IUCN European Programme

BUG RIVER VALLEY AS THE ECOLOGICAL CORRIDOR

STATE – THREATS – PROTECTION

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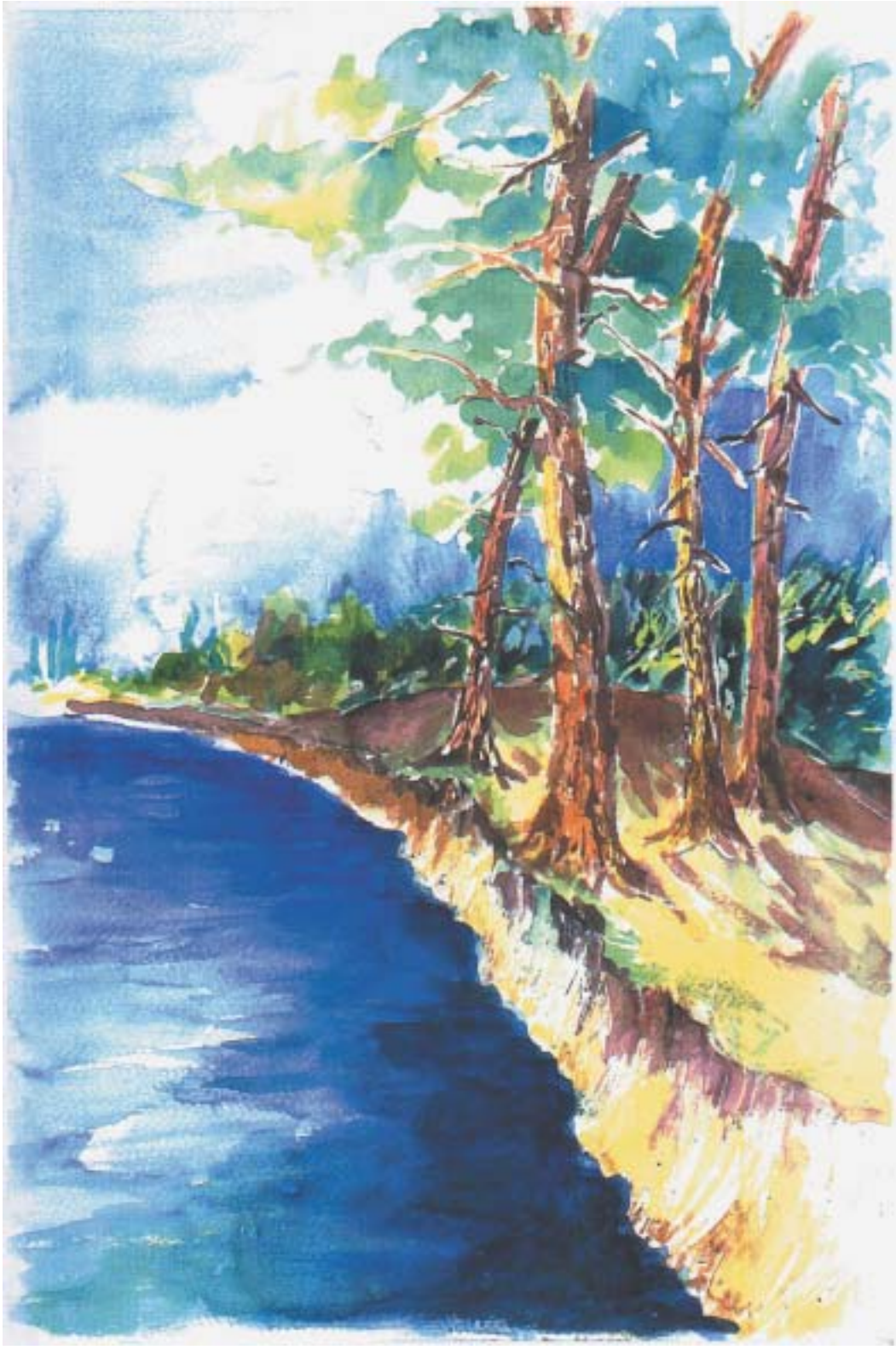

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The Institute for Forestry and Nature Research (IBN-DLO) and Foundation IUCN Poland acting as IUCN Office for Central Europe would like, on behave of experts teams in Belarus, Ukraine and Poland, to express their gratitude to the Ministry of Agriculture, Nature Management and Fisheries of The Netherlands for its financial support for the project administered by IUCN – The World Conservation Union.

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From the Publisher

In the early 1990s IUCN – The World Conservation Union has began to develop a new initiative which took into account the need to create an integrated pan-European system concerned with the conservation of the natural heritage of the whole continent.

In November 1993, at the International Conference "Conserving Europe's Natural Heritage – Towards a European Ecological Network" in Maastricht, under the auspices of the European Commission, the General-Secretariat of the Council of Europe and by IUCN – The World Conservation Union, participants gave their full approval of the concept of ***E****uropean* ***Eco****logical* ***Net****work (EECONET) in the Conference Declaration.*

The Ministerial Conference in Sofia in 1995 has adopted The Pan-European Biological and Landscape Diversity Strategy, with among others Action Team 1 – Establishing the Pan-European Ecological Network and Action Team 6 – River ecosystems and related wetlands. Under the latest, eight rivers in Europe, among others Vistula and Bug river, were listed as river ecological corridors of major importance for establishing and functioning of the Pan-European Ecological Network.

In support of the above mentioned initiatives, in 1993 the IUCN European Programme started series of projects to develop National Ecological Networks (ECONETs) in four Easter European countries (Hungary, Poland, Czech and Slovak Republics), a well as to evaluate the status of rivers ecosystem conservation in Central and Eastern Europe. As a result several reports have been published, among others, "Vistula as an Ecological Corridor. State – Functioning – Threats" (1995) and "Odra as an Ecological Corridor. State – Functioning – Threats" (1995), River Corridors in Hungary (1995).

In 1997, IUCN Office for Central Europe and the Dutch Institute of Forestry and Nature Research acting as the Dutch partner and coordinating the project on behalf of the Dutch government, have started, having first acquired the approval of the authorities responsible in each country, a project called ***Natural values of the Bug river valley: state – threats – conservation,*** *focussing on:*

- *preservation and restoration of the biological diversity of the Bug river and its valley.*
- *promotion of the nature values of the Bug and its valley.*

- *starting long-term international cooperation between Poland, Ukraine and Belarus in order to design and implement a sustainable management plan for the conservation of nature in the Bug river valley.*

The presented book is an abridged English version of the full report published in Polish. In addition, there are separate reports made available in Ukrainian and Belarussian, which cover the parts of the river valley located within these countries.

The achieved results of the project contribute to implementation of several international initiatives having global, European and regional scope, e.g. the Convention on Wetlands of International Importance (Ramsar Convention), the Convention of the Conservation of Migratory Species of Wild Animals (Bonn Convention) and the Pan-European Biological and Landscape Diversity Strategy (PEBLDS).

The main part of the Polish section of the Bug river and its valley is included in the National Ecological Network for Poland (ECONET-PL). It therefore should be regarded as a priority area for nature conservation. By making a regional vision for the Bug area, the project provides basic information for physical planning of nature conservation on a national, regional and local level.

Subsequently, the regional vision provides with recommendations for nature protection and landuse priorities in all parts of the river and its valley. The vision emphasises international aspects of the Bug river and its valley, such as the international corridor function for plants and animals. The regional vision should be the basis for a national and international management plan for sustainable use and protection of the area.

While developing the recommendations provided, especially regarding landuse, the authors met the criteria laid down in the EU's conservation directives and regulations – in particular Habitats and Birds Directives and Rural Development Regulation. Thus the results of the project provide information for the designation of NATURA 2000 sites within the Bug river valley as well as recommendations regarding active conservation measures as agri-environmental programmes.

The publication is addressed to governmental institutions, international organisations, sponsors and non-governmental bodies interested in nature conservation. It can be used to establish priorities for actions aimed at working out the methods of nature conservation in the Bug river valley as a part of the European natural heritage.

It is believed that the presented results of the project and the recommendations being put forward will enable active and efficient protection of the Bug river valley as one of the last wild rivers in Europe.

The project has had international dimension involving scientists and conservationists from Belarus, Poland and Ukraine. More than 50 experts from those three countries have been contributing to this grate transboundary work. While sharing their ownership of the results with broad public, I would like to express on behalf of IUCN the appreciation and gratitude to all of them.

Dr Zenon Tederko
IUCN Office for Central Europe

Introduction from Project Leader

International cooperation between the Netherlands and Poland

In recent decades the political relationships in Europe have changed drastically. East and West have become closer, and in many areas polarisation has been superseded by collaboration. The Netherlands has sought to collaborate in the area of nature conservation with several Central and Eastern European countries. Poland has figured centrally in this from the outset, because of similarities in the conservation and management of nature.

Both the Netherlands and Poland have a predominantly agricultural landscape characterised by a large area of low-lying grassland with rivers and streams, floodplains and floodplain forest, swamps and lakes. In the Netherlands, intensification of agriculture in combination with other economic activities has led to severe degradation of the ecological features in the water-rich landscape. So far, Poland has largely escaped such developments, especially in the east of the country. Thus, in Poland there are wonderful areas that can serve as benchmarks when planning the rehabilitation of nature in the Netherlands. And, on the other hand, the experience accumulated in the Netherlands can be useful for protecting and managing nature in Poland.

European rivers

In the Netherlands, as in the rest of Europe, most rivers have been greatly influenced by human manipulation: their natural course has been changed, the levees have been reinforced to form dikes, and swamps and the floodplain forest associated with rivers have largely disappeared. In addition, the water quality has been severely reduced as a result of various types of pollution. The result of this is that in many places the plant and animal species that require clean water have vanished. One exception is the Bug river, which extends over parts of Ukraine, Belarus and Poland. Throughout its total length of 772 kilometres its course is natural. In the upstream there are hardly any dikes or other structures preventing the river from overflowing its banks. The steep-sided banks and sandy point bars testify that natural processes such as erosion and sedimentation are proceeding natu-

rally. The river valley contains many natural elements, varying from natural deciduous woodland and semi-natural flowery meadows, to abandoned meanders, river dunes, and swamps. In many places there are high densities of characteristic and rare species of plants and animals. The river valley is not pristine throughout, of course. Alongside the river there are dozens of villages, there are roads and bridges and, locally, there are forest plantations, arable farms, and industries. Nor is the water of the Bug totally pollution-free, though the effects of pollution have so far remained relatively limited. In spite of these infringements, the Bug is an area of nature of international significance.

From threat to protection

Economic development is still a threat to nature. Poland is in a phase of rapid development, and with the prospect of future admission to the European Union, the Polish agricultural sector will change drastically and the flowery unfertilised meadows, wet river valleys and other river-associated ecological features will come under severe pressure. This is why it is so important to safeguard the ecology along the Bug.

It was the uncertain future of the Bug that led to the project "Nature values of the Bug river: state – threats – conservation" being carried out as an international collaborative project. The project was initially developed under existing Dutch – Polish collaboration, but in the preparatory phase it soon became clear that Ukraine and Belarus should also be involved – for a river that flows over national borders can only be protected effectively with participation from all the countries in its catchment.

The aims of the project were to make an inventory of the existing ecological features, to identify threats to them, and to propose ways of safeguarding the most important areas in the future. One of the results of the project is this book, published in Polish, with an abridged English version. In addition, there are separate reports in Ukrainian and Belarussian, which cover the parts of the river that flows through these countries.

It must be emphasised that the final report is only the completion of the first step: actions that follow up the findings are needed at national, regional and local levels. Conservation plans will have to be drawn up for parts of the area, with the aim of having them declared protected areas. And then management plans will have to be drawn up for the effective management of the flora, fauna and riverscape.

Important results have also been obtained in the area of international cooperation. This is the first time that scientists and conservationists from Poland, Ukraine and Belarus have collaborated closely. There has been intensive discussion about the methods and techniques for inventorying and evaluating. The project was coordinated by the IUCN Office for Central Europe in Poland. As the coordinator from the Dutch side, I would like to express my appreciation of all the staff involved in the project. I hope that the results of the project will contribute to nature conservation along the Bug and to ongoing collaboration between conservationists in Europe.

Dr Jan Veen
Coordinator on behalf of the
Dutch Ministry of Agriculture,
Nature Management and Fisheries

Chapter I

Introduction from the Editors

The Bug river is one of the main trans-boundary rivers in Central and Eastern Europe – its springs are in the Ukraine, and the majority of its course creates the borders between Poland and Ukraine; and between Poland and Belarus. The Bug river belongs to the small number of European rivers that have maintained the natural character of the channel in the majority of their course up to the present day. It is the biggest river in Central and Eastern Europe, which has not been dammed, the flood embankments were created on a short – apart from the lower course – section, and the regulation works had a limited range. The location of the river in the boundary zone and its vast distance from big urban centers supported the preservation process of natural assets on the major area of the Bug river valley. Due to the conditions mentioned above, the Bug river, in addition to the Vistula river, was included in the category of Pan-European ecological corridors. The systems of both rivers were put on a priority list of regions for watercourse protection, playing a major part in maintaining the diversity of bio-geographical regions (point 6.3 – "Regional targets" of Pan-European Biological and Landscape Diversity Strategy (PEBLDS).

The Bug river is one of few rivers in Europe, which in its whole course preserved not only its natural meandering channel, but also experienced only minor changes of its valley. The spontaneous river processes are still the major shaping and diversifying factor to affect habitation in the river's bed area and around the valley edges. Frequent changes of the profile of the bed channel and terraces are signs of the accumulated erosion activity of the Bug river. It is manifested by the presence of steep, water-washed, concave shores, central sandy bars and shore scroll ridges; and by the presence of aged oxbows and terraces. The relief channel for raised water also cuts through the river terraces. The destructive power of the river mostly shows itself in the places, where the current presses directly on the edge of the moraine plateau. Here, the lateral erosion creates picturesque gaps with steep and high (up to 30 m) edges. In the transverse section of this well shaped valley different levels can be seen, from flood terraces of a modern river to non-flooded

overflood terraces. The topography of the non-flooded overflood terraces is diversified by windblown sand dunes. The humidity gradient that changes across the valley and the fertility of habitats as well as various forms of human activities influence directly the rich mosaic of plant life, which finally results in the remarkable richness of fauna and flora.

Slight transformations of the environmental structures are in contrast with an exceptionally high level of the water pollution in this river. The Bug river is most probably the only large river in Central and Eastern Europe in which reaching a good ecological condition could be achieved simply by lowering the pollution load.

In Poland the Bug river is the only large river of high natural values both in the channel and the flood terrace. It is so because the other two bigger rivers (Odra and Warta) were regulated and embanked almost along their whole length and extraordinary values of the Vistula river are present only in its channel (the interlevee sphere) as the flood terrace was strongly transformed. It is remarkable that the biggest country rivers are characterized by their location in areas that are influenced by large urban centers and the pressure of the intense agriculture including fruit and vegetable farming. In addition, the ecological functions of the corridor of the Vistula river are strongly limited by the dam in Włocławek. With such a background, the Bug river valley is a unique ecological corridor with great natural value of an international range.

In such an important area up to date researches, which included the structure and functioning of biocenosis, were only conducted on chosen groups of plants and animals. Expertise studies conducted on a large scale were limited to show natural values of the selected fragments of the valley, in order to establish a specified legal form for environmental protection, and some of the conclusions of those studies were most curious (quote: "...The major threats for almost the whole area of the planned reserve are most often constituted by the raised water stages of the river Bug, due to the relatively low location of the flood terraces over the actual water stages in the mentioned river. During the overflow of the Bug river the riparian forests growing close to the river corridor are mostly damaged... ").

So far, the above-average water pollution was cited as the biggest threat in the Bug river valley. Yet the degradation of natural values is increasing in the whole valley area. The negative processes were stopped either by establishing various forms of legal protection or by declarations connected with the management of so called functional areas:

1) Green Lungs of Poland,
2) The Bug River Euroregion,
3) Trans-boundary Protected Area "The Bug River Gap",
4) Pan-European Ecological Corridor,
5) International Bird Area (IBA. Poland 095),
6) Nodal area of an international range no. 24M in ECONET conception,
7) Nature Site CORINE no. 1999.

In 1995, as a result of a Mazovian Society for the Protection of Fauna initiative, a new concept for a functional area called Nadbużańska Strefa Ekologiczna (NSE)

was created so in the basin of the central part of the Bug river the ninth area will be added: Biosphere Reserve "Western Polesie". Unfortunately the destruction of the environment of the Bug river area is proportional to the pace of the creation of new structures called the functional areas.

In spite of establishing many nature reserves as well as various forms of multi--regional system for nature protection (area of protected landscape, landscape parks) the natural values of the river may not be considered to be adequately protected; on the contrary, degradation is increasing and threats of further embankment or destruction of abandoned channels under the pretext of their re-naturalization continues. In connection with that, at the end of 1990s the idea of vast, interdisciplinary researches based on the results of the area's exploration was created, they were conducted between 1998–2000. The researches dealt with – for the first time – the whole course of the Bug river, from its springs to its mouth and also for the first time they were conducted on the basis of methodical assumptions common to all individual examination groups. It must be underlined that the hydrological conditions during the main period of field researches (April – June) were more characteristic of earlier periods, especially in 1999 – the course of the spring flood was exceptionally vast and long-lasting in comparison to previous decades. The whole flood terrace was under water until the end of May, while the longest flood periods marked in previous years lasted till the middle of April. This enabled the establishment of fauna and flora in the background of more natural hydrological conditions.

The targets of the conducted field researches were:

1) evaluation of the geophysical and geographical conditions of the Bug river valley with a special interest paid to the flood terrace,
2) analysis of social and economical aspects of the Bug river water basin management,
3) evaluation of the state and the degree of the threat to plant cover and selected fauna, indicating animal group (otter, beaver, breeding avifauna, fish, butterflies),
4) selecting areas of the highest natural value and/or mostly threatened in order to include them in a proper form of legal protection,
5) establishing postulates in the field of active protection and optimal management – biased toward maintaining the values of fauna and flora,
6) establishing targets, tasks and strategies for the protection of natural assets,
7) presentation of the possibilities for using – in the conditions of the Bug river valley – structural funds of European Union for the prevention of extensive farming forms.

The above mentioned targets serve a greater purpose – the protection and strengthening of the function of the Bug river valley as an ecological corridor. Therefore, the strategy for the protection of natural assets of the Bug river valley presented in this book, includes various tasks aiming at the protection of present values and initiation of various actions towards the re-establishing of the natural values in the areas damaged after the construction of flood embankments and riverside forest clearances. Surely, not all aspects connected with the threat to the Bug river valley were resolved, yet there is no doubt that the postulates included

here can become a huge help in the current governmental and self-governmental activities of the nature protection services, space planners or activists from associations outside government. It is also difficult to deny the educational value of this book.

Chapter II

Physiographical characterization of the Bug river valley and its basin

Wojciech Szwajgier
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Zdzisław Michalczyk
Marek Turczyński

The location and general characteristics of the basin

The Bug river is the longest left-bank tributary of the Narew river with a length of 772 km, out of which almost 185 km of the upper course are outside the borders of Poland. In its next section 363 km from Gołębie, the river constitutes a natural border between Poland, Ukraine and Belarus. The lower course of the river of the length of 270 km starting in Niemirów is situated in the Polish territory.

The Bug river basin embraces territories of three countries – North-West Ukraine, South-West Belarus and Middle-Eastern Poland. The springs of the river are situated in the northern fringe of the edge of Podole in Gołogóry at 311 m above sea level and the river mouth to the Narew river is in the Zegrze Reservoir area, which was created after the Narew river water dammed at the Dąbie barrage. The average absolute height of the basin is 183 m above sea level, out of which ¾ of the area is the range of height from 100 to 200 m above sea level [Mikulski 1963].

The characteristic shape of the Bug river basin is created out of two different parts connected by a pronounced narrowing between Horodło and Włodawa (Figure 1). In the upper part the width of the basin is about 70–100 km, in the lower part it is up to 120 km and in the afore-mentioned narrowing the width is between 30–40 km. Geological researches conducted in previous years give rise to the idea that there are two river systems, which were connected with each other in the not too distant geologic past. This could be supported by the fact that the layout of the valley network in the upper part of the basin is completely different from that in the lower one. The upper part of the Bug river basin was created as a result of a geologic transformation, which lasted several million years, many facts support the idea that it belonged to the catchment of the Black Sea as part of the Dniestr river basin. The lower part of the Bug river basin was created after the retreat of glacial ice, which still covered this area 170 thousand years ago. Heterogeneity of

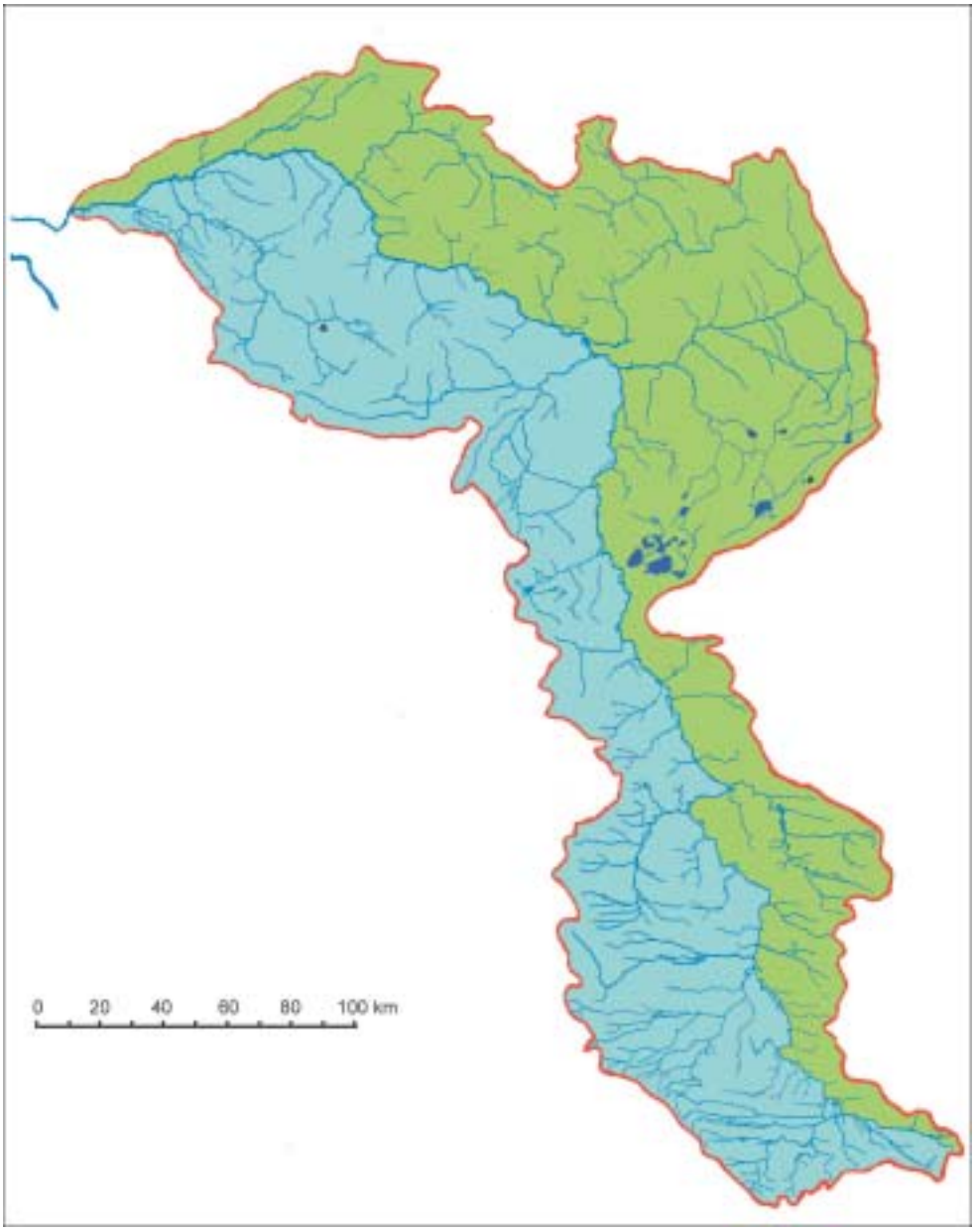

Figure 1. The Bug river catchment area

this part of the basin proves that its shaping process took place gradually along with the retreat of glacial ice. In the initial phase, melting water flowed away towards the Black Sea through the valley of the rivers: the Krzna and the Muchawiec to the Prypeć river basin. There are clearly identifiable fluvial systems in a lower range, which exhibit a similar pattern for example: the Udal – the Nieretwa rivers. In the upper and central part of the Bug river basin left and right tributaries create a near parallel layout which, in connection with the Bug river valley, creates

picturesque gap sections in the areas near Sokale, Horodło, Dorohusk, Uhrusk, Włodawa, Janów Podlaski, Mielnik and Kamieńczyk.

According to the regional division of Europe [Kondracki 1998] the Bug river basin is located within three provinces: Ukrainian Uplands, East-Baltic-Belarussian Lowland and Middle-European Lowland.

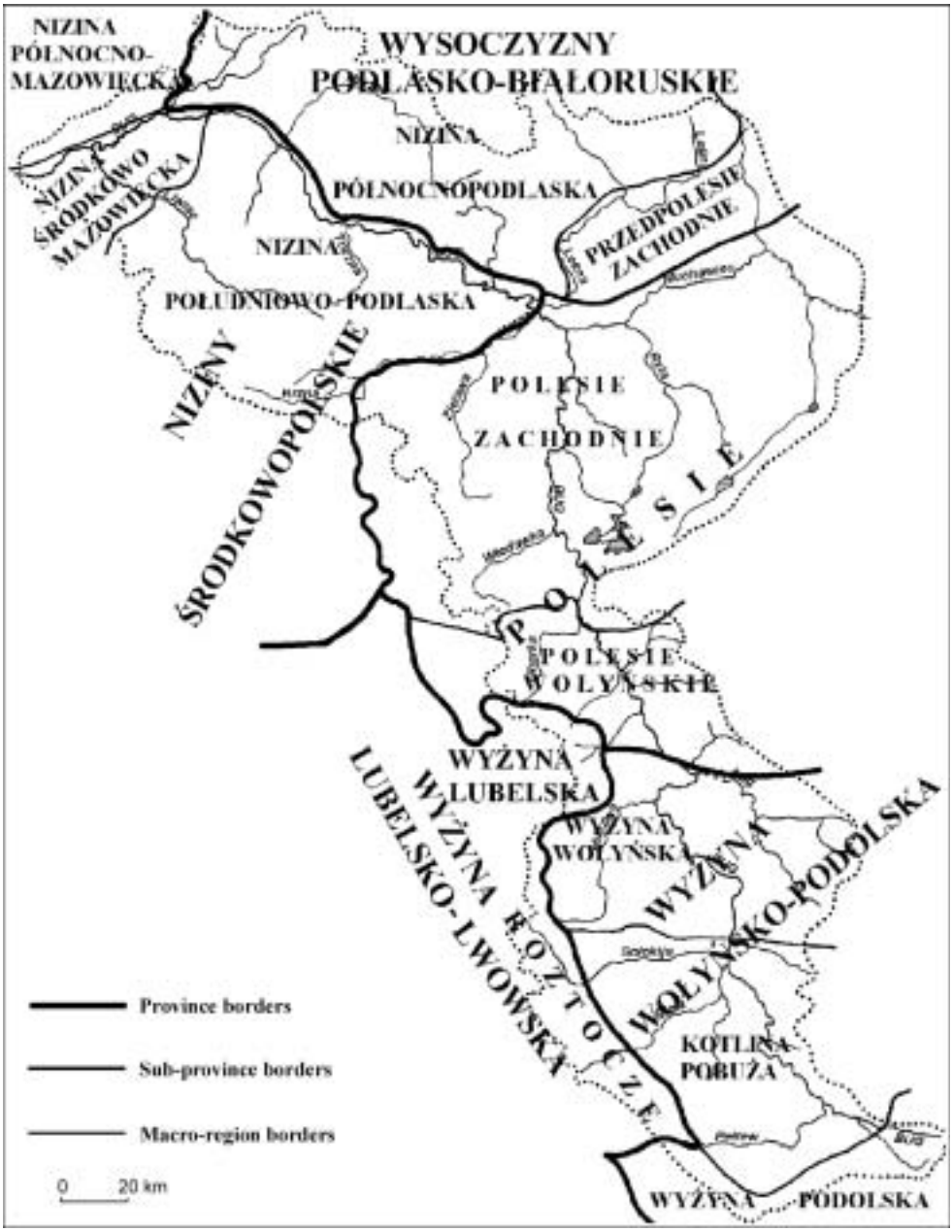

Figure 2. Physiographical division of the Bug river basin

The Bug river is one of the few rivers in Europe, which the valleys have retained their original character to the present day and have been only slightly changed by human activities. From its springs the Bug river flows through the Kotlina Pobuża, then through Volynian Upland and its subregions: Grzęda Sokalska, Kotlina Hrubieszowska and Grzęda Horodelska. The bend of the river near Horodło is considered as a border between Ukrainian Uplands and East-Baltic-Belarussian Lowland [Kondracki 1998]. From Horodło up to the mouth of the Krzna river, the area of the Bug river catchment is situated in subregions of Polesie: Dubienka Depression (Polesie Wołyńskie) and Polesie Brzeskie (Polesie Zachodnie). The part of the Bug river beneath the mouth of the Krzna river is in the Podlasie area, in the province of Middle European Lowland, subprovince of Middle-Poland Lowlands: The Podlasie Gap of the Bug river and the Valley of the Lower Bug river [Kondracki 1998].

