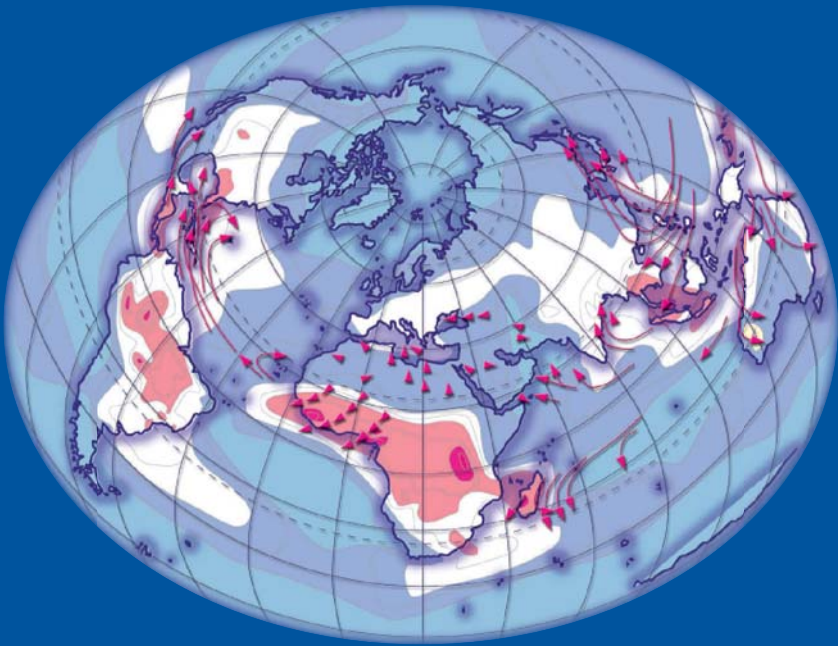


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# GEOGRAPHIA POLONICA



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INSTITUTE OF GEOGRAPHY AND SPATIAL ORGANIZATION

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# SOCIAL PRODUCTION OF URBAN SPACE (A CASE STUDY OF 'BAD' AREAS IN POZNAŃ)<sup>1</sup>

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**Abstract:** This article reflects upon the role of residents and social groups in assigning meaning to urban space. The research on which it is based was intended to: a) support a thesis about the importance of the social use of urban space in the shaping of urban structures, b) augment our knowledge as to the assignment of meaning to city areas and support the paradigm accounting for urban phenomena in terms of the everyday life of city dwellers, and c) identify the processes of urban marking in Polish metropolitan conditions by reference to criminal behaviour and its perception in Poznań. The research reported allows a more general conclusion to be drawn in that the stigmatization of urban areas only affects small areas and is fairly rare, while stereotypization of varying intensity is characteristic of much wider areas and is a more frequent mechanism underpinning social perceptions of places in a city.

**Key words:** Social production (marking) of urban space, stigmatization, stereotypization, Poznań city.

## INTRODUCTION

From the very dawn of the existence of towns, it has been possible to identify a mosaic of areas in them inseparably associated with specified social groups. Artisans, clergymen, authorities, socially-isolated groups—they all had a place in the spatial structure of the medieval town. Because of its smaller scale, its socio-spatial structures were easy to grasp, both in terms of their distribution within the town and their social characteristics. For

example, socially branded areas were, as if by laws of nature, endorsed by town councillors, and located marginally in relation to the town centre understood in both its spatial and social aspects (Wiesiołowski 1997). The executioner, ladies of easy virtue, the usher, and the lamp keeper in late-medieval Poznań used a common area clearly marked and separated both socially and spatially. The relatively uncomplicated social structure of the then urban community involving only a few constituent elements of its spatial mosaic made it possible for those divisions to be maintained in accordance with social norms, and with their administrative emanation in the form of intra-urban location rules (Ihnatowicz *et al.* 1979).

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<sup>1</sup> This article is an elaboration of the paper delivered at the Seminar on Urban Knowledge (Łódź, April 2004) and published as Kotus, J. and Dolata, M. (2004), Społeczne naznaczanie obszarów miasta [Social Marking of Urban Areas] in Jażdżewska, I. (ed.), *Konwersatorium Wiedzy o Mieście*, Uniwersytet Łódzki, 245–256.

The present situation in small towns of Poland may be somewhat similar to that of ages ago. A town's layout and social characteristics are clear and simple. However, in larger towns, spatial and social order at the general urban level is practically a utopia, with smaller or larger social groups taking over the use of various areas and giving them various meanings. In large cities, the scale is such that general urban phenomena fail to be fully controlled by either city administrators or the urban community. Moreover, the socio-spatial structures of the largest Polish cities are affected significantly by outside users, as well as potential and actual investors, who contribute to the fragmentation of the urban space (Martinotti 1996).

Poland's large cities are clusters of various, often disparate, areas located side by side. Within its administrative limits, each city constitutes a world of its own in which it is possible to identify spatially diversified social communities—communities using those areas and through use giving them a specified shape. One might say that, through those social users, city areas become fully urban. This is to say, that the strictly spatial layer has feelings engendered by being in different areas superimposed upon it, as well as opinions and imaginings concerning them, assigned thereto by certain social groups. As Amin and Thrift (2002: 8) put it, a city of socially produced space is 'an amalgam of often disjointed processes and social heterogeneity, a place of near and far connections, a concatenation of rhythms; always edging in new directions.'

Large cities generate a heterogeneous community engaged in a multitude of social activities, often very intensive in places. Of key importance in this process are 'street communities' (Jacobs 1961). It is those communities of one street, one alley, one gate, or one corner that determine opinions about a place by marking it with their behaviour. Sometimes the opinions are restricted to the place alone, sometimes they extend to adjacent areas or an entire quarter. There are areas used by residents with a 'good' social profile, and those controlled by socially marginal groups. Close to entertainment

centres there are office buildings, schools, and all kinds of housing arrangements. The contemporary city embraces many areas that are socially produced (socially marked) and hence perceived by residents, visitors and investors as good or bad places to live, enjoy themselves, or invest in. When studying the results of such production, one should note whether the residents' images of city fragments are being fixed by decisions of urban planners, and, as a result, whether they initiate processes of social and spatial polarization (Hamnett 2001).

### THE ROLE OF RESIDENTS IN GIVING URBAN SPACES SOCIAL MEANING

There is a clash of opinions among researchers analyzing urban phenomena as to the relations holding between the development of urban space and social behaviour. Some emphasize the importance of the material-spatial sphere of the city, claiming it to be superior to the social sphere. The former is comparatively constant and rather difficult to change, in contrast to the city's social traits, which can be altered faster and more readily. Hence social behaviour can be regarded as a result of spatial development (Wódz 1989). In an interesting study of the formation of spatial barriers in a city intended to restrict freedom of use of various areas, Flusty (1997: 48) lists five categories of space, which he characterizes briefly as:

- 'Stealthy space—space that cannot be found, is camouflaged or obscured by such view impediments as intervening objects or grade changes,
- Slippery space—space that cannot be reached, due to contorted, protracted or missing paths of approach,
- Crusty space—space that cannot be accessed, due to obstructions such as walls, gates and checkpoints,
- Prickly space—space that cannot be comfortably occupied, defended by such details as wall-mounted sprinkler heads activated to clear loiterers or ledges sloped to inhibit sitting,

- Jittery space—space that cannot be utilized unobserved due to active monitoring by roving patrols and/or remote technologies feeding to security stations.’

Naturally, the individual categories of spatial limitations interpenetrate and occur in various combinations, forcing the city-user to adapt his/her behaviour to the requirements of a space. In various situations, the material endowment of an urban space is supposed to subdue spontaneous behaviour on the part of its residents. The materialistic paradigm imposes the view of the city as a holistic system superior to its inhabitants (Geddes 1915).

However, other scholars feel there is no doubt about the social roots to the generation of space or endowment of some areas with certain social meanings (Wallis 1979; Jałowicki 1988; Lefebvre 1996; Allen 1999; and Pile 1999). Llewellyn (2004: 230) claims, after Lefebvre (1996), that ‘space is not merely produced for simple consumption, but that spaces can be adapted, manipulated, appropriated and produced by a range of individuals.’ This can be called a dispute between architectural and social determinism, between subjective and objective meaning of space (Herbert and Thomas 1990), between traditional urbanism and new urbanism (Amin and Thrift 2002). ‘Neotraditional urbanism seeks to provide quality public spaces that are semi-enclosed and legible, and that connect places that people use, in contrast to the amorphous, illegible, isolated and largely unused public spaces of the master-planned community’ (Ellin 1997: 30). Socially produced and reproduced are both ‘indoor residential settings’ and ‘outdoor residential spaces close to home,’ while such territorial markers as ‘swept sidewalks, scrubbed steps, trimmed bushes, ... pink flamingos, pottery cats [...] convey information to neighbors, passers-by and would-be burglars’ (Delaney 2005: 50).

There is no doubt that cities offer their residents material-spatial structures that are indeed more permanent than social phenomena. However, the very fact of people moving into a developed urban area involves

their giving individual places a full shape, sometimes modifying their functions. Thus, social traits of a place can directly influence a wider body of opinion about it, making it flourish or perish. One can say that a sociological answer to the question of what a city is and what mechanisms control it provides a basis for the consideration of many other urban issues (Mumford 1937/2002).

Lefebvre (1991, 1996) calls the social marking of urban locations the production and reproduction of places in the city. ‘Anglo-Saxon’ scholars speak of (re)negotiation of the meaning of areas and their (re)structuring under the influence of user groups (Mooney 1999). With the help of these terms, in a theoretically ideal situation, the process of city structuring and social participation can be said to go through the following stages:

- The stage of planning the new city (or new objects therein, e.g. housing estates, entertainment parks, green space),
- The stage of introducing new users into the city (into the new objects),
- The stage of assigning meaning to (re-negotiating meaning in) the city (to the new objects), and
- The stage of restructuring of the city or its areas, as a result of the social renegotiation of meaning.

In search of examples of this process among cities built from the ground up with a certain social mission that has been altered in social practice, one may mention the well-known case of Brasilia (Holsten 1989; Bauman 2000). Brazil’s capital, designed to be a social urban ‘Eden’, with ideally planned neighbourhood areas and places for various group activities, has become an example of the unpredictability of social movements and the social impotence of town planners. A Polish example of such a town is Borne Sulinowo. During the Second World War it was a closed unit housing German soldiers. After the war the town’s status did not change, except that it was now occupied by the Soviet Army (the last soldiers of what was by then the Russian Federation left in 1992). For almost half a century, then (until January 2003), the town was practically closed



to civilians. Thereafter its character started to change, and the residents and authorities began adjusting the military infrastructure to the needs of a civilian population. While the origin of this particular settlement unit is different, one might assume that the 'new' history of Borne Sulimowo started when the Soviet troops had left it, and observe how the new users have been changing the functions of individual places in the town in a way common to the entire settlement unit.

In most cases, however, the process of the social renegotiation of the meanings of places and their restructuring is limited to certain areas, e.g. a park or fragment of a housing estate (Llewellyn 2004). A spectacular example of appropriating places and giving them meanings is described in Young (2003: 617). Studying the spatial behaviour of street children in Kampala (Uganda), he noted a tendency for niches to be created in marginal spaces. A variety of places occupied created 'untouchable spaces', 'underground spaces', or 'rooftop spaces.' Those places came to function as homes and playground, and these new functions were accepted and authorized by other inhabitants. At times, however, persons with different ideals or different place-images of city life made an effort to prevent the children from appropriating public and neighbourhood areas, and to prevent those areas from acquiring a bad name.

Sometimes the appropriation and social marking of urban places by certain social groups combine with conflicts over neighbour and public spaces to force local authorities into legal and/or administrative action. When prostitutes in Portland's central streets became a nuisance to other everyday users of the same areas, the authorities felt it their duty to issue a Prostitution-Free Zone Ordinance, in which they delimited a 'zone of exclusion' and thereby removed the women from the city centre. In this way the local authorities counteracted its social marking (Sanchez 2004). Hubbard (2004) describes changes in the area of London's Soho, which had become an informal 'prostitution tolerance zone' as a result of social

stigmatization and the authorities' silent approval. Thus, in the 1970s the Soho area became dominated by the pornographic industry and earned the reputation, also abroad, as the centre of London's sex industry and a 'red-light district.'

It was only wide-ranging measures instituted by the local and central authorities that arrested the process of the negative stigmatization and stereotypization of Soho (Hubbard 2004). The creation and use of 'red-light districts' in British inner cities is an explicit example of the social stigmatization of a city by its users (Hubbard and Sanders 2003).

Sometimes, however, city authorities have initiated measures reinforcing the stigmatization of places on their territory. That is what happened in Chicago with the launch of the North Halsted Streetscape Project, under which areas occupied by ethnic minorities received small-architectural accents: miniature copies of temples, monuments, gates to the quarters, etc. (the Grektown Project, Chinatown Project, Puerto Rico Project). In this case, the administrative measures were a consequence of earlier social behaviour and were intended to meet social needs (Reed 2003).

A short but unequivocal description of such a process in Poland is given by a Polish sociologist Wódz (1989) in respect of the so-called 'Nowa Huta Scarp'. Nowa Huta is a district of Cracow built in the 1950s as a huge housing estate for workers of a metallurgical plant. Among the many blocks of flats there was an undeveloped piece of land on a scarp. Groups of residents spent their free time there marking it socially. The author distinguishes three stages in the social production of the scarp space: 'no-man's-land'; start of 'occupation' by residents; and 'established' patterns of behaviour.

## **BETWEEN STIGMATIZATION AND STEREOTYPIZATION OF URBAN AREAS**

The social renegotiation of meaning as regards places in a city can lead in some cases to their social stigmatization or stereotypiza-

tion. The term stigmatization can be found in the professional literature, although it is not defined explicitly (Mooney 1999: 81; Wacquant 2002: 225). The present article thus seeks to endow it with a more precise definition, and to elucidate the relationship between it and stereotypization.

The urban dimension to stigmatization is initiated by the appropriation and use of certain places in a town by specified social groups. This concerns both individual objects like a pub and larger areas like a good or bad neighbourhood (Mellor 1985; Campbell 1993; Robins and Aksoy 1995, 1996). What is important, on this reading of social stigmatization, is that the opinions of residents about some places in their city are true, resulting from a knowledge of places plus groups ascribed to them and constituting a confirmation of the existing state of affairs.

The social stigmatization of urban places can sometimes be the first stage of a broader process of their stereotypization, or the assignment to them of meanings under the influence of simplifications and erroneous and or superficial social beliefs. Beliefs about places that become fixed and pass into public opinion are sometimes derived from a true source, but often also from a source that has long ceased to exist (Figure 1). In such cases, city areas will be neither as good nor as bad as they are commonly reported to be, and the same will be true of the groups that

live in them. A fixed opinion may sometimes have nothing to do with the facts (Aronson *et al.* 1994).

Wódcz (1989) notes the very bad opinion Nowa Huta acquired for itself among Cracovians in the 1960s and 70s. The opinion embraced the entire area, which was talked about in terms of it being a 'bad space' or 'bad neighbourhood'. The Cracovians did not distinguish any particular 'bad' places within the district. In reality, however, Wódcz's research showed that 'deviant behaviour' was characteristic of only one area in it. He suggests that the widespread opinion as to the neighbourhood being 'bad' stemmed from the presence within it of particular places that were egalitarian and devoid of any spatial distinctions. This is certainly an interesting observation as regards socially stigmatized areas, in the sense that it portrays stigmatization turning into stereotypization. If respondents call entire districts bad (Jałowicki 1980; Biderman 1999), this could be deemed a clear example of stigmatization-turning-into-stereotypization of urban areas. Finally, opinions about places in a city may emerge as totally out of touch with reality, or reflect an old, historically distant past. This situation is termed full stereotypization.

In summing up the above reflections about stigmatization and stereotypization of certain urban areas, we can restate the

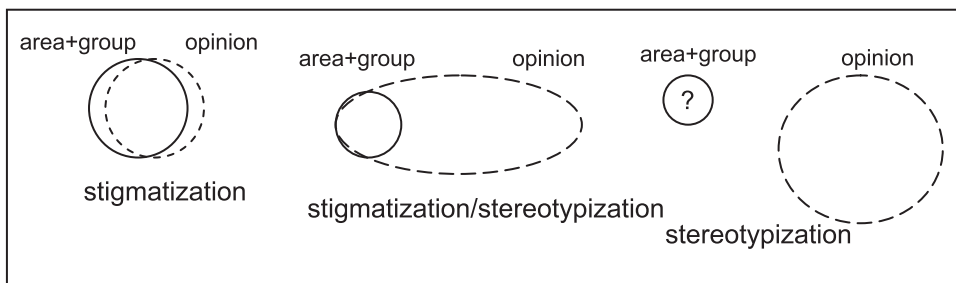


Figure 1. The mechanism of the transition of a different use of space into a socially stigmatized and stereotyped one.

Source: Authors' own compilation on the basis of Kotus, J. and Dolata, M. (2004).

three dimensions to the phenomenon, i.e. (Figure 2):

- Stigmatization: when the opinion about a place and the group using it coincides with the actual situation, users initiate social stigmatization of the place.
- Stigmatization turning under the influence of stereotypization from full to partial: when the opinion about a place and its group of users is exaggerated in relation to reality, the area that social opinion extends to is larger than that in which the phenomenon actually occurs.
- Full stereotypization: when the opinion about a place and its group of users is

solely the product of beliefs based on old, almost historical, facts, or when the opinion is entirely groundless.

Social production involves both actual (stigmatization) and stereotypic (stereotypization) attribution to urban areas of specific social characteristics that become fixed in the consciousness of city dwellers. The observers ( Figures 1, 2) are the residents of the thus-produced areas, or of other parts of the city who perpetuate their image in public opinion and collective awareness.

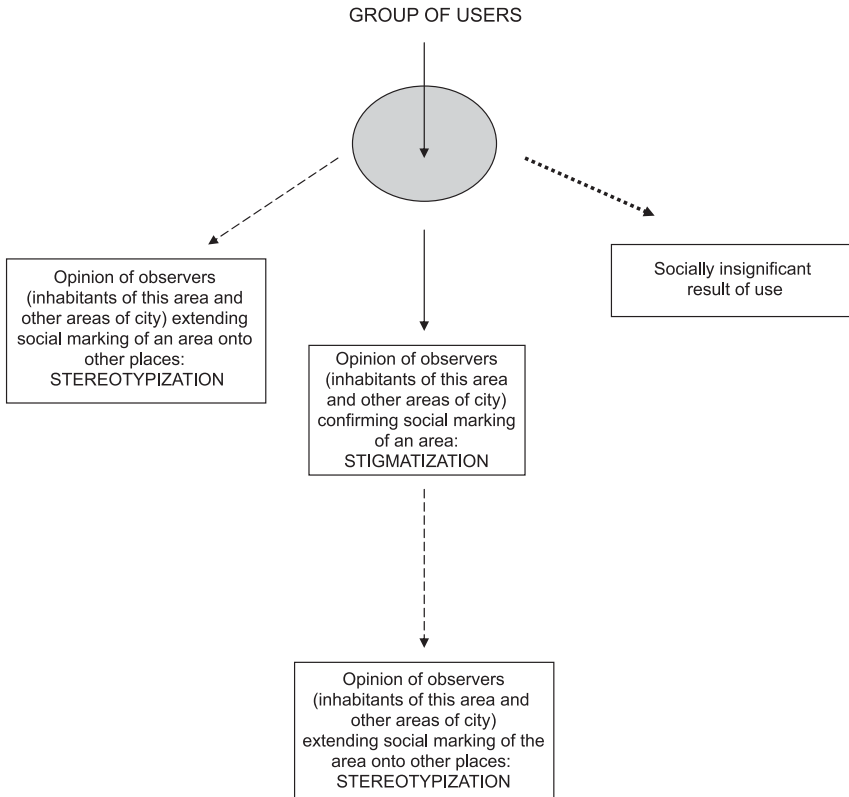


Figure 2. Dimensions to the social marking of urban areas —The perspective of an observer.

Source: Authors' own compilation on the basis of Kotus, J. and Dolata, M. (2004).

## 'DANGEROUS PLACES': THE CASE OF THE SOCIAL MARKING OF CERTAIN AREAS IN POZNAŃ<sup>2</sup>

As negative phenomena are often a source of very strong opinions, they are a good background to descriptions of place marking in cities. In addition, the identification of really bad places (those stigmatized through their users) and their differentiation from those that are bad by virtue of a stereotype allows for the instituting of various measures to improve the image of the urban space and create a community enjoying a sense of safety (Pain 2000, Pain and Townshend 2001). The presentation of the processes of stigmatization and stereotypization of places in the city of Poznań will proceed through three stages:

- Presentation of the negative popular opinion about certain places in Poznań (stereotypes) and reasons why the Poznań residents can regard those places as bad (stigmas),
- Presentation of the results of a research on crimes and offences in Poznań, and
- Comparison of those results with the opinions of city residents—as research participants—in regard to their feelings of safety, and their perceptions of certain places as dangerous.

### STEREOTYPES AND STIGMAS CONCERNING PLACES IN POZNAŃ THAT ARE BAD IN POPULAR OPINION

In the popular opinion of Poznań residents, Wilda and Jeżyce, together with their subsections: Łazarz and Stare Miasto (Old Town)<sup>3</sup>, have long been regarded as bad districts (Cichocki and Podemski 1998; Biderman 1999). This means that there is a category of city quarters of ill repute which includes those with a predominant building pattern of old tenement houses or with a large number of such areas. Interestingly enough, a century or more ago these were the high-

est-esteemed quarters on the residential map of Poznań. Jeżyce and Łazarz were then much sought-after as housing locations and residence there was highly appreciated (Skuratowicz 1999). Another category of areas seen by Poznań residents as notorious includes the large block estates of Piątkowo, Winogrady and Rataje; and a third includes the extensive green spaces within the city limits (Cichocki and Podemski 1998, 1999). Each of these extensive areas is judged in general terms, without resort to the indication of specific places. The bad opinion can thus be assumed to be largely stereotypic, especially in the case of Jeżyce and Wilda, which are actually two extensive, and highly diversified districts of Poznań. The all-inclusive bad opinion and perpetuation of a stereotype is also revealed in the assessments of the block estates and green spaces. The reasons for the areas in question being considered bad by respondents are (Biderman 1999: 1001, Cichocki, Podemski 1998: 91):

- that the areas with old tenement houses support a high level of social deviance and no safety, while the buildings are old and dilapidated and the inhabitants 'bad',
- that the block estates sustain a higher level of anonymity and no safety,
- that the green spaces are gathering places for hooligans offering no safety.

Naturally, there is no defending the thesis that all inhabitants of old tenement houses manifest social ills and are marginal, that all quarters are dangerous, that each major green area is threatened with delinquency, and that residents of block housing estates live in a permanent sense of danger. The opinions revealed by the respondents are clear generalization of a stereotypic nature.

In looking for the roots of such views, the most one can find are 'bad' city blocks, fragments of streets, or possibly even single building gates, in which socially deviant behaviour can be observed. It is thus possible to advance a thesis, which will be elaborated in more detail in subsequent sections, that such negative stereotyped opinions are usually underpinned by a grain of truth as regards a concrete place at which criminal acts

<sup>2</sup> One of Poland's largest cities with close to 600,000 inhabitants. It is a regional centre of industry, culture, education and science.

<sup>3</sup> For their location see Figs.

tended (or still tend), to occur more often than usual, or where such acts are merely suspected of the group using the place. For example, the old parts of the city may indeed feature groups of younger or older people loitering around gates, sometimes drinking alcohol or teasing passers-by; the same holds true for the green spaces. Certain block estates do in turn include places appropriated by young people, who like to meet there and sometimes also drink alcohol or harass other users. There have been individual cases of obvious vandalism or crime. We are thus faced with typical examples of places being stigmatized by reference to the social groups using them. The negative traits of the users are noted, fixed in public opinion via labels, imposed on such places and, with time, extended to cover a larger area. There is no doubt that this negative stigmatization turning into stereotypization is greatly enhanced by the media, which publicize individual 'bad' cases and make generalizations.

#### AREAS OBJECTIVELY THREATENED BY CRIME

The identification of areas within Poznań variously threatened by crime was based on an analysis of crimes and offences recorded by the police in March 2003.<sup>4</sup> In objective terms (the number of incidents), the threat of crime is markedly higher during the day than at night (Figure 3). The particular categories of offence extend across the whole of Poznań, despite differences in rates (Figure 4). There are some police precincts, in which certain kinds of offence are more frequent. For example, the Old Town precinct reports the highest rate for crimes and offences as

measured by the number of incidents reported per 10,000 head of population. This index (at 179.2) was three times higher than the city average, though should be treated with caution, since the numbers present in the city centre every day are higher than that of permanent residents. The phenomenon of population concentration in the downtown part of a city during the day, as swelled by the inflow of people from the periphery of the metropolitan area is well known. In terms of the kinds of offence, as broken down by day and night, the Old Town did not depart from the city average with its 61% of crimes taking place in daytime. The precinct was peculiar in terms of the kinds of act perpetrated there, however. Unlike other sectors of the city, it had an unusually high rate (53%) of acts committed in typical public space, i.e. thefts in shops and pubs; street robberies, thefts and battery; night disturbances, and misdemeanours of groups of young people. On the other hand, it had the lowest percentage (25%) of offences involving cars.

In the residential quarter of Wilda, which is old, densely built up and of ill repute, the rate of crime (offences per 10,000 head of population) over the study period amounted to 75.2, which was markedly higher than in the neighbouring precinct of Grunwald (49.6). Wilda had a very high percentage of daytime crime (70%), while in terms of the kind of offence, those involving public space predominated (38%). Next came those involving cars (32%), most of which (unlike in the Old Town), were thefts of or damage to cars near the houses of their owners.

As has already been observed, the police statistics make it clear that a Poznań citizen can fall victim to crime in most parts of the city, with particular places differing only in the rate and locally predominant kind of crime. However, each precinct has trouble spots in which a larger number of offences are concentrated. These are not spatially indeterminate and often have easily delineated ranges. For example, the common belief that block estates generate the kind of deviant behaviour associated

<sup>4</sup> The presented results derive from an analysis, made in 2003, of materials found among the records of incidents and police interventions at particular police stations (PS) of the Municipal Police Department (MPD) in Poznań. The available statistics on crimes and offences were chiefly presented by station, whose precincts coincide with the limits of the city's administrative districts. An exception is the Old Town district, which has two police stations: Poznań-Old Town and Poznań-North. The month in which criminal acts were committed was chosen at random, because it was impossible to obtain material for the entire year. The statistics only cover events reported.

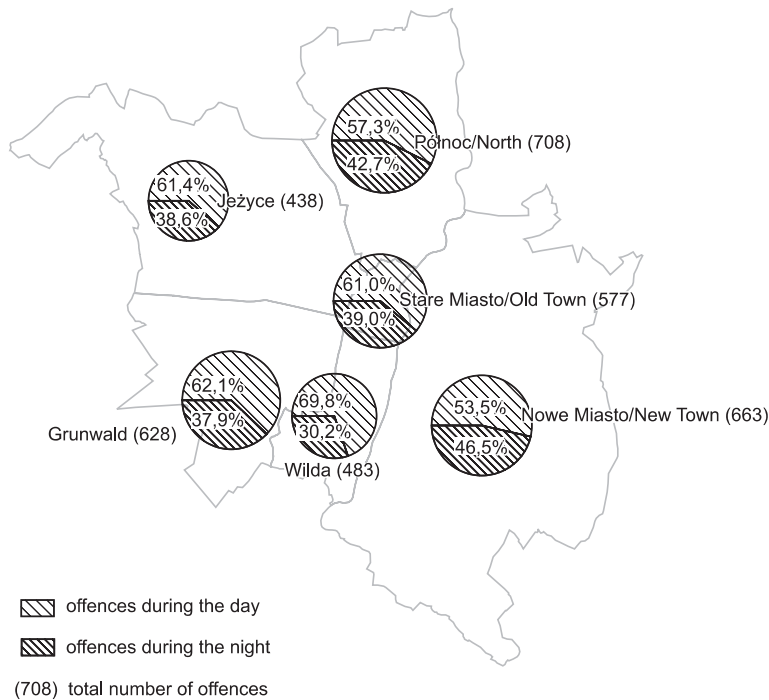


Figure 3. Offences in Poznań during the day and night, by police station, March 2003.

Source: Authors' own compilation on the basis of police data.

with hooligan groups, is not borne out by the fact that (with three exceptions) most Poznań estates of this type do not display an increased incidence of offences. The exceptions, for which the data collected reveal a prominent place among police records are the black areas in Figure 5. The situation is similar in Jeżyce precinct, in which the majority of criminal acts concentrate in the few streets forming 'Old Jeżyce'. The aforementioned Wilda, seemingly dangerous throughout, also in fact has individual streets and squares that are especially unsafe and thus give the whole district a bad name. Places in Wilda most exposed to crime include, as in the Stare Miasto (Old Town), both busy streets with shops and services (Wierzbicice, Górna Wilda) and less busy ones on the periphery (Figure 5).

