban managers.

KEY WORDS: bid-rent zones, Łódź, privatisation, retailing, urban managerialism.

INTRODUCTION

The introduction of the market economy in Poland in 1989 has given rise to fundamental changes in the economic system; some developments have been negative none more so than in manufacturing — but in retailing the events have been unquestionably positive. In the Łódź *województwo* alone the number of shops in both the public and private sector combined increased from 5297 at the end of 1990 to 8800 at the end of 1991 (Wojewódzki Urząd Statystyczny w Łodzi), and such rapid transformation is probably universal in Poland. While this doubtless represents a natural talent for entrepreneurship, there are sound economic reasons why retailing should have been singled out in this manner. Start-up costs are low, no particular skill is required in contrast with manufacturing, and the market is captive in the sense that shoppers in one city are not likely to divert all their retail spending to another. In this way the powerful foreign competition faced by Polish manufacturing industry does not affect retailing.

However, simply because retailing is operating within a market economy,

it should not be assumed that it does so without reference to the Polish institutional framework, for quite apart from the legal system, ground rules have been established in the first place by central government, and these are interpreted and executed at lower hierarchical levels by urban bureaucrats. In tracing recent changes in retailing with respect to Łódź's principal shopping street, Piotrkowska, this paper documents the role of the urban bureaucrats, or managers, in the *process* that has given rise to the spatial *pattern* on the ground.

URBAN MANAGERIALISM

Early work on retailing was firmly placed in a positivist mould, following on from Christaller's (1933) pioneering work. Shops' location was determined by the size of their customer threshold, by the distance that rational shoppers were prepared to travel, by their need for nodality and by rents. Elegant mathematical models were constructed, describing spatial patterns which were assumed to appear without being subject to decision-making by governments and by cities, or to the rich variety of entrepreneurial and customer behaviour (Berry 1967). The tendency has persisted, as may be seen in the work of Polarczyk (1976) on Poznań and of Chudzyńska (1981) on Warszawa. At least Grocholska (1975), in building a mathematical model of influences on urban land use in Warszawa, does recognise the importance of government directives and of planners' ideas, but is unable to include them in her model.

Dissatisfaction with this approach gave rise to behavioural analysis and the notion of the 'satisficer' taking decisions which were 'good enough' (Pred 1967), but the realisation that decision makers such as retailers have constraints placed upon them at the settlement level, prompted researchers to consider the role of urban managers, or gatekeepers, in the location process. These actors include not only local government officers and elected members, but also solicitors, financiers and estate agents, who open the gate for those who are seen to qualify, and close it for them who do not (Gray 1976; Leonard 1982; Williams 1982). Much of the work on gatekeepers has been concerned with the allocation of housing (Bassett and Short 1980), but this is not to say that their influence on retailing is muted. They are involved with planning permission, with the implementation of local policy on shop type, including supermarkets and department stores, with the quality of shop fronts, and with construction of new shopping areas, to say nothing of the issue of compulsory purchase orders (in the UK) which result in change of land use to retailing.

In socialist economies, where there was greater emphasis on central control than in market economies, the powers of the urban managers were rather weak, effectively requiring the study of managers at the national level. Little work appears to have been undertaken by geographers in this field, but preliminary findings indicate that in Poland state shops were grouped under the control of five associations similar to those in manufacturing (one was

solely concerned with delicatessen), and these were responsible to the Ministry of Commerce. However, different levels of investment were applied to various regions at particular times as part of development policy, further complicating geographical patterns. The ideological bias against consumerism caused retailing to receive scant investment, suburban areas not to be allocated "appropriate" retailing capacity, and central areas to become the local shopping centre for entire cities (Prawelska-Skrzypek 1988). The absence of a rent gradient and of competition (Turnock 1989) ruled out the application of market forces, which lay at the very heart of Christaller's system of central places. It is therefore interesting to find that the retail hierarchy in Warszawa closely resembled Garner's model based on land values (Chudzyńska 1981), but it cannot have been derived from the same process. Against the weight of such powerful constraints upon retailing, it is difficult to understand the rationale of studies which examine pattern and ignore the underlying processes which give rise to that pattern. That we should want to understand causative influences is understandable, but that the realist approach, which encapsulates this aim, was not formally introduced into human geography until the early 1980s is rather surprising. (Sayer 1984).

Attenuated though their powers may have been under communism, urban gatekeepers nevertheless played a part in the geography of retailing. Some elements of control, for example, relating to the physical structure of the shop, were delegated to cities (Zarząd Miasta Łodzi). Equally, private retailing, which existed as a legacy of prewar ownership, and which was obliged to rely uppon the state distribution system which gave priority to supplies to state and cooperative outlets, may also have been influenced by local controls. Certainly, powers to allocate shops to private individuals were so delegated; in fact decisions concerning private applications to open shops of less than 100 m^2 floorspace were taken by the *dzielnica*, that is, the lowest level of the administrative hierarchy. Private applications for shops of more than 100 m^2 floorspace were dealt with at the City level (Zarząd Miasta Łodzi). The retail clusters identified by Chudzyńska in Warszawa are therefore unlikely to have been the result of market forces which generate notable speciality agglomeration in Western cities, but rather the result of decisions by national and urban gatekeepers.

THE EXPECTED CHANGES AFTER 1989

The relaxation of central controls after 1989, giving individuals considerable freedom of action, might be expected to change the spatial characteristics of urban retailing in several ways. Competition would remove many (but not all because of the local population density) lower order daily need shops from central areas, their places being taken by higher order retailing more dependent on nodality. Within central areas, locations perceived to be most advantageous by retailers would generate the highest order shops, some of

which might be foreign. And on the grounds that the former system was insensitive to shoppers' requirements, a substantial change towards goods for which there was a strong demand would be expected. Outside central areas low order shops, some of which were squeezed out of central areas, would appear, to provide better neighbourhood provision. These four thrusts are predicated on three fundamental changes in process: that a free market should exist, that shops controlled by the state and by cooperatives could become private, and that the notion of spatially differentiated rent be introduced. Urban managers received delegated authority to structure this latter exercise, and at a stroke their powers equalled, and arguably surpassed those of Western managers. They were charged with the responsibility of selling off the entire stock of state-run shops, at particular rents to particular tenants at particular times at particular locations. No such power had ever been vested in gatekeepers in the West.

THE FIRST CHANGE: STREET TRADING

In practice, immediate espousal of the market gave rise to change of a most primitive kind, not involving shops as such, but rather individual street traders, whose activities were almost entirely free of external control. Appreciating the need to display their goods to the maximum number of potential customers, the traders flocked to Piotrkowska, as indeed they did to railway stations, especially Kaliska, in the city. The way they lined Piotrkowska bore an uncanny resemblance to the behaviour of Hotelling's (1929) ice cream salesmen on a beach in summer, each realising that to cluster at the best perceived sites might cause such confusion that exposure to shoppers would be completely lost; hence late-comers simply spilled out to the edges of the best sites to find a site where they would be visible to passers-by. The Polish decision to accept a free market had thus created the simplest form of retailing and individuals related to this by establishing their own spatial system. Meanwhile the Łódź gatekeepers were invisible.

Until 1992 licences for street trading were easy to secure, although not all traders applied for a licence, and for a short interim period the phenomenon was much in evidence along Piotrkowska. Very little capital was required — just enough to buy a few packets of cigarettes or a few cans of Coke for instance — no outlay on premises was necessary, although some traders did use a table for display purposes, and they possessed freedom of mobility. This much could be observed, but work undertaken by students from the University of Portsmouth revealed a number of interesting characteristics. Predictably traders were found to congregate at nodal points even along the busy Piotrkowska, but what was not predictable was that locations on the east side of the street were very much more popular that those on the west side. Since the surveys were undertaken in March 1990 and March 1991, it was concluded that the presence of the afternoon sun on the east side and absence on the other was the

overriding factor. Traders were discovered to cluster outside large shops and department stores, and in some cases immediately inside such premises, to capture shoppers' attention in a parasitic fashion. Some traders were found to take up different locations during the day, while others did not appear every day (one, a student, said he traded only when he was short of cash or when he had no lectures!). It was evident that even among traders a hierarchy existed, ranging from someone standing holding packets of cigarettes or a few scarves, to people with goods on a cloth placed on the pavement, to traders with tables and others displaying articles, often imported, in the boot of their car. It was noticed that there was a relationship between the age of the trader and the type of goods sold, younger people selling items such as tapes, cigarettes and jeans, likely to appear to a youthful market, while older people concentrated uppon clothing, craft objects and flowers. A relationship was also found between goods sold and gender, men preferring to sell electrical equipment, tools and gadgets, and women clothing, flowers and vegetables. Attempts were made to establish whether there was a price gradient along Piotrkowska which might have reflected the competition for the best sites, and therefore of potential rent, but the results were inconclusive.

Street trading is an important part of post-1989 Polish retailing history and deserves more attention that it has received, but the work undertaken in Łódź certainly demonstrates the fundamental importance of individual decision-making. Large-scale street trading came as close to the notion of perfect competition as is feasible; that it proved to be a short-lived phenomenon was due to the action of the urban managers, who were effectively demonstrating that the free market operates within constraints.

THE SECOND CHANGE: BID-RENTS AND COMPETITION FOR SITES

It could be argued that the appearance of street traders was the informal result of an imbalance between supply and demand under socialism, but a much more formal system of competition involving shops was obviously required. So in place of the former controls exercised by the state and possibly the city, with their powers under parliamentary legislation of 1990, urban managers now created a new privatisation framework for retailing, based on competition for location, but yet based on the rules set up by themselves. In this sense it may be seen that the "free market" is a concept, not a reality. Decisions are made as to which state shops are to be leased at a particular time (the purchase of shops is not on the agenda at the moment, possibly because of doubts relating to ownership), and the details, including floorspace, equipment and former function, are announced in the press. An auction is then held at which entrepreneurs bid against each other, the rent payable being the highest bid. A minimum price per m^2 is imposed by the managers as a guideline. This minimum price, which is what the gatekeepers think is a reasonable market price, varies according to location and function. Five zones (*strefa*) have

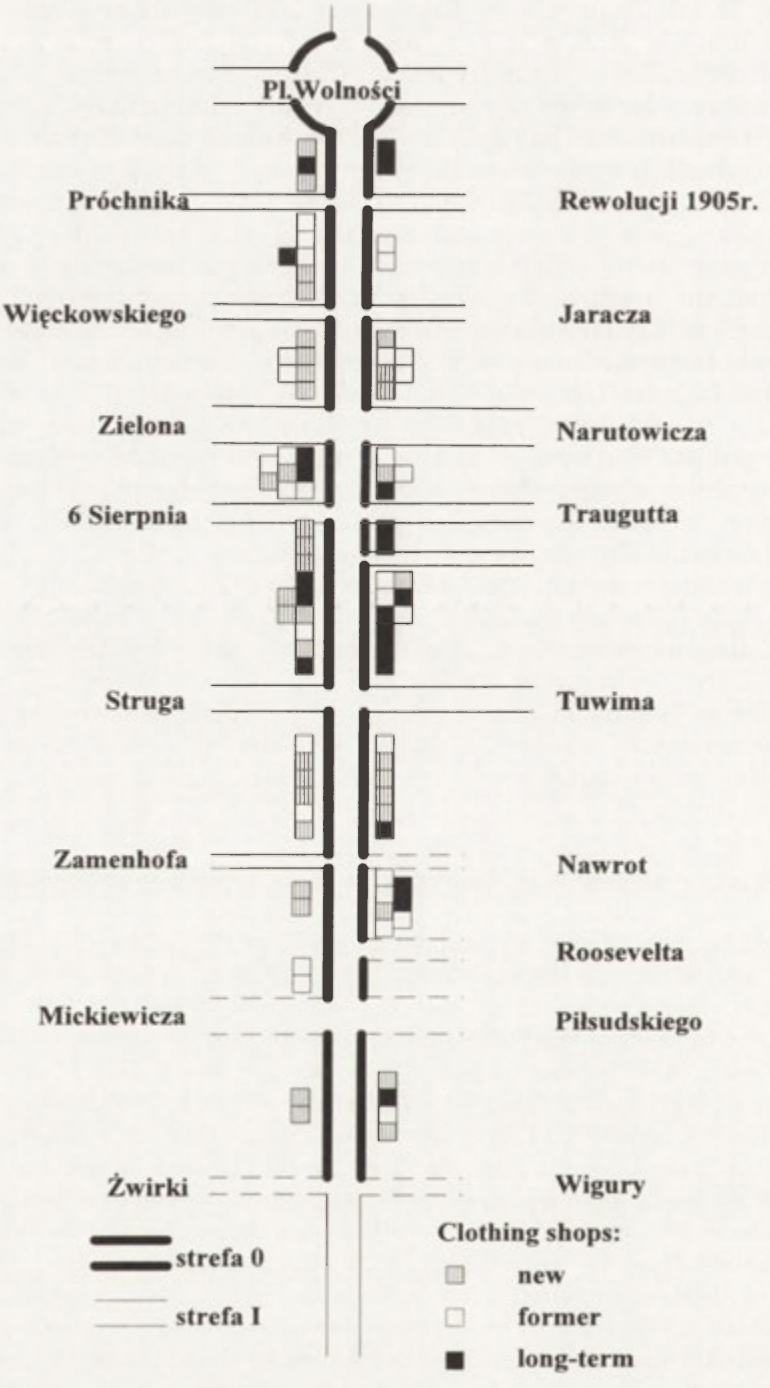

Fig. 1. Change in clothing shops 1989-1993, Piotrkowska street, Łódź

been drawn up for the city. The inner zone, *strefa* 0, comprises properties facing on to Piotrkowska between Plac Wolności to the north and Zwirki-Wigury to the south (making it the same as the study area). Strefa 0 and part of strefa 1 are mapped in Figure 1.

As may be seen in Table 1, there are different minima for particular retail functions. The divisions are purely arbitrary, but as a result it is likely that restaurants, bookshops, picture galleries, opticians, hairdressers and even milk bars will be more numerous in Łódź than would have been the case had all retail outlets attracted the same minimum rate. The situation is complicated further by the existence of vertical rent differentiation. Basements, second floors and above in *strefa* 0 are classified as being in *strefa* 1, while yards and courtyards in *strefa* 0 are treated as being in *strefa* 2. It is apparent from Table 1 that for standard shops there is a substantial differential between *strefa* 0 and 1, offering considerable advantages to sites on roads entering Piotrkowska. In the reverse direction it seems that the urban managers want to attract restaurants, bookshops, picture galleries, opticians and hairdressers to Piotrkowska since the differential between *strefa* 0 and 1 is small. A further constraint on the "free market" is the managers' decision to ensure that groceries retain their function even when they are privatised. Should the minimum price not be reached at the auction, the site is advertised again at a lower price. Four months' rent in advance is a condition of the lease. Although no information is available on the methods employed by tenants to raise the necessary finance, it is clear that the requirement to find rent in advance and cash for stock introduces the role of the bank manager as a gatekeeper. He must assess the creditworthiness of the prospective retailer, whose request may be rejected.

TABLE 1. Minimum bid prices, '000zł per m^2 per month (1993)

	Strefa 0	Strefa 1	Strefa 2
Standard shop	200	25-50	20-35
Restaurants	70	35-65	35-60
Bookshops, picture galleries, opticians, hairdressers	50	20-40	15-30
Milk bars	12	9	6

Source: Zarząd Miasta Łodzi

Potential tenants must weigh up the merits and demerits of this rent framework, and clearly not all will come to the same conclusion. Additionally, an important random element is present, for particular sites are selected for leasing at particular times, and are likely to be taken by people who happen to be in the market at that time. A futher behavioural complication is that the framework described is subject to change. Thus the managers admit that while

the boundaries of *strefa* 0 reflect the demand for inner zone sites whith reasonable accuracy, the other four zones cover too wide a spectrum of land uses and accessibility. There are plans to modify the *strefa* map to create 13 zones, and to increase the minimum bid price of the standard shop in *strefa* 0 to 500 000 zł per m^2 a month. If this is put into practice, it will cause less profitable shops to leave the zone, helping to change Piotrkowska from Łódź's general shopping area as it was under socialism, to one of specialist retailing on the 'western' model of central area retailing. The decision by the City to pedestrianise and to rebuild Piotrkowska between Struga-Tuwima and Zamenhofa-Nawrot in 1992 to a high standard will unquestionably increase the desirability of this section. Bid prices will reflect this, high order shops will be attracted and low order shops will leave. The urban managers, acting within the market economy, will thus have been responsible for the location of the highest order outlets in Piotrkowska, and in the Łódź retail hierarchy. Enough has been said to justify the contention that attempts to analyse spatial patterns, without considering the gatekeeping processes involved, can hardly be fruitful.

PIOTRKOWSKA: THE LOCATIONAL PATTERN OF RETAILING

OWNERSHIP CHANGE

Data collection for the study comprised a shop-to-shop survey; it was not always possible to establish the former function and ownership of every outlet. Of those 214 shops for which data were available, some 78% were formerly state-run, 17% were private and 5% were cooperatives. By March 1993, 83% were private, 9% were cooperatives and only 7% state-run. The increase in the importance of cooperative shops was not expected, but this may be a method of risk-spreading. That only 7% of shops are state-run indicates that the privatisation process is nearly complete.

OWNERSHIP AND CHANGE OF GOODS SOLD

Privatisation has been accompanied by a substantial change in goods sold. Some 64% of shops moving from the public to the private sector changed their goods. Considerations for the new tenants such as the nature of the fittings and of 'goodwill', that is, the extent to which shoppers become used to the presence of a shop selling particular items, do not seem to have been very important. However, this may not have applied everywhere, for of the 11 bookshops only 1 lost its function, of the 5 picture galleries only 1 changed, and all 3 privatised restaurants remained so. As Table 1 indicates, all these types of shop attract lower minimum bid-rent prices, and the retention of these functions must in part be due in large part to the action of the urban managers.

By contrast tenants of shops always in the private sector have been very

active, some 80% changing the goods sold. Doubtless in the new economic climate the shopkeepers could see that it would be foolish to continue selling the relatively unprofitable items supplied to them by the former regime. Even 65% of the remaining state shops changed their products.

CHANGE IN SHOP TYPE

Data under this heading appear in Table 2. Because of the discrepancy of data for each period it is more productive to consider the percentage scores. The similarity between the two sets of percentages is quite remarkable, suggesting a relatively stable situation. However, when shops with smaller numbers are considered, there is evidence that higher order functions are increasing: the number of jewellers, pharmacies, cosmetic shops and florists actually doubled. In the reverse direction a number of low order functions have disappeared: greengrocers, dairies, hardware shops, bread shops and dry cleaners. It is justifiable to argue that the retention of a substantial number of food shops is a result of the urban managers' policy of trying to retain such functions.

TABLE 2. Principal shop types, Piotrkowska street

	Former	%	Present	%
Clothing	49	22.1	69	24.5
Food	22	9.9	23	8.2
Electrical	12	5.4	16	5.7
Shoes	11	4.9	12	4.3
Books	11	4.9	12	4.3
Bars	9	4.0	13	4.6
Total	222	100.0	281	100.0

Source Survey

CHANGE IN GOODS SOLD, BY SHOP

In Table 2 shop types are aggregated and stability is suggested. But when each shop is considered individually a very different picture emerges. Thus although the share of electrical shops in the two time periods is very similar, it can be seen from Table 3 that the shops which now sell electrical goods are effectively not the same shops which sold such goods previously. In other words, 92% of electrical shops have only recently begun to sell these goods. Clothing is not such an extreme case, but more than half the shops now selling clothes did not previously do so, while a similar proportion of former clothing shops now sell something else. The situation is fairly similar for shoes. A more stable

situation is to be found in food shops, although half the former number have ceased this activity, but only in bookselling is there real stability. Such dramatic changes are to be expected in a period of rapid political and economic change, but these powerful processes at the national scale have been modified by the urban managers who have drawn up special rules for food retailers and bookshops.

TABLE 3. Change of functions by individual shops

	% (clothing) shops ceasing to sell (clothing)	% (clothing) shops starting to sell (clothing)
Clothing	59	63
Food	45	25
Electrical goods	93	92
Shoes	45	40
Books	10	18

Source: Survey

The dynamism of these changes at the level of the shop is emphasised by Figure 1 which depicts the clothing sector. One block (Jaracza-Narutowicza) completely lacks stability, while three others have only a single shop whose function is unchanged. The Traugutta-Tuwima block has the greatest mix of opening, closure and continuity, but the map does suggest that the greatest gains have been made in the pedestrianised sector between Tuwima and Nawrot. The hand of the urban managers must once again be considered as an influence.

KIOSKS

The 6 former Ruch kiosks have been privatised, but of more significance has been the appearance of 35 new kiosks of a standard format approved by the gatekeepers. Unlike the Ruch kiosks, which sold a variety of goods, the new kiosks are much more specialised, no less than 19 selling food and drink; 5 sell tapes, and 4 clothing. Now that street traders have largely been banished, the kiosk represents the easiest way of entering the retail business, and is therefore at the base of the hierarchy (unless this is regarded as the market stall in a covered or non-covered market). The location of the kiosks is readily controlled by the gatekeepers, and the spatial patterns, namely the notable clusters at the north end of Piotrkowska (15 kiosks) and at the opposite end, south of the pedestrianised precinct (18 kiosks), is a further indication of the control process operated by the urban managers.

CONCLUSION

Essentially this study has been concerned with two issues: the ecological sorting of shops to fit a market system preceded by an interlude of street trading, and the extent to which this process has been constrained by urban managerialism. It has been demonstrated that Piotrkowska's function as a general shopping area for Łódź is changing to that of a more specialist zone as lower order retailing begins to give way to higher order outlets able to justify the higher rents payable because of competition for sites. As part of the process there have been substantial changes in the goods sold by particular shops as new tenants search for what they perceive to be profitable lines; some areas of retailing, such as electrical products and clothing, illustrate this transition stage very well. However, these events have been constrained by urban managers who have set out the ground rules. It was they who brought street trading to an effective conclusion and who accepted the kiosk as a viable alternative. It was they who have determined the speed of the privatisation process by releasing blocks of shops at particular times. It was they who instituted the system of bid-rents with spatial minima based on the strefa, which they set up according to their own perception of land values. It was they who drew up differentiated minimum bid-rents according to the type of shop, to bend the market system ensuring the presence of partiular forms of retailing in Łódź's main shopping street. It was they who, by acting in a socially responsible fashion, have been responsible for the continuing presence of more food shops than might otherwise be expected. And finally, the construction of the precinct, which is likely to become the high order retailing core of Piotrkowska, is the most visible indication of the importance of the city's gatekeepers. If geographers wish to unravel the causes of spatial patterns, rather than merely describe them, then the study of urban managerialism becomes an essential prerequisite for the understanding of spatial phenomena in the city.

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RECENT BIOCLIMATOLOGICAL STUDIES IN POLAND

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ABSTRACT: The study presents the results of bioclimatic investigations carried out in Department of Climatology of the Institute of Geography and Spatial Organization of the Polish Academy of Sciences. The aims of this research involve evaluation and regionalization of a bioclimate of Poland in different spatial scales from the point of view of climatotherapeutical and recreational potential as well as work under an open air. Bioclimatic weather classification and human heat balance method were used in this study.

KEY WORDS: bioclimatic mapping, weather classsifications, human heat balance.

INTRODUCTION

Bioclimatic research of Poland were begun in Department of Climatology of the Institute of Geography and Spatial Organization of the Polish Academy of Sciences (IGiPZ PAN) about 20 years ago. They were conducted both in regional and local scales. The studies have not only cognitive meaning but also practical aspects. They afford knowledge dealing with bioclimatic conditions of Poland. Some new methods were also developed, adapted and verified by the authors (Kozłowska-Szczęsna, ed. 1985). At present the Department of Climatology of the IGiPZ PAN is the only one research unit in Poland carrying out investigations on human bioclimate, including research and methodology.

Regional scale research concerned annual variability of atmospheric circulation as well as types of weather. An analysis of bioclimatic conditions was also completed based on various complex indices. The studies mentioned above have been based on meteorological data for the midday observations which characterize part of the day actively used by man in temperate climate for work, tourism, recreation, climatotherapy and other purposes. A few attempts at elaborating bioclimatic typology, evaluation and regionalization of Poland were also made (Błażejczyk 1992a; Kozłowska-Szczęsna 1986, 1987, 1988, 1991a, 1991b; Krawczyk 1991; Kuczmarski 1990). Regional scale studies based on multiannual data collected at national meteorological network.

Local scale research were carried out in regions mostly transformed by economic activity of man (Upper Silesian) as well as on the territory with the least polluted environment (northeastern Poland) which is called "Green Lungs of Poland".

Investigating the Silesian Plateau the attention was paid not only for spatial distribution of meteorological elements and bioclimatic indices but mainly for dust and chemical air pollution as a very important anthropogenic factor (Błażejczyk 1992a; Kozłowska-Szczęsna 1990a, 1990b).

In northeastern Poland investigations were performed on the territory of the Mazurian Lakeland. The results deal with general evaluation of bioclimatic conditions as well as with analysis of man-environment heat exchange in wood-and-lake landscape in different weather situations (Błażejczyk 1981, 1991, 1993)

The aim of this study is presentation of both the recent knowledge about bioclimatic conditions of Poland as well as the methods used.

BIOCLIMATIC STUDIES IN REGIONAL SCALE

CLASSIFICATION OF WEATHER

Variability of weather conditions is a typical feature of a climate of Poland. Bioclimatic classification of weather bases on thermal sensations of man as an effect of complex influence of air temperature and wind speed on the human organism (Błażejczyk 1992b). Thermal sensations were defined with the use of cooling power of air (H), calculated according to Hill equations. Six main weather types were distinguished:

I	hot weather	$H < 210.0\ W \cdot m^{-2}$,
II	warm weather	$H = 210.1 - 420.0\ W \cdot m^{-2}$,
III	comfortable weather	$H = 420.1 - 840.0\ W \cdot m^{-2}$,
IV	cool weather	$H = 840.1 - 1260.0\ W \cdot m^{-2}$,
V	cold weather	$H = 1260.1 - 2100.0\ W \cdot m^{-2}$,
VI	very cold weather	$H > 210.1\ W \cdot m^{-2}$.

In each of above types the weather classes were defined depending on cloudiness as well as on occurrence of atmospheric precipitation, fogs and sultriness. Thus weather classes: with small, moderate or big cloudiness; without precipitation, with transitory rain (snow) or with whole-day precipitation; without fog, with morning/evening fog or with whole-day fog; without sultriness or with sultriness were specified.

On the basis of an analysis of usefulness for tourism, recreation, climatotherapy and work on an open air purposes the weather classes were counted to the one of the following groups: very favourable, favourable, moderate favourable, slightly favourable, relatively unfavourable or extremely unfavourable.

In bioclimatic research a frequency of different weather groups and stability of weather from day to day are considered. These characteristics are used for a calculation of complex, evaluation index of weather conditions (Błażejczyk

1992b). Its nondimensioned values vary from 0.01 (extremely unfavourable) in the winter on the peaks of Tatra and Sudety Mts to 0.84 in the summer in Lower Silesian region.

The longest duration of the period with predomination of very favourable weather conditions (from May or even April till October) occurs in the south of Poland and the shortest one (no more then three summer months) is observed on the north and northeast (Fig. 1).

The period with predomination of unfavourable weather is noticed throughout 1-4 months of winter season only in the eastern Poland as well as on a seaside, in Wielkopolska and in the top parts of mountains (Fig. 2).