The climatic conditions of the Bug river basin are influenced by two substantial air masses: the polar-maritime and the polar-continental. The polar-maritime air masses are predominant amounting to 57.8% of the total air mass, mainly in the summer, this results in an increase of the relative humidity of the air, cloud cover and precipitation. Polar-continental air masses amount to 35.7% of the total air mass and inflow mainly in the colder seasons of the year resulting in improved weather conditions. The proportion of the polar-maritime air masses results in the predominance of westerly winds [Zinkiewicz 1963]. The climates in Polesie, Podlasie and Lublin Upland are described according to Romer [1949] as climates of the Great Valleys District.

According to the Climatic Atlas of Poland [1973] yearly average air temperature in years 1881–1960 were in the range 7–8ºC. July is the warmest month with an average temperature of 18.5ºC and January the coldest with average temperatures from -4.0ºC to -5.2ºC. In winter, the researched area has a characteristic long lasting snow cover (85 days in a year). Annual range of temperatures reaches 23ºC. The growing season lasts 213 days. Very short transitional seasons and long lasting summer and winter are major signs of climate continentality of the researched area [Zinkiewicz W., Zinkiewicz A. 1975]. Distribution of precipitation also implies the climate continentality. According to the data from 1931–1960 the highest rainfall occurs in July and August – it is three times higher than in January and February. In the warmer half of the year rainfall is twice as high as in the cold half of the year. The annual average precipitation is from 500–600 mm [Climatic Atlas... 1973]. Low precipitation and strong evaporation as well as insufficient humidity are the reasons why the Polesie region is characterized by high water deficit, especially in spring period.

In the upland, upper – Volynian-Podolian – course – the Bug river is supplied by water from five tributaries which collect water from an area of 933 to 1820 km^2 (the Pełtew, the Rata, the Sołokija, the Huczwa, the Ług rivers). In the middle course (in the northern part of the Polesie region) there are two rivers: the Muchawiec and the Krzna and in the lower – Podlaski course – the Leśna, the Nurzec and the Liwiec, with the catchment area of 6594 to 2102 km^2.

Major components of the Bug river valley relief

Volynian-Podolian reach of the Bug river valley

The Bug river starts with the springs situated at 311 m above sea level in Wierchobuż village in Podole. Wierchobuż is located at the foot of a massive hill rising up to 420 m above sea level in the northern edge of a vast Kotlina Kotłowska. Water flows out from the fissures in the Tertiary limestones creating a large stream. After leaving the village Wierchobuż the stream channel was remodelled, straightened and transformed into a ditch draining Kotlina Kotłowska. Starting with Sasów, the Bug river crosses another, swampy basin to enter the northern edge of the Podole. At its edges the valley suddenly narrows to the width of 1 km. In the river area at the foot of the edge is a place called Biały Kamień, where the Upper Bug river located in Podole ends and "Polesie Buskie" starts. It is a swampy and meadowed area where small hills are covered with loessial layers. Although meandering, the river continues in a steady north-western direction. In Busko, the Bug river is supplied by its tributary, the Pełtew river, that carries highly polluted water from Lviv. At Kamionka Bugska the river turns to the north, near Dobrotwór a dam was built which resulted in the creation of a water reservoir designed to fulfill the needs of the thermal power station. Then the Bug river flows into the Bug river basin. At the beginning of the century it was still a region where "The Bug river suddenly divides itself into several forks and in this way creates the widely famous, prized by hunters, water labyrinth, which no other Galician river has" [Rehmann 1904]. In the postwar period this unique region was to be transformed into an agricultural one. Melioration works and swamp drainage resulted in a change of water conditions and finally created a region of an over-dry wasteland. Starting at Czerwonohrad (former Krystonopol) located at the mouth of the Sołokija river, the Bug river enters the area of a loessial Volynian Upland. The Bug river valley bottom, narrows itself to 1–2 km, and the edges of the overflood terrace reach several meters [Kovalchuk 1997]. In the past, the Bug river was used for navigation starting at Krystynopol. Somewhere near Horodło, a clear edge of a parallel course, separates the belt of loessial uplands from the Dubienka Depression (Polesie Wołyńskie).

Polesie part of the Bug river valley

From Ustiług the Bug river valley passes through the area of the Polesie Wołyńskie region and the river enters the province of East-Baltic-Belarussian Lowlands. The length of the valley in the Polesie area is about 140 km. Throughout this section the valley has a sinusoidal course. The width of the valley from Horodło to Włodawa oscillates from 2 or 3 km to over 10 km. A floodplain dominates the shape of the valley. A fragment of this section of the river below Ustiług is characterized by many straight stretches of the river, which smoothly passes from the left to the right side. Occasionally the oxbows can be seen, the valley bottom is flat and swampy.

In the Horodło Gap course of the Bug river, two Pleistocene terrace levels and a Holocene valley-bottom clearly stand out. The higher overflood terrace at 9–13 m marks itself in the part attached to Grzęda Horodelska. It is built up with loesses with thickness reaching several meters [Maruszczak 1972]. In the loesses that cover

the surface of the terrace, a characteristic cluster of forms developed, among which, small dry valleys of denudation and erosional-denudation stand out. Some of them are like ravines with signs of intensive tunnelling processes. The lower overflood terrace is 5–6 m high and joins the higher level terrace without a clear edge. In Horodło area the edge zone is covered with deluvial deposits and constitutes a narrow shelf cut through by numerous, short erosional-denudation valleys.

In Horodło area two significant tributaries supply the Bug river: the Huczwa river from the left and the Ług river from the right. Catchments of these two rivers constitute a southern border of the narrowing of the basin of the middle river and the Middle Bug river starts at their mouth.

The width of the Middle Bug river valley remains within the limits of 2 to 3 km up to over 10 km. Estimation of a total width of the valley, including terraces, is difficult because the surface of the main overflood terrace often transforms itself in a vast denudation or depositional plane. The valley clearly distinguishes itself from the surrounding regions, and in the Horodło, Wola Uhruska areas and below Włodawa, it has almost a gap character. Narrowing and widening of the valley are characteristic features of the researched part of the Bug river valley. It clearly reflects itself in the conditions of the valley bottom formation.

The floodplain is a dominant feature of the Bug river valley. Its 1 km wide in the southern part up to around 5 km near Dorohusk, and its height, above the average water stage in the channel, changes from 4 m in the south up to 3 m in the north. Between Dorohusk and Okopy the valley bottom narrows to about 1.5 km. The valley maintains its gap character for about 5 km. The surface of the floodplain is diversified by numerous, cut-off meanders marking a pronounced meandering belt. Close to the channel, at the spurs of developed meanders small areas of meandering scroll ridge, shaped by present channelling processes can be seen (those areas are called beach terraces). They are 1 to 1.5 m lower than the main surface of the valley bottom.

In the remaining part of the valley bottom, oxbows with different shapes and bends can be seen. These are the traces of the activities of the river with mega--radius meanders especially next to the edge of the overflood terrace in Uchańka, Dorohusk and Hniszów area. The traces of mega-radius paleo-meanders are accompanied by clearly visible sandy meander scroll ridge banks, which rise at 1 to 2 m above the floodplain. Besides that the surface of the valley bottom is diversified by single, isolated "islands" of the overflood terrace, sticking out up to several meters above the valley bottom. The biggest ones are below Dubienka and Uchańka and the Nieretwa and the Rapa rivers in the right. The Wełnianka and the Udal rivers create on the surface of the floodplain clear alluvial cones with marks of a river's mouth section that was often transferred.

Two overflood terraces rise above the valley bottom [Rzechowski 1963, Szwajgier 1998a]. The lower terrace rises at 4 to 5 m over the valley bottom and is created by flattening of different widths along the valley or isolated "islands" within the flood terrace (Fig. 3).

More characteristic is the surface of the higher overflood terrace at 8 to 10 m over the surface of the floodplain. In many places on the surface of the terrace there are fields of windswept sands (Dubienka area), which have created its sinuous charac-

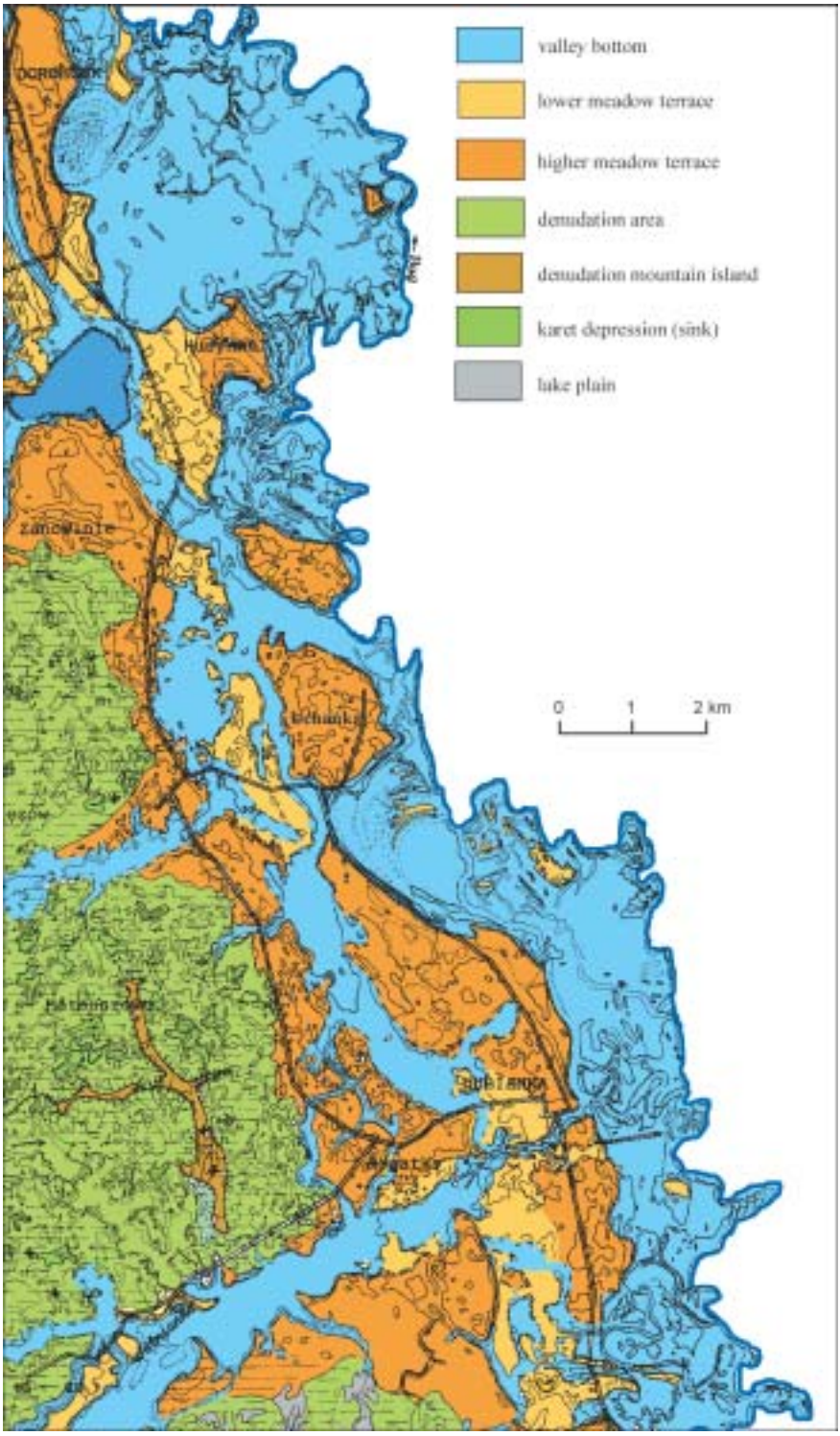

Figure 3. Geomorphologic sketch of area near Dubienka (according to M. Harasimiuk, J. Rzechowski and W. Szwajgier... 1993)

ter. More vivid eolian forms (dunes) can be seen in the eastern side of the valley in the Jagodin line and in the left in the Starosiel line.

Concave forms, with various causes, which diversify this surface are interior hollows with diameters of 2 to 3 m to several hundred meters and 4 to 5 m deep. They are filled with mineral or mineral-organic deposits and sometimes peat. The surface of this terrace changes without a clear border into a denudation that cuts down the older substratum or in a surface of a flood-lake accumulation.

In Świerże, the Bug river enters the Zachodnie Polesie macroregion. Between Okopy and Uhrusk the Bug river valley suddenly broadens and the edges of the overflood terrace reach 8 to 10 m over the water level. In this part, the Uherka as well as a tributary from the right side supply the Bug river – also on a parallel course. The diversity and sharpness of the forms within the valley – bottom are exceptional here. From the outlet from the Doruhusk Gap the valley – bottom widens up to about 4 km, the decline of the channel (0,1‰) and meander belt (0,17‰) decreases and meanders are quite irregular, diphased (sinuosity reaches its maximum values up to 1.6). In Świerża area the channel is of sinuous character (sinuosity about 1.3) with a longer (about 1.5 km) straight part below the western edge of the overflood terrace. Below Świerża, the valley bottom is even wider (about 4,5 km) and islands of the overflood terrace appear within it around Hniszów (Fig. 4).

At Hniszów the Bug river valley changes its system from a meridional course, turning toward the north-west; its width in this part is about 4 km. At the Uherka mouth the valley bottom suddenly narrows down to about 1 km – the start of the Uhrusk Gap [Szwajgier 1998].

The Bug river channel translocates in a curve from under the western part of the valley (from Hniszów) towards its eastern one (at Sosnowiec) returning under its western edge at the mouth of the Uherka river. In this section the Bug river is a meandering one, and just before the gap, meanders appear to be crowded (sinuosity 1.6). The complexity of the flood water's flow is visible here, its multi-phase and multi-level character within the pronounced meander belt.

There is a connected channel ridge 0.5 to 1.5 m high and about 50 to 100 m wide. In many places it is cut through by "krewasy" functioning at higher water level. This ridge separates the channel zone from the outside embankment zone. In Sosnowiec area it reaches a width of 4 km. The flood terraces (higher and lower) as well as "insular" fragments of the erosion lowered high terrace are distinctive elements of this zone.

Traces of activities of rivers with huge meanders (scroll ridges, paleo-channels) can be seen near the eastern edge of the over-flood terrace.

The appearance of these forms is connected with the surface of the higher flood terrace. The main element of the immediate area outside embankment – the lower flood terrace is located at 165.5 m above sea level and constitutes 50% of the surface of the Bug river valley-bottom in this section. On the surface of this terrace a system of anastomozing channels has developed. Apart from the main channel that is 30 to 70 m wide, there are two others permanently filled with water. They run from Hniszów to the Uherka river mouth for about 5 km (Fig. 4).

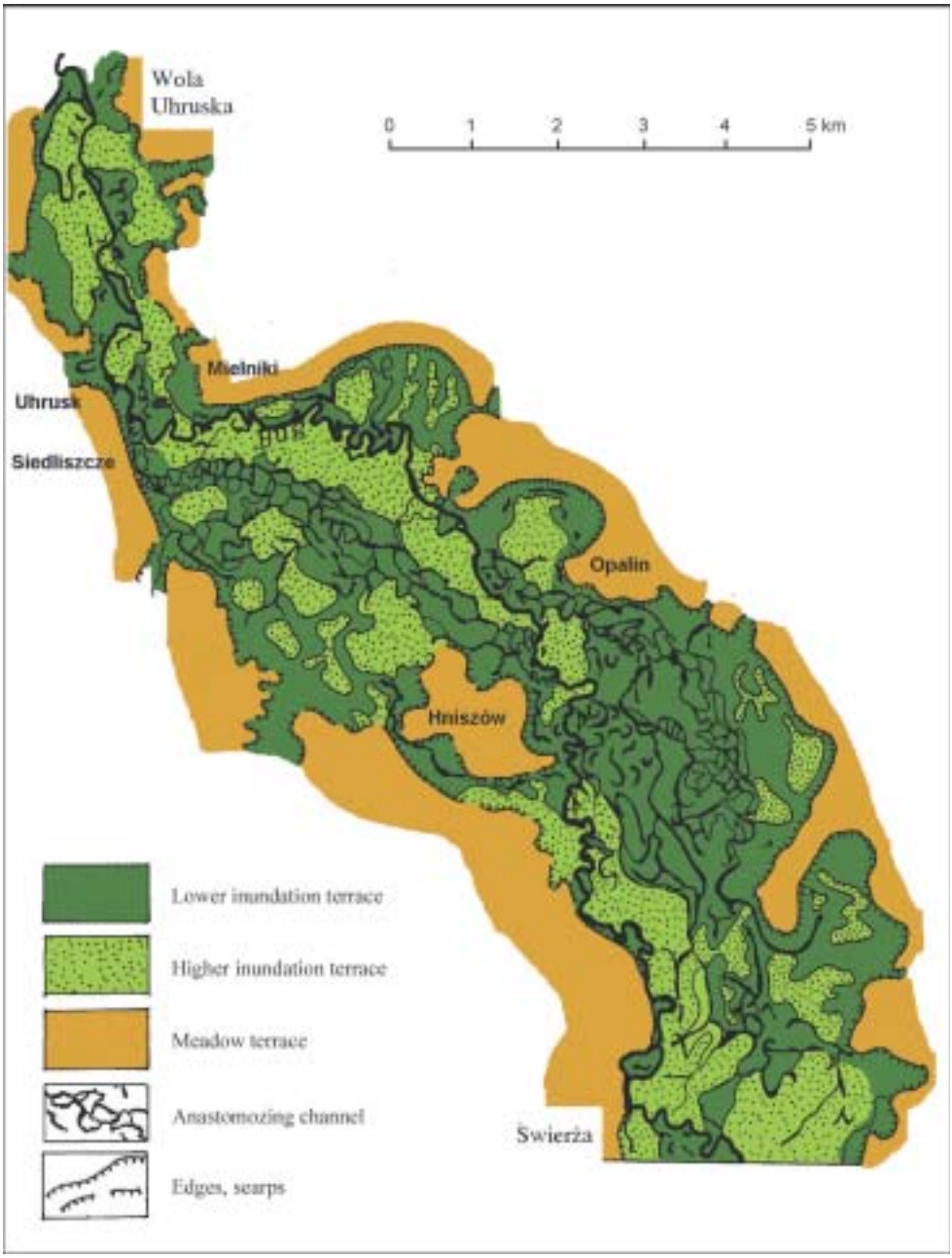

Figure 4. Elements of the relief of the Bug river valley below Hniszów

Their character reflects the main channel and the width reaches from 6 to 15 m. On the surface of the lower flood terrace signs of highly complex flood channels can be seen. Some of them are permanently filled with water and their measurements match those of the anastomozing channels. Forks of the anastomozing river present in this part shape the interchannel areas. According to Brice [1978] the

interchannel areas of the anastomozing river are of the width which is at least 3 times bigger than the width of the channel during medium water stage and the length which is at least 7 times bigger than the channel width.

The higher flood terrace in this part appears in two zones: near the edge of the overflood terrace and in the neighbourhood of the Bug river channel where it partially joins the zone of the connected channel. It is formed out of loam and sandy loam at 167 to 167.5 m above sea level. Its surface forms connected with the development of mega-radius meanders. The shape of the paleo-channels and forms of the meander ridges remain within the parameters of the mega-radius meanders below Dorohusk.

From the Uhrusk Gap to the Włodawa Gap, the length of this section of the Bug river valley is about 30 km. Modern floodplain is the main element of the Bug river valley here. Its width varies from 2 km at its outlet at Uhrusk Gap to 4.5 km below Stulno falling to less than 1.5 km wide in Włodawa Gap. The height of the floodplain reaches from 1.5 to 3 m above the average water stage in the channel. The most remarkable surface features are: oxbows of various origin as well as numerous narrow channels of flood water incised into the surface of the plain for 0.5 to 2.5 m. Those forms are clearest below Stulno and near Sobibór. Scroll ridges and oval hills of about 1 m and concave forms. Near Stulno, Sobibór and Dubnik there are clear signs of vast mega-radius paleo-meanders with the radius of curvature 10 times bigger than modern meanders. Scroll ridges that are 2.5 m high accompany the courses of paleo-meander channels.

Over the modern valley bottom, the level of the overflood terrace rises, it is 7 m high in its southern section (behind the Uhrusk Gap) up to 5.5 m below Sobibór and of about 3 m in Włodawa Gap. In this section the surface of the terrace consists of several parts of various widths. The first one, found between the Uhrusk Gap and Stulno, is about 6 m long and 1 km wide. Near Majdan Stuleński a small valley with an intermittent stream cuts the surface of the terrace. At the outlet of the valley a clear alluvial cone developed in the flood terrace. Below Stulno, 3 km in, the terrace joins directly onto a fluvioglacial plane. Northward from Stulno, up to Sobibór and Dubnik there is the largest, in this section, fragment of the overflood terrace. It is about 3 km wide near Stulno and reaches 200 to 300 m below Dubnik. Near Orchówek in the section of the Włodawka river mouth the over-flood terrace is broken into several, rather small fragments. Small dune forms (up to 2,5 m high) diversify the surface of this terrace near Stulno, Wolczyn and Orchówek. There are characteristic concave forms on the surface of the terrace, namely oblong depressions, parallel to the Bug river valley which are 1 m deep, up to 100 m wide and up to several kilometres long. In the zone where these forms exist there are also oval hollows filled with organic deposits.

Near Włodawa there are several lakes: Białe, Glinki, Czarne, Brudno with complex origins. Wilgat [1954] distinguished two generations of lakes: remains of the Pleistocene lake and post-pergelisol lakes from the turn of Pleistocene and Holocene eras. This way he questioned the idea that they are remains of Pleistocene pockets. Pleistocene reservoirs disappeared through transformation into peat swamps. The second generation of lakes came into existence through the carst processes in a non-typical environment of sandy formations. Maruszczak [1966] thinks, that all lakes are of carst origin. Buraczyński, Wojtanowicz [1983], Wojtanowicz [1994]

support the theory of thermocarst genesis of most of the lakes of the Łęczyńsko-Włodawskie Lakeland.

The genesis of the lake and peat basins in the Łęczyńsko-Włodawskie Lakeland Harasimiuk [1996] relates closely with the complicated conditions of the flow of groundwaters in this region at the end of last glacial period, under conditions of degradation of a long-lasting pergelisol. Thermal features of the Cretaceous rocks (warm) and the Quaternary deposits (cold) generated the circulation of the groundwaters. At greatly differing pressures there were cases of piercing and the creation of ice cubes in the Quaternary deposits just underneath the surface. These cubes underwent a thawing process only in the final phase of the pergelistol degradation effectively resulting in the creation of remarkably deep lake basins. The author describes this process as deep thermocarst. Shallow and vast lakes as well as other interior forms in the lake district are connected with the thermocarst process – according to Wojtanowicz [1994].

After leaving the gap near Włodawa the Bug river still flows in a northern direction and the valley reaches a width of 4 to 8 km. In this section the valley cuts through a typical region of countryside for the Polesie plain, monotonous and waterice plain which can be about 155 m above sea level. The culmination of small hills creates a morainic plateau with smooth slopes, which transform into plains without clear borders.

The Bug river channel is situated in the western part of the valley bottom (near Włodawa) and is in some sections sinuous and other sections straight. In the valley bottom two flood terraces stand out, where the higher one is in the shape of small islands. The overflood terrace is cut through by several small valleys of various size, and its border with the water-ice plains is not clear. On the surface of this terrace there are small circular areas of windblown sands as well as small interior hollows of an unspecified origin [Mojski 1972]. Some of them though, may be of carst origin.

Near Dołhobrody in the Bug river valley bottom there is a mosaic of forms resultant from turbulent channel changes: shorter and longer parts of abandoned channels caused by the avulsion process, old river beds from the separated meanders as well as older forms connected with the development of the mega-radius meanders.

The valley bottom is about 4 km wide in this section and is made of Holocene deposits, which create two flood terraces: lower (0.5 to 2.0 m) and higher (2.0 to 3.8 m over the average water level). The Bug river channel in this section is 30 to 100 m wide. Near Hanna, its tributary, the Hanna river, flows into the Bug river. From Sławatycze the channel moves toward the western part of the valley bottom and meanders create wide bends with clear gliding surfaces.

The present meander belt is very clear and is about 1.5 km long. Near Sławatycze and Domaczewo the Bug river valley cuts through the morainic plateau, which gently slopes down towards the valley. From Mościska Dolne up to Kodeń (in 12 km) there is a clear bi-partition in the valley bottom. An island of over-flood terrace separates the valley bottom into two arms, the right of which is inactive. Near Kodeń the Bug river channel is 50 to 100 m wide, its relative height is 144.4 m above sea level. There are two flood terraces here: one at 2.5 m and on at 4.0 m above the average water stage in the channel. The depositional overflood terrace

rises from 4 to 6.5 m above the level of the Bug river – from the west it is cut by tributary valleys of the Czepelka and the Kałamanka rivers which in their lower courses have channels artificially regulated. The Czepelka river together with its tributaries drains the northern part of Polesie and takes its water into the Krzna river. Its middle and lower course constitute the line of the sand water runoff during the glaciation process which functioned as an alternative track for the lower course of the Krzna. From Kostomłoty, the Bug river valley spreads from 2 to 3 km to 20 km near Terespol and Brześć. In this part the Bug river is swelled by the water from three large rivers: the Krzna, the Muchawiec, the Leśna. It is one of the most important hydrologic systems in the Bug river basin. Up to the mouth of the Krzna river (Neple – 128 m above sea level), and onward to the northern border of Polesie, in the valley bottom there are two flood terraces and one over-flood terrace. The Krzna river mouth and the connected part to the Bug river valley is called "Szwajcary" or "Szwajcaria Nepelska" which emphasizes the diversity of the region, resulting from the fact that it is situated in the frontal-moreanic zone from the early phase of the recession of "warciański" glacial [Nowak 1977].

Podlasie Lowland

In this section the Bug river valley constitutes the border between the Northern and Southern part of Podlasie Lowland which are marked in the geophysical division made by Kondracki [1998]. The river network of the Podlasie Lowland manifest a clear dependence on the formation which appeared during the land-ice wastage during the younger part of the Middle Poland glaciation – of "warciański glacial".

Numerous streams flow to the south, where they are gathered in the valley with the characteristics of a marginal stream turning through the Krzna river towards the east up to the Bug river. From the hills in the marginal zone numerous streams flow towards the north and north-west, where they are assimilated into the Bug river and the upper course of the Narew river (that already in the northern part of the Podlasie Lowland).