From the above three conclusions are relevant to reflections on social marking in a city:

- most acts are committed by day,
- precincts differ as regards the rate and kinds of crime, but all areas are at risk,
- there are no especially crime-ridden districts, only places (streets, squares, estates) in each precinct with increased incidences of offences.

These conclusions were set against opinions of Poznań residents regarding their exposure to crime.

#### AREAS PERCEIVED BY POZNAŃ RESIDENTS TO BE EXPOSED TO CRIME

A survey of public opinion on levels of crime in Poznań and on the spatial distribution thereof, was carried out in 2002. It involved

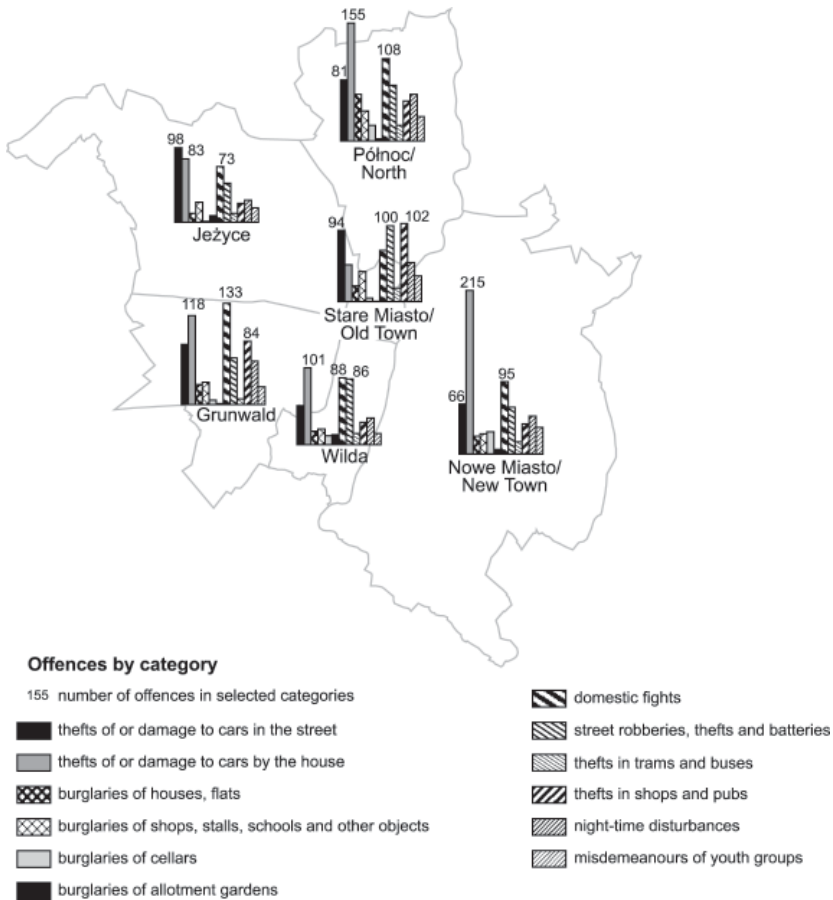


Figure 4. Offences in Poznań during the day and night, by kind and police station, March 2003.

Source: Authors' own compilation on the basis of police data.

457 city residents<sup>5</sup> representing three sections distant from one another and differing in town-planning and architectural terms. These were: the old part of Jeżyce within the city centre, as featuring a compact building pattern of old tenement houses (32.8% of respondents), the Pod Lipami (Lime Tree) Estate in the city centre, in which the build-

ing pattern is of multi-family blocks of flats (34.2% of respondents), and the Bajkowe (Fairytale) Estate, a suburban quarter with predominantly single-family houses (33.0% of respondents).

The respondents were asked to assess safety in Poznań, to indicate especially dangerous places in their immediate neighbourhood and in more distant parts of the city, and to appraise their reliance on sources of opinion about dangerous places. It should be emphasized that most respondents had never been victims of crime themselves. Only 10% had suffered as a result of an offence

<sup>5</sup> The sample was of 58.7% female and 41.3% male; 4.4% persons had elementary education, 16.4% vocational, 45.9% secondary, and 33.3% higher; there were 27.1% persons aged 18–25, 24.3% aged 26–39, 16.8% aged 40–49, 16.4% aged 50–59, and 15.4% were 60 and over.

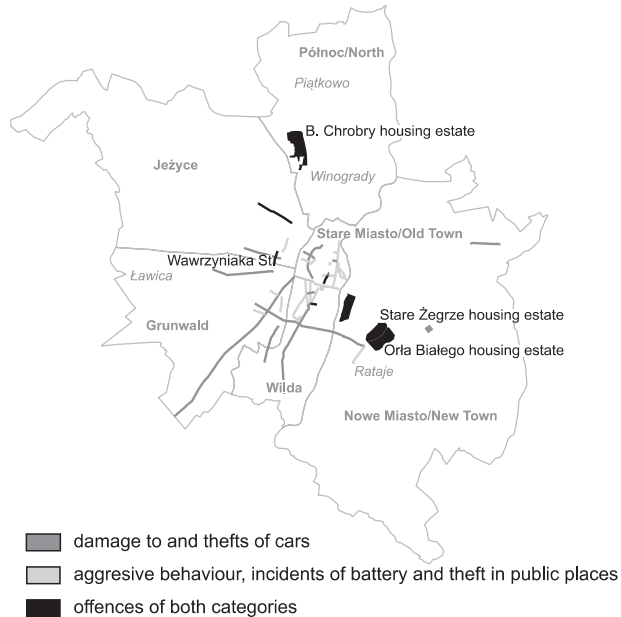


Figure 5. Places in Poznań with the highest rates of selected categories of offence, March 2003.

Source: Authors' own compilation on the basis of police data.

committed in their flats, houses or their vicinity; 14% in the nearest neighbourhood of their places of residence; and about 20% in a more distant public space. Often enough, the same people were involved. This offers sufficient grounds for the conclusion that the respondents formed their opinions largely on the basis of all kinds of reports (prejudices and stereotypes prevalent in the Poznań urban community), rather than their own experience.

The assessment of the feeling of safety showed it to be clearly dependent on two factors: the time of day and the distance from the place of residence<sup>6</sup>, with the former seeming to be more important. The respondents feel safest in their homes (a mean of 4.3) and in the daytime in both their own

neighbourhood and in public places (3.9 and 3.7, respectively). They feel most threatened after dusk, and more so in public places (2.4) than near home (below 2.8)(Figure 6). In view of the facts presented these results justify the statement that the perception of the threat of crime in terms of day and night is false. It reveals a stereotyped valuation of city sections following on from the conviction that it is more dangerous after dusk and at night, and in public places and parks. In reality, the rate of daytime crime is higher, irrespective of whether we are dealing with a neighbourhood or spaces of community life.

The following points can be made when comparing the above opinions of the respondents in terms of their types of residential quarters:

- There are no major differences in the assessment of the safety level near home by day. Differences do, however, appear, regarding walks after dusk, which were mainly judged dangerous by inhabitants of old tenement houses (over 60% of responses as against 47% of residents of the block estates,

<sup>6</sup> The assessment of the feeling of safety in the city ranged from 0 (highly unsafe) to 5 (very safe). The respondents had to consider six categories: (a) staying at home, (b) walking near home in daylight, (c) being in public places in the daytime, (d) being in parks, (e) walking near home after sunset, and (f) being in public places after sunset.



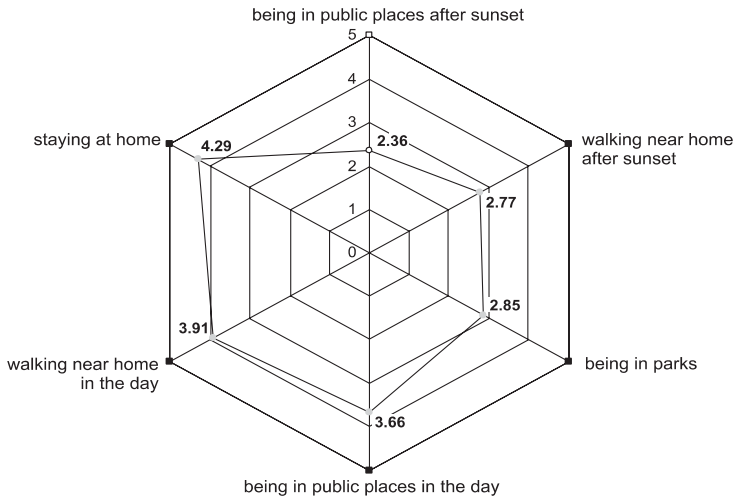


Figure 6. Evaluation of the sense of security in the city  
(arithmetic mean: 0 – very unsafe, 5 – very safe)

Source: Authors' own compilation on the basis of poll data.

and 38% of those living in single-family houses). Parks are another category which elicited differences of opinion: they scored the lowest with residents of single-family houses, a group of respondents that also felt less safe in public places by day and night.

- Public places after sunset tended to be seen as dangerous by older people, as well as by the less-educated, while the youngest age group (18–25) perceived them as fairly safe. People with higher education were ambivalent. Women were also more inclined than men to be afraid (over 80% as against 45%).

- In the assessment of safety in public places by day, in contrast, gender was no discriminating factor. Those with higher education and younger tended to think better of this than those with elementary and vocational education and of advanced age.

- Neither gender nor age were discriminating factors when it came to the assessment of safety near home in the daytime. The respondents who felt safer in those areas after dusk were younger, with higher education, and male.

The survey was absolutely positive about the actual occurrence of dangerous places in Poznań. As many as 75% of respondents stated that there were such places in the city, while a mere 2.5% claimed there were none. The dangerous places were to be found primarily in 'other parts' of the city, i.e., not in the respondents' places of residence or their immediate vicinity (57%). Only 15% claimed dangerous places were located mainly in their own neighbourhood. This clearly suggests that respondents were more prejudiced against outside areas, in other words those that were less known to them. The assessment as to where dangerous places are located is equally interesting when analyzed by the respondents' places of residence, viz. old tenement houses in the city centre (Jeżyce), multi-family blocks of flats (the Pod Lipami Estate), and single-family houses (the Bajkowe Estate)(Figure 7).

Residents of the single-family Bajkowe Estate considered that such places were mostly located outside their own neighbourhood, in other parts of the city. This opinion also prevailed among block residents,

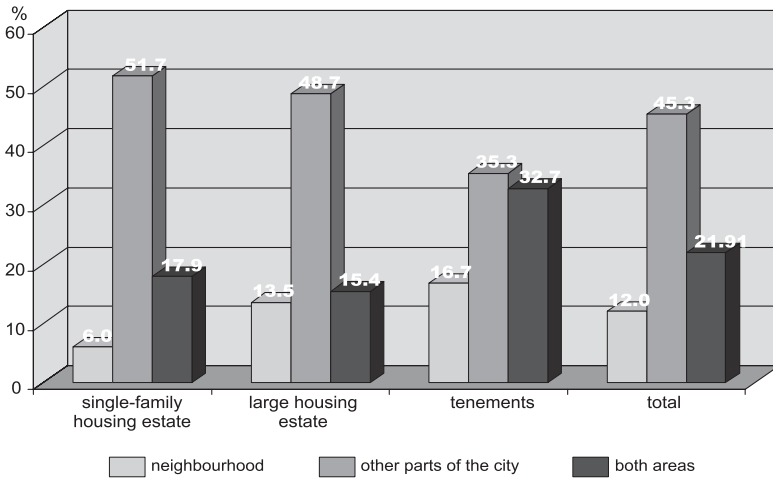


Figure 7. Location of especially dangerous places in the opinion of residents of particular areas  
 Source: Authors' own compilation on the basis of poll data.

though a higher proportion than in the previous group (13.5%) believed that they could be found mainly in the neighbourhood. It was the group of tenants of old houses that was most pessimistic about their place of residence: fewer responses pointed to other parts of the city as dangerous.

Moreover, residents of the single-family Fairytale Estate were more likely than the other respondents to claim that:

- there were rather more breakings on their estate than elsewhere in the city,
- there were decidedly no cases of aggressive behaviour in the street,
- there were no, or decidedly fewer incidents of battery and theft in the street,
- damage to, and thefts of, cars were more frequent there than anywhere else,
- there were none of the offences under study on their estate, or decidedly fewer than in other parts of the city.

The tenants of the old houses (Jeźyce):

- felt there were more cases of aggressive behaviour in the street where they lived than anywhere else,
- felt there were more incidents of battery and theft in the street,
- felt there were more thefts of cars,

- were less likely to claim that there were fewer offences in their neighbourhood than anywhere else.

The people living in blocks of flats on the Pod Lipami Estate largely declared that there were fewer incidents of aggressive behaviour, battery and theft in the estate streets than anywhere else. This is interesting in account of the prevalent opinion in Poland, fuelled by the mass media, that block housing estates are often controlled by gangs of juvenile delinquents, so-called 'blockers'. As the poll showed, these negative stereotypes were not corroborated by respondents living in one of the areas in question.

The analysis of sources of opinion on dangerous places in Poznań confirms that respondents usually form their statements on the basis of hearsay. In the case of 72% of respondents, statements were based on opinions of friends and other people. A significant role was also played by the press and television (65% of respondents relied on them, 'definitely' or 'rather', in forming their opinions). A decidedly smaller opinion-forming effect was ascribed to police reports and the respondents' own negative experience (44% and 39%, respectively) (Table 1).

Table 1. Reliance on sources of opinion about dangerous places in the city (missing data are omitted)

Sources of opinion about dangerous places	Categories of reliance				Net indicator
	Definitely yes	Rather yes	Rather not	Definitely not	
Own negative experience	20.1	18.8	32.2	15.9	-9.2
Press and TV	18.8	46.4	18.2	5.0	42.0
Friends and other people	22.9	49.5	12.0	3.3	57.1
Police reports	14.0	29.9	27.7	15.9	0.3

Source: survey

The tenants of old houses usually claimed that their opinions on places of danger relied on their own negative experiences and opinions of friends. Inhabitants of single-family houses mostly relied on media information. Women were more likely to rely on news from the media (nearly 80%) than men (under 60%). There were also about 10% more women who gained their knowledge in this respect from friends, people with lower education largely relied on their own negative experiences, while those with higher education tended to indicate the indirect sources of information, viz. the press, friends, or police reports.

A qualitative analysis of places indicated as dangerous by the three groups of Poznań

residents produced the following results (Figure 8). In their own neighbourhood, the Jeżyce inhabitants chose mainly Jeżyce Square and Wawrzyniaka Street (areas with old tenement houses). The former is a typical public space and the district’s principal centre of small street trade. Densely packed in the surrounding frontages are services, chiefly shops. During the day it is one of the busiest places in the city. Wawrzyniaka Street, in turn, is a relatively short (550m long), rather quiet street with few characteristic features, lined by old tenement houses. In the light of the statistics, the opinion of the Jeżyce respondents concerning the threat of crime in their district is only half justified. While Wawrzyniaka Street indeed



Figure 8. Dangerous places in Poznań in the opinion of residents of the Pod Lipami and Bajkowie housing estates and of the Jeżyce area.

Source: Authors' own compilation on the basis of poll data.

has a high incidence of criminal acts, Jeżyce Square can hardly be counted among the especially dangerous areas. Its bad opinion may partly stem from the fact that the empty stalls are nocturnal meeting places for groups given to alcohol consumption.

Among dangerous places in their neighbourhood, respondents from the Pod Lipami Estate (of blocks of flats) primarily mentioned the nearby green spaces, including the immediately adjacent Gagarina Park and the Citadel across the street (mentioned in two-thirds of all responses) (Figure 8). However, in none of those areas did the police record an increased incidence of crime over the study period. On the other hand, it is significant that only a small proportion of the respondents indicated other comparatively close areas, like the B.Chrobry Estate (also of blocks of flats), which is known to feature an above-average incidence of criminal acts.

The Bajkowie Estate respondents gave the Marcelin Wood as an especially dangerous area in their neighbourhood (referred to by 66%!) (Figure 8). This is a small (ca. 200 ha) stretch of municipal woodland, hardly attractive in landscape terms and poorly developed, used by the inhabitants of the nearby estates for walks. It is crisscrossed by the shortest footpaths and cycle paths joining the Bajkowie Estate and Ławica with the central part of the Grunwald district. As in the case of the Gagarina Park and the Citadel, we are here dealing with respondents' false images of the scale of crime in their immediate neighbourhood. The Marcelin Wood does not by any means figure as a 'black beat' in the local police records, in terms of the crimes and offences associated with it.

Among dangerous places in other (non-neighbouring) sections of the city indicated by the respondents from Jeżyce, and the Pod Lipami and Bajkowie Estates, the most prominent was Wilda (26–37%), especially the old section of the district with the railway and coach stations. Next came other downtown areas: so-called Old Jeżyce, the Old Town, and the oldest part of Grunwald, Łazarz. These opinions are closer to reality

and reflect a correct appraisal of the central part of the city as an area with an above-average incidence of crime. The opinions did not indicate precisely which places were dangerous, but conveyed negative views about a wider area.

## **BETWEEN STIGMATIZATION AND STEREOTYPIZATION—CONCLUSIONS**

Given the conclusions to the theoretical reflections presented earlier, the authors used the results of their research to identify cases of stigmatization (whether full or partial) and stereotypization in the area under analysis.

An undoubted example of full stigmatization is Wawrzyniaka Street in Jeżyce district. Worth noting is the fact that it lies in respondents' neighbourhood. Hence the very precise identification of an area which shows an increased incidence of criminal acts and functions as dangerous in social consciousness.

The analysis also makes it possible to indicate cases of stereotypization in the city. Between stigmatization and stereotypization a certain continuum is assumed to exist, in the form of partial stigmatization or stigmatization changing into stereotypization (Figure 2). That there were stereotypes of areas was revealed by respondents from the Pod Lipami and Bajkowie Estates. They expressed their opinions about the Citadel and the Marcelin Wood as places especially exposed to criminal acts, but the opinions are not corroborated by known facts as reflected in police records. Detailed qualitative research might lead to the uncovering of the genesis and strength of those stereotypes. It is impossible to establish what has made the park and the wood earn the opinion of high-risk places. Perhaps the sentiment originated in some isolated event (like a vicious murder or rape) which, although dating to a rather distant past, has been fixed in the collective consciousness of the local communities and passed on in the form of a bad opinion about the place. In both cases,

after all, we have areas with trees and shrubs, by their very nature isolated, less frequented, convenient for a potential criminal as a place of action and refuge. It is also highly probable that those places are a summer haunt for groups of alcohol drinkers, which, in the opinion of observers, may be associated with potential crime.

There is also partial stereotypization in the case of the district of Wilda. As has been mentioned, this section of the city does indeed feature an above-average incidence of selected categories of crime. They include primarily daytime offences committed in the so-called public space (robberies, thefts and misdemeanours in the street, shops and eating places). The district was indicated as dangerous by a substantial percentage of the respondents, and not only by those living relatively close to it (Jeżyce and the Pod Lipami Estate), but also by residents of the more distant section of the city (the Bajkowe Estate). In this case social opinion marks the entire district ('dangerous Wilda', 'bad Wilda'), while the groups making reference to it display characteristics that may or may not favour marginal phenomena. The users that initiated the negative social stigmatization of the area turning into stereotypization are the Wilda inhabitants. They derive partly from socially and economically degraded groups of the old proletariat working in the local heavy industry. In recent years, however, a new group of residents has emerged as a result of the appearance of new housing estates that are monitored and closed. They are inhabited either by people of better material status and good jobs, or by students renting flats in a section of the city close to the centre. In the opinions of the respondents, the latter also contribute to the 'bad Wilda' image, notwithstanding the fact that this is far from being the true situation.

Stereotypization also occurs on block housing estates, which are elements typical of the spatial structure of all large cities in Central and Eastern Europe. The Poznań districts with such estates are the aforementioned Rataje (the Nowe Miasto (New Town) district) and Winogrody together with

Piątkowo (the Poznań-North precinct). Both these areas are inhabited by a total of some 250,000 people. They have come to be generally regarded as an arena of a 'new' type of crime manifesting itself primarily in offences committed by youth groups representing the sub-culture of so-called 'blockers'. And indeed, as follows from police records, some large block estates (the B.Chrobry, Stare Żegrze, and the Orła Białego Estates) stand out for their incidence of criminal acts. However, in most of them misdemeanours by juvenile delinquents rarely define broader spaces. Rather, the groups tend to mark small sections of the estate space, and the occurrence of an offence in any particular spot is hardly predictable. Thus, what we are dealing with here is a situation in which the area covered by social opinion (all the large block-of-flats estates) is greater than that in which the phenomenon concerned actually occurs, i.e. with partial stigmatization.

It is possible to draw a more general conclusion from the research reported: the stigmatization of urban areas only affects a small area and is fairly rare, while stereotypization of varying intensity is characteristic of much wider areas and is a more frequent mechanism of social perception of places in the city.

Phenomena involved in the social production of urban places are not easy to control. They are spontaneous, result from psycho-social processes of perception, are difficult to anticipate, and develop over a period of many years or even decades. Hence it is practically impossible to avoid stigmatization and stereotypization of places in a city. In itself, the social production of urban places analysed in the present article is not a negative process. These mechanisms cause urban spaces to acquire social meanings and stop being physical locations. What is negative is the transformation of the opinion about certain places into a standard that guides decision-makers, investors, planners, and outside users, e.g. tourists. Such mechanisms can be dangerous, in that they may reinforce the processes of urban polarization, whether at the level of individual places (like housing

estates), categories of place (parks at night, block estates), districts, or larger sections of a city. The division into good and bad places determined by social opinion, whether on the basis of observation and reports of the actual behaviour of user groups or on the basis of stereotypes, can be of consequence to town planning. The prevailing good or bad opinion may affect actions by the local authorities and the investment climate. This, in turn, may lead to the location of investment in ostensibly good places, and hence to a further decline of those commonly considered bad.

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# FROM MIGRATION TO SEGREGATION IN THE FORMER CLOSED CITY

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**Abstract:** Based on the case of the military-industrial city of Ust'-Kamenogorsk, Kazakhstan, this paper explores (a) Soviet and post-Soviet era migration into former closed cities, and (b) the present housing situation of migrant groups living in them, paying particular attention to their ethnic background. The study is based on a survey carried out by the author and the regional statistical authority in January 2001. The principal findings suggest that there has been a clear increase in migrants from the oblast's rural areas to the regional capital, which is attributable to the regional urbanisation pressure which had been created during the city's period of 'closure', and that the origin of these migrants has shifted in favour of areas with larger Kazakh populations. Also, contradicting the Soviet goals, and resulting from structural factors re-enforced by the closed city regime, the ethnic housing gap is greatest among those who arrived during the Soviet period.

**Key words:** Closed cities, Kazakhstan, migration, ethnicity, housing, residential segregation.

## INTRODUCTION

The paper studies (a) Soviet and post-Soviet era migration into former closed cities, and (b) the housing situation of the migrant groups living in such cities in light of their time of arrival. The example of Ust'-Kamenogorsk (Kazakh Öskemen, population approx. 300,000) will be taken as a case in point, based on survey data collected by the author and the *oblast*' statistical authority of East Kazakhstan in January 2001.

The analysis moves through various scales, but the emphasis will fall on the hitherto poorly studied intra-regional level. Furthermore, given the dramatic turnaround in the ethnic migration patterns in the Former Soviet Union (FSU), the eth-

no-compositional aspect of the migration flows will be covered extensively. The focus on housing which follows is justified by the findings from previous research which suggest that migrant-fed industrialization in the non-Russian republics favoured the migrant population—most of which came from Russia—with regard to the housing allocation system. This happened often at the expense of the titular ethnic group (Lubin 1984; Tammaru 2001b; Kährlik 2002; Gentile and Tammaru 2006; Blejere *et al.* 2005). In non-Russian closed cities, where the process of industrialization was strictly regulated and accomplished in concerted development with the Soviet military effort, the relative advantage of the industrially skilled core nation(s) of the Soviet



Union, the Slavs, was presumably even more evident.<sup>1</sup> By the time of the demise of the Soviet Union, we may surmise, the titular ethnic groups of many former Soviet republics were underprovided in terms of housing and basic urban amenities *vis-à-vis* the Soviet-era immigrants. With the transition from central planning to market allocation, and the growth of the service sector and relative shrinkage of heavy industry, the structural preconditions of the dynamics of Soviet ethnic segregation are nowadays absent. However, the inherited legacies in the form of Soviet 'socialist' socio-spatial and ethno-spatial patterns are not (Gentile 2003b). In this paper, we compare an aspect of legacy—Soviet urban in-migration patterns—with an aspect of transition—post-Soviet urban in-migration patterns. As we will see, the two differ considerably, but is post-Soviet in-migration eroding the socio-spatialities of the previous industry-fed migration? This is the field which is explored in this paper, and the particular case of the former closed city—and we should not forget that it was a rather common occurrence—is expected to yield illuminative results.

The structure of the paper is as follows. First, the migration context of the FSU will be outlined and the areas needing more research put into evidence. Then, existent research on Soviet migration management and its significance will be presented, from which the paper's prime research questions will be extrapolated. Finally, the data, methods and results of the study will be reported.

## THE POST-SOVIET MIGRATION CONTEXT

The demise of the Soviet system has had a radical impact on migration in the regions of the ex-USSR. Late Soviet trends, such as

<sup>1</sup> In Russia, as elsewhere in the USSR, the development of the cities which hosted significant military-industrial activities took place at the expense of the city's non-defence related activities. In the absence of any particularly clear ethnic division of labour, this resulted in unequal access to urban amenities of unequal quality by socio-professional status (see Gaddy 1996).

the depopulation of the far northern regions and the 'sunbelt' effect in the far southern regions of Russia have accelerated (Denisenko and Khorev 1996; Heleniak 1997; 1999), whereas a reversal in the previously negative population trend of rural areas has been identified, with pre-urban rural areas absorbing the most significant of population increases (Wegren *et al.* 1997). On the other hand, there has been a dramatic change in migration flows between the Russian Federation and the countries nowadays termed as the 'Near Abroad', particularly the Baltic States, Kazakhstan, Kyrgyzstan and Moldova. After decades of Slavic in-migration, these regions have experienced substantial net losses among the Slavic (Zayonchkovskaya 1999) and German (Brown 2005) components of their populations. Coupled with a distinct tendency towards decreased fertility, this has resulted in a total population decrease of notable magnitude (Masanov 2002, p. 18; Sadovskaya 1999, p. 119). Conversely, the population decrease in the Russian Federation, largely a result of increased mortality rates (Mäkinen 2000), has been somewhat compensated by a wave of return migration which is approaching exhaustion (Becker *et al.* 2003, p. 229; Zayonchkovskaya 2007). International migration of this type is the focus of interest of a sizeable volume of literature (for example, Dunlop 1994; Vitkovskaya 1999; Zayonchkovskaya 1999). Recently, this interest has expanded to encompass 'non-traditional' immigration (i.e., refugees from Afghanistan, illegal and legal labour migrants from East Asia, etc.) and its accommodation within immigration policy (Popson and Ruble 2000). In contrast, inter-regional flows have been followed to a lesser extent (for the Soviet period, Ball and Demko 1978; Mitchneck 1991; Cole and Filatotchev 1992; for the post-Soviet period, Wegren *et al.* 1997; Heleniak 1997; Wegren and Drury 2001),<sup>2</sup> whereas intra-regional (intra-*oblast'*) flows are thus far virtually

<sup>2</sup> Nevertheless, there has been a somewhat surprising upsurge in interest for migration-related issues concerning the Russian Far North and East (Heleniak 1999; Kontorovich 2000; Thompson 2004; Round 2005).

unstudied.<sup>3</sup> Part of the explanation is the lack of detailed data beyond *oblast*-level, which implies that other sources and methods are necessary if one wishes to bring the analysis down to the local level.

Put differently, we know little about the actual volumes of intra-regional migration, nor do we know much about the socio-compositional characteristics of the migrant groups, the specificities of their principal destinations, and the causalities of their existence. Furthermore, because of the scarcity of the data, there is not much in-depth research of a comparative nature discussing migration before and after the collapse of the Soviet Union. This paper addresses both issues within the unstudied context of the former closed city. The choice of this particular case is motivated by the fact that the group of former closed cities was by no means a small one, given the secrecy requirements of an essentially militarised economy (Gaddy 1996). Likewise, previous research shows that the closed city's urbanization context under central planning was remarkably different from that of cities which were not subjected to particular regimes of closure (Gentile 2003a; 2004b).