An analysis of frequency and stability of different weather classes was a basis for delimitation of 9 regions with individual structure of weather conditions (Fig. 3). With the comparison to the Central region which characterizes average weather conditions (relatively favourable weather occurs from March till December and very favourable — from May till September; in the winter weather conditions are mild) other regions are distinguishable by: very big seasonal variability of weather and short (1-2 months) period with predo-

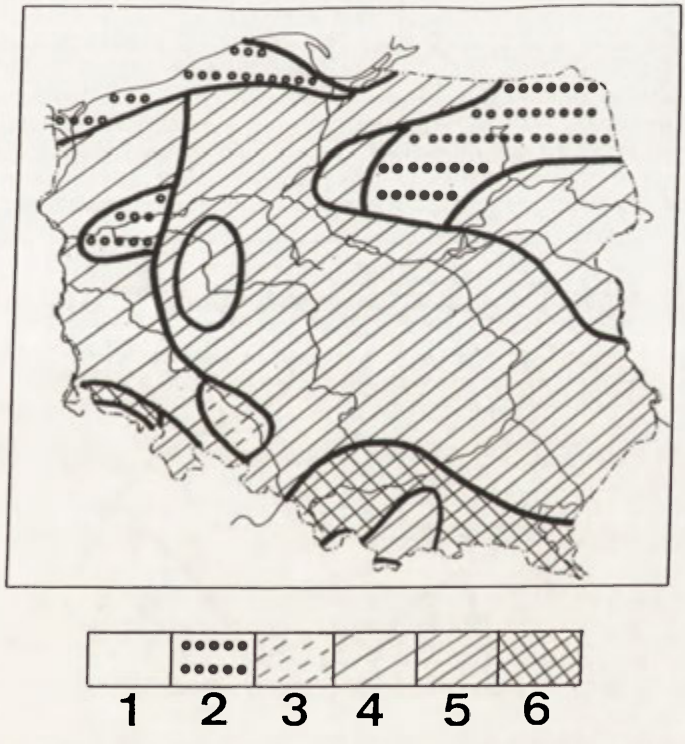

Fig. 1 Duration of very favourable weather conditions; useful for all forms of human activity outdoor (by Błażejczyk 1992b): 1 — no more than one month, 2 — two-three summer months, 3 — three months at spring and/or autumn, 4 — from June till September, 5 — from May (or June) till September (or October), 6 — from May (or April) till October

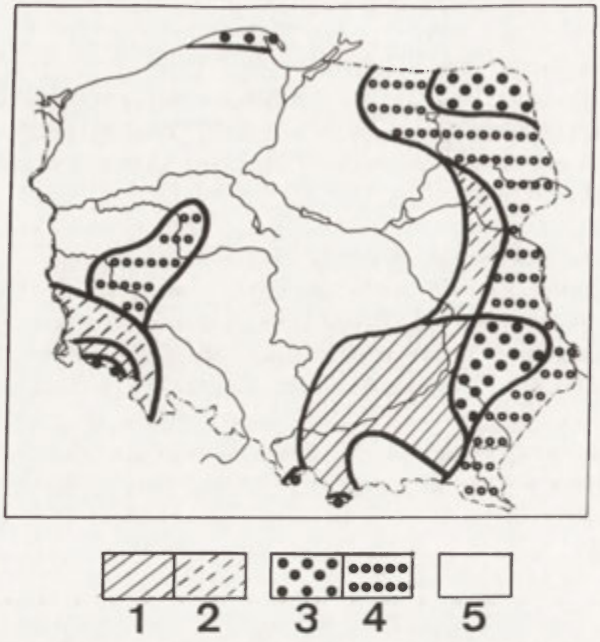

Fig. 2 Duration of unfavourable weather conditions (by Błażejczyk 1992b); relatively unfavourable weather: 1 — three-four months between November and March, 2 — one-two months between December and February; extremely unfavourable weather: 3 — three-four months between November and March, 4 — one-two months between December and February; 5 — without predomination of unfavourable weather conditions

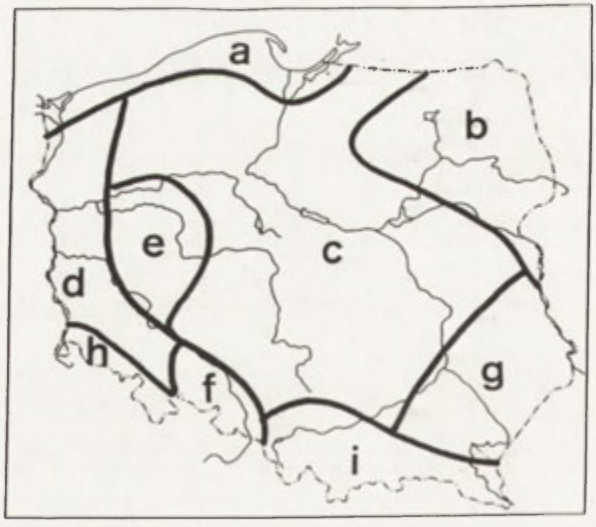

Fig. 3 Bioclimatic regions of weather conditions of Poland (by Błażejczyk 1992a)
a — Seashore, b — Northeastern, c — Central, d — Western, e — Wielkopolian, f — Lower-silesian, g — South-eastern, h - Sudethian, i — Carpathian

mination of very favourable weather (Seashore); big seasonal variability of weather and sever, unfavourable weather during 4 winter months (North-eastern); average weather conditions during warm half-year and prevalence of unfavourable weather in the winter (Southeastern); occurrence of relatively favourable weather during whole year (Western); average weather conditions during warm half-year and relatively sever winter (Wielkopolian); the longest in Poland period, i.e. from March till November, with predomination of very favourable weather (Lower Silesian); occurring of especially favourable weather in September and October (Sudethians and Carpathians).

COMPLEX EVALUATION, REGIONALIZATION AND TYPOLOGY OF BIOCLIMATE

Complex bioclimatic regionalization of Poland is the next example of studies carried out in regional scale. Bioclimatic regions were distinguished on the basis of a number of days onerous for man i.e. days with extremal climatic stimuli (Kozlowska-Szczęsna 1987, 1991a, 1991b).

Three groups of atmospheric stimuli are regarded in bioclimatology (Kozłowska-Szczęsna, ed. 1985): physical (radiative, hygro-thermal, mechanical, electric and acoustic), chemical (due to quality of air) and biological (deal with biological organisms observed in air).

Onerousness of physical stimuli was defined taking into consideration the following bioclimatic indices: great change of atmospheric pressure (> 8 hPa per day), strong wind (> 8 $m \cdot s^{-1}$), sultriness (vapour pressure > 18.8 hPa), hot discomfort (cooling power < 210 $W \cdot m^{-2}$), cold discomfort (cooling power > 1260 $W \cdot m^{-2}$), a whole-day precipitation and a whole-day fog. As an onerous were classified days in which at least one of the indices listed above occurs (Kozłowska-Szczęsna 1986, 1991a, 1991b). After an analysis of spatial and seasonal differentiation of onerous days 7 bioclimatic regions and 4 subregions were distinguished on the territory of Poland (Fig. 4).

Another approach to a problem of bioclimatic differentiation of Poland are studies concerning heat balance of the human body outdoor which evaluates heat state of man in the most complex way. Heat state of man forms under the influence of meteorological and physiological factors as well as physical activity of man and kind of clothing. Bioclimatic evaluation and regionalization of Poland was elaborated taking into account the index of clothing insulation required for thermal comfort of man (Icl in clo units). A Budyko's stationary model of the human heat balance, adapted by B. Krawczyk (1983, 1993), was used for this purpose. General equation of heat balance of the human body surface has the following form:

$$R + M = C + E + L + Res \qquad (1)$$

where R is solar radiation absorbed by man, M — metabolic heat production, C — sensible heat loss (by convection), E — latent heat loss (by evaporation), L — heat loss by long-wave radiation, Res — heat loss due to respiration. All

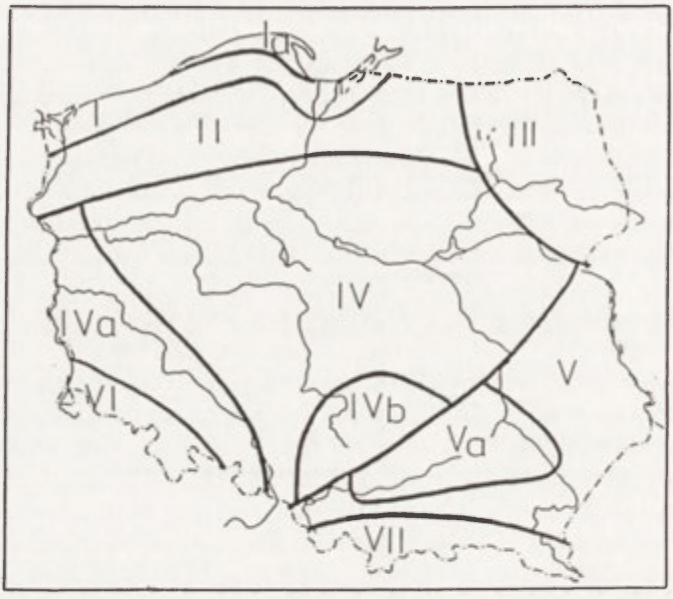

Fig. 4 Bioclimatic regions of Poland (by Kozlowska-Szczęsna 1991b); I — mostly influenced by the Baltic sea (subregion Ia — with the most stimulativity), II — bioclimate softer than in the region I, III — the coolest (besides mountains) bioclimate, IV — with moderate bioclimatic conditions (subregions: IVa — with a weak stimuli, IVb — with a relatively strong stimuli due to air pollution), V — the hotest bioclimate (subregion Va — with the strongest thermal stimuli), VI — sudethian, VII — carpathian (region VI and VII have very differentiated bioclimatic conditions)

values are expressed in $W \cdot m^{-2}$. Absorbed solar radiation was computed taking into account a vertical cylinder as an analog model of man.

Spatial differentiation of mean monthly values of Icl index was analyzed for the coolest (January) and the warmest (July) month in Poland (Krawczyk 1992). In Jauary clothing insulation keeping heat comfort of man fluctuates from 3.9 clo in mountain basins to 5.3 clo on Tatra and Sudety peaks (Fig. 5). The lowest (during the year) values Icl index (0.9 - 1.5 clo) is observed in Poland in July (Fig. 6). Only at the seaside and mountain areas the annual minimum of Icl values occurs in August. It is necessary to add that on Tatra and Sudety peaks required clothing insulation in the summer is even 3.0 - 3.2 clo.

An analysis of the human heat balance was a basis of bioclimatic typology of Poland as well. Spatial units with similar structure of the human heat balance were distinguished through the use of the following criteria. First were annual amplitudes of an index of thermal clothing insulation requirements (Δ Icl), i.e. difference between the highest and the lowest mean monthly values of Icl index. Increasing of annual amplitude of clothing insulation means that man needs more different clothing garments in his disposal. On the territory of Poland Δ Icl values vary from 2.2 clo on Kasprowy Wierch to 3.6 clo in

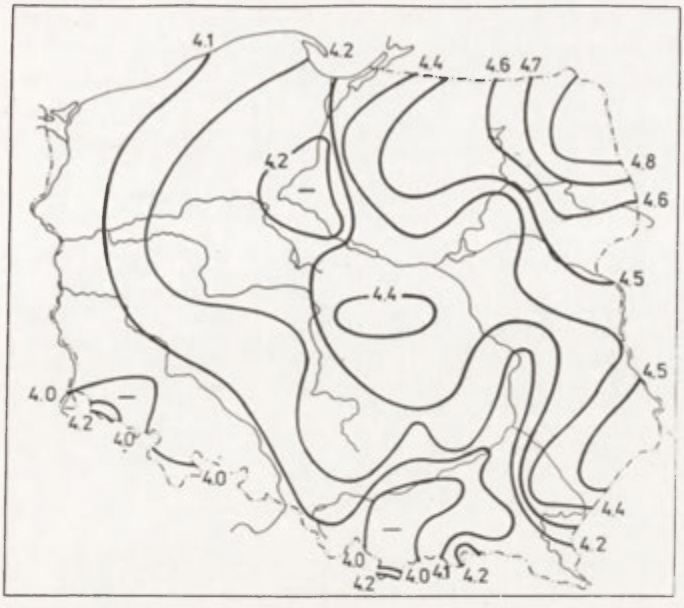

Fig. 5 Insulation of clothing (in clo) required for thermal comfort of standing man ($N = 70\ W \cdot m^{-2}$), January, mean values for the period of 1961-1970, 13:00 official time (by Krawczyk 1993)

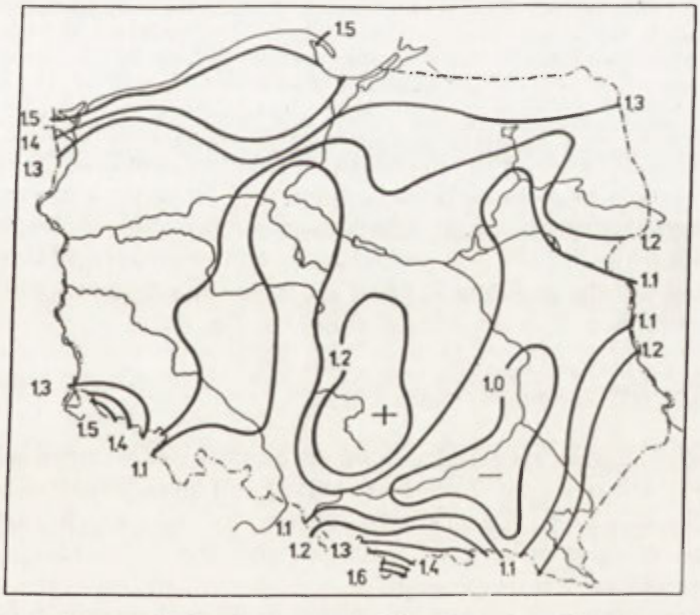

Fig. 6. Insulation of clothing (in clo) required for thermal comfort of standing man ($M = 70\ W \cdot m^{-2}$), July, mean values for the period of 1961-1970, 13:00 official time (by Krawczyk 1993)

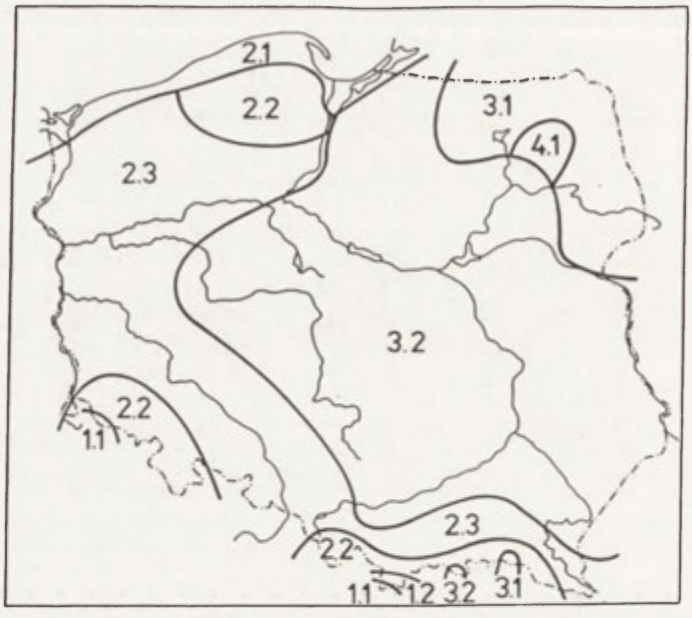

Fig. 7 The types of bioclimate of Poland (by Krawczyk 1993) 1.1 — very small differentiation of clothing insulation (ΔIcl) throughout the year and slight load of thermoregulative system due to evaporation (E/(C+E+L+Res)), 1.2 — very small ΔIcl and very small E/(C+E+L+Res), 2.1 — small ΔIcl and very smallE/(C+E+L+Res), 2.2 — small ΔIcl and small E/(C+E+L+Res), 2.3 — small ΔIcl and moderate E/(C+E+L+Res), 3.1 — moderate ΔIcl and small E/(C+E+L+Res), 3.2 — moderate ΔIcl and moderate E/(C+E+L+Res), 4.1 — considerable ΔIcl and small E/(C+E+L+Res)

northeast Poland. The second criterion was share of evaporative heat losses — which occur with heat equilibrium of man — in their total amount. The E/(C+E+L+Res) values point to intensity of a heat load of thermoregulative system. Differentiation of E/(C+E+L+Res) is rather small and fluctuates from 0.20 at the mountain peaks to 0.27 in southern and western Poland. Thus 8 types of bioclimate of Poland was established (Fig. 7).

BIOCLIMATIC STUDIES IN LOCAL SCALE

The Silesian Plateau was chosen as an example of an area with environment strongly changed by industrial activity of man (Kozlowska-Szczęsna 1990a, 1990b). Air pollution and transformed by man earth surface (settlements, waste-dumps, colliery excavations) are the main factors modifying bioclimatic conditions in this region.

Comparing mean annual values of meteorological parameters inside and outside Silesian agglomeration it was noticed that bioclimate of agglomeration characterizes by:

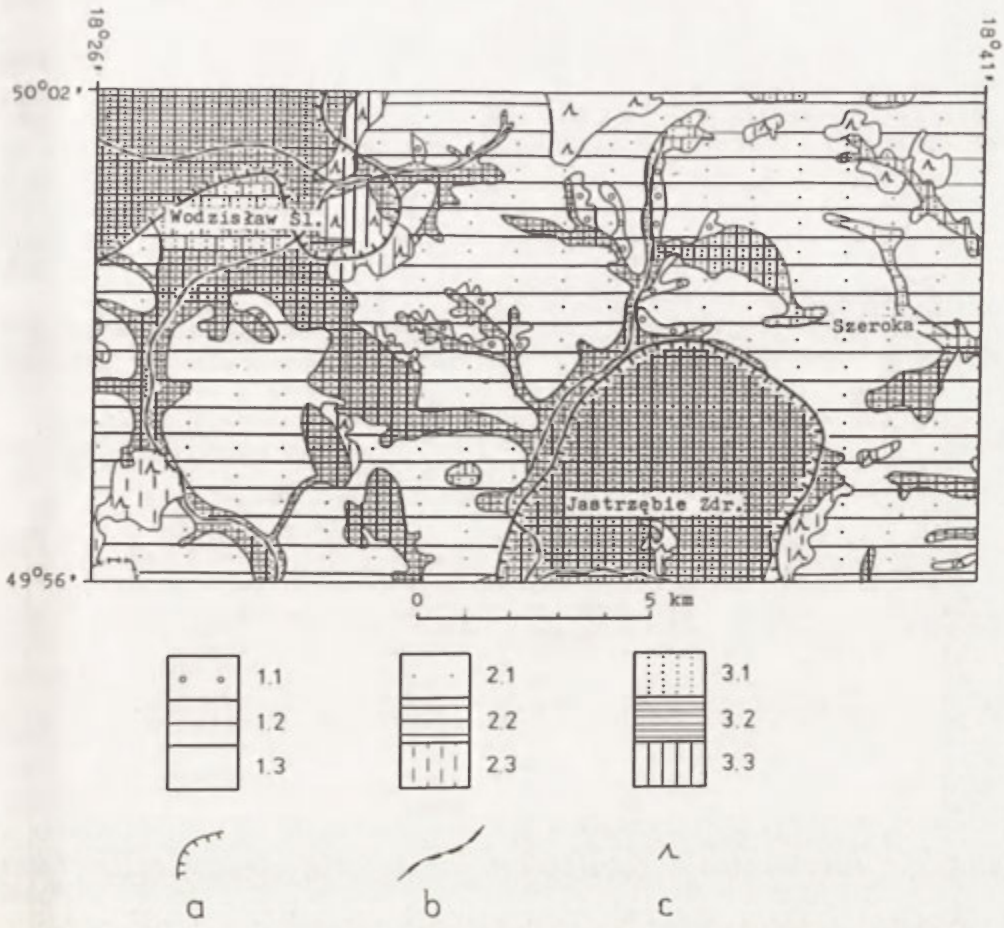

Fig. 8 Topoclimatic assessment map of Jastrzębie Zdrój (by Kozłowska-Szczęsna 1990b)
1 — favourable areas: 1.1 — for agriculture, 1.2 — for location of housing, 1.3 — for recreation; 2 — less favourable areas: 2.1 — for agriculture, 2.2 — for location of housing, 2.3 — for recreation; 3 — unfavourable areas: 3.1 — for agriculture, 3.2 — for location of housing, 3.3 — for recreation; a — areas of the greatest air pollution, b — extremely polluted rivers, c — forests

— reduction of solar radiation income of 20 - 25%,
— decreasing of sunshine duration of about 15%,
— increasing of air temperature of about 2°C (daily means) or 5°C (minimal air temperature),
— decreasing of air temperature amplitudes of about 7°C,
— decreasing of air humidity of 2-5%,
— increasing of atmospheric precipitation of 5 - 10%,
— enlargement of a frequency of stormy days of 5 - 10 per year and foggy days of about 30% (in the summer) or 100% (in the winter),

— reduction of wind speed of 20 - 30% (as an effect of big number of calm days and specific city system of air motion),

— worsening of air quality, especially at SW winds blowing from Ostrava, the Czech industrial region.

Local differentiation of bioclimatic conditions was presented on topoclimatic map made by J. Grzybowski (with the use method proposed by J. Paszyński 1980, 1983) and on biotopoclimatic map made by K. Błażejczyk (with the use of his own method). Evaluation map of bioclimate, made by T. Kozłowska-Szczęsna and B. Krawczyk, based on both maps mentioned above. Additionally maps deal with distribution of air pollution (dust fall, condensation of Pb, S, NO_x) were analyzed.

Topoclimatic studies show that local differentiation of bioclimatic conditions of the Silesian Plateau depends mainly on kind and intensity of human

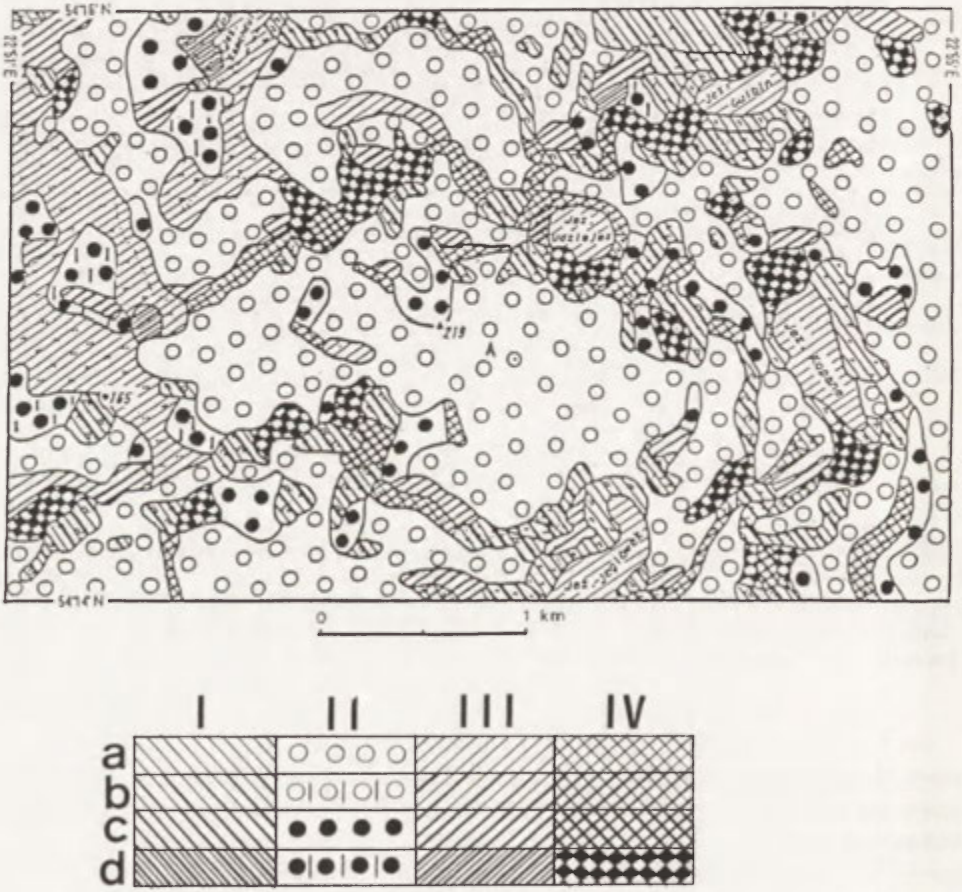

Fig. 9 Biotopoclimatic map of Mazurian Lakeland (a fragment) — northeast Poland (byBłażejczyk 1993); thermal conditions: I — mild, II — slightly loaded, III — loaded, IV — strongly loaded; types of man-environment heat exchange: a — convective, b — radiative, c — evaporative, d — mixed

activity and secondly on relief and ground cover. The worst bioclimatic conditions prevail in the central part of the Uppersilesian Industrial Region as well as in the environs of Rybnik, Racibórz, Jastrzębie, Tychy, Siersza, Zawiercie and Tarnowskie Góry.

On the territory of the Silesian Plateau only one health resort is situated — Jastrzębie (Fig. 8). Unfortunately this city lies in a zone with the greatest pollution of air, soil and water. Degradation of environment is here the most intensive as an effect of industrial development and increase of population. Thus Jastrzębie lost its therapeutic advantages (Kozłowska-Szczęsna 1990b).

An another example of detail bioclimatic research performed in local scale are studies of the human heat balance and heat load in man outdoor, in different weather conditions and in different types of landscape of the Mazurian Lakeland (Błażejczyk 1991, 1993).

In this purpose a new model of man-environment heat exchange in non-stationary, fluctuating outdoor climate (MENEX) was developed (Błażejczyk 1992c, 1993). General, mathematical form of the model is following:

$$M + R + C + L + E + Res = S \qquad (2)$$

where S is net heat storage (surplus or deficit); another symbols are the same as at equation (1). As just as in thermophysiological investigations a vertical ellipsoid is assumed as an analog model of man in upright posture (Błażejczyk et al. 1993).

The MENEX model may be used for estimation of heat state of man outdoor (structure and quantity of heat exchange, net heat storage, heat load) as well as for assessment of maximal time of exposure (MTE). MTE value defines time not threatening man with overheating or overcooling of an organism.

Heat load of man, which is a function of net heat storage and absorbed solar radiation, is a measure of thermal state of an enviroment. Classification of heat load consists of 6 classes (Table 1).

TABLE 1. Classification of heat load of man

<table>
<tr><td rowspan="2">Net heat storage ($W \cdot m^{-2}$)</td><td colspan="3">Absorbed solar radiation ($W \cdot m^{-2}$)</td></tr>
<tr><td>< 15.0</td><td>15.1 – 30.0</td><td>> 30.1</td></tr>
<tr><td>> 90.1</td><td colspan="3">Hazard of organism overheating</td></tr>
<tr><td>45.1 – 90.0</td><td colspan="2">Loaded conditions</td><td>Strongly loaded conditions</td></tr>
<tr><td>20.1 – 45.0</td><td colspan="2">Slightly loaded conditions</td><td>Loaded conditions</td></tr>
<tr><td>- 20.0 – + 20.0</td><td>Mild conditions</td><td rowspan="2" colspan="2">Slightly loaded conditions</td></tr>
<tr><td>- 45.0 – - 19.9</td><td>Loaded conditions</td></tr>
<tr><td>- 90.0 – - 44.9</td><td>Strongly loaded conditions</td><td colspan="2">Loaded conditions</td></tr>
<tr><td>< -90.1</td><td colspan="3">Hazard of organism overcooling</td></tr>
</table>

In bioclimatic research the MENEX model may be especially useful for thermal charateristic of different weather situations, for evaluation of climate in regional, local and micro scale as well as for assessment of work conditions outdoor and for forecasting of heat state of man. Biotopoclimatic map of the Suwalki Landscape Park (a fragment of the Mazurian Lakeland) is an example of studies performed in local scale. Areas with different heat load of man were distinguished as well as prevailing type of heat exchange was stated (Fig. 9). Such kind of map may be a basis for detail evaluation of terrain from the point of view of man living there permanently, working outdoor or resting.

FINAL REMARKS

The results presented in this paper have not only cognitive meaning but they also provide practical information for different forms of human activity, e.g. climatotherapy, recreation, tourism as well as for town-planing and for occupational health protection. The methods of investigations applied in our studies can be recommended for a further bioclimatic research in different climatic conditions and in different spatial scales.

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THE DIAGNOSIS OF CLIMATE CHANGE IN CRACOW AGAINST A BACKGROUND OF CIRCULATION AND LOCAL CONDITIONS

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ABSTRACT: The multi-annual variability of thermal, solar and cloudiness conditions in Cracow was examined from the point of view of the impact of natural and anthropogenic factors on the climate change. The analysis concerned the annual air temperature range (RAT) and daily ranges of air temperature (DAT) in January and July. Special attention has been paid to the climatic trends and changes of climatic continuity. Long-term changes of RAT reflect the impact of the circulation factors, these of DAT are influenced by the urbanisation.

KEY WORDS: climate, monitoring, research of climatic changes, global warming.

INTRODUCTION

Monitoring the climate signals which is very popular nowadays because of widely discussed greenhouse effect, may be carried out:

— by means of comparison of climate system states at various times,

— by means of diagnostic studies based on the analysis of long-term instrumental measurement series assessing the multi-year variability of various elements of climate (Bernhardt 1991, Brázdil 1991).

The authors of this paper chose the latter way, using multi-year series of meteorological measurements from climatological station of the Climatology Department of the Jagellonian University, which has long, homogenous records of measurements.

PURPOSE AND METHOD

The series of annual air temperature ranges and their daily values in January and July, as well as the characteristic of sunshine inflow in the form of sunshine duration totals and the frequency of days with various number of sunny and cloudy days, have been chosen for the subject of analysis in this

paper. Basic statistical methods (including the characteristics of mean values, smoothing the data series by 20-year running averages, trend equations, the characteristics of deviation course and cumulative values of deviations) have been used. Amplitudes of air temperature and characteristics of cloudiness have been investigated for the years 1863-1992 as well as sunshine duration data for the years 1884-1992. M. Morawska (1963) extrapolated monthly totals of sunshine duration back to the year 1859 using the long series of cloudiness in Cracow.

Special attention has been paid to the search for climate trends by use of linear regression and to the changes of climatic continuity within the trends, and periods when a shift towards thermal oceanity or continentality of climate occurred.

The aim of this article is the characteristics of climate changes treated as the deviation of climate elements from long measurement periods on a regional and local scale from mean values. Such an attitude is in accordance with the conclusions of various contemporary research papers (Maunder 1993).