In the Podlasie Lowland, the Bug river valley has one depositional terrace, with origins connected to the North Poland glaciation. Its relative height in the section from Neple (128 m above sea level) up to Małkinia (100 m above sea level) oscillates from 4 to 8 m. The terrace appears on both sides of the river and its surface occupies at least half of the Bug river valley in this section. In the cross-section, the surface of the terrace drops towards the edges of the plateau, which results in the presence of water-logged areas as well as traces of the river channel at its foot. As a result the highest points of the terrace are relatively near to the valley bottom and the river channel. The formation of the surface of the terraces is diversified by forms of eolic origin: dunes and fields of windblown sands. In the areas, where dunes are present, concave forms can be seen namely: windblown troughs. This terrace is created by fine and medium sands with a mixture of loam sands of thickness about 10 m.

Between Neple and Janów Podlaski the Bug river valley spreads from 12–15 km (including the area of the overflood terraces). The valley bottom which is 5 km wide is made of deposits of Holocene over-bank facias (sporadically of channel facias) which create the lower and higher flood terraces [Galon 1972]. On the sur-

face of both terraces there are numerous oxbows and near the edge of the overflood terrace, the oxbows of the mega-radius meanders. In this part, the Pulwa river flows into the Bug river near Stawy. The channel meanders, and before the gap course (Janów Podlaski, Mielnik), the meanders become crowded.

Near the mouth of the Krzna river, the Bug river changes the direction from the meridional course to the north-west. The valley bottom clearly narrows itself to about 5 km, so that near Janów Podlaski it becomes a narrow (1 km wide) gap valley. Just before the Janów Gap the channel is sinuous and the present meander belt is from 2 to 2.5 km wide. Numerous oxbows prove the existence of quick channel changes related to the development of meanders. In one of the Bug river bends, near Janów Podlaski, there is an old-growth oak forest under reserve protection – "Łęg Dębowy" of about 132 ha.

From Janów Podlaski to Drohiczyn the valley has a gap character – cuts the Wysoczyzna Drohicka that constitutes a mesoregion of the North Podlasie Lowland [Kondracki 1998]. It is a denudation plain, slightly wavy and the hills reach up to 200 m above sea level. The valley goes through the zones of frontal moraine of warciański glacial – in their inselberg forms, from which the glaciation-river water turned to the east. The slopes of the valley are characterized in this section by remarkable denivelations – some of up to 60 m (Góra Zamkowa 55 m in Mielnik).

Below Mielnik the Bug river creates a typical gap, between Klepaczew and Osłowo, in this section of 8 km length (Fig. 5). A river with a course south-east – north-west cuts across the plateau here, fitting in with the zone of the moraines from the Warta river land-ice recession process. The Bug river cuts into the hump of the Cretaceous substratum, which reflects itself in the narrowing of the valley and the increase of the slope heights. The width of the valley in Klepaczew and Osłowo is 1.3 km, the slope height reaches 55 m.

In the gap section there is an overflood accumulations terrace, and its fragments in the shape of narrow shelves rise from 6.0 to 8.5 m over the average water level in the Bug river channel. The present gap valley bottom is made by two alluvial Holocene terraces, lower (1.0 to 1.5 m) and higher (2.0 to 2.5 m). Numerous oxbows, frequently filled with water as well as embankments of meander scroll ridge create the 'living' micro-sculpture.

After leaving the gap section, the Bug river turns towards the north-east and remains in this course up to Małkinia. The valley bottom widens up to 5 to 8 km and the width of the valley, including the over-flood terrace, is from 10 to over 12 km. The thickness of the deposits on the overflood terrace is from 8 to 10 m, but there are places where the platform of the substratum is placed relatively high and where the thickness of the fluvial deposits is only 3 m – below there is glacial till.

The edges of the terrace are preserved in the best form near the river channel reaching from 3 to 5 m high. However, more often the surface of the terrace transforms smoothly (without a clear edge) into the surface of the valley bottom. In such a situation the Holocene fluvial deposits reach the Pleistocene terrace, which in the end result in the creation process of dunes (near Sterdyń). From Gródek up to Nur the Bug river valley bottom is divided into two arms by the presence of the "islands" of the overflood terrace. The right arm occupies the Bug river channel

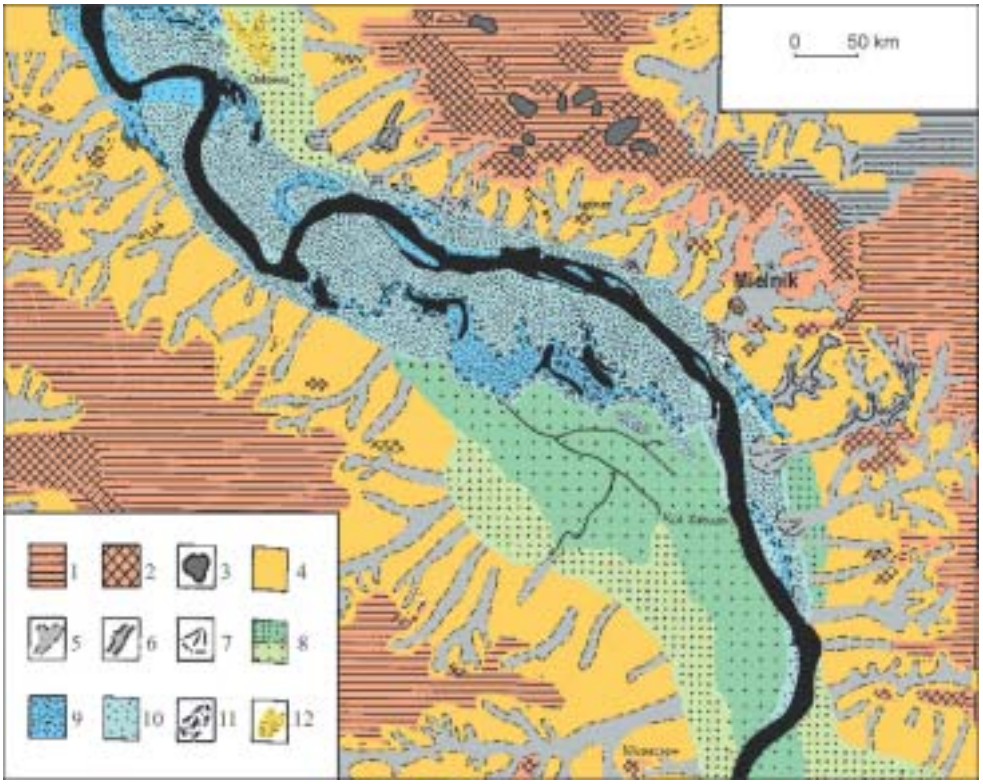

Figure 5. Podlasie Gap of the Bug river below Mielnik

1 – hilltop of the morainic plateau; 2 – frontal moraines; 3 – hollows; 4 – slopes of the valleys; 5 – denudation valleys; 6 – young erosional cuttings; 7 – proluvial cones; 8 – overflood terrace: a – lower, b – higher; 9 – lower flood terrace; 10 – higher flood terrace; 11 – oxbows; 12 – dunes

and the present meander belt, the left one (extinct) is filled with peat and organic silts. In this part the Bug river channel is almost straight, with several islands and shallows, and its width is about 200 m (in the places where the islands are, the width reaches up to 500 m). In the line of Kamieńczyk two tributaries: the Nurzec and the Cetynia rivers flow into the Bug river on the opposite side each.

North-Mazovian Lowland and Middle-Mazovian Lowland

According to the physiogeographic division described by Kondracki [1998] the lower Bug river valley constitutes the border between North-Mazovian Lowland and Middle-Mazovian Lowland. North-Mazovian Lowland is located to the north of the Vistula river valley, the mouth of the Narew river and the lower Bug river. The meridionally located belt of hills of Czerwony Bór between the valleys of the Narew and the Bug rivers is regarded as the eastern border of North-Mazovian Lowland. The surface of the lowland is sloped from the North to the South and reaches up to 200 m above sea level.

Middle Mazovian Lowland is a cuneate depression, and the geological structure of the substratum has resulted in the concentric system of the river network, which is

exemplified in the confluence of the valleys of the following rivers: the Vistula, the Narew, the Wkra, the Bug, the Bzura, and the Pilica. In the formation of these are vast denudation levels and wide valleys with sandy flood terraces and clayed pocket terraces [Galon 1972]. On the terraces there are vast dune fields, and in the valley bottoms there are several types of marshy meadow. Below the junction of the rivers Bug and Narew, by partitioning the river with a dam a large reservoir was created called Zegrze Reservoir. Among the described lowlands, the lower Bug river valley should be treated as an equally important physiographic unit.

Below Małkinia the thickness of the deposits of the overflood terrace ranges from 9 to 11 m, its structure combines deposits of two cycles of the river sedimentation with the diameter of grain decreasing upwards.

Near Małkinia the Bug river valley cuts the sand and water-ice plains and below Zakrzew morainal hills with relative heights up to 40 m. In the valley bottom, which is up to 10 km wide, there are two flood terraces: lower and higher. The channel is sinuous (with the characteristics of a wild river) with a width up to 200 m with numerous shallows and mid-channel islands. From Nur up to Małkinia the river channel is situated under the northern edge of the valley, which directly connects with the sandr plain. In the area of the flood terraces there are traces of oxbows of different origin, and within the present meander belt, loops of separated meanders as well as abandoned longer sections of channels can be dis-

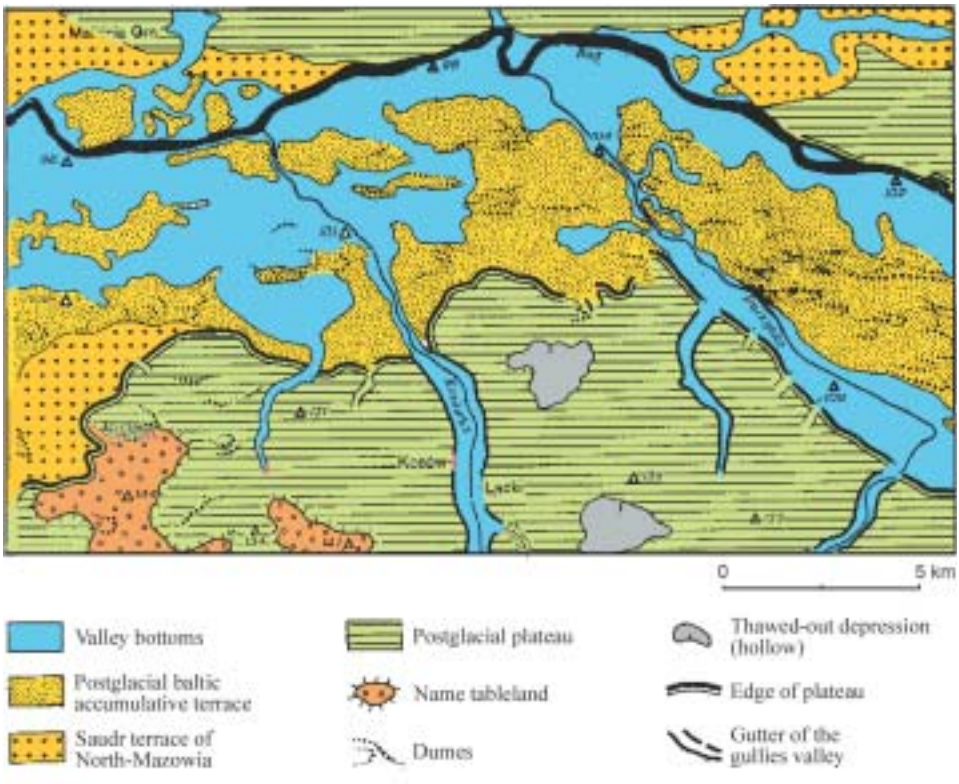

Figure 6. Geomorphological scheme of the area near Małkinia

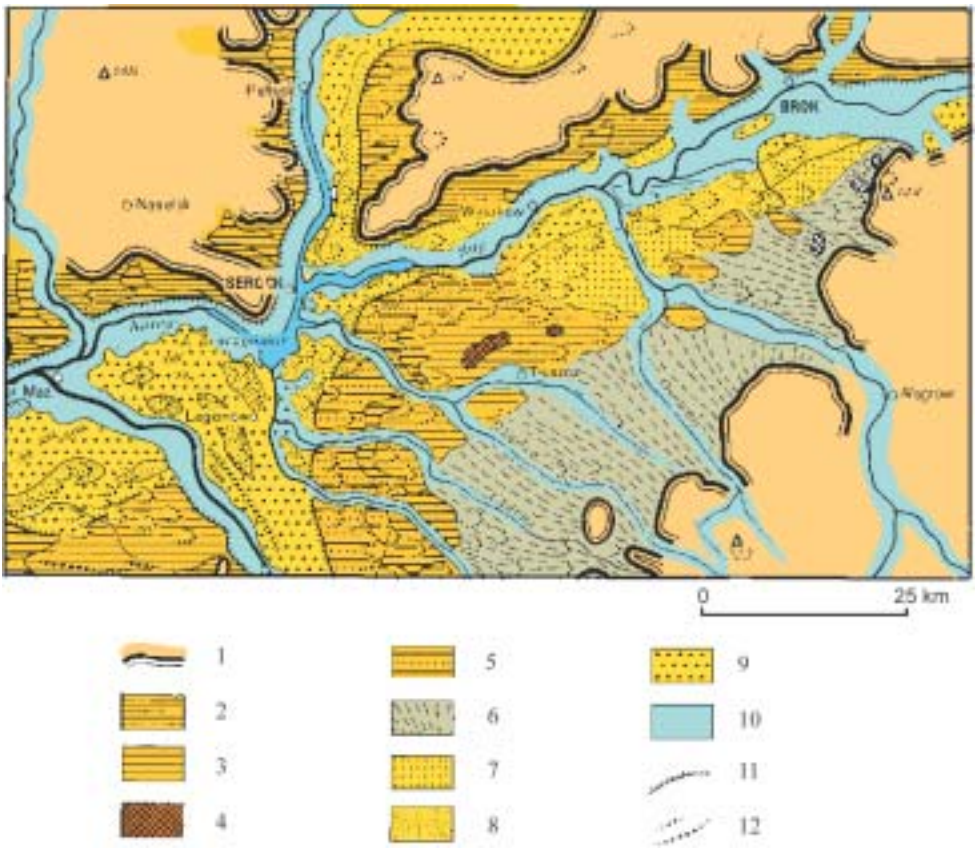

Figure 7. Geomorphological scheme of the valley of the Lower Bug river

1 – morainic plateau; 2 – inferiorly located, denuded part of the plateau with forms of the postglacial sculpture; 3 – inferiorly located, denuded part of the plateau with forms of the postglacial sculpture; 4 – kames; 5 – hollow plains; 6 – slopes; 7 – over flood terraces; 8 – dunes; 9 – over flood terraces; 10 – valley bottoms; 11 – river valley edges; 12 – oblong dune banks

tinguished. The southern edge between the valley bottom and the flood terrace is not easily visible, fields of windswept sands and dunes cover it. The older river beds and deflation hollows are filled with peat and organic silts.

In the area of Ostrów Mazowiecka the Bug river valley runs a parallel course and the width oscillates from 5 to 10 km. The valley cuts the sand and water-ice plain at a maximum height of up to 125 m above sea level. Near Brok, within the valley bottom two flood terraces can be distinguished: lower and higher. The higher flood terrace appears here in the form of single inselbergs, and the surface of the lower flood terrace is diversified by oxbows network of various newness levels. On the surface of both flood terraces numerous flood channels are visible which function during raised water stages in the channel. Near the channel and near the oxbows, there are embankments, outward parallel channels in many places broken by "krewasy" and return channels. Within the reach of the current channel numerous shallows are visible (especially during low water stages) as well as mid-channel islands which may proof the fact that the river is running wild.

The Bug river channel is situated under the northern edge, which directly separates the valley from the sandr plain. From the southern side, in the Bug river valley there is an accumulative overflood terrace at the absolute height of 99 m above sea level to the east and 96 m above sea level to the west from Brok. The overflood terrace consists of sand and sand with gravel with thickness of 16 m. On the sandr plain which cuts the Bug river valley as well as on the surface of the overflood terrace, there are dunes and fields of the windswept sands. Parabolic dunes prevail, flexed towards the ast as well as oblong dunes created as a result of tearing of the parabolic dunes. The heights of the dunes vary reaching up to 10 m.

On the surface of the overflood terrace the height of the dunes is reduced by half. The dunes are accompanied by deflation hollows, wet depressions filled with peat and peaty silts. From the northern side the Bug river valley bottom is reached by several valleys which cut into the edge and have characteristics of young erosional dissections (for example: the Brok river valley).

Between Brok and Kamieńczyk the appearance of the valley changes drastically: from the wide valley bottom (about 6–8 km below Brok), narrowing down to 1.0 to 1.2 km below Kamieńczyk (this section has a gap character). Before the gap section the channel is sinuous and the meanders are crowded. The oxbows visible here were created as a result of cutting the meander loops and through the avulsion process (leaving the longer parts of the channel). In the gap section (Kamieńczyk – Wyszków) the whole width of the narrow bottom is occupied by the current meander belt. Just before the gap section in Kamieńczyk, the Bug river is joined by the Liwiec river through a narrow valley, cutting the deposits of the overflood terrace on the surface of which forms of eolic origin have developed.

From Wyszków up to mouth of the Narew river in Serock, the Bug valley is 10 to 15 km wide. Within the valley bottom there are two flood terraces (lower and higher) and two overflood accumulation terraces. The wide valley bottom has traces of turbulent channel changes (oxbows with meanders, longer sections of abandoned channels) which took place naturally in contrast to the river mouth section, which is artificially regulated. This section is the beginning of the Zegrze Reservoir which was created by building barrage on the Narew river in 1963.

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Chapter III

Hydrological characteristic of the Bug river basin and the water quality

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Groundwaters

Meridionally spread the Bug river basin is situated in several, diversified physiographic and geologic regions, this location is very vividly marked in the conditions of occurence and circulation of the water. This diversity is the result of territorial and climatic factors – mainly geological structure, the surface relief and land use, the size and seasonal variability of precipitation, and evapotranspiration. The water conditions and surface relief of the area influence on the landscape diversity of the basin as well as apparent in its agricultural development. The Bug river in its whole meridional course gathers water from several geographical regions. In the upper part it drains the uplands [Maruszczak 1987], including the western part of the Wolynian Upland and Kotlina Pobuża connected with the edge zones of the Roztocze and the Podole regions. The upland area is built from the carbonate rocks of the upper Cretaceous, largely covered with silty deposits. On this surface fertile soils formed, which are used for agriculture – dominant form in the structure of the land use. Good fertile soils and exploited mineral deposits resulted in a relatively high population density.

Groundwaters of the first useful aquifer appear in sediments of varying age and lithology. They create three multiaquifer formations relative to Cretaceous, Tertiary, and Quaternary deposits. Waters in the respective multiaquifers are most often hydraulically connected. They form, with only few exceptions, one water table, the height of which relates to the surface relief. The Bug river and its tributaries drain the Cretaceous and Quaternary multiaquifer formations, locally, they even drain the Tertiary strata. The fluctuation amplitude of the groundwater levels is very diverse and shows only a slight relationship with the depth of the water occurence. In the flat areas of the Polesie region the water table is shallowly located and changes of the water level can be dynamic. Almost every year there is a high increase of the water level in the spring and a decrease in the summer. In wells located on the plains the fluctuation amplitude reaches from 4 to 6 m. From a statistical point of view the fluctuation amplitude of groundwaters is propor-

tional to the thickness of the unsaturated zone. When the groundwaters are deeper the changes of the water table level are smaller.

Groundwaters are found at the highest level in the area of the Roztocze and the Gołogóry regions, where the water table of the Cretaceous-Tertiary multiaquifer formation is over 320 m above sea level. From the Roztocze region the groundwater table drops towards the North. Generally, groundwater slope is modified by the deeply dissected river valleys. The groundwaters are found at the height of 80 to 90 m above sea level in the zone of the lower Bug river valley. Longitudinal gradients of the groundwater table are visible in the profiles transversal to the river valleys. However, they are periodically variable due to changes in the water stages in the river channels. During the periods of the flood stages groundwaters are dammed up by river waters and surface waters infiltrate to the groundwater resources.

The steepest hydraulic gradients can be found in the edge zones of the Roztocze and the Podole regions as well as in the neighbourhood of the deeply dissected and strongly draining river valleys. Areas situated close to the deeply dissected and assymetric the Bug river valley (in the regions of Grzęda Horodelska, Łuk Uhruski, Garb Włodawski, and gap parts of the Podlasie region) are characterized by high diversity of the water table height. Compact areas with small gradients are typical for wet and peat areas within the Polesie region. The groundwaters surface slope increases near bigger river valleys, which drain the groundwater resources. Groundwater table of the lowland part of the river basin occurs close to the ground surface, sometimes within the range of the soil forming processes and diurnal temperature changes.

From a hydrogeologic point of view, the highest (Ukrainian) part of the basin is situated near the Wołyńsko-Podolski reservoir (Wolynian – Podolian artesian basin) in which two subregions were identified: "Galicyjsko-Wołyński" (Galician-Wolynian) with water-bearing Paleozoic and Mesozoic horizons and "Podolsko--Poleski" (Podolian-Polesian) with water resources in Tertiary and Quaternary deposits [Kleczkowski 1979]. Abundant groundwaters resources of an excellent quality are found relatively deep, except the river valley bottoms and hollow depressions. Density of the river network is relatively low, despite of deeply dissected valleys of the plateau regions. Groundwaters of the first horizon are found most often in fissure-porous rocks of the Upper Cretaceous, in the form of marl and chalk. They are covered with loesses and loessial deposits, and they appear on the ground surface as weathered chalky clay [Szablij *et al*. 1992]. In the southern part of the river catchment, in the Roztocze and the Podole regions, groundwaters occur in Tertiary limestones, sandstones and sands. Shallow groundwaters are found in the fluvioglacial sands, dusty sands and sandy clays in the wide valley depressions [Atłas prirodnych 1978].

The Belarussian part of the basin belongs to the Cretaceous-Quaternary Brzeski reservoir. In Poland this reservoir is connected with the South-Mazovian region which includes the areas of the central and lower basin of the Bug river; with water resources mainly in the Cretaceous and Tertiary multiaquifer formations. The Polish, upland part of the basin is in the Lubelski hydrogeological region, with important water resources circulating in the Upper Cretaceous carbonate rocks [Malinowski 1991]. Groundwaters occur in the Quaternary deposits in the rivers

valleys. Thickness of these deposits changes from 20 to 35 m in the Bug river valley. Those deposits are lithologically diversified in their geologic profile: sands with gravel, sands, dusty sands, silts and silty sands, and peats and muds on the ground surface.

The central part of the basin is situated in the Polesie region that landscape characterized by flat denudation and alluvial plains with many lakes and swampy areas, some of which are permanently and others periodically wet. Because of poor soils and shallow groundwater occurrence the grasslands in the neighbourhood of bushes are predominant element of the land use structure. The use of arable land in the land use structure is small and fairly diverse. The lack of good conditions for agriculture is reflected in a low population density and in a lack of area management. The first stage of groundwaters appears close to the ground surface in Pleistocene and Holocene deposits, going deeper there is water in the Cretaceous or in the Tertiary and the Cretaceous deposits.

Part of the basin situated north the Krzna river valley belongs to the hydrogeological regions of the Podlasie and Mazovian Lowland, with groundwaters retained in the porous Quarternary and Tertiary deposits, and deeper even in Cretaceous rocks. Denudation forms of glacial and fluvioglacial accumulation are dominant in the surface relief of lowland – plateau features. Soils created from postglacial sediments are more fertile than in the middle part of the basin. Surely, this factor determines the arable land use affecting the density of population and area management. Groundwaters of the first aquifer occur on the depth of couple of meters below the ground surface in the Quaternary deposits. Confined groundwaters of the Tertiary and the Cretaceous multiaquifer formations of an excellent quality are found much deeper.

The average runoff from the Bug river basin

Water resources of the Bug river basin are most distinctly defined by the average runoff whereas its annual and seasonal diversity points at the changes in water resources. The amount of water which runs off from the Bug river basin was described on the basis of archive and published materials by the IMiGW and put together for the water gauge profile in Wyszków [Fal *et al*. 1997] which covers the catchment area of the Bug river, some 39 119.4 km^2. This water gauge is just 33.8 km from the place where the Bug river flow into the Narew river, so it can be taken for granted that the data from the profile is characteristic for water resources throughout the basin. The average discharge of the Bug river in Wyszków between 1951 and 2000 was 153.7 m^3/s. The multiannual average specific runoff is 3.93 $l/s \cdot km^2$ and the annual runoff index is 124.1 mm. The intensity of the discharge implies great variation in both the annual and seasonal time frame. The highest discharge (2400 m^3/s) was rejected in 1979, during the spring flow of the snowmelting water, and extremely low discharge (19.8 m^3/s) was reported in December 1959. So, the irregularity of discharges is 121, which is not a great value for Poland. The share of the underground recharge in the total runoff, estimated on the basis of analysis of monthly minimum runoff was 104.6 m^3/s in the researched period, which is 68,0% of the total runoff. The regime of the runoff can be estimated as moderate with ground-pluvial recharge.

The average annual discharges of the Bug river in Wyszków changed from 65.4 m^3/s in 1954 to 335 m^3/s in 1974 (Fig. 1). It is a relatively small annual variation of discharge, just a little bigger than the variation recorded for the rivers of the Lublin Upland, which are evenly recharged from the groundwater resources.

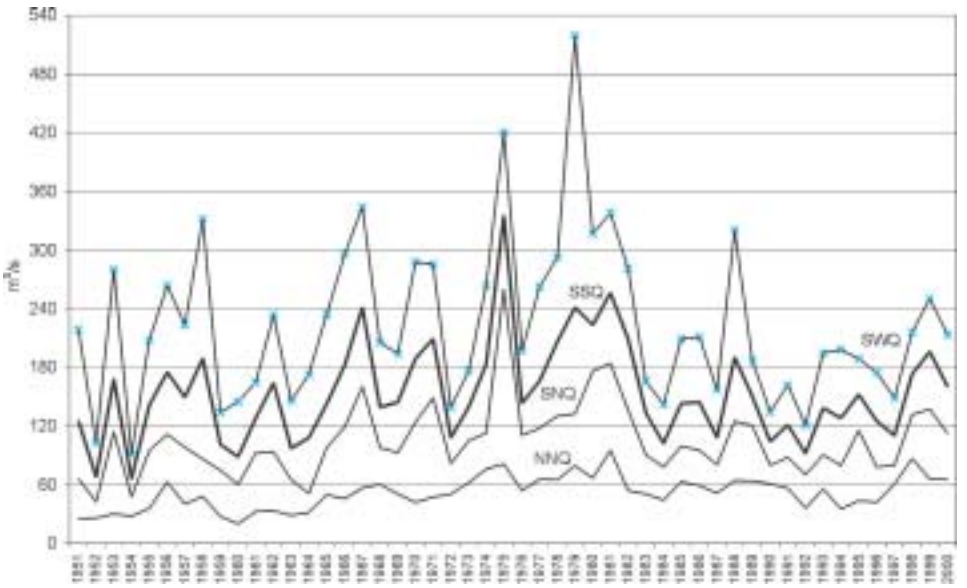

Figure 1. Extreme annual averages and annual averages of minimum and maximum monthly discharge of the Bug river in Wyszków between 1951 and 2000 (data IMiGW): SWQ – average of monthly maximum; SSQ – monthly average; SNQ – average of monthly minimum; NNQ – annual minimum

The values of the average annual discharges between 1951 and 1981 show a clear upward tendency. In the next decade the amount of water running off from the basin was just below the modulus. The discharges in recent years were also slightly lower than the average values. The annual values of characteristic discharges – average high, average, average low and minimum are shown in Figure 1 while Figure 2 shows the monthly values of characteristic discharges in the years 1996 to 2000 that is – maximum, average and minimum which were rejected each month.