## MIGRATION, MIGRATION MANAGEMENT AND CLOSED CITIES

The migration literature on the Soviet Union can roughly be divided into three inter-related groups. The first group, which is dominated by works of Soviet vintage, includes studies whose primary focus is to provide an accurate description of migration patterns and flows in the region (e.g. Moiseenko 1997; Kendirbaeva 1997), often within the context

of a broader discussion on the geodemography of the USSR and of its regions for planning purposes (for example, Akhmedova *et al.* 1976). Within this group, there also is growing literature on the various forms of forced migration which took place and are still occurring within the Soviet (e.g. Polyan 1999) and post-Soviet realms (e.g. Zayonchkovskaya 1997; Pilkington 1998; Riddle and Buckley 1998). The second group focuses on explaining the observed patterns with a primary focus on the determinants of the migration event (for an overview, see Kulu 2003 and 2004). The third group concerns the factors which diverted or prevented migration, or which were at least expected to divert/prevent it. Rather than emphasising the pull factors at the potential migrants' place of origin, this body of literature recognises that, under conditions of central planning, population movements must necessarily be managed and planned to ensure the optimal (i.e. most plan-coherent) territorial distribution of labour, the adequate preservation of state secrets, and the desire for urban development in line with the concept of the 'socialist' city (Gang and Stuart 1999, p. 118). Such planning and managing of migration made use of economic, administrative and propagandistic ('educational') methods (Kumskova 1983, p. 80).

The Soviet authorities attempted to curtail unplanned or undesired migration by means of various sorts of administrative restrictions, with the so-called internal passport and *propiska* (registration) system at the forefront position (Lewis and Rowland 1979; Morton 1984; Matthews 1993; Buckley 1995; Popov 1995a-b; Gaddy 1996; Højdestrand 2004; Wegren and Drury 2001). To a varying extent, this strategy inspired most other socialist polities, for example Albania (Sjöberg 1992), Romania (Ronnås 1982) and the People's Republic of China (see Buckley 1995, p. 912). Agreement as to whether such measures actually worked has yet to be reached. Buckley (1995) contends that the success of the limits imposed on the growth of specific cities, which were presumably to be enforced through the *propiska*

<sup>3</sup> There is, however, the notable exception of "pendulum" migration (commuting). Commuting has been particularly targeted by Soviet scientists since the late 1970's (see for example Orlova and Sitnik 1981; Kenigshtein 1983; Khorev and Likhoded 1983). Furthermore, eased by the recent data improvements, there is a growing and by now rather voluminous literature on suburbanisation, particularly on the urban regions of the Baltics (Tammaru 2001a; Tammaru 2005.; Leetmaa and Tammaru 2007; Krišjāne *et al.* 2005).

system, was at best slight. However, she emphasises that the *propiska* gained in importance after the unplanned migrant's arrival to the city, being the base for access to all sorts of important urban amenities, particularly to public sector housing, but also to schools, hospitals etc. On the other hand, based on sample of 308 cities, Gang and Stuart (1999) show that urban growth restrictions indeed did matter, and that unrestricted cities grew about twice as fast as restricted ones. Furthermore, they identified significant growth differences between regions and, based on a smaller but more secure sample, between cities with total expansion restrictions (i.e. *propiska*-enforced) and restrictions on industrial expansion (and therefore of the demand for labour). Surprisingly, the limits on industrial expansion seemed to produce stronger results than the total restrictions, implying that economic means were more effective in curtailing migration than the direct forms of administrative control of the *propiska* type. This point allows for some reconciliation with Buckley's (1995) more sceptical view of the efficacy of the *propiska*, but it also indicates that the requirements of economic planning (in labour input terms, in this case) preceded the social and political goals of the system of administrative migration control.

The problem is that, as mentioned above, restrictions were also imposed on cities which involved significant military activities, to the extent that some were even kept entirely secret, even though the latter's share of the total population was relatively small (see Rowland 1999). The picture is further complicated by the fact that many other cities—and it is impossible to know which ones or how many<sup>4</sup>—were effectively closed, not just to migrants without a *propiska*, but to all unauthorised visitors. This is an issue of

certain concern which the literature rarely acknowledges, and usually at best *en passant* (for example, in Wegren and Drury 2001, p. 40, it is relegated to an endnote). Within the group of closed cities, the degrees of closure surely varied greatly from case to case and at different points in time, in response to the development and perceived secrecy requirements of the powerful military-industrial complex (Gentile 2004b). Even so, we may surmise that in-migration to such closed cities must have been subject to much stricter control than in-migration to open cities, including the ones subject to restrictions on in-migration or industrial expansion. It may also be assumed that most closed cities do not coincide with the totally restricted ones reported by Lewis and Rowland (1979), Buckley (1995) or Gang and Stuart (1999), which casts some doubt on the accuracy of these scholars' conclusions regarding the efficacy of administrative restrictions on in-migration, as the better sealed cities seem to have fallen under the open category in their analyses.

Given the military's important 20–30% share of the Soviet GDP (Kotkin 2001, p. 61; Åslund 2003), the group of closed cities might indeed be more important than hitherto imagined. Certainly, this does not mean that 20–30% of the Soviet population actually lived in closed cities—after all, the military-industrial complex was well represented in such metropolises as Moscow and Leningrad—but a recent study by Gentile (2004b) suggests that, in 1989, up to almost 70% of the total population of Kazakhstan's 19 largest cities, excluding the two capitals of Almaty (until 1997) and Astana (since 1998), might have resided in an urban place to which access was strictly limited.

Recent studies on urbanization in the Former Soviet Union (FSU) indicate that former closed cities and their *umlant* differ from their open counterparts with regard to their population development since the demise of the USSR and the administrative restrictions on urban-bound in-migration associated with it (Gentile 2003a; 2004b). Importantly, these studies suggest that

<sup>4</sup> This problem stems partly from the fact that the concept of the closed city is used rather lightly in the literature. Some authors use it as synonym for 'totally restricted city', i.e., a city subject to a strict *propiska* regime. Such a view would mean that most large cities in the USSR were 'closed', and that Moscow still is, at least on paper (see Hoffmann, 2002).

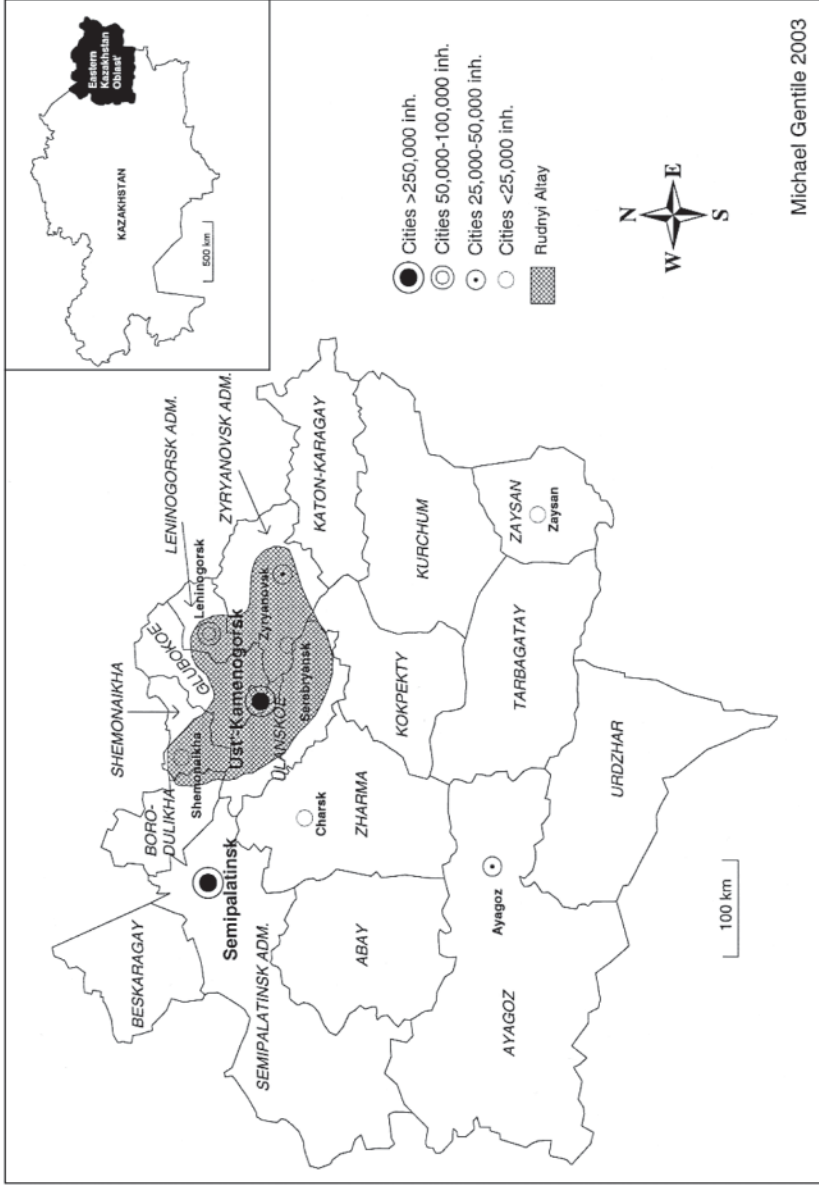
former closed cities were, on the one hand, more developed from an infrastructural point of view, with a better supply of housing, schools and other necessities. On the other hand, access to closed cities was restricted, and in-migration was certainly tightly controlled and selective, favouring skilled migrants from afar at the expense of the relatively untapped regional labour supply. Accordingly, closed city gates were assumed to limit potential urbanization from local sources, causing a mounting regional urbanization pressure during the city's period of closure. The abolishment of most cities' regime of closure by the early 1990's enabled the sudden unleashing of this pressure. Consequently, in Kazakhstan, the population development of former closed cities turned out to be less negative than that of open ones. Furthermore, the population size of the settlements within commuting distance of closed cities also experienced a relatively positive development during the 1990's, displaying a pattern reminiscent of the one predicted by the underurbanization thesis which was simply labelled 'delayed underurbanization' (Gentile 2003a; for more on the underurbanization thesis see Konrad and Széleányi 1977; Murray and Széleányi 1984). Under both delayed and 'regular' underurbanisation, the settlement pattern arises from a shortage of urban housing, but the cause of this shortage differs. During the post-Soviet epoch, and especially in light of the large number of vacancies resulting from mass out-migration, the shortage arises from the population's and, especially, the migrants' low purchasing power, rather than from limited supply. Compared to single-family dwellings, living in Soviet-era apartment blocks implies relatively high maintenance costs which cannot be influenced by the individual (electricity, gas, heating etc.). Within the Russian context, Wegren *et al.* (1997) identified similar quasi-underurbanizational tendencies of rural population increase in the areas surrounding the cities of the European non-Chernozem region. However, this similarity conceals the fact that Russia was a net receiver of interna-

tional migrants throughout the 1990s, and that many of them settled in the peri-urban rural areas, at least in part due to the urban housing shortage. Conversely, during the same period Kazakhstan was a net sender—in the year 2001 the in-migration to rural areas from abroad was almost three times lower than was its counter-flow, and in East Kazakhstan almost six times lower, i.e. only 527 persons (Agenstvo 2002c). The delayed underurbanization character of the settlement system surrounding former closed cities in Kazakhstan is mainly fuelled by internal migration, which is in contrast with the Russian experience described in Wegren *et al.* (1997; see also Wegren and Drury 2001, p. 24).

Summing up, the findings reported above suggest that former closed cities may be expected to reveal significantly different long-term migration trajectories than their open counterparts, especially in pre-/post-Soviet comparisons. Given the number of closed cities in the post-Soviet urban network and the suggested influence exerted by the previous regime of closure on the current regional migration trends, it is proposed that this category be analysed more carefully to the extent that this is possible given the limited tools available for research. The theoretical contribution of such a study lies in that it advances our understanding of the effects of the more extreme forms of migration regulation which were commonplace under certain circumstances (prevalence of the military-industrial complex) in the urban areas of the Soviet-type polities. Furthermore, an adequate understanding of migration processes at the intra-regional level is necessary for various levels of public administration in order to make informed planning decisions.

In light of the above discussion, the following research questions are set forth:

- Where did the urban-bound migrants come from during the 'closed' period, and where did they come from during the first 'open' decade?
- What was the ethnic composition of the closed period migrants, and what has it been during the open period?



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Figure 1. Map showing the location, administrative subdivision and major cities of the East Kazakhstan oblast’.

- What is the housing situation of Soviet era migrants as compared to that of the post-Soviet migrants?

- Are there any differences between the housing situations of the Kazakh migrants *vis-à-vis* the Russian migrants?

To answer these questions, in-migration to the former closed city of Ust'-Kamenogorsk (pop. approx. 300,000), East Kazakhstan *oblast'*, will be analyzed using survey material collected in early 2001. Samples of persons who had immigrated to Ust'-Kamenogorsk during and after the Soviet period have been extracted from the larger sample of 1,836 respondents, which also includes the native population. Unfortunately, though, the sample does not include persons who had immigrated to Ust'-Kamenogorsk but have emigrated since. Likewise, the sample of migrants excludes those who have been involved in an intra-urban mobility event since their first arrival. Therefore, our analysis is limited to those who have migrated to Ust'-Kamenogorsk and remained there ever since without ever moving within the city. Despite the ensuing skewness in the sample, the findings will be distinct enough to allow a number of interesting conclusions.

Before moving on to the details of the data and methods employed, a few words on the case study city and its region are warranted (Figure 1). Located in the north-eastern corner of Kazakhstan, the East Kazakhstan *oblast'* contains two similarly sized cities which both used to be *oblast'* capitals until 1997: Ust'-Kamenogorsk and Semipalatinsk (Semey). Comparing the fate of these two cities is instructive. Ust'-Kamenogorsk evolved into an important node in the Soviet military-industrial complex, hosting a number of non-ferrous metallurgical enterprises of all-Union significance, with close or direct ties to the military-industrial complex. Semipalatinsk became the host of a large food-processing industry, particularly for meat products. Owing to these different production specialisations and relative priority status during the Soviet epoch, the population development of these two cities differed considerably, and so did their sta-

tus with regard to the web of administrative restrictions imposed on population movement and in-migration to cities. Ust'-Kamenogorsk was closed, Semipalatinsk open.<sup>5</sup> Ust'-Kamenogorsk has paved sidewalks, Semipalatinsk, for the most, does not. Ust'-Kamenogorsk has tramlines, Semipalatinsk does not. Ust'-Kamenogorsk has various technologically advanced Soviet-era production facilities, Semipalatinsk has a symbolically powerful post-2000 suspension bridge. In many ways, Ust'-Kamenogorsk is what Semipalatinsk is not, which is why they are useful opposites for comparison when possible.

Ust'-Kamenogorsk is inhabited by a Russian ethnic majority, even though its share of Kazakhs has increased during the 1990s (Alekseenko, 1994; survey)(Table 1). In contrast, the former open city of Semipalatinsk, the city of Dostoyevskii's exile, is much more Kazakhified, with the share of Kazakhs in its population having increased significantly—from 26.5 percent in 1989 to over 50 percent in the year 2002.<sup>6</sup> The increased share of Kazakhs in Semipalatinsk is most likely due to natural increase, combined with stronger Slavic out-migration, rather than to Kazakh in-migration. In Semipalatinsk, the rate of natural growth in 2002 was of 0.89 ‰, whereas there was a -3.39 ‰ natural decline in Ust'-Kamenogorsk (Upravlenie, 2003a; 2003b). Unfortunately there are no data available for rates of natural population change within cities broken by ethnicity, but figures at the national level reveal that Kazakhs have a high annual rate

<sup>5</sup> Of course, the territory of the Semipalatinsk Test- ing Polygon was entirely off limits, but it was located at over 100 km from Semipalatinsk proper. In fact, it hosted a closed (and secret) city of its own, Semipalatinsk-126, nowadays Kurchatov.

<sup>6</sup> The figures for 2002, however, refer most likely to the territory of the city administration rather than to that of the city *per se*. If this is the case, it is worth considering that the city administration territory includes a dispersed rural population of approximately 30,000 individuals (Agenstvo 1999, p. 41; Agenstvo 2002a, p. 87; Agenstvo 2002b), most of whom Kazakhs. Therefore, it would be reasonable to revise the share of Kazakhs to, possibly, 40% of the city's population, whereas Russians would probably reach approximately 50%.

of natural growth, whereas Russians are experiencing sharp natural decline (and out-migration) (Agenstvo, 2001, p. 58), which may help explain the rapid Kazakhification of Semipalatinsk.

*last'*-level migration balance of the group (approximately -28,000 individuals) (Aleksenko 1994). Hence, given moderate Russian natural growth, the city's relative closure and the *oblast's* Russian rural population loss (which

Table 1. Share of Russians and Kazakhs in the population of the major cities of East Kazakhstan *oblast'* in 1989 and 2001 (+Zyryanovsk rayon [1989] or city administration [2002]; ‡as of the year 2002)

City	Russians (1989, %)	Russians (2001, %)	Kazakhs (1989, %)	Kazakhs (2001, %)
Ust'-Kamenogorsk	81.5	74.2	10.6	18.6
Semipalatinsk	59.6	40 <sup>‡</sup>	26.5	51.1 <sup>‡</sup>

Source: survey; Agenstvo, 2000a; Aleksenko, 1994, p. 16; Upravlenie statistiki VK *oblasti* (2003a; 2003b); Goskomstat SSSR (1991, p. 21).

Ust'-Kamenogorsk experienced population growth throughout the Soviet period, mainly due to positive net migration. Between 1979 and 1989, the city grew by 17.4%, with 64.5% of this growth attributable to the Russian ethnic group. During the same period, the city's Kazakh population grew at a rate six times higher than that of the Russians. At the *oblast'* level,<sup>7</sup> Kazakhs increased 4.2 times faster than Russians, presumably because of their high but decreasing birth rate (Aleksenko 1994). This suggests that Kazakh in-migration to Ust'-Kamenogorsk during the 1980s might stand for about one third of the increase (i.e., about 5,000 individuals) in the size of the city's Kazakh 1989 population of about 34,000. Russians, on the other hand, increased largely as a result of in-migration, although it is not known from where. In the meantime, the *oblast'* was experiencing net migration losses, especially of Russians, whose numbers decreased by over 30% in several southern *rayony* (Kurchum, Tarbagatay, Katon-Karagay and Markakol' [now part of Kurchum]). These ethnic Russian losses did not 'reappear' commensurately in any of the other *rayony*, because of the negative *ob-*

does not seem to have been equally compensated by urban growth), the Russian population growth of Ust'-Kamenogorsk must to a certain degree have been the result of in-migration from outside the *oblast'*, most likely from Russia, though certainly not to the same extent as in the first two post-war decades.

Ust'-Kamenogorsk experienced a four-percent population decline during the 1989–1999 inter-census period, which is a rather moderate decrease compared to the standards of the time—neighbouring Leninogorsk and Zyryanovsk, for instance, shed 18 and 17% of their populations, respectively (Agenstvo 2000b). However, since 1999, the city's population decline has continued steadily. The out-migration of Slavs to the other republics of the CIS is the main explanation, together with a modest (0.3%) annual natural population decline (Upravlenie 2003b).

As is the case in most of the FSU, the urban economy of Ust'-Kamenogorsk was severely damaged by the economic turmoil during the crisis of transition from socialism to a market economy in the early 1990's. Since 1997, however, industrial output has started to pick up again, and the enterprises started to re-hire (Moskal'tseva 09/2000). The demand created by the relatively high wages within heavy industry injected new

<sup>7</sup> At the time, the East Kazakhstan *oblast'* was only half its current size, as Semipalatinsk *oblast'*, abolished in 1997, had not yet been incorporated in it.

energy in Ust'-Kamenogorsk's commercial and service functions. Accordingly, the city became the main magnet for migrants in the *oblast'*, which partly happened at the expense of similarly-sized Semipalatinsk, whose industrial sector remains largely inactive.<sup>8</sup>

### DATA AND METHOD: THE CITIES OF THE RUDNYI ALTAY DATABASE

The *Cities of the Rudnyi Altay* database collects information on the socio-economic status of the three cities of Ust'-Kamenogorsk, Leninogorsk and Zyryanovsk, based on an extensive questionnaire survey (N=3,136 adult respondents, >18 years of age) carried out in January 2001 by the author in cooperation with the statistical authority of East Kazakhstan *oblast'*, based in Ust'-Kamenogorsk, and with the participation of the city statistical offices in Leninogorsk and Zyryanovsk. The overall goal of the survey was to create a knowledge base on the socio-geographical characteristics of small and medium-sized post-Soviet industrial cities undergoing transition.

The author pre-tested the questionnaire form, which was in Russian, in a minor pilot study in December 2000 (N=64) and supervised the entire subsequent survey process, mostly from the premises of the statistical authority in Ust'-Kamenogorsk.<sup>9</sup>

<sup>8</sup> Even though the available pool of migrants mostly consists of ethnic Kazakhs from the rural areas of the *oblast'*, it is interesting to note that Semipalatinsk, with a considerably larger share of ethnic Kazakhs in its population, does not appear to be a particularly attractive destination. Employment opportunities—or a perception of their existence—are more important migration motivators than ethnic composition in independent Kazakhstan. Previous research shows that this might be otherwise for Russians and other ethnic minorities (IOM 1998; Sadovskaya 1999; Becker *et al.* 2005).

<sup>9</sup> The questionnaire form was divided into four sections (themes) and 41 questions: (a) General information about the respondent, (b) Housing status, (c) Housing and living conditions and (d) Employment. The topic of migration is covered *en passant* in all four themes, with the exception of the last few questions which explicitly concern potential *out*-migration, making them less relevant for this paper. The questionnaire form, and a translation into English, may be obtained from the author upon request.

Before the distribution of the questionnaire forms, around the 20th of December 2000, the survey was presented in the principal *oblast'* media (regional television, radio and newspaper). The questionnaire forms were subsequently distributed and collected during the evening hours and on week-ends by 58 professional statisticians (45 in Ust'-Kamenogorsk), who acted as interviewers. In Ust'-Kamenogorsk, they were rewarded with 50 KZT (approximately US\$ 0.30 at the time), and, as a result, only 2% declined participation. An additional 5.1% of the dwellings in the sample had been abandoned, evacuated or demolished since the register was created, which gave a response rate of almost 93%.<sup>10</sup>

The sample covered 1,836 respondents in Ust'-Kamenogorsk, 700 in Leninogorsk and 600 in Zyryanovsk, and was extracted from the complete register of households created on occasion of the 1999 census of the Republic of Kazakhstan. Of the 1,836 respondents in Ust'-Kamenogorsk, 1,516 belong to an original sample, and 320 were added to about 15 neighbourhoods which had few respondents in the original sample. This implies that the extended sample is somewhat less representative than the original one. However, it is the author's opinion that the benefits obtained from increased sample size outweigh the risks incurred from allowing a certain bias towards certain neighbourhoods. This is because the data used for this paper target the population operationally defined as migrant, i.e., those whose previous place of residence was beyond the municipal boundaries of the city in which they resided at the time of the survey. This rather narrow definition implies that individuals that might have immigrated to the city are excluded from the migrant sample whenever they have been involved in an intra-urban mobility event since

<sup>10</sup> In line with common local practice, refusals and abandoned or demolished dwellings were replaced by neighbours living in the dwelling immediately to the right (a similar strategy was adopted in a UN-funded survey-based study by O'Hara *et al.*, 2007). A detailed discussion of the method problems encountered while working with the survey is provided elsewhere (Gentile, 2004a).



their arrival to the city. This depends on the fact that the database only registers the most recent mobility event, whether it be intra-urban or external.

For clear reasons, the survey also excludes those who had migrated to the city during previous years but have left since, either to Russia or elsewhere. This means that this article essentially compares those persons who had moved to Ust'-Kamenogorsk before 2001, are still alive and living there, and have never moved within the city since their arrival. In a Western context, such limitations would have decimated the size of the initial sample; in the low mobility contexts of socialism and post-socialist transition, the situation is different.

Summing up, the sample certainly underestimates the size of the migrant group, even within the rather low mobility context. Perhaps paradoxically, this is particularly true for the 'post-Soviet' migrant sample (migrants who have arrived during the 1990s), as its respondents arrived after the introduction of market relations in the provision of housing, thus making their position more volatile. Nevertheless, the size and quality of the migrant sample should allow the extrapolation of valuable insights for Soviet/post-Soviet comparison. In the following sections, the migrant sample will generally be divided into those who arrived during the Soviet epoch, and those who arrived during the post-Soviet period until 2001. For the sake of simplicity, these sub-samples will be referred to as 'Soviet' and 'post-Soviet' migrants, but the reader should remain aware that the operational definition used is rather narrow.

## RESULTS: MIGRATION AND SEGREGATION IN UST'-KAMENOGORSK<sup>11</sup>

This empirical section will proceed by describing and analysing the migrant sample (based on the unconventional operational definition provided above) extracted from the *Cities of the Rudnyi Altay 2001* database.

<sup>11</sup> This section is based on the survey unless indicated otherwise.

We will begin by presenting the general differences in the patterns of in-migration to the three cities before and after the demise of the Soviet Union at the aggregate level. After taking the example of Ust'-Kamenogorsk to elucidate the ethnic dimension of Soviet and post-Soviet in-migration, the section will proceed by examining in-migration to the city in greater geographical detail, emphasising the origin of the migrants and the changes that have occurred in this respect since 1991. Finally, with the ethnic variable in mind, the housing situation of 'Soviet' and 'post-Soviet' migrants will be compared in order to establish whether there are any significant differences.

## GENERAL PATTERNS OF IN-MIGRATION TO UST'-KAMENOGORSK AND THE RUDNYI ALTAY REGION CITIES

Table 2, which is based on the entire Ust'-Kamenogorsk sample, shows that two thirds of the population of the city were born outside of its administrative boundaries. This stands in contrast with the cases of neighbouring Zyryanovsk and Leninogorsk, where only about one third of the inhabitants were born outside of their respective cities, suggesting that Leninogorsk and Zyryanovsk have long stopped absorbing significant volumes of in-migrants. Specifically, 38 percent of Ust'-Kamenogorsk's citizens were born within the *oblast'*, primarily in rural areas, whereas 22.2 percent were born outside of Kazakhstan. A modest 6.3 percent were born in a different Kazakhstani *oblast'*, approximately half of which in urban areas.

The situation is quite different in Leninogorsk and Zyryanovsk. First of all, locals prevail by birth.<sup>12</sup> Secondly, the share of those born abroad is somewhat greater than that of the population born in a different locality of the *oblast'*. As in Ust'-Kamenogorsk, few originate from the other *oblasti* of the republic. Therefore, contradicting two of Ravenstein's classical migration 'laws'

<sup>12</sup> In this case, 'regional' is a very relative term, as the size of the *oblast'* is comparable to that of Poland.

Table 2. Place of birth of respondents born outside of Ust'-Kamenogorsk's official boundaries and their share in the city's total population, based on entire sample of 1,836 respondents

Place of birth	Urban (N)	Rural (N)	Total	% of total population
Other rayon within <i>oblast'</i>	115	583	697	38.0
Other <i>oblast'</i>	59	57	116	6.3
Abroad (mostly Russia)	—	—	408	22.2
Total born outside of city	—	—	1,221	66.5

Source: survey.

(see Ravenstein 1885, pp. 198–199, and Boyle *et al.* 1998, p. 60), that most migration is short-distance and of step-by-step character, the share of international migrants in Leninogorsk and Zyryanovsk is greater than that of 'regional' migrants, which is surprising given the cities' relatively small sizes. However, Ravenstein's observations are based on the assumption that migration flows are voluntary. This was not necessarily the case in the Soviet Union, where coerced (e.g. prison labour) and semi-voluntary (e.g. specific job assignments after graduation from higher education) migration was implemented when the centrally determined national and local economic and political goals were not achievable otherwise.

### ETHNIC DIMENSION OF SOVIET AND POST-SOVIET IN-MIGRATION TO UST'-KAMENOGORSK

The ethnic composition of the migrant sample in Ust'-Kamenogorsk has changed since 1991 (Table 3). An overwhelming ma-

jority of those who arrived during the Soviet period are Russian (75.5%), whereas almost half of the post-Soviet migrant sample, on the other hand, is Kazakh (46.2%), although Russians still do stand for a significant share (43.7%). The share of other ethnicities has declined slightly, from 11.8% to about ten percent. However, it should be noted that the ethnic composition of the group of other ethnicities has changed. The pre-1991 sample mostly includes Ukrainians and Germans, whereas post-1991 sample includes many Tatars and Chechens.