The usefulness of air temperature range for examining some inconsistencies in the behaviour of the climate system has been tested and an attempt to interpret the obtained results from the point of view of natural and anthropogenic factors, has been made. The results of the analysis of the multi-year course of air temperature range and the characteristics of cloudiness and sunshine duration have been useful for that purpose. Basing on the data from the Cracow station ($\phi = 50^{0}04'N$, $\lambda = 19^{0}58'E$, $h = 220$ m) requires the assessment of the influence of developing urban agglomeration upon the climate. The urban heat island, increasing its space and intensity, shows not only local influences, but depends upon regional changes of circulation conditions as well (Lewińska et al. 1990; Bernhardt 1991).

CHANGES OF THERMAL AND SOLAR CONDITIONS IN CRACOW AND THEIR REPRESENTATIVENESS FOR CLIMATE CHANGE IN EUROPE

The investigation of air temperature series in Cracow and at other European stations was carried out by W. Gorczyński (1915) and W. Gorczyński, S. Kosińska (1916), who proved the existence of coherence in their change at the axis of Nantes-Khazan in January and at the axis of Aberdeen-Odessa in July by means of coefficients of linear correlation. Significant correlation connections between Cracow and other places in Europe exist also in the setting of frequencies of circulation macrotypes — mainly in winter (Kożuchowski, Trepińska 1986, Trepińska1988); and Cracow may be treated as a representative example for Central Europe.

The analysis of annual and daily air temperature range has a special place in the evaluation of climate change in Cracow. The constant increasing trend in mean winter air temperature was already noticed in the 1970s, while the characteristics of summer temperatures remained at almost the same level (Trepińska 1971, 1973). This phenomenon may be seen till 1990 (Bednarz et

al. 1993, typescript). The decreasing trend in the difference between summer and winter temperatures is an additional feature of the long-term air temperature changes in Cracow (Trepińska 1981, Trepińska, Marciniak 1986).

The long-term course of sunshine duration in Cracow shows a general decreasing trend in the number of hours with sunshine. According to M. Morawska (1963), the decrease in sunshine duration calculated for the years 1890-1958 amounted to about 3.3 hours a year. It results from the 100-year-long series of measurements (till 1990) showing that such a trend has remained at the same level. While annual totals and totals for summer months were subject to significant variations, the sunshine duration for winter months was characterised by a constant decrease during the whole period mentioned.

The cloudiness for Cracow from half of the 19th century to the 1950s was characterised by, increasing trend, manifesting itself mostly in winter months. In 1950s the decreasing trend in cloudiness (much greater in summer months than in winter ones) started. The last 40 years have been a period of the decrease both in cloudiness and sunshine duration. A new trend may be seen in the course of annual totals of sunshine duration since the mid-1980s. Annual totals of sunshine duration for this period begin to grow systematically, which brings up speculations concerning the origin of this phenomenon (Brázdil 1991).

THE VARIABILITY OF ANNUAL AND DAILY RANGES OF AIR TEMPERATURE IN CRACOW

Annual air temperature range (RAT) has been treated in this paper as the difference between mean temperatures of the warmest and the coldest month in a given year. Methodical problems connected with the calculation of annual air temperature range were discussed in the article by J. Trepińska and K. Marciniak (1986). The mean daily range for July and January were determined as the differences between maximum and minimum temperatures in the succeeding days of these months for the years 1863-1992, and then they were averaged for each month in the examined series. In this way, series of 130 values were created for January (DAT I) and July (DAT VII).

The mean annual range in the period 1963-1992 amounted to 23.2°C, and was 0.5°C lower in comparison with the mean from the years 1826-1984 (Trepińska, Marciniak 1986). The standard deviation of 3.24°C almost did not change in comparison with the previous period (3.29°C). Other statistic characteristics are included in Table 1.

The years 1863-1992 were characterised by a constant decreasing trend in annual air temperature range, described by the linear regression equation:

$$y = 23.9 - 0.0105x$$

where: y — the value of the trend
x — the number of the year; x_1=1863,..., x_{130}=1992

TABLE 1. Statistical characteristics of air temperature ranges in Cracow in 1863-1992 (in °C)

Variable	RAT	DAT I	DAT VII
Average	23.2	5.4	10.4
Standard deviation	3.24	0.76	1.29
Standard error	0.28	0.07	0.11
Maximum value	32	7.6	14.5
	1929	1881	1880
Minimum value	16.2	3.4	7.9
	1990	1923	1980
Range	15.8	4.2	6.6
Upper quartile	24.9	5.9	11
Lower quartile	21.4	5	9.6

RAT — annual range of air temperature; DAT I — mean daily range of air temperature in January; DAT VII — mean daily range of air temperature in July.

It results from the above regression equation that the annual temperature range has decreased by more than 1°C for 100 years and by 1.36°C for 130 years.

The annual ranges of temperature, smoothed by running averages with 20 year period, prove the appearance of oceanity (decrease in RAT value) and continentality (increase in RAT value) periods.

The period of oceanity of climate in Cracow started at the end of the second half of 19th century and ended in late 1920s and early 1930s (period /1/). In the following years (till 1960s) the phase of continentality of climate existed. In recent years the phase of oceanity may again be noticed, with small fluctuations in the value of RAT (Fig. 2). Such a classification is supported by calculated regression equations and linear regression coefficients between mean 20-year values of RAT:

/1/	$r_{x,y}$=-0.86	y=90.7 – 0.075x	years 1863-1928
/2/	$r_{x,y}$= 0.96	y=0.15x – 120.6	years 1923-1958
/3/	$r_{x,y}$=-0.94	y=77.4 – 0.056x	years 1959-1992

where:
$r_{x,y}$ — linear correlation coefficient between x and y;
x — the middle year of each 20-year period for the years 1863-1992, without the leading 1000(110 values);
y — the value of RAT for each 20-year period in the years 1863-1992.

The general trend in the course of RAT values was decreasing in the examined period (Fig. 1), which has already been mentioned.

The course of daily temperature ranges in January and July was different.

The ranges in January revealed a constant decreasing trend, which may be described by the equation:

$$y = 5.597 - 0.00257x$$
$$r_{x,y} = -0.49 \text{ (for 20-year means)}$$

where: x — values from 1 to 130 (years),
y — values of DAT I for all the years.

It must be mentioned that the decrease was not very big; it amounted to 0.28°C in the 130 years (0.26°C/100 years). However the continuity of the decrease since the end of the 19th century is worth noticing (Fig. 2).

In July the daily range took yet another course. After a period of distinct decrease in the phase of climate oceanity, a period of slightly diversified course existed, and later — a slight increase. The general trend was decreasing (Fig. 1), which is shown by the following trend equation:

$$y = 11.09 - 0.0112x$$
$$r_{x,y} = -0.754 \text{ (for 20-year means)}$$

It results from the equation that mean daily temperature ranges in the examined period (130 years) decreased by 1.23°C, that is by 1.12°C/100 years.

The courses of annual and daily values of air temperature ranges (for January and July) have been additionally presented in Fig. 3. In the first years of the examined period till 1920s (the period of oceanity of European climates) a great correlation between deviations of RAT and DAT VII from multi-year means may be noticed. Later a diversification in the formation of these values appeared. The increasing number of positive deviations of DAT VII from multi-year value in 1975-1992 is an important phenomenon. It may be

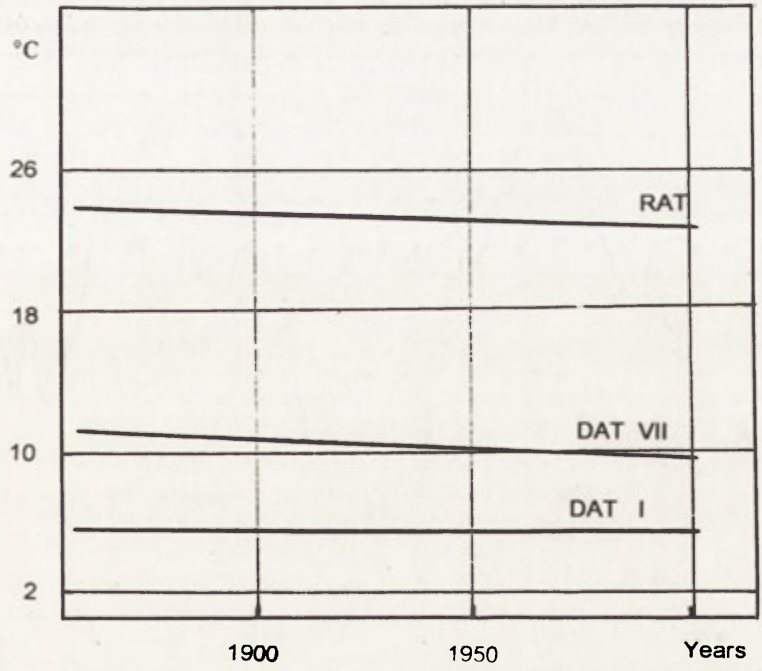

Fig. 1. Trends in the courses of air temperature ranges in Cracow (1863-1992)
RAT — annual range of air temperature, DAT I — mean daily range of air temperature in January, DAT VII — mean daily range of air temperature in July

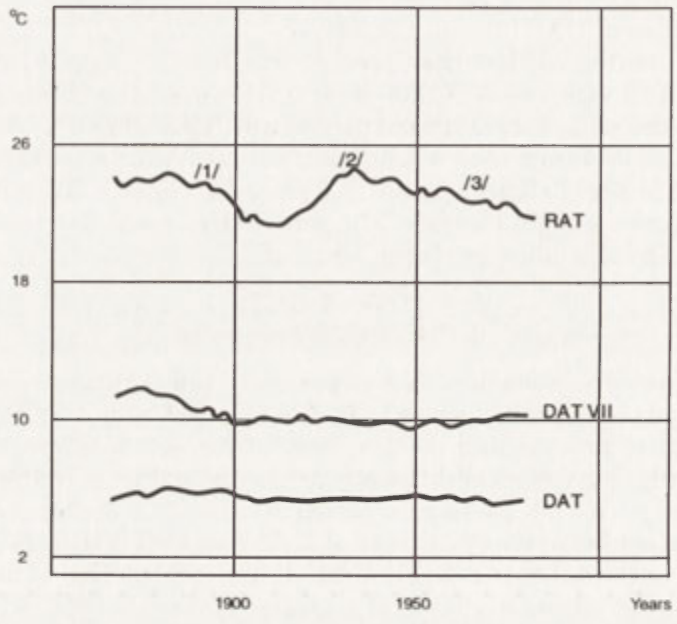

Fig. 2. 20-year running averages of air temperature ranges in Cracow (1863-1992) (in °C) RAT — annual range of air temperature (1) , DAT I — mean daily range of air temperature in January (2), DAT VII — mean daily range of air temperature in July (3)

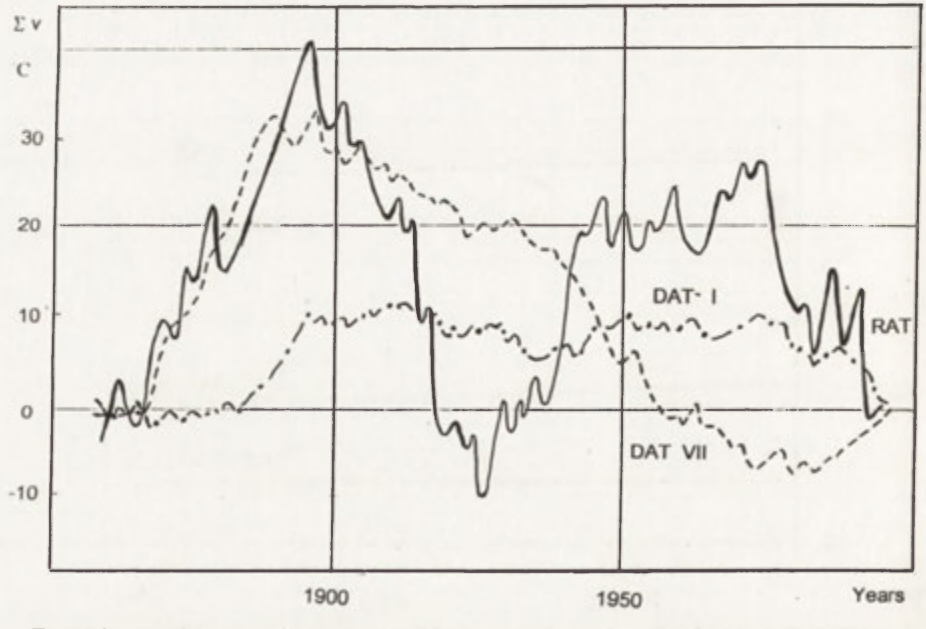

Fig. 3 Cumulative deviations from multi-year mean air temperature range in Cracow (1863-1992) (in °C). RAT - annual range of air temperature, DAT I — mean daily range of air temperature in January, DAT VII — mean daily range of air temperature in July

connected with the increase in the number of sunny days and the days with sunshine duration longer than 10 hours in these years (Fig. 4).

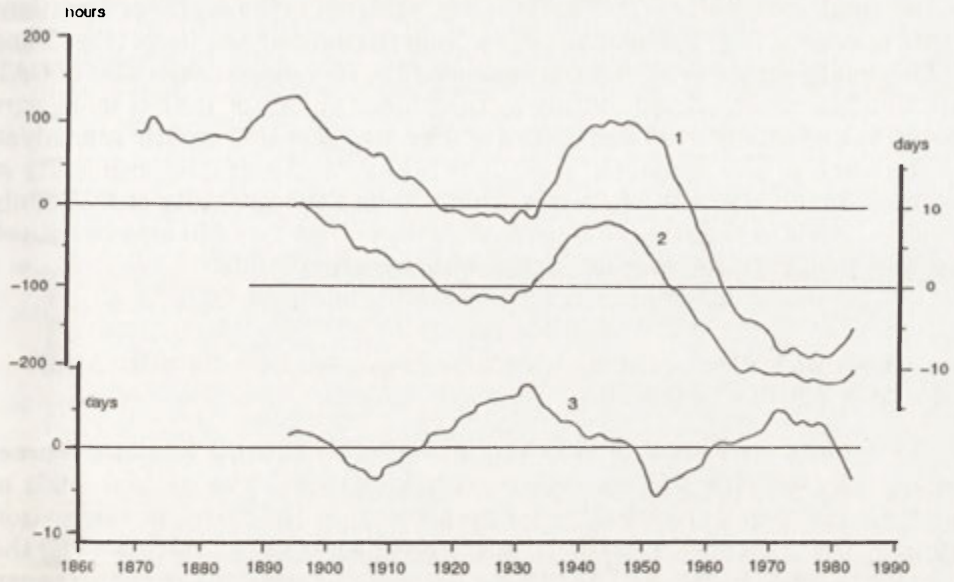

Fig. 4 Deviations of annual totals of sunshine duration (1), number of days with sunshine duration > 10 hours (2), and number of days without sunshine (3) from multi-year (1884-1990) mean in Cracow

The mean values of DAT changed very little in January, which in turn means, that in spite of great diversification of minimum and maximum temperatures, the differences between them stay at a constant or almost constant level. The slight decrease in DAT in January may result from the increase in minimum temperature. Thus, the differences between minimum and maximum temperatures reflect the general features of a temperate climate (represented by Cracow), at a constant increase in mean winter temperature (Trepińska 1988) and the influence of the city upon the value of maximum and minimum temperature (the influence on minimum temperatures is greater).

The annual ranges of temperature (RAT) correlate with the course of deviations from the multi-year mean of cloudiness and the number of cloudy days (Figs. 7 and 8). In the phase of climate oceanity, both these factors had higher values, and the number of sunny days was decreasing (Fig. 4).

Some relationships exist between the course of RAT (Fig. 2) and the multi-year course of sunshine duration (Figs 2 and 4). The decrease in the number of hours with sunshine and the decrease in the value of RAT in the years of progressing oceanity, as well as the increase in RAT value and in sunshine duration in the period of continentality (which took place in the 1940s) (see Figs 3 and 4) are understandable. The later rapid decrease in sunshine duration and its increase in the latest years may be connected both

with the local influences and with natural processes, resulting from decreased air pollution caused by the economic recession.

The small variability of DAT in January is related to the course of deviations of the number of days without sunshine from the January average (Figs 2 and 6). The smaller number of such days caused the increase in the value of DAT. A similar situation existed in July — the higher values of DAT (Fig. 2) were related to higher values of sunshine duration totals in this month, but only in the first half of the examined period — till 1920s. Later, the variability of sunshine duration totals was much greater than the variability of DAT. Only since the 1980s, a slight increase of DAT in July (Figs 2 and 5) may be noticed in connection with the increase in sunshine duration totals.

THE VARIABILITY OF ANNUAL AND SEASONAL VALUES OF SUNSHINE DURATION AND CLOUDINESS

The multi-year course of sunshine duration in Cracow has two characteristic maxima. The first one occurred in the 1890s. The annual totals of sunshine duration were then higher by more than 100 hours in comparison with multi-year mean of 1550 hours with sunshine in a year, calculated for the years 1884-1990. In the mid-1890s the decrease in sunshine duration began and lasted till the 1930s, the annual number of hours with sunshine decreased down to the value 20 hours lower than the average (Fig. 4).

The second maximum of sunshine duration occurred in Cracow in 1940-1950. The annual totals were higher by about 100 hours from the multi-year mean for this period. In the late 1940s and early 1950s, a significant decrease in the number of hours with sunshine occurred, and lasted till 1980s, when the annual totals of sunshine duration were lower by about 200 hours from the mean value. At the same time, the lowest value of sunshine duration was recorded in Cracow — in 1980 it amounted to only 1067 hours. In the next years, a slight decrease in sunshine duration may be observed.

The general decreasing trend in sunshine duration during the examined period by about 3 hours a year, is not distributed evenly throughout the course of a year. In July, the course of sunshine duration is correlated with the course of the annual totals (Fig. 5). The number of hours of sunshine was greater by 15-20 hours in the periods of the greatest sunshine duration and lower by about 20 hours after 1960, as compared to the multi-year mean (200 hours) for that month.

The multi-year course of sunshine duration in the winter months has been forming differently. Till 1910 the sunshine duration in January was, on average, more than 10 hours greater than the multi-year mean of 48 hours (Fig. 6). In the 1920s the course of deviations dropped below the mean value down to -10 hours for the years 1970-1980, but an increasing trend appeared in the 1980s.

This results from the comparison of the multi-year course of sunshine duration with the courses of other characteristics, such as the number of days with sunshine duration longer than 10 hours and the number of days without

sunshine, that the first of these characteristics has greater influence upon the value of sunshine duration (Figs 4 and 5). In winter, when the days with a sunshine duration longer than 10 hours do not occur, the course of sunshine duration shows no apparent correlation with the course of days without sunshine (Fig. 6).

The mean annual cloudiness in Cracow amounts to 68%, varying from 61% in July to 76% in January. According to M. Morawska (1963), Cracow is characterised by greater cloudiness than should result from its geographical position.

The analysis of multi-year course of cloudiness presented in Figure 7 as deviations from the averages from the years 1861-1990, proves that a decrease

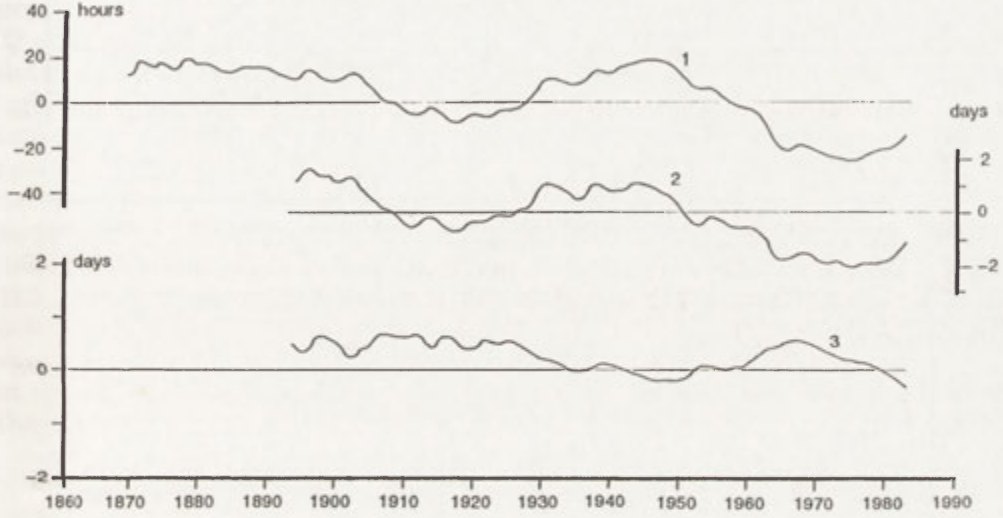

Fig. 5. Deviations of monthly totals of sunshine duration (1), number of days with sunshine duration > 10 hours (2), and number of days without sunshine (3) from the multi-year (1884-1990) mean in Cracow in July

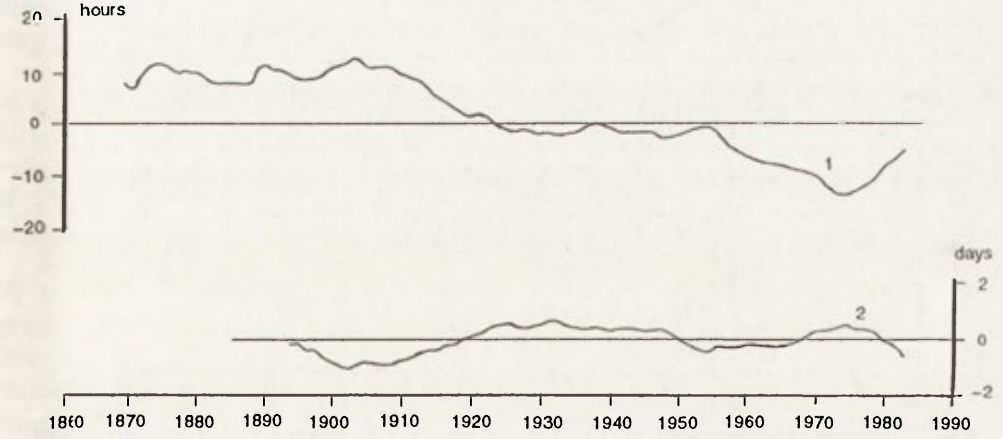

Fig. 6. Deviations of monthly totals of sunshine duration (1), and number of days without sunshine (2) from the multi-year (1884-1990) mean in Cracow in January

in mean annual values of cloudiness occurred in the second half of the 19th century. The cloudiness of the winter months was similar, with a distinct minimum about 1900. Contrary to the changes of cloudiness in winter, the cloudiness of summer has been showing increasing trends since the beginning

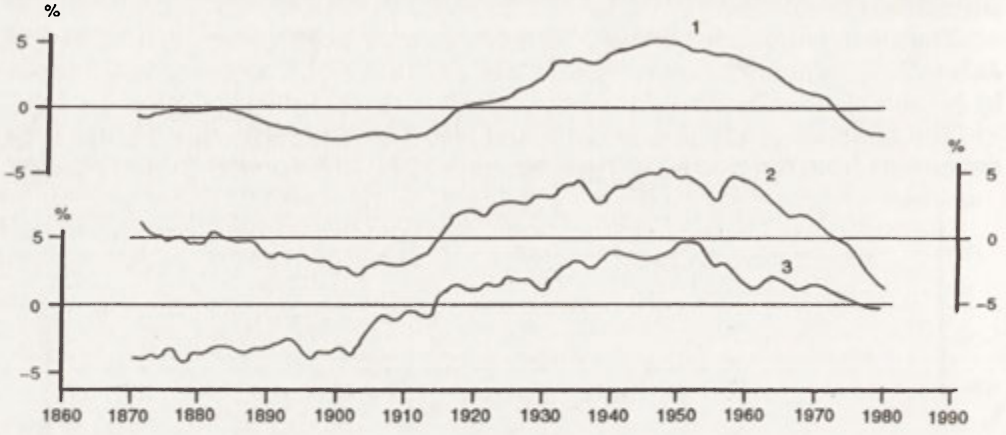

Fig. 7. Deviations of annual means of cloudiness (1), and monthly mean values of cloudiness for January (2) and for July (3) from the multi-year (1861-1990) average in Cracow

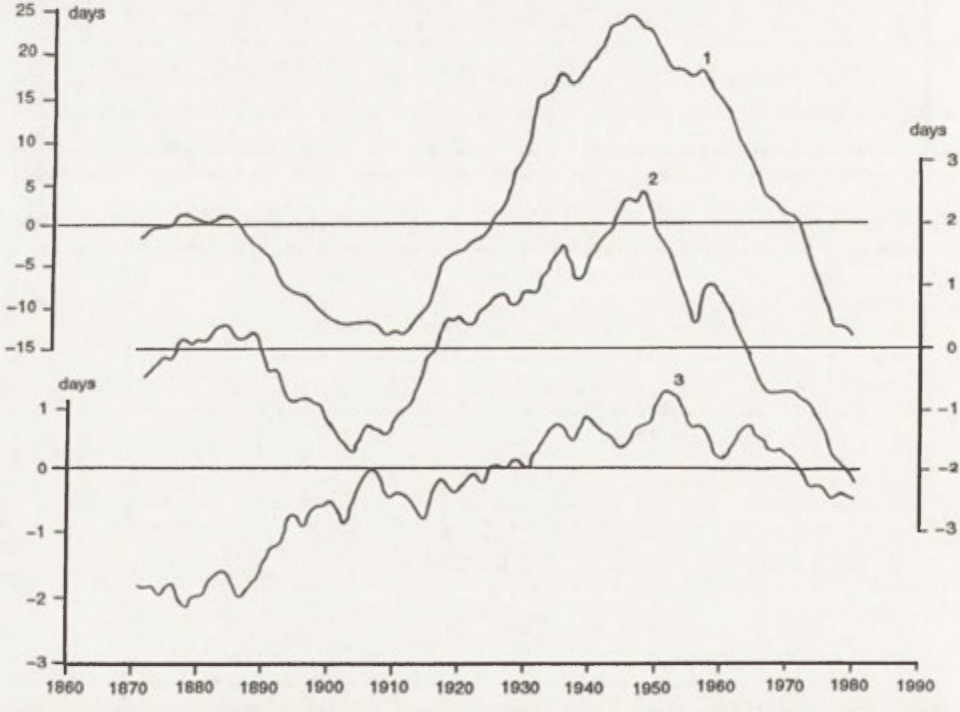

Fig. 8. Deviations of annual means (1) of the number of cloudy days, and of monthly means of the number of cloudy days for January (2) and July (3) form the multi-year (1863-1990) average in Cracow

of the observation periods, i.e. since 1861. The apparent increase in cloudiness of Cracow was greatest in the years 1940-1950. Both, annual means and monthly means of cloudiness were about 5% higher than the multi-year mean. After 1950, the decrease in cloudiness began and has lasted up to the present.

The course of number of cloudy days is strongly connected to the course of cloudiness during the examined period. The annual mean of number of cloudy days reaches 160 days and varies from 10 in July to 18 in January throughout a year. The multi-year variability of this parameter has been presented in Fig. 8.

The fluctuations of sunshine duration and cloudiness in Cracow for a period of almost 130 years is the reflection of changes occurring in circulation processes over Europe and of the location of the city in a narrow Vistula valley. The city's location seems to have had a great importance during the last decades, when the air pollution strongly increased because of urbanisation and industrial development. One of the results, apart from the increase in air temperature, the decrease in annual and daily amplitudes, the increase in the reach of urban heat island, etc., is an unusual phenomenon of the concurrent decrease in sunshine duration and cloudiness. This relationship between sunshine duration and cloudiness used to be attributed to the increase in air pollution (Kuczmarski 1982, Morawska-Horawska 1981, 1984, 1985). In 1950-1990 the annual sunshine duration totals decreased on average by about 300 hours, and the average cloudiness by about 7-10%. The slight increase in sunshine duration in recent years has been probably caused by the decrease in the concentration of air pollutants since the late 1980s, caused mainly by the economic recession.

CONCLUSIONS

On the basis of the analysis carried out of the long-term course of air temperature, cloudiness and sunshine duration in Cracow, the following conclusions may be drawn:

1. The annual air temperature range (RAT) most fully reflects the trends in climate change on the macroscale because it is influenced by circulation factors and it shows the periodical appearance of oceanic and continental influences as a result of the change in solar energy inflow. The large variability of this value in a multi-year period makes the interpretation of climatic phenomena easier.

2. The daily ranges of air temperature in January (DAT I) and July (DAT VII) differ from the RAT in much smaller variability. They are influenced to a great extent by local factors, formed by urbanisation processes. According to the research carried out after 1950, a minimum temperature reacts to urban conditions, which in turn influences the small variability of DAT I and the values of this characteristics are almost stable. Large cloudiness and a high number of cloudy days and days without sunshine are additional factors influencing such a situation.