Sesonal diversity of runoff from the Bug river basin appears to be strongly influenced by climatic continentality. The monthly discharge values for the Bug river in Wyszków are compiled in Table 1 [Fal *et al*. 1997]. The monthly discharges in the summer half-year are considerably lower than the discharges in the winter period (Fig. 3) and the variation in the monthly average discharges is almost 4. In the winter half-year 62% of the volume of the run off water is drained while in summer it is only 38%. Maximum monthly discharges appear in April so they are related to the period of the snowmelting water downflow. Minimum monthly discharges appear in September, after the dry summer period. The water resources in summer period, despite high rain falls, decrease. The renewed increase of the discharge is caused by autumnal rainfalls. In winter the discharges remain at a level only slightly below the average for the multiannual period. A remarkable increase of

Table 1. Monthly characteristic discharge of the Bug river in Wyszków between 1951 and 1990 in m^3/s [Fal *et al.* 1997]: WWQ – maximum discharge; SWQ – average from maximum; SSQ – average; SNQ – average from minimum; NNQ – minimum

Discharge	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X
WWQ	1170	715	680	738	2400	2130	617	645	405	472	335	787
SWQ	180	216	198	238	479	519	255	164	143	136	112	143
SSQ	142	152	146	146	254	342	179	124	109	100	87,1	109
SNQ	108	99,5	102	98,7	141	194	122	95,3	82,4	75,8	70,8	79,4
NNQ	31,1	19,80	27,4	27,8	34,5	64,7	49,5	40,2	27,4	25,6	25,0	25,6

the flowing water is reported during the downfall of the snowmelting water in March and April. During those two months almost ⅓ of the yearly volume of the water drained from the basin runs off.

The course of the calculated values of the average from monthly minimum discharges is very similar to the changes of the monthly average discharge. The lowest reported discharge between 1951 and 2000 was in December (Fig. 3). Changes in the monthly minimum discharges are small, with the maximum appearing in April. The average of the minimum discharge (SNQ) is 50.0 m^3 which equals the specific runoff of 1.28 $l/s \cdot km^2$.

Spatial diversity of discharges and runoff

The rivers in the Bug river basin have rather small discharges, which is a consequence of a low atmospheric recharge and small catchment areas. The discharges of only a few rivers in their low courses overcome 5 m^3/s (the Pełtew, the Rata, the Muchawiec, the Krzna, the Leśna, the Nurzec, and the Liwiec rivers) and usually,

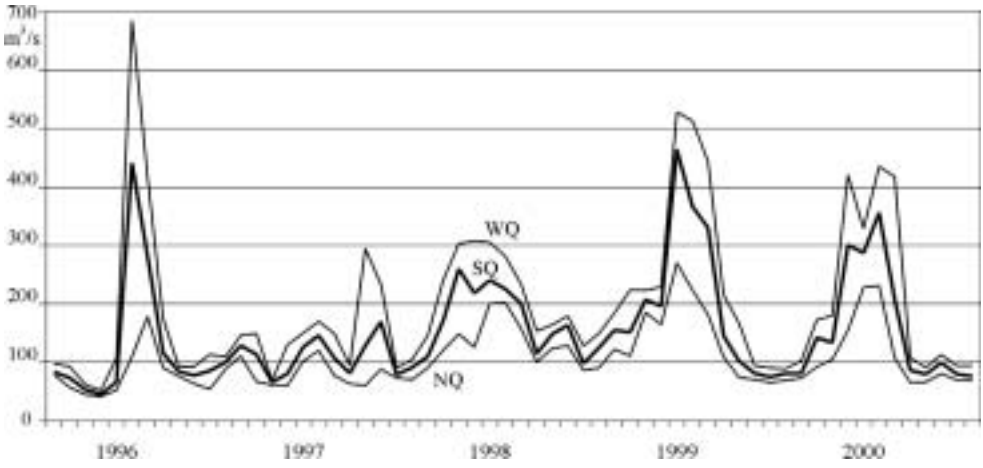

Figure 2. Monthly characteristic discharges of the Bug river in Wyszków between 1996 and 2000 (data IMiGW): WQ – maximum discharge; SQ – average; NQ – minimum

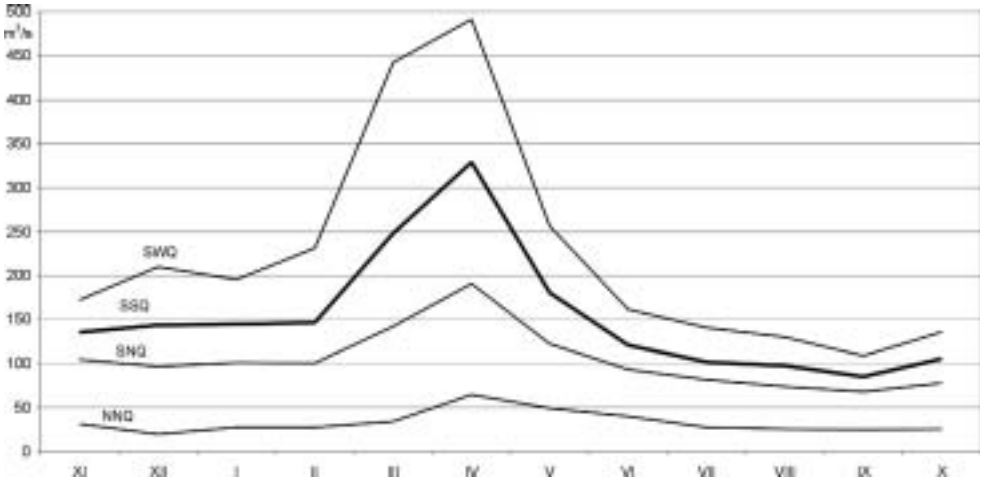

Figure 3. The average monthly discharges of the Bug river in Wyszków between 1951 and 2000: SWQ – the average of monthly maximum; SSQ – monthly average; SNQ – the average of monthly minimum; NNQ – monthly minimum

they do not reach 2.0 m^3/s. The Bug river reaches about 40 m^3/s in Poland. In its border section the average discharge of the Bug river increases to 100 m^3/s. As it enters the Zegrze Reservoir its average discharge is almost 160 m^3/s.

The average specific runoff from the Bug river basin between 1951 and 2000 was 3.93 $l/s \cdot km^2$. Its value in the upper and border course of the river decreases as the catchment area is increasing. In the lower course, due to the higher rain recharge in the Siedlecka and the Bielska Plateau, the specific runoff increases slightly.

In the Ukrainian part of the catchment the average specific runoff of the Bug river was about 4.5 $l/s \cdot km^2$. The streams of the upper part of the basin gather water from the northern slope of the Roztocze and the Podole – regions with relatively high rain recharge. Higher precipitation, over 650 mm, lead to relatively high values of specific runoffs, which remain around 4.2 to 5.0 $l/s \cdot km^2$. Substantially, lower values of runoff are recorded in the northern part of the Wolynian Upland, which has the basins of the Huczwa and the Ług rivers with specific runoff of about 2.95 $l/s \cdot km^2$. Even lower runoffs were recorded in Polesie in the southern part of the Muchawiec river catchment.

In the border section the rain recharge is smaller, which is illustrated by lower specific runoff – from the Bug river and its tributaries catchments (Tab. 2). From the Polish area of the basin the down-flowing rivers are rather low in water: the Huczwa, the Uherka and the Krzna, as their specific runoff remains in the range 2.6–3.6 $l/s \cdot km^2$. Similar values of specific runoff are reported in the Ukrainian and Belarussian catchments. The lowest specific runoff in the whole Bug river basin is found in an area enclosed by two water gauges in Strzyżów and Dorohusk, where only 2.28 $l/s \cdot km^2$ was reported. Simultanously, this is a zone of low precipitation value, the annual value oscillates around the 550 mm. Further along, in the section between Dorohusk and Włodawa, the specific runoff slightly increases to 3.73 $l/s \cdot km^2$, between Włodawa and Krzyczew it is 3.67 $l/s \cdot km^2$. In the Podlasie

Table 2. The average specific runoffs from the catchments in the Bug river basin

Specific runoff in l/s·km^2	Catchment
Over 5,00	Bug to Sasów, Bug to Kamjanka Buzka, Pełtew to Busk, Kostrzyń to Jagodno
4,6–4,99	Bug to Sokale, Rata to Mieżereczija, Nurzec to Boćki
4,2–4,59	Bug to Strzyżów, Leśna to Tiuchiniczi, Nurzec to Brańsk, Brok to Kaczków, Liwiec to Łochów, Osowiec to Zawiszyn
3,8–4,19	Bug to Dorohusk, Bug to Wyszków, Sołokija to Czerwonohrad, Muchawiec to Brześć, Liwiec to Zaliwie
3,4–3,79	Bug to Włodawa, Bug to Frankopol, Żeldec to Ługowije, Uherka to Ruda Opalin, Włodawka to Okuninka, Ryta, Liwiec to Kreślin
3,0–3,39	Świnia to Niestierów, Krzna to Malowa Góra
2,6–2,99	Ług to Włodzimierz Wołyński, Huczwa to Gozdów, Osipówka

section, in the lower course of the Bug river the specific runoff increases: between Krzyczew and Frankopol it is 4.52 l/s·km^2 and between Frankopol and Wyszków increases to 5.02 l/s·km^2. This is caused by distinctly higher rain recharge. In the catchments in this part of the basin the value of specific runoff exceeds 4.5 l/s·km^2. As a result of high recharge the specific runoff in the lower course of the river increases, to such a high value, that for the whole Bug river basin it is 4.0 l/s·km^2. Characteristic values of the specific runoff in the catchments of the Bug river basin are collected together in Table 2. These are values collected from various measurement periods, from observational data and publications. In the group of rivers characterized by highest specific runoff there are catchments located both in the lower and upper courses, in which the value of precipitation recharge was higher than 650 mm. The lowest specific runoff exists in those catchments where precipitation recharge is lower than 550 mm. This indicates the basic role of precipitation in the creation process of the runoff from the catchement.

The amount of outflowing water depends on the difference between the precipitation and the evapo-transpiration indexes. In the Bug river basin the average value of evapotranspiration is about 450 mm. The river runoff creates precipitation higher than the value of evapotranspiration. The difference between those two values – precipitation and evapotranspiration – illustrates the size of the hydrological water resources. In the Bug river basin the water resources expressed with the average precipitation index, change from 200–220 mm in the Roztocze and the Podole regions to 95–100 mm in the zone of the middle Bug river valley – at the northern edge of the Wolynian Upland and the Polesie. The highest runoffs are found in the Roztocze, the Podole, and in the hills of the Siedlecka and Bielska Plateau (Fig. 4) that is, in the zones with the highest precipitation recharge. The runoff index consequently decreases with the increase of the catchment area. In Figure 4 there is a large gradient indicating a significant change in the water resources in the Pobuże and the Polesie areas. In the central part of the basin, in a zone with a shallow occurence of groundwater and low precipitation recharge a low runoff index does not imply a significant spatial diversity. Its increase takes place in the northern part of the basin.

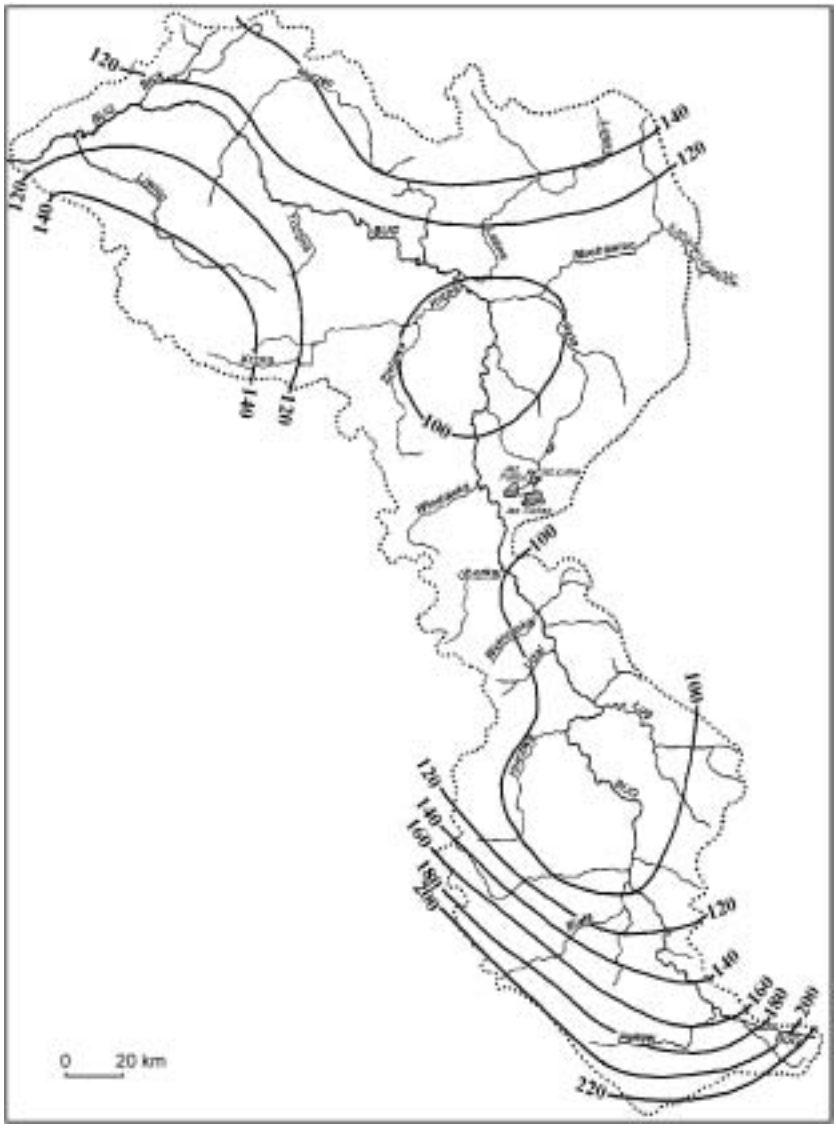

Figure 4. Isograms of the runoff index in the Bug river basin (in mm)

Characteristic water stages and rivers' discharges

Analysis of the diurnal amount of the flowing water indicates the occurence of an extreme annual values of the maximal and minimal discharges every season of the year. Similarly, in other rivers in Eastern Poland, high river discharges are registered most often in the springtime, and rarely in the summer months. High flood stages appeared in the snowmelting periods, when rain fell on the snow cover in the Bug river basin. The highest values during the snow – melt flood stages were recorded in March and April 1979 while the highest rainfall flood stages were recorded in July and August 1960 and October 1974. During periods of the high

flood stages, the water in the Bug river rises to 3 m and in Strzyżów up to as much as 7 m. Characteristic high flood stages and values of alarm and warning levels are illustrated in Table 3.

The range of the Bug river's water stages changed from 738 cm in Strzyżów to 444 cm in Włodawa. Maximum water stages were seen during the spring water flow and minimum ones were seen in autumn. In the Bug river's tributaries the difference in the water stages was lower, it remained between 200 and 300 cm. An increased range of water stages was reported in the lower course of the Brok river. A wide range of water stage changes is the result of a simultaneous surface flow from the whole catchment area.

Observation of this part of the Bug river during 1999 revealed fairly high water stages. The alarm level in Włodawa was exceeded from 11th to 29th of March. Maximum water stages reported in 1999 were about 50 cm lower than the absolute maximum (Tab. 3). In February 2000 the water stage exceeded the alarm level by several centimetres. The absolute maximum water stage in Włodawa, which was 506 cm, was reported during the spring flood stage in 1964.

Minimum discharge of many rivers decreased to several or several hundred l/s. Maximum discharge increased up to several hundred cubic meters per second. This irregularity of discharge ranged from 62 at Huczwa up to 1340 in Brok. Also of note are the higher discharge irregularities of the rivers in the lower course of the Bug river. The variability of the Bug river discharge estimated as a quotient of the maximum and minimum discharge remained between 100 and 200.

Table 3. High characteristic stages in the water gauges of the Bug river in cm between 1961 and 1995 [Hydrologia...1998]

Water gauge	Absolute maximum	WWW	SWW	Alarm level	Warning level
Strzyżów	912	912	726	750	600
Włodawa	506	506	339	350	250
Frankopol	521	521	325	350	250
Wyszków	653	653	450	450	400

Physico-chemical properties of the water

The physico-chemical features of the water in the border and lower course of the Bug river were presented in the paper "Water of the Bug river basin" [Michalczyk 1999]. The Bug river water flowing into the Polish territory does not have a natural composition, according to Szczukariew-Prikłoński's criterion the water have of an HCO_3, SO_4, CI, Ca, and Na type. There is a decrease of mineralization in the water leaving the uplands caused mainly by a reduction of about ⅓ of the ions of natural origin HCO_3 and Ca and those which indicate an anthropopressure of Cl and SO_4 (Tab. 1). In the lower course of the river hydrochemical changes of the water ranging from 2 to 5 ion concentration are periodically reported.

Table 1. Characteristic water quality parameters of the Bug river from 14 to 15 of September [Michalczyk *et al.* 1999]

Profile	Reaction pH	Hardness, mval/l		HCO_3	Cl	NO_3	SO_4	Ca	Mg	Na	K	Mineralization
		Total	Non Carbon type	mg/l								
Gołębie	7,87	8,04	2,46	340	73	10	113	137	19	45	4	741
Dorohusk	7,61	7,50	1,26	381	67	6	91	136	9	42	4	737
Włodawa	7,98	7,45	1,45	366	66	6	93	132	10	41	4	718
Wyszków	8,11	4,43	0,62	232	31	4	58	72	10	32	5	444

The chemical composition of the Bug river water changes seasonally, not only because of groundwater and surface recharge in the river runoff but also because of high seasonal pollution drop into the rivers. For example, in Wyszków from 1990 to 1993 the specific ion concentration changed as follows: calcium 36–131 mg/l, magnesium 7–20 mg/l, sodium 10–55 mg/l, potassium 2–39 mg/l, chloride 15–48 mg/l, nitrates 0–30 mg/l, and sulphates 32–100 mg/l. The average annual total runoff of substances in these years was around 1.5 million tonnes per year, anthropogenic substances accounted for 1/3 of the solutions [Chmiel 1995]. Maruszczak and Wilgat [1989/1990] described similar proportions of anthropogenic substances in the total runoff from the Bug river basin between 1976 and 1985. The more urbanized and industrialized part of the upper Bug river catchment supplies the water with more substances of anthropogenic origin, than the lower part.

Biogenic substances the occurence of which, in large amounts, results mostly from the poor sewage treatment decrease of the water quality. An improvement in the Bug river's water purity can be achieved by investment in the sewage treatment plants.

Evaluation of the water quality of the Bug river

The water quality of the Bug river depends on the amount of flowing water in the river channel and the amount of pollution dropped into the river in Ukraine, Belarus and Poland. An examination of the water's quality was conducted in 1997 along the entire course of the river – in 14 controlled and measured sections. In Poland the quality of water was determined by sewages from the towns located near the Bug river and the sewages carried in water from tributaries, including those which enter Poland from beyond Polish borders.

The basis for the evaluation of the water quality of the Bug river and its tributaries was established in the paper "Comparative evaluation of the state of pollution of the rivers between 1996 and 1997" (Porównawcza ocena stanu zanieczyszczenia rzek z lat 1996–1997) [Bożek *et al*. 1998]. Characteristic concentration of particular water quality parameters of the Bug river in Wyszków are put together in Table 2.

The calculations of pollutant loads in the water, highlight the large quantity of organic substances and nitrates carried from abroad. Therefore, the first steps should be reduction of the pollutant load and improvement of the quality of water coming from Ukraine and Belarus.

Table 2. Characteristics of the Bug river water quality in Wyszków in 1997 [Bożek *et al.* 1998]

Parameter	Unit	Range of measured concentration		Conclusive concentration		Guaranteed concentration p=90%	
		from	to	value	evaluation	value	evaluation
1	2	3	4	5	6	7	8
Flow	m^3/s	61,6	294	–	–	–	–
Colour	mg Pt/l	20	85	–	–	70	–
Turbidity	mg/l	NF	45	–	–	40	–
PH	pH	7,3	9,1	–	–	7,8–9,0	II
Dissolved oxygen	mg O_2/l	6,2	15,7	8,71	I	7,24	I
BOD5	mg O_2/l	1,4	18,6	4,43	II	15,4	BSF
ChOD–Mn	mg O_2/l	6,4	22,7	9,14	I	19,4	II
ChOD–Cr	mg O_2/l	15	66,7	30,8	II	60	II
Organic carbon	mg C/l	5,5	21,6	10,1	–	19,9	–
Chlorides	mg Cl/l	16	40	31,6	I	31,6	I
Sulphates	mg/l	11	71	50,6	I	56	I
Total dissolved solids	mg/l	229	414	343	I	396	I
Total suspension	mg/l	2	133	8,5	I	74,2	BSF
Total hardness	mg/l	196	390	293	I	314	I
Calcium	mg Ca/l	61,8	124,3	97,1	–	105	–
Magnesium	mg Mg/l	5,1	19,9	11,9	–	18,1	–
Sodium	mg Na/l	23,6	42,7	36,3	I	37,3	I
Potassium	mg K/l	3,4	7,1	4,91	I	5,26	I
Ammonium nitrogen	mg N/l	0,13	1,18	0,4	I	0,95	I
Nitrate nitrogen (III)	mg N/l	NF	0,098	0,01	I	0,05	III
Nitrate nitrogen (V)	mg N/l	NF	2,52	0,2	I	2,3	I
Kjeldahl's nitrogen	mg N/l	0,91	4,83	2	–	3,6	–
Total nitrogen	mg N/l	2,47	5,53	3,2	I	4,4	I
Phosphates	mg PO_4/l	0,03	0,58	0,25	II	0,46	II
Total phosphorus	mg p/l	0,15	0,61	0,22	II	0,31	III
Total Iron	mg Fe/l	0,01	0,14	0,03	I	0,1	I
Manganese	mg Mn/l	NF	0,23	0,08	I	0,1	I
Total Chromium	mg Cr/l	NF	0,003	0,0002	–	0,002	–
Zinc	mg Zn/l	NF	0,05	0,01	I	0,03	I
Cadmium	mg Cd/l	NF	0,0014	0,0002	I	0,001	I
Copper	mg Cu/l	NF	0,004	0,001	I	0,003	I

1	2	3	4	5	6	7	8
Nickel	mg Ni/l	0,001	0,013	0,005	I	0,01	I
Lead	mg Pb/l	NF	0,018	0,0002	I	0,001	I
Volatile phenols	mg/l	NF	0,013	0,001	I	0,004	I
Anion detergents	mg/l	0,02	0,1	0,06	I	0,1	I
γ - HCH	µg/l	0,001	0,003	0,0018	–	0,0027	–
DDE	µg/l	0,0011	0,0053	0,0023	–	0,0048	–
DDD	µg/l	0,0012	0,0078	0,0047	–	0,0073	–
DDT	µg/l	0,0018	0,0078	0,004	–	0,0072	–
PCBs	µg/l	0,0024	0,0112	0,0065	–	0,0104	–
Chlorophyll "a"	µg/l	3,1	213,8	13,1	II	147	BSF
Coli-form index type faeces	ml/bact.	20	0,01	0,01	III	0,04	III

Abbreviations:
BOD5 Biochemical Oxygen Demand for 5 days (determining the oxygen absorbed by a sample of water at 20°C for 5 days)
DDT Dichlorodiphenyltrichloroethane, pesticide
DDE Dichlorodiphenyldichloroethylene, pesticide, chemical similar to DDT
DDD Dichlorodiphenyldichloroethane, pesticide, chemical similar to DDT
PCBs Polychlorinated Biphenyls
NF Not found
BFS Below formal standards

According to reliable concentrations the water in the Bug river up to the mouth of the Leśna river, was below the acceptable level at Class III – because of the excessive amount of coli-form bacteria. In the lower course, below the Leśna river water quality of Class III was recorded. The evaluation of the water quality determined by selected attributes is presented in the following way:

Due to the presence of organic substances water quality was mostly of Class II, in the section from the Krzna river to the Cetynia river it was of Class I.

Due to a large quantity of dissolved solids – from the country border to the river Wełnianka and from Włodawa up to the mouth of the Muchawiec river – water quality was of Class II. In the remaining course the salinity qualified the Bug river water as Class I purity.

In the Ukrainian course the level of solids in suspension in the Bug river gives a water purity of Class II. There is a similar level of solids in suspension in the lower course of the river – below the Kosówka river. In the remaining course the level of solids in suspension in the water is lower with a water purity of Class I.

The amount of the biogenic substances in the water of the upper and middle course cause the water purity to be Class III. Below the Leśna river the quality of water improved and purity was within the range for Class II.

The sanitary state of the water in the border course was below the acceptable levels.

The bacteriological content of the water exceeded the acceptable levels up to the Leśna river. Further along the river course the amount of coli-form bacteria in the water was within the range for Class III.

In hydrobiological terms the quality of the Bug river water was within the range for Class II purity throughout the examined section.

Evaluation of the water quality of the Bug river carried out according to physico-chemical criteria showed that in 1997 at 246.7 km the water was within the purity range for Class II and at 323.5 km it was within the range of Class III.

Comparison of the results of the pollution evaluation conducted in 1995 and 1997 shows an improvement of the Bug river water's quality.

In 1997 the water of purity Class I was recorded at 230.6 km and in the remaining section the water was of Class II. Overpolluted waters were not registered.

The reason for such an improvement was a lower quantity of suspension in the Bug river water. The Bug river water could not provide a habitat for salmonids due to a high concentration of ammonium nitrate and a shortage of oxygen. For carp fishes the Bug river water was only suitable above Strzyżów, below the place where the Bug river enters the Wełnianka river and at the river mouth section. The Bug river water was not suitable for recreational purposes due to the sanitary conditions.

The water quality of the Bug river and its tributaries in the border section was checked in 1998 by the Voivodship Inspectorate of the Environmental Protection (Wojewódzki Inspektorat Ochrony Środowiska) in Lublin. These researches show that the water quality of the Bug river did not meet mandatory standards [Raport 1999]. The main indicator of the persistent pollution of the Bug river water was a very high characteristic concentration of chlorophyll "a" registered in seven lower measurement profiles. Moreover, the quality of the water was disqualified by concentration of ammonium nitrate and its coli-form index [Raport 1999]. Other parameters indicating the water's purity: phosphates, total phosphorus, universal suspension were within Class III purity standards. Other parameters – (amount of dissolved oxygen, oxidisability, ChOD, chlorides, sulphates, universal ammonium, saprophyticity Seston) met the standards for water purity of Class I or Class II.

Low quality of the Bug river water in the whole border section was recorded also between 1990 and 1996 [Charakterystyka... 1997]. The measurements were done in 9 control-measurement profiles. Annual concentrations of phosphates were near the borderline for Class III purity, and in half of the results they were far below the basic standard. In all 9 control profiles (apart from Sławatycze) the coli-form index was below the standards for Class III [Charakterystyka... 1997]. Concentration of BOD_5 and the amount of dissolved oxygen in the Bug river water were below basic standards from the border with Ukraine up to Dorohusk. Further in, these parameters were within standards for Class II or Class III. The amount of ammonium nitrate and total ammonium met the standards for Class I or Class II purity [Charakterystyka... 1997].

In the Ukrainian part of the Bug river and its tributaries there is high sewage inflow with varying pollution levels. The Bug river as well as its tributary rivers: the Pełtew, the Świnia, the Rata and the Sołokija rivers are seasonally highly polluted below the sewage outlets.

Evaluation of the water quality of the Bug river tributaries in 1997 (based on the papers of Bożek *et al*. [1998])

The Huczwa, a river of 74.6 km flows into the Bug river on the left bank (547.2 km). The water quality of the Huczwa river was directly influenced by the sewage drop from Werbkowice and Hrubieszów and water inflow of the tributaries: the Wożuczynka, the Sienocha and the Białka rivers. According to a general estimation, only the part from the Sienocha river's mouth to Werbkowice was within the range for Class III, in the remaining section the quality of water was below the standards. The amount of organic substances indicated a possible Class III: in the upper course, below Werbkowice – within 6.3 km and in the river's mouth section below Hrubieszów. In the remaining course, the pollution did not exceed the level for Class II. However, the biogenic substances disqualified the quality of water. Only in the section from the Sieniocha river to Werbkowice did the water meet the criteria for Class III.