The share of Russians in the urban-bound migrant sample is perhaps not as interesting as that of the Kazakhs. With the majority of the rural population within the *oblast'* being of Kazakh ethnicity, the Kazakhs' 12.7% share of the pre-1991 Ust'-Kamenogorsk migrant group is very low indeed, suggesting that the city's gates were not open to all. More evidence of this can be found in Table 4, which shows that there were considerably more Russian in-migrants from within the *oblast'* than Kazakhs (see below), suggesting that the gates were not only open

Table 3. Ethnic composition of migrants to Ust'-Kamenogorsk during the Soviet and post-Soviet periods

Year of arrival	Kazakhs		Russians		Other		Total	
	(N)	%	(N)	%	(N)	%	(N)	%
Before 1991	26	12.7	154	75.5	24	11.8	204	100
1991–2001	110	46.2	104	43.7	24	10.1	238	100

Source: survey.

restrictively, but also ethnically selective. Somehow, the Kazakhs were underurbanised (see Tammaru 2001b), and precluded from the city privileges. This does not necessarily imply that there were direct forms of ethnic discrimination at work, although the possibility cannot be excluded. Instead, the economic policy of intense industrialization inevitably favoured the Slavic ethnic groups, whose skills and educational background better met the demands of the industrial enterprises in Ust'-Kamenogorsk. This pattern is not an unknown one: the link between economic and ethnic policy has already surfaced elsewhere and was particularly evident in the Baltic States (Park 1994; Gentile and Tammaru 2006).

A comparison between the origin and ethnicity of the migrant sample to Ust'-Kamenogorsk during the 1980s and 1990s uncovers additional interesting geographical features (Table 4). At a first glance, it may seem that there was much more migration to Ust'-Kamenogorsk during the 1990s than during the previous decade. Although the magnitude of this gap is probably considerably smaller than it appears to be because of the characteristics of the migrant sample used in the study, many of those who arrived during the 1980s have probably already moved at least once within the city. Even so, because of the absence of a legal housing market, Soviet cities were characterized by relatively low residential mobility (French

1995, ch. 6), implying that the volume of immigration to Ust'-Kamenogorsk should have been significantly smaller during the 1980s anyway.

In the 1980s, the bulk of intra-*oblast'* migrants was Russian, a pattern which was reversed during the 1990s. The inter-*oblast'* and international migrant group was dominated by ethnic Russians during both decades, but the share of inter-*oblast'* Kazakh migrants has increased considerably. It is interesting to notice that the in-migration of Russians from within the *oblast'* during the 1990s seems to be the continuation of a trend established during the 1980s, if not earlier, whereas Kazakh immigration seems to be experiencing an explosion. This makes it easy to suggest that the Kazakhs were in a disfavoured position when applying for an urban residential permit, and that the closed city of Ust'-Kamenogorsk was more closed for Kazakhs than for Russians. However, such a conclusion needs to be treated carefully, for the discrepancy could depend on spurious elements, for instance divergent educational levels between ethnic groups and, therefore, different ethnic employment patterns (which may, of course, have been the result of other discriminatory practices) (Lubin 1984; Kaiser 1995). In this light, closed cities exacerbated the underurbanization of the titular ethnic group (see Tammaru 2001b).

Table 4. Ethnicity and origin of migrants to Ust'-Kamenogorsk between 1981 and 1991 and between 1991 and 2001

Migrants to Ust'-Kamenogorsk from:	Migrants 1981–1991 (N)			Migrants 1991–2001 (N)		
	Russian	Kazakh	Other	Russian	Kazakh	Other
Within <i>oblast'</i>	32	19	2	70	97	10
Other <i>oblast'</i>	8	1	2	14	12	6
Other republic	14	0	3	20	1	8
Total	54	20	7	104	110	24

Source: survey.

## GEOGRAPHICAL ANALYSIS OF IN-MIGRATION TO UST'-KAMENOGORSK

Let us proceed to the detailed analysis of the origin of migrants to Ust'-Kamenogorsk during the Soviet period as a whole (those who arrived before 1991), its last decade (those who arrived between 1981 and 1991), and the post-Soviet period (those who arrived between 1991 and 2001) (Table 5). The data concerning the former Semipalatinsk *oblast'*, which was abolished in 1997, are included in the figures for the East Kazakhstan *oblast'*.

There were three types of Soviet-era intra-*oblast'* (regional) migration flows directed towards Ust'-Kamenogorsk. The first flow, accounting for nearly one third of all regional migrants, is from the other major cities of the *oblast'*, the second flow (over one third of the regional migrants) is from the neighbouring *rayony*, and the third flow is from the more distant Kurchum *rayon*. Inter-*oblast'* (inter-regional) flows came almost exclusively from the city of Almaty and from Almaty *oblast'*, with the addition of a little group originating from South (Yuzhnyi) Kazakhstan *oblast'*. International migrants stood for a significant share of all migrant arrivals to Ust'-Kamenogorsk.

Similar patterns prevailed in the 1980s, although the bulk of the migrants from the city of Almaty had already arrived by 1981. It also appears that the regional and inter-regional flows had become relatively more significant at the expense of the international flow. This probably reflects the increasing labour shortage in the European USSR, which no longer acted as prime labour supplier (Ball and Demko 1978), as well as the shift in migration motives—partly facilitated by the toning down of the *orgnabor* (organized recruitment of labour) system—from productivist to environmentalist. In other words, migration no longer strictly echoed the employment and career opportunities available. The latter tendency is confirmed by Mitchneck and Plane (1995) in a study that shows that migrants in late-Soviet Russia were prone to accept less-paid and lower-prestige jobs if this meant that they could

move to a more desirable location, such as the 'sun belt' of the southern part of the European USSR.

The most significant changes in the pattern of in-migration to Ust'-Kamenogorsk occurred during the post-Soviet period (1991–2001). Not only has the volume of in-migration (size of the sample) increased considerably (with the reservation that comparison is complicated by the characteristics of the migrant sample used in the study), but its geographical sources have changed. Recent in-migrants typically come from the Kazakh-dominated, rural, and relatively sparsely populated Katon-Karagay, Kurchum and Tarbagatay *rayony*, together with Zyr'anovsk and Ulanskoe *rayony*. The increase in migrant arrivals from Ulanskoe *rayon* is surprising and might have an ethnic dimension because (unlike the case of Glubokoe *rayon*), a significant share of the *rayon's* population consists of Kazakhs. Again, this suggests that Kazakhs might have been precluded from the local urbanisation process of the Ust'-Kamenogorsk region during the Soviet epoch. This suspicion is strengthened by the fact that other *rayony*, with even larger Kazakh population shares, experienced similar in-migration jumps, whereas *rayony* with a prevailing Russian population (Glubokoe, Shemonaikha, Leninogorsk) experienced only moderate increases since the 1980s. One possible explanation lies in the well-documented discrepancy between the quality of education in rural areas and the qualification requirements for industrial jobs in the Soviet Union (see Wegren *et al.* 1997). In a centrally planned quasi-labour market (Mitchneck and Plane 1995), this implies limitations on rural-urban migration supported by coercive measures. But then again, these limitations should apply to the predominantly Russian rural areas as well. Certainly, part of the explanation is that a segment of the Slavic population is attracted by competing international destinations, particularly (according to the survey) Altayskii *kray*, Tomskaya *oblast'* and Novosibirskaya *oblast'* of the Russian Federation, but the likelihood of trans-boundary migration

Table 5. Previous place of residence of respondents whose previous dwelling was located outside of Ust'-Kamenogorsk

Origin:	Migrants to Ust'-Kamenogorsk (N)		
	Year of arrival		
	-91	81-91	91-
Other rayon within oblast'	115	55	177
Semipalatinsk city administration	13	5	12
Zyryanovsk	12	8	19
Ust'-Kamenogorsk city administration	-	-	-
Leninogorsk city administration	10	5	6
Zaysan	4	2	9
Ayagoz	2	2	4
Glubokoe	22	9	14
Zharma	3	2	0
Katon-Karagay	6	4	23
Kokpekty	2	1	9
Kurchum	14	7	22
Tarbagatay	3	2	18
Ulanskoe	12	3	29
Urdzhar	2	0	0
Shemonaikha	9	5	11
Beskaragay	1	0	0
Borodulikha	0	0	0
Other oblast'	19	9	32
Akmolinsk and Astana (city)	1	1	2
Aktiubinsk	0	0	0
Almaty (city)	5	1	9
Almaty	4	4	10
Atyrau	1	1	0
Zhambyl	1	1	2
Zap.-Kazakhstan	1	0	0
Karaganda	1	1	5
Kustanay	1	0	0
Kzyl-Orda	1	0	1
Mangistau	0	0	1
Pavlodar	0	0	1
Sev.-Kazakhstan	0	0	0
Yuzh.-Kazakhstan	3	0	1
Abroad (mostly Russia)	69	17	29

Source: survey.

straight from rural areas is not very high, mainly because of the high economic and social costs of migration.

Therefore, it is beyond any doubt that the *oblast's* rural Slavs were already being urbanised during the Soviet era (and for various reasons at the expense of the Kazakhs)(Alekseenko 1994; survey). Hence, at the eve of the collapse of the iron curtain, and of the strict permit regime in Ust'-Kamenogorsk, a large group of Kazakhs was waiting to be urbanised and was allowed to do so upon the opening of the city's gates in the early 1990s. It is also worth noting that the former *oblast'* boundary between East Kazakhstan and Semipalatinsk *oblasti* is reflected in both Soviet and post-Soviet migration figures. In-migration from the former Semipalatinsk *oblast's* Ayagoz, Zharma, Beskaragay and Borodulikha *rayony* was and remains low or inexistent. One would expect Semipalatinsk to attract migrants from these *rayony*, but other studies suggest that this city does not attract as many migrants as Ust'-Kamenogorsk (Gentile 2003a; 2004b). This suggests that Semipalatinsk (which was open in Soviet times) had not experienced the same urbanization pressure build-up during the Soviet period, and/or that economic reasons for migration prevail (there are fewer—and less paid—jobs in Semipalatinsk than in Ust'-Kamenogorsk). Ust'-Kamenogorsk's relative prosperity may well be attributable to the *longue durée* of the city's high priority status under central planning. In short, the findings on intra-regional migration indicate that Ust'-Kamenogorsk's regime of closure was particularly strict towards the ethnic Kazakhs, who remained 'underurbanized' throughout the Soviet period. Conversely, the open city of Semipalatinsk was indeed open to all.

Inter-regional migration has increased considerably since the 1980s, though it continues to originate primarily from Almaty city and Almaty *oblast'*, with the addition of Karaganda *oblast'*, whereas international in-migration has increased moderately (although net international migration is, of course, negative), probably reflecting the return migration generated by the early 1990s

exodus towards Russia and other post-Soviet republics. Part of this return migration may consist of skilled metallurgical workers returning to Ust'-Kamenogorsk in response to resumed production, for example at the Titanium-Magnesium Combine (Shayakhmetov 13/09/2000).

### THE HOUSING SITUATION OF MIGRANTS IN UST'-KAMENOGORSK

The data presented above suggest that a strong inflow of migrants to the former closed city and current *oblast'* capital of Ust'-Kamenogorsk has taken place since the USSR's demise. We now proceed to see how this flow is being accommodated by the city's housing supply.

We will seek to establish whether there are any significant differences between the general housing situation of migrants who arrived during the Soviet and post-Soviet periods. The assessments are based on four types of variables—dwelling type, the level of the respondents' satisfaction with the dwelling, the availability of three common amenities (cold running water, connection to municipal sewerage, and telephone line), and living space measured as the number of persons per room (excluding kitchen and bathroom) and surface per capita in square metres. The initial analysis will be followed by a comparative assessment of the role of ethnicity before and after 1991.

The data presented in Table 6 indicate that the post-Soviet migrants are more likely to live in apartments than the Soviet migrants, whereas the latter are about twice as likely to live in detached houses. Furthermore, about 18% of the post-Soviet migrants live in a communal apartment or rented room (both generally considered inferior in terms of residential utility) rather than in a dwelling of their own, a share which is three times higher than that for the Soviet migrants. As dwellings, apartments are generally more comfortable than detached houses (only about 1% of the latter have running water, see Gentile and Tammaru 2006),

but they do not allow the household to earn extra income (or save) through backyard agriculture. However, there are clear differences *within* the two dwelling types, and general conclusions cannot be drawn on the basis of this distinction.

Table 6 also suggests that the representatives of the post-Soviet migrant sample are only marginally less satisfied with their current housing conditions. However, as Szelényi (1983, p. 141) points out, people tend to be realistic about their housing chances, opting to answer that they are relatively satisfied to general questions about housing quality. For example, a recent survey in Poland suggests that Poles have rather modest housing aspirations (Kaltenberg-Kwiatkowska 2002, p. 116). If this is true and if, as one may sus-

pect, post-Soviet migrants indeed do live in poorer housing, it is necessary to proceed by analyzing the 'objective' indicators.

Dwellings occupied by post-Soviet migrants are slightly more likely to have internal access to cold running water and are clearly more likely to be connected to the municipal sewerage system, which only has marginal significance, for the majority of the detached housing stock is not connected to the sewerage system, even though many houses are quite well-equipped otherwise. Post-Soviet migrants are also slightly more likely to have a private telephone line reaching their dwelling. On the basis of these three indicators, it would seem as though post-Soviet migrants live in slightly better equipped dwellings. In a certain sense, this is not surprising. If it is

Table 6. Housing characteristics of Soviet and post-Soviet migrants in Ust'-Kamenogorsk

		Soviet migrants		Post-Soviet migrants	
		N	%	N	%
Dwelling type	Apartment	104	51.0	144	60.3
	House	88	43.1	51	21.3
	Communal apartment	12	5.9	31	13.0
	Room	0	0.0	12	5.0
Level of satisfaction	Very satisfied	14	6.9	14	5.9
	Satisfied	111	54.4	113	47.3
	Not very satisfied	35	17.2	54	22.6
	Unsatisfied	44	21.6	57	23.8
		% of dwellings inhabited by Soviet migrants		% of dwellings inhabited by post-Soviet migrants	
Amenities	Cold running water	79.9		81.1	
	Sewerage connection	54.9		74.8	
	Telephone	35.3		38.1	
		Dwellings inhabited by Soviet migrants		Dwellings inhabited by post-Soviet migrants	
		value	% of city average	value	% of city average
Living space	Persons per room	1.15	98.3	1.64	140.2
	m <sup>2</sup> per capita	23.35	126.6	18.58	100.7

Source: survey.

true that (mainly Russian) urban-bound immigrants in the non-Russian republics were granted privileged access to housing in the form of units in new prefabricated apartment blocks with 'full conveniences' (Ruoppila and Kährik 2003), as the Soviet parlance has it, then these dwellings should be over-represented among the units that were vacated during the exodus of the early 1990s, which mainly involved ethnic Russians.

The data concerning the level of crowding in housing suggest quite a different story. Whereas Soviet migrants live at a density of 1.15 persons per room, there are 1.64 persons per room in housing occupied by post-Soviet migrants. In relative terms, these figures are equal to 98.3 and 140.2% of the city average. Hence, in terms of housing, it appears that Soviet migrants are even better off than the average inhabitant of Ust'-Kamenogorsk, which is perhaps part of the explanation as to why they still live in their current dwelling rather than having moved. This might reflect a more generous allocation at the outset, or it could mean that number of household members has changed through either a decrease (death, children moving out, etc.) or an increase (childbirth, relatives moving in, subtenants, etc.). Post-Soviet migrants, on the other hand, live in much more cramped conditions than the average citizen. In order to exclude the possibility that the post-Soviet migrants might live in housing with larger rooms—which would be the likely case in the coveted Stalin-era apartments—per capita living space, including kitchen and bathroom, has been calculated as well. The previous picture is confirmed and reinforced: Soviet migrants live considerably more spaciouly, with 23.35 square metres per capita (126.6% of the city average of 18.45m<sup>2</sup>), as compared to 18.58m<sup>2</sup> (100.7%) for post-Soviet migrants. To put it shortly, post-Soviet migrants live in somewhat better quality dwellings but in much more cramped conditions than their Soviet counterparts.

Let us now proceed to the ethnic dimension. The focus will primarily be on the distinctions between Russian and Kazakh

migrants, although some insights about the aggregated group of 'other' ethnicities will be provided. The data indicate that both Soviet and post-Soviet *Russian* migrants are more likely to live in apartments and less likely to live in communal apartments or rented rooms (Table 7). Nonetheless, housing satisfaction among Russians and Kazakhs is relatively similar. Kazakh post-Soviet migrants seem to be somewhat more satisfied and Russian post-Soviet migrants somewhat more dissatisfied with their housing situation than their Soviet counterparts. Is this a sign that previous Russian ethnic privileges are gradually starting to dissipate? The remainder of the data that are going to be discussed provides a surprising though somewhat contradictory picture.

Soviet migrants generally live considerably more spaciouly, but in slightly less modern dwellings. However, both Soviet and, especially, post-Soviet *Russian* migrants live in better-equipped dwellings than their Kazakh counterparts. Other ethnicities seem to be somewhere in between. In terms of crowding, the disparities are even greater. Kazakh Soviet migrants are worst off, with less than 15m<sup>2</sup> of living space per capita, i.e. just 80.1% of the city average. By contrast, Russian Soviet migrants have over 25m<sup>2</sup> per capita (138.4% of the city average), which is rather high even by the standards of the European USSR, and other ethnic Soviet migrants have 18.57m<sup>2</sup> per capita. In terms of persons per room, the pattern is replicated: Kazakh Soviet migrants live at a density of 1.48 persons per room (126.5% of the city average), as compared to 1.08 for Russians (92.3%) and 1.26 for other ethnicities (107.6%). Given that the state-sector built dwellings were largely built by the metallurgical enterprises and allocated to their own staff and their families, an overwhelmingly Slavic population segment (Gentile 2005), we may conclude that Kazakhs that did make it through the gates of the closed city during the Soviet period probably did so in order to work in the low priority economy (i.e. in schools, hospitals, light industry, etc.), which was not able to meet the housing demands of those employed by it.



Table 7. Housing characteristics of Soviet and post-Soviet migrants in Ust'-Kamenogorsk by ethnicity

		Soviet migrants			Post-Soviet migrants								
		Kazakhs (N)	Russians (N)	Other (N)	Kazakhs (N)	Russians (N)	Other (N)						
Dwelling type	Apartment	9	83	12	52	77	15						
	House	9	67	12	27	16	8						
	Communal apartment	8	4	0	23	7	1						
	Room	0	0	0	8	4	0						
Level of satisfaction	Very satisfied	2	11	1	5	6	3						
	Satisfied	10	88	13	53	48	12						
	Not very satisfied	7	25	3	22	25	7						
	Unsatisfied	7	30	7	30	25	2						
		% of dwellings inhabited by Soviet migrants			% of dwellings inhabited by post-Soviet migrants								
		Kazakhs	Russians	Other	Kazakhs	Russians	Other						
Amenities	Cold running water	73.1	76.0	62.5	75.5	89.4	70.8						
	Sewerage connection	61.5	54.5	50.0	69.1	82.7	66.7						
	Telephone	26.9	37.0	33.3	30.9	42.3	50.0						
		Dwellings inhabited by Soviet migrants				Dwellings inhabited by post-Soviet migrants							
		Kazakhs		Russians		Kazakhs		Russians		Other			
		value	% of city average	value	% of city average	value	% of city average	value	% of city average	value	% of city average		
Living space	Persons per room	1.48	126.5	1.08	92.3	1.26	107.6	1.86	159.0	1.41	120.5	1.58	135.0
	m <sup>2</sup> per capita	14.78	80.1	25.54	138.4	18.57	100.6	16.3	88.3	20.5	111.0	20.76	112.5

Source: survey.

The housing stock occupied by the post-Soviet migrants also conceals a gap between Russians and Kazakhs in terms of per capita living space and crowding. The Kazakh post-Soviet migrants, with their 16.3m<sup>2</sup> average, are somewhat better off than Kazakh Soviet migrants in terms of living space, but they are also worse off than the Russian post-Soviet migrants, who still occupy over 20m<sup>2</sup> per capita. On the other hand, the Russian post-Soviet migrants have experienced substantial

losses in living space, when compared to the Russian Soviet migrants. This indicates that the Russians have lost their *formal* privileges in access to housing. The housing gap which remains between the Russian and Kazakh post-Soviet migrants is most likely due to two major factors. On the one hand, at the city aggregate level, the Russians have a higher disposable income than the Kazakhs—by almost 20%, according to the survey. On the other hand, it is beyond any doubt that the

Kazakhs are discriminated against in the housing rental market. A quick look at the local private advertisement newspaper confirms this,<sup>13</sup> as there are plenty of advertisements which explicitly state that the dwelling in question may only be rented out to 'European' nationalities or that 'Asians' are not welcome. As long as this attitude proceeds and most dwellings remain occupied by 'Europeans', the Kazakhs will retain their disadvantaged position in the rental market.

The findings reported above support the idea that Russians were very strongly favoured in the allocation of housing during the Soviet years, and that housing allocation by need (rather than by merit, presuming that Russian workers were generally more skilled) was a concept that did not manage to move from ideology to practice. This ethnic favouritism occurred in an indirect manner through the industrial enterprises' housing construction and allocation functions, which ensured preferential (*de facto* exclusive) access to housing for the workers. The latter were predominantly Russian, especially within the industrial enterprises which enjoyed highest priority during the Soviet period (Gentile 2005; see Kaiser 1995, for more on the representation of the titular ethnic groups in Soviet industry and other branches of the economy). Such enterprises were also the ones most enveloped by security regulations, including the closure of the city in which they were located, and were forced to offer a housing 'carrot' in exchange. But this carrot was not available to everyone—on the contrary, it only concerned the workers engaged in the most sensitive activities. The rest of the population lived as usual, in a city with poor housing resources, greater environmental problems, but somewhat better sidewalks and public transportation. The defence industry—as previously noted by

Gaddy (1996, p. 154)—parasitized the rest of the economy in the sense that 'there was no trickle down effect from the defence industry to the rest of the region' and 'on the whole, the development and well-being of the defence industry was at the expense of the rest of the local economy'.

In fact, if Ust'-Kamenogorsk may be taken as a sufficiently representative example, we may conclude that the housing stock of closed cities was (and is) somewhat more polarised than that of open cities,<sup>14</sup> and that the enterprise-based housing allocation system contributed to the ethnification of this divide. The housing divide, in turn, is the tangible foundation of socio-economic and ethnic residential segregation (Gentile 2005). Nowadays, segregation is supported by the increasing income gap on the one hand, and by a certain degree of ethnic discrimination, on the other. In the past, Soviet policies indirectly favoured industrial workers, especially within the military industrial complex, and therefore Russians. Again, as both Ruble (1989) and Tammaru (2001b) state, economic policy becomes ethnic policy.

## MAIN CONCLUSIONS

This paper has contributed to migration and segregation research on post-Soviet countries by comparatively analysing data on urban-bound migrants towards the former closed city of Ust'-Kamenogorsk. Despite the shortcomings of the sample, three irrefutable trends have been brought to the fore.

- First of all, in-migration to Ust'-Kamenogorsk has changed dramatically. The most significant development is the clear increase in migrants from the *oblast's* rural areas to the regional capital, and the origin of these migrants has shifted in favour of the *rayony* with a larger Kazakh population, suggesting that particular segments of the population,

<sup>13</sup> Although the author currently does not have access to such publications, an example taken from the website of the *Iz ruk v ruki* (10/12/2003) private advertisement newspaper in Almaty may help illustrate the situation: 'Room in one-room apartment, Gogol str., 3<sup>rd</sup> floor, for rent to working European lady, 8000 tenge/month'.

<sup>14</sup> With the exception of the most extreme cases of closure, where it is presumed that all families were allocated self-contained apartments with generous floor space in exchange for not existing on the map.

particularly rural Kazakhs, were closed off from the regional urbanization process during the Soviet period. Restrictions mattered to some.

- Secondly, and as a consequence of the above, the ethnic composition of the former closed city-bound migrant flow has shifted in favour of the previously poorly represented Kazakhs. Together with the out-migration of Slavs and Germans, this is gradually changing the ethnic structure of the city.

- Thirdly, in terms of housing provision, those who arrived during the Soviet period are generally better off than the post-Soviet migrants. However, within both groups, there is a sizeable ethnic gap: the Russians are considerably better-housed. In contrast with the official Soviet goals of equality, the ethnic gap within the Soviet migrant group is larger than that within the post-Soviet migrant group. This reflects the housing differences indirectly created as a result of the relative priority ascribed to certain industrial enterprises, coupled with the structural factors which hindered the Kazakhs from being at equal terms with the Russians in the labour market and, accordingly, the housing allocation system.

The findings of this paper shed some new light on the *relation* between migration and segregation in the Soviet Union, and particularly in the closed city. It is reaffirmed that ethnic segregation in the USSR resulted from the past practice of blending industrial policy with housing policy. In order to achieve the centrally established economic targets, the high priority enterprises were forced to offer a bundle of benefits in order to attract and retain their personnel, a practice which occurred at the expense of those employed in the low priority sectors of the economy. The low-high priority distinction is also a well-acclaimed ethnic one (Lubin 1984; Sacks 1992; Tammaru 2001b; Gentile 2005; Gentile and Tammaru 2006), and its implications at the level of unequal access to housing have been shown to be all the more significant in the context of the closed city, where the power and prestige of the high priority industrial actors was such that it

enabled them to parasitize and damage the rest of the urban economy, and the Kazakh population disproportionately so. Gradually, the effects of these past legacies will be eroded by the realities of transition. For the time being, however, the Soviet-made Slavic ethnic advantage in housing, as indeed in many other spheres of urban life in the northern half of Kazakhstan, still persists. Elsewhere, such as in the Baltic States, it has long since dissolved, but there the relative advantage was marginal at the outset. The situation is thus quite different in Central Asia, and particularly in the region's former closed cities, where the ethnic consequences of Soviet industrialisation run deeper.

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## DEFINING HEAT WAVES—DIFFERENT APPROACHES

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**Abstract:** Heat waves have not been defined officially, however there are many non-official definitions in use. This paper reviews some of the most frequently used definitions of heat wave and its measures. It also reveals different numbers of heat periods that result from an analysis employing different definitions of a heat wave. This has been exemplified on the basis of data from Poland and confirmed the need for regionally accepted guidelines by which to define heat waves.

**Key words:** definitions of heat wave, extreme weather, thresholds, synoptic approach, Poland.

### INTRODUCTION

Heat waves, as extreme weather phenomena, are more dangerous for people than any other weather events on account of their wide, relatively frequent occurrence, especially in highly populated areas, and the great increase in mortality rates they cause. The general perception is that the number of heat waves has increased over the past decade, and, as the global climate continues to warm, the number and intensity of heat waves and the death tolls they give rise to might increase considerably.

One of the first descriptions of heat waves comes from the United States of America and dates back to the New York of 1896, in which the weekly mean maximum

air temperature was 29°C. The comparison of the air temperature values reached in different events of hot weather indicates the much greater severity of sporadic heat waves occurring in some inland US cities within continental air mass, as compared with the coastal cities where maritime air prevails (Table 1).