3. The turning periods may be observed in the 1870s and 1880s, when, as it is supposed, the global warming began; in the 1930s, when the continentality of the climate increased; and in the beginning of the 1950s, dominated by anthropogenic influences. The first two periods are caused by natural reasons of a global character, whereas the last one, though coinciding with the period of climate oceanity, integrates also the results of human economic activity.

4. The great difficulty in determining the trends connected with the air temperature, cloudiness and sunshine duration, gives no basis for forecasting the changes of these elements in the nearest future.

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TRANSPORT OF SUSPENDED LOAD IN THE PARSĘTA RIVER DURING THE FLASH FLOOD OF JUNE 1988, POLAND

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ABSTRACT: In the first half of June 1988 intense rainfall was recorded in the center of West Pomerania. It caused a flash flood in the catchment of the upper Parsęta which made itself felt also in the lower reaches of the river. The flood occurred in three periods of flood waves (11.1, 2.2 and 6.6 m^3s^{-1} respectively, mean annual discharge equalled 0.7 m^3s^{-1}). In the analysis attention is paid to hydrological and geomorphological aspects of the transport of suspended load along the Parsęta course as effects of processes taking place in the catchment area. The transport of the suspended sediment load varied over the flood period because of a strong hysteresis effect. We distinguished three kinds of hysteresis loops: clockwise, anticlockwise and two-part. They represent different conditions of water and sediment supply from the catchment and the Parsęta channel. During the flood period 203 tons of suspended sediment load were removed, compared with 891 tons for the whole year. When comparing water flow and the transport of suspended material recorded at two extreme stations of the longprofile of the Parsęta River, the striking aspect is their dependence on the distance from the agent, i.e. the heavy rainfall in the upper Parsęta catchment, and indirectly on the catchment size. In the case of a small catchment, the responses are more dynamic and diversified, while in a large one they are more stable and even. The results allow an evaluation of the role of an extreme phenomenon in fluvial transport in the lowland and young glacial catchments.

KEY WORDS: fluvial transport, suspended load, flash flood, Parsęta River.

INTRODUCTION

There is extensive literature on the transport of suspended load in river channels. It deals with global issues (e.g. Walling and Kleo 1979), regional issues (e.g. Walling and Webb 1981), various sedimentary sub-environments, e.g. glaciofluvial (Gurnell 1987), and many detailed problems, including flood discharges (e.g. Olive and Rieger 1984). The last mentioned question is especially interesting due to the role of flood discharges in the transport of suspended load. The concept of an extreme process considered in terms of its

recurrence, spatial extent, and sedimentological and morphological effects has not been dealt with in detail yet (Starkel 1986). Little is known about the role of these processes in a river channel and catchment in young glacial and lowland regions in the temperate climatic zone.

In the first two weeks of June 1988 periods of heavy and intense rains were recorded in the central part of West Pomerania. New data thus collected help define the part played by extreme meteorological phenomena in the magnitude of soil erosion in the upper Parsęta catchment, in the nature and intensity of fluvial transport in this catchment and in the downstream drainage basin of the whole Parsęta River, as well as in the style of denudation of a lowland and young glacial area. The data allow the characteristics of the flood to be analysed on a regional scale.

Studies of the present-day denudation system of young glacial areas have been carried out in the Parsęta catchment (Fig. 1) situated in the middle part of West Pomerania (Kostrzewski and Zwoliński 1992). The catchment lies on the north-facing slope of the central Pomeranian belt of end moraines and is a part of the Baltic drainage area. The Parsęta headwaters are found at an altitude of 137 m a.s.l. The total length of the river is nearly 132 km, its sinuosity is 1.55 and its slope 0.00105, while its drainage area amounts to 3,151 km^2. There are four water-gauging stations of the Institute of Meteorology and Water Management located on the river (Table 1).

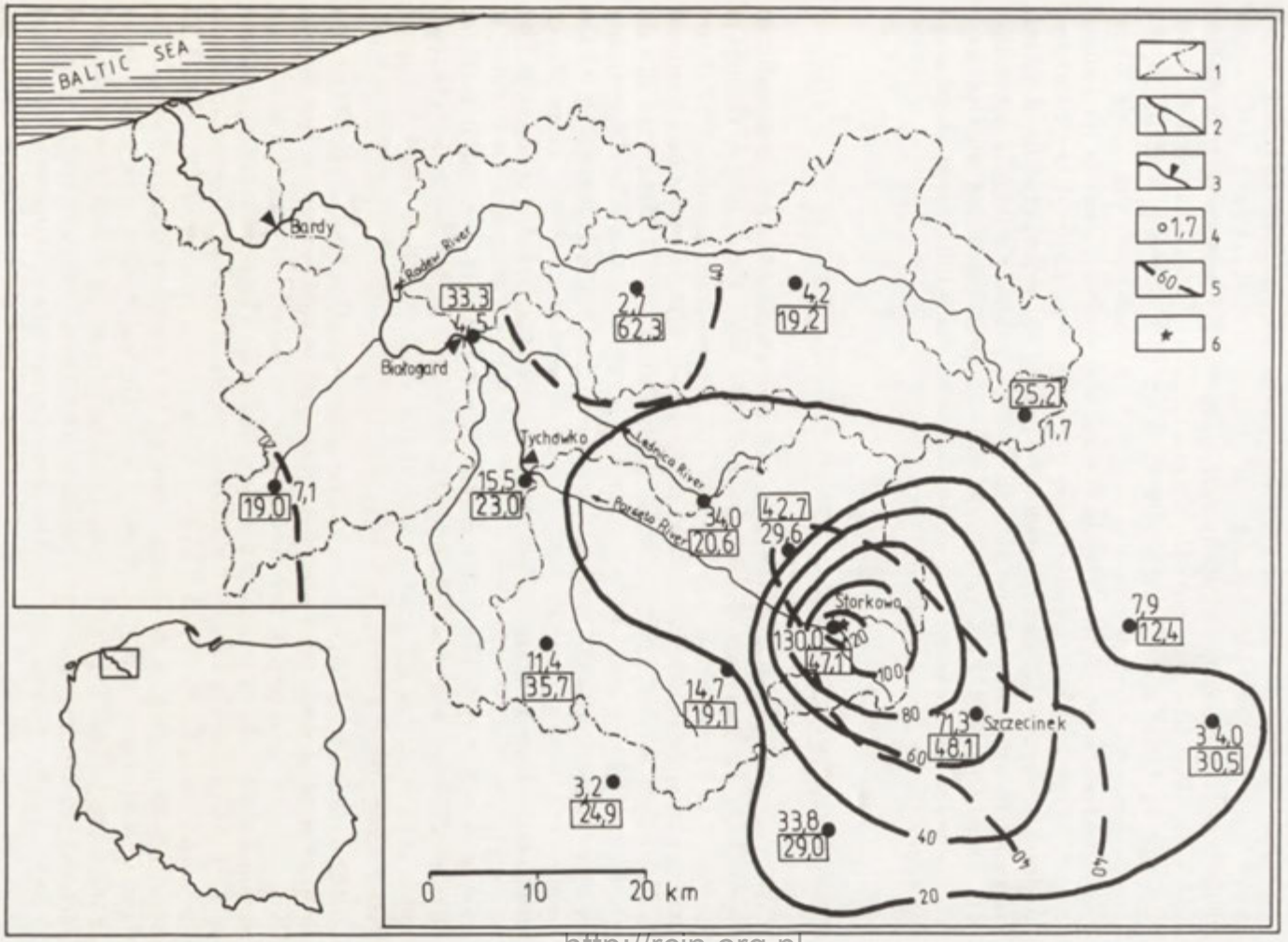
TABLE 1. Hydrometric characteristics of water-gauging stations on the Parsęta River

Parameter	Unit	Storkowo	Tychówko	Białogard	Bardy
Distance from the mouth	[km]	118.7	75.7	59.5	25.0
Drainage area	[km^2]	74.0	895.8	1129.6	2955.2
Average discharge	[m^3s^{-1}]	0.7[a]	8.3[b]	10.8[b]	26.8[b]

[a] 1986-90, [b] 1960-79

Detailed studies of surface runoff and soil erosion are being carried out on three slopes with different land-use patterns in the lower portion (the Młyński Brook catchment) of the upper Parsęta catchment (Klimczak 1993). In June 1988 material was collected from Seiler's traps after three falls of rain. The effects of this precipitation involved the transport of 10.3 t ha^{-1} from ploughed fields, and averages of 50.7, 0.146 and 0.021 kg m^{-1} of slope width in the ploughed field, forest and meadow, respectively (Kostrzewski et al. 1992). These rates represent 92%, 94% and 28% of the annual totals, respectively. Particularly intense rill erosion occurred in a maize-field lying about 5 km

Fig. 1. Location of the Parsta River drainage basin and spatial distribution of precipitation on 7 June 1988 (solid line) and on 11 June 1988 (dashed line)
1 — watersheds of the Parsęta River and component catchments at Storkowo, Tychówko, Białogard and Bardy, 2 — streams and brooks, 3 — water gauging stations of Institute of Meteorology and Water Management, 4 — rain gauging stations and diurnal precipitation totals on 7 June 1988 and on 11 June 1988 in frames, 5 — isohyets, 6 — Research Station at Storkowo



north-east of the research station at Storkowo. The total erosion rate in the slope catchment was about 80 t ha^{-1} (Kostrzewski et al. 1992).

Erosion material was mostly deposited on the slope or at its foot, and only a part of it reached the valley bottom. The greatest erosional effects in the upper Parsęta catchment were reflected in river transport. In the assessment of Walling and Webb (1983), the sediment delivery ratio usually varies between 0.05 to 5%.

Every morning water stages are read at each gauging station on the Parsęta. Extra limnographs have been installed at Storkowo and Bardy. Water is sampled at these stations to determine the concentration of suspended material. Frequent hydrometric measurements were made at the Storkowo gauging station on the upper Parsęta during the third period of flood waves, and water samples were taken at 1-, 2- and several-hour intervals depending on changes in the water stages. The concentrations of suspended material were determined using the weight method given in Brański (1968) for medium-sized filters and water samples of 1 dm^3 in volume.

HYDROLOGY OF THE FLOOD

West Pomerania displays certain climatic characteristics, especially in respect of precipitation, that distinguish it from other young glacial regions of the Polish Lowland. From 7 to 11 June 1988 the research station at Storkowo measured 192.8 mm of rainfall, which amounted to 30.7% of the mean annual total (1963-82) as well as 23.3% of the total rainfall in 1988. Data from 30 rain gauges located in central West Pomerania served as a basis for determining the spatial distribution of precipitation received on 7 and 11 June (Fig. 1). On 7 June more than 100 and 80 mm fell on areas of 64 and 192 km^2, respectively. From 7 to 11 June an area of 1,086 km^2 received a rainfall of over 100 mm. The maximum precipitation intensity was recorded at Szczecinek on 9 June; it amounted to 3.75 mm $min.^{-1}$. The probability of diurnal precipitation totals of 130 mm at Szczecinek was determined for a 30-year period (for the whole year) and is of the order of 103 years, whereas it can occur in June every 122 years (Kostrzewski et al. 1992).

The June series of effective rains brought about a flood on the upper Parsęta River of a magnitude unobserved at Storkowo in this century, if not longer. Over the pre-flood period the water stage remained low and the discharge equalled about 0.39 m^3s^{-1} (5.3 $dm^3s^{-1}km^{-2}$) (Fig. 2). The flood occurred in three periods of flood waves (Fig. 2, Table 2) which could have been associated with successive periods of rainfall. The first wave after a storm rain lasted 49 h 15 min. (7-9 June) and its discharge attained 11.1 m^3s^{-1} (152 $dm^3s^{-1}km^{-2}$). The flooding water was rapidly delivered from the catchment area to the river channel and thus this phase was characterised by steep increases and decreases in water stage. Over a period of 3 h 45 min. the water stage increased by 389%, i.e. from 44 to 171 cm. The second wave was of shorter duration and lower, as it lasted 32 h 45 min. (9-11 June), and its maximum discharge,

amounting to about 2.5 $m^3 s^{-1}$, persisted for 12 hours. Finally, the third wave generated by heavy rain lasted 43 h 15 min. (11-12 June), and its maximum discharge amounted to 6.6 $m^3 s^{-1}$. The hydrogram of the recession limb of this wave shows a slight bulge indicating the throughflow supply of the river

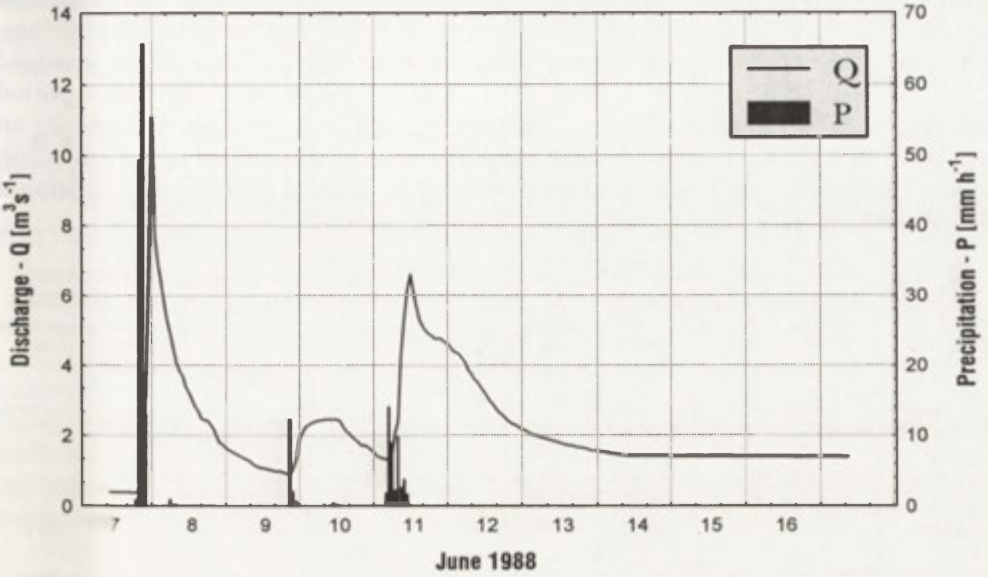


Fig. 2. Hourly precipitation (P) and water discharge (Q) of the upper Parsęta River from the 7-17 June 1988 at Storkowo

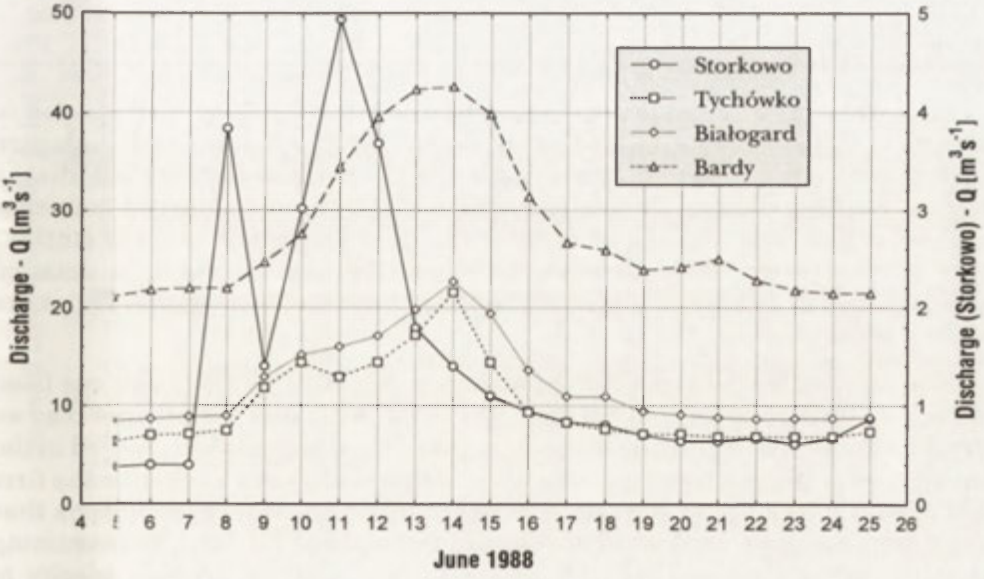


Fig. 3. Daily water discharges in the Parsęta drainage basin

channel (Anderson and Burt 1982, Burt and Butcher 1985, Finlayson 1977). Peak waves were observed about 4-5 hours after the increase in the water stage and about 5-6 hours after the beginning of rain.

The whole flood embracing the three waves was marked by a rapid supply of water to the river channel and an equally quick flow of this water. This indicates that the dominant supply of water to the river channel was over the land surface. The quick flow of the flood waters from 7 June (18:45) to 12 June (24:00) involved 1.3×10^{-6} m^3 of water, which amounts to 5.5% of the annual runoff in a period equal to 1.4% of the year (Table 2). Discharges of this magnitude are a rarity on the upper Parsęta; since the mean annual discharge amounted to 0.75 m^3s^{-1} in the hydrological year 1988, the June flood can be classed as a highly exceptional event not only in that year, but also in a longer period.

TABLE 2. Water runoff (AQ), total suspended load (As), mineral (Asmin) and organic (Asorg) suspended material outflow from the upper Parsęta catchment during a flash flood, June 1988

Period	Pre--flood period	1st flood wave	2nd flood wave	3rd flood wave	Post--flood period	Three waves totals	Flood period	Hydrol. year 1988	Units
Beginning	88.06.07 08:00	88.06.09 18:45	88.06.09 20:00	88.06.11 04:45	88.06.13 00:00	88.06.07 18:45	88.06.07 18:45	87.11.01	
End	88.06.07 18:45	88.06.09 20:00	88.06.11 04:45	88.06.12 24:00	88.06.17 08:00	88.06.12 24:00	88.06.17 08:00	88.10.31	
Duration of flood	–	21.48	14.28	18.87	45.37	54.63	100.00	–	[%]
Time of the year	0.12	0.56	0.37	0.49	1.18	1.43	2.61	100.00	[%]
AQ	8 136	477 936	227 414	608 582	506 509	1 313 933	1 820 441	23 805 743	[m^3]
As	0.7	62.9	21.0	82.3	37.2	166.2	203.4	890.6	[t]
Asmin	0.4	52.2	15.9	67.8	26.8	136.0	162.8	626.8	[t]
Asorg	0.8	12.0	6.0	14.8	14.4	32.7	47.1	264.8	[t]

The water flow at the successive stations during the flood is illustrated in Figure 3. The great similarities between the Tychówko and Białogard hydrograms are due to the short distance of 16 km between these localities, a narrow channel reach in the plateau area, and the absence of large tributaries. Unlike at Storkowo, the appearance of the flood waves at these two stations was delayed three days. However, it should be kept in mind, as detailed observations at Storkowo showed, that the first wave was higher and more violent than the second.

The streamflow looked different at Bardy (Fig. 3). There was only one flood wave which reached its peak on the night of 13/14 June as the result of the two (Tychówko and Białogard) or three (Storkowo) flood waves which formed in the upper part of the catchment. There was a delay of almost a week after the first fall of rain in the upper Parsęta catchment. Knowing from hydrographs that the first peak was recorded at Storkowo at midnight of 7/8 June, and assuming that the highest discharges of the Parsęta flow with an average velocity of about 1 ms^{-1} (Zwoliński 1989), it could be concluded that, with the flow

unimpeded, the peak should have been registered at Bardy after 26 hours. Hence, the delay of the actual flow was 5.5 times the theoretical one, i.e. 144 h. The factors contributing to the delay were not only a high retentive capacity of the catchment, but also of the river channel itself, with its more than ten working and disused hydrotechnical devices together with reservoirs. Overbank flows occurring in many reaches of the river also played a contributing role.

DYNAMICS OF SUSPENDED LOAD TRANSPORT

THE UPPER PARSĘTA CATCHMENT

The transport of suspended sediment load varied over the flood period. The estimates given below should be treated with great caution and regarded as minimum values. This is due to a stronger hysteresis effect and marked exhaustion of reserves available for transport in suspension during successive flood waves. It may be presumed that the concentration of the suspended sediment load was considerably higher during the first flood wave than that estimated by means of regression because of the preceding prolonged rainless period.

The above remarks are illustrated by a loop of suspended sediment concentration recorded at the third flood wave (Fig. 4). Increases and decreases in the discharge were accompanied by markedly different patterns in the

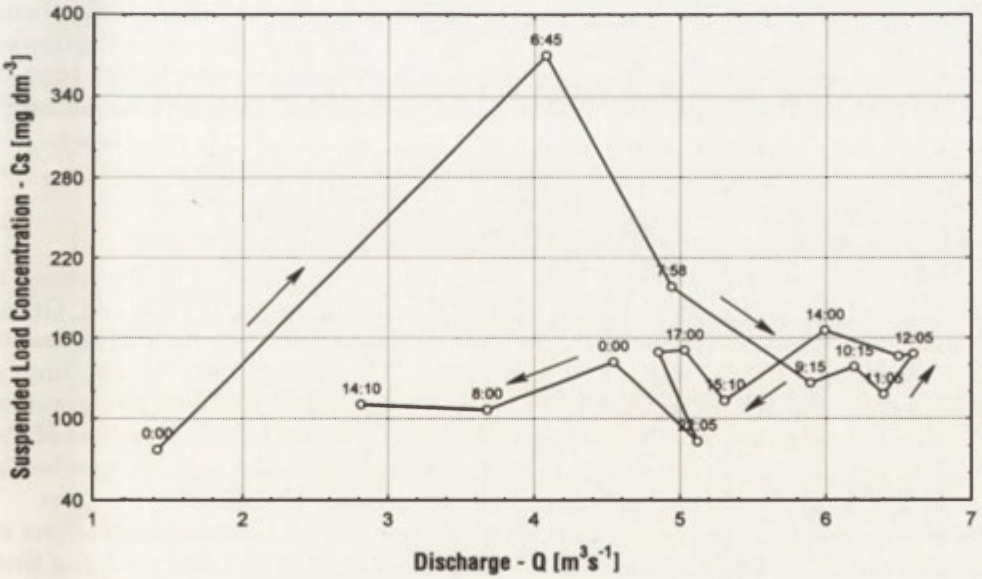


Fig. 4. Hysteretic loop for suspended load concentration (Cs) during the 3rd flood period (11-12 June 1988) for the upper Parsęta River at Storkowo

suspended load. The maximum concentration, 370 mg dm^{-3}, occurred two hours after the water stage started to rise. The lowest concentration, 117 mg dm^{-3} at the peak stage, was recorded an hour before the maximum discharge (11:05), and then it rose twice (14:00 and 17:00) while the water stage was falling. On the one hand, the two concentration rises correspond with changes in the precipitation intensity on 11 June, but on the other hand, they may reflect the duration of water travel from particular component catchments and supply areas remote from the channel (Klein 1984, Olive and Rieger 1984). To illustrate this issue: in the lowermost left-bank component catchment (the Młyński Brook) of the upper Parsęta the maximum discharge was estimated at 2.5-3 m^3s^{-1} (the storage capacity of the weir is 1.36 m^3s^{-1}). The unit suspended load varied from 2 to 84 g $s^{-1}km^{-2}$ during the third flood wave. The maximum suspended load of 84.0 g $s^{-1}km^{-2}$ (1051.2 mg dm^{-3}) was recorded when the discharge declined. For comparison, in the hydrological year 1988 average unit loads of suspended material, measured daily every morning, amounted to 0.225 g $s^{-1}km^{-2}$.

During the flood period 203 tons of suspended sediment load (3.4 g $s^{-1}km^{-2}$) were removed (Table 2). Over the period of the three flood waves (55% of the flood duration), 82% of the load was carried away. It equalled 166 tons (5.0 g $s^{-1}km^{-2}$). During the three consecutive periods of peak waves, 63, 21 and 82 tons of suspended load, respectively, were transported. The third flood wave proved the most efficient for the suspended load. After the period of the quick flow that accounted for 45% of the flood duration, water carried 37 tons of suspended load (1.2 g $s^{-1}km^{-2}$ on the average).

The flood period took up 2.61% of the hydrological year. Its runoff value was 1.82×10^{-6} m^3 (Table 2). Throughout the period of quick flow (three waves) and the whole flood period 5.5 and 7.6% of the average annual water amount flowed away, respectively. In the hydrological year 1988 water carried 891 tons of suspended load (12.1 t $km^{-2}a^{-1}$). Thus, the quantity of the load carried away during the mentioned periods amounted to 18.7 and 22.8%, respectively.

FLOOD EFFECTS IN THE LONGPROFILE OF THE PARSĘTA RIVER

The response of a given catchment was largely conditioned by the amount, characteristics and spatial distribution of the precipitation it received. Other factors, especially those controlling the three lower catchments at Tychówko, Białogard and Bardy, seem less important. The upper Parsęta catchment differs from the others in that it is of a lower order and received the greatest rainfall. As far as the Bardy profile is concerned, the hydrological regime of the Radew, the largest Parsęta tributary (1,058 km^2) with the biggest number of lakes in the whole of the catchment, may have a marked effect.

Hysteresis loops can be drawn for daily suspended load concentrations at the Storkowo and Bardy stations (Fig. 5). Two loops associated with the first and third flood waves are available for Storkowo (Fig. 5a). Those of the first wave are aligned in the opposite direction (anticlockwise loop — from 8 to 10

June). This provides evidence for a supply of the suspended load from sources outside the channel, e.g. throughflow and soil erosion (Klein 1984). The flat loop is clockwise during the third flood wave (from 10 to 12 June, see Fig. 4 also). This direction of loop indicates supply of the suspended load from the

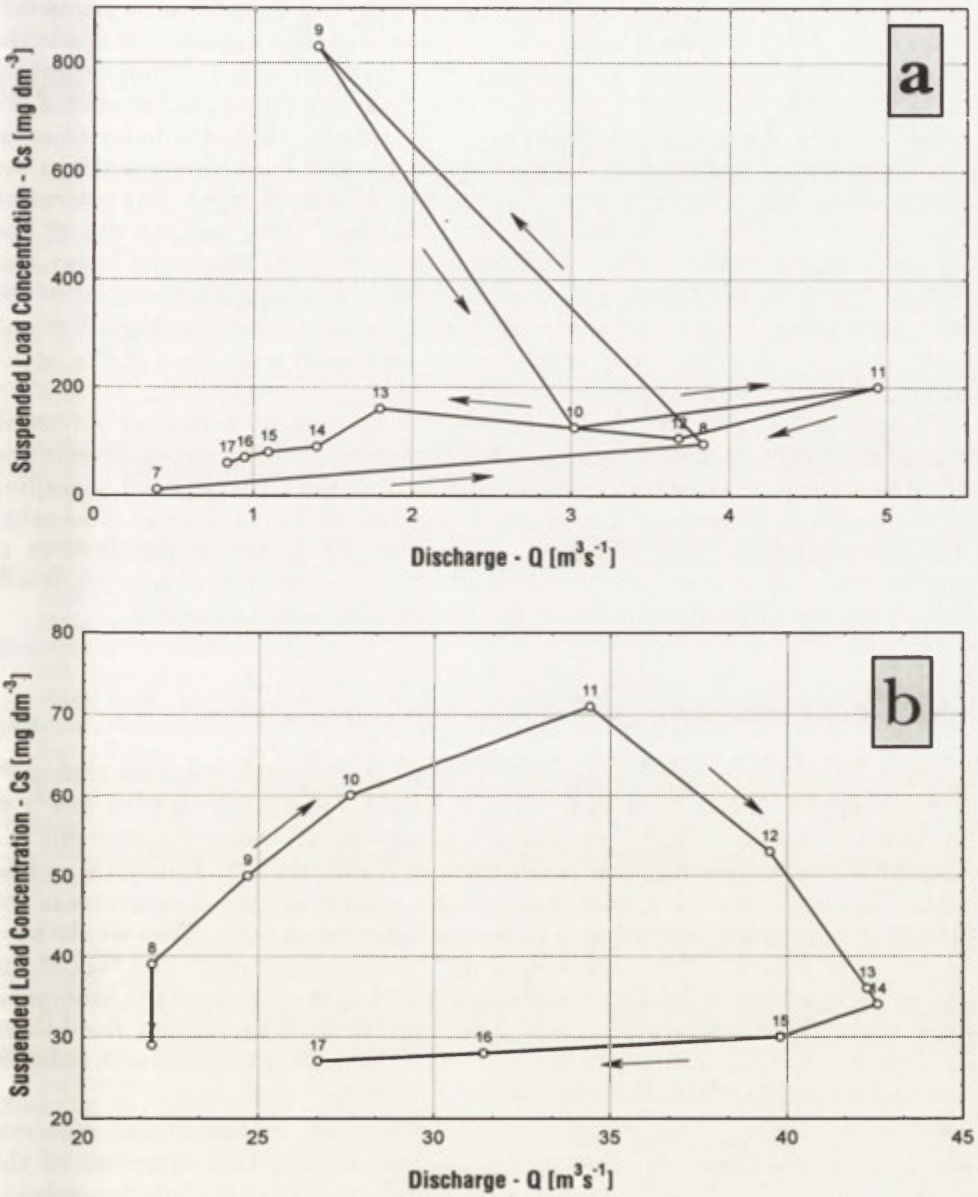


Fig. 5. Hysteretic loops for diurnal suspended load concentrations (Cs) at Storkowo (a) and Bardy (b) from 7 to 17 June 1988

channel and tributaries. It is a response to the fast reaction of the Parsęta river on quick flow in the main channel and a different temporal reaction in tributary channels within the Parsęta catchment.