Evaluation of the quality of the water based on physico-chemical criteria indicated that water within the standards for Class III made up to 11%, in the remaining section the water did not meet basic standards. On the basis of the coil-form index it was stated: that 5% of the water was of Class II, 48% of Class III and 47% did not meet the standards.

The Udal, a river of 32.4 km, flows into the Bug river on the left bank in its 460.8 km. The examination covered the whole river on the basis of the results from the tests at two control-measuring profiles. The purity of the water along its course was influenced by the outflow from the sewage treatment plant in Żmudź. General estimation showed that the water met the criteria for Class III. The level of organic substances and suspention met the criteria for Class II. Biogenic substances did not exceed the standards for Class III.

Based on physico-chemical criteria and the coli-form index it was reported that in the whole controlled section the water met the standards for Class III.

The Uherka, a river of 44.9 km; is a left-bank tributary of the Bug river, flowing into the river at 429.7 km. Classification dealt with a section 36 km long from the town of Żółtańce. The main source of pollution in the Uherka river is the sewage from Chełm. General estimation of the pollution level showed that the water of the Uherka river was excessively polluted. Classification based on particular pollution groups showed that the organic substances in the checked section met the criteria for Class III, and the biogenic substances exceeded the allowed standards for Class III. Based on physico-chemical criteria the water of the Uherka river did not meet the allowed standards in the whole the examined section. According to a sanitary examination, water of Class III made up only 10% of the total water and the rest was below basic standards.

The Włodawka, a river of 31.5 km flows into the Bug river at 375.8 km on its left bank. The quality of water in the Włodawka river was influenced by sewage from Hańsk and Suchawa. General estimations showed that the pollution level of the Włodawka river exceeded the standards of Class III in the entire examined section

and the level of biogenic substances disqualified the water totally. Estimation based on physico-chemical criteria showed that 100% of the water did not meet basic standards. The sanitary estimation showed that 50% of the water was of Class II purity while the remainder was of Class III.

The Krzna, a river of 119.9 km flows into the Bug river at 272.2 km. Estimation of the pollution level for the entire river course was made at 8 control-measuring profiles. The quality of the water was influenced by the pollution brought from Łuków, Międzyrzecz Podlaski, Biała Podlaska and Małaszewicze.

General estimation showed, that in its entire course the standards for Class III water purity were exceeded.

The level of organic substances disqualified the water in the sections from Łuków to the mouth of the Wieprz – Krzna Channel and below Międzyrzecz Podlaski – at around 13.4 km. In the remaining water Class III standards were met.

The salinity of the water met the standards for Class I above Łuków and below the Wieprz – Krzna Channel, in the remaining course the level of salinity met the standards for Class II.

The concentration of suspention in the upper course of the river, above Łuków, did not exceed the standards for Class I. From Łuków to the outlet of the Wieprz – Krzna Channel the quality of the water dropped to Class III, below Łuków the water met the standards for Class II. In the outlet section – below Małaszewicze the concentration of suspention increased with the water being Class III.

The level of biogenic substances disqualified the quality of water in the entire river course.

Estimation based on physico-chemical criteria and the coli-form index showed, that the water did not meet basic standards throughout (in 100%).

The Leśna river, is a right-bank tributary flowing into the Bug river at 263.7 km. In the Polish, upper section, a length of 27.7 km – from the sources up to the border with Belarus, the water was excessively polluted; the level of organic substances disqualified the quality of the water, as did the biogenic substances. Based on the sanitary conditions the water meeting the standards for Class II made up 17%, 22% of the water was of Class III and the remaining water fell below basic standards. Sewage from Hajnówka is the key harmful factor here. The quality of the water in the Leśna and the Muchawiec rivers was established at their mouth sections. According to the quality standards applied in Belarus, both rivers were considered to be moderately threatened. The water is well oxygenated, bio-chemical oxygen requirements within 5 days is from 3 to 4, however it possesses an increased amount of iron, phosphates and oil products [Gidrołogiczeskaja 2000].

The Toczna, a river of 35.0 km flows into the Bug river at 178.8 km on the left-bank. The main source of water pollution is sewage brought in from Łosice. The level of pollution in the Toczna river did not meet the standards for Class III at a section of 15.3 km long below Łosice. In the remaining water Class III standards were maintained. Based on physico-chemical criteria water meeting the standards for Class III class made up 56%,while the remainder did not meet basic standards. Based on

sanitary conditions, only 75% of the water met the standards for Class III, the remaining water was below basic standards.

The Cetynia, a river of 35.6 km flows into the Bug river on its left-bank at 131.7 km. The main source of pollution is the sewage from Sokołów Podlaski. The general pollution level of the Cetynia river did not meet the standards for Class III along its entire course. Based on the amount of biogenic substances and the coli-form index the water in the entire section did not meet basic standards. Estimation of water purity based on the quantity of organic substances in the Cetynia river section, from its source up to Sokołów Podlaski, showed that standards for Class III were maintained. Below the sewage outlet pollutant levels exceeded those acceptable. At 13.6 km and further along the course of the river the water met the standards for Class III.

The Kosówka, a river of 17.6 km long flows into the Bug river at 101.5 km. Based on physico-chemical criteria and the coli-form index its water did not meet basic standards. The same applied to the amount of biogenic substances that disqualified the quality of the water throughout its entire course. The quality of the water was influenced by pollution from Kosów Lacki.

The water of the Kamianka river in its mouth profile did not meet basic standards due to both its physico-chemical parameters and its low coli-form index.

The water of the Nurzec river in its mouth profile met the standards for Class II – the value of the coli-form index qualified the water to Class III.

The water of the Brok river where it flows into the Bug river, based on physico--chemical and bacteriological criteria did not meet the standards for Class III purity.

Liwiec, a river of 126.2 km flows into the Bug river at 42.7 km. The main source for pollution is the sewage from Siedlce and Węgrów. General estimation of the pollution level showed, that the water of the river in the section examined did not meet basic standards. This was determined by estimation based on physico-chemical criteria, the coli-form index and the amount of the biogenic substances in the water. The level of organic substances above the mouth of the Sosna river and from the Muchawka tributary to the mouth profile of the Krzna river did meet the standards for Class III while the remaining water did not exceed the standards for Class II.

Economic use of water

Water supplied to people living in the Bug river basin is mainly achieved by using groundwater resources. Most of the industrial plants use only groundwater resources. Only plants such as the sugar-factories and the tanneries use surface water. Most of the surface water resources are used in agriculture – for irrigation purposes.

In 1998, in the Polish section of the Bug river basin water intake for the national economy was about 83.3 mln m^3 [Ochrona... 1999]. Water was distributed in the following way: industry used about 12.4 mln m^3, agriculture 38.8 mln m^3, and

water supply systems 32.1 mln m^3. Relative water use is diverse in the basin area. This results from the way the land is used, mostly for farming. Of the water used for the industry, 88% was from the groundwater resources – 11.8 mln m^3, 1.6 mln m^3 was surface water. Out of 32.1 mln m^3 of industrial and municipal sewage in 1998, 95% was mechanically and biologically cleaned and the remainder was discharged directly to the surface waters or drainage systems.

In the Belarussian section of the Bug river basin the average annual water intake is about 89 mln m^3, of which 74 mln m^3 comes from the groundwater resources and 15 mln m^3 from the surface. Most of the water is used to serve municipal needs – 52 mln m^3, industrial – 17 mln m^3, village supplies 10 mln m^3, watering 0.7 mln m^3, fish breeding 6 mln m^3. 47 mln m^3 of sewage is dropped into the surface waters and 7 mln m^3 to the ground. It is estimated that 400 mln m^3 of pure water is needed to dilute the sewage to an acceptable level of pollution concentration.

In the Ukrainian section of the Bug river 225 mln m^3 of water was used. 219 mln m^3 of sewage was dropped to the surface waters [Strelc 1987]. Based on materials published in "Charakterystyka wód granicznego odcinka Bugu w latach 1990–1996", supplemented with other archive materials, it can be estimated that the annual amount of sewage drop in those years, in the Ukrainian section of the catchment area, was 226 mln m^3 per year. In recent years the amount of the dropped sewage decreased slightly: in 1999 191 mln m^3 of sewage was dropped to the Bug river, most of it coming from Lviv.

In the Bug river basin there are many small towns and industrial plants dropping sewages. Collected research material indicated that during 1 year 300 mln m^3 (that is 9.5 m^3/s) of sewage is discharged in the Bug river basin. The amount of sewage decreases along the river course. Most of the polluted water flows from the Lviv and Wolynian and Briest areas.

Over several years a process of economic transformation in Eastern Poland was observed, related to the opening of the eastern markets to Polish and western products, including food crops. Increased investment in the Bug river catchment area will be followed by a great increase in water demand – in comparison to present use. This applies mainly to the increased intake of surface waters for agriculture and groundwaters for municipal purposes.

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Chapter IV

Management elements in the Bug river valley

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Hydrotechnical activity within the river channel and the valley bottom directly influences both past and present threats to the natural assets of the valley. Based on archival researches and territorial works a record was made of the effects of engineering activities in the Bug river valley.

Even the most detailed, actual data about the condition of the natural resources does not present a real picture of the environmental transformation, as it does not convey the intensity and the character of this transformation.

An attempt to grasp this phenomenon is seen in a study of changes in the land use structure in the Bug river valley. The study was based on a comparative analysis of maps of selected areas representing the valleys physiographical regions. In each case details of land use were presented from two periods separated by at least 50 years (Fig. 1–4).

Within this comparative analysis of maps it is important to remember that, despite the fact that maps are a rich source of information, it is not always possible to treat them as a reliable source. Not so long ago topographical information on the maps was purposely falsified. Also, maps have different scales, different degrees of generalization and detail which can encumber any detailed comparison.

Hydrotechnical and transportation development

Most management elements disturb the ecology of the river valleys. Hydrotechnical constructions (accumulating, regulating, flood control) and constructions of the transportation infrastructure (road, railways, bridges, border crossings), play a major role here. Some of them constitute parallel or longitudinal obstacles that prevent organisms from reaching the water or moving freely, as well as hindering seasonal animal migration. They also hinder the spatial continuity of the valley in its role as an ecological corridor.

The boundary character of the Bug river conditions hydrotechnical and transportation management of its valley. This divides the river into three sections: the Ukrainian section, the Belarussian section and the Polish section. The presence of a carefully guarded border between Poland and USSR hindered any actions aimed at constructing and regulating an embankment along the river, and the development of border crossings (bridge crossings over the Bug river). However, the situation supported the preservation of the unique natural assets in the area. The situation in the Ukrainian (upper) and Polish (lower) course of the river was different. Management of the valley was unlimited, allowing the construction of two dams and numerous bridges as well as a regulated embankment along some sections of the Bug river. Still, hydrotechnical and transportation management, especially in Poland, was not too intensive. This was mainly due to the financial situation, which also limited actions taken in the boundary section: for example the existing embankments were not developed despite the often high water stages of the Bug river, and the bottom of the flood terrace was almost left untouched in this section.

Hydrotechnical and transportation structures were constructed over several hundred years depending on economic need and technical ability. At present remains of those structures are still found in certain parts of the Bug river valley; to a certain extent they also act as an ecological barrier. Some of those remains were adopted by nature: near Łęgi (Janów Podlaski) a habitat is being designed which will adopt the remains of the bridge crossing.

The term "hydrotechnical structures" comprises the following items: flood control embankments, dams, weirs, barriers, structures related to regulation of the river (strengthening of the river channel) and drainage ditches. Their presence not only disadvantages the hydrological condition of the river: acceleration of the water flow and decreased underground water level, but also decreases the diversity of habitats and organisms.

There is deterioration of islands, old river beds, and natural, sandy slopes which create good conditions for bird nesting: terns, plovers, sand martins, and kingfishers for example near Wyszków and Wywłoka [Nowicki *et al*. 1993]. The moisture level in the valley also decreases, which results in characteristic changes in the uses of the valley (specially the deterioration of the wet meadows). Limitation of the flooded areas results in a lack of re-development of natural habitats (riparian forests, flood hay-growing meadows).

In the Ukrainian section the Bug river is dammed in two places: Sosnówka and Dobrotwór. In the much longer, boundary sections there are no such structures. There is only a small damming in the debris under the railway bridge in Dorohusk and a needle weir on collapsible wheels built in 1931 near Terespol, 2.5 km, below the outlet of the Muchawiec river – which was designed to dam the channelled Muchawiec river [Monografia... 1985].

In the Polish section there are no big hydrotechnical structures. The only structures present are related to the regulation of the Bug river. These are: transversal groins and strengthened banks near Wyszków, and a new channel near Wywłoka and the outlet section Kuligów – Popowo Kościelne. Structures of this type are also present in other sections. Some of them are remains of old activity (mainly in the second half of the 19th century). For example, in Mościce Dolne and Jabłeczna the river

bank was changed in such a way that the present buildings were constructed on the left bank of the river [Rąkowski 1996].

The Polish section of the Bug river is characterised by the channel's embankment. The flood control embankments were raised too close the channel. These are: an embankment of 65 km length running from Krzemień – Zagacie (Jabłonna Lacka) to Szynkaszyzna (Sadowne) located in the left-wing of the Bug river valley. This is mainly a single embankment. In the section from Brok to Małkinia a double embankment was raised. In this section there is also a bilateral embankment from the outlet of the Bug river to the Zegrze Reservoir – from Popów (Kuligów) to Serock (each of them is 6 km long).

In the boundary section there are two kinds of flood control embankment: old ones: lower (2 to 3 m high) and new ones – higher (about 5 m high). They are present near Dorohusk (old one – 2 km long), in Włodawa (old one – 2 km long), from Wola Uhruska through Stulno to Zbereż (new one – lower about 5 km long), near Terespol (new ones, outer and inner embankments, each one about 2 km long).

In the Ukrainian and boundary section on the Ukrainian and Belarussian side the embankments were raised in several places: near Brześć and Czerwonograd.

Draining meliorations took place mainly in the boundary section of the Bug river. They were conducted in the second half of the 19th century and then continued in the 1960's and 1970's. The drainage ditches from that period are not currently conserved, therefore they overgrow and do not fulfil their role. They are present near Strzyżów, Horodło, Bereźnica, Matcze, Skrychiczyn, Świerże, Uhrusk. In Poland near Bubel Stary and Serpelice.

The old hydrotechnical structures: dams and dykes related to the water mills are also worthy of mention. They were present near Strzyżów, Mielniki, Uhrusk, Wola Uhruska, Niemirów and Gnojno [Mapa Kwatermistrzowska... 1839–1843, Gloger 1903]. At present there are no remains of them that could constitute an ecological barrier.

In contrast to hydrotechnical structures, the transportation infrastructure is a specific ecological barrier. These are mainly bridges related to well established roads in the traffic network (including border crossings), with varying degrees of traffic, which run transverse to the valley-axis. Apart from the bridges and slopes in the Bug river valley there are roads and railway lines (very often on the slopes) which run parallel to the valley-axis. They give an indication of the width of the ecological corridor in their given section As with the hydrotechnical structures, some parts of the current transportation infrastructure are remains of the old (defunct) traffic routes. This is clear especially in the boundary section where, after the border in the Bug river was established in 1945, some of the routes disappeared and some bridges were closed.

Contacting neighbours from the other side was only possible via the border crossings (road and railway) in Terespol, the railway crossing in Dorohusk and the bridge crossing of the metallurgical-sulphur line in Gródek.

After the fall of the USSR and the rising of the independent states of Ukraine and Belarus, three new road border crossings were developed: in Dorohusk, Zosin (with Ukraine) and Sławatycze (with Belarus).

Current traffic structures in the boundary section of the Bug river are: bridge crossings and road embankments leading from Gródek, Zosin, Dorohusk, Sławatycze, Terespol and Kukuryki. A special attention should be paid to the area near Dorohusk where there are two steel bridges (a railway and road bridge leading from a road on a bilateral road embankment). The same applies to the area near Terespol where there are eight bridges – two road and two railway bridges and four smaller ones designed for pedestrians – at present used only by boarder guards (it may be assumed that in the past they served as walking bridges).

In Poland there are nine bridges – three railway bridges and six road bridges. They are located in Fronołów/Mierzwice (railway), Kózki (road), Tonkiele (road), Nur (road), Małkinia (railway and road), Brok (road), and Wyszków (road and railway).

There are remains of two kinds of old traffic structures: bridges, for example in Terespol and transverse embankments in: Kryłów, Strzyżów, Dubienka, Włodawa, Orchówek, Kodeń, Łęgi near Pratulin, Jabłeczna, Wirów, Krzemień, Brańszczyk, Kamieńczyk and Rybienko. They were connected with, currently, non-existent routes that lead to the crossing or to the bridge over the Bug river.

The roads that run mostly on the embankments along the valley create a transverse barrier. In the first place these are: "Nadbużańska Road" Zosin – Terespol (816) and fragments of national roads from Hrubieszów to Zosin (844), Terespol – Janów Podlaski (698), Anusin – Tonkiele (637) and Nur – Brok (694). Bridges built on the crosssection of the tributaries (for example on the "Nadbużańska Road" in Dubienka) are connected to the afore-mentioned roads.

The single-track railway from Chełm to Włodawa is also a transverse barrier, which runs along several of the embankments. It reaches the Bug river valley near Wola Uhruska and leads to Orchówek through its 28 km.

The project to develop a water road East-West and the development of the bridge border crossing on the Bug river may also threaten the ecological corridor of the Bug river valley. The first project would require concentration of the current, straightening and deepening of the channel, the building of longitudinal dams (minimal solution) or a full embankment of the valley and construction of 7 or 13 water steps: Neple, Mielnik, Granne, Zuzele, Małkinia, Brańszczyk, Barcice (maximum solution) which would cause flooding of the valley in the dam reservoir [Monografia... 1985]. Realization of either of the two projects would result in destruction of the natural assets of the river and its valley followed by questionable economic returns [Chylarecki *et al*. 1993, Kajak 1993].

The second project – the development of the border crossings is less damaging. There are plans in the near future to build a third bridge over the Bug river in Dorohusk. It would be built 20 m to the north of the existing road bridge in order to improve the operations of the border crossing. A further project of this kind would be the development of the border crossing (bridge crossing) between Poland and Belarus in Włodawa.

However, current representatives of technological sciences follow the "new wave" of thinking and will more often incorporate ecological criteria in their hydrotechnical and traffic structures. Based on the idea of adapting the afore-mentioned structures to the needs of living organisms and eco-systems. Taking these criteria

into consideration would allow for the preservation of the natural assets of the river valleys (space protection, continuity of the valley ecological corridors, environmental mosaic and biological diversity); and create a modern flood control system. Ecological development of the rivers would support their new role – that of attractive tourist routes [Kołodziejski 1999]. This is one of the aims of ecological policy in the Bug River Euroregion. Improvement of water purity is the first among the strategic programs. Attention is also given to the development of the Bug river as a center for water tourism and the development of tourist border crossings equipped with pontoon bridges, foot-bridges or ferry crossings [Polski 1997], which do not create an ecological barrier. The actions described give an optimistic vision for the future of the ecological corridor of the Bug river valley. If there are not enough funds to realize those plans there should still be enough to stop prevent further damage and to preserve the natural richness of the area. This is what we can learn from history.

Land use and management elements of the selected sections of the Bug river valley

Volynian-Podolian Section

Study area. The subject of the paper is the fragment of the Bug river valley which is bounded by the valley edges as determined in the geomorphologic mapping and borders of the Army Topographical Map 1:50 000 Dubienka (M-34-36 D). Analysis of land use and management within this section was based on the afore-mentioned topographical map (state from 1975–1984) which was compared with a topographical Map from the Polish Army General Staff 1:100 000 chart – Chełm (state from 1994) and terrain observations in 1999. The comparative material includes: tactical map WIG 1:100 000 scale chart – Chełm (belt 44, column 37, state from 1931) and Lubomia (belt 44, column 38, state from 1933). To unify the scales the chart for Dubienka was re-produced in 1:100 000 scale and presented on two maps showing the state from 1993 and 1999.

The selected section of the Bug river valley comprises the natural areas of Poland and Ukraine located to the south of the border crossing in Dorohusk. In physiographical terms this area belongs to Polesie Wołyńskie [Kondracki 1998]. It is a very interesting area. It includes parts which are legally protected: Strzelecki Landscape Park (in the south), ecological premise – retention reservoir in Husynne, and areas proposed for legal protection: Dębowiec habitat – currently in the design phase. This area is a refuge for birds. In this section the Bug river takes in many left-bank tributaries – the largest being the Udal and the Wełnianka river. There are many old oxbows – most of them overgrown. In the spring this area is often flooded, this results in a natural fertilization of the valley and ensures its proper use. All these elements indicate great promise of the selected section of the Bug river valley to act as an ecological corridor.

Good natural assets make the area ideal for recreational purposes. This is the case in Poland. In Starosiel there is a resort with clearly marked paths for walking ("Starorzecze", "Dolina Bugu"). Agrotouristic Assosiation of Dubienka has its headquarters in Dubienka.

Land Use. This section of the Bug river valley is characterized by large amounts of meadow and pastureland. They are mainly found on the flood terraces of the Bug river and its tributaries. There are also many areas of scrubby brushwood (mostly in Ukraine). In addition, on the flood terrace, and also on the overflood terrace there is arable land especially near to settlements – near Dorohusk, Husynne, Uchańka and Dubienka. Forest communities mainly cover the overflood terrace. The largest are near Dubienka (Starosiel) in Poland and almost the whole section in Ukraine. There is a clear contrast between the left and the right wing of the Bug river valley – in Ukraine there are 10 times more forests than in Poland (10.12 km^2 and 0.91 km^2 respectively).

During the last 60 years in Poland, there was an increase of arable land at the cost of meadow and pasture land, for example: northward from Husynne and eastward from Dubienka. There was also an increase in forest areas (from 0.36 km^2 to 0.91 km^2), for example: eastward from Turki, south west from Husynne and north-west from Dubienka. According to "Local Plans of Dubienka district management" the forest areas are to grow systematically. In Ukraine (former USSR) the area of meadow and pasture decreased while the forest area grew (from 0.51 km^2 to 10.12 km^2),as did the scrub lands. At present there is a remarkable difference in the forest areas on the opposite sides of the Bug river valley, this was much smaller 60 years ago (0.15 km^2). The total forest area occupied 0.87 km^2 (now 11.03 km^2). The changes in the land use structure were caused by an increased drainage of the land.

Settlement. Most settlements are found on the overflood terraces. These are small villages, the largest being Dubienka and Dorohusk (in Poland) and Bereżce (in Ukraine). It is important to note changes in the distribution of settlements that have occurred over the last 60 years. While in Poland settlements were not too large (for example: a resort was built on the location of Farim in Starosiel), drastic transformations took place in Ukraine. Some of the villages located near the Bug river channel in the line of Dubienka disappeared: Binduga, Bystraki and Kładniów. It is also of note that at present in Poland this process whereby villages disappear continues for example: Kolemczyce (located on the overflood terrace near the Bug river channel) is depopulating.

Transportation. A major role (in transportation) is played by the "Nadbużańska Road", much of which runs in a meridional direction along the edge of the overflood terrace in Poland. It connects two villages: Dorohusk and Dubienka and also, through numerous side branches, villages located to the north of these.

There is no equivalent of the "Nadbużańska Road" in Ukraine. There are roads with a shorter range, the most important of which is that connecting the two villages: Wysock and Bereżce.

The last 60 years has brought changes the transportation structure. The most important is the disappearance of routes connecting the villages on the left (presently Polish) side with villages located on the right (presently Ukraine) side of the Bug river valley. They disappeared or were reduced to the size of paths, among others: the roads connecting Dubienka with Binduga and with Bystraki, and connecting Dorohusk with Bereżce.

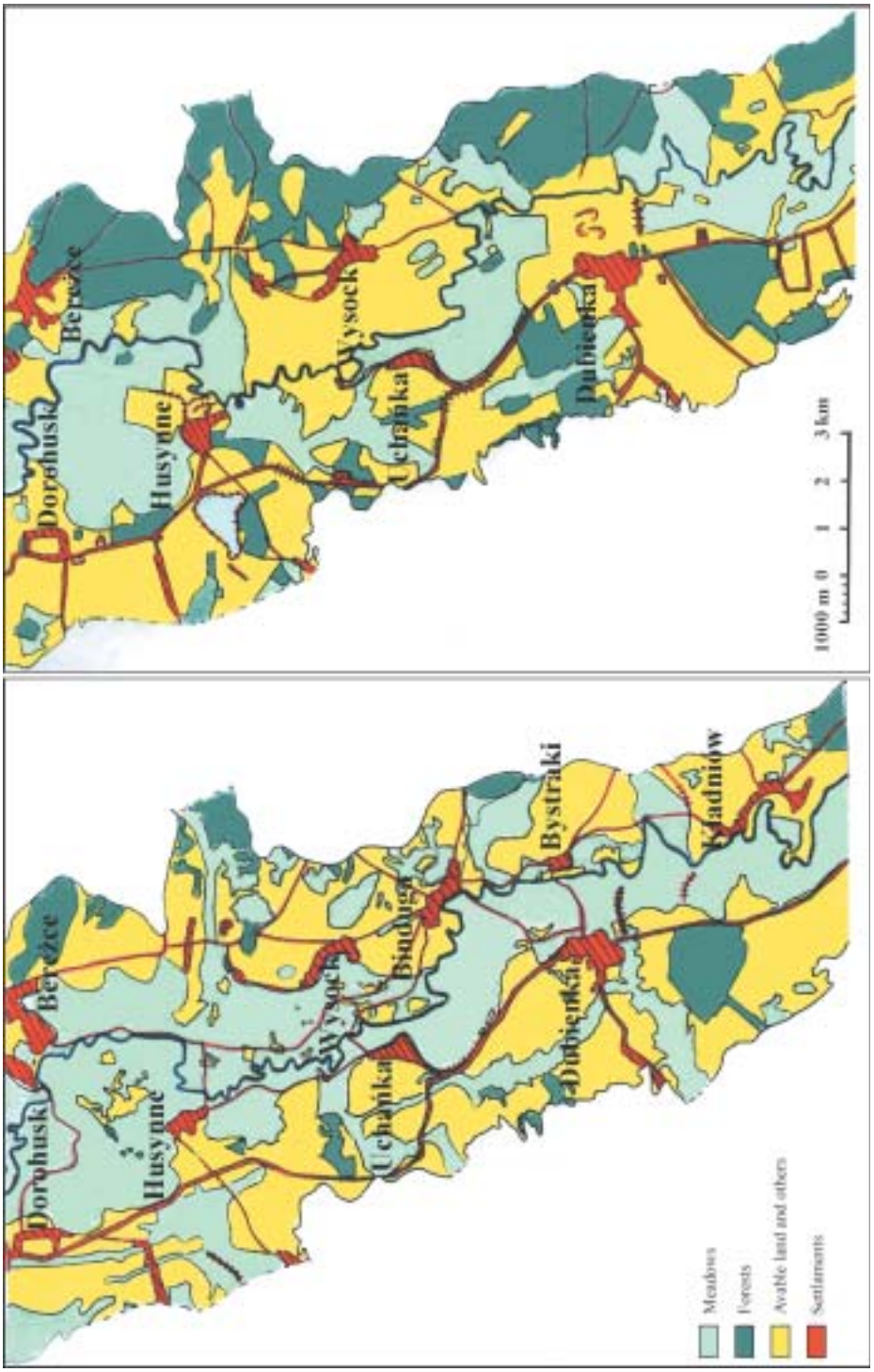

Figure 1. Changes in land use structure in Volynian-Podolian Section in the period 1933–1999

Other management elements. Embankments, dams and dikes are rarely found in this section. They are mostly found near the flood terrace in Poland. The first few are related to the "Nadbużańska Road", mainly in places where it crosses the side valleys, for example: near Uchańka. Eastward from Dubienka there is a great transverse embankment that almost reaches the Bug river channel. A very big dike (embankment) surrounds a retention reservoir in Husynne, built on the Udal river. A small embankment that acts as a road can be found near Husynne village. Special attention should be drawn to a mound in Uchańka that commemorates a battle between Polish Army under Tadeusz Kościuszko and the Russian army, with trenches between Uchańka and Dubienka located on the edge of the flood terrace. In this section there are many excavations that adversely influence the landscape. The biggest are in the south from Dorohusk near the "Nadbużańska Road". Two of them act as dumping grounds. Southward from Dubienka, in the Wełnianka river valley, there are also concave forms divided by dikes which are most probably the remains of old ponds. There are also drainage ditches de-watering the forest area in Starosiel. Most of the afore-mentioned forms did not exist 60 years ago.