In the 1970s, the description of heat wave also began to be applied to Europe. At that time, the summer of 1976 was the hottest summer in the United Kingdom since records began. As the hot, dry weather continued the whole summer, an extremely severe drought ensued in August, devastating heaths and causing forest fires. Summer 1994, in turn, brought severe heat in Central Europe and the Benelux, lasting with



Table 1. Examples of heat waves

Place	Date	Characteristics	Effects	Authors	Comments
New York, USA	1896	mean weekly $T > 29^{\circ}\text{C}$	unknown	Ellis and Nelson 1978	-
St. Louis, Missouri, USA	1936	Mean weekly $T_{\text{max}}$ up to $39.4^{\circ}\text{C}$	Rise of mortality in the 40-80 age group	Ellis and Nelson 1978	Lasted over almost 2 months
New York, USA	1948	Daily $T_{\text{max}}$ up to $38.3^{\circ}\text{C}$ , mean daily $T$ up to $33.2^{\circ}\text{C}$	Over 100% rise in $M_{\text{a}}$ , over 200% increase among heart and arteries diseases especially in 60-90 age group	Ellis and Nelson 1978	5 days (25-29 August)
New York, USA	1975	Daily $T_{\text{max}}$ up to $36.7^{\circ}\text{C}$ , mean daily $T$ up to $31.1^{\circ}\text{C}$	100% rise of deaths from ischemic heart diseases and strokes especially among 65 and older	Ellis and Nelson 1978	7 days (30 July-5 August)
United Kingdom	1976	Almost one month with $T_{\text{max}} > 26.7^{\circ}\text{C}$ , within it 15 following days with $T_{\text{max}} > 32.2^{\circ}\text{C}$ ;	Severe drought in August, fires	BBC Weather	H.W.: 22 June - 16 July; summer 1976 - the hottest in UK since records began
Central and Southern USA	1980	Kansas City, $T > 38^{\circ}\text{C}$ for 17 days and $T < 32^{\circ}\text{C}$ for 2 days in 3 months; Texas, $T > 48^{\circ}\text{C}$	1,250 - 10,000 excess deaths, one of US history's most devastating natural disasters	Smoyer <i>et al.</i> 2000	$T_{\text{max}}$ over $32^{\circ}\text{C}$ almost every day from June to September
Greece	1987	In the suburbs of Athens $T_{\text{max}}$ up to $43.6^{\circ}\text{C}$ and $T_{\text{min}} > 24.4^{\circ}\text{C}$	1000 excess deaths	Matzarakis and Mayer 1991	H.W.: 20-31 July
Benelux, central Europe (Czech R., Poland)	1994	Belgium: mean daily $T$ up to $27.5^{\circ}\text{C}$ ; Czech R.: mean $T_{\text{max}}$ in H.W. $33.3^{\circ}\text{C}$ ; Poland: mean $T_{\text{max}}$ in H.W. $33.8^{\circ}\text{C}$ in Torun, $T_{\text{max}}$ up to $37.8^{\circ}\text{C}$ in Wroclaw	Belgium - 1226 excess deaths; Czech - 294 deaths (11.5% rise in total $M_{\text{a}}$ , 13.6% rise in CVD $M_{\text{a}}$ ); Warsaw (Poland) - 132 excess deaths (33% rise in total $M_{\text{a}}$ , 37% in CVD $M_{\text{a}}$ )	Sartor <i>et al.</i> 1995 Kysely 2004 Kuchcik 2001, 2006	H.W.: 22 July - 7 August
United Kingdom	1995	$T_{\text{max}}$ up to $35.2^{\circ}\text{C}$ (1 August)	More than 460 extra deaths (8.9% increase in total $M_{\text{a}}$ )	Rooney <i>et al.</i> 1998	August 1995, the hottest in UK since records began (1659).
Chicago, USA	1995	$T_{\text{max}}$ up to $40^{\circ}\text{C}$	700 excess deaths (85% rise in mortality, 11% rise in hospital admissions)	McGeehin, Mirabelli 2001 Semenza <i>et al.</i> 1996	H. W.: 12 -16 July
Western and Southern Europe	2003	UK: $T = 38.5^{\circ}\text{C}$ ; France: $T_{\text{max}} > 40^{\circ}\text{C}$ for 2 weeks of August; Switzerland: $T = 41.5^{\circ}$	At least 35,000 excess deaths; loss in thickness of glaciers in Alps; drought	Kosatsky 2005 Michelozzi <i>et al.</i> 2004 UNEP 2004	Many $T$ records, $T$ rose of 20%-30% higher than seasonal averages
Europe (Poland, Czech R., UK, Netherlands), USA, Canada	2006	July 2006 - the warmest-ever month in most European countries, with monthly mean $T$ higher of $5^{\circ}\text{C}$ then average	500-1000 extra deaths in Netherlands, at least 370 extra deaths in USA, severe drought	Twoja Pogoda [Polish portal Your Weather] BBC Weather NOAA	H.W.: end of June - end of July Many $T_{\text{min}}$ records

$M_{\text{a}}$  - mortality, CVD - cardiovascular, H.W. - heat wave,  $T$  - air temperature,  $T_{\text{max}}$  - maximum air temperature,  $T_{\text{min}}$  - minimum air temperature

some breaks from 26th June to 7th August (Table 1). In 2003, western and southern Europe was plagued by a record heat wave that extended from northern Spain to the Czech Republic and from Germany to Italy. It produced maxima in the range 35° to 40°C repeatedly, over almost the whole of Europe. In the United Kingdom, temperature records were broken with 38.5°C noted on 10th August at Brogdale in Kent. In France, temperatures soared to 40°C and remained unusually high for two weeks of August. In Switzerland, June was the hottest month ever recorded in 250 years of archives and a temperature record of 41.5°C was established on August 11th (UNEP 2004). At least 35,000 people died as a result of this heat wave in France, Germany, Spain, Italy, the UK, the Netherlands, Portugal, Belgium, Switzerland and the Czech Republic. France suffered the worst losses with more than 14,000 deaths, especially among the very old. The excess mortality in France was estimated at 20% for the 45–74 years age group, at 70% for those aged 75–94, and at 120% for people over 94 years. Prior to this heat wave only a few deaths during heat waves were declared due to hyperthermia, heatstroke or other classic heat illnesses. However, according to the French medical reports from summer 2003, 24% of the excess deaths among people over 74 years of age were directly heat-related (Kosatsky 2005).

Heat waves take the greatest toll in the cities, because Urban Heat Island, which has been thoroughly examined and documented, usually intensifies after sunset and reaches its maximum before sunrise (Oke 1987, Fortuniak *et al.* 2006, Szymanowski 2005). In rural areas people generally obtain some relief from the heat at night. The air pollution which is usually more severe in cities than in the countryside can also exacerbate the health-damaging effects through additional stress to the human respiratory and circulatory systems (Katsouyanni *et al.* 1993, Larsen 2003). Such extreme weather conditions also have wide adverse environmental effects on aquatic ecosystems and glaciers, as well as destroy crops and large

areas of forest by fire. The losses due to Europe's 2003 heat wave are estimated to have exceeded 13 billion euros (UNEP 2004).

The aim of this paper is to review some approaches to the definition of the term 'heat wave' and to show how the number of heat waves differ as various definitions are applied. There is thus confirmation of the need for a standard definition of the term heat wave on the regional scale at least.

## TYPES OF 'HEAT WAVE' DEFINITIONS

Paradoxically, the most common way of defining heat waves is not to define them at all. Many studies, especially the older descriptions of heat waves, and the medical or epidemiological studies on hot weather-related mortality, do not demand the definition of the heat wave (Ellis and Nelson 1978, Rooney *et al.* 1998, Keatinge *et al.* 2000). They describe unusual hot periods of a few days or weeks, or only separate days with especially high temperatures. And, although the key word 'heat wave' appears in such papers, there is no need to define this precisely.

The term 'heat wave' has not gained an official definition from the World Meteorological Organization, although reports about particularly high and sustained temperatures come from many parts of the world and many definitions are in use. The Oxford English Dictionary defines a heat wave as a 'wave or access of excessive heat in the atmosphere'. The most common meteorological definition of a heat wave is a wave of unusually hot weather which may be accompanied by excessive humidity. Although a heat wave is a weather event, it should not be evaluated or considered without reference to its effects on human beings. Thus 'the commonly adopted definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected populations' (Robinson 2001).

Such general definitions could be used successfully in describing separate events

of heat and its impact on the environment (fires, droughts), people (morbidity, mortality), or the economy (the costs of the losses). However, for comparative studies between different countries, for any calculations of the influence of heat on morbidity or mortality or for implementing a Heat Health Warning System coherent for the whole of Europe definition is needed. Also, an impact-related definition of a 'heat wave' must meet the criteria that society is susceptible to or unable to cope with these events (Koppe and Jendritzky 2004, Souch and Grimmond 2004).

The majority of the definitions described below are not official, which is to say that there is no national agreement for using that definition of the term 'heat wave'. All definitions could be divided into: those using thresholds (of separate meteorological parameters e.g. air temperature or the values of multivariate indexes) and those using synoptic classifications.

#### THRESHOLDS

Thresholds could relate to both single weather parameters (e.g. air temperature) or simple indices (e.g. Apparent Temperature) and to complex indexes based on human heat balance (e.g. Perceived Temperature). Thresholds are absolute or relative in type. An absolute threshold definition of heat wave implies that there will be rare heat load in colder regions and frequent heat load in warmer regions. Relative thresholds (e.g. the 97% percentile) are based on the assumption that the probability of heat load is of the same order of magnitude everywhere. The relative thresholds are often based on local climate-health relationships and include the important issue of human adaptation to climatic conditions (Koppe and Jendritzky 2004). According to the Intergovernmental Panel on Climate Change (IPCC), heat wave as an extreme weather event is as rare as or rarer than the 10th or 90th percentile of a particular distribution of an atmospheric variable (IPCC 2001). It is evident that the upper 10% of air temperature differs in line with the baseline climate. However, as the threshold of the 90th percentile of air tem-

perature is in many cases too low to define the heat, other upper percentiles are in use. Temperature and time threshold According to the American Meteorological Society in 1900, A. T. Burrows quite rigidly defined a 'hot wave' as a spell of three or more days on each of which the maximum shade temperature reaches or exceeds 90°F (30.6°C) (AMS, Glossary of meteorology). This definition with the threshold 30°C is in use in the Czech Republic (Kyselý 2004). In turn, the Polish meteorological dictionary defines a heat wave as a period of several days or weeks with maximum air temperature above 30°C, separated by few cooler periods (Kuchcik 2001, Niedźwiedz 2003).

The Netherlands Royal Meteorological Institute defined a heat wave as a period of at least 5 days, each having a minimum temperature of at least 25°C, including at least 3 days with a maximum temperature equal to or higher than 30°C (Huynen *et al.* 2001). In Finland, the threshold temperature is 25°C. In the United Kingdom a heat wave should have an air temperature 3°C higher than the average for 5 consecutive days. In France, a heat wave is a period of at least 2 days with daily maximum air temperature above 36°C and a daily minimum air temperature above 23°C. In Greece, the threshold for maximum air temperature equals 38°C for 3 consecutive days (Koppe *et al.* 2003).

The threshold values naturally grow from north to south, from 25°C in Finland to 38°C in Greece. In regard to the IPCC definition of the weather event, the upper 10% of the temperature probability in Athens will be very different from the same quantile in Helsinki, and of course heat stress for the organism will be greater in Greece than in Finland (Beniston and Stephenson 2004).

In Canada, a heat wave is defined as a period of time more than three days long of maximum temperatures at or above 32°C. The Weather Channel in the USA uses the following criteria for a heat wave: a minimum of ten states must have 32°C or higher temperatures, while temperatures must be at least five degrees above normal in parts of that area for at least two days.

Climate change researchers use, in examining the trends and variations as regards extreme hot periods, the 'heat wave duration index' (HWDI) or 'warm spell duration index'. The 'heat wave duration index' is defined as the 6 or more consecutive days during the year over which the daily maximum temperature is in excess of 5°C above the normal maximum temperature. The daily means of maximum temperature are calculated for a 5-day window centered on each calendar day from the reference period. Although extreme hot days were included among the numbers, any period of 'warmer than normal' days during the year which met the above defined criterion is considered. In the 'warm spell duration index' the maximum air temperature is replaced by the 90th percentile of daily mean temperature (Environment Canada ...; European Climate Assessment...). Therefore, the definitions of heat waves in climate-change scenarios on trend or anomaly maps are not precisely 'meteorological' definitions but 'annual warmer than normal' ones.

Research on heat wave indicators also explored high night-time temperatures, so-called tropical nights, during which the air temperature remains above 20°C even at night. High night-time temperatures affect people adversely because of the lag time in the night-time cooling of urban dwellings (Thornbrugh 2001).

Multivariate indexes. Human physical comfort is dependent not only on air temperature, but also on the interaction of a number of weather variables. For example the human response to outdoor conditions is worse on sultry days than at the same air temperature in a dry air mass (Baranowska *et al.* 1968, Thompson *et al.* 1996, Changnon *et al.* 2003).

Over the past several years, numerous indices have been developed to measure human discomfort in heat, these were able to be used successfully in defining heat waves. However, among them it is the simplest indices using widely measured meteorological elements, such as: Humidex, Apparent Temperature (heat index), Weather Stress Index

or Heat Stress Index that are most common. Nevertheless, precise indexes, based on human heat balance models and demanding more data, are sometimes also applied in defining heat waves; examples being the Perceived Temperature (PT), as calculated using the Klima-Michel-Model (Laschewski and Jendritzky 2002).

Humidex was first developed in 1965 by Canadian meteorologists. It combines temperature and water vapor pressure into one number to reflect the perceived temperature. Humidex remains a useful, and hence popular, means of determining how hot one actually feels outside in Canada, where its value also generally decreases as latitude increases (Meteorological Service of Canada).

$$\begin{aligned} \text{Humidex} &= T + h \\ h &= (0.5555)^*(e - 10.0) \\ e &= 6.11 * \exp(5417.7530 * ((1/273.16) - (1/T_d))) \end{aligned}$$

where:

T is dry bulb temperature (°C), e is water vapor pressure and T<sub>d</sub> is the dew point temperature (kelvin).

The Apparent Temperature (heat index) is probably the best-known and most widely used (USA, many European countries) heat stress index. Its basic version derived from research by R.G. Steadman (1979), who evaluated human physiological responses to various weather conditions. At the beginning he took into consideration, not only air temperature and humidity, but also ventilation rate, surface radiation and convection, clothing resistance to heat and moisture transport. Later he developed a simplified definition of Apparent Temperature (AT) using temperature, vapour pressure and wind speed for conditions indoors and outdoors (in shaded and sunny locations) (Steadman 1984). As a result of further studies an even simpler algorithm of AT was developed—using only two commonly measured inputs of air temperature and dew point temperature yet explaining almost all of the variation in Steadman's published apparent temperature tables (Steadman 1979, Kalkstein and

Valimont 1986, Michelozzi *et al.* 2000). It is (assuming no or a light wind):

$$AT = -2,653 + 0,994T + 0,0153T_d$$

where:

T is dry bulb temperature (°C) and  $T_d$  is the dew point temperature (°C).

Humidex and AT have predetermined health impacts associated with various levels of the index (Table 2).

Threshold levels for both the discussed indexes could define heat waves. In its hot weather response plan Toronto Public Health suggests declaring heat warning when there is a predicted or observed Humidex of 40–45°C for at least 2 days, and declaring a heat emergency when the Humidex value is greater than 45°C (Smoyer and Rainham 2001). However in Ontario (Canada), as an increase in mortality was noted when the maximum heat index exceeded 32°C and this level became the indicator of heat-stress days there (Smoyer 1998, Smoyer *et al.* 2000).

In the United States, several thresholds for the heat indexes were tested with a view

to watches or warnings being issued by the National Weather Service. Finally, for much of the southern states a heat wave was defined as a period of at least 48 hours during which neither the overnight low nor the daytime high heat index falls below 26.7°C and 40.6°C respectively (Robinson 2001).

A heat wave in Italy is defined as the period over which maximum AT is above the 90th annual percentile and which begins with an increase of 2°C compared to the previous day (Michelozzi *et al.* 2004). For calculating maximum AT, daily maximum air temperature and the dew point temperature from the same hour as the maximum temperature are taken (this not necessarily being the maximum dew point temperature) (Smoyer *et al.* 2000).

Apparent Temperature (AT) in its simplest, exclusively meteorological form is very useful in statistical analyses. Like the air temperature it also gives threshold values above which the mortality rates are statistically significant higher than the baseline rate (Davis *et al.* 2003, Michelozzi *et al.* 2000) and in some cases it correlates better with

Table 2. Health effects associated with different values for Humidex and Apparent Temperature (AT)

Range (°C)	Health impact
Humidex	
< 30	No discomfort
30–39	Some discomfort
40–45	Great discomfort; avoid exertion
> 45	Dangerous
> 54	Heat stroke imminent
AT (heat index)	
<26.7	Comfort
26.7–32.1	Fatigue possible with prolonged exposure and/or physical activity
32.2–40.6	Sunstroke, heat cramp and heat exhaustion <b>possible</b> with prolonged exposure and/or physical activity
40.7–54.4	Sunstroke, heat cramp, or heat exhaustion <b>likely</b> and heatstroke <b>possible</b> with prolonged exposure and/or physical activity
>54.4	Heatstroke/sunstroke highly likely with continued exposure

Source: Environment Canada and the United States National Weather Service (Smoyer-Tomic and Rainham 2001).

mortality than does air temperature only (Kysely and Huth 2004).

AT served as a basis for two other climatological indexes developed to evaluate geographical variations in human discomfort during heat waves, and used in the USA: the Weather Stress Index and the Heat Stress Index. The Weather Stress Index (WSI) is constructed by calculating the AT and comparing how the AT value on a particular day varies from the mean for that day at a particular location. The index ranges from 0 to 100%, with the most uncomfortable conditions at the highest values. This relative index compares a particular value of apparent temperature to a climatic normal for a given location, and evaluates how unusual a definite value might be (Kalkstein and Valimont 1986). The Heat Stress Index (HSI) is the newest comprehensive summer index to evaluate summer relative heat stress as the deviation from the norm (average calculated on the basis of a long period). It includes daily minimum and maximum AT, mean cloud cover, cooling degree-days and the number of consecutive days of extreme heat. The statistical distribution of meteorological variables calculated for 10-day periods (from May to September) gives rise to the daily percentiles values of each variable, which are then summed before being fitted to a statistical distribution. The daily HSI value at some location is the percentile of each summation value. For example, a 97% HSI value indicates that only 3% of days on that date are expected to experience more stressful conditions than that particular day. HSI was calculated for each summer day for over 230 weather stations across the United States over the period 1971–2000, and can easily be used in forecasting conditions that impair human health (Watts and Kalkstein 2004).

An example of the use in defining heat waves index, based on a heat budget of the human body is given by Deutscher Wetterdienst in Germany. It uses Perceived Temperature (PT) in °C, which is defined as the air temperature of a reference environment

(slight breeze, mean radiant temperature equals to air temperature and relative humidity 50%), in which the perception of heat or cold would be the same as under the actual conditions. This index takes all relevant mechanisms of heat exchange into account, with due consideration given to well-adapted clothing. Perceived heat and cold is computed by means of the comfort equation which is based on a complete heat budget model of the human body and the thermophysiological assessment is made for a male person, the 'Klima Michel'. Deutscher Wetterdienst issues heat warnings when strong to extreme heat load is involved, and there must be 3 or more days forecast of moderate or higher heat load based on PT (Laschewski and Jendritzky 2002, Koppe and Jendritzky 2004).

#### SYNOPTIC APPROACH

This approach requires the development of a synoptic or weather type classification that can be more or less sophisticated. As an alternative to the 'individual variable' approach, the synoptic approach takes into account the entire weather situation, rather than single elements. However, most of the biometeorological synoptic classifications are the determination of categories of atmospheric circulation type and the analysis of weather maps—a prolonged procedure that is very often more subjective than objective. Therefore, despite recent advances in the classification of synoptic-scale events, there has been a need to develop a simpler, automated, large-scale air mass-based procedure. This need was met by the idea of the Temporal Synoptic Index (TSI) developed by L.S. Kalkstein and his co-workers at the University of Delaware in the 1980s. This is widely used in the United States of America, where it describes impacts of hot weather on mortality comparably or even better than other methods and has been shown to be successful in heat/health studies (Kalkstein and Corrigan 1986, Kalkstein 1991, Kalkstein *et al.* 1996a, Kalkstein and Green 1997).

The synoptic procedure was designed to classify days that are meteorologically

similar. Under the TSI, each day is defined in terms of a variety of available meteorological variables (such as: air temperature, dew point temperature, cloud cover, air pressure, wind speed and direction) measured at the four main standard times (00, 06, 12, 18 UTC). Then, by way of principal component analysis (PCA), each day is expressed in terms of a set of component scores. A clustering (average linkage) procedure is then used to group days with similar component scores into meteorologically homogenous, distinct weather types (units, clusters), i.e. types of air mass. Weather map analysis for selected days in each cluster allows the general characteristics of each TSI air mass to be described. A standard stepwise multiple regression analysis then makes it possible to determine which factors within the oppressive air mass contribute to elevated mortality (Kalkstein and Corrigan 1986, Kalkstein 1991). The basic assumptions of the TSI are: that the magnitude of the variable should vary significantly between air masses but little within air-masses; that the variable should be one of the regularly-observed weather elements available for many sites; that the index should be based on surface data only, to permit widespread application, with the most important air mass indicators being those describing heat and moisture properties (Kalkstein and Corrigan 1986).

The Spatial Synoptic Classification (SSC) was developed in 1990s. It permits inter-site comparison of daily types of air mass across a very large region. SSC requires initial identification of the major air masses, on the basis of long series for an extended set of meteorological parameters for each site. 'Seed days' representative of the typical meteorological character of each air mass at a location are then selected. Every effort is made to maximize the number of seed days for each air mass (at least 30 being selected in most cases), without jeopardizing group homogeneity. Seed days are next used as input for a linear discriminant function analysis to generate a linear function for each air mass from its group of seed days.

The result of this evaluation is a calendar listing the air mass to which each day has been assigned. A second discriminant function analysis is used to determine whether a day is to be considered transitional between air masses (Kalkstein *et al.* 1996a, Kalkstein and Green 1997).

Types of air masses defined in the SSC are: dry polar (DP), moist polar (MP), dry temperate (DM), moist temperate (MM), dry tropical (DT), moist tropical (MT), moist tropical plus (MT+) and transitional (TR). The nomenclature identifies the character, rather than source region, of the air mass.

The SSC was redeveloped into SSC2, in which the process of the selection of seed days was changed into 'sliding seed days'. Identification of seed days takes place in four two-week 'windows' throughout the year (one for each season), and an algorithm to produce a theoretical 'seed day' for each weather type for each day of the year is created. The four two-week periods shift by location, to correspond with the hottest and coldest two weeks and the midway points in between (Sheridan 2002).

Studies funded by the U.S. Environmental Protection Agency (EPA) and pointing to very strong relationships between particularly hot and oppressive air masses, allowed for the use of TSI and SSC in implementing systems to warn against heat waves—the Heat/Health Watch Warning Systems (HWWS) first applied in 1995 in Philadelphia, and later in other American cities, then in Rome and other Italian cities, Shanghai and Toronto (Kalkstein *et al.* 1996b, Kalkstein 2004). In most locations it is the maritime tropical (or subtropical) air mass (MT+) that is most oppressive—with very warm and humid conditions and high overnight temperatures, as well as dry tropical (DT)—with hot and dry conditions and high solar radiation. In Rome both of these air masses appear on 11–12% of all summer days and approximately correspond to days that heat waves occur, and are associated with 26–35% excess mortality (de Donato *et al.* 2005, Kalkstein 2004).

## AN EXAMPLE OF THE DETECTING OF HEAT WAVES USING TWO DIFFERENT DEFINITIONS

To show how different the output obtainable using different approaches might be, an example of the number and duration of heat waves in 10 Polish cities over the whole period 1993–2002 is to be presented. The heat waves were defined on the basis of meteorological data (daily data and those from 00, 06, 12, 18 UTC) that were available to the author. Two types of definitions, one based on air temperature and time threshold and the other on multivariate indexes were applied. Other definitions illustrating the synoptic approach could not be tested due to the lack of adequate data. The following definitions were tested:

- a minimum 6-day period (5 days for a heat wave starting in May or June) with Apparent Temperature (AT) calculated for 12 UTC (2 pm in Poland in a summer) above the 95th annual percentile and an increase of 2°C compared to the previous day. In the possible 1–day breaks, AT may not drop below the 90th percentile. To define the first heat waves in a year, which are perceived by humans to be more burdensome, the shorter period was adopted (Kozłowska-Szczęśna *et al.* 2004, Koppe and Jendritzky 2004).

- at least 3 consecutive days with daily maximum air temperature above 30°C—so called tropical days according to the Polish meteorological dictionary (Huynen *et al.* 2001, Kysely 2004, Niedźwiedz 2003).

- at least 2 consecutive days with Humidex of 40°C (Smoyer and Rainham 2001).

The first definition was applied for Polish climatic conditions, considering the distribution of air temperature values. The second is in use in, e.g. the Czech Republic and The Netherlands. Maximum air temperature and air temperature from 12 UTC (that is used in AT), very often occur close together in time. The correlation coefficients between them are 0.98–0.99 on average, and air temperature from 12 UTC is about 1–1.3°C lower than the maximum air temperature.

The third definition is derived from the weather service in Toronto, this making it clear just how ineffective a definition borrowed directly from another city can be, even if this city is situated in the same (temperate) climatic zone and in the same type of transition climate (though south of 9° of latitude).

Geographically, the selected cities represent the whole area of Poland (Figure 1). Among them yearly mean air temperature varies from 7.4°C in Białystok (north-east) to 9.2°C in Wrocław (south-west). The climatic conditions change from the milder with maritime influences in the west to the more severe and continental in the north-east. The value of the 95th percentile for AT varied geographically in a different way to air temperature: from 23.2°C in Gdańsk (on the sea, where wind and air humidity mostly reduce the subjective temperature) to 27.7°C in Rzeszów (in the very south-east, where climate is more continental than in Wrocław) (Kuchcik and Blazejczyk 2005, Kuchcik 2006). A daily maximum air temperature of 30°C corresponds to the following percentiles of  $T_{\max}$ : 0.977 in Toruń, 0.978 in Rzeszów and Wrocław (the warmest city in Poland) and 0.996 in Gdańsk (Table 3).



Figure 1. Polish cities analyzed in this study



Table 3. Values of the 95th and 90th percentiles of Apparent Temperature (AT) (b), percentile values at  $T_{\max} = 30^{\circ}\text{C}$  (c), AT values corresponding to percentiles in column c (d) and the yearly mean air temperature (e) in 10 Polish cities, 1993–2002

a	b		c	d	e
	AT percentile [ $^{\circ}\text{C}$ ]				
Cities	95 <sup>th</sup>	90 <sup>th</sup>	$T_{\max} = 30^{\circ}\text{C}$ $T_{\max}$ percentile	AT value at $T_{\max}$ percentile (column c)	Mean air temperature T [ $^{\circ}\text{C}$ ]
Białystok	26.2	23.6	0.985	29.8	7.4
Gdańsk	23.2	20.6	0.996	30.3	8.6
Kraków/Cracow	26.9	24.2	0.980	29.8	8.6
Lublin	26.4	24.0	0.987	30.7	7.8
Poznań	26.5	23.8	0.979	28.7	8.9
Rzeszów	27.7	24.8	0.978	30.3	8.4
Szczecin	26.2	23.3	0.982	29.6	9.1
Toruń	26.7	23.9	0.977	29.3	8.6
Warszawa/ Warsaw	26.8	24.2	0.981	30.2	8.4
Wrocław	26.8	24.2	0.978	29.1	9.2

Source: Author's own elaboration

The application of the 'Apparent Temperature' definition only reduces slightly the number of heat waves in the analyzed cities (69 as opposed to 74 with the air temperature threshold  $30^{\circ}\text{C}$  definition). However these lasted 9 days on average, more than twice as long as the heat waves defined using the threshold of  $30^{\circ}\text{C}$  (4 days). The 'hottest' heat waves according to this definition occurred in Toruń, a city situated in the center of Poland on the Vistula River and characterized by a greater frequency of hot days than the surrounding area. In line with the ' $30^{\circ}\text{C}$ ' definition, the 'hottest' heat waves are noted in Poznań. However, Toruń has vet-higher values for Apparent Temperature. While the second definition is far more restrictive and resulted in 'hotter' yet shorter heat waves, it is interesting that the minimum air temperature is almost equal in the 2 types. At the Polish seaside there were no heat waves defined as at least 3 days with air temperature above  $30^{\circ}\text{C}$ . Applying the Humidex threshold of  $40^{\circ}\text{C}$

resulted in only 13 days with heat waves in all analyzed cities over a 10 year. These included 9 days in Szczecin in which two heat waves were generated in the same year, one of 4 days (July 23–26, 1994) and another of 3 (July 30 to August 1, 1994) (Table 4). Moreover, Szczecin distinguishes itself from other Polish cities by the highest dew temperature, relatively high humidity and a low wind speed.

Most heat waves that are defined in line with the 3-day threshold of  $30^{\circ}\text{C}$  definition last exactly 3 days and are usually included in the 'Apparent Temperature' defined ones, sometimes with two being included in one of the second type. For example, in Warsaw, only 3 of 11 defined heat waves lasted longer than 3 days, in Lublin—just one (Table 5). In a few cases the dates of the heat waves defined in these two different ways do not even overlap. The application of Humidex didn't result. Does it mean that there are no longer periods perceived by people as heat? It means rather that the

Table 4. Heat wave statistics for Poland over the years 1993–2002 in relation to three definitions.

Heat waves	Min. 6 days with AT > 95th percentile					Min. 3 days with $T_{\max} > 30^{\circ}\text{C}$					Humidex > 40°C	
	No. of heat waves	Mean duration	$T_{\max}$	$T_{\min}$	AT	No. of heat waves	Mean duration	$T_{\max}$	$T_{\min}$	AT	No. of days	No. of heat waves
Białystok	7	9.9	29.4	15.0	29.4	6	4.8	31.9	14.8	31.0	-	-
Gdańsk	4	13.8	24.4	18.4	25.7					-	-	-
Kraków/ Cracow	8	7.6	29.9	15.8	28.4	10	4.0	32.2	16.2	30.4	-	-
Lublin	5	10.0	29.2	16.2	29.7	6	4.2	31.6	16.3	32.3	2	-
Poznań	6	8.3	30.2	15.4	29.3	6	4.5	33.0	16.2	30.7	1	-
Rzeszów	7	8.6	29.7	14.4	30.1	10	4.5	31.7	14.7	32.7	-	-
Szczecin	10	9.8	28.6	14.7	29.1	8	4.6	32.2	15.7	32.0	9	2
Toruń	7	8.3	30.4	15.9	30.6	9	4.2	32.8	17.1	32.4	-	-
Warszawa/ Warsaw	8	7.9	30.0	16.7	30.3	11	4.0	31.8	16.5	31.6	-	-
Wrocław	7	8.6	30.0	14.2	29.4	8	4.9	32.2	14.7	30.2	1	-
Mean	6.9	9.3	29.2	15.7	29.2	8.2	4.4	32.2	15.8	31.5	-	-

AT – Apparent Temperature, T – air temperature,  $T_{\max}$ ,  $T_{\min}$  – maximum and minimum air temperature

Source: Author's own elaboration

threshold of air temperature could have been inappropriate for the entire area of Poland because obviously at many locations the level of  $30^{\circ}\text{C}$  is exceeded on just a few days each year.