The hysteresis loop for the suspended load at Bardy is clockwise (Fig. 5b) due to the fact that the lower Parsęta carried material coming from the upper reaches of the river channel where the heaviest and most intense rains fell. There was, furthermore, no supply from the interfluve areas, because the heavy rain only fell in the upper and part of middle Parsęta. Diurnal estimates suggest that the maximum concentration of the suspended load preceded the peak discharge that occurred three days later. It seems impossible for an error to arise as a result of observations of the suspended load concentrations not being kept constant, because of the river size and its discharges. The activation of the suspended load indicates that water derived from surface runoff had reached Bardy before the flood wave attained its peak. Thus, the latter was affected by groundwater runoff associated with the lagging function of the catchment storage capacity. The evidence also comes from the higher runoff coefficients of the three lower catchments, compared with that of the upper Parsęta River.

To sum up, it appears that a two-part loop may be proposed for small catchments over which heavy rains will fall. One part will be anticlockwise and will show a supply of material from sources outside the river channel, including the slopes. It will correspond to a phase of quick flow in the river. The other part, associated with a falling phase, will be clockwise and indicative of supplies from the channel, the adjacent saturated areas and tributaries. It will result from the different relaxation time of the denudative system.

CONCLUDING REMARKS

From 7 to 20 June the Storkowo and Bardy stations recorded the transport of, respectively, 337.5 tons (4.6 t km^{-2}) and 1,416.8 tons (0.48 t km^{-2}) of suspended material. There was only an interval of two days between the maxima of the suspended load transport at Storkowo and Bardy (9 and 11 June). This supports the hypothesis that the sedimentological response of the Parsęta catchment is more rapid than the hydrological one. This would bear out the observation of Webb and Walling (1982), who explain the fact of the flood wave being preceded by material transport by a reversal of the kinematic wave effect. This reversal is caused by overbank flows on the floodplain. Morphological and sedimentary traces of such flows were found to occur almost along all segments of the Parsęta (Zwoliński 1992).

When comparing water flow and the transport of suspended material recorded at Storkowo and Bardy, the stations at the two extremes of the longitudinal profile of the Parsęta, the most striking aspect is their dependence on the distance from the agent, in this case the heavy rainfall in the upper Parsęta catchment, and therefore indirectly on the catchment size. In the case

of a small catchment, the responses are more dynamic and diversified (the Młyński Brook, the upper Parsęta at Storkowo), while in a large one they are more stable and even (the Parsęta at Bardy). Small catchments are dependent on local conditions, whereas in large ones regional controls produce average results, thus reducing the final effects of a local and unusual phenomenon.

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DISTRIBUTION AND DYNAMICS OF RURAL POPULATION IN CENTRAL EASTERN EUROPE IN THE 20th CENTURY

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ABSTRACT: The work deals with demographic problems of the rural areas in Estonia, Latvia, Lithuania, the Kaliningrad District, Belarus, Ukraine, Poland, Czechoslovakia, Hungary, Rumania, Moldavia, Bulgaria and Yugoslavia. In the text, the common term "Central Eastern Europe" is applied to these countries. A statistical analysis has been employed with regard to nine time intervals/time points: 1897/1900; 1910/1913; 1920/1921; 1939/1941; 1948/1950; 1960; 1970; 1980 and 1987/1990. For each of them the size of rural population and its density have been evaluated, and then, the dynamics of demographic evolution described. An important part of the analysis has been the comparison of rural population to total population. On the basis of this comparison, structural changes and demographic trends have been defined. Particular attention has been paid to the processes of depopulation as well as their range and intensity in rural areas of Central Eastern Europe.

KEY WORDS: rural population, density, migrations towards urban areas, dynamics, depopulation of rural areas.

INTRODUCTION

We do not know much about the demographic processes which have been developing, since 1989, in rural areas of Central Eastern Europe. Attempts at cooperation with authors from the neighbouring countries have been impaired for methodical reasons and because of the unsatisfactory condition of the existing statistics.

Nevertheless, thanks to personal contacts, the flow of information has been ensured so that an introductory comparative analysis, on an international scale, is possible. The new conditions have enabled us to confront the demographic processes, developing in the Polish rural areas, with the analogical evolution taking place in some other European countries.

An international research campaign can make it clear whether, what has occured in Poland, are universal phenomena or if their appearance is

exceptional. In order to follow the demographic changes, occuring in a long period of time, one has to establish their territorial range and the exact time covered. It is only through an extended retrospective analysis that we can distinguish constant from sporadic tendencies. The present study deals with the great territory of Central Eastern Europe in the period of one hundred years.

It is difficult to fix the area of the highly indefinite region of Central Eastern Europe. The term "Central Eastern Europe" carries many ambiguous historical meanings, supported by a number of stereotypes. Side by side with measurable geographical phenomena, which open the possibility of applying the procedures to regionalization, there appear some difficult and changing ideological aspects of the problem. By heightening emotions, they hamper, the acceptation of the objective rules of deliminatation.

Nevertheless, the research workers dealing with the problems of Central Eastern Europe, must draw the limits of the area of this important region. The geographers of the region often treat sets of countries of Central Eastern Europe, groupped for statistical reasons, as a basis for their geopolitical concepts. This raises suspicions in the neighbouring countries and makes international comparative studies difficult. The historical events of the last few years make for still greater complications. The breakdown of the communist system, in this part of Europe, undermined the social stability and started the process of disintegration. The criteria of proper delimitating procedures are difficult to establish. Political and constitutional premises have changed their meaning. Therefore, it is not the search for the so-called geographical, economic or demographic criteria that should become the point of departure; the suitability of the adopted regionalization for a given research project should become its measure.

The present comparative analysis presents demographic transformations occuring in communities which, for a long time, kept their traditional values, i.e. situated in that part of the Continent where urbanization and industrialization appeared later than in Western Europe. Another important problem, raised in the present paper, is the analysis of the demographic repercussions in the countries which, for a long time, belonged to the socialist system. The rural areas in communist countries were subject to various forms of collectivization which disturbed the evolutionary process of agrarian changes. All of the above-mentioned factors decided on including a group of countries as the region of Central Eastern Europe.

The examined territory comprises Poland, Czechoslovakia, Hungary, Rumania, Bulgaria, Yugoslavia, Ukraine, Moldavia, Belarus, Lithuania, Latvia, Estonia and the Kaliningrad District — an enclave situated between Poland and Lithuania which formally belongs to Russia.

In works of Polish geographers this has been called "the Isthmus", while in Germany it has often been given the name of Middle Europe, with Germany situated within its boundaries. That term has been rejected by Slav geographers as an embodiment of German expansionism. In West-European countries, the area situated east of the Elbe and the Lusatian Nysse is often

called Eastern Europe. Political criteria have become determinants so that Greece and Finland are treated as parts of Western Europe while Czechoslovakia, Hungary or Poland are ascribed to Eastern Europe. Presently, these divisions have become anachronisms.

We must remember that letting the term "Central Eastern Europe" cover six ex-Soviet republics, one Russian administrative district and six European countries, we are making a highly arbitrary choice. It results from the geographic and political heterogeneity of the countries under discussion; e.g. Yugoslavia, considered to be a Mediterranean country, has been included here, while Albania, politically close to the Eastern Block, has been excluded. The eastern limit of the selected set of countries is the western boundary of the Russian Federation. Finland, Sweden and Norway, belonging to Northern Europe, have been excluded.

Eventually, the present study encompasses the territory situated between the ethnic Russia in the east and Germany in the west. On the north it is bounded by the Baltic Sea and on the south by the Black Sea. The components of the common European region are both the western republics of the ex-USSR and independent countries which, however, after World War II, were economically and politically dominated by the Soviet Empire. These countries, because of their long membership in the Eastern Block, have common economic and agrarian problems to solve.

However, in spite of certain likenesses, they are not a monolithic organism. Central Eastern Europe, as a whole, is a specific social and economic region which, in this respect, does not reach the level of Western Europe. There are sound reasons for treating the complex of the countries under discussion as a distinctive part of the European Continent.

The next obstacle, in this field of study, is connected with the fluctuations of the political borders of the countries belonging to the analysed group. The study covers about one hundred years. The earliest statistical data come from the turn of the century — the most recent from the years from 1987 to 1990. The assumed points of reference are the present borders and the territory of the countries included. Such a view is geographically justified for it guarantees the spatial comparability of statistical materials. On the other hand, viewed in a poitical and historical perspective, it brings about serious deformations. That is why we have to remember that the data concerning Poland, Rumania and Czechoslovakia, in the period between the two World Wars, must not be referred to the statistical materials for the then political structures of these countres, but to their present territories.

In the fragment of the present paper dealing with the period before the World War Ist, the term "Ukraine" covers not only the lands belonging to the Russian Empire, but also e.g. to Eastern Galicia which, at the time, was a part of the Austro-Hungarian Empire and, in the period between the two World Wars, a part of the integral territories of Poland such as Wołyń and Podole.

The further back we go, the greater the deformations but had we accepted a different assumption, the complications would have been much greater. An

example from the history of Poland may serve as a proof. This country would be absent from the statistical data apportioned for the time sections up to the World War Ist. The statistical data, concerning the years from 1921 to 1939, would apply to a territory different from the present one. This would result in a disappearance of spatial comparability. The acceptation of the rule of territorial stability, in place of the changing borders and political status, brings about significant statistical consequences. The changes of borders resulted in migrations. The arrival of new national groups reshaped the character of some territories. These facts, if omitted, may cause errors. There is a need for a close interpretation of the numerical data given in the present paper. The present work deals with the demographic potential of the rural areas in a number of countries observed over a long period of time.

CHANGES IN THE SIZE OF RURAL POPULATION IN THE YEARS FROM 1897/1900 TO 1910/1913

The turn of the century, the thirteen political units under discussion had a total population of over 111 million, where farm dwellers accounted for 86 million. They made up about 77% of the population in the area (a proof of a low level of urbanization). Most farm dwellers (in absolute numbers) lived in the present territory of Ukraine and Poland.

During the first decade of the 20th century, the rural population increased by 15% and approached 100 million persons (the double data are referred to different dates of the censuses taken in the area). The growth was so dynamic that the density of the rural population of Central Eastern Europe showed a marked rise. The proof of the growth of spatial concentration may be the fact that the average density grew by 6 persons and, in the eight "countries", exceeded 40 persons per km^2. In the first decade of the 20th century, we may speak of a real demographic explosion in the rural areas. Most parts of the area under discussion had an average growth of over 15% per year. This occured in the southern part of the region, i.e. in Poland and in Ukraine and, to a smaller degree, in Lithuania and Latvia. The process of depopulation appeared only in two of the analysed "countries", i.e. in Estonia and in the northern part of the then Eastern Prussia. In case of Estonia, it can be ascribed to agrarian changes and to the closeness of Petersburg which could attract migrants from the country. On the other hand, from the end of the 19th century, there was active emigration (Ostflucht) from Eastern Prussia so that, in spite of a great natural increase, the countryside was loosing a part of its population. The area of the present Czechoslovakia and Hungary had a fairly, small natural growth. The area of Czechoslovakia had already entered a period of advanced capitalism which brought about energetic industrialization and urbanization processes, stimulating the flow from villages to towns and cities. The slower demographic growth of the Hungarian farm dwellers could have been largely caused by the dynamic development of Budapest which was absorbing throngs of migrants.

The data concerning Belarus raise serious doubts. I believe they are not very reliable. We can assume that the numerical data, taken from the Russian census of 1897, had been raised upward. This, in turn, resulted in lowering the growth in the years preceding World War I. The present author could not fully verify the data coming from the Demographical Yearbook, published in the USSR and concerning the area of the present Belarus.

Generally speaking, the period preceding World War I in Central Eastern Europe, was marked by strong demographic dynamics. In spite of the accented growth of urban population, expressed in absolute numbers (from 25.0 million to 33.0 million), the town dwellers accounted for a fairly constant percentage of the area's total population (1897/1910 — 22.6%, 1910/1913 — 24.9%). It was the result of the rapid growth of the rural population. It is worth noting that even the considerable emigration to America could not check the dynamic growth of the rural population.

CHANGES IN THE SIZE OF RURAL POPULATION IN THE YEARS FROM 1910/1913 TO 1920/1921

The fronts of World War I, which had rolled over Europe, left its Central Eastern regions with deep wounds. The military defeat of Russia, Germany and the Austro-Hungarian Empire had undermined its stability and caused great demographic losses.

They were intensified by the Russian Revolution, the Hungarian Revolt, etc. and the rise of new states in this part of Europe, which caused many conflicts on the frontiers. The result was a decrease of population, especially among the farm dwellers. We can accept the view that, in the 2nd decade of the 20th century, the rural population in the area under discussion decreased by about 5 million. The losses were observed mostly in Poland (50% of the general loss), then in Ukraine, Yugoslavia and Latvia. The greatest decrease, measured in proportion to total population, occured in the Latvian countryside.

The population, which inhabited the present territory of Poland, decreased by about 2 million; the decrease was noted exclusively among the farm dwellers while the urban population increased at the time by 0.5 million. The loss of life among Poles mobilized by the Russian, German and Austro-Hungarian armies, in the years from 1914 to 1918, was estimated at about 400 000 persons, while losses of the Polish Army during the Polish-Bolshevik War, in the years from 1919 to 1920, amounted to 98 000 soldiers. Much greater and more irreversible changes were caused by migrations and by natural decrease resulting from worsening material and sanitary conditions. In the years from 1914 to 1915, about one million persons were evacuated from the Kingdom of Poland (formed in 1815 at the Congress of Vienna) at command of the Russian authorities. The moving frontline caused great migrations and demographic losses. For all the reasons discussed above, the farm dwellers who inhabited the present territory of Poland, decreased from 20.5 million to 18.0 million.

Grave losses in the territory of Ukraine were connected with the turbulent post-revolutionary times and with the fights among political fractions (1918-1920). The losses in Yugoslavia (1914-1915) supposedly concerned mainly Serbia and Macedonia. We should realize that, during World War I, the growth of rural population in Bulgaria was not checked. The level of population, in the territories of Rumania, Moldavia and Hungary was, practically, constant.

On the basis of the trends, existing in the 1st decade of the 20th c, it could be assumed that the rural population inhabiting the territory under discussion would, after ten years, grow to much more than 110 million persons. However, the census and the estimative data, concerning the years from 1920 to 1921, pointed out that the population of the countryside amounted to less than 95 million. Therefore we can accept the view that the difference between the two numbers represents direct and indirect losses caused by World War I.

CHANGES IN THE SIZE OF RURAL POPULATION IN THE YEARS FROM 1920/1921 TO 1939/1941

In the two decades between the two World Wars, the demographic losses, resulting from World War I and the Russian Revolution, were not only compensated for but the population potential on the territory under discussion, grew by nearly 10 million. The greatest increase, in relative values, comprised the southern part of the European region under discussion; i.e. Yoguslavia, Bulgaria and Rumania with Moldavia which, at the time, were parts of one state. A significant increase was noted in Belarus.

The population of the Ukrainian countryside in that period of time, is difficult to determine; the problem cannot be definitely determined without the help of the Ukrainian research workers. The situation in the western areas, mainly in the Polish territory, took on a different shape. To a lesser degree, this was also true for Czechoslovakia (Ruś Zakarpacka — Transcarpathian Ruthenia) and Rumania (Northern Bukovina) but not for Ukraine proper which was then a part of the USSR. In the west there was a great increase in rural population which, over the twenty years, might be estimated at 25%. At the same time, the conditions in Eastern Ukraine were different.

After a short period of public disorder (1920-1923) connected with epidemics and hunger, in the years from 1923 to 1930, the population grew rapidly. The dominant components of the increase were high natural increase and small migrations.

The following years brought about collectivization and the accompanying liquidation of the kulaks and deportations of farm dwellers. The next to come was a famine which caused the death of from three to five million people. At the end of the 30s, there were far more births than deaths but mass deportations and repression had an impact on the rural population. In the years from 1939 to 1941, the policy of extermination and the waves of deportation covered

the western parts of Europe absorbed by the USSR. The general balance is complex and difficult to estimate. The sources bring contradictory data. In spite of the great fluctuations, after twenty years, the situation approximated that of the first post-revolutionary years and amounted to 27 million farm dwellers. However, the territorial distribution was changed. The major growth in the Western Ukraine made up for serious demographic losses in its eastern regions.

There was a considerable growth of rural population in the present territory of Belarus. It was especially marked in the western area, belonging then to Poland, where the living conditions were better.

The territory of today's Poland was a stage of important demographic differentiation. The population of the then Polish lands developed dynamically (from 18.3 to 23.2 million), while in the territory owned, up to 1945, by Germany and in the ex-Free City of Gdańsk, the population increased from 8.4 to 8.85 million. The dominant component of this growth was a high natural increase in Poland and a low natural increase in Germany. A great migration, from the East to the West of Germany, was another meaningful factor. The changing demographic conditions had an impact upon the general dynamics of the rural population. In the territory, which first belonged to Germany and, from 1945, to Poland, the rural population decreased by 0,5 million people. At the same time, the farm dwellers, living on the remaining Polish territory, reached 2.7 million persons. The general result — the rise from 18,092 thousand to 20,250 thousand, i.e. by 11.9% — was brought about by the growth of the rural population inhabiting the present territory of Poland.

The facts, furnished by statistical analysis, which point to a considerable dynamics of the rural population of Latvia, the growing stability in the Lithuanian countryside and the decreasing population of Estonia, are difficult to interpret. The sources of the data, mentioned above, are not very reliable. The censuses in these countries were not simultaneous, (1923 in Lithuania; 1935 in Latvia; 1934 in Estonia). The estimative data, concerning the stormy years from 1939 to 1941, are fairly ambiguous for, if we assume that the beginning and not the end of the year 1940 is the final year in a given analysis, the result will be different. This is connected not only with the Soviet deportations of the inhabitants of the three countries, conducted after they had been annexed by the USSR. After signing the Soviet-German pact, the people of German nationality left this area for the Reich. The data, concerning these countries given above, demand further verification. They were quoted after the already cited Soviet work which did not contain any explanations. The size of the population of Lithuania was even more difficult to establish; the estimate of the population of the Wilno region, annexed by Lithuania in 1939, was based on the Polish census of 1931 while the later estimative data call for a special revaluation, connected with the new border of Eastern Lithuania.

We should not forget that both the general population potential of the three Baltic states and the changes, measured in absolute numbers, and concerning growth and decrease, are negligible. That is why possible mistakes cannot

change the general demographic tendencies in the vast region of Central Eastern Europe.

In spite of the marked interior heterogeneity of this area which had its roots mainly in politics and, to some extent, in economics, its rural population was on the increase in the 1920's. As was its demographic potential. The natural increase was large enough to make up for the decrease caused by migrations but, in the end, the number of farm dwellers grew by about 10%. At the end of the 30's, the rural population in the area under discussion, reached about 104 million and its density was 48 persons per km^2. Further developments proved that it was the highest point, which would never be approached in the future. Therefore, in this case, we can speak of the peak growth. Its intensity varied according to the place of occurence, but the long lasting demographic tendencies in the countryside began to change from a minor to a growing depopulation of villages.

CHANGES IN THE SIZE OF RURAL POPULATION IN THE YEARS FROM 1939/1941 TO 1948/1950

The historical period from 1939 to 1950 may be divided into two parts: 1) from 1939 to 1945, i.e. to the end of World War II, and 2) from 1945 to 1950. The first post-war years were marked by a rapid growth of births, connected with so-called demographic compensation which made up for some of the war losses. The study of this whole span of time cannot, therefore, fully illustrate the war losses. However, the great differences between the initial and final data confirm the general view of great demographic changes caused by the war cataclysm.

The population of the whole area under discussion decreased in the decade by about 15.5 million while more marked changes occured in the countryside. While the urban population decreased by approximately 3.3 million persons, the number of country dwellers was reduced by 12.2 million. There were great differences in the distribution of the decrease. In Bulgaria and Hungary a certain growth was even noticed (minimal in Hungary, more visible in Bulgaria). In the rest of the analysed units, the decrease of the rural population was evident. The greatest percentage of losses appeared in the Kaliningrad District, and in East Prussia which had been divided between Poland and the USSR. Up to 1945, the area had been inhabited by Germans and a small Lithuanian minority. All the Lithuanians were deported. Their place was taken by Russians. The rural population in the area decreased threefold (from 620 to 200 thousand). The range of the decrease is well illustrated by the lowering of the density from 41 to 13 persons per km^2.

The greatest demographic regression, in absolute numbers, occured on the territory of Poland. It was caused not only by great war losses, but also by migrations, following the changes of the borders. The population of the present Polish territory decreased by 7.0 million, with farm dwellers accounting for

5,750 thousand. In the western and northern regions, which were incorporated into Polish territory at te Potsdam Conference, the rural population decreased from 4.6 million (in 1939) to 3.1 million (in 1950). The change of borders implied deportations of Germans and an influx of Poles, resulting in a new ethnic composition of these regions. In the territory which, between the two World Wars had belonged to Poland, direct war losses of life, caused by World War II and the German occupation, were aggravated by the loss effected by migrations (during the war, Poles were sent to Germany as forced labour), and by the post-war migrations to the western and northern regions. The settlers were the Poles who, until the war had lived on the then-Polish territory and the Poles repatriated from the USSR.

The rural population of Czechoslovakia largely decreased because of the post-war deportations of Germans from the so-called "borderland", i.e. in the first place, from the regions of Bohemia, bordering on Germany (among others from the Rudava and Šumava mountains and from Český Les). The rest of Bohemia and all of Slovakia did not undergo any significant process of depopulation.

The population of Ukraine fell by 3 million, and of Belarus by about 1 million. There were several reasons for the decrease. In the period of 1939-1941, this was connected with deportations, then, from June 22, 1941, with the evacuation of factories and their staffs to the East. Between September 1939 and June 1941, about 1,5 million people were deported from Western Belarus and Western Ukraine. Among those deported to the East, mainly to Siberia, Poles made up the largest group, but there were also many Jews, Ukrainians and Belarusians. The demographic losses to follow were caused by the moving frontline which twice ran through both countries, by the high death rate among the soldiers mobilized by the Red Army, by the German occupation and the international fights between national groups and political parties. Another factor, which influenced the balance of population, was the number of Polish citizens repatriated to Poland from her historical territories. Direct war losses exceeded the numbers for the years 1939 and 1950 because the rural districts of Ukraine and Belarus had, in the years from 1946 to 1950, high natural increases which, to a certain degree, compensated for the war losses.

The rural population of the three Baltic republics decreased by less than 20%. The fall had to be bad for the future national structure of the area because of its small demographic potential. It is difficult to establish which of the three factors: the war losses, the post-war deportations or the terror connected with the second incorporation of these countries into the USSR, was the greatest cause of the decrease. Nevertheless, during the decade under discussion, the Baltic countries lost about 650 thousand farm dwellers.

The rural population of Rumania and Moldavia, measured jointly, decreased by over 1.1 million; the decrease was greater than in Yugoslavia. It is surprising that the rural population in this country suffered rather small losses in spite of the bloody wartime fighting. As we remember, Bulgaria was

the only country of the disputed area, where the rural population presented a significant rise. Its long-standing neutrality became its shield.

The events of World War II had a great impact upon the demographic situation of the countryside in Central Eastern Europe. The rural population in the 1950s was not much larger than at the beginning of the century. The range of the demographic loss is well illustrated by the fact that it was much higher than the increase of rural population in between the two World Wars.

CHANGES IN THE SIZE OF RURAL POPULATION IN THE YEARS FROM 1948/1950 TO 1960

An analysis of the 50's has to take into account an apparent natural high increase in all the countries of Central Eastern Europe. The peak growth was achieved in Ukraine, Poland, Yugoslavia and Rumania but, in the remaining countries, it kept close to 10% a year for over 10 years. In about ten years, the population of the whole area increased by about 20 million, thus making up for the war losses, with interest. The general demographic processes, resulting from birth-rate compensation, had a great impact on the dynamics of the rural population, which was also affected by a variety of socio-economic problems. The countries of Central Eastern Europe entered a period of great changes, connected with industrialization and urbanization. Mass migrations from villages to cities, which had begun earlier, were stimulated by the governments' economic policy. The analyzed area found itself in the so-called socialist camp and it had to undergo experiments corresponding to certain ideological concepts, the theory of priority of the development of industrial organization included. The new economic situation made for changes in the living conditions in the countryside. That is why, in spite of a great natural increase, migrations developed on such a large scale that, in all the Central European countries, the rural population became a constant (the general decrease was not greater than 1%). Up to that time, peace had been connected with the growth of the rural population. But, in spite of political stability, the natural increase among the farm dwellers could not, for the first time, make up fully for the minus balance of migrations. There appeared the first signs of changing tendencies within the dynamics of the rural population. Side by side with the countries where the population was growing, went those with marked depopulation processes. In the general balance, they prevailed, leading to a small decrease in the size of the rural population.

The processes of depopulation developed in the western Soviet republics. They were most intense in industrialized Latvia and not much less in the two other Baltic republics and in Belarus. They also began in the Ukrainian villages. All of these countries had been fully collectivized. A striking difference could be noticed in Moldavia where the rural population was steadily growing.

In the remaining countries, the increase of the rural population was, generally, small. The age and sex structures of farm dwellers were, at the time,

good in all the countries under discussion. Their characteristic features were a high percentage of young people, minor processes of ageing and a balanced number of men and women. Against the background of the general demographic process, a decrease was noted only in Bulgaria and Czechoslovakia (the Soviet Union excluded).

Interregional differences pointed to the end of an historical period which had been marked by high activity and demographic vigor of the rural population, situated between the Baltic Sea and the Adriatic.

CHANGES IN THE SIZE OF THE RURAL POPULATION IN THE YEARS FROM 1960 TO 1970

The transitional period of the 50's was followed by a decade which had already developed a well defined demographic tendency. It was a decade of rapid depopulation of the countryside. The population, in the area under discussion, decreased by over 4 million people, while its total population increased by 15 million persons. The data, given above, concerning the size of the depopulation of rural districts and the range of the total growth, point to intensive urbanization. Depopulation was taking place over wide areas, with the exception of Poland, where the population did not decrease. A noticeable rise occured only in Moldavia. The remaining eleven "countries" were all undergoing a regression. At the time, Czechoslovakia, Bulgaria, Rumania and Hungary underwent a process of full collectivization which changed their agricultural structure. The liquidation of private farms and the rise of collective organization stimulated the flow of farmers to towns and cities. In Czechoslovakia, Bulgaria, Rumania and Hungary collectivization did not take such a drastic form as in the USSR. There were no compulsory deportations and no losses of life. The demographic repercussions took more time and resulted from the changing economic conditions. The demographic consequences were more apparent in the regions where collectivization had been introduced earlier.

The greatest decrease of the rural population, in absolute numbers, occured in Ukraine; the explanation lies in its great demographic potential. Bulgaria, where the rural population fell by 900 thousand, between the years from 1960 to 1970, was the second on the list; the per cent index of the decrease is therefore very high. During one decade the rural population fell by almost 20%. The example of Bulgaria may well serve as an illustration of the influence of the demographic processes on the economic situation in agriculture. A sudden decrease in rural population signalled the coming crisis in Bulgarian agriculture. But the demographic consequences did not appear with full force before a period of over ten years. Nevertheless, the future crisis was to be reflected in a lowered percentage of the more demanding forms of farm-work and the extensive mixed farming caused by a sudden decline of the labour force in rural districts.

A comparable process could be observed in the west of the USSR. In the three Baltic countries, in the Kaliningrad District and in the republics of Ukraine and Belarus, taken jointly, the rural population decreased, in the years from 1960 to 1970, by over 1.8 million, i.e. by a number equal to that of the years from 1950 to 1960. The process of depopulation was taking on a continuous character. Its length influenced the age structure of the remaining farm dwellers, subject to selective migrations and the flow of young people to towns. For this reason, although in 1970 the western part of the Soviet Union, mentioned above, still had a rural population of about 30 million, its demographic structure was worsening and must have played an essential role in demographic reproduction. The decreasing numbers of young women in childbearing age limited a natural increase so that further negative phenomena had to follow. We could speak here of a feedback leading to further decrease.

The decline of the rural population became the cause of a significant parallel decrease of density in the Latvian and Estonian Republics and in the Kaliningrad District. In the District, the density of the rural population decreased, in the years from 1939 to 1970, from 41 to 13 persons per km^2.

In the decade from 1960 to 1970 we had to deal with growing urbanization. The share of rural people was steadily declining. While, in 1960, 57.3% of the population of the area under discussion lived in the countryside, in 1970 there were more town dwellers. With the rural population in decline, it accounted only for 49.8% of the total population. The quantitative balance between the rural and the city population, reached about 1970, resulted from great differences in the size of the countries included. In the Kaliningrad District the city dwellers accounted for 74.8%. A comparably high index of urbanization characterized Estonia, Latvia and Czechoslovakia. In Yugoslavia and Rumania, the rural population still predominated. Nevertheless, both quantitative and qualitative changes occured in the area under discussion. Before long the dynamics of the growth of the city population, concurrent with the demographic regression in the country, began to influence the social and economic transformations in the territories of Central Eastern Europe.