Bridges are also elements of management, yet they are present only on the Bug river tributaries: Udal and Wełnianka. The biggest are related mainly to the "Nadbużańska Road". This situation is similar to the one 60 years ago, yet the bridges are different. It is important to note, that at that time there were several crossings (people were transported by boats) on the Bug river (for example: to Kładniów, Bystraki and Bereżce) which have since disappeared.

Conclusions. Characteristic changes in land use and the management of this section of the Bug river valley included in the Dubienka chart are connected to the change of the area's status to that of a boundary, requiring that it remain uncultivated or utilized to some small degree. It resulted in the transformation of small areas and even the disappearance of some villages, and an increase in the forestation of Ukraine.

In Poland, the cause of the changes is more complicated. For example the increase in arable land area near Dubienka could be caused by the loss of importance of this village in favour of Dorohusk (privileged by important railways and roads), distance from main transportation routes, lack of industry and the fall of navigation on the Bug river. Such a situation made people turn to farming which increased the areas of arable land in the valley.

In times of economic transformation and the opening of borders it is important to direct land use and management of the valley in such a way that the pressure of border crossing (road and railway) in Dorohusk would not become a threat to the natural assets of the ecological corridor of the Bug river valley.

Polesie Section

Study area. The research dealt with a section of the Bug river valley presented on a chart of the Military Topographic Map in 1:50 000 scale (M-34-24-C Zabużje). This area is located in the section that is a border between Poland and Ukraine, between Dorohusk and Włodawa. The edge villages within the limits of the Zabużje chart are: Zabuże and Małoziemce in the south and Koszary in the north. The researches were based on comparison of the content regarding land use from

a map issued by WIG [Military Geographical Institute] in 1:100 000 scale (Opalin chart, row 43, column 37 showing the state from 1933) and a current topographical map in 1:50 000 scale, showing the state from 1975 to 1984. The total area of the researched section of the valley was 135 km^2.

The section selected for analysis is the Polesie section of the Bug river valley – southern border of Western Polesie [Kondracki 1998]. The Bug river valley runs from the south to the north here. In contrast to the valley, the river is meandering, changing direction every couple of hundred meters. The Bug river had this character during the whole researched period and before; traces of the meandering course are seen in numerous old river beds from different development phases – ranging from those connected to the river current, to those completely cut off from the river, which are often located far from the river channel. In this section the river takes in small nameless tributaries along both banks. The width of the valley ranges from about 4 to 8 km and is typical of the Polesie section. The height of the valley bottom changes from about 170 to 154 m ASL.

Due to considerable natural assets in this area, many protected sections were established within the analysed fragment of the valley, or near to it. These are nature reserves: Małoziemce (fauna – created to protect the nesting place of common heron), Magazyn, the Brudziniec Lake, Three Lakes (water-peat) and the Sobiborski Landscape Park, together with the buffer zone.

Land Use. Currently, this area is characterised by remarkable natural and recreational value. Forests and meadows cover almost half of the researched area. These areas are seen as slightly transformed, but almost natural elements of the landscape. Green regions are located in the lowest parts of the area and forests are located either near to the channel, or in the drier habitats on the overflood terrace.

Comparison of the two maps shows a doubling of the forest area from 15.4% to 34.7%. A vast forest area appeared in Poland in the central part of the chart between Stulno and Wołczyny. At present this forest is protected as a landscape park. This increase took place at the cost of meadows, their area decreasing greatly from 29.4% to 13.7%. Meadows were partially drained thanks to drainage works near Adamczuki and Stulno (drainage ditches), and thanks to development of flood control embankments, mainly in Poland on the southern part of the chart. Most probably, natural processes also influenced the decrease of the meadow area. The drained meadows were covered partially by forests and partially by arable land. Comparison of the maps allows one to draw conclusions not only about the quantity but also about the quality changes of the meadows. It appears that today meadows are drier than in the pre-war years.

Analysis of the maps also implies a major increase of the stream length. This is due to the development of drainage ditches.

Settlement. At present settlement in the analysed area consists of 10 villages evenly distributed on the overflood terrace, on both sides of the valley. Buildings are of a rural character. The level of settlement has decreased over the last half-century. Some villages such as Małoziemce disappeared almost completely, only single farms remained. Other villages, for political reasons, were trans-located – Koszary, Olszanka – outside the valley. Most of the settlements disappeared and the village buildings weakened.

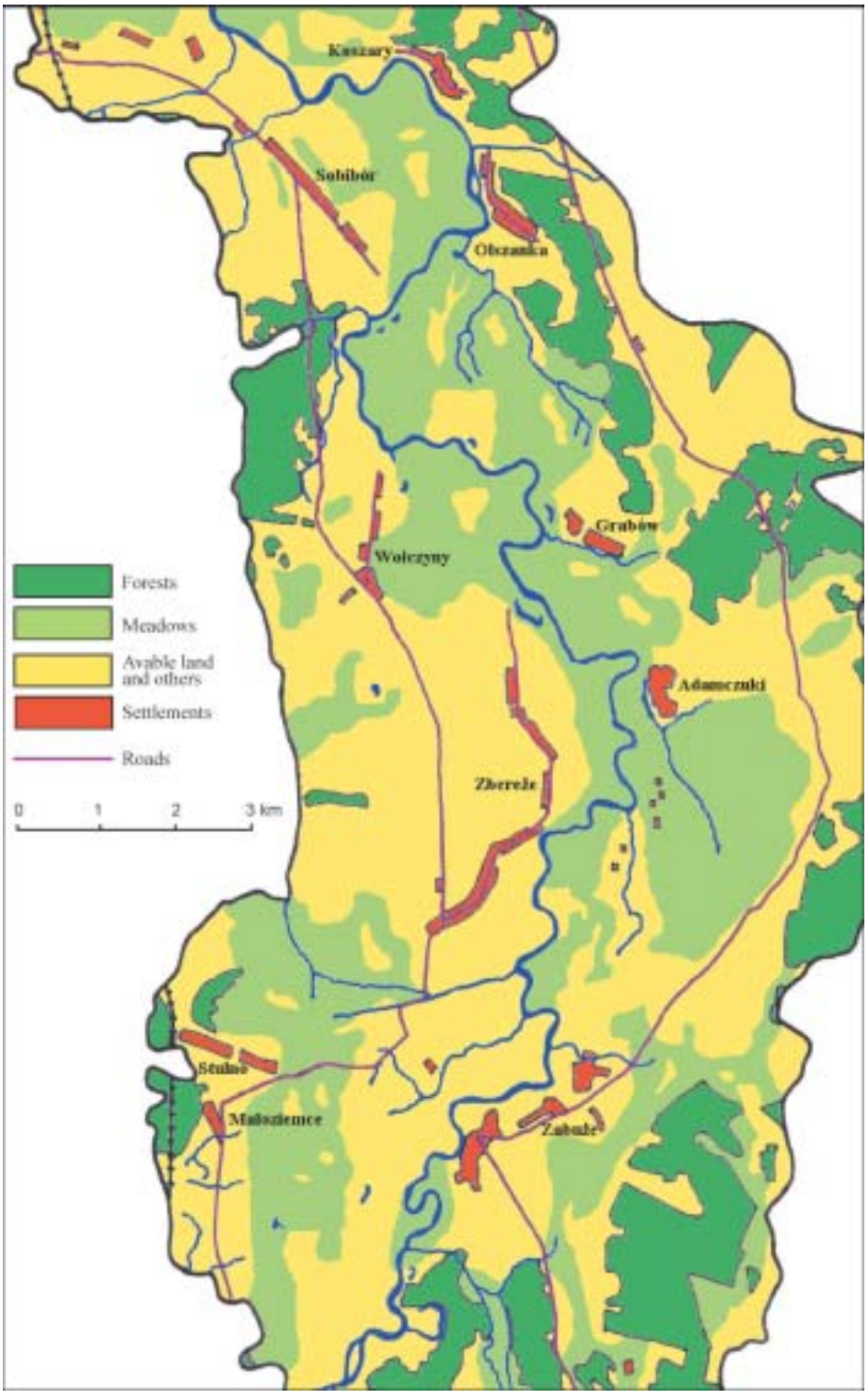

Figure 2a. Land use structure in Polesie Section in 1933

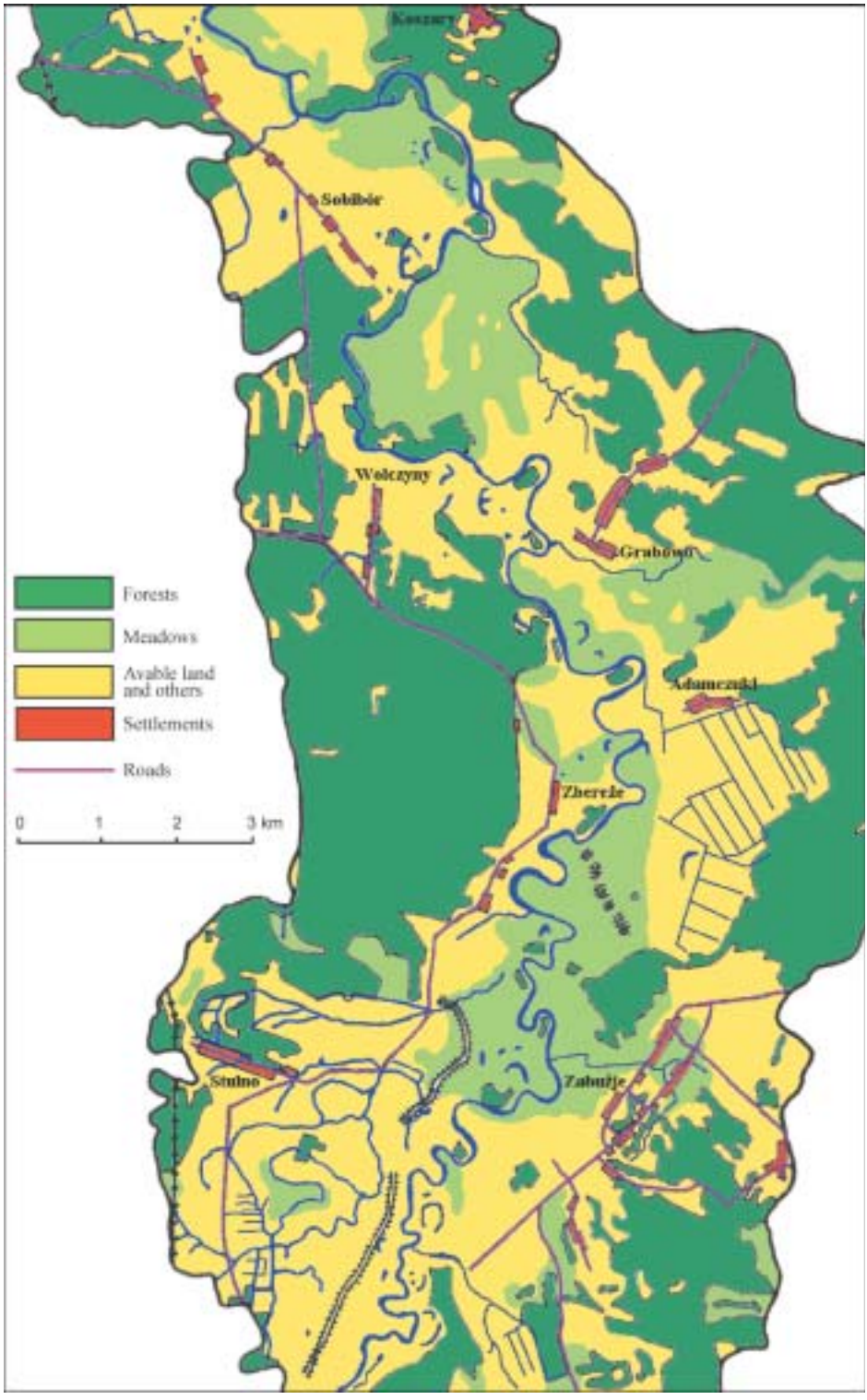

Figure 2b. Land use structure in Polesie Section in 1975–1984

Transportation. These degeneration processes also apply to the road network. Before the war there were two parallel roads with a paved surface on both sides of the Bug river. At present there is only one such a road in Poland, the course of the roads did not significantly change here. The road fragments near Zabużja and Grabów, currently in Ukraine, are the remains of the second road. One can only hope that present roads are of a better quality than those from the pre-war times.

A railway line from Chełm to Włodawa runs through the western periphery of the researched area – it already existed in the inter-war period.

Other management elements. There is no investment in these areas. The only things worthy of attention are flood control embankments in the southern parts of the chart, mainly in Poland. The drainage works were done mainly in Ukraine, south of Adamczuki village. Facilities and drainage ditches make up a secondary management element, apart from the flood control embankments, crucial for the valley's function. The afore-mentioned ditches were built in areas called (before the war) – Zabużańskie Holendry. The name comes from the Dutch who came in the 19th century from Żuławy Wiślane and are known for their drainage skills.

Podlaski Section

Study area. The subject of the paper is a section of the Bug river valley from Janów Podlaski (part of a village called Wygoda) to Mielnik, bounded by the edges of the valley established during geomorphologic researches and borders of the chart taken from the Military Topographical Map 1:50 000 Janów Podlaski (N-34-143-A) showing the state from 1975–1982. The comparative material includes maps from WIG [Military Geographical Institute] in 1:100 000 scale – charts: Siemiatycze (row 39, column 36 – state from 1937) and Biała Podlaska (row 40, column 36 – state from 1931). This area is 117.85 km^2. To unify the scale the chart – Janów Podlaski was reduced to 1:100 000 scale.

The researched area represents the Podlaski Gap of the Bug river [Kondracki 1998]. In this fragment the Bug river valley has a southeast to northwest course (in the Janów Podlaski – Niemirów section south-north), despite the fact that the meandering river flows in certain sections in a northerly direction and even north to west. The old river beds "bużyska" are the remains of the old course of the Bug river channel; they are of various sizes and development phases – from those connected to the current to those completely cut off and dry, which form curved hollows. The biggest ones (meander lakes) even have proper names: Zatoka (located to the northwest of Borsuki village) and Bużysko (northward from Bubel Stary village). In the upper part of the researched section of the Bug river valley there is an outlet of the left bank tributary – the Czyżówka river.

In this section the Bug river narrows significantly, the relative height of the edges – increases reaching 55 m in Mielnik (Góra Zamkowa). This fragment of the valley is said to have the most picturesque landscape due to the dramatic height differences, there are many viewing points – places with a very wide view of the meandering river. This was on of many reasons why the researched area was included in the borders of a landscape park – the "Podlaski Gap of the Bug river".

On the high bank of the Bug river, on Góra Zamkowa in Mielnik, there is an early medieval (11th to 12th century) castle – a key archeological point. In Wygoda village

(part of Janów Podlaski) there is the oldest, working stud in Poland (established in 1817) where Arabian horses are bred. The annual horse auctions take place here.

The analysed area is situated on what has been the border for more than 400 years. From 1569 to 1795 it was a border between Lithuania and the Crown (separating Brzeskie and Podlaskie voivodships), near Niemirów in 1795 three partitioned sectors of Poland were brought together: Prussian and Russian (on the right bank of the Bug river) and Austrian (on the left bank), during World War II the Bug river separated German – occupied Poland (GG) from the territories occupied by the USSR. Currently in the section above Niemirów the Bug river is a frontier river between Poland and Belarus. Below Niemirów the border leaves the river's course and runs further to the northeast along the so called "Napoleonian" road.

Land Use. This section of the Bug river valley is characterized by a relatively high (over 50%) concentration of "seminatural" areas (forests and shrubs, meadows and pastures). Green grounds are located in a vast (up to 2 km wide) – area in the neighbourhood of the river channel – mainly on the flood terrace. The banks of the Bug river and of the old river beds together with the islands on the Bug river are covered by osier brushwood. Forest communities cover mainly the overflood terrace but they can also be found in lower locations. Arable land is found almost only beyond the flooded area.

The most obvious difference in land use during the last 50 years is the major (almost double from about 10.9% to about 21.4%) increase of the forest area at the cost (mainly) of arable land. The newest forest complex grew in the bend between Mielnik, Sutno and Wajkowo. There are also more forests in the north from Borsuki, in the south from Niemirów and in other places.

The area of meadow did not undergo any significant changes (it increased slightly from 23.9% to 26.6%). There is, however, a dense network of surface water on the meadows within the valley. These are draining ditches created by people, which de-water the area during the more humid periods. One can assume then, that the meadows are currently drier (the compared maps are of different scale; and the different levels of generalization hinder a detailed comparison of the content – the right bank of the old river bed northwards from Nowosiełki, is clearly visible in the newer map, while it is not marked on the inter-war map, though its shape clearly indicates its natural origin).

Settlement. Modern settlement in this area consists of small, up to 1000 inhabitant, villages (three with the status of a town: Janów Podlaski, Niemirów, Mielnik). They are located mainly on the overflood terrace but as close to the river as possible. Therefore, the topographic location of villages: Buczyce Stare, Bubel Łukowiska, Bubel Stary, Gnojno, Borsuki (on the left bank) and Nowosiełki, Niemirów, Sutno, Wajków, Mielnik (on the right bank) indicate the range of the flood terrace.

Postwar settlement underwent both evolutionary and revolutionary changes during the past 50 years. The first major change was the trans-location of Krynki and Wieliczkowicze villages (after the establishing of the border between Poland and USSR, presently Belarus). Both villages located at the river's edge were moved and totally rebuilt, now they are located about 1.5–2 km from the river (border). Changes in names (Ponikwy – Panikwy, Nowosiółki – Nowosiełki, Wieliczkowicze – Wieliczkowiczy), after the change of national status are not important.

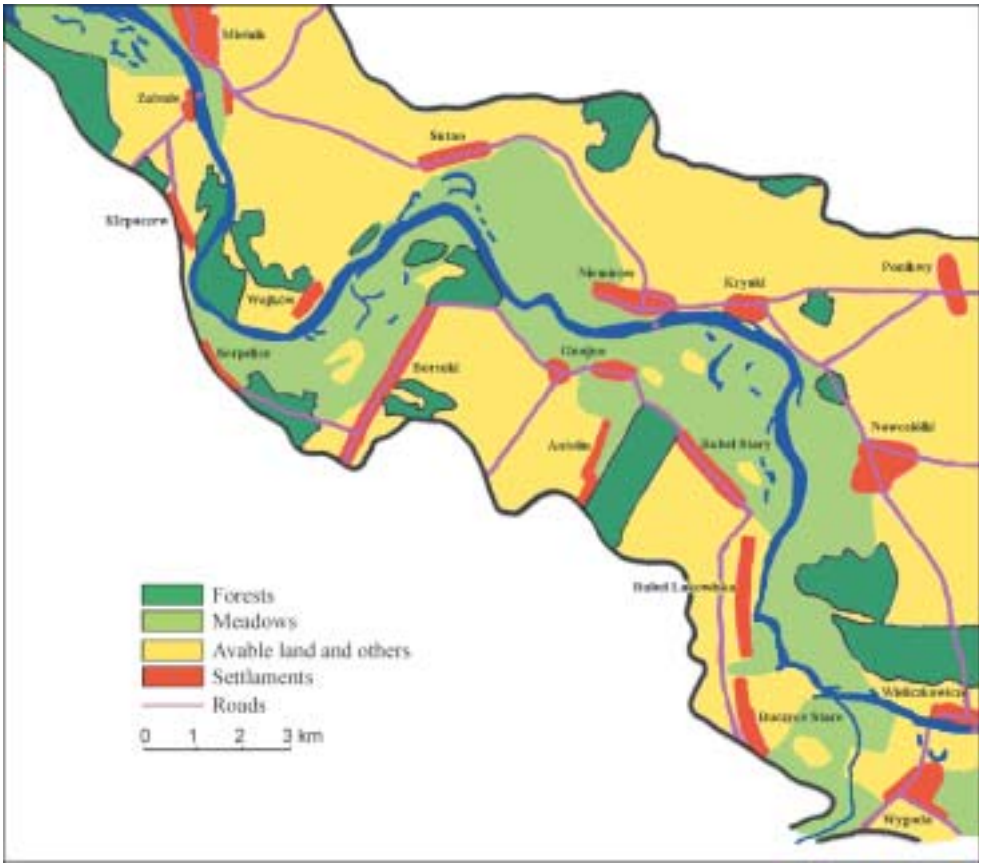

Figure 3a. Land use structure in Podlasie Section in 1931–1937

Evolutionary changes, resulting from the depopulation of the villages, are based on degeneration of farms and the scarceness of buildings. An extreme example is the almost complete disappearance of Zabuże in the lower part of the researched area. During the inter-war period this village stood by the defunct crossing on the right bank of the Bug river to Mielnik.

Transportation. The transportation network in this section of the Bug river valley plays only a local role. It consists of hardened roads, which lead along the borders of the flood terrace (and on the overflood terrace) on both sides of the valley and connect the villages located along the river. There is no railway.

During the last 50 years the network of paved roads changed, it was not only the expected growth (a road connecting Mielnik with Wajków was built) but also the decrease in the number of roads. Due to the change of national status and establishing the border between Poland and Belarus the network was broken. There is no road connecting Niemirów and Krynki and Krynki with Nowosiółki. The direct connection of the boundary villages disappeared.

During the inter-war period transport across the valley played an important part. This is illustrated by ferry or boat crossings marked on the WIG map in Wielicz-

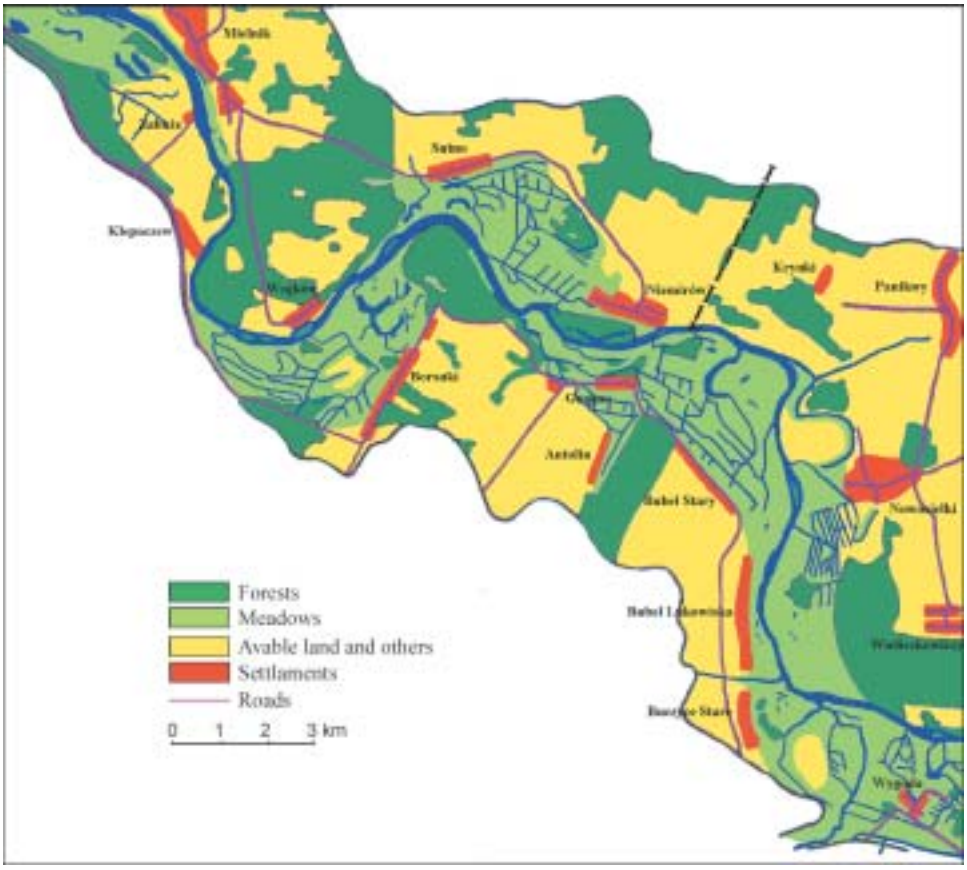

Figure 3b. Land use structure in Podlasie Section in 1975–1982

kowicze, Niemirów, Zabuże. Currently, none of them is functioning. The reason for this was the establishment of the border on the Bug river (Wieliczkowicze and maybe Niemirów) and the increased popularity of vehicular transport (Zabuże from where its not far to the road bridge in Kózki).

Other management elements. Among other management and land use elements, the only one worthy of attention is the compact network of drainage ditches on the meadows within range of the valley bottom, on the flood terrace (near Wygoda, Nowosiełki, Bubel Stary, Gnojno, Sutno, Borsuki). Divided meadows are drier therefore easier to cultivate.

Comparison of the maps from 1930s and 1980s suggests that all drainage ditches were built within the last few years, yet varying degrees of detail leaves room for uncertainty.

Other management elements (embankments, dikes, dams, excavation for clay, sand, gravel, peat exploitation) are so rare as to have no influence on the landscape.

Conclusions. There are several causes for the afore-mentioned transformations in the management and land use of the Bug river valley in the section between Janów

Podlaski and Mielnik. The most important (influencing all aspects of the valley management) are political issues: World War II (destruction) and the later establishment of national borders on the Bug river and within the valley bottom. This led not only to changes in the settlement and transportation patterns but also to translocation of some of the area into the peripheral zone of the country, which is used less. Therefore, there is only minor development of the transportation network and in some places it has even degenerated.

Disadvantageous demographic processes (depopulation and aging of the villages) lead to a decrease in population, which might influence the development of this area. Pre-war towns (Janów Podlaski, Niemirów, Mielnik) lost their municipal status (Mielnik in 1934, the others after the II World War), which surely decreased their appeal for eventual habitation. This process was later intensified by the migration of the younger, or more dynamic people, to the cities.

The afore-mentioned reasons explain the discontinuation of development (or the stagnation) of this region. On the opposite end of the scale there should be the melioration process and as a result the increased intensity of cultivation of the green grounds in the Bug river valley (however, it is possible that the melioration of meadows and the increased intensity of their cultivation was a short-term process).

On the whole, the results of these processes, while difficult to judge from the economic point of view, are favourable to the environment. The green grounds and forests, which are in a majority in the valley, seem to relate best to the natural predisposition of the environment. Therefore the increase of their surface should be positively regarded. The natural course of the Bug river channel is an additional asset (the river was not regulated). A peripheral location to this area and the lack of a predisposition for anything other than farming guarantees (only after improvement of the Bug river's water purity) permanently good environmental conditions.

The Lower Bug river valley

Study area. The researched section of the Bug river valley is located within the range of the Lower Bug river valley [Kondracki 1998] on an area included in the map chart 1:50 000 Sterdyń (N-34-129-B). The state of the area as documented for a 1993 map 1:100 000, chart N-34-129/130 Sokołów Podlaski PPWK was accepted as the actual state. Comparative material included in a WIG map in 1:100 000 scale, charts: Ciechanowiec (row 38, column 35, state from 1937) and Małkinia (row 38, column 34, state from 1936). The outcome of the analysis of the map 1:50 000, chart Sterdyń, state for 1980 was included as additional data.

This section roughly covers the river between Gródek (Jabłonna Lacka district) and Nur.