## CONCLUSION

This survey of the approaches to heat waves presented in this paper make it clear just how important to particular studies the proper choice of the definition is. Generally, at the basis of defining heat waves lies the idea that several consecutive very hot days are more burdensome to people than separate hot days. The effect of the 'wave' should thus be tested through detailed weather-health studies. This is why the best way to specify heat waves in a given location and to indicate adequate thresholds or air-mass

types defining them, would seem to be by analyzing heat waves in relation to mortality and/or morbidity. Such analyses have already been undertaken by the author (Kuchcik 2001, Kuchcik in Kozłowska-Szczęśna *et al.* 2004, Kuchcik and Błażejczyk 2005).

The issue of heat waves is especially valid when account is taken to IPCC projections pointing to an increased frequency or magnitude of extreme events such as heat waves in a warmer global environment (WMO 2001). An example of such a scenario was brought to Poland in summer 2006, in which there was a heat wave lasting almost one month, 2 months of drought and a flood at the end. However, even where precisely-calculated indices for mortality during past periods are at our disposal, one major unknown to be taken account of as future impact: is estimated is whether or not the population will be able to adapt and acclimatize to changes in climate (WHO 2003)?

Table 5. Dates and air temperature characteristics of heat waves in Poland, 1993–2002, as defined in two different ways.

City	Min. 6 days with AT > 95th percentile						Min. 3 days with $T_{max} > 30^{\circ}\text{C}$					
	Start	End	No. of days	$T_{max}$ [ $^{\circ}\text{C}$ ]	$T_{min}$ [ $^{\circ}\text{C}$ ]	AT [ $^{\circ}\text{C}$ ]	Start	End	No. of days	$T_{max}$ [ $^{\circ}\text{C}$ ]	$T_{min}$ [ $^{\circ}\text{C}$ ]	AT [ $^{\circ}\text{C}$ ]
Białystok	25 July 94	7 Aug. 94	14	32.5	14.1	30.8	12 July 94	16 July 94	5	30.7	12.9	29.0
	27 May 95	2 June 95	7	27.7	12.2	27.3	25 July 94	2 Aug. 94	9	33.5	13.5	31.6
	6 June 98	11 June 98	6	28.6	14.7	29.7	4 Aug. 94	6 Aug. 94	3	32.2	14.3	31.1
	14 July 01	30 July 01	17	27.8	16.4	28.9	21 June 00	23 June 00	3	31.4	14.1	29.3
	16 Aug. 01	22 Aug. 01	7	29.6	14.7	30.5	15 July 01	17 July 01	3	31.8	18.7	34.9
	10 July 02	19 July 02	10	29.0	17.0	29.5	28 July 02	2 Aug. 02	6	31.7	15.6	29.9
	28 July 02	4 Aug. 02	8	30.6	16.2	29.4						
Gdańsk	21 July 94	10 Aug. 94	21	25.6	18.9	27.3						
	17 Aug. 97	3 Sep. 97	18	25.1	16.6	24.9						
	31 July 02	6 Aug. 02	7	23.8	20.0	25.9						
	14 Aug. 02	22 Aug. 02	9	23.2	18.1	24.6						
Kraków/ Cracow	24 July 94	8 Aug. 94	16	32.0	15.3	29.2	3 Aug. 93	5 Aug. 93	3	31.4	14.2	29.6
	9 July 95	16 July 95	8	29.0	16.2	28.4	26 June 94	29 June 94	4	31.1	15.5	29.8
	18 Aug. 95	24 Aug. 95	7	29.1	13.6	27.7	25 July 94	3 Aug. 94	10	33.1	15.0	29.9
	7 June 96	12 June 96	6	29.5	14.7	27.8	5 Aug. 94	7 Aug. 94	3	32.0	16.0	29.5
	16 Aug. 00	21 Aug. 00	6	31.6	17.1	30.3	7 June 96	10 June 96	4	30.4	14.1	28.6
	15 Aug. 01	20 July 01	6	29.7	16.7	28.7	28 June 97	30 June 97	3	32.7	17.3	31.3
	18 June 02	23 June 02	6	29.7	15.7	27.8	20 July 98	23 July 98	4	32.6	17.0	30.9
	28 July 02	2 Aug. 02	6	28.7	17.5	27.4	4 July 99	6 July 99	3	32.1	16.3	30.3
Lublin							19 Aug. 00	21 Aug. 00	3	33.5	18.8	32.4
							14 July 01	16 July 01	3	33.1	18.4	31.3
	24 July 94	8 Aug. 94	16	31.8	15.6	30.3	25 July 94	3 Aug. 94	10	32.8	15.9	31.1
	5 June 98	11 June 98	7	27.7	15.5	29.4	5 Aug. 94	7 Aug. 94	3	31.7	15.2	30.3
	15 Aug. 01	22 Aug. 01	8	28.5	15.7	29.2	8 June 96	10 June 96	3	30.3	14.4	30.6
	7 July 02	19 July 02	13	28.1	17.2	29.2	21 July 98	23 July 98	3	31.5	17.3	34.4
	28 July 02	2 Aug. 02	6	29.8	17.3	30.5	19 Aug. 00	21 Aug. 00	3	31.9	16.8	33.0
							15 July 01	17 July 01	3	31.6	18.0	34.3
	21 July 94	6 Aug. 94	17	32.4	16.0	30.5	24 July 94	2 Aug. 94	10	34.3	17.0	32.6
	8 July 95	16 July 95	9	29.7	16.6	29.3	8 July 95	10 July 95	3	31.7	15.3	30.5
Poznań	7 June 96	12 June 96	6	30.2	15.3	29.5	7 June 96	9 June 96	3	31.9	14.8	30.5
	10 Aug. 97	15 Aug. 97	6	28.2	13.4	27.9	20 June 00	22 June 00	3	35.0	15.0	31.9

Poznań	22 Aug. 97	27 aug 97	6	28.9	13.7	28.0	9 July 02	11 July 02	3	32.9	17.8	27.6
	28 July 02	2 aug 02	6	31.7	17.5	30.8	28 July 02	1 Aug. 02	5	32.5	17.2	31.4
	23 July 94	9 Aug. 94	18	31.9	13.5	31.2	27 June 94	30 June 94	4	31.5	14.6	32.4
	9 July 95	15 July 95	7	28.8	13.9	29.8	24 July 94	8 Aug. 94	16	32.3	13.6	31.5
Rzeszów	7 June 96	12 June 96	6	30.2	10.7	29.6	8 June 96	10 June 96	3	31.6	11.0	31.4
	6 June 98	11 June 98	6	29.1	15.5	30.8	20 July 98	23 July 98	4	31.8	15.3	33.6
	15 Aug. 01	21 Aug.01	7	29.4	13.9	30.7	4 July 99	6 July 99	3	31.2	14.0	32.8
	7 July 02	18 July 02	12	29.4	16.7	29.4	21 June 00	23 June 00	3	31.7	14.3	32.5
	28 July 02	2 Aug. 02	6	29.1	16.3	29.5	19 Aug. 00	21 Aug.00	3	33.2	16.9	34.8
							14 July 01	16 July 01	3	32.1	15.9	34.2
							16 Aug. 01	18 Aug.01	3	30.1	14.5	31.6
							14 July 02	16 July 02	3	31.4	16.6	32.1
							21 July 94	6 Aug. 94	17	33.4	17.1	34.8
							11 July 94	15jJuly 94	5	32.1	14.8	31.2
Szczecin	7 July 95	16 July 95	10	29.2	15.8	30.3	21 July 94	2 Aug. 94	13	34.3	17.8	36.3
	27jJuly 95	7 Aug. 95	12	28.4	13.4	28.5	8 July 95	10 July 94	3	31.0	15.1	32.2
	18 Aug. 95	24 Aug.95	7	29.9	13.5	29.5	29 July 95	31 July 95	3	30.6	15.2	31.3
	7 June 96	12 June 96	6	28.5	14.8	30.3	18 Aug. 95	20 Aug.95	3	30.5	13.0	30.7
	19 aug 96	24 aug 96	6	28.3	14.6	27.9	20 June 00	22 June 00	3	33.2	14.5	32.1
	8 Aug. 97	15 Aug.97	8	27.3	14.4	27.4	9 July 02	11 July 02	3	32.7	17.1	28.7
	22 July 01	30 July 01	8	26.6	13.9	27.0	29 July 02	1 Aug. 02	4	32.7	18.1	33.1
	19 Aug. 01	26 Aug.01	8	26.9	15.9	27.9						
	16 Aug. 02	31 Aug.02	16	27.7	14.1	27.3						
							23 July 94	6 Aug. 94	15	33.8	16.3	32.4
Toruń	7 July 95	15 July 95	9	30.4	15.3	30.4	24 July 94	3 Au.g 94	11	34.6	16.5	33.2
	17 Aug. 95	24 Aug.95	8	29.8	13.5	31.0	8 July 95	10 July 95	3	33.0	15.7	32.6
	7 June 96	12 June 96	6	30.0	15.4	29.9	7 June 96	9June 96	3	31.7	15.6	31.6
	25 July 01	30 July 01	6	27.6	15.4	27.6	28 June 97	30June 97	3	33.1	19.0	32.6
	15 Aug. 01	22 Aug.01	8	29.9	18.1	31.3	4 July 99	6 July 99	3	32.1	18.5	32.7
	28 July 02	2 Aug. 02	6	31.4	17.0	31.5	20 June 00	22 June 00	3	35.0	15.9	32.2
							15 Aug. 01	17 Aug.01	3	32.0	18.4	33.3
							29 July 02	2 Aug. 02	5	31.8	18.4	32.4
							11 July 94	17 July 94	7	29.7	16.8	29.8
							13 July 94	16 July 94	4	30.7	17.3	30.7
Warszawa/ Warsaw	23 July 94	7 Aug. 94	16	32.6	16.6	32.1	24 July 94	2 Aug. 94	10	34.0	16.3	33.1
	8 July 95	14 July 95	7	29.0	15.3	29.6	4Aug. 94	6 Aug. 94	3	31.7	16.9	32.5
	18 Aug. 95	24 Aug.95	7	30.0	14.1	29.6	19 Aug. 95	21 Aug.95	3	30.5	14.6	30.4
	6June 98	11June 98	6	29.2	17.2	29.3	8 June 96	10 June 96	3	31.4	15.4	30.4
						15 Aug. 01	22 Aug.01	8	29.4	16.9	31.0	
						28 June 97	30June 97	3	31.5	17.9	31.8	

City	Min. 6 days with AT > 95th percentile						Min. 3 days with T <sub>max</sub> > 30°C											
	Start	End	No. of days	T <sub>max</sub> [°C]	T <sub>min</sub> [°C]	AT [°C]	Start	End	No. of days	T <sub>max</sub> [°C]	T <sub>min</sub> [°C]	AT [°C]						
Warsaw	13 July 02	18 July 02	6	28.8	18.6	29.8	4 July 99	6 July 99	3	31.8	16.4	31.8						
	28 July 02	2 Aug. 02	6	31.6	18.1	31.2	20 June 00	22 June 00	3	32.9	14.2	30.7						
							14 July 01	16 July 01	3	32.8	17.7	33.4						
							19 Aug. 01	21 Aug. 01	3	30.3	17.1	31.3						
							28 July 02	2 Aug. 02	6	31.6	18.1	31.2						
							22 July 94	7 Aug. 94	17	33.2	15.3	31.1	26 June 94	29 June 94	4	32.2	16.1	32.3
							8 July 95	16 July 95	9	29.7	16.1	29.3	13 July 94	15 July 94	3	31.2	14.3	29.6
							18 Aug. 95	24 Aug. 95	7	29.4	13.9	28.8	22 July 94	6 Aug. 94	16	33.5	15.2	31.3
	Wrocław	7 June 96	12 June 96	6	30.5	14.4	30.1	7 June 96	9 June 96	3	31.4	13.1	30.7					
22 Aug. 97		27 Aug. 97	6	28.9	12.4	28.3	20 July 98	22 July 98	3	32.2	15.7	30.3						
14 Aug. 00		21 Aug. 00	8	30.0	14.1	29.7	20 June 00	22 June 00	3	33.4	13.7	31.3						
25 Aug. 02		31 Aug. 02	7	28.4	13.3	28.7	9 July 02	11 July 02	3	32.3	15.6	27.2						
							28 July 02	31 July 02	4	31.6	14.1	28.9						

Source: Author's own elaboration

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## CHANGES OF THE VISTULA RIVER CHANNEL AND FLOODPLAIN IN THE LAST 200 YEARS

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**Abstract:** The Vistula River is a typical Central-European river flowing from the mountains across basins and upland belts to the lowlands. The Vistula valley is modelled by a river with a complex hydrological regime. In its upper reaches, floods driven by summer rainfall prevail, while in the lower reaches snowmelt floods are important. Deforestation favoured a natural propensity for river braiding. In the mid-19th century, the channelization of the upper Vistula (in the Carpathian foreland) and the lower reaches was commenced with, while the middle stretch was left in a natural state, such that the river has in places preserved a braided pattern up to the present day. The channelization followed by construction of reservoirs caused downcutting and aggradation to occur, such that opposing tendencies were observed in particular reaches of the river channel. In addition, flood embankments confined aggradation to the intra-embankment area. Thus, the functioning of the Vistula River system is largely controlled by diverse human activity. Unconstrained flow and river load transport along the whole river length are only partly possible during extreme floods. The present-day adjustment tendencies also relate to ongoing changes in land-use in the drainage basin, as well as on global climatic changes.

**Key words:** Vistula River, channelization/regulation, present-day changes of floodplain, downcutting, aggradation.

## INTRODUCTION

The Vistula River is one of the great central European rivers, flowing from the mountains in the South (the Alps, Sudetes, Carpathians) towards the North or Baltic Seas. All these rivers traverse a series of morphological units, starting from the mountain headwaters and submontane basins, crossing an upland belt and, then, entering an extensive lowland zone which, in the eastern part, was several times occupied by the Scandinavian ice sheet. In the catchments of the Elbe, Oder and Vistula rivers, we find the remains of former streamways, later crossed by rivers flowing straight to the sea. Another characteristic feature of this zone is a gradual change of hydrological regime from one dominated by rainy floods in the West to one with more pronounced snowmelt floods towards the East. Therefore, in their upper reaches especially, the river floods are driven by heavy summer rainfall.

The evolution of the Vistula River valley in the last 10–15,000 years has been studied in detail under IGCP Project 158, which focused on the palaeohydrology of the temperate zone (Starkel *et al.* 1991), as well as on the role of human impact in the last few millennia. It was the largest catchment and the longest river studied within this Project. The results were published in six volumes (Starkel, ed. 1982–1996).

This paper tends to continue those studies but concentrates on the processes of and trends to the evolution of the Vistula river channel and floodplain. Its aim is to characterize these during the last 100–200 years of direct human impact, by focusing on the metachronous regulation of the river course and the transformation of water discharge and the sediment load. It therefore supplements previous studies. Specifically, this paper results from multi-specialist cooperation of geographers, namely a geomorphologist concentrating on the role of humans in long-term trends (L. Starkel), a hydrologist working on the Vistula River regime (R. Soja), a cartographer-analyst of river-channel changes over time (J. Plit), and two other ge-

omorphologists, of which one is interested in studying the impact of regulation works on geomorphic processes (J. Warowna) and the other focuses on present-day sediment loads (A. Łajczak).

In contrast to other European rivers (Petts *et al.* 1989), the Vistula had a specific feature in the last few centuries. Its catchment area once constituting the central part of the Polish state was divided, in the late 18th century, between the three neighbouring countries of Austria, Russia and Prussia. Only in 1918 did it come back under Polish rule. Water management in the three countries in question differed greatly. Prussia was the first to start intensive regulation works in the lower course of the Vistula in the mid-19th century. At about the same time, after several major floods in the Upper Vistula catchment, the Austrian government started channelization works there. The longest (middle) reach of the Vistula River, left under Russian rule, remained practically unchanged (except in local fragments) until independence was regained. Even now, this segment of the river preserves many features inherited from previous centuries (e.g. braided channels and islands). This tripartition is still visible in present-day processes and forms, as being superimposed upon the natural sequence of processes along the longitudinal profile of the Vistula.

## CHARACTERISTICS OF THE VALLEY, FLOODPLAIN AND CHANNEL

The Vistula River drainage basin, with an area of 199 813 km<sup>2</sup>, is drained by a 1047 km long river. In what is an asymmetric drainage basin, right-bank tributaries predominate in both the upper reaches (Carpathian tributaries) and the middle reaches (Figure 1).

The Vistula flows across numerous morphotectonic units of diversified relief (Table 1). Particular sections of its valley differ in depth and width, the extent of the floodplain, channel width and gradient (Starkel 1990). A short Carpathian section of a narrow valley cut in flysch rocks has a gradient

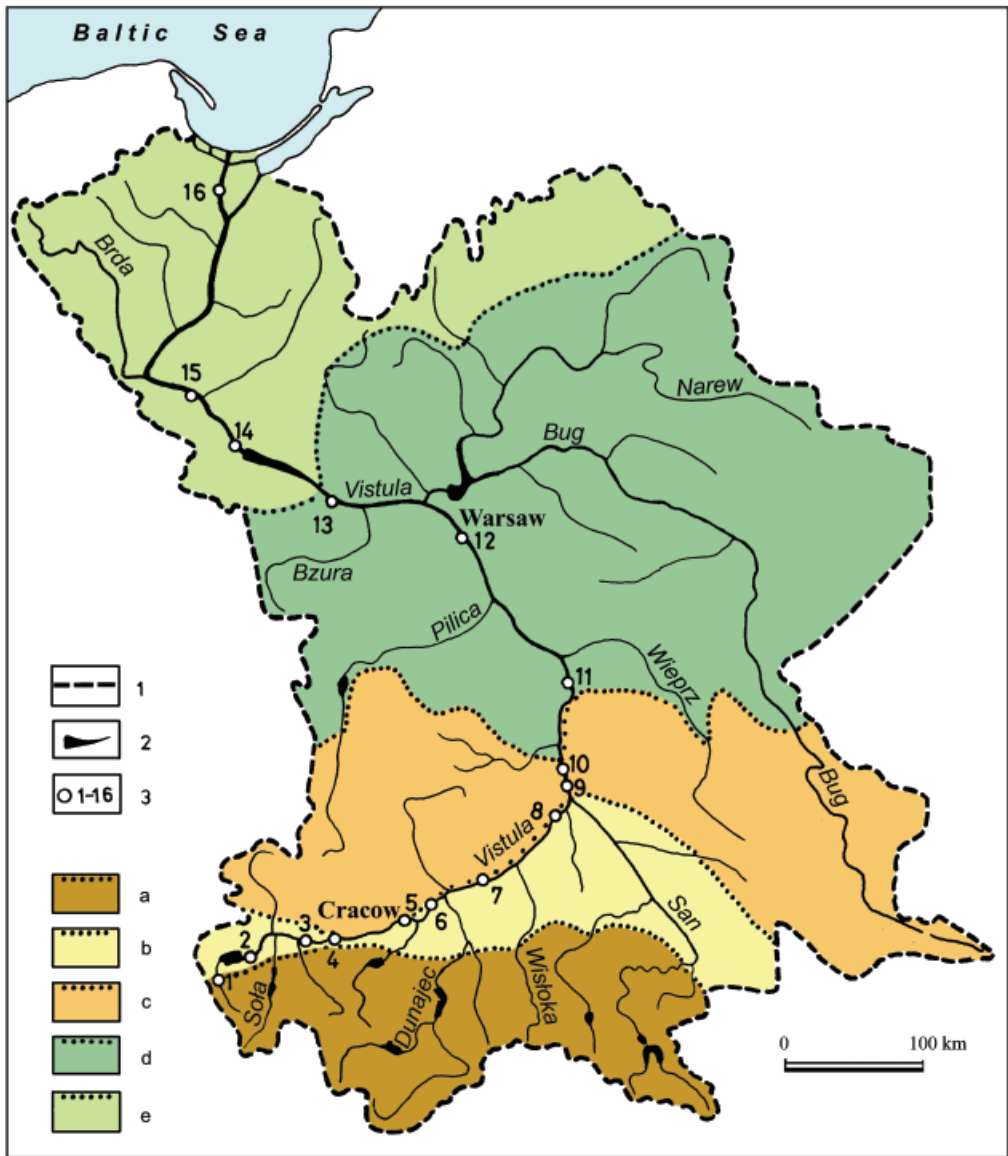


Figure 1. The Vistula River catchment against a background of geomorphic regions  
 1. main watershed; 2. water reservoirs; 3. hydrological stations mentioned in this paper  
 (1. Skoczów, 2. Goczałkowice, 3. Smolice, 4. Tyniec, 5. Sierosławice, 6. Jagodniki, 7. Szczucin,  
 8. Sandomierz, 9. Zawichost, 10. Annapol, 11. Puławy, 12. Warszawa, 13. Kępa Polska,  
 14. Włocławek, 15. Toruń, 16. Tczew).  
 a—Carpathians; b—Subcarpathian basins, c—Polish Uplands,  
 d—Polish Lowlands (Mazovian part),  
 e—Polish Lowlands (Kuyavian-Pomeranian part)

Table 1. Morphometric characteristics of Vistula Valley reaches

Reach	1.46	0.85	0.37	0.35	0.27	0.28	0.24	0.27	0.21	0.19	0.17	0.11
Length of reach in km	36	70	35	170	75	215	260	44	—	>40	>40	45
Depth of valley in m	450	20-40	40	19-90	30-80	25-55	35-80	—	—	—	—	—
Valley width in km	0.1	1-15	0.3	8-25	1-15	12-20	4-20	>40	>40	>40	>40	>40
Width of floodplain in km	<1	1-5	0.3	3-10	1-10	2-8	2-9	>40	>40	>40	>40	>40
Length of channel in km	40	109	46	208	86	246	275	45	45	45	45	45
Number of wide and narrow sections	1	2-1	4-5	5-4	1-2	1-1	4-1	45	45	45	45	45

Source: Starkel (ed.)(1990)

of 14.6‰ on average. As the Vistula turns eastward, (in the Oświęcim Basin), the valley broadens, and the winding or meandering channel has a width varying from 20 to 50m. In the section considered, several tributaries merge with the Vistula. Over the next 35km section, the river flows across limestone horsts of the Cracow Gate, then along the northern margin of the Sandomierz Basin where it is shifted by the Carpathian tributaries. Here, in the river valley (8 to 25km wide), the Holocene alluvial plain is 3 to 10km wide. A regulated and embanked winding Vistula channel (once a meandering one), with a width of 100–200m tends to occupy the middle of the valley floor, albeit undermining the river left-bank plateaus in certain sections. At the confluence point with the river San, the Vistula turns northward and enters a gap across the Polish Uplands cut into limestones and gaizes. In the narrowed sections of the valley, the 1–2km wide floodplain occupies the whole floor, while in broader basin-shaped sections it is up to 10 km wide. The up to 1km wide channel has been braided before the last few decades. The Vistula then turns north-west and flows towards the Warsaw Basin (Mazovian Lowland), where it is joined by the river Narew and then turns westward. Here, the 0.5–1km wide braided Vistula channel uses one of the two marginal depressions. Downstream of the Bzura river, (a left-bank tributary), the Vistula starts its lower Kuyavian-Pomeranian reach incised in deposits from the last glaciation. The river channel gradient declines gradually to 0.1‰ and the valley confined by es-

carpments widens and narrows. The straight or winding river channel is only 300–500m wide, yet is regulated and embanked. The river flow is controlled by Włocławek Reservoir. The 45 km long outlet section of the regulated Vistula crosses the reclaimed area of the delta. The marked variability in relief of the Vistula valley—as controlled by lithology and tectonics, as well as the deglaciation pattern and spatial pattern of larger tributaries—has an unquestionable influence on the processes which have modelled and model its floor (Starkel 1990).

### HYDROLOGICAL CHARACTERISTICS OF THE VISTULA

The complex hydrological regime of the Vistula is related to the location of its drainage basin in the transient temperate climatic zone. The dominance of a continental or maritime influences varies across an annual cycle, resulting in marked year-to-year variability in discharges. Depending on precipitation distribution in the drainage basins of the tributaries, hydrological parameters of the Vistula increase first rapidly but in an irregular manner to Zawichost (gauging station no. 9, see Figure 1), and then gradually in the downstream reach of the river.

Following the contribution by Fal *et al.* (1997), the hydrological characteristics are based on data from four gauging stations located along the Vistula River (Figure 2, Table 2). In winter, the river discharges increase steadily in the whole Vistula drainage

Table 2. Characteristic flows [ $\text{m}^3/\text{s}$ ] at four hydrological stations along Vistula River, 1951–1990

Gauging station	$Q_{\text{av}}$	$Q_{\text{av Nov.-Apr.}}$	$Q_{\text{av May-Oct}}$	$Q_{\text{max1\%}}$	$Q_{\text{min1\%}}$
Nowy Bieruń	20.7	20.9	20.6	804	1.29
Sandomierz	292.0	294.0	289.0	7,500	54.70
Warszawa	573.0	614.0	533.0	7,400	102.00
Tczew	1,080.0	1,230.0	932.0	9,190	243.00

Source: Fal *et al.* 1997.

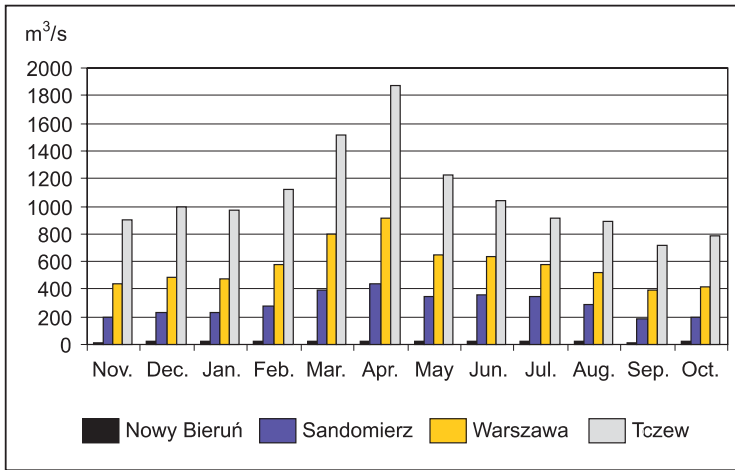


Figure 2. Mean monthly discharges of the Vistula River at four hydrological stations

Source: after Fal et al. 1997

basin from November through to the culmination of meltwater flow. From May, discharges decrease along the Vistula's whole length, yet the flow is always greater than the annual average. In the summer months (June–August), the second peak flow is related to extreme summer floods in the Carpathians. It progresses along the Vistula to Sandomierz (gauging station no.8, see Figure 1) and then ceases in the middle and lower reaches of the river. The lowest flows occur in September and are related to precipitation deficit and the small storage capacity of the drainage basin. Summer–autumn droughts take in the whole Vistula drainage basin. The mean annual flows increase from  $6\text{m}^3/\text{s}$  in Skoczów to  $21\text{m}^3/\text{s}$  in Nowy Bieruń,  $292\text{m}^3/\text{s}$  in Sandomierz,  $573\text{m}^3/\text{s}$  in Warszawa and  $1080\text{m}^3/\text{s}$  in Tczew (Figure 2). Winter flows predominate by 1% over summer-season flows to Nowy Bieruń, farther downstream by 7%, and finally by 14% in Tczew. This pattern reflects variable sources of water supply and a diminishing influence of the Carpathians downstream. In the Carpathian part of the drainage basin the river regime is controlled by heavy summer rain storms, with accompanying overland flow. Rainfall diminishes northward, permeable

sandy covers store rainwater, and thus in the downstream section winter-season outflow predominates over summer.