CHANGES IN THE SIZE OF THE RURAL POPULATION IN THE YEARS FROM 1970 TO 1980

The decade from 1970 to 1980 was a period of intensive depopulation of the countryside in the 13 countries. The rural population decreased by 8.0 million (about 10%), i.e. twice as much as in the previous decade. The density of the rural population fell by 4 persons per km^2.

The regression developed while the total population of the discussed area increased, reaching over 13.0 million, with city dwellers accounting for 21.2 million. This had to lead to greater disproportions and to a lower demographic importance of rural districts.

The greatest decrease, in absolute numbers, was noted in Ukraine; while the percent values were lowest in Czechoslovakia, Belarus and Bulgaria. The

data concerning Czechoslovakia are especially interesting. The greatest decrease was caused, to a certain degree, by formal and administrative changes. The actual fall was much smaller. However, the data concerning the rest of the countries, are fully reliable. The depopulation process was accelerated and developed with growing intensity, so much so that it found its reflection in the general demographic and social conditions.

The rural regions of Poland experienced a noticeable decrease of population for the first time since the War. Although, in Poland, the demographic regression was not so marked as in the other countries, the fall by 800 thousand proved that Poland had entered an advanced phase of depopulation, typical for the rest of the countries of the region. It seems that Belarus and Bulgaria were losing their populations so fast that they were approaching a demographic collapse. Belarus is a good example of this; the rural population fell from 25 do 20 persons per km^2 during the decade. Such a considerable regression, combined with a selective migration, had to be accompanied by an intensive process of ageing of the farm dwellers. The countryside, devoid of young people, becomes a social anachronism, without a chance of development. In the case of deformed demographic structures, the cost of healing is not only high but also unrealistic. In Ukraine intensive depopulation began later than in Belarus. While the rural population of Ukraine decreased in the 50's and in the 60's by about 1.2 million per decade, during the following ten years it fell by about 2.5 million.

In Hungary, Rumania and Yugoslavia depopulation started later and took a less advanced form. A decrease in rural population was, for the first time, observed in Moldavia, the country which, throughout the decades, had had a marked progressive dynamics of demographic growth of farm dwellers.

The changing level of urbanization was reflected in the decrease of the rural population of both the whole region under discussion and of its parts. The share of the rural population of the whole area fell by 9.9 points (from 49.8% to 41.0%). Only in three countries, i.e. in Rumania, Yugoslavia and Moldavia, did the index go over 50%. The adopted social model which favoured urbanization and industrialization, had a growing influence on the distribution of population in the country and in the industrial areas. Population density in towns and cities was rising while depopulation was becoming an outstanding feature of the demographic changes in Central Eastern Europe.

CHANGES IN THE SIZE OF THE RURAL POPULATION IN THE YEARS FROM 1980 TO 1987/1990

From the point of view of statistical analysis, the period of 1980 — 1987/1990 does not fully admit comparisons. The present author had no access to statistical data from the year 1990, therefore our information comes mostly from 1989 or even from 1987 and 1988. For this reason, the considered period of time is shorter than the ones discussed earlier. Moreover, there is no time convergence. Once we obtain access to the relevant information, the data will be duly updated.

In the 80's the tendencies prevailing in the preceding decade were continued, over about ten years the total rural population decreased by 5.7 million (falling from 78.5 to 72.8 million) thus reaching the lowest point in the 20th c. in spite of the growth of the demographic potential of the 13 countries (except Hungary) by about 8 million.

The decrease, expressed in absolute values, was still exceptional in Ukraine where the population potential declined by over 2 million. The scale of its demographic regression is best exposed against the population of the Polish countryside. According to post-war data (1950), the rural regions of Ukraine were inhabited by 8.8 million persons more than the respective area of Poland. Following the next twenty years (1970), the difference still equalled 5.8 million but, by 1990, it had fallen to 2.4 million. Should the tendency continue, by about the year 2000, the population of the Ukrainian and the Polish countryside might reach a comparable level. If we consider the demographic potential, which is much higher in Ukraine than in Poland, we can find a reflection of the rapidity of urbanization in both countries.

It seems that living in the collectivized Ukrainian farms was so bad that it occasioned a mass exodus of the farmers to towns and cities. In Belarus the migration processes were even more advanced. In the period under discussion, its rural population decreased further, by almost 20% (766 thousand) and fell below 3.5 million. The decrease was rapid for, in 1950, there were more than 6 million farm dwellers in Belarus.

The process of depopulation was accelerated in Rumania and Yugoslavia but slowed down in Bulgaria where it could be ascribed to rapid ageing of the rural population. This, in turn, caused a decrease of potential migrants. The average population density decreased, in the period of the las forty years, from 48 to 27 persons per km^2.

A marked change appeared in Estonia, Latvia and in the Kaliningrad District (from 10 to 12 persons per km^2). Supposedly, if we leave the suburbs out, we have to deal with highly depopulated rural districts.

The data, given in the present paper, point to the fact that depopulation in Central Eastern Europe concerned large groups of people and covered great areas. The changes started in the fifties (the previous decrease of rural population was connected with war losses or the changing borders) and, since then, they have played an important role, in the social and demographic transformations. The process, which has been developing over the last forty years, seems to be invariable. In that period of time the rural population of the area under discussion, fell by 18.8 million persons. The greatest decrease was observed in the last twenty years. It amounted to 13.8 million inhabitants. It means that the growing depopulation has had serious, all-embracing demographic consequences. But, in the 90's, we have to deal with some new tendencies. On the one hand, advanced depopulation had become a fact in the countries where, in the preceding decades, depopulation developed slowly. On the other hand, the process was checked in those countries which had had high depopulation.

The population density index has pointed to a deepening depression. The highest area difference/range index was noted in 1980. Estonia had the lowest area index (9 persons per km^2) and Moldavia the highest one (71 persons per km^2).

The growth of the urban population, connected with the decrease of the rural population, influenced the urbanization index. The growing numbers of city dwellers accounted for 62,7% of total population; the numbers were the highest in the Kaliningrad District and the lowest in Moldavia (47,7%). The progress of urbanization has been rapid in the 13 countries so that, at the present moment, farm dwellers account for only one third of total population.

The up-to-date information concerning the 80's makes up a picture of the present demographic situation in the countries of Central Eastern Europe. The great, modernity-oriented structural transformation is reflected in the falling numbers of farm dwellers. On the other hand, in view of the problems of spatial organization, ineffective agrarian economics and an extensive urbanizing process, we have to confirm the existence of uncontrolled depopulation, which brings about economic devastation and weakening demographic equilibrium/ /balance over large rural areas.

CHANGES IN THE SIZE OF THE RURAL POPULATION IN THE YEARS FROM 1897/1900 TO 1987/1990

An empirical analysis of the consecutive decades of the 20th century allows us to state that intensive depopulation in the Central Eastern Europe has been developing against a background of the general growth of population. The intensity and the advancement of the processes differs from country to country, for each of them has a character of its own. We can speak of both short-lived and long-lasting trends. Political events (mainly World War I and II) and economic conditions have influenced the range and the speed of demographic transformations. An essential, and also a spectacular, process which developed in towns and cities, was that of urbanization. It consisted in a rapid growth of urban population, both in absolute and in positive values, that concern the total population discussed in the present study. Urbanization caused a decrease in the rural population. We have pointed out that, in the first half of the 20th century, depopulation resulted from war losses, while in the 2nd half of this period, from the growing migrations from the country to towns and cities.

We have established the size of the total population and the size of the rural population living in the 13 states which, because of their geographical situation and their history, belong to Central Eastern Europe. The study has been divided into time sections covering the 20th century. Both these procedures let us establish the dynamics of the rural population, its density and its percentage within the total population. The emerging information has thrown light on the process of shaping the demographic situation of the rural areas in the territory of 2171.9 thousand km^2 i.e. 20.6% of the area of Europe. In our analysis we

were not concerned with details. Many problems call for more thorough studies. Statistical evidence has to be verified. Only the most important facts have been interpreted in order to establish the essential territorial differences and the changes which have occured during the fixed span of time. We have tried to present some of the constant tendencies of development that change the existing demographic structures.

The statistical data from the turn of the century served us as a point of departure, while the final evidence came from recent information. Against that temporal background the changes in the size of rural population could be displayed.

The population of the discussed "states" increased from 111.2 million (1897-1900) to 194.9 million (1987-1990), i.e. by 83.7 million persons. Therefore, we have to admit that, in spite of numerous cataclysms which rolled over the countries of Central Eastern Europe, their demographic potential grew significantly in the 20th century. At the same time, the rural population decreased from 86,1 million to 72,8 million, i.e. by 13.3 million farm dwellers. The distribution of this loss differed, according to the place of occurence; in some areas there was a great decrease, while in others the size of the population was fixed or increasing. The greatest increase, in absolute numbers, was noted in Ukraine (by 7.1 million), in Czechoslovakia (by 3.2 million), in Poland (by 2.6 million) and in Belarus (by 1.0 million). The sourhern part of the area (Yugoslavia, Rumania and Moldavia) had more rural population at the end of the 20th c. than at the turn of the century. The changes, in absolute numbers, influenced the changes expressed in per cent values and the population density index. If we exclude the specific case of the Kaliningrad District, the three Baltic countries, Belarus and Czechoslovakia denoted the highest percentage of decrease.

The average population density in rural districts has decreased by 7 persons per km^2 and, at the present moment, averages 33 persons per km^2. The differences among the population density indices increased. It was characteristic that while their values fell in the northern countries, they grew in Yugoslavia, Rumania and Moldavia.

An intensive depopulation of rural districts in the western Soviet republics, concurrent with an increase in the number of farm dwellers in the South of the area, gave rise to a great transformation in distribution of the rural population. This vital process revealed that the demographic potential of the countryside was relocated from the North to the South of Europe. For instance, at the turn of the century, in the territory of the five Soviet republics, (the three Baltic countries plus Belarus and Ukraine) and in the Kaliningrad District, there were about 35.0 million farm dwellers which accounted for over 40% of the total population of the territory. Now, in the same rural districts we have about 23.0 million persons, i.e. 12.0 million less (31.5% of total population). At the same time, in the southern part of the discussed region, (Hungary, Rumania, Moldavia, Bulgaria and Yugoslavia), around the year 1900, the rural population amounted to 27 million (31.0% of total population). During the final

period included in the present paper, there were 31.4 million persons, i.e. 43.1% of total population. The data, given above, lead us to the conclusion that there were great relocations of rural population and that demographic transformations were not uniformly distributed.

In the territory of contemporary Poland, depopulation had a character of its own. The demographic losses of the rural population were mostly the outcome of the two World Wars and the resulting territorial changes. The number of Polish farm dwellers decreased in the years from 1910 to 1921 by almost 2.5 million and in the years from 1939 to 1950 by over 5.2 million. In peacetime, up to 1970, the Polish rural population was increasing. In all the other countries depopulation was mainly caused by economic reasons. Major changes occurred in the second half of the 20th century. Compared to parallel processes in Czechoslovakia, Ukraine, Belarus and Lithuania, the depopulation in Poland was less intensive. The result is that the present demographic potential of the Polish rural districts has reached a higher level while urbanization is not as developed as in the neighbouring countries.

There were three simultaneous processes of demographic transformation:

— the increase of total population;
— a rapid growth of urban population;
— a relative and, in most cases, absolute decrease of rural population.

Radical changes in the distribution of the population and its social and demographic structure sprang from these three causes. It is evident that, in the 20th century, Central Eastern Europe has undergone revolutionary demographic changes. While at the beginning of the 20th century it had a rural character, at the end of the age it has become a highly urbanized area.

At the beginning of the 20th century, the rural population prevailed. Urbanization was only beginning. Even in Czechoslovakia, where industrialization was very advanced, there were more people living in the country than in the urban areas. The city dwellers, in most countries discussed in the present paper, accounted for only over 10% of total population. In eight countries rural population made up over 80% of the inhabitants. At the same time, in the area of contemporary Poland, where one fourth of the population lived in towns and cities, the average level of urbanization was higher. At present, the situation in Central Eastern Europe is completely different. The level of urbanization is comparatively high. Rapid structural transformations have occurred in Ukraine, Belarus and in the three Baltic republics. In Hungary, Czechoslovakia and Poland they have been comparatively slow.

We do not intend to answer the question as to whether the tempo at which the processes have developed had better or worse consequences but, in fact, they served as a springboard for great structural changes. The development of urbanization was strongly connected with and dependent on migrations from the country to towns and cities. The migrations were great enough to cause vital processes of depopulation of the rural districts which could not be compensated for by natural growth. Our analysis has proved that the process of depopulation encompassed steadily growing areas. The trend was strongly

TABLE 1. Population in East Central European countries in 20th century (in thousands)

Lp	State	1897-1900	1910-1913	1920-1921	1939-1941	1948-1950	1960	1970	1980	1988-1990
1	Estonia	975	954	1 107	1 052	1 097	1 209	1 356	1 474	1 583
2	Latvia	1 929	2 493	1 596	1 885	1 944	2 113	2 364	2 529	2 687
3	Lithuania	2 536	2 828	2 629	2 880	2 573	2 756	3 128	3 420	3 723
4	Kaliningrad District	1 129	1 155	1 226	1 240	455	650	740	817	878
5	Belarus	6 673	6 899	6 700	8 912	7 709	8 147	9 002	9 611	10 254
6	Ukraine	28 445	35 210	34 000	40 469	36 588	42 469	47 126	49 953	51 839
7	Poland	23 417	28 630	26 688	32 055	25 008	29 731	32 642	35 735	38 038
8	Czechoslovakia	12 155	12 995	13 006	14 428	12 388	13 654	14 333	15 311	15 624
9	Hungary	6 854	7 612	7 987	9 316	9 204	9 961	10 322	10 709	10 604
10	Rumania	11 200	13 500	13 800	16 748	15 872	18 403	20 252	22 201	22 940
11	Moldavia	1 615	2 056	2 025	2 452	2 290	2 968	3 569	3 968	4 362
12	Bulgaria	3 715	4 496	4 897	4 897	7 273	7 905	8 515	8 876	8 970
13	Yugoslavia	10 600	12 962	12 545	16 000	15 841	18 549	20 523	22 425	23 411
Total		111 243	131 790	128 206	153 732	138 242	158 515	173 872	187 029	194 923

State territories taken as constant according to contemporary political borders.

TABLE 2. Rural population in East-Central European countries in 20th century (in thousands)

Lp	State	1897-1900	1910-1913	1920-1921	1939-1941	1948-1950	1960	1970	1980	1988-1990
1	Estonia	818	777	827	697	581	518	475	441	449
2	Latvia	1 387	1 554	1 005	1 222	1 063	922	887	784	774
3	Lithuania	2 181	2 461	2 182	2 221	1 844	1 673	1 557	1 314	1 174
4	Kaliningrad District	700	670	650	620	200	215	194	183	183
5	Belarus	5 774	5 909	5 695	7 057	6 090	5 542	5 094	4 213	3 447
6	Ukraine	24 125	28 420	27 200	26 900	23 811	22 618	21 438	18 981	16 970
7	Poland	17 207	20 536	18 092	20 250	15 009	15 249	15 578	14 756	14 623
8	Czechoslovakia	7 049	7 277	7 021	7 150	6 045	5 836	5 408	4 183	3 814
9	Hungary	4 249	4 491	4 529	5 001	5 107	5 229	4 892	4 665	4 326
10	Rumania	9 184	10 800	11 040	13 063	12 159	12 491	11 994	11 186	10 476
11	Moldavia	1 364	1 699	1 720	2 124	1 902	2 298	2 439	2 382	2 293
12	Bulgaria	3 002	3 508	3 881	4 883	5 281	4 947	4 047	3 355	3 063
13	Yugoslavia	9 116	10 920	10 386	12 670	12 552	13 302	12 609	12 088	11 237
Total		86 156	99 022	94 228	103 858	91 644	90 840	86 612	78 531	72 829

State territories taken according to contemporary and time-constant political borders.

marked in the regions undergoing depopulation. But our analysis centred mainly round demographic problems that are known to bring about social consequences. Nevertheless, the present author did not intend to deal with those problems because he could not define the economic aspects of the phenomenon. If we want to find out whether migrations from the country to towns and cities were, in each of the 13 countries, to the general advantage, we have to first answer a few difficult questions. It is a well known fact that, in the first half of the 20th century, the larger part of the rural territory under discussion was overpopulated and had a labour surplus but we do not know when the possibility of the transfer of the labour force without capital investments stopped and at which point in time, the depopulation of rural districts began to result in a high cost of substitution. The answers to these questions cannot be simple as they demand probing into the situation of individual countries, but without it the advantages of migrations from villages to urban areas cannot be properly estimated.

The purpose of the present study was to present the main trends in the dynamics of the rural population in Central Eastern Europe which have developed over a long period of time. We have proved that, for both political and economic reasons, the distribution and the potential of the rural population have been undergoing important transformations throughout the 20th c.

The tendencies, described in the present paper, signal further processes of demographic transformation which may be complex and difficult to appraise. However, they certainly will influence the life in this part of the European Continent.

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MULTIREGIONAL DEMOGRAPHIC PROJECTIONS: POLISH EXPERIENCES

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ABSTRACT: The papers discusses the development of theoretical issues and applications of multistate and multiregional demographic projections in Poland. It is structured arround following problems: 1. Development of the theory of multistate demographic projections; 2. Generation of projections and analysis of their results as the source of knowledge on the current demographic situation in its spatial dimension; 3. Application of different parameters of projected population for better understanding and measurement of the dynamics of multiregional population; 4. Simulations; 5. Comparison of a series of projections for one time point, but using various types of data concerning spatial mobility of population; 6. Analysis and comparison of a series of projections for the constant spatial setting and for one type of data but using data for various years; 7. Generation of multistate projections; 8. Assessment of the exactness of multistate population projections. The paper ends with some remarks on future developments of multistate demography in Poland.

KEY WORDS: multistate, multiregional, projection, forecast, Poland, demography, population.

INTRODUCTION

Polish geographers and demographers have practised multiregional projections for more than a decade. Judging by the number of publications, the methodology, particularly popular in the eighties, seemed to be losing its appeal recently. It may be therefore appropriate to assess how it has been used and what was the value added by Polish researchers.

MULTIREGIONAL POPULATION PROJECTIONS: A POLISH PERSPECTIVE

There is a real monoculture in Poland in the domain of multiregional demographic projections. Namely, the only model that has been widely used until now is the one presented in the books by A. Rogers (1975): "Introduction

to Multiregional Mathematical Demography", and Willekens and Rogers (1978): "Spatial Population Analysis: Methods and Computer Programs". In the course of this paper, whenever multiregional population projection is referred to, it means the multiregional Rogers model and its modifications. It is significant that almost no attention has been paid in Poland to demographic accounting modelling.

Chronologically, the first multiregional projection of Polish population was presented in the publications by Dziewoński and Korcelli (1978) and Korcelli (1978). These publications were of an introductory nature. Since that time research based on multiregional and occasionally multistate projection model has been going in Poland in eight following directions[1]: 1. Development of the theory of multistate demographic projections; 2. Generation of projections and analysis of their results as the source of knowledge on the current demographic situation in its spatial dimension; 3. Application of different parameters of projected population for better understanding and measurement of the dynamics of multiregional population[2]; 4. Simulations; 5. Comparisons of a series of projections for one time point, but using various types of data concerning spatial mobility of population; 6. Analysis and comparison of a series of projections for the constant spatial setting and for one type of data, but using data for various years; 7. Generation of multistate projections; 8. Assessment of the exactness of multistate population projections. Developments in each of the categories enumerated above will be discussed in brief.

DEVELOPMENT OF THE THEORY OF MULTISTATE DEMOGRAPHIC PROJECTIONS

Jóźwiak (1988) defined the fundamental matrix of the multistate population projection model. This concept is similar to the one introduced by Kemeny and Snell (1960) with respect to Markov chains and is new in multistate demography. The author proposes two possible applications of the concept: "Properties of the fundamental matrix may be utilized, first of all, to assess the mean level and dispersion of time spent by individuals of the system in specified states. Another possibility for application of the fundamental matrix is related to evaluating the multistate population structures." (Jóźwiak 1988 p. 7). Comparison of the structures of multiregional female population of Poland observed in 1977 and 1982 was the basis for testing the concept.

The question of the method of data aggregation in the spatial cross-section and according to age has been solved by Jóźwiak (1983, 1985). She has proposed the aggregation method and presented the necessary and sufficient condition for perfect aggregation. A number of earlier papers dealt with the problem

[1] An earlier assessment of the achievements of Polish multistate demography may be found in Paradysz (1985a, 1987) and Kupiszewski (1987a).

[2] The approaches presented in points 2 and 3 are similar from a substantial point of view, but from a methodological point of view they differ. This is why they were separated.

(Rogers 1975, 1976, Gibberd 1981). As Paradysz (1987) noted, the solution proposed by Jóźwiak is an advance in comparison to the results of Rogers (1975) because it is independent of time. What's more, Jóźwiak (1983, 1985) has demonstrated that the matrix of weights allocated to aggregated elements of the system should obey very general conditions. This solution is different from what Gibberd (1981) has proposed because his method of aggregation did not hold the condition for perfect aggregation. Jóźwiak (1983, 1985), without doubt, has brought an important methodological achievement, making a connection with the theoretical studies conducted elsewhere in the world. Alas, the Polish literature in this subject lacks the empirical approach to determining the magnitude of errors arising as the result of various forms of spatial aggregation.

PROJECTIONS RESULTS AS THE SOURCE OF KNOWLEDGE ON THE CURRENT DEMOGRAPHIC SITUATION

Virtually all publications describing the use of the Rogers model present the results of analysis concerning changes in population dynamics within an adopted regional system, related to directions and intensities of flows and to the regional processes of natural growth. However some of them are solely devoted to this sort of analysis rather than to methodological problems. To this category belongs the publications by Dziewoński and Korcelli (1978, 1981), Korcelli (1978, 1985, 1986, 1987, 1990), Kupiszewski (1990, 1991a) and Korcelli and Kupiszewski (1990, 1992). A particular place on this list is occupied by the work reported by Kędelski (1985), because of the novel, in Poland, application of projection to the assessment of dynamics of changes in the professional structure of rural population (see page 100).

APPLICATON OF DIFFERENT PARAMETERS OF PROJECTED POPULATION FOR BETTER UNDERSTANDING AND MEASUREMENT OF DYNAMICS OF MULTI-REGIONAL POPULATION

The basic idea behind this category of applications is to use various indices characterising projected population(s) to learn more about observed population(s). Three examples can be enumerated here: Kędelski's (1986) analysis of the evolution of the mean age of multiregional population, Kupiszewski's (1989) comparison of the changes in age structures of the multiregional population of Poland, and Kupiszewski's (1991a) assessment of fertility changes over time in multiregional population based on intrinsic single- and multiregional birth rates. This direction of research seems to be very promising because it allows for a more precise description and analysis of various features of population.

SIMULATIONS

Usually, projections of multiregional population are carried out based on the assumption of constant age dependent birth, death and mobility rates, equal to the ones observed at the initial time point. It is possible, however, either to take into account mathematically or statistically forecasted changes of fertility, mortality and/or mobility, as Rogers suggests, or to assume some trajectories of changes based on scholar's knowledge, experience and intuition. In both cases the procedure is usually highly arbitrary. However this procedure allows us to study various alternative paths of the development of the population system and answering "what-if" questions. Such an approach was applied by Dziewoński and Korcelli (1981). They run two simulations: in the first one they reduced by half the population flows among all the regions with exception of the South-Eastern macroregion, while in the second one the authors "intended to study the effects of implementing major economic-investment programs" (op. cit. p. 64) in the Eastern macroregion, encompassing the Lublin Coal Basin then being created. It was assumed that outflows from this region shall be neutralized by the inflows. The authors of the simulation would evaluate their experiment in the following way: "Further tests of this kind would seem useful especially if they incorporate more comprehensive scenarios, including simultaneous or stepwise alterations of more than one demographic component at a time" (op. cit. p. 66). An effort aiming at realization of the latter postulate has been undertaken, on the basis of experiences gained by Scherbov and Usbeck (1983), by Kupiszewski (1990), who modified the Rogers model in such a way that the changes of agedependent births, deaths and migrations rates could be possible at every step of projection. This requires, of course, generation of the growth matrix at each step of projection. The thus modified model served to simulate the changes in depopulation processes of Polish rural areas.

Recently multistate models with an option allowing for altering parameters of projected multiregional population are almost standard[3], however in the early 1980's approach proposed by Dziewoński and Korcelli was quite innovative.

COMPARISONS OF SERIES OF PROJECTIONS USING VARIOUS TYPES OF DATA CONCERNING SPATIAL MOBILITY OF POPULATION

An evaluation of the consequences of introduction of various types of migrational data into the Rogers model was presented in publications by Kupiszewski (1987b, 1988a). The author ran two series of computations, introducing two types of migrational data to the Rogers model. The first type of data concerned the numbers of migrations acquired from the current registration, while the second concerned the numbers of migrants over the

[3] Compare, for example, Scherbov's DIALOG or Willekens' MUDEA models.

period of one year and were acquired from the National Census of 1978[4]. It has been stated that various types of the data considered generate in the projections a specific spatial population distribution and structure patterns, which results not only from the different concepts of measuring population mobility, but also from the fact that these sets of data concern different categories of the migrating population (during the National Census the criterion of the *de facto* residence was used, while in current registration it was the formally-legal criterion). Analysis of the phenomenon was made difficult by the incoherent treatment of the migrating population by the Polish statistics[5].

ANALYSIS AND COMPARISON OF SERIES OF PROJECTIONS FOR DATA FOR VARIOUS YEARS

Korcelli (1986, 1987, 1990), Korcelli and Kupiszewski (1990, 1992), and Kupiszewski (1988b) have performed a series of projections on the basis of data for various years and compared trajectories of projected growth of these populations. Korcelli and Kupiszewski (1990, 1992) adopted the 13-regional setting used already in the earlier works (see Dziewoński and Korcelli 1981) and ran projections for the data of the years 1977, 1978, 1981 and 1983. In other publications Korcelli (1986, 1987) used five-regions system (Warsaw, other towns of the Warsaw voivodship, rural areas of the Warsaw voivodship, other towns of Poland, other rural areas of Poland) and two series of the input data: for 1978 and for 1983. In that way multistate projections were applied for analysis of urban change in a mesoscale. In the paper by Kupiszewski (1988b) the biregional schema was used, distinguishing urban and rural areas, and two series of the input data — for 1978 and for 1983.

The purpose of such studies can be expressed as follows: "Comparison of the time series of input data with the corresponding series of projections, generated on their basis, should allow an assessment of the sensitivity displayed by the Rogers model with regard to small, but observable differentiation of the output structures of the population. In case when the time series of data observed present certain temporal trends it is an interesting question to follow the representation of these trends in particular stages of projections. (...) A parallel, more practically oriented goal of analysis was recognition of the implications of changes observed in the years 1978-1983 for the future population transformations of Poland in the interregional setting" (Korcelli 1985 p. 4). Studies quoted above proved that the multipoint approach was very useful for comparative and measurement purposes.

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[4] The questions asked during the Census were about the place of last residence and about the date of move. The data obtained are therefore not transitional data, where we compare the place of inhabitation at two fixed points in time.

[5] More detailed analysis of the Polish sources of data on population mobility may be found in Kupiszewski (1992).

GENERATION OF MULTISTATE PROJECTIONS

The fact that application of the Rogers model is not limited to the multiregional cases, but can be made for the multistate settings (Essays in multistate... 1980, Multidimensional mathematical... 1982), found its reflection in the studies conducted in Poland, both in the theoretical and in the empirical sphere. The analytical form of the multistate model was presented by Jóźwiak (1985). The multistate projection of the rural and urban population by age, and with respect to rural population by occupational structure was prepared by Kędelski (1985). This author has distinguished as states the following states: "population of large cities", "population of medium and small towns", "agricultural population of the rural areas", and "non-agricultural population of the rural areas". The two latter states express the occupational structure of rural population splitting it up into two groups: living in rural areas and working in agriculture and living in rural areas and working in agriculture and living in rural area and working outside agriculture. The study considered made it possible to analyze the hypothetical changes of spatial--occupational redistribution of the rural population, which reflects the urbanization processes. It is a well known phenomenon that changes from rural to urban style of life could either start or be enhanced with the change from agricultural to non-agricultural occupation. It should be mentioned that a similar analysis, in which the set of rural communes, the set of communes having the character of small towns, the set of township communes, and finally the set of large cities were distinguished, was carried out for the former German Democratic Republic by Usbeck (1985), however he did not recognize a non-spatial dimension.