In the analysed section, the Bug river valley bottom, including the river channel and two terrace levels is from about 4 km to about 7 km wide. The Bug river takes a south-east to north-west course here. The Bug river channel, with small bends, runs along the whole section of the valley, just under its right slope (significantly marked by the clear edge of the plateau).

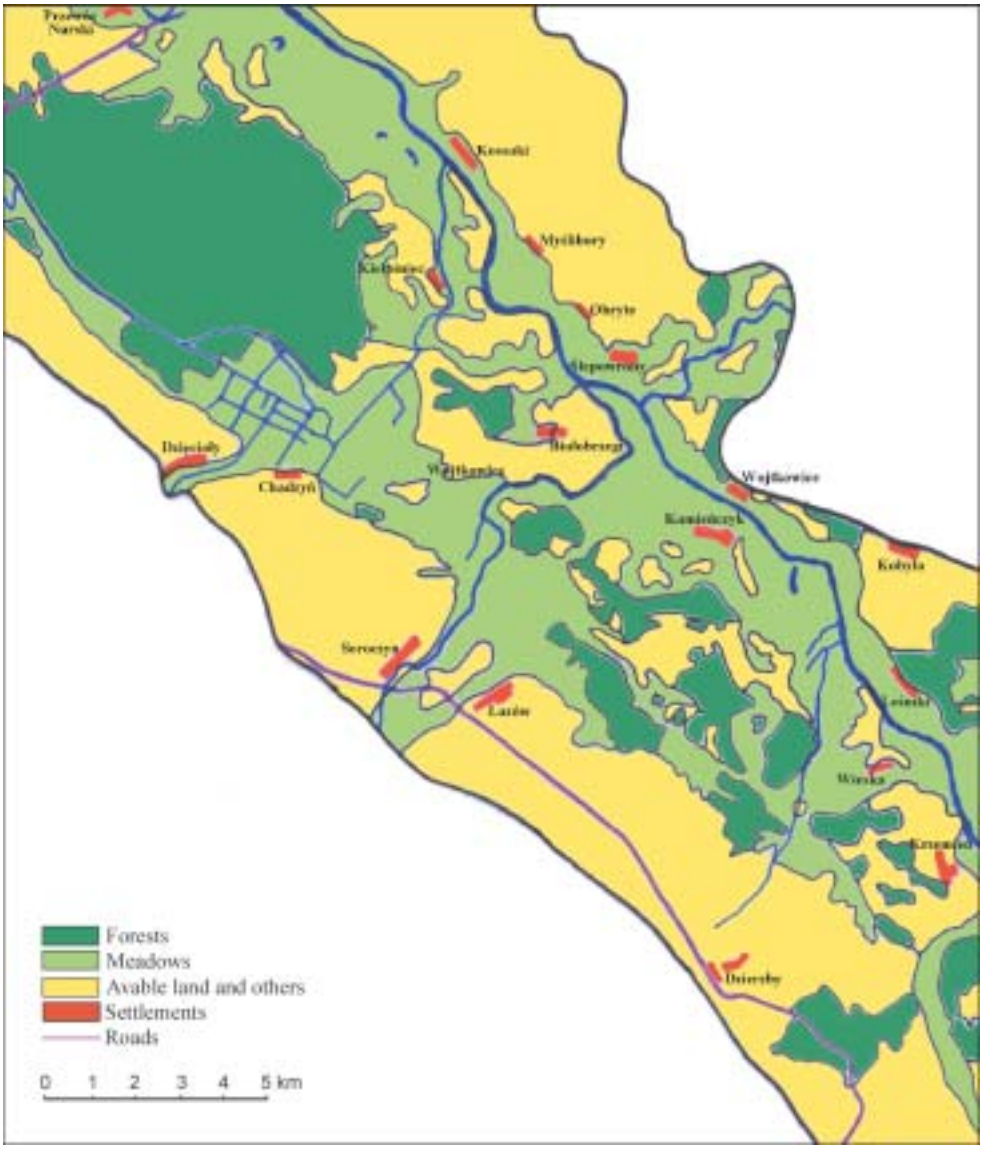

Figure 4a. Land use structure in Lower Bug Section in 1936–1937

In this section the Bug river takes in three tributaries – Nurzec from the right side and from the left two small streams: the Turna and the Cetynia. Beside that, in the north-west section of the valley at the left edge there is a tributary of the Bug river – the Budzynka, joining the river outside the researched area.

Land Use. Comparison of the maps from the 1930s and 1990s leads to a conclusion that this area of the Bug river valley underwent relatively rapid transformations as far as the proportions of the selected types of land use are concerned. Until the 1980s the increase of the forest surface in the eastern part of the section was the most important element. This increase caused an enlargement of the existing forest

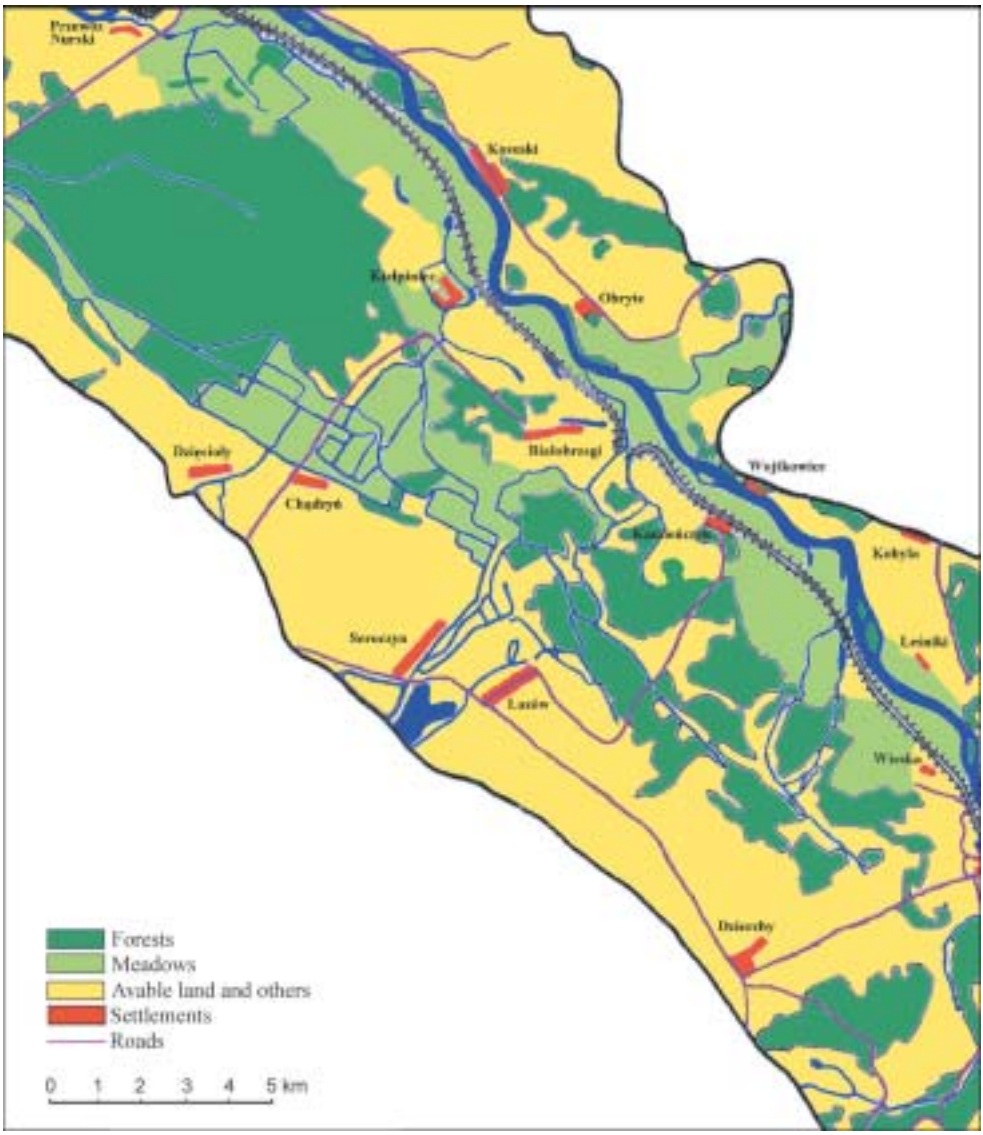

Figure 4b. Land use structure in Lower Bug Section in 1993

patches connecting the isolated, small forest clumps into larger complexes. This increase of the forest are took place at the cost of arable land, green grounds and mostly deforested or brushy areas of dune sands. It is unique that that biggest increase in forest area took place near to the only new settlement.

Remarkable decrease of the green grounds took place as late as the 1980s and 1990s, after the development of the flood control embankment, so that the state from 1993 is very different from the one reported in 1980. In the area protected by the embankment, mainly on the higher terrace, arable land took over former areas of meadows.

Settlement. The settlement network did not undergo any remarkable changes during the researched period. Only one new settlement was developed – Kamieńczyk colony. Other villages did not change in size at all.

Transportation. In this area there was a remarkable increase of the length of the hardened road network, presently connecting all villages within the researched area.

No major new structures were developed: bridges, viaducts etc.

Other management elements. The most important for the natural assets of the valley is the new flood control embankment which runs along the Bug river channel, on the left side of the valley, along the whole length of the researched valley section.

The development of this embankment radically decreased the water area including the old river beds, causing the almost complete disappearance of a long meandering lake near Kiełpiniec.

Regulation of the water, in the wet areas of the researched section of the valley, was conducted a long time ago as is indicated by the name "Holendernia" near Chądzyń. In the last half-century drainage works were also conducted on the vast swampy areas between the Cetynka river and previously drained meadows near Chądzyń.

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Chapter V

Plant cover of the Bug river valley and major threats

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General characteristic of flora

The present plant cover of the Bug river valley is the result of a secular migration of plants, lasting from the early post-glacial period to the present day and influenced by the widely acknowledged pressure of people inhabiting the area. Primary forms of human influence on the natural environment were mainly connected with forest clearing, extensive farming and pasturing. They were examples of interaction between nature and man. Moreover, they supported the preservation of biological diversity and did not cause irreversible changes in the environment. New forms of anthropopressure and the intensification of traditional economic actions (especially during the last few years) are conducive to faster degeneration of natural eco-systems as witnessed in the disappearance of many species and environments.

On the basis of up to date researches in the Bug river valley, 1280 species of vascular plans were identified, excluding 64 microspecies of dandelion (*Taraxacum*) [Głowacki & Øllgaard 1999, Øllgaard *et al*. 2000] – 14 species are regarded as extinct. 1252 species are permanent components of the Flora, 6 species appear ephemerally or temporally running wild after breeding. 1024 species are native or indigenous (*spontaneophytes*). There are 234 *antropophytes* out of which 112 are *archeophytes*, 79 *epecophytes* and 43 – *agriophytes* – species naturalized in natural and semi-natural communities.

Flora of the non-vascular plants is poorly researched [Mickiewicz 1960]. The existence of 76 species of moss including 2 from the Red List (*Ortotrichum lyelli* and *Splachnum ampullaceum)* and 5 species of liverworts were recorded. Even less is known about the flora of lichens [Głowacki 1988]. The presence of 11 species of lichens were identified including 3 from the Red List: *Anaptychia ciliaris, Cladina stellata* and *Ramalina fraxinea.*

Lacking natural barriers, the European Lowland is influenced both by the continental and Atlantic climate. It results in a mutual penetration of floristic elements, of both oceanic and continental character. Generally, in the Bug river valley, European, Mid-European and European-West-Siberian species are in the majority. They are the major components of plant communities such as mesophilic leafy forests, for example: yellow anemone (*Anemone ranunculoides*), wood anemone (*A. nemorosa*), purple flumewort (*Corydalis solida*), the rare hollow flumewort (*C. cava*) and lesser celandine (*Ficaria verna*); and meadows, for example: meadow buttercup (*Ranunculus acris*), buttercup variation (*R. auricomus*), cuckoo-flower (*Cardamine pratensis*) and many others.

Along the entire length of the valley there are also Sub-continental species, including survivors from the post-glacial period, which occupy very specific habitats, for example: inland dune forms. The plants occupying such habitats are: sand pink (*Dianthus arenarius* ssp. *borussicus),* baby's breath (*Gypshophila fastigiata*), large blue hair grass (*Koeleria glauca*), catchfly (*Silene chlorantha*), campion variety (*S. tatarica*), kashubian vetch (*Vicia cassubica*) and others.

In the western part of the valley there are Sub-Atlantic species, coral necklace (*Illecebrum verticillatum*) and spring vetch (*Vicia lathyroides*), species found also in Belarus, most probably they were brought there. Further to the West there are only Sub-Atlantic-Mid-European species present: grey hair-grass (*Corynephorus canescens*), water pennywort (*Hydrocotyle vulgaris*), marsh clubmoss (*Lycopodiella inundata*) and pearlwort spurrey (*Spergula morisonii*) and transferring regionally to segetal communities: annual vernal-grass (*Anthoxanthum aristatum*), shepherd's cress (*Teesdalea nudicaulis*). More continental taxa are in the majority here: rosemary variety (*Libanotis montana*), Siberian rosemary (*L. sibirica*) and yellow whitlow-wort (*Draba nemorosa*), and boreal taxa: Charle's sceptre (*Pedicularis sceptrum-carolinum*) and Greek valenian (*Polemonium coeruleum*); *Succisella inflexa*, reaches (in large stocks) the south-west edge of the Bug river valley, yet it is also seen in separated sites further to the south.

An interesting phenomena reflecting the geographical diversity of the Bug river valley can be seen in the lower level of taxa within one species. One such example is: subspecies of motherwort (*Leonurus cardiaca*), where the typical subspecies (*L. c*. ssp. *typicum*) occupy the western part of the valley and the subspecies hairy (*L. c*. ssp *villosus*), the eastern part. Analogues phenomena can be observed between closely related mallows, *Malva alcea* and *M. excisa*, which are treated by some "taxonomies" as subspecies.

An important role in the researched plant cover is played by species characteristic of big river valleys: yarrow variety (*Achillea salicifolia*), false hope sedge variety (*Cuscuta lupuliformis*), shining spurge (*Euphorbia lucida*), Walenburg's glory (*E. palustris*), given from Lublin region, Fijałkowski [1995], hedge hyssop (*Gratiola officinalis*), southern sweetgrass (*Hierochloë australis*), holygrass (*H. odorata*), leafy skullcap (*Scutellaria hastifolia*), water germander (*Teucrium scordium*), meadow rue (*Thalictrum flavum*) and fen ragwort (*Senecio paludosus*). There is no known presence of certain species from the Vistula and Odra rivers – broad leaved ragwort (*Senecio fluviatilis*) and characteristic of the Vistula river, branched horsetail (*Equisetum ramosissimum*).

In the Bug river valley there are numerous species of water plants related to the present river channel and the oxbow lakes. This is due to the fact that the water plants have mostly azonal characteristics (not connected to a specific climatic zone). The presence of specific species depends on the availability of specific habitats.

Most of the flora in the researched area consists of antropophytes found mostly in segetal and ruderal habitats. Special attention, in the context of biological diversity, should be drawn to wild 'weeds', which have accompanied traditional croppings (where sites are undergoing a recession process) over the ages. Plants which were common in the past but are now disappearing, are: wild cockle (*Agrostemma githago*), scarlet pimpernell (*Anagallis arvensis*), cornflower (*Centaurea cyanus*), larkpur (*Consolida regalis*) and some species of poppy (*Papaver*). The species which disappear are related to habitats formed on calcareous soil: rotundifoliate thoroughwax (*Bupleurum rotundifolium*), wart cress variety (*Coronopus squamatus*), small spurge (*Euphorbia exigua*), flaciform spurge (*E. falcata*), sharpleaf cancerwort (*Kickxia elatine*) and in more fertile sands: *Polycnemum arvense* and *Herniaria hirsuta.*

Many rural species are threatened by the modernization of settlements, which decreases the number of compost and rubble heaps that are potential habitats for synanthropic plants. This is the main reason for the disappearance of suitable habitats for the following species: stinkweed (*Datura stramonium*), henbane (*Hyoscyamus niger*), nettle-leaved goosefoot (*Chenopodium murale*) and among the most endangered: plain horehound (*Marrubium vulgare*).

Apart from geographically alien plants, ploughed land forms a refuge for apophytes especially for the primary components of pioneer communities found on wet sands and more fertile soils. Among representative of this ecological group of species one finds: a tiny herb of the genus Centunculus (*Centunculus minimus*), tall spear grass (*Isolepsis setacea*), capitae rush (*Juncus capitatus*), low cudweed (*Gnaphalium uliginosum*), St. John's wort variety (*Hypericum humifusum*), Norwegian five-leaf (*Potentilla norvegica*) and a plant in the flax family (*Radiola linoides*) [Fijałkowski 1995, Głowacki, Ćwikliński 2000]. They are found mostly in secondary habitats of wet stubble.

Among antropophytes translocating into the natural communities, some enrich the indigenous flora without threatening it for example American species of *Aster* type. In most cases foreign species are invasive and cause degradation of autochthonous communities and expulsion of indigenous species from their secular habitats. The most dangerous are: ash-leaved maple (*Acer negundo*), wild cucumber (*Echinocystis lobata*) and small-flowered touch-me-not (*Impatiens parviflora*). Less expansive are: horseweed (*Conyza canadensis*), evening primrose variety (*Oenothera rubricaulis*) and false acacia (*Robinia pseudoacaccia*). Only in Brześć presence of rare antropophytes was marked: Siberian geranium (*Geranium sibiricum*) and small-flowered evening primrose (*Oenothera parviflora*) [WSRP, leg. Z. Głowacki]. The distribution of geographic elements and exceptionally interesting species is shown in Figure 1 and 2.

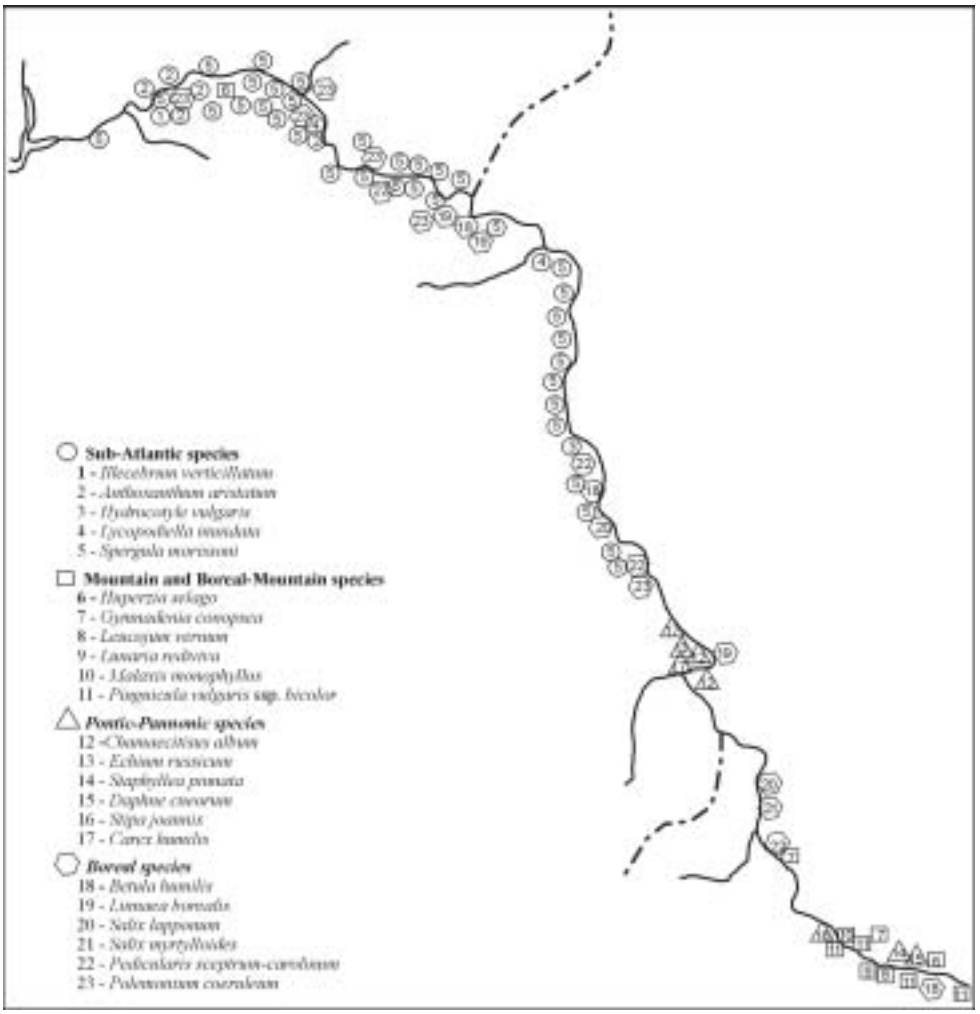

Figure 1. Selected geographical elements in the Bug river valley

Floristic peculiarity of particular sections of the Bug river valley

The presence of many species is related directly to a specific geographical region. Such taxa create the unique character of particular sections of the Bug river valley.

The whole upper course of the Bug river is located in Ukraine and is distinguished by the presence of mountain and piedmont species: Heufell crocus (*Crocus heuffelianus*) (extinct), fragrant orchid (*Gymnadenia conopsea*), spring snow-flake (*Leucoium vernum*), moonwort (*Lunaria rediviva*), adder's mouth orchid (*Malaxis monophyllos*) and bicolour butterwort (*Pinguicula bicolor*). Further to the north and west some boreal-mountain species are present: meadow thistle (*Cirsium rivulare*),

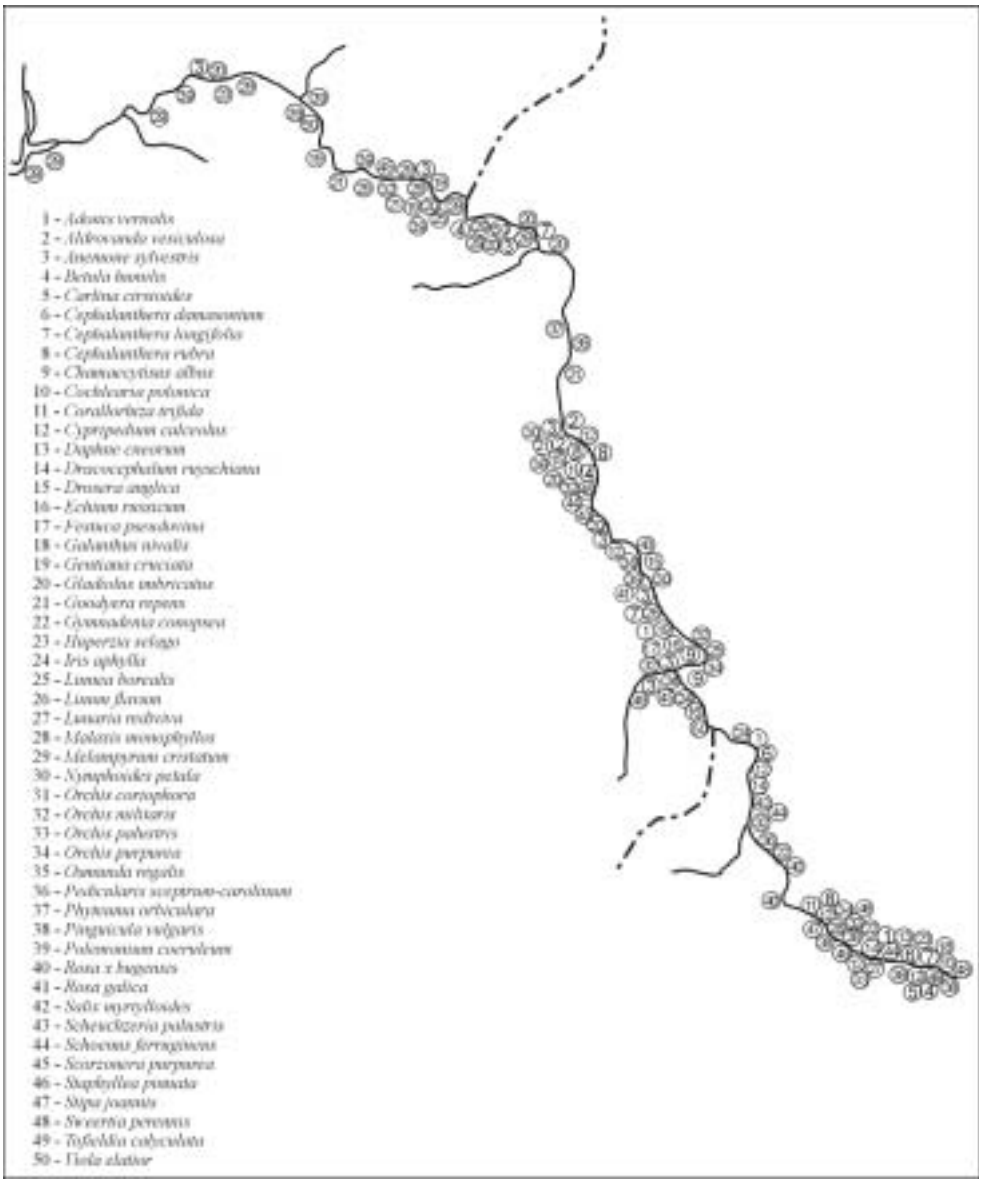

Figure 2. Selected vascular flora species in the Bug river valley

mountain aspidium (*Dryopteris expansa*), forked carrion-crow (*Huperzia selago*) and *Sweertia perennis*. Other species worthy of attentinon are: carline (*Carlina cirsioides* = *C. acaulis* ssp. *simplex*) and pinnated bladdernut (*Staphyllea pinnata*). The greatest floristic speciality of this area is Danish scurvy grass (*Cochlearia* sp.), it's status is not fully established. Fröhl [1935] described it as *Cochlearia pyrenaica* DC. In the Ukrainian Red Book it is described as *Cochlearia polonica* Fröhl. It is identified with *C. pyrenaica* DC. var. *eupyrenaica* Thell – the name is regarded as a synonym for *C. polonica*. Present Ukrainian botanists believe that it is a local endemic plant only.

A different floristic character is seen in the Bug river gap through the limy Highland Belt. Soils comprising calcium carbonate and the well-heated slopes of the valley edges create a habitat for continental species. Among others are: spring adonis (*Adonis vernalis*), *Carlina onopordifolia*, dwarf cherry (*Cerasus fruticosa*), variable laburnum (*Chamaecytisus ruthenicus*), red viper's-bugloss (*Echium russicum*), stool iris (*Iris aphylla*), southern species of thyme: Austrian thyme (*Thymus austriacus*), fragrant wild thyme variety (*Th. glabrescens*), Marschall's thyme (*Th. marschalianus*), fragrant wild thyme variety (*Th. kosteleckyanus*) [Fijałkowski 1995], and, found only on the Ukrainian side, garland flower (*Daphne cneorum*) and great feather grass (*Stipa pennata agg*).

Common to both the afore-mentioned sections is the presence of unique species of orchid (*Orchidaceae*): white helliborine (*Cephalanthera damasonium*), sword-leaved helliborine (*C. longifolia*), red phantom (*C. rubra**), early coralroot (*Corallorhiza trifida*), yellow ladies' slipper (*Cypripedium calceolus*), dark red helleborine orchid (*Epipactis atrorubens*), orchid variety (*Orchis purpurea*) [Fijałkowski 1995] and, found only on the Ukrainian side, earlypurple orchid (*Orchis mascula*), green-winged orchid (*O. morio*) and *Orchis palustris*.

The flora in the Polesie region is also interesting, it is connected with the peatbogs. It is characterized by a large number of boreal species. Floristic character of this region is distinguished by: blistery aldrovanda (*Aldrovanda vesiculosa*), sedge variety (*Carex chordorhiza*), Dawall's sedge (*C. davalliana*), saw sedge (*Cladium mariscus*), great sundew (*Drosera anglica*), long-leaved sundew (*D. intermedia*), lousewort variety (*Pedicularis palustris*), Charle's sceptre (*Pedicularis sceptrum-carolinum*), common butterwort (*Pinguicula vulgaris*), Lapland willow (*Salix lapponum*), whortle-berry willow (*S. myrtilloides*), scheuchzeria (*Scheuchzeria palustris*), red genus schoenus of sedges (*Schoenus ferrugineus*), Tofield's asphodel (*Toffieldia calyculata*) and *Veratrum lobelianum* [Fijałkowski 1995].