The amplitude in Vistula water levels results from the presence of flood embankments, which cause the water level to rise in the intra-embankment area. In the Carpathian reach of the Vistula, without embankments and with a steep gradient, the water level amplitude is 2m, and cf. 3.5m in the foothill reach. On the other hand, in the area of Subcarpathian Basins this amplitude varies from 5 to 8.5m, depending on the gap between the embankments. Downstream of the San river mouth, in the broad channel, the amplitude of water level diminishes to 6–7m in Warsaw, while in Tczew it reaches its highest value of 10m. Over the whole length of the Vistula, the highest recorded water levels coincide with the heights of the embankment. Under natural conditions, (i.e. prior to straightening and deepening of the Vistula channel), water-level amplitude was possibly only half as great (Makowski and Tomczak 2002).

The Vistula is a river with high and frequent summer floods triggered by continuous rainfall in the Carpathians and their

foreland (Figure 3). The flood of 1813, which occurred across the whole Vistula drainage basin, is believed to have been the most spectacular in the whole period for which observations were carried out. The floods of 1844, 1903, 1839, and 1934 were of a slightly smaller magnitude. The flood of 1997 was characterized by the highest recorded discharges at the majority of the Vistula's water-level gauging stations to Zawichost. The analysis of water levels in the lower reach at Toruń (gauging station no.15, see Figure 1) since 1770 points to the occurrence of some years without significant floods (5–8 cases in a century), as well as a few years recording 2 or 3 high floods (Makowski and Tomczak 2002). Spring floods, which occur regularly, predominate, while summer and winter floods are less frequent.

Flood waves formed in the Carpathian part of the Vistula drainage basin reach their maxima at Sandomierz or Zawichost, before being quickly flattened downstream such that only occasionally does the peak flow increase to the river mouth (as in 1962, Figure 3). The summer flood of 1997 had a discharge of  $2000\text{m}^3/\text{s}$  in Cracow,  $5830\text{m}^3/\text{s}$  downstream of the Dunajec river mouth,  $5800\text{m}^3/\text{s}$  in Sandomierz,  $4730\text{m}^3/\text{s}$  in Warsaw, and  $4220\text{m}^3/\text{s}$  at Tczew (Barczyk *et al.* 1999). The increase in maximum discharge values, resulting from superimposed flood waves of the Vistula and its tributaries, usually occurs in the Sandomierz Basin. The peak discharges might be altered through embankment breaking and the formation of an episodic flood lake. An inundated area in excess of  $300\text{ km}^2$  was formed during the summer flood of 1934.

Extreme snowmelt floods (Figure 4) occur less frequently than the rainfall-induced ones, though in this case the maximum discharges increase steadily down the river. In 1979, the peak discharges of the Vistula were  $1290\text{m}^3/\text{s}$  at Sandomierz,  $2550\text{m}^3/\text{s}$  at Warsaw and as much as  $7020\text{m}^3/\text{s}$  at Tczew, the result of a superimposed flood wave of the Vistula and the thawing flood waves of the Bug and Narew drainage basins. Ice-jam floods occurred very often in the past. How-

ever, the channelization of the Vistula River in the last 150 years, as well as thermal and chemical pollution of the water, reduced ice-jamming. On the other hand, frazil-ice-jams began to form in backwater areas of the reservoirs.

The highest observed Vistula discharges reached  $7450\text{m}^3/\text{s}$  at Zawichost ( $Q_{1\%}$  is  $8160\text{m}^3/\text{s}$  at Zawichost, according to Punzet 1991) and  $8000\text{m}^3/\text{s}$  at Tczew. However, if the first peak flow resulted from a rainfall flood, the second was due to a snowmelt flood. The 1% water flow corresponds to a specific runoff of  $460\text{ l/s/km}^2$  at Nowy Bieruń,  $236\text{ l/s/km}^2$  at Sandomierz, only  $88\text{ l/s/km}^2$  at Warsaw and  $47\text{ l/s/km}^2$  at Tczew. The frequency of floods ( $p\%$ ) was calculated using the log Pearson type III distribution applied by Polish hydrologists (Punzet 1991). In case of the Vistula basin the extreme floods in the upper and middle course of the river are generated by summer rainy floods in the Carpathians and downstream the Narew junction mainly by snowmelt floods.

In the 20th century, the mean annual outflow from the Vistula drainage basin did not show statistically significant trends (Fal 1993). Studies on changes in the flood regime of the Vistula River and its major tributaries have been performed many times. The obtained negative regression coefficients referred to peak flow and the frequency and duration of floods in the years 1901–1970 (Stachy and Nowak 1977). Similar results were found when examining the variability to extreme annual discharges in the years 1921–1992 (Stachy *et al.* 1996). In the medium-size catchments of the Carpathian part of the Vistula basin, there is a trend towards a decrease in flood magnitude (Soja 2002), but there is a steady increase in minimum discharges related to reservoir management. In general, the hydrological regime of the Vistula River in the 20th century has been characterized by a decrease in the number of floods. Nevertheless, catastrophic floods have occurred, some of these being clustered in subsequent years, but then followed by 15–20-year periods without major floods (Starkel 2001).



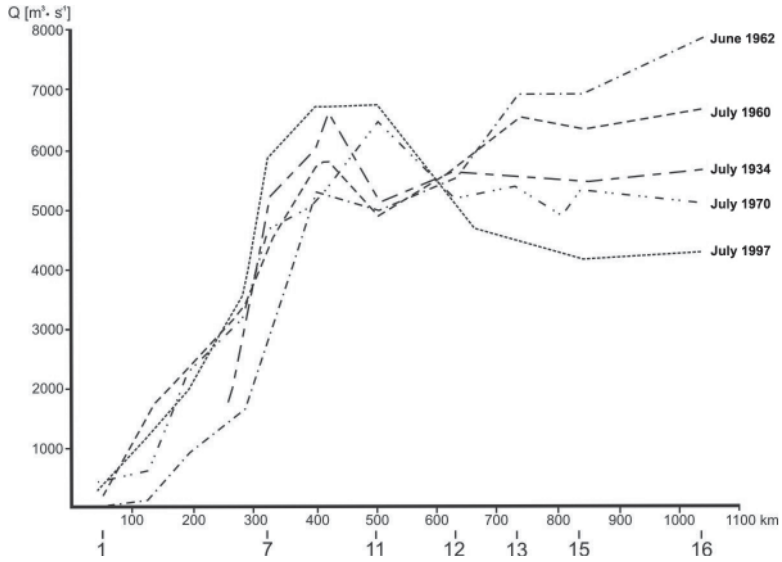


Figure 3. Maximum discharges in the longitudinal profile of Vistula River during summer rainy floods  
*Source:* based on Soja and Mrozek in Starkel (ed.) 1990

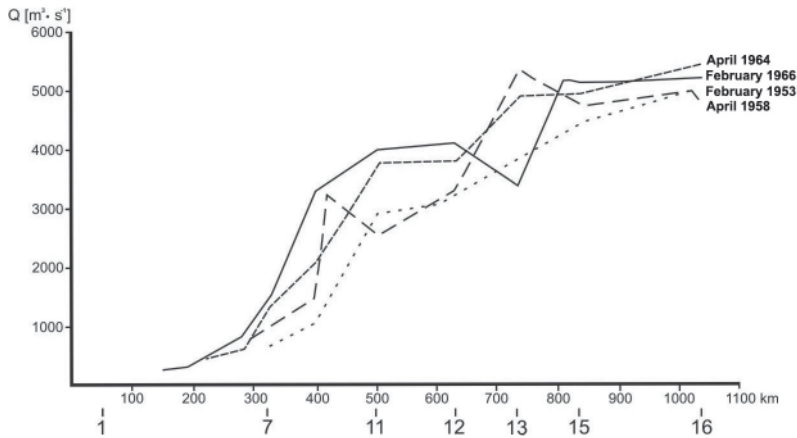


Figure 4. Maximum discharges in the longitudinal profile of Vistula River during snowmelt floods.  
*Source:* based on Soja and Mrozek in Starkel (ed.) 1990

## PROCESSES IN THE REGULATED VISTULA VALLEY—CHANGES IN THE PATTERN AND SHAPE OF THE RIVER CHANNEL

### THE UPPER REACH: FROM SPRINGS TO THE SANDOMIERZ BASIN

Apart from in the short mountainous section, the Vistula valley become deforested, farmed and densely populated. Analysis of the three maps dating from the turn of the 18th century to the mid-19th century<sup>1</sup>, shows that the Vistula formed its channel freely on a valley floor of diverse width. At that time, it was a meandering, unregulated river (excluding the section within the city of Cracow). The river upstream of the Cracow Gate had meanders of small (50–200m) radii, the channel being 140–170m wide.<sup>2</sup> Downstream of Cracow to the Dunajec outlet, the Vistula channel was very winding, with small-radii meanders (300–400m). The old maps do not depict larger bars and natural levees. Downstream of the Dunajec river mouth, the Vistula was 400m wide, bars occurred in the channel and the meander radii were larger (500–600 m).

From the beginning of 19th century, the section upstream of Sandomierz was characterized by accumulation, the channel became shallower and wider, and numerous bars and islets were formed. In the mid-19th century, the channel changed gradually in the reach between the mouths of the Dunajec and San rivers. Although the Vistula still flowed in a sinuous channel, the river was shallower; it occupied a wider channel and had left numerous bars. Numerous distributaries and abandoned channels occurred. The crucial transformation was related to embanking and straightening of

the river channel (Figures 5, 6). In the years 1800–1980, the upper Vistula was shortened by 34,3km in the Oświęcim Basin (Czaja et al.1993) and by 35,5km in the Sandomierz Basin (Trafas 1992).

The channelization works started in various reaches of the Vistula at different times. In the Carpathian part only one reservoir (Czarne), with a capacity of 4.5 million m<sup>3</sup>, was built in 1974. A series of concrete sills have been constructed to prevent downcutting. The next reservoir (Goczałkowice), on the flat floor of the Oświęcim Basin, is up to 14m deep and 11km long, and accumulates all bedload and a majority of suspended load. In the area of the Oświęcim Basin the Vistula preserved its winding character, despite the channelization in the 1920s, when the river channel was shortened by 40%. As a result the channel gradient increased from 0.34‰ to 0.56‰ (Czaja et al. 1993) and downcutting has been activated. In the 1950s, the construction of a cascade of dams with canal locks in the region of Cracow inhibited the process of intensive downcutting which has been observed since the mid-19th century. Ingarden (1922) estimated the channel deepening at 2.5m, while Punzet (1981) reports the value of 3m for the period of 1871–1954. Such extensive erosion was supported by the cutting and filling of the abandoned channels (these playing the role of bypass channels), and by exploitation of sand from the river bed up to 1950.

In the Sandomierz Basin, channelization works entailing cutting of river bends started in 1848. At the same time, the channel was narrowed by a system of dykes and groynes. The gradient thereby increased from 0.28 to 0.32‰ (Trafas 1992). In the second half of the 20th century, the erosion rate of the Vistula channel bottom was ca. 1 cm/year. The channel sinuosity in the Upper Vistula dropped from 1.7 to 1.4 (Babiński and Klimek 1990). The downcutting is reported to reach from 0.5 to more than 1m (Ingarden 1922, Punzet 1981). The cutting works resulted in river bends of large curvature—extending the radius to 1km (Trafas 1992).

<sup>1</sup> Detailed Map of the Polish Kingdom provinces of 1783 (*Mapa szczegulna wojewodztw koronnych*) of Karol de Perthès, scale 1: 225 000, *Regna Galiciae et Lodomeriae Josephi II et M. Theresiae...* of 1790 of Joseph Liesganig, scale 1: 28 800 and *Carte von West-Gallizien...* of 1808 of Mayer von Heldensfeld, scale 1:172 000.

<sup>2</sup> Measurements based on *Übersichts Plane Weischel Stromes...* 1:14 400, manuscript map of 1851–1852.

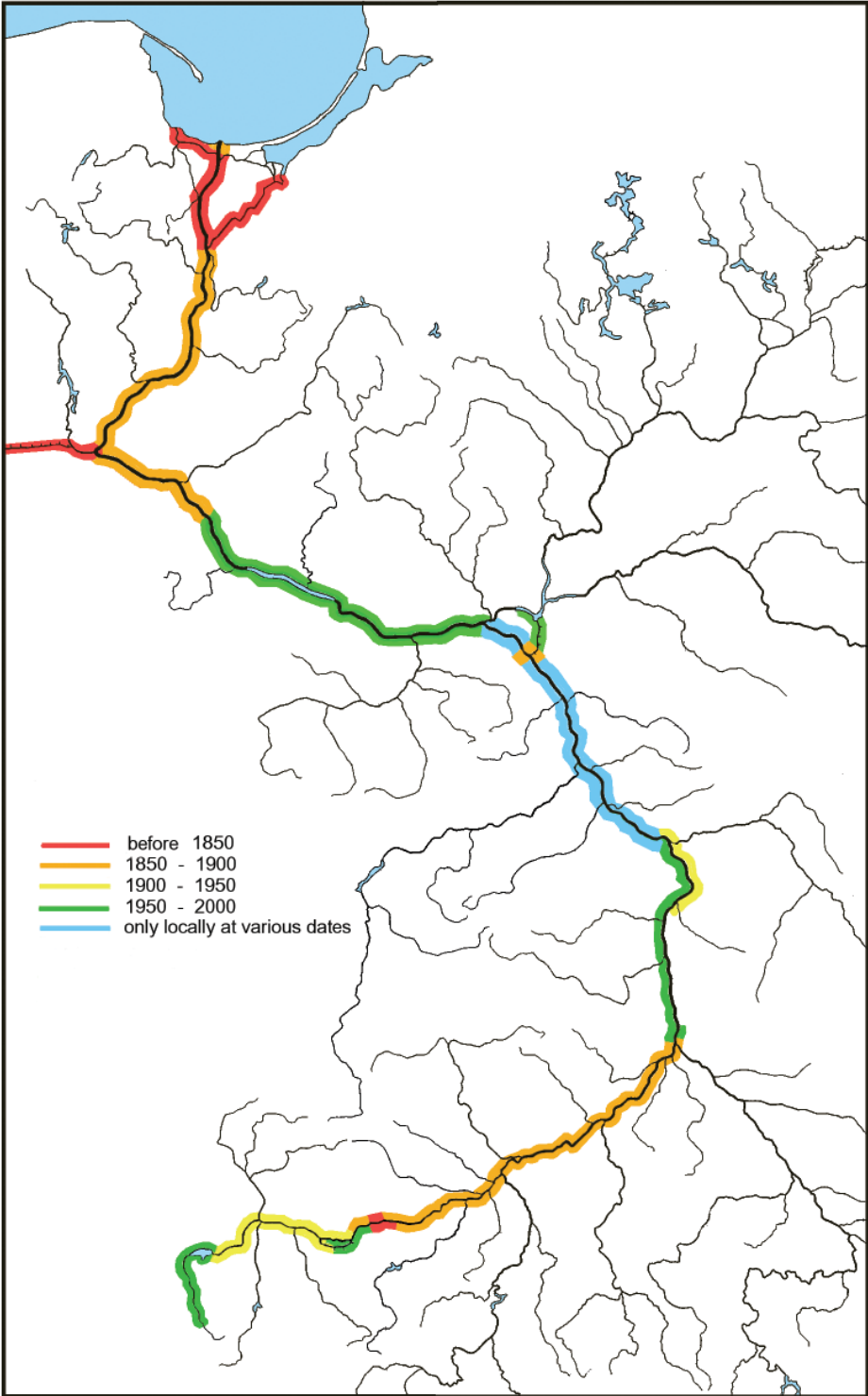


Figure 5. Times of regulation of the Vistula River channel  
 Source: elaborated by J.Plit and J.Warowna

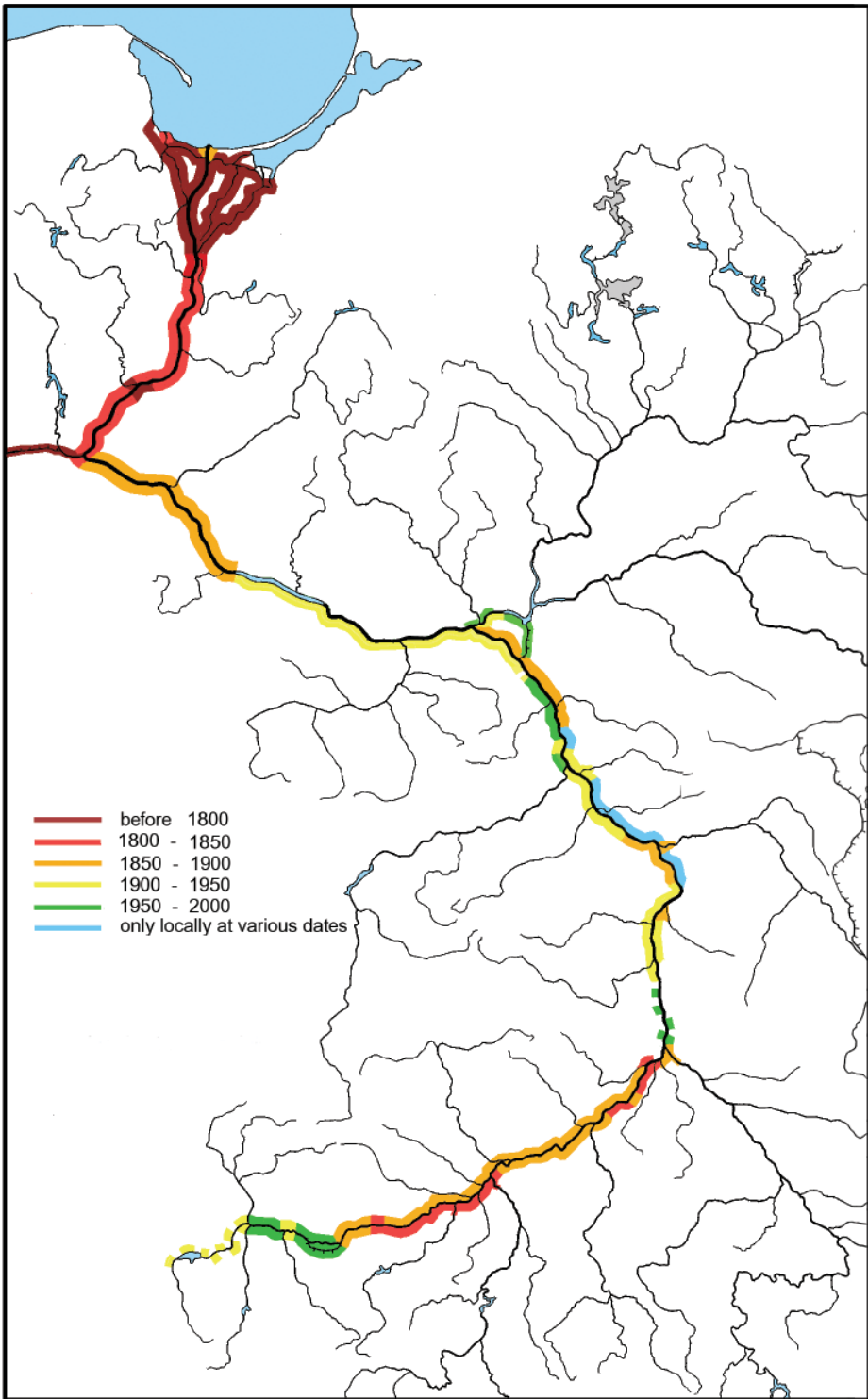


Figure 6. Times of embankment of the Vistula River  
 Source: elaborated by J.Plit

The substantial narrowing of the flood channel resulted in repetitive breaking of flood embankments and the formation of crevasse splays (Gębica *et al.* 1998).

#### THE VISTULA IN THE GAP THROUGH THE UPLANDS

The Vistula valley in the gap section (see Figure 1 and Table 1) was continually deforested from the Middle Ages on. Channel mobility depended on valley width. At sites where the valley was narrower, the river was confined in the same location. Still at the beginning of the 19th century, the Vistula meandered in certain sections, and flowed in two or three parallel winding branches. The main channel shifted from one bank to the other. Numerous islets stabilized by vegetation were formed at that time. The abandoned meanders or flood channels of the Vistula were often used by the tributaries (Kalicki and Plit 2003).

Changes in river character occurred in stages, especially after the series of large floods in the 19th century. The river deposited numerous bars, formed islands, and occupied an extensive area. The width of the meandering channel was 100–200m, while that of the braided channel was 300–1500m (Warowna 2003). The average annual rate of bank erosion was 3–9m.

In the 19th century, an increase in the size of particles deposited on the floodplain (from mud to sand) was recorded (Falkowski 1967), and a change from a sinuous channel to a wide, shallow and straightened one with shifting bars. This transformation resulted from accelerated outflow of water and sediment load through the channelized reaches of the Upper Vistula and tributaries (Warowna 2003). The sedimentation of sand in the upper part of the gap reached 1m (Falkowski 1967). The channelization works performed partly in the 1920s and later between 1960 and 1990 resulted in a narrowing of the mean water level channel (by a system of dams and groynes) to 120–300m and to the cutting off of side branches by dykes (Figure 7). The width of the bankfull channel is 500–600m. The lateral erosion was

limited to short, non-channelized reaches (locally reaching 20–100m in 1980–2003) and to the formation of bank failures, which are several meters deep and tens of meters long, to the leeward of dykes. Sandy material transported as bedload was accumulated between the artificial structures in the intra-groynes areas. Based on the volume calculation, the average sedimentation rate was 1.3 million m<sup>3</sup> per year. The polders have filled up to 2m above mean water level and a new man-made terrace is being formed. This floodplain terrace may be up to 350m wide. Its flat surface is slightly inclined towards the river or raised as a levee-like form near the channel, and, then, descends towards the natural flood plain where backswamps occur. The intra-groyne sedimentation is accompanied by downcutting in the active channel axis. Evaluation of the incision rate is hindered by migration of the bed bars, which causes fluctuations in the floor heights of up to 2m per year (Warowna 2003). The presence of groynes results in the formation of potholes up to 12m deep.

#### THE VISTULA VALLEY IN THE MAZOVIAN REACH

After leaving the gap, the Vistula used to transform its main channel, chiefly in the locations where the valley widened. As recently as in the 18th century, the Vistula was still meandering in the central section up to the confluence with the Narew. After the flood of 1813, the Vistula used 2, or more rarely 3, branches. In certain sections it became a braided river with channel width reaching 1000m (Plit 2004). Over the last 250 years, the width of the belt where the channel shifted was 1–4 km (Falkowski 1967). This process was limited artificially to the intra-embankment width in the 19th century (Figure 6). The narrowed sections of the valley are related to the presence of rocks resistant to erosion (clays mainly) and are characterized by a deeper channel and strong lateral erosion. The embanking of the river was performed successively, section by section. It started after the catastrophic floods in 1844 and 1888/1889, but the undertaking was ended after the Second World War.

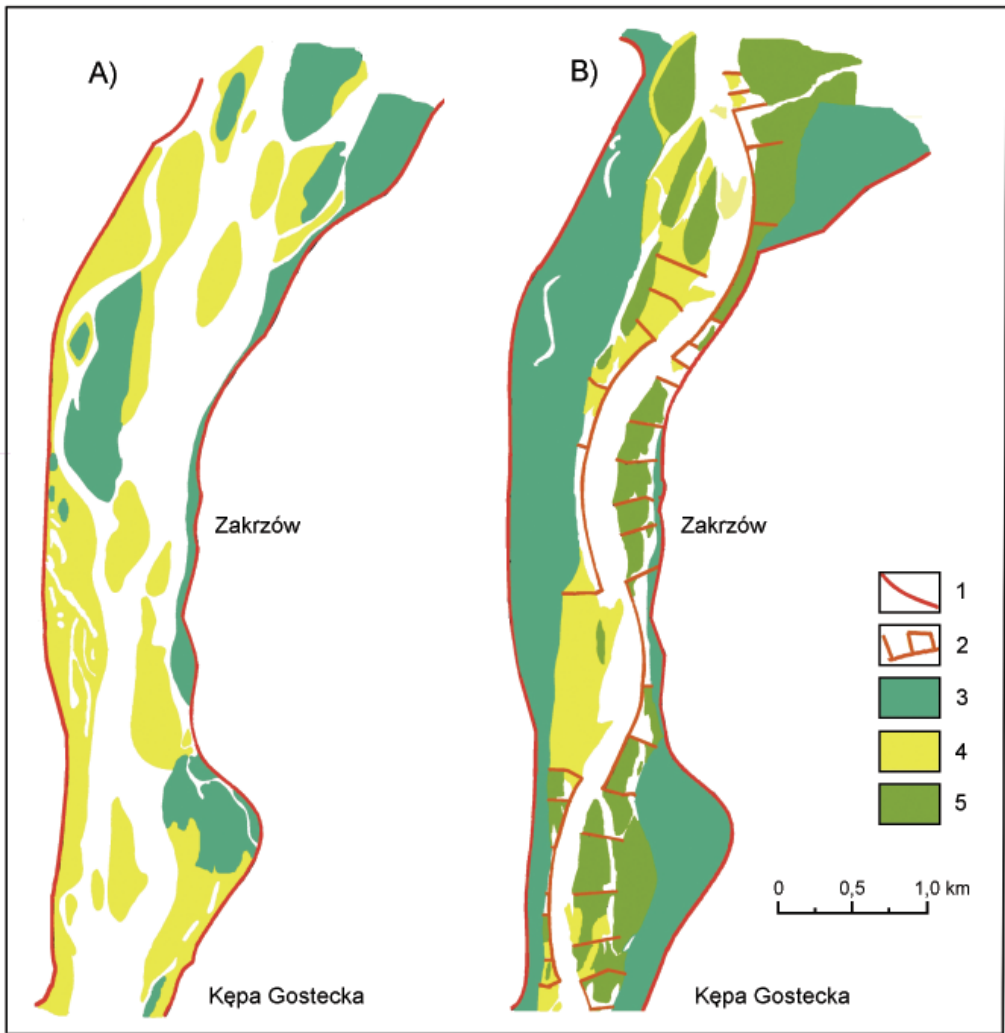


Figure 7. Changes in channel and floodplain form caused by the regulation in the middle course of the Vistula River between 1960 (A) and 1995 (B).

- 1—embankments, 2—various regulation constructions, 3—bars revegetated before 1960, 4—active channel bars, 5—bars revegetated after new regulation works.

Source: elaborated by J. Warowna

Antierosional protection was provided for bridge pillars, industrial plants and the urbanized area of Warsaw. In this reach, the lateral erosion may rise to 4–5m per year. In Warsaw channelization started after the flood of 1884, when the river channel shifted 500m eastward. The reach was regulated

by longitudinal works and rip-raps, so the channel narrowed from 500–700m to 340m. Successively, particular side branches were cut off, so the whole flow concentrated in one main channel. Due to highly resistant clay deposits exposed in the bottom, downcutting does not occur despite the fact

that the channel is narrowed (Jacewicz and Kuźniar 2000).

In the 18th and 19th centuries, the lower Vistula downstream of the Narew mouth was a braided river with bars and islands. Two or rarely three parallel troughs functioned in short sections in the 19th century. On the valley floor the series of troughs, which evidence a parallel shifting of the river, are preserved. Abandoned meanders occur only locally, in places where the valley widens. In this area, which was under Russian rule up to 1918, the first flood control structures and regulation works had been initiated by the end of the 19th century (Babiński 1992).

The reach downstream of Warsaw, where singular groyenes do not modify the braided pattern of the river, was not channelized until the 1960s. At present, the mean flow channel has been narrowed to 300m. The primary width of the braided river bed was 1.1–1.6km, with a mean water table width of 0.6–0.9km. The patterns of the side bars and river current vary and 60% of the bank lengths are eroded. Migration of the channel bars follows at a rate of 0.6–1.4m/day (Babiński 1992). However, the construction of the reservoir in Włocławek in 1969 modified the ongoing processes. The backwater affects a 58km section upstream of Włocławek. The amplitudes in the water table reach 2.2m. The lateral erosion has give way to abrasion and mass movements (affecting 45% of bank lengths), which were most intensive in the first years just after reservoir construction. The edge of the morainic plateau retreated by 150–200m in places. After the ice-jam flood of 1982, the low inundated islands have been removed and up to 1.5m high sandy-gravel protective benches have been set up along 15% of the banks (Banach 1994). The reach below Włocławek was channelized in the 1950s, but ca. 25% of the banks are eroded at present (Banach 1998). Downstream of the reservoir, downcutting reached 2–3m in the first 20 years, over a distance of 3km from the dam. Downstream erosion is ceasing gradually (Babiński 1992). Armouring of the bottom with cobbles is a protection

against the ongoing erosion. Accumulation forms appear just 25km down from the dam. The material building those forms is much coarser when compared with that known from the pre-reservoir years.

The formation of an ice cover, flow of ice floes and ice jams are independent factors modelling the bottom and banks of the channel (Grześ and Banach 1983). The shores of Włocławek Reservoir are deformed by thermal expansion of ice causing ice-plough ridges to form. Those ridges can be several tens of centimetres high and up to 1.5m wide (Banach 1994). The ice floes drifting downstream damage the unregulated banks, while ice-jams divert the current towards the distributary troughs, reactivating them or triggering downcutting downstream of a jam. It is believed that still-existing unregulated river reaches are ice-jam generating.