ASSESSMENT OF THE EXACTNESS OF MULTISTATE POPULATION PROJECTIONS

Two papers have tried to analyse the exactness of population projections. The first has set up a theoretical framework (Jóźwiak 1987). The other (Kupiszewski, 1988c) used some measure of structure similarity/dissimilarity to assess the exactness of various multiregional and single-regional population projections and forecasts. Despite the fact that there are a large number of papers on the accuracy of projections it is unusual that they deal with the idea of multidimensionality in demography. In that sense these papers were additions to the literature.

CONCLUSIONS

Studies on the applications of multiregional projection models and wider multistate demography are conducted in Poland in three centres: in the Academy of Economics in Poznań, in the Central Trade School (the former Central School of Planning and Statistics) in Warsaw and in the Institute of

Geography and Spatial Organization of the Polish Academy of Sciences in Warsaw. In the first two centres the research is conducted by the demographers, while in the third one — by geographers. This has an obvious influence on the way that questions of multiregional analysis are approached. Demographers concentrated mainly on the model theory (Jóźwiak 1985), fertility questions (see numerous publications of Paradysz, 1980, 1982a,b, 1984, 1985b, who combined the multistate and longitudinal approaches) and on the problems related to construction and computation of multiregional (Englert and Paradysz 1978, Kędelski 1981) and multistate (Kędelski and Golata 1986, Gołata 1987) life tables. Geographers are primarily interested in the spatial problems and especially in the generation of multiregional projections. Research carried out by the demographers concentrated on generalizing the multiregional analysis to encompass the multistate case. Kędelski (1981) states that "further progress in this domain will be connected not so much with the geographical approach and spatial delimitation of the populations, but with the demometric decomposition of more homogeneous subpopulations, distinguished mainly from the point of view of factors shaping demographic processes" (p. 63). Ten years later it is clear that Kędelski was wrong, as much of the research effort over the last decade has been invested in handling more complicated spatial divisions, as for example small areas (Rees 1991) or very large areas (Rees, Stillwell and Convey 1992) where multilevel multiregional models were indispensable. Still, because acquisition of data for the multistate analysis, especially with regard to the interstate flows is extremely difficult, all the studies performed by Polish demographers to date use the standard division into the urban and rural population. This cross-section is very significant but, it does not reflect regional differentiations. There is also a lack of multistate cross-sections, except for the unique study by Kędelski (1985). It should be emphasized that the studies to date display very limited sets of potential states and apparently do not implement, at least in the empirical sphere, the research postulates forwarded by Kędelski.

Until now, geographers were not — with detriment to the studies conducted by them — interested in the introduction of multiple states to their analyses. The regional breakdowns they used, on the other hand, are far more sophisticated. They have also conducted a number of experiments concerning three factors of the model: time, the manner of data acquisition, and space. Further essential progress in these studies can be achieved mainly through integration of the "demographic" approach, tending to encompass possibly many states in the analysis, with the "geographic" approach, characterized by the emphasis on spatial aspects of the analyses.

Polish research was predominantly "blue sky" research, without attempting to apply multistate methodology to solve any practical problems. This is mainly because there was no real market in Poland for that advanced demographic research technology. It was probably one of the fundamental weaknesses of Polish research — the lack of incentives from the real world. This may change in the late 1990's provided that the economy will take off and

the profits of mathematical modelling of social processes understood by governmental and commercial organizations. Nevertheless it seems that the input of Polish researchers into multistate demography has brought a number of innovative concepts, both theoretical and empirical.

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AN ATTEMPT AT THE ZOOGEOGRAPHICAL REGIONALIZATION OF EUROPE ON THE BASIS OF THE DISTRIBUTION OF VERTEBRATES

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ABSTRACT: Presented is a zoogeographical regionalization of Europe on the basis of the contemporary distribution of mammal faunas. The richness of families, genera and species of these animals was defined on the basis of source materials. The data obtained enabled analyses to be made of the zoogeographical similarity of the mammal species in 29 administrative units and 58 territorial-biogeographical units.

KEY WORDS: zoogeographical regionalization, mammal distribution, administrative units, biogeographical units, similarity.

INTRODUCTION: AIM AND SUBJECT OF THE ANALYSIS

The aim of this work was the presentation of a zoogeographical regionalization. This was carried out against the background of the contemporary distribution of mammals on the European continent, as well as of the richness of species (and other systematic units) of this group of animals. The regionalization presented in this work was produced in two ways. The first involved the statistical analysis and comparison of material for 58 natural (biogeographical) units (Trampler et al. 1990). The second zoogeographical division of Europe was carried out for 29 administrative units. Statistical comparison of the units referred to and the subsequent regionalizational division was carried out on the basis of one criterion: the qualitative differences in mammalian species composition.

The fauna of a given territory is understood as the total number of species (or other systematic units) of animal occurring in that territory (Udvardy 1978). Today's fauna is not merely an expression of the spatial mosaic of physico-geographic habitat conditions, but is also the result of continuous human activity in the course of many centuries — since the Neolithic period at least (Bocheński et al. 1968; Serafiński and Wielgus-Serafińska 1976).

To date there have been a number of papers on regionalization, whose basic

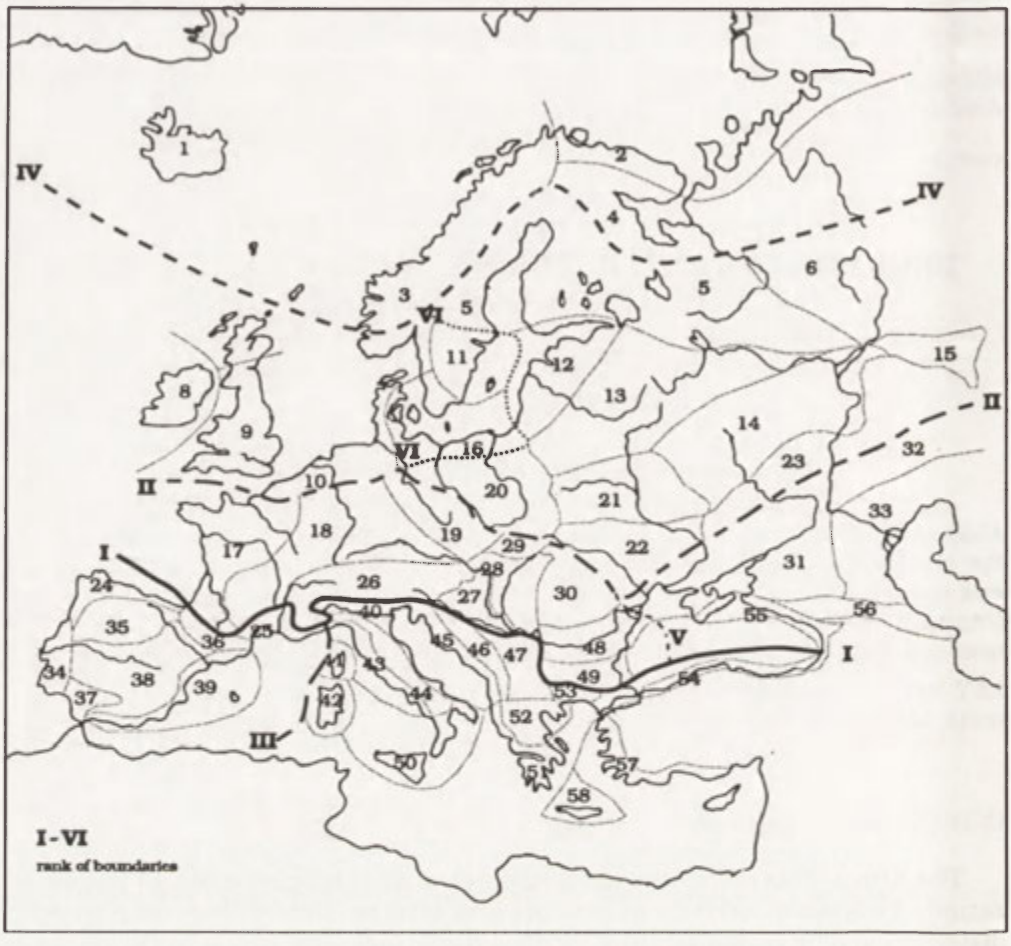

Fig. 1. Zoogeographical regionalization of Europe for "biogeographical" units; 1-58 unit numbers

materials have been living organisms. These have been classified by Kostrowicki (1965). However, contemporary biogeographic, and particularly zoogeographic, works do not contain regionalizations done on a continental scale and on the basis of empirical assessments of the species diversity of vertebrates.

METHODS

The main taxonomic unit used in this paper is the species. The necessary data have been obtained from faunistic works, monographs, atlases and — first and foremost — from the catalogue of mammals by Görner and Hackethal (1987).

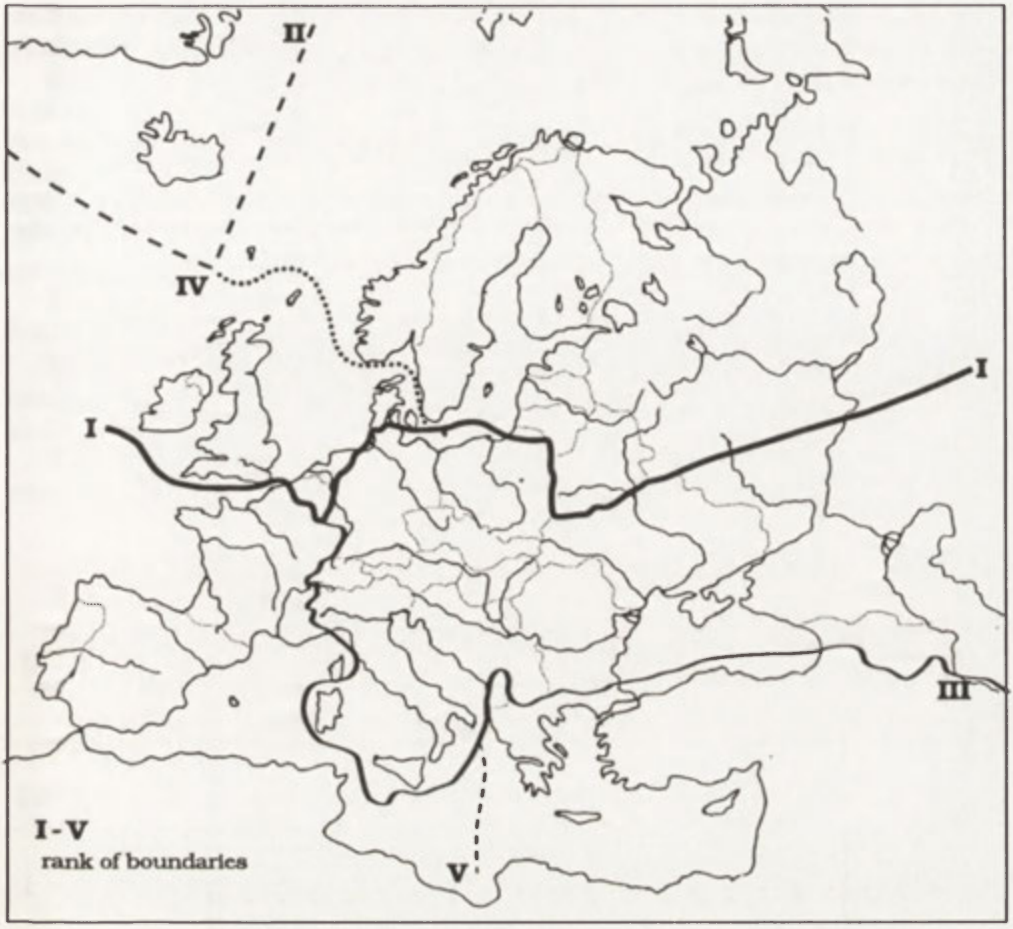

Fig. 2. Zoogeographical regionalization of Europe for "administrative" units

The taxonomy and nomenclature of the species taken into account has mainly been derived from the aforementioned atlas and from Polish works under the editorship of Z. Pucek (1984).

Assessments have been made of the occurrence of 186 species of mammal in 58 biogeographical units delimited on an *a priori* basis (Fig. 1), as well as-separately — in 29 administrative regions (Fig. 2). In the latter case analysis was carried out within state boundaries or within regional units (e.g. in the following areas delimited in the USSR: Northern (boreal) Russia, Belarus, Ukraine and Southern (meridional) Russia. In the course of compilation, some islands, e.g. Iceland, Corsica and Sardinia, have been treated as separate units (Grabińska 1992). In addition to the main group of land mammals, consideration has also been given to aquatic mammals of the order *Pinnipedia*. However account was not taken of any species of whale.

The data obtained were processed statistically using the "Tytan" computer

program. The similarity of the delimited spatial units was assessed in relation to the species composition of mammals, and in accordance with the formula of Marczewski and Steinhaus (1959):

$$S = \frac{w}{a + b - w}$$

where: S = the similarity of two comparable sets (in this case units); w = the number of elements common to both sets; a = the number of elements in the first set and b = the number of elements in the second set.

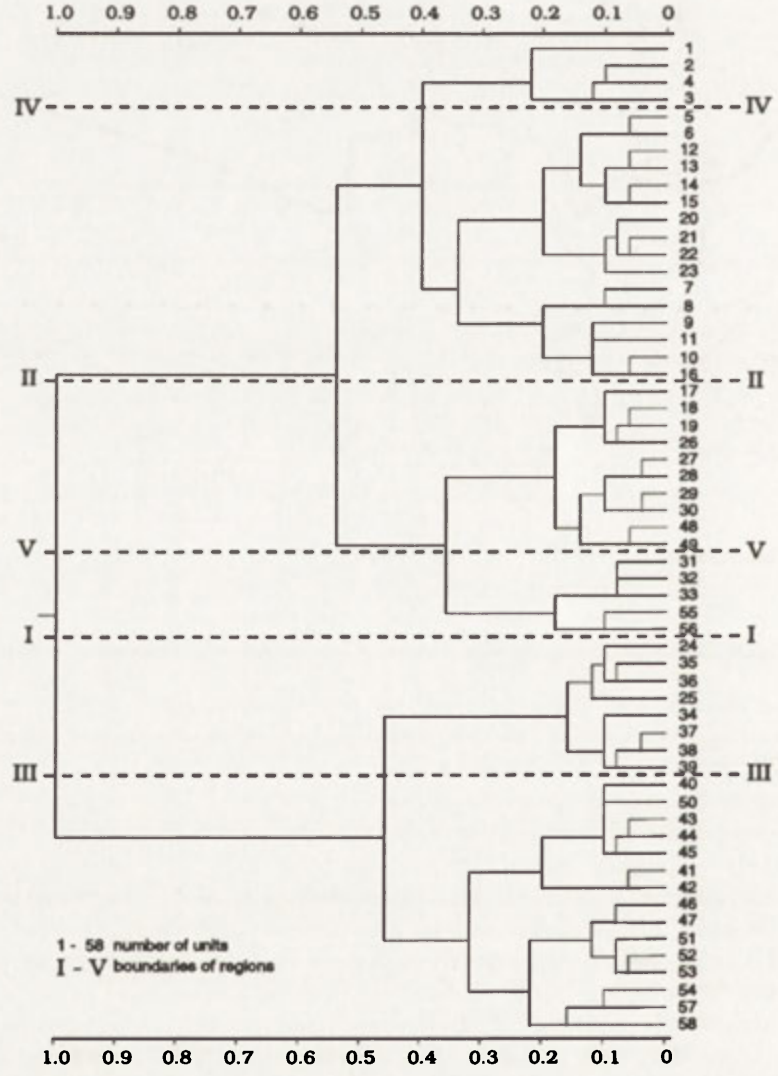

Fig. 3. Magnitudes for Europe's "biogeographical" units of indices of distance after Marczewski and Steinhaus

If all elements are common to both sets, then S takes the value of 1 or 100%. If two sets have no common elements, then S = 0.

Similarity may also be defined by a distance. The distance between two sets is given by the formula: r = 1-S, where r = distance and S = similarity of the two sets being compared. The smaller the number of common elements, the greater the distance, and the greater the number of common elements, the smaller the distance. The calculated values for similarity serve in the calculation of the distance between the analyzed units from the point of view of their species compositions.

The similarity values obtained are presented in the form of diagrams (Figs 3 and 4).

The grouping of European units from the point of view of faunistic similarity made it possible for the borders between different zoogeographical regions to be drawn (see Figs 1 and 2).

The absolute numbers of animal species in each of the analyzed units are contained in Tables 1 and 2.

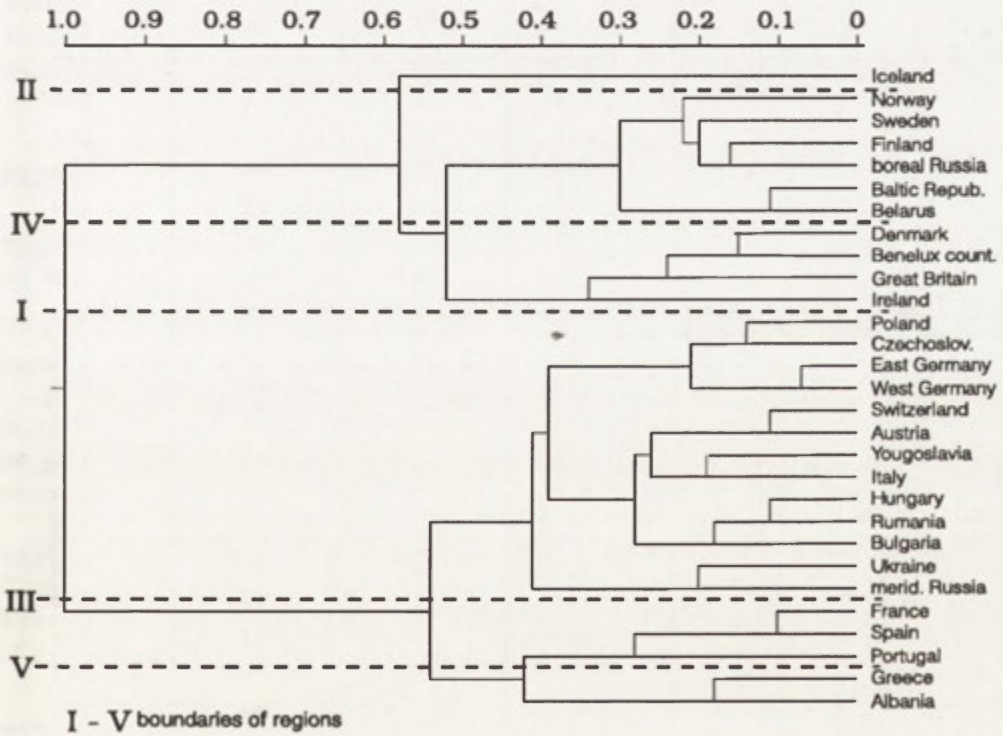

Fig. 4. Magnitudes for administrative units of indices of distance after Marczewski and Steinhaus

TABLE 1. Number of mammal species in "biogeographical" units

Unit number see Fig. 1	Number of species	% of all species	Unit number see Fig. 1	Number of species	% of all species
31	89	47.8	16	63	33.9
48	86	46.2	15	62	33.3
20	82	44.1	24	62	33.3
26	82	44.1	35	62	33.3
19	81	43.5	53	62	33.3
22	81	43.5	44	59	31.7
18	80	43.0	45	59	31.7
47	80	43.0	43	57	30.6
49	79	42.5	6	56	30.1
27	77	41.4	50	56	30.1
29	77	41.4	39	55	29.6
30	77	41.4	51	53	28.5
13	74	39.8	55	53	28.5
21	74	39.9	34	51	27.4
28	74	39.8	54	51	27.4
23	73	39.2	38	50	26.9
36	72	38.7	9	49	26.3
14	70	37.6	11	46	24.7
17	70	37.6	37	45	24.2
32	70	37.6	4	43	23.1
46	68	36.6	2	41	22.0
56	68	36.6	3	41	22.0
12	66	35.5	57	41	22.0
40	66	35.5	42	40	21.5
10	65	34.9	41	39	21.0
33	65	34.9	7	35	18.8
52	65	34.9	58	30	16.1
25	64	34.4	8	28	15.1
5	63	33.9	1	15	8.1

TABLE 2. Number of mammal species in the designated administrative units of Europe

Name of unit	Number of species	% of species	Name of unit	Number of species	% of species
Iceland + Spitsbergen	14	7.4	Federal Rep. of Germany	72	37.9
Ireland	29	15.3	boreal Russia	73	38.4
Denmark	43	22.6	Hungary	73	38.4
Portugal	45	23.7	Austria	75	39.5
Norway	50	26.3	Czechoslovakia	75	39.5
Benelux countries	52	27.4	Bulgaria	75	39.5
Great Britain	52	27.4	meridional Russia	76	40.0
Albania	54	28.4	Ukraine	79	41.6
Sweden	58	30.5	Italy	79	41.6
Baltic republics	59	31.1	Spain	80	42.1
Finland	60	31.6	Yougoslavia	83	44.2
Belarus	64	33.7	Rumania	84	43.7
Greece	65	34.2	France	85	44.7
German Dem. Rep.	66	34.7	Poland	92	48.4
Switzerland	67	35.3			

RESULTS

THE TAXONOMIC DIFFERENTIATION OF THE AREA OF OCCURRENCE OF EUROPE'S MAMMALS

Consideration was given to a total of 186 species of mamal, in 7 orders, 29 families and 95 genera.

In the regions discussed, the number of species of mammal ranged from 15 in Iceland to 89 in the Northern Black Sea area. At the same time, it should be pointed out that species with extensive "cosmopolitan" ranges were not numerous; constituting only 1% of the total number of species.

Also small was the proportion of species occurring in only one of the analyzed units, and therefore attesting to the specific nature of a given fauna. Seven such cases were noted, involving 3.8% of the total number of species. There were far more species — in fact 49 or 26% — with slightly wider ranges of 2-5 units (Table 3).

The most well-represented families (with at least 10 species in Europe) were: voles (*Arvicolidae*), bats (*Vespertilionidae*), shrews (*Soricidae*), mustelids (*Mustelidae*), mice (*Muridae*), squirrels (*Sciuridae*) and deer (*Cervidae*) (Table 4). The species in these families were variously distributed across Europe and the most widely-occurring families were *Vespertilionidae*, *Muridae*, *Canidae*, *Mustelidae*, *Soricidae*, *Erinaceidae*, *Leporidae*, *Arvicolidae* and *Cervidae*.

TABLE 3. Relationship between the number of species and the number of units in which they occur

area of occurrence (number of units in which species occurs)	number of species with the given area of occurrence	% of all species	area of occurrence (number of units in which species occurs)	number of species with the given area of occurrence	% of all species
1	7	3.8	31 - 35	12	6.5
2 - 5	49	26.3	36 - 40	15	8.1
6 - 10	32	17.2	41 - 45	8	4.3
11 - 15	10	5.4	46 - 50	9	4.8
16 - 20	14	7.5	51 - 55	7	3.8
21 - 25	12	6.5	56-58	2	1.1
26 - 30	9	4.8			

TABLE 4. Mammalian families taken into account

Family	number of umits in which the family occurs	number of species in family	Family	number of umits in which the family occurs	number of species in family
Odobenidae (walrus)	2	1	*Talpidae* (moles)	45	3
Hystricidae (porcupines)	3	1	*Suidae* (pigs)	47	1
Dipodidae (jerboas)	4	5	*Gliridae* (dormice)	49	5
Procyonidae (raccoons)	9	1	*Felidae* (cats)	49	2
Viveridae (civelts and mongooses)	11	3	*Sciuridae* (squirrels)	50	11
Desmanidae (desmans)	13	2	*Arvicolidae* (voles)	54	32
Spalacidae (mole rats)	16	3	*Cervidae* (deers)	54	10
Phocidae (seals)	20	7	*Erinaceidae* (hedgehogs)	55	4
Castoridae (beavers)	21	1	*Canidae* (dogs)	57	6
Molossidae (free-tailed bats)	25	1	*Soricidae* (shrews)	57	17
Cricetidae (hamsters)	25	3	*Vespertilionidae* (typical bats)	57	24
Zapodidae (jumping mice)	27	2	*Leporidae* (rabbits and hares)	57	3
Ursidae (bears)	31	2	*Muridae* (mice)	58	11
Bovidae (cows, goats etc.)	35	8	*Mustelidae* (weasels etc.)	58	13
Rhinolophidae (horseshoe bats)	43	5			

The species considered in the paper belonged to 95 genera (Table 5). It must be emphasized that Europe has some genera that are very poorly-represented but whose species are very widespread, and others that are equally poorly--represented but also with species of very restricted ranges.

TABLE 5. Mammalian genera taken into account

Genus	Number of "biogeographical" units in which genus occurs	Number of species in genus	Genus	Number of "biogeographical" units in which genus occurs	Number of species in genus
Acomys	1	1	*Procyon*	9	1
Hydropotes	1	1	*Alopex*	10	2
Muntiacus	1	1	*Vormela*	10	1
Odocoileus	1	2	*Genetta*	10	1
Mesocricetus	2	1	*Tamias*	11	1
Lemmus	2	1	*Marmota*	11	2
Dinaromys	2	1	*Halichoerus*	11	1
Odobenus	2	1	*Microspalax*	12	1
Erignathus	2	1	*Phoca*	12	3
Cystophora	2	1	*Capra*	12	3
Ovibos	2	1	*Rupicarpa*	14	1
Myomimus	3	1	*Alces*	15	1
Meriones	3	2	*Citellus*	16	4
Allactagulus	3	1	*Cricetulus*	16	1
Dipus	3	1	*Ovis*	16	1
Scirtopoda	3	1	*Suncus*	19	1
Hystrix	3	1	*Cricetus*	20	1
Thalarctos	3	1	*Castor*	21	1
Saiga	3	1	*Ondatra*	22	1
Hemiechinus	4	1	*Tadarida*	25	1
Galemys	4	1	*Dryomys*	27	1
Allactaga	4	2	*Sicista*	27	2
Dicrostonyx	5	1	*Nyctereutes*	28	1
Lagurus	5	1	*Ursus*	30	1
Ellobius	5	1	*Eliomys*	31	1
Gulo	5	1	*Muscardinus*	31	1
Herpestes	5	2	*Micromys*	32	1
Myopus	6	1	*Oryctolagus*	33	1
Spalax	7	2	*Barbastella*	34	1
Rangifer	7	1	*Vespertilio*	35	1
Bison	7	1	*Miniopterus*	36	1
Pteromys	8	1	*Glis*	37	1
Monachus	8	1	*Clethrionomys*	39	3
Desmana	9	1	*Rhinolophus*	43	5

cont. Table 5.

Genus	Number of "biogeographical" units in which genus occurs	Number of species in genus	Genus	Number of "biogeographical" units in which genus occurs	Number of species in genus
Cervus	43	4	*Lutra*	53	1
Talpa	45	3	*Eptesicus*	54	2
Canis	45	2	*Microtus*	54	18
Neomys	46	2	*Meles*	54	1
Crocidura	46	5	*Erinaceus*	55	3
Capreolus	46	1	*Myotis*	55	10
Sciurus	47	3	*Martes*	55	3
Sus	47	1	*Vulpes*	56	1
Felis	49	2	*Apodemus*	56	5
Sorex	49	9	*Lepus*	57	2
Plecotus	50	2	*Rattus*	58	2
Arvicola	51	2	*Mus*	58	2
Nyctalus	52	3	*Mustela*	58	6
Pipistrellus	53	4			

TABLE 6. Relationship between the number of genera and the number of "biogeographical" units in which the genus occurs

Area of occurence (number of units in which genus occurs)	Number of genera	Area of occurence (number of units in which genus occurs)	Number of genera
1 - 5	27	31 - 35	6
6 - 10	11	36 - 40	3
11 - 15	8	41 - 45	4
16 - 20	5	46 - 50	8
21 - 25	3	51 - 55	10
26 - 30	4	56 - 58	6
total genera			95

Measured in this case by the number of units in which a genus occurred, the range of eurytopicity of the group under discussion was very wide. Three genera were represented by single species, which currently occur in only one unit. Examples are the genera *Hydropotes* — the Chinese water deer, *Mutiacus* — the muntjac, and genus *Acomys* — a mouse of the family *Muridae*. However it should be emphasized that the two genera *Muntiacus* (the muntjac) and *Hydropotes* (the Chinese water deer) are introduced, and might occur in a greater number of units on the basis of their ecology. The natural range of the muntjac includes the temperate zone of China, and the species may acclimatize

successfully in Europe. In a similar way, *Hydropotes inermis* (the Chinese water deer) is easy to raise and might also potentially occur in a greater number of units. Standing in contrast to these are three genera with single species whose ranges include at least 50 units, and which therefore have a wide area of occurrence. 46 genera have ranges covering no more than 15 units, and the remaining 49 genera occur in between 16 and 58 units. 27 genera occur in 5 units or less (Table 6). Three genera: *Rattus*, *Mus* and *Mustela* occur in all 58 units (Table 7).

TABLE 7. Genera of mammals with the greatest areas of occurence

Genus	number of "biogeographical" units in which genus occurs	Number of species in genus	Genus	number of "biogeographical" units in which genus occurs	Number of species in genus
Rattus (rats)	58	2	*Eptesicus* (bats)	54	2
Mus (mice)	58	2	*Microtus* (voles)	54	18
Mustela (weasel, stoat etc.)	58	6	*Meles* (badger)	54	1
Lepus (hares)	57	2	Pipistrellus (pipistrelle bats)	53	4
Vulpes (fox)	56	1	*Lutra* (otter)	53	1
Apodemus (mice)	56	5	*Nyctalus* (bats)	52	3
Myotis (bats)	55	10	*Arvicola* (voles)	51	2
Erinaceus (hedgehogs)	55	3	Plecotus (bats)	50	2
Martes (martens)	55	3			
total species					67

THE ZOOGEOGRAPHICAL REGIONALIZATION OF MAMMALS

REGIONALIZATION IN RELATION TO NATURAL UNITS

The statistical analysis of faunistic similarity in the 58 working "biogeographical" units revealed the following arrangement of cohesive 14 uniform subgroups:

— Northern areas (arctic and boreal),

— Areas of north-eastern Europe together with the Baltic Sea Basin, the continental section of mixed forest and a part of central Europe together with its uplands,

— North-western regions of the Atlantic area, associated with oceanic and marine waters,

— Areas of western Europe including both those neighbouring the Atlantic (the Armorican area) and upland and mountainous areas; the Burgundy-Rhine area, the Hercynian-Czech area and the Alpine area,

— The Hungarian Lowland, a part of the European-Siberian steppe belt (Pannonian areas), and the Carpathians,

— A small part of the European-Siberian steppe belt (the Wallachia area) and a part of the Mediterranean area (the Thracian area),

— The Black Sea and Caspian Depressions - within the European-Siberian steppe belt,

— The Caucasus Mountains and the Euxine area of the Black Sea's eastern shore,

— The Galicia-Aquitaine and Provence areas, and the northern part of the Iberian peninsula and the Pyrenees,

— The Mediterranean Baetic area and southern Iberia,

— The Appenine Peninsula, the Ligurian-Lazio area and areas linked with the Adriatic, as well as southern Italy and Sicily,

— Corsica and Sardinia,

— The Illyrian, Aegean and Ohrid areas by the Mediterranean, as well as the Rhodope Mountains,

— A part of the Euxine area (the south coast of the Black Sea), and a part of the Aegean area including Crete.

The borders between the enumerated groups of biogeographical units have been drawn up on the basis of the results obtained (see Fig. 1). In terms of distance and faunistic similarity, the degree of linkage between the delimited groups of units serves to delimit borders of various rank.

The main border of rank I separates the regions of northern and central Europe from what is widely-understood as the Mediterranean. It divides Europe latitudinally and runs along the main mountain chains.

A border of rank II within the northern division separates some regions of central Europe from those characteristic of the warm-temperate zone.

Borders of rank III distinguish the south-western part of Europe;

— the Alantic Galicia-Aquitaine area,

— the Provencale part of the Mediterranean area,

— the Pyrenees,

— the Iberian peninsula and the Baetic area.

Borders of rank IV separate:

— the Arctic area,

— part of the European-Siberian boreal area with western Scandinavia and the Karelia-Pechora area.

Borders of rank V separate:

— the Black Sea and Caspian Depression of the European-Siberian steppe belt,

— the Caucasus Mountains,

— the eastern shores of the Black Sea (the Euxine area).

Borders of rank VI separate:

— the European Atlantic area,

— the North Sea basin,

— areas adjacent to the central and southern Baltic.

REGIONALIZATION IN RELATION TO ADMINISTRATIVE UNITS

The adopted administrative division was up-to-date at the time the material was drawn up, but embraced states and countries which now no longer exist.

Analysis of the similarity between the mammalian fauna of states existing then, and the delimited regions, allowed for classification into two main groups (see Fig. 2):

— areas situated in the north of Europe and with relatively poor faunas,

— remaining states and regions.

Borders between zoogeographical regions were drawn up on the basis of values for the index of similarity.

The main border of rank I separates:

— Iceland and Spistbergen, Norway, Sweden, Finland, boreal Russia, the Baltic Republics, the Belarus, Denmark, the Benelux countries, Great Britain and Ireland.

A border of rank II separates European countries from: Iceland and Spitsbergen. The faunistic distinctness of the islands results from their rather poor species composition.

A border of rank III separates:

— France, Spain, Portugal, Greece and Albania from the remaining European countries.

A border of rank IV separates and also clearly distinguishes from the remaining countries of northern Europe:

— Denmark, the Benelux countries, Great Britain and Ireland.

Also marked on Fig. 2 is a border of rank V which separates, in the south of Europe:

— Greece and Albania.

SUMMARY

Presented in the paper is an analysis of the diversification of the natural environment on the basis of the criterion of species richness of the regions' faunas. Regionalization was performed using a formal technique which employed the statistical distances obtained by the method of Marczewski and Steinhaus. Grouping was carried out using Ward's method.

Borders at various hierarchical levels were drawn up to separate the different faunistic regions. In doing this, trends were revealed in relation to the spatial variability of fauna on the European scale.

It must be pointed out that the specifics of the local fauna of some areas of Europe were confirmed by the regionalization obtained. This was particularly true of the islands in the north of Europe and the Mediterranean Sea (see Fig. 2).

The aim of the included faunistic analysis on the basis of administrative units was not only to inventory the fauna of European countries, but also to

determine the differences in their faunistic richness. The zoogeographical regionalization presented on this basis may later serve in the evaluation of environmental diversity, and in the estimation of the influence of historical factors and of man, on the diversity and the shaping of the faunas of various countries.

Worthy of note in the division based on administrative units of state rank was the inclusion of Italy along with Sardinia in the group of countries with a "temperate" fauna, and the inclusion of the whole of France in the group of countries with a "thermophilic" fauna. This is an example attesting to the imperfection of using the accepted administrative divisions of higher rank as a basis for drawing zoogeographical conclusions. Natural units would appear to be better suited to the purpose.

The determination of the borders of the regions, and the delimitation of units of defined qualitative faunistic composition, may also serve in the assessment of the state of, changes in and threats to, the natural environment. It may be suggested that, when preparing spatial management plans, any natural regionalizations should also include zoogeographical regionalization, in order that living natural resources be used in an appropriate manner.

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PRICES OF FOOD PRODUCTS IN POLISH TERRITORY AS INDEX OF CLIMATIC OSCILLATIONS IN THE LITTLE ICE AGE

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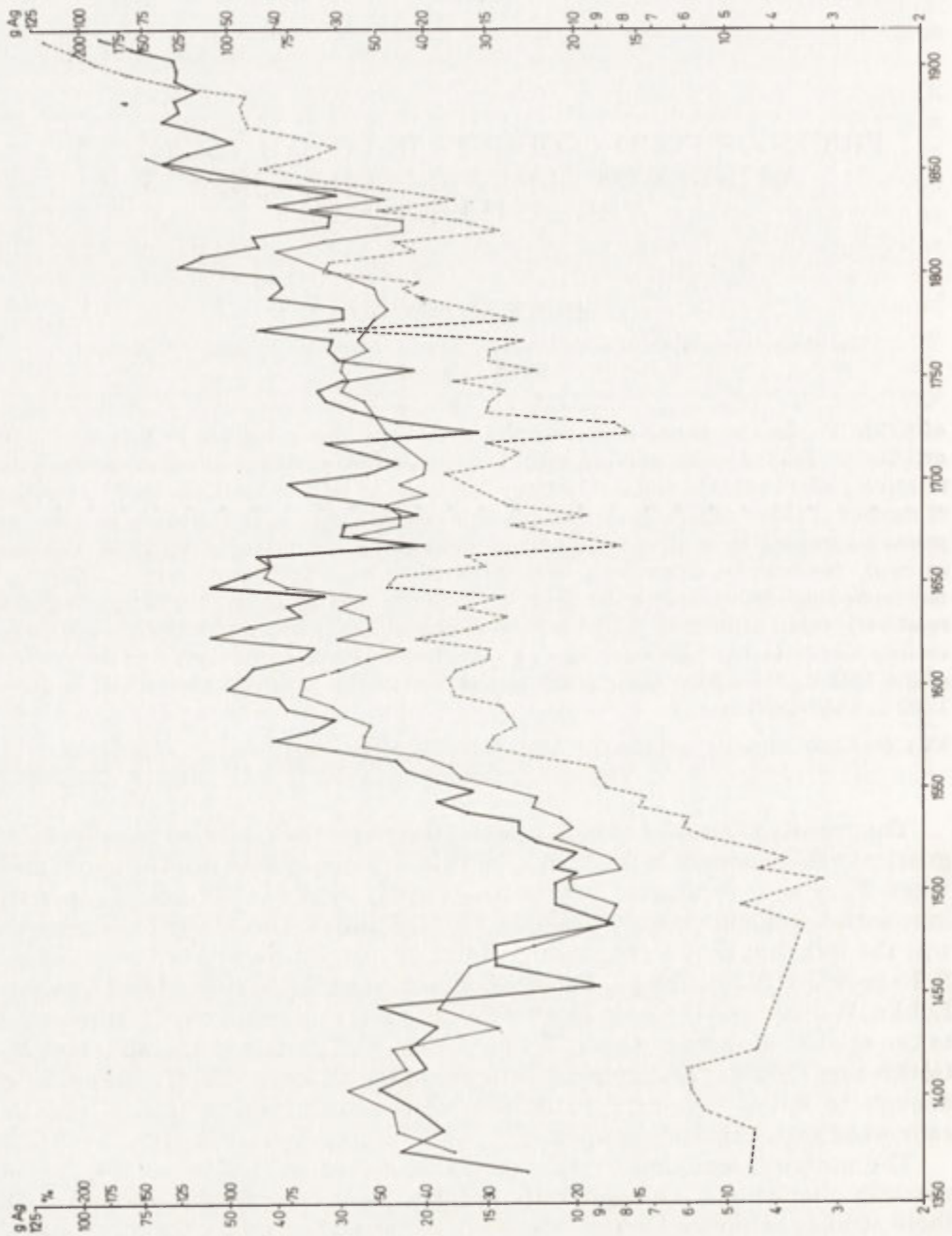
ABSTRACT: In the period between the two World Wars studies of prices of food articles in Poland were carried out. The particular authors, however, dealt with relatively short periods and did not pay attention to secular oscillations. The results of studies of three different authors made it possible to plot for Cracow a diagram of prices expressed by a silver equivalent, comprising the period 1369-1914. Besides general tendencies depending on economic conditions, long-term oscillations corresponding with climatic changes are found in this diagram. Three periods of a relatively rapid growth of prices can be distinguished which correspond with three cooling waves during "Little Ice Age": I — from the middle of the 14th c. to the middle of the 15th c.; II — from about 1520 to the turn of the 17th and 18th c.; III — from 1700 to 1850/1890.

KEY WORDS: climatic oscillations, Little Ice Age, Polish territory, price indices.

The results of studies of food product prices can be qualified as one of the greatest achievements in the history of Polish economy between the two World Wars. They were conducted at that time largely by the Lvov team of research in to social-economic history headed by Prof. F. Bujak. One of their advantages was the fact that they were conducted by one method worked out in detail by S. Hoszowski (1928). The published results concerned five cities: Lvov, Cracow, Lublin, Warsaw and Gdansk. Most of the data was collected from Cracow owing to the studies of three authors: J. Pelc (1935), E. Tomaszewski (1934) and M. Górkiewicz (1950). This comprised the years from 1369 to 1914, a period long enough to follow secular fluctuations which, among other things, can be connected with climatic changes.

The authors, studying Cracow prices, analysed the influence of extreme climatic phenomena, i.e., generally speaking, various natural disasters. As their studies comprised relatively short periods, they concentrated more on individual cases. The lack of appropriate distance of time made it difficult to follow changes of a general character. In the period between the Wars,



historians of the economy were interested only in cycles of economic changes, not exceeding 50 years; thus, they did not attempt to follow changes of a secular character (Hoszowski 1938).

METHODICAL REMARKS

For an analysis of secular tendencies I have summarized in one diagram (Fig. 1) the price indices determined for Cracow by the three authors, involving a period of almost 550 years. I have taken into consideration only the prices of those articles the production of which was most likely to depend on climatic conditions. From numerous indices used in the basic studies, I have chosen prices of oats and beer the records of which were most complete. Besides, I took into account the "general price index" of products of plant origin (oats + peas + peeled barley + buckwheat + beer).

The authors of the Lvov school presented the product prices at a constant measure, i.e. in grams of silver (Hoszowski 1928). The conversion of nominal prices into a silver equivalent facilitated the comparison and evaluation of changes occurring in space and time, particularly because of the fact that different currencies were used in Polish territory. The rule of such a conversion was criticized by W. Kula (1993), an outstanding historian of the Polish economy. He questioned the view of S. Hoszowski that nominal price is something ostensible, but its real value can be represented only by a silver equivalent. W. Kula expressed his opinion that conversion was, among other things, made in various ways (e.g. according to the currency values or mint regulations), causing considerable differences. At the same time, however, he stressed that conversion into silver is justified when dealing with prices in international trade (Kula 1993, p. 145-146). As in this paper a broader international context is significant, the silver equivalent for prices was adopted.

A diagram of prices similar to that for Cracow, was also made for the other four cities in which basic studies were carried out. It appeared that similar tendencies of changes were observed in them. However, the diagrams for these cities refer to shorter time periods. The diagram of prices in Gdańsk (Fig. 2) made from the studies of T. Furtak (1935) and J. Pelc (1937) is shown as an example of these. This city was chosen because the prices recorded in it depended, to a greater extent, on international trading than those in Cracow.

Fig. 1. Changes of prices of selected food articles in Cracow in 1369-1914, determined by H. Maruszczak on the basis of the data of J. Pelc (1935) comprising the years 1369-1600, E. Tomaszewski (1934) — 1601-1795, and M. Gorkiewicz (1950) — 1796-1914
The dashed line — oats for one quarter of a bushel ≈ 1.1 of the new bushel ≈ 55-60 kg (price expressed in grams of silver — g(Ag); continuous thin line — beer for one achtel ≈ 2 hl (price in g(Ag); continuous thicker line — group index of prices expressed in percentage (100% = prices of 1596-1600) determined for selected articles of plant origin (oats + peas + pearl barley + buckwheat + beer).

Thus, it can be concluded that the tendencies of Gdansk prices to change could better reflect more general regularities (in the European scale).

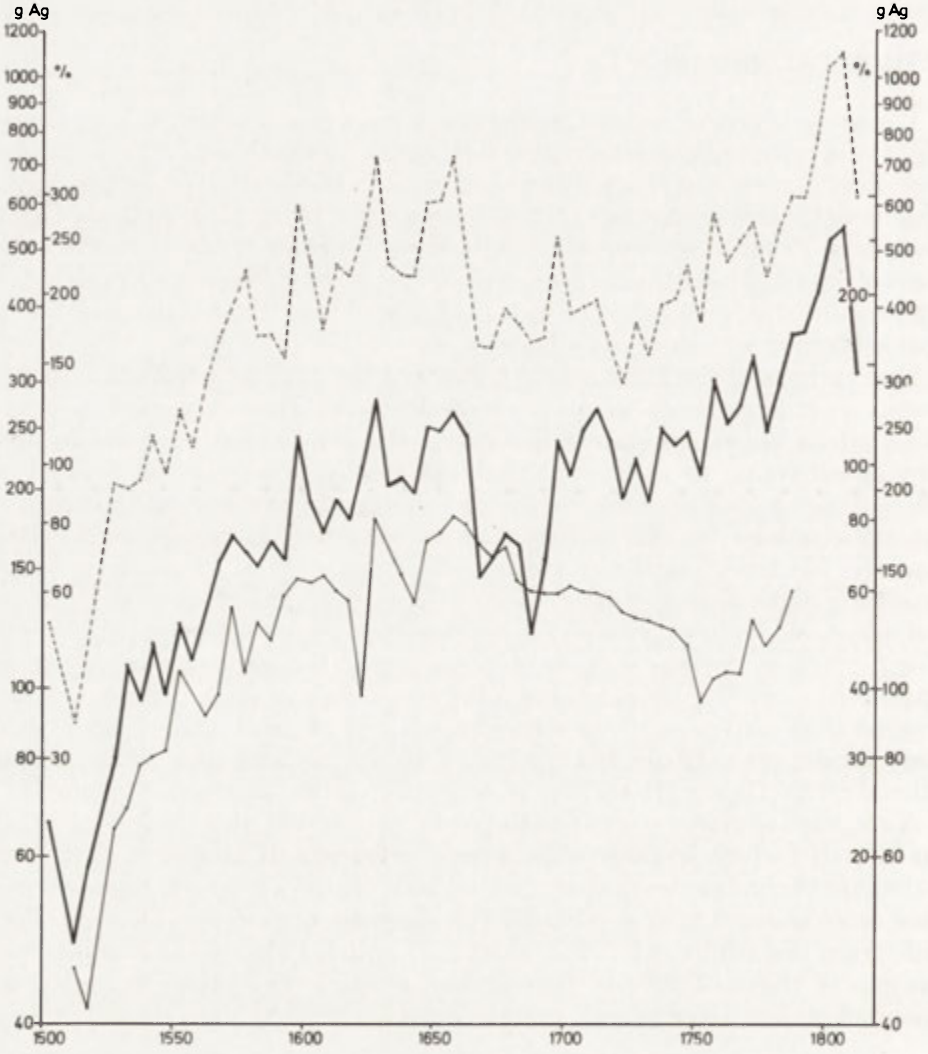


Fig. 2. Changes of selected food articles in Gdansk in 1500-1815, determined by H. Maruszczak from the data of J. Pelc (1937) comprising the years 1500-1700, and T. Furtak (1935) — 1701-1815

The dashed line — oats for 1 last ≈ 30 Warsaw bushels ≈ 2,200 kg (price expressed in grams of silver — g(Ag); continuous thin line — beer for 2 barrels ≈ 3 hl (price in g(Ag); continuous thicker line — group index of prices epressed in percentage (100% = price of 1596-1605) defined for selected food articles of plant origin (wheat + rye + barley + oats + peas).

PRICES OF AGRICULTURAL PRODUCTS IN THE POLISH ECONOMIC SYSTEM TILL THE 17th CENTURY

Till the beginning of the 19th c. a natural economy specific for a typical feudal agricultural society predominated in Poland. The larger part of agricultural production was consumed by its population; a very small part of it went to the market. Therefore, market prices did not correspond to the processes specific for global agricultural production and domestic consumption (Kula 1968). In such conditions the market prices of cereals largely depended on the international situation of the market, particularly on export possibilities.

From the 15th to 16th c. large landowners started to develop, on a considerable scale the production of cereals on grange farms exploiting "free", villein man power. In this way Poland became one of Europe's "granaries"; any quantity of grain could be sold profitably in England and the Netherlands through Gdansk. Thus, extensive grange grain farming developed rapidly, at the expense of the local rural population (of its labour and consumption). Grain was exported even in the leanest years and when there was famine. Such an economic system lasted till the end of the 18th c., i.e. till the English blockade of the Continent in Napoleon's time (Kula 1967).

Thus, it seems that prices in Cracow, located on the continental route between the West and East, and in seaside Gdansk depended on changes in international trade.

From the diagrams it appears that prices expressed by the silver equivalent tended to grow in the period from the 14th to 18th c. The growth was very irregular. The first period of intensive growth must have been connected with the medieval urbanization of Poland in the 13th and 14th c., which was particularly enhanced under the rule of the King Kazimir, due to which he was later called "The Great". The second period in the 16th c., marked by the highest growth of prices, was connected with the appearance of American noble metals in Europe; particularly the second half of that century was defined as a period of "price revolution" (Rutkowski 1946). The third period of rapid growth in the 19th c. was connected with "the industrial revolution".

Thus the outlined tendencies of agricultural products to increase in Poland seem to correspond well with the secular rhytm of favourable economic situations according to F. Braudel (1979). From the facts known in West Europe, he distinguished four succesive trends of this type: 1) 1250-1510 with a phase of maximum increase about 1350; 2) 1510-1740 with a maximum about 1630; 3) 1740-1900 with a maximum about 1817; 4) the presently developing in the 20th c. From the diagram of prices in Cracow the maximum growth of the first trend was about 1400, the second between 1600 and 1650, and the third about 1800. It seems, however, that our curve of price changes does not only register the trends of a satisfactory economy but also, the changes of climatic conditions.

INFLUENCE OF CLIMATE ON PRICES OF AGRICULTURAL PRODUCTS IN POLAND

The almost double growth of Cracow prices in the second half of the 14th c. must have not only been caused by the favourite economic situation. It may have been connected with the distinct cooling which started in Europe after the medieval climatic optimum (Lamb 1984). From the first "high ceiling" (about 1400) prices dropped even more than double during the 15th c. This can be interpreted by an economic crisis connected with the seizure of Constantinople by the Turks; for Cracow it meant a decline of trade with the pontine basin. It seems that, though short-lived, a distinct warm up occurred at the turn of the 15 and 16th c., which was of some importance at that time. A significant role of the climate seems to be accounted for by the very big, short-lived changes of Cracow prices in that period.

About 1520 the most rapid growth of prices started over the whole period presented in Fig. 1. This was connected not only with the phase of economic increase, but also with a big inflow of American noble metals. From about 1580 the price curve did not go up rapidly, but it showed big, short-lived fluctuations; over one or two decades prices went down or up by 100 per cent or more. Such big, short-lived fluctuations can be observed on the price curve till the middle of the 19th c. This period, i.e. from the middle of the 16 to the middle of the 19th c. is distinguished by H. H. Lamb (1984) as the Little Ice Age. Besides such rhythms, two waves of secular range with culminations in the middle of the 17th c. and at the beginning of the 19th c. can be observed on the price curve. Two cooling waves with culminations determined for the Polish territories at about 1650 and 1810 corresponded with them (Maruszczak 1987).

On the price curve, a period of very high prices in the first half of the 17th c. is marked particularly distinctly. In Cracow they reached a level which was exceeded as late as the middle of the 19th c. Thus, it seems that prices of that period corresponded with the climatic pessimum of the Little Ice Age. The second wave of high prices lasted a shorter time, but its culmination was marked more sharply because the consequences of cooling coincided with those of the continental blockade in Napoleon's time.

The results of analyses of cereal yields indices may also account for a significant influence of climate deterioration in the Little Ice Age on prices of food articles. For Poland such an analysis was carried out among others by W. Kula (1967). It appears from it that from the middle of the 16th c. to the turn of the 17th and 18th c. crop yields decreased by 40 to 50%; this had already started before the period of damage caused by the wars with the Swedes and Cossacks. Therefore, the author mentioned above interpreted it as "exhaustion of all possibilities" for the feudal system to develop. This does not appear to be fully convincing because a certain growth occurred at the beginning of the 18th c., i.e. when this system predominated. A drastic decrease of crop yields in the 17th c. must have been connected with the deteriorating climate. This interpretation may be supported by the fact that in the same period, i.e. from

the middle of the 16th c. to the end of the 17th c. cereal yields ceased very distinctly to grow also in West Europe, e.g. in England and in The Netherlands (Kula 1967, p. 63).

The extent of the deterioration of the climate in the 17th c. Poland has, among other things, been accounted for also by anthropological studies of the biological structure of the inhabitants of this land in the Middle Ages. They have shown that the highest stature indices of adults occurred in the years 1200-1300, and the lowest in 1600-1650 (Piontek 1992). Other signs of climate deterioration in the Little Ice Age, resulting from natural phenomena, were listed by H. Maruszak (1987). There is no need to recall them in the context of the present analysis of price indices. It can only be stressed that the signs of climatic changes were, of course, not as spectacular as, e.g., in the Alps, where transgressing mountain glaciers destroyed settlements. Nevertheless, these changes had a major influence on economic life, i.e. on prices as well.

PERIODS OF THE LITTLE ICE AGE IN POLAND IN THE LIGHT OF STUDIES OF PRICES

The diagrams of prices of food articles of plant origin show that deterioration/cooling of the climate in Poland took place in three phases (Fig. 3).

The first cooling wave started in 1300-1350 and lasted till the middle of the 15th c. After its culmiantion, about 1400 prices went down even below the level of the middle 14th c. There is some evidence that this wave of cooling was followed by a short warm up at the turn of the 15 and 16th c.

The second cooling wave started about 1520 and was over at the turn of the 17th and 18th c. The extensive culmination of this wave occurred in the years 1620-1650. Signs of later improvement/warm up of the climate were much weaker than at the end of the first wave; the price index in the last decades of the 17th c. decreased to a level similar to that about 1580.

The third cooling wave started about 1700 and lasted to 1850/1890. It was "lower" than the preceding, but its short-lived culmination in the years 1800--1810 was marked very sharply.

Diagrams of prices seem to illustrate changes of thermic relationships in Poland corresponding to 180-year rhythms of solar activity (Gutry-Korycka and Boryczka 1992, p. 167). I drew attention to the occurrence of three cooling cycles in Poland several years ago (Maruszczak 1987). Now I would like to stress additionally that the basic limits of time and the triple division differ from the conception of H. H. Lamb (1984), promoted for several decades. According to this author, the term "Little Ice Age" refers to the period 1550--1850 characterized by two cooling waves.

The term "Little Ice Age" has not been defined unequivocally, as natural events, specific for the period called in this way, occurred several times in Holocene, which was already given attention by R. W. Fairbridge (1968). The last, i.e. subtlantic Little Ice Age has more and more often been presented as

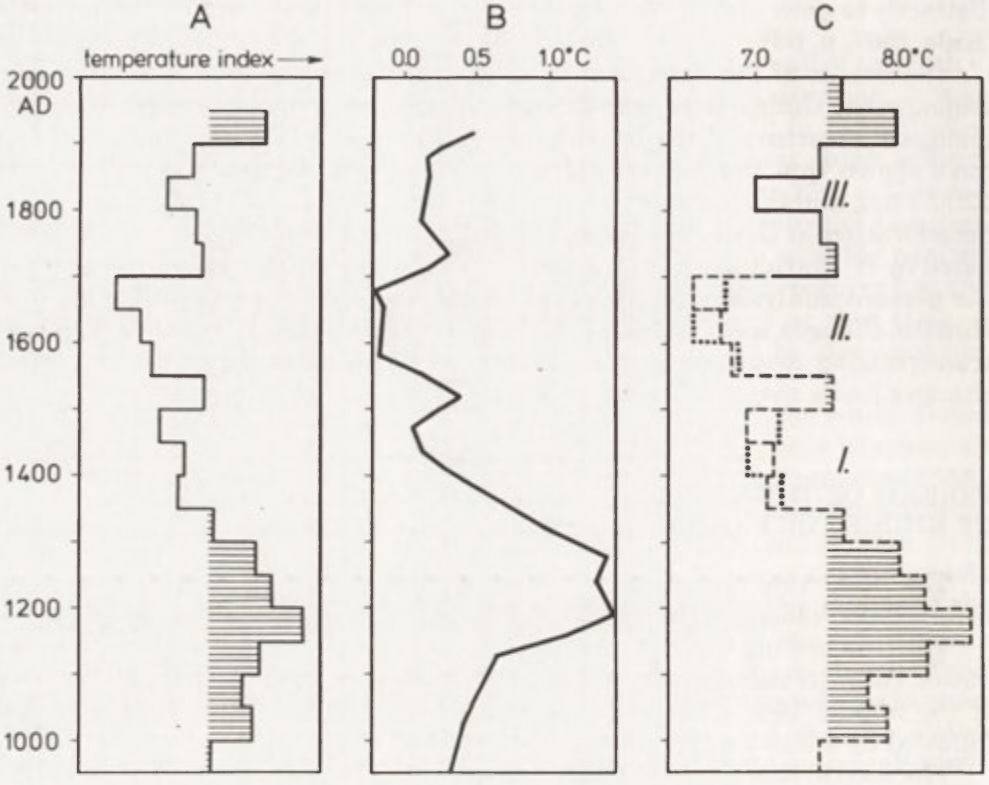


Fig. 3. Tendencies of climatic changes in the last millenium according to indices of thermic relationships

A — index of temperature changes in the Northern Hemisphere determined by different criteria (after C. V. Hammer et al. 1980). B — range of temperature changes in Great Britain (after H. H. Lamb 1966). C — mean 50-year temperatures in Central Poland determined from measurements in the 18-20 th c. (continuous line) and extrapolated in reference to diagram A (dashed line) or the diagram of price changes of food articles in Cracow (dotted line); cooling waves in the "Little Ice Age" I, II, III.

triple in the latest papers. Its beginning, according to the geophysical studies of the layers of Greenland ice sheet, was in the interval 1250-1450 (Hammer et al. 1980, Yavitt 1992). For the Alps this beginning is dated to about 1300 on the basis of complex analyses of studies of the upper forest limit, level of lakes and the range of mountain glaciers. Such dating was recently confirmed by M. Magny (1993) from studies on the content of ^{14}C of atmospheric origin. It results from them that the Little Ice Age in the Alps was triple; the beinning of successive coolness waves took place about 1300, 1500 and 1700 (Magny 1993, p. 6).

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