#### THE VISTULA VALLEY IN THE KUYAVIAN-POMERANIAN REACH

The first regulation of the partly braided and partly anastomosing lower Vistula in the areas formerly under Prussian rule was performed in the 18th century. The hydro-technical works comprised the construction of groyenes and dykes or rip-raps, the clearing of the willow thickets from the channel, the levelling of the bottom and narrowing of the channel, the shifting of the river bed and the construction of a canal connecting the Vistula and Oder rivers. Modernization and banking up ended in 1880–1892.

Up to the end of the 19th century, it was accumulation processes that occurred, then regulation followed. Channel deepening was intensified after the shortening of the outlet to the Baltic Sea in 1840, and in the years 1895–1915. The deforested floor of the Vistula valley was then used as farmland and meadows. Frequent catastrophic floods in the 19th century caused people to abandon settlement and cultivation in the floodplain.

The Lower Vistula was channelized systematically in the last 25 years of the 19th century (Figure 4). The regulatory measures were miscellaneous. The channel was narrowed to 350–375m, but in the delta both

branches were narrowed to 250m and 125m, respectively. Accumulation of the sandy-silty deposits in polders between the groynes and on the regulation structures reach 3.4–4.2m above the river level (Szymańska 2000). The channel capacity decreases, because the deposition at the channel banks is larger than the volume of the eroded material. The man-made terrace is 375–450m wide (Babiński 1992), and is higher in the narrowed parts of the channel. The formation of levees 2–20m wide and up to 1m high, which separate decantation pools up to 1.8m deep and 36m wide, is observed. The mean depths of the channel upstream of Fordon were 1.6–2.0m (at widths of 730–780m) prior to channelization, but the minimum depths decreased to 0.7m. Since the mid-1970s, depths have been reaching 3.0m. As a result of the channelization, this section of the river is straight, with alternating bars and pools.

#### THE VISTULA DELTA

The Vistula delta has been deforested for centuries, subjected to intensive farming, and dissected by a dense network of artificial drainage canals. Both the rivers and the canals were embanked. At the beginning of the 19th century, the Vistula entered the Baltic sea using three branches. The majority of flow was concentrated in the right branch. According to Majewski (1969), in the 19th century, this branch of the river used to shift the landline 25–30m offshore per year. The embankments confined accumulation to the intra-embankment area and to the fans, explaining why the Vistula channel is located higher than the surrounding plains. The delta was inundated very often. Snowmelt floods were particularly hazardous, as the flood wave entered the still-frozen lower Vistula and the Gulf of Gdańsk. In February 1840, the left branch of the river was ice-jammed. The flood wave formed a new outlet route ca. 14km shorter, which started to form a fan-delta quickly, while the accretion of the old delta was hindered. Some hazardous floods (especially ice-jammed ones) in the 1880s, forced a 9km long shortcut and the formation of an artificial outlet allowing 90% out-

flow of Vistula water. Higher embankments were built and the intra-embankment area broadened. The original natural outflow routes were abandoned (Makowski 1997). Once development work ended, river alluvia ceased to fertilize the delta. Accumulation in the form of an underwater delta occurs at the bottom of the Gulf of Gdańsk.

#### THE ROLE OF FLOOD EMBANKMENTS

Construction of the flood embankments and confining of the peak flood flow zone has been carried out progressively since the mid-19th century (Figure 6), although long embankments have been present in Żuławy since the beginning of the 14th century (Makowski 1997). In the Upper Vistula, the gap between the embankments is of 600–800m (Czajka 2000), increasing to 900–1500m downstream of the junction with the San. However, this zone shrinks to 600m occasionally, due to bridging, or to 450m, if the old embankments are located closer to the river channel. In the Mazovian Lowland, the width of the intra-embankment area is 1000–1700m, excluding within Warsaw where it is narrowed to 400–600m (Jacewicz and Kuźniar 2000). Downstream of Włocławek, the gap between the embankments is 1000–1500m. Reduction of the flood sedimentation area to 25–40% of the primary one causes fast aggradation in the intra-embankment area, and the formation of a new terrace level in the channelization zone (Warowna 2003). In the Oświęcim Basin, accretion of a 1.5m thick layer has been noted since the 1950s (Czajka 2000). If the embankments are broken, as during July 1997, flood crevasse troughs up to 300m long and 10m deep form, as well as crevasse splays to one kilometre long and 0.7m thick (Gębica *et al.* 1998).

#### SEDIMENT TRANSPORT, DEPOSITION AND LOADS

The north-facing slope of the Carpathians is the major source area of material supplied to the river as dissolved and suspended loads



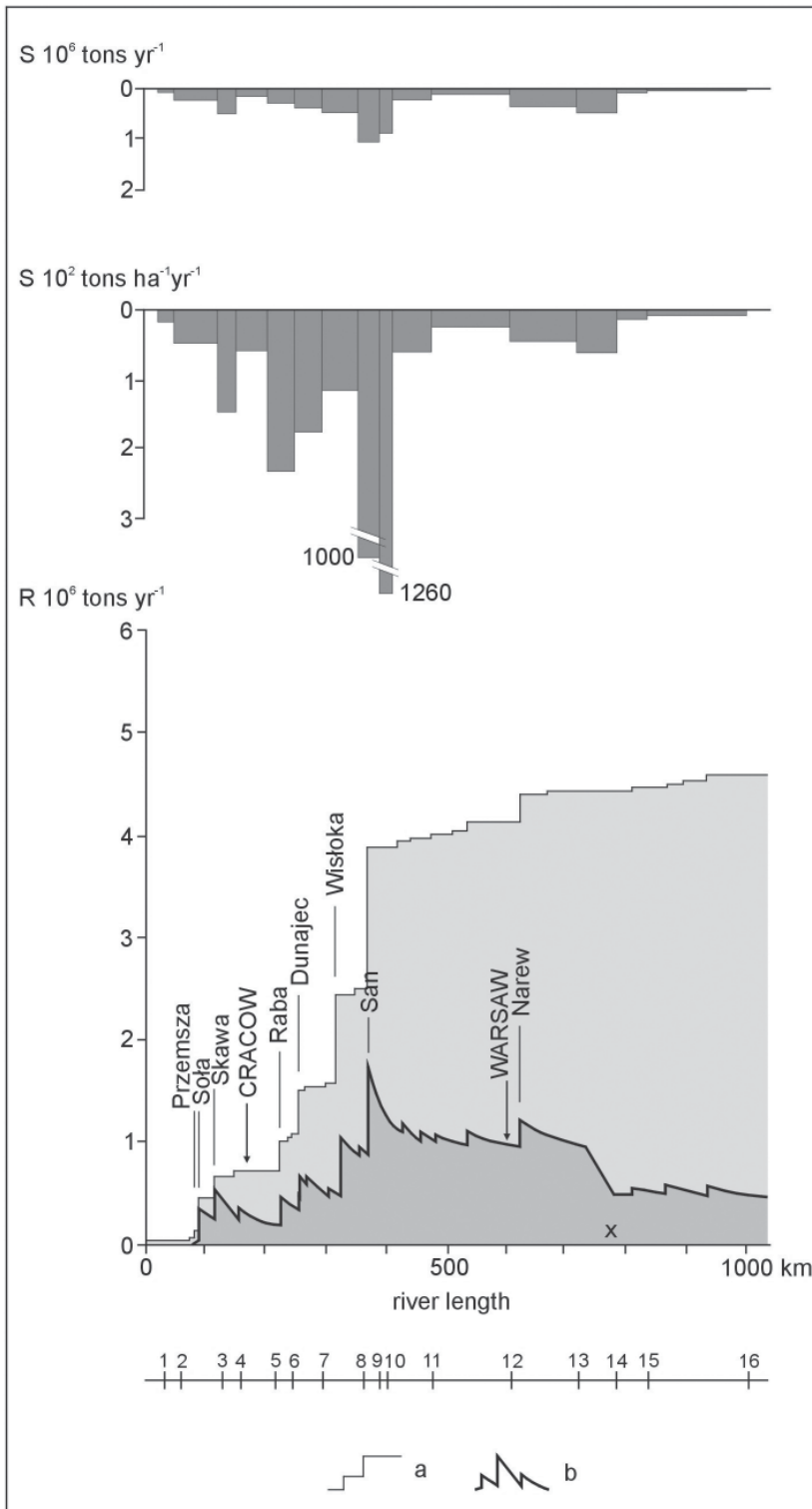


Figure 8. Differentiation of mean annual suspended load  $R$  (in tons) along the Vistula River between 1946 and 1995.

and as bedload (Brański 1974; Maruszczak 1984; Łajczak 1999). The role of the Polish Uplands in this supply is less significant, the lowland area making a minor contribution. The average suspended load transport in the Carpathian, upland and lowland parts of the Vistula drainage basin is of 200, 10 and 3t/km<sup>2</sup> per year respectively, while the average dissolved loads are 100, 60 and 45t/km<sup>2</sup> per year (Maruszczak 1984; Łajczak 1999). Only in the mountain area of the Vistula drainage basin does suspended load and bedload transport predominate. In upland and lowland terrain, the level of ionic transport is several times greater than suspended-load transport. In the mountain and upland tributaries of the Vistula and the stretch of the main river in the Carpathian foreland does suspended material dominate the bedload load (Brański and Skibiński 1968; Froehlich 1982).

The rate of suspended-load transport offers only indirect evidence of erosion intensity in a catchment. Downstream in a river, any estimation of erosion magnitude in the drainage basin becomes more and more difficult. The losses in transported suspended load are expressed by reference to the sediment delivery ratio (DR), which indicates the percentage of entrained material which flows out at a gauging site. This ratio decreases downstream, and in sub-catchments of the order of 10<sup>2</sup>–10<sup>4</sup> km<sup>2</sup> in area it reaches from a few to a dozen percent (Maruszczak 1984). In the mountain catchments this ratio is higher. In the small catchment of a stream, cart tracks and forest ways can supply about 80% of the suspended load to that stream (Froehlich 1982; Froehlich and Walling 1992). On the scale of the whole drainage basin of the Vistula, DR does not exceed 1% as a result of the presence of many res-

ervoirs. The contribution of suspended load to the overall transport of clastic material shows a downward trend downstream in the Upper Vistula, and varies from 90% to 70%. In the lowland tributaries, suspended-load transport amounts to 50%, if 23–28% in the lower Vistula, according to Babiński (1992). The examination of the grain-size composition of deposits in the Carpathian reservoirs confirms the dominance of clay-silty particles (Łajczak 1999). In Włocławek Reservoir, the silty-clay deposits only dominate in the deepest parts.

The mean annual suspended-load transportation in the Vistula increases suddenly at the mouth of tributaries, and then decreases between river junctions (Figure 8). Among the Carpathian tributaries, the San supplies the largest load to the Vistula, i.e. 0.8 million tons per year. The greatest transport of suspended load occurs in the stretch of the Vistula downstream of the San river mouth, where the average load was ca 1.6 million tons in the second half of the 20th century. The magnitude of the transported load prior to dam construction was estimated at 2.3 million tons (Łajczak 1999). In the lower reach of the Vistula, prior to construction of the Włocławek Dam (in 1968), the magnitudes of transported loads were steadily graded over the whole length of the river. After the reservoir came into use, the magnitude of the load decreased to 0.5 million tons.

The magnitude, seasonal and multi-annual pattern of transport and sedimentation in the Vistula have changed drastically due to human impact. Significant changes occurred in the 20th century due to channelization works and the setting up of hydro-technical structures (Łajczak 1995, 1999). The total supply from the tributaries was



a—hypothetical sediment load (without depositional effects), b—real sediment load  
 S—mean annual deposition (in tons/yr and tons/ha/yr. in the balanced reaches (calculation based on difference between successive measuring points). On the longitudinal axis indicated 16 hydrological stations (see Figure 1) and position of the dam in Włocławek.

Source: elaborated by A.Łajczak

of ca 3.6 million tons per year in the second half of the 20th century, the upland tributaries supplying 0.4 million tons per year and the lowland ones 0.5 million tons.

In the annual cycle, suspended-load transport in the Upper Vistula predominates in the summer months (June–August) over the spring months (March–April). The influence of the mountain tributaries decreases downstream. Therefore, in the middle reach of the Vistula, the early spring and summer transported load are similar, while in the lower reach it is spring loads that predominate. Downstream of the dams, transported loads have started to even out during a whole year.

The effects of human impact are most noticeable when multi-annual changes in suspended load transport are analyzed. Upstream of the Cracow surroundings large changes in transport in the second half of the 20th century were related to the supply of physical pollutants to the river (mainly from coal mines via the Przemsza river). The size of the suspended load increased up to 1970, reaching double the value of the period 1946–1950 (from ca 0.2 to 0.4 million tons respectively). Up to the mid-1980s, suspended-load transport decreased rapidly, the following years bringing a stabilization at a lower level than before 1950 (Łajczak 1999). Downstream of Cracow, up to the mouth of the river, the suspended load transport showed a downward trend. This is related to a larger number of reservoirs set up and to changes in land-use (a reduction in the area of arable fields). The most significant decrease, by a factor of six, occurred in the lower reaches of the San river in 1946–1995, as an effect of significant changes in land use within the river catchment post 1947. Despite human induced changes, the influence of hydroclimatic factors on the multi-annual pattern to suspended load outflow is still evident. In the Carpathian tributaries and along the whole course of the Vistula to its mouth, almost decade-long fluctuations in suspended load transport result from the major floods which occur every few years.

The suspended load settles partially on the floodplain during floods (in the intra-embankment area at present) and in reservoirs. The average annual losses in transported load attest to intensified overbank sedimentation and have been calculated for successive river reaches between the gauging stations, according to the input-output method, for the period 1946–1995. They show an upward trend along the whole Upper Vistula (Figure 8). These losses diminish considerably downstream, and only beyond the Narew mouth and in the backwater stretches of the Włocławek Dam are they larger. Accepting that, since the beginning of the 20th century it is channel deepening, initiated by channelization, that predominates, the accumulation of suspended load can only be related to the intra-embankment area. The overbank accumulation increases along the Upper Vistula and reaches almost 1000 tons/ha beyond the San confluence. This fact is confirmed by the complete filling of abandoned channels, which were cut off there at the beginning of the 19th century, and by accretion of the Vistula floodplain in the gap stretch (Maruszczak 1982; Łajczak 1999). In contrast, the morphology of older abandoned channels of the Vistula located upstream is still visible. In effect, shoaling of this reach of the Vistula takes place and results in prolonged overbank flooding leading to greater floodplain sedimentation (Łajczak 1999; Warowna 2003). In further stretches of the Vistula, to its mouth, overbank sedimentation decreases to ca 10 tonnes per ha per year, and just between the Narew river outlet and the dam in Włocławek it exceeds 50 tons per ha per year. Repeated surveying indicates that the accumulation of suspended load in the intra-embankment area occurs at the highest rate in the zones occupied by natural levees, and at the lowest rate in the vicinity of the flood embankments.

Two reservoirs on the Vistula River play an important role in sediment storage. The Goczałkowice Reservoir, stopped storing suspended load durably after 20 years in operation, though it captures the entire bedload. The Włocławek Reservoir stores half

of the incoming suspended load and the entire bedload. The influence of this reservoir on the transport of suspended load in the lower reach of the Vistula has varied over time, depending on reservoir shoaling and dragging. Small dams on the Vistula River near Cracow hardly stop suspended load at all. The most significant reduction in sedimentation, even by a factor of five, has been noted downstream of the mouths of tributaries on which deep reservoirs are located.

## CONCLUSIONS

From its mountain reach, via the foremountain basins and the upland belt, as well as through the lowland zone down to the delta at the outlet to the Baltic Sea, the Vistula valley is currently modelled by a river whose hydrological regime is complex. Besides the summer floods related to extreme rainfall occurring in the mountains, thawing floods also occur and are often combined with ice-jams (such floods becoming more significant downstream in the river). The floods triggered in the mountains lose their impetus in the foreland, where the inundating rivers leave behind a considerable load of transported material.

The significant deforestation of the drainage basin prior to the 19th century led to a change from a meandering to a braided channel pattern in the Upper and Middle Vistula and to a change from an almost anastomosing or winding pattern to a braided one in the lower reaches. Ice-jam floods, especially in the middle reach, have resulted in channel shifting and avulsion in widened sections.

Channelization started in the mid-19th century in the areas which were formerly under Austrian rule (the upper reach) and Prussian rule (the lower reach). This resulted in channel braiding in the middle reach, as well as progressing delta aggradation and simultaneous channel deepening in regulated reaches (Figure 9). Since the beginning of more extensive channelization in the first three decades of the 20th century, a gen-

eral increase in transport and in overbank sedimentation due to channel deepening has been observed. In the following decades, the rates of transportation and sedimentation declined as more deep reservoirs were constructed. The channelization and simultaneous intensified chemical pollution caused the natural Vistula River to take the role of a canal directing the water surplus out of the drainage basin. The diversity of channelization works undertaken in the second half of the 20th century, combined with the setting up of reservoirs and dams on the Vistula and its tributaries, brought about changes in the size of transported and deposited material, and in effect, aggradation in the intra-embankment zone at many locations, the formation of a man-made terrace and an exceedance of maximum water stages hazardous to the whole floodplain (Figure 7). The role of major floods has become more important, so the unconstrained flow and river load transport over the whole river length are possible only during extreme floods, while aggradation can occur on the whole floodplain. The milder winter seasons (with a lesser hazard due to thawing floods) seem to influence the transportation of the river load positively. Ice-jam floods occur rather rarely, due to severe water pollution and a rise in water temperature. On the other hand, the power-generation function of the reservoirs has a negative influence on flood control safety. The Vistula floods downstream of the Włocławek Reservoir which occurred in 1982 and at the beginning of April 2006 are good examples here.

The changes in land-use (especially reduction in arable area) observed in the last 20 years favour decreases in suspended-load transport and in aggradation. The summer floods favour channel-deepening in the upper reaches of the rivers, but simultaneously increase the hazard of sudden floods downstream. This may lead to changes in valley-floor management, and to more rigorous compliance with water management rules. The widening of the intra-embankment zone and withdrawal of settlements and infrastructure from flood areas will become

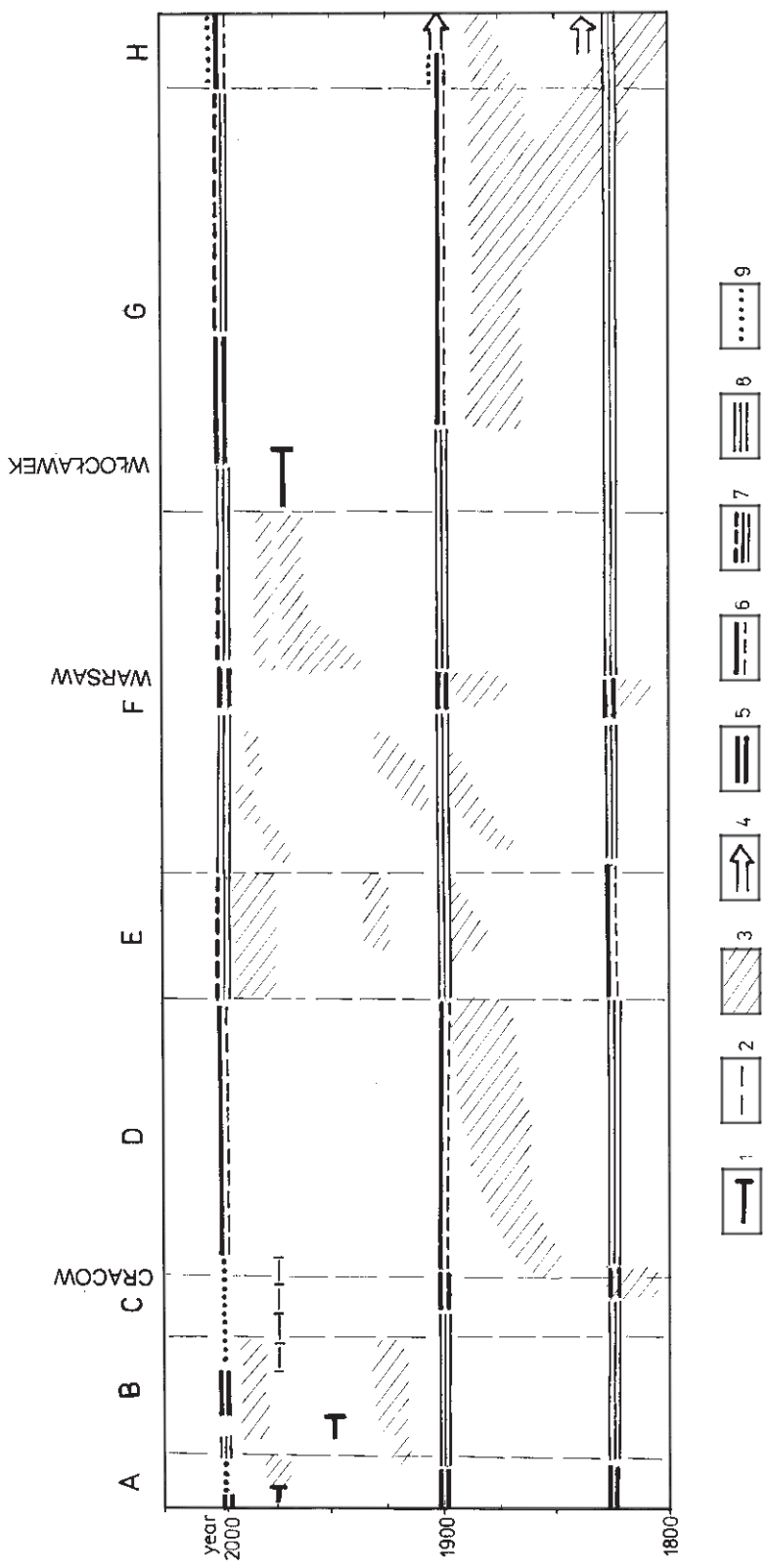


Figure 9. Channel regulation, embankments and erosional-depositional tendencies in the longitudinal profile of Vistula River during last two centuries.

- 1—water reservoirs (time of construction), 2—water steps and weirs, 3—main periods of channel regulation and construction of dam, 4—new outlets of Vistula River to the Baltic Sea, 5–9—main trends of fluvial processes in three time transects: before flood series in 1840s at the beginning and at the end of 20th century; 5—distinct tendency to downcutting, 6—downcutting prevailing over aggradation, 7—aggradation prevailing over downcutting, 8—distinct tendency to aggradation, 9—river section transformed to canal.

Source: elaborated by L. Starkel

necessary, as will reconstruction of natural channel patterns and riverside plant communities. Extensive polders for temporary flood water storage will need to be built, especially if we consider the increase in flood frequency during the progressive climate change. All these tasks are foreseen, but may not reach the investment stage. Restoration of fluvial ecosystems through reduction of the input of sewage and industrial pollutants has to progress simultaneously.

When comparing the Vistula with those Western or central European rivers whose headwaters are located in mountains (examples might be the Rhine, Elbe, Oder, or Danube (Petts *et al.* 1989), we can conclude that Vistula never attained any uniform system of channel regulation. The river still bears the 19-century traces of the different models of water management applied independently by each of the three countries then occupying partitioned Polish territory. For each of these countries, the Vistula played only the a marginal role of a frontier river.

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## BOOK REVIEW

*Hungarian Spaces and Places: Patterns of Transition*, edited by G. Barta, É.G. Fekete, I. Kukorelli-Szörényiné, J. Timár, Centre for Regional Studies Hungarian Academy of Sciences, Pécs, Hungary, 2005, 595 pp.—Dariusz Świątek

No more than five years ago the 10th anniversary of the transition in central and eastern Europe (CEE) was widely discussed (Lavigne, 2000), yet the 15th anniversary went almost unnoticed, without a large number of conferences, special issues of journals, reports, books, etc. However it did not pass completely unnoticed, now over 15 years since the beginning of the transition from state socialism to capitalism, some researchers are arguing that this process is nearing the end, and some even announced its end. The group of Hungarian geographers re-assessed 15 years of changes in Hungary in book *Hungarian Spaces and Places Patterns of Transition*.

The book contains five parts which are created from 33 papers, preceded by a short but very useful introduction on transition issues in Hungary. Each paper makes one chapter which gives the impression that the whole book is rather a compilation than a coherent study. Having 33 authors in one book means it is difficult to shape it differently. To do justice it should be mentioned that the four editors made every effort to arrange the book in the way that makes it easier to move through the complex problems identified by the different authors. Apart from two parts on the direct and indirect impacts of political, economic and social transition, the book contains three parts on new patterns of spaces, places and uneven development in Hungary. The analyses of these changes show the effects

of transition in different contexts, places and spaces.

At the beginning the study deals with regionalisation, an important contemporary Hungarian issue. As majority of authors from the first part of the book suggest, regionalisation is an inevitable process, not only because of Hungarian presence in international structures like EU or NATO, and globalization or modernization influences, but mainly because of national economic growth. A number of questions arise, such as whether new regional structures should be connected to public administration, how resources should be redistributed among the regions or how to reduce governmental control. These questions are answered in different ways in the first part of the book, dependent on the authors' views. However what seems to unite almost all of papers is belief that special attention should be paid to settlements and regions which are not integrated into the network regions. From all the chapters in this part of the book, we can draw the conclusion, expressed in one of the chapters, that regionalisation still needs long-term purposeful preparation.

The processes that have changed Hungarian economy since the beginning of the nineties re-made also spatial perspectives; new differences and inequalities appear in different areas and places of public life. The second part of the book *Spatial Processes in the Economy in the Era of Transformation* presents a number of empirical studies which deal with major sectors of economy like: agriculture, industry, service and retail. The main conclusion that arises from almost all these chapters is that Hungary is experiencing significant and increasing polarisation of economic space. This division is created by Budapest and adjacent regions on one hand,

where the majority of industrial investments, financial services or ICT (Information and Communication Technologies) sector are located and on the other hand by rest of the country experiencing considerably lower economic activity.

Transformation also influenced the shape of Hungarian social space. New problems appear and others which were very often were hushed up during communism now become more visible. One of the most noticeable and probably unwanted results of changes was creation of unevenness which leads to such phenomena like poverty, social exclusion or segregation. Social problems exemplified in the book were oscillating around work, gender inequalities, and ethnic problems. All were depicted in the chapters grouped in the third (*Social trends in transition*) and fourth (*Changing places and spaces*) parts of the book. One of the most interesting examples shown here was the emergence of non-governmental organisations (NGOs). The analysis of this phenomenon in the context of Hungarian public life brings also questions about the consolidation of the democratic regime in Hungary. Unfortunately none of book's chapters is devoted to the policy issues which seem to be essential in the context of shaping both social and economic reality.

According its title, *Changing places and spaces*, the fourth part of the book seems to be the core of the volume. This part begins with an analysis of employment in Hungary (both rural and urban areas) and goes further to illustrating changes of Hungarian urban network in context of access to good and services, location of knowledge based investments, innovations and globalisation processes. Once again we can observe strong polarisation but this time of Hungarian urban space, with Budapest and regional centres on one side and the rest of the towns on the other. This impression of polarisation is underlined by two chapters that focus on cultural investments and architectural changes caused by new global trends in Budapest. All the chapters in this part

contrast with the two last chapters not only because they describe transition of rural space and small villages, but also because these chapters include lists of suggestions for rural policy-makers which should lead to economic activation in this areas.

Euroregions and cross-border cooperation are the main topic of the last part of the book. All the chapters that deal with these issues include an extended historical background. After the First World War, the country was deprived of 2/3 of its territory and about 30% of its inhabitants (Kocsis 1998) and this fact in essential factor in shaping local cross-border cooperation, which seems to be very important in context of European integration. The last two chapters of this part raise problems of protection areas located along country borders giving good examples of good cooperation from Hungarian borders.

Besides the aforementioned lack of analysis of political changes, a picture of the changes in other areas of public life like education, health care or administration is also missing. However readers will find interesting in-depth analyses of changes that take place in Hungarian 'places and spaces' between 1990 and 2005. The majority of the book has an empirical character, which helps the reader to understand the nature of changes that took place in Hungary within last 15 years. The book can be recommended not only to readers interested in Hungarian changes but also to those interested in broad transformation processes.

Five years ago Hungarian economist Janos Kornai stated that although economic transformation in Hungary was not over yet, transition certainly was. The system had become capitalist. What was missing from a successful transformation was a set of broadly- understood institutions that would shape contemporary Hungarian space (Kornai 2000). Five year later after reading *Hungarian Spaces and Places Patterns of Transition* we can boldly abide by this statement.

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## REFEREES AND ADVISERS TO GEOGRAPHIA POLONICA 2005–2006

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