Up to the Podlaski Gap of the Bug river, there are some continental xerothermic species of cross gentian (*Gentiana cruciata*), wood whitlow grass (*Draba nemorosa*), *Inula hirta*, *Thesium ebracteatum* and military orchid (*Orchis militaris*), and various species of *Libanotis*. Regionally there is the *Petrorhagia prolifera*, meditterean type – which is fairly new [Głowacki 1985]. Some boreal species are also present – medical bearberry (*Arctostaphylos uva-ursi*), shrubby birch (*Betula humilis*), Jacob's ladder (*Poelmonium coeruleum*) and twin-flower (*Linnaea borealis*). Annual gentian (*Gentianella amarella*) is found in soils of neutral pH. Near Korczew this species used to appear en-mass. Unfortunately, as a result of an unsuccessful attempt at establishing a plantation of black-currant in this area, the population of this species became drastically reduced. Postulates recommending the establishing of a legal protection over this area were not realized. In this area one can find the rare agriophyte *Thlandiatha dubia*.

The area of the Low Bug river valley is characterized by vast river terraces which are used for agriculture. There are big meadow areas and the largest of the old river beds. The northern edges of the valley constitute a migration route for Sub-Atlantic species. Epecophytes migrated here from Warsaw, brought after the war, species such as *Iva xanthiifolia* and *Cannabis sativa* L. ssp. *spontanea*

* The only existing habitat is known from the Podlaski Gap of the Bug River.

(*C. ruderalis*). In this area the following species were also identified: mouse garlic (*Allium angulosum*) – and after the disjunction, also appearing in Lublin region are; narrow leaved water plantain (*Alisma lanceolatum*), madwort (*Asperugo procumbens*) and forking campion (*Silene dichotoma*). In contrast to the other parts of the valley, this area is distinguished by the lack of several species: continental and boreal. Some continental plants such as *Centaurea diffusa* and *C. micranthos* are only found near Treblinka which gives some idea about their origin.

Characteristics and plant communities of the Bug river valley

River valleys are characterized by a zonal structure of plant communities. This is a direct result of the changing level of the river water, which diversifies wetness and trophy of particular habitats in the cross-section of the valley.

The lowest land formation, which appears during low water periods is still within the channel: point bars and central sandbanks. These habitats compose the biochory of a pioneer complex *Cypero-Limnoselletum aquaticae*. It is based upon terophytes such as: brown cyperus (*Cyperus fuscus*), mudwort variety (*Limosella aquatica*), cudweed variery (*Gnaphalium luteo-album*) and the rare Ukrainian dock (*Rumex ucrainicus*). Longer periods of desiccation of these habitats are conducive to the formation of communities called *Chenopodion fluviatile*. Distinguished by the presence of the following species: spear-leaved atriplex (*Atriplex prostrata*), oak leaved goosefoot (*Chenopodium glaucum*), goosefoot variety (*Ch. rubrum*), small rush (*Juncus minutulus*), pale smartweed (*Polygonum lapathifolium*), and occasionally low five-leaf (*Potentilla supina*).

The lower flood terrace is occupied by willow brushwood representing the *Salicetum triandro-viminalis* complex. It is based upon shrubby willows including almond leaved willow (*Salix triandra* ssp. *discolor*), and less often, in a typical subspecies ssp. *traindra* – most probably planted, basket willow (*S. viminalis*) and purple willow (*S. purpurea*), sometimes on local dune forms, sharp leaf willow (*Salix acutifolia*), riverside willows are often accompanied by communities of great grass – reedy canary grass (*Phalaris arundinacea*), and less often reeds (*Phragmites australis*), which form their own rush communities. From the land side, so called veil communities appear, their physical shaped created by climbers: hop (*Humulus lupulus*), hedge-bind weed (*Calystegia sepium*), common dodder (*Cuscuta europaea*) and false hop sedge variety (*C. lupuliformis*), and wild cucumber (*Echinocystis lobata*) as alien species. In the gaps among the bushes there are often herbalvetation created by great perennial plants: yellow meadow rue (*Thalictrum flavum*), shiny spurge (*Euphorbia lucida*), hedge nettle (*Stachys palustris*) and fen ragwot (*Senecio paludosus*), plus others.

Higher levels of the flood terrace are a primary location for habitats of woody marshy meadow of the willow-poplar type *Salici-Populetum*. The woodland consists of: white willow (*Salix alba*), crack willow (*S. fragilis*), white poplar (*Populus alba*), black poplar (*P. nigra*). Among the bushes the most common species is red dogwood (*Cornus sanguinea*). Channelside marshy meadows were preserved only fragmentarily due to human activities. Their place was taken by numerous supple-

mentary communities: the *Corynephoro-Silenetum tataricae* complex, communities of heliotrope variety (*Petasites spurius*) and poor pastures of a *Festuco-Sedetalia* type with yellow everlasting (*Helichrysum arenarium*), rupturewort (*Herniaria glabra*), narrow-leaved tussock grass (*Poa angustifolia*), sandwort (*Potentilla arenaria*), wild thyme (*Thymus serpyllum*), dove clover (*Trifolium arvense*) and stonecrops especially (*Sedum sexangulare*) identified as the *Sclerantho-Herniarietum glabrae* association [Głowacki 1980].

On the unstable dune sands the *Spergulo-Corynephoretum* association appears, which is characterized by large quantities of grey hair grass (*Corynephorus canescens*). The new low dunes are occupied by a pioneer, ephemeral community of *Corispermum leptopterum* and *Salsola kali* ssp. *ruthenica.*

Fine-grained, compound, alluvial soils of the higher flood terrace, located usually at a distance from the river channel, are occupied by marshy meadow woods from the *Alno-Padion* group. The woodland consists of several species of deciduous trees, such as: field elm (*Ulmus minor*), European ash (*Fraxinus excelsior*), English oak (*Quercus robur*), small-leaved linden (*Tilia cordata*), black adler (*Alnus glutinosa*), and Norway maple (*Acer platanoides*). Dominant in the undergrowth are cluster cherry (*Padus avium*) and red dogwood (*Cornus sanguineus*). In the undergrowth there are also spring geophytes: spring pilewort (*Ficaria verna*), yellow anemone (*Anemone ranunculoides*) and golden saxifrage (*Chrysosplenium alternifolium*), also colicweed – full, and less often, purple flumewort (*Corydalis solida*) and hollow flumewort (*C. cava*).

Supplementary communities of these habitats are mainly various types of watery and variably wet meadow and pasture. Bigger phytosociological diversity is seen in the meadow communities. Depending on the degree of wetness and the character of the substratum several plant communities can be identified. The lower areas are occupied by meadows divided into two groups: *Polygono-Cirsietum rivularis* with colourful meadow thistle and, specific to big river valleys, *Violo-Cnidietum dubii*, with species: globe flower (*Cnidium dubium*), marsh pea (*Lathyrus palustris*), fen violet (*Viola stagnina*) and very rarely taller violet (*V. elatior*), 2 sites. In the autumn there is sometimes an abundance of mouse garlic (*Allium angulosum*), which has a clear eastern boundary near Małkinia, appearing again in the meridional section of the Bug river. On the contact zone of woods and brushwood with the afore-mentioned community there is also leafy skullcap (*Scutellaria hastifolia*).

The least common meadow group is wet meadow of the molinia type, *Molinietum medioeuropaeum*. In its floristic composition there are species, which are disappearing on a country-wide scale: superb pink (*Dianthus superbus*), Siberian iris (*Iris sibirica*) and marsh gentian (*Gentiana pneumonanthe*). The speciality of the meadows near Korczew is the kalcyphilous orchid (*Orchis militaris* L.). This is the only location of this species in the lower course of the river, in the highland part of the valley it is a component of the green grounds.

Hygrophilous pastures present a community with *Juncus effusus*. Apart from a broad presence of spread rush there are also more interesting taxa such as: knotted pearlwort (*Sagina nodosa*) and Bonnan's clover (*Trifolium fragiferum* ssp. *bonannii*).

The old river beds and terrace hollows created after the passing of flood water, nurture specific habitats for natural river valleys. In deeper synclines, where there

is a water table, plants with swimming leaves are found especially colourful nenuphars represented by common white water lily (*Nymphaea alba*) and yellow water lily (*Nuphar luteum*). In more shallow places there are communities of swimming pondweed (*Potamogeton natans*) and a water-born form of swimming polygonum (*Polygonum amphibium*).

Above water there are inflorescences of immersed plants – various species of pondweeds and water milfoils. In spring the surface of the water is often covered in white flowers of the white water buttercup variety (*Batrachium circinatum*). In the most shallow waters there is occasionally mare's tail (*Hippuris vulgaris*); the old, shallow water regions where there is a thick loam layer are covered with vast patches of water soldier and frogbit *Hydrochari-Stratiotetum*.

The riverside zone of "bużyska" is covered by grand rush species. From the water to the edge of the reservoir there are the following patches of: bulrush (*Schoenoplectus lacustris*), reed-mace (*Typha latifolia*) and *T. angustifolia*, branched bur-reed (*Sparganium erectum*), swamp horsetail (*Equisetum limosum*) and reed (*Phragmites australis*).

Some distance from the river channel, synclines with a restricted outlet are occupied by swampy adler woods. In the Bug river valley these are represented mostly by a fertile group of the currant adler swamp *Ribo nigri-Alnetum*. The woodland consists of black adler (*Alnus glutinosa*) and downy birch (*Betula pubescens*), other species are present only sporadically. The most common bushes are: black currant (*Ribes nigrum*), cluster cherry (*Padus avium*) and black dogwood (*Frangula alnus*). The habitats of the currnat adler are usually in the form of clumps and small valleys which divide the undergrowth into two ecological species groups. Flooded for most of the vegetative period the small valleys are occupied by swamp and peat plants. Clumps growing around the tree trunks are occupied by species of the fresh and wet habitats.

In the dynamic cycle of this there is also a swampy community of the *Salicetum pentandro-cinerae*. It consists of compound brushwood of different willow species, especially of grey willow, which is alternately accompanied by laurel willow (*Salix pentandra*), eared willow (*S. aurita*), dark leaved willow (*S. myrsinifolia*) and black dogwood (*Frangula alnus*). During the previous succession phases this group was preceded by numerous peat and rush phytocenosis groups. Rarely seen is the community of tufted hair grass (*Carex caespitosa)*.

The flood terraces, primarily covered by the woods, are presently occupied by the communities of fresh meadows and pastures. The meadows are represented by the *Arrhenatheretum elatioris* group. Meadows of this type form a habitat for threatened species of hollygras (*Hierorchloë odorata*). Pastures are represented by a plain group of *Lolio-Cynosuretum*.

The valley edges create a habitat for grassland stenothermal forest edge and brushwood communities. As a result of the succession of plants these phytocenosis transform into communities of bright oak wood *Potentillo albae-Quercetum* and stenothermal dry ground forests. The most interesting communities are those of the xerothermic grassland. The richest patches of these phytocenosis are present on the edges within the belt of lime highlands. Northward the composition of these communities becomes poorer. The following unusual species are present:

cross gentian (*Gentiana cruciata*), dwarf Alpine onion (*Allium montanum*), *Inula hirta,* vetch variey (*Vicia pisiformis*), *Thesium ebracteatum*, dyer's woodruff (*Asperula tinctoria*) and *Scorzonera purpurea*.

There are rare xerothermic communities with *Seseli annuum* and *Polygala comosa* which are also found on the uplifts of the Bug river valley bottom; they, however, were not researched.

The dune forms leaning against the valley edges are covered by psammophilous grasslands called *Koelerion glaucae* with sub-continental species: sand pink (*Dianthus arenarius*), chalk plant variety (*Gypsophila fastigiata*) and *Jovibarba sobolifera*. The *Sileno otitis-Festuceum* group has a medial character between the communities of the *Festuco-Brometea* and *Sedo-Scleranthetea* class. The *Sileno otitis-Festuceum* is characterized by the presence of timothy grass (*Phleum phleoides*) and Spanish catchfly (*Silene otites*). Some rare sub-Mediterranean species are also present in this region: bur medic (*Medicago minima*), one site eastwards from Niemirów and proliferous pink (*Petrorhagia prolifera*), a species that appeared not long ago and is spreading [Głowacki 1975].

Also worth mentioning are forest edge communities of the *Trifolio-Geranietea* class. In their species composition there are also plants coming from the xerothermic sward communities. The more interesting ones are the communities of milk vetch (*Astragalus cicer*), northern hawk's beard (*Crepis mollis*), crested cow-weed (*Melampyrum cristatum*) and great umbellifers species: moon carrot (*Libanotis pyrenaica*) and Siberian (*L. sibirica*).

The edges of the flood terrace and moreanic plateau are also covered by stenothermal brushwood of the *Quercetalia pubescentis* order as well as fresh and mixed coniferous forests, and dry-ground forests.

Threats to the plant cover of the Bug river valley

Since the very beginning of human habitation, human activities have influenced the creation of the natural environment of the Bug river valley. By determining functions of particular ecosystems man has created and still creates spatial structure and species composition of the biocesosis, in this way influencing the dynamics of ecological processes. Moderate human pressure related to a traditional management of the area, positively influences the preservation of biological diversity in the area. Changing forms or intensity of management usually decrease the natural value of the area. During the last 40 years, especially, there is an increase in activities which cause degradation of the ecological systems of the Bug river valley. Such influences are often of a global character and cause crucial floristic transformations in the whole section of the valley where they can be observed.

The most damaging factors, causing negative synanthropization processes which decrease plant cover and bio-diversity in the Bug river valley are:

1) narrow embankments of the valley and clearing of the inter-embankment,
2) melioration processes that drain the Bug river terraces and regulation of its tributary channels,

3) eutrophization of oligotrophic communities and the decreasing of fertile habitats,
4) changes of the land usage and structure (creating fields from meadows),
5) intensification of farming and foresting (high doses of fertilizers, plant protection chemicals, introduction of mono-cultures and geographically alien species, oversized felling sites),
6) increased tourism and the uncontrolled development of its infrastructure (especially within the valley and near its edges).

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Appendix: Selected vascular flora species in the Bug river valley

B – Belarus; L – Lublin region; M-P – Mazovia and Podlasie; P – Poland; U – Ukraine;
+ – present species; # – extinct species; * – species included in the Red Book of the selected country

Latin name	Presence				Red Book		
	M-P	L	B	U	P	B	U
1	2	3	4	5	6	7	8
Achillea salicifolia Besser	+	+	+				
Aconitum besseranum Andrz. ex Trautv.				+			
Aconitum variegatum L.	+	+					
Adonis aestivalis L.		+					
Adonis vernalis L.		+		+			
Ajuga genevensis L.	+	+					
Aldrovanda vesiculosa L.		+	+		*	*	*
Alisma lanceolatum With.	+	+					
Allium angulosum L.	+	+					
Allium montanum L.	+	+					
Alyssum turkestanicum Regal & Schmahlh.	+		+				
Androsace septentrionalis L.	+	+					
Anemone narcisifolia L.				+			
Anemone sylvestris L.	+	+		+		*	
Antennaria dioica (L.) Gaertn.	+	+					
Anthyllis schivereckii (DC) Błocki				+			
Aquilegia vulgaris L.	+	+		+		*	
Arabis hirsute L.	+	+					
Arabis planisiliqua (Pres.) Rchb.	+	+					
Arctostaphylos uva-ursi (L.) Spreng.	+	+		#			*
Aristolochia clematitis L.		+					
Aruncus dioicus (Walter) Fernald	+	+				*	
Asparagus officinalis L.	+	+	+				
Asperula cynanchica L.		+					
Asperula tinctoria L.	+	+	+				
Asplenium ruta-muraria L.	+						
Asplenium trichomanes L.	+						
Aster amellus L.	+	+					
Astragalus danicus Retz.	+	+					
Astrantia major L.		+		+		*	
Betula humilis Schrank.	+	+		+			
Blysmus compressus (L.) Panzer ex Link	+	+					

1	2	3	4	5	6	7	8
Botrychium lunaria (L.) Sw.		+					
Botrychium multifidum (S. G. Gmel.) Rupr.		+					
Bromus benekeni (Lange) Syme	+	+					
Bulboschoenus maritimus (L.) Palla		+		+			
Bupleurum rotundifolium L.		+					
Camelina alyssum (Mill.) Thuill.		+					
Campanula bononiensis L.	+	+	+				
Campanula latifolia L.	+	+				*	
Campanula persicifolia L.	+	+	+			*	
Carex cespitosa L.	+	+					
Carex chordorhiza L.		+					
Carex davalliana L.		+		+		*	*
Carex hartmanii Cajander	+						
Carex hostiana DC.		+					
Carex supina Willd.		+					
Carex tomentosa L.		+					
Carex umbrosa Host.	+	+	+			*	
Carex vesicaria L.	+	+		+			
Carlina aculis L.		+					
Carlina cirsioides Kłok.				+			
Carlina onopordifolia BESSER				#	*		*
Centaurea phrygia L.		+					
Cephalantera damasonium (Mill.) Druce		+		+		*	
Cephalantera longifolia (L) Fritsch.		+	+	+			
Cephalanthera rubra (L.) Rich.	+	+	+	+		*	*
Chamaecytisus albus (Hacq.) Rothm.		+		+	*		
Chimaphila umbellata (L.) W. P. C. Barton	+	+					
Cimicifuga europaea Schipcz.	+	+				*	
Cirsium canum (L.) All.		+					
Cladium mariscus (L.) Pol.				+		*	*
Clematis recta L.		+				*	
Cnidium dubium (Schkuhr) Thell.	+	+					
Cochlearia polonica E. Fröhl.				+			
Coeloglossum viride (L.) Hartm.				#			*
Coralorhiza trifida Chatel.		+		+		*	
Corydalis cava (L.) Schweigger & Koerte	+	+				*	
Crepis mollis Jacq. Asch.	+	+					
Crepis praemorsa (L.) Tausch		+					
Crepis rheadifolia M. Bieb.	+	+					
Crocus heuffelianus (Herbert) Hegi				#			*
Cruciata laevipes Opiz		+					
Cucubalis baccifer L.	+	+					
Cuscuta lupuliformis Krock.	+	+	+				
Cypripedium calceolus L.		+	+	+		*	
Cystopteris fragilis (L.) Bernh.	+	+					

1	2	3	4	5	6	7	8
Dactylorhiza fuchsii (Druce) Soó	+						
Dactylorhiza maculata E		+	+				
Dactylorhiza traunsteineri (Saut.) Soó	+			+			
Daphne cneorum L.	+			+		*	
Dentaria bulbifera L.		+				*	
Dentaria glandulosa Waldst. & Kit		+		+			
Dianthus arenarius L.	+	+	+	+			
Dianthus armeria L.	+	+					
Dianthus superbus L.	+	+	+	+			
Digitalis grandiflora Miller	+	+	+			*	
Diphasiastrum complanatum (L.) Holub	+	+					
Diphasiatrum tristachyum (Pursh) Holub		+					
Draba nemorosa L.	+	+	+				
Dracocephalum ruyschiana L.				+			*
Drosera anglica Hudson		+		+			
Drosera intermedia Hayne		+					
Drosera rotundifolia L	+	+		+			
Dryopteris cristata	+	+					
Echium russicum J. F. Gmel.		+		+			
Eleocharis ovata (Roth) Roem. & Schult.		+					
Epipactis atrorubens (Hoffm.) Besser				+		*	
Epipactis palustris (L.) Crantz	+	+		+			
Eriophorum gracile Koch		+					
Eriophorum latifolium Hoppe	+	+					
Euphorbia angulata Jacq.	+	+					
Euphorbia lucida Waldst. & Kit.	+	+	+				
Euphorbia palustris L.		+					
Festuca pseudovina Hack. & Wiesb		+			*		
Festuca valesiaca Schleich.		+					
Fragaria moschata Duchesne		+					
Galanthus nivalis L.				+			
Galium polonicum Błocki				+			
Gentiana cruciata L.	+	+		+		*	
Gentiana pneumonanthe L.	+	+	+	+			
Gentianella amarella (L.) Börner	+						
Gladiolus imbricatus L.	+	+	+	+		*	
Glyceria nemoralis (R. Uechtr.) R. Uechtr. & Koern.	+						
Goodyera repens (L.) R. Br.	+	+	+	+			
Gratiola officinalis L.	+	+					
Gymnadenia conopsea L.				+			
Hedera helix L.	+	+	+	+		*	
Hepatica nobilis L.	+	+	+			*	
Herniaria hirsuta L.	+	+					
Hieracium caesium (Fr.) Fr.	+	+					
Hieracium echioides Lumn		+					

1	2	3	4	5	6	7	8
Hieracium flagellare Willd.	+						
Hieracium lactucella Wallr.	+	+					
Hierochloë odorata (L.) P. Beauv.	+	+					
Hippuris vulgaris L.	+	+					
Huperzia selago (L.) Bernh. ex Schrank & Mart	+			+		*	
Hydrocotyle vulgaris L.		+	+				
Hyoscyamus niger L.	+	+					
Illecebrum verticillatum L.	+						
Inula ensifolia L.	+	+					
Inula hirta L.	+	+					
Inula salicina L.	+	+	+				
Iris aphylla L.		+		+	*	*	
Iris sibirica L.	+	+	+	+		*	*
Isopyrum thalictroides L.	+	+				*	
Jovibarba sobolifera (Sm.)	+	+					
Juncus atratus Krock.	+	+					
Laserpitium latifolium L.	+	+	+			*	
Laserpitium pruthenicum L.	+	+	+				
Lathyrus palustris L.	+	+					
Lathyrus pisiformis L.		+					
Leucoium vernum L.				+			*
Libanotis pyrenaica (L.) Bourg.	+	+					
Libanotis sibirica (L.) W. D. J. Koch	+	+					
Lilium martagon L.	+	+	+	+		*	*
Linnaea borealis L.	+	+		+		*	
Linum flavum L.	+						
Liparis loeselii (L.) L. C. Richard	+	+					
Lobularia maritima (L.) Desv			+				
Lonicera periclymenum L.	+						
Lunaria rediviva L.				+		*	*
Lycopodiella inundata (L.) Holub	+		+				
Lythrum hyssopifolia L.	+						
Malaxis monophyllos (L.) Swartz				+	*		
Melampyrum arvense L.	+	+					
Melampyrum cristatum L.	+						
Melittis melisophyllum L.	+	+	+			*	
Moneses uniflora (L.) A. Gray (*Pyrola uniflora* L.)	+	+					
Muscari comosum (L.) Mill.				#			*
Najas flexilis Willd.) Rostk. & W. I. E. Schmidt		+					
Najas marina L.		+					
Neottia nidus-avis (L.) Rich.	+	+		+			
Nigella arvensis L.	+	+					
Nymphaea alba L	+	+		+		*	
Nymphaea candida C. PRESL		+		+			
Nymphoides peltata (S. G. GMEL.) KUNTZE		+				*	

1	2	3	4	5	6	7	8
Oenothera ammophila Focke	+		+				
Orchis coriophora L.				+			
Orchis mascula L.				#		*	*
Orchis militaris L.	+	+		+		*	
Orchis morio L.		#		#		*	*
Orchis purpurea Hudson		+		+	*		
Osmunda regalis L.			+			*	
Ostericum palustre Besser	+	+		#			*
Pedicularis palustris L.	+	+		+			
Pedicularis sceptrum-carolinum L.	+	+		+			*
Pedicularis sylvatica L.		+		+			
Petrorhagia prolifera (L.) P. W. Ball & Heyw.	+						
Peucedanum alsaticum L.		+					
Phyteuma orbiculare L.		+					
Pimpinella maior (L.) Hudson	+	+	+				
Pinguicula bicolor Wol.				+			*
Pinguicula vulgaris L. circumpol (oc)		+		+		*	*
Platanthera bifolia (L.) L. C. M. Rchb.	+	+	+	+		*	*
Platanthera chlorantha (Custer) Rchb.		+		+		*	
Polemonium coeruleum L.	+	+					
Polypodium vulgare L.	+	+	+			*	
Polystichum aculeatum (L.) Roth		+					
Populus alba L.	+	+	+				
Populus nigra L.	+	+	+				
Primula elatior (L.) Hill.	+	+				*	
Primula veris L.	+	+	+			*	
Prunella grandiflora L.	+	+					
Pulsatilla patens (L.) Mill.		+					
Pulsatilla pratensis L.	+	+				*	
Pulsatilla vulgaris Mill. ssp. *grandis* (Wender) Zamels				+			
Quercus petrea (Mattuschka) Liebl.	+	+	+			*	
Ranunculus zapalowiczii Paczoski				+			
Rhynchospora alba (L.) Vahl.		+					
Rosa galica L.		+			*		
Rosa x bugensis Chrshan				+			
Rumex ucranicus L.	+						
Salix lapponum L.		+		+			
Salix myrtilloides L.		+		+	*		
Salvinia natans L.			+			*	
Saxifraga granulatas L.	+	+	+	#		*	*
Saxifraga tridactylites L.	+						
Scheuchzeria palustris L.		+		+			
Schoenus ferrugineus L.		+		+			*
Scorzonera purpurea L.	+	+				*	
Scutellaria hastifolia L.	+	+					

1	2	3	4	5	6	7	8
Senecio erucifolius L.			+	+			
Senecio intergrifolius (L.) Clairv.		+					
Senecio paludosus L.	+	+					
Silene borysthenica (Gruner) Walters	+		+				
Silene lithuanica Zapał.	+	+	+	+			
Sparganium minimum Wallr.		+					
Stachys recta L.	+	+					
Stipa joannis ČELAK. s. s.				+	*		
Succisella inflexa (Kluk) Beck.	+						
Swertia perennis L.				+		*	
Teucrium chamaedrys L.		+		+			
Teucrium montanum L.				+			
Teucrium scordium L.	+	+	+				
Thalictrum flavum L	+	+					
Thalictrum simplex L.	+	+					
Thesium ebracteatum Hayne	+	+					
Thesium linophyllon L.		+					
Tofieldia calyculata (L.) Wahlenb.		+		+		*	
Trifolium rubens L.	+		+				
Triolius europaeus L.	+	+	+	+		*	
Utricularia intermedia Hayne		+					
Utricularia minor L.		+					
Valeriana sambucifolia Mikan		+					
Verbascum phoeniceum L.	+	+	+				
Veronica montana L.				+			
Veronica teucrium L.	+	+					
Vicia lathyroides L.	+		+				
Vicia pisiformis L.	+						
Viola colina Besser	+	+					
Viola elatior Fries	+	+					
Viola hirta L.	+	+					
Viola stagnina Kit.	+	+					
Wolffia arhiza (L.) Hoekel ex Wimm.	+	+					

Chapter VI

General characteristics of the fauna and the major threats

Andrzej Dombrowski

Data on the key species for valorization of different habitat types in the Bug river valley were collected in 1998–2000. Only avifauna was observed along the entire course of the Bug from the springs to the mouth. The remaining groups of animals or selected species such as diurnal butterflies, fishes, otters, and beavers were monitored in detail only in the middle and lower courses of the river, whereas nocturnal butterflies at selected sites of the Podlasian river section. Previous studies, not included to the present IUCN project, were also concentrated in the lower Bug, then in the middle reaches, and they were least intense in upper reaches.

Most studies on spiders of the Bug valley were conducted by workers of the Podlasian University in Siedlce within the Podlasian gap (Podlasian Bug Gap = "Podlaski Przełom Bugu") in the early 1980s. In total, 252 spider species were noted in the Bug valley by 1993 [Próchniewicz 1986, 1991a, 1991b, Zygadło 1993], accounting for 32% of about 780 species recorded from Poland. The great richness of arachnofauna in this small fragment of the Bug valley is due to an unusually high habitat diversity ranging from coniferous and oak-hornbeam forests situated on the upland (marginal valley), through fertile, moist meadows with forbs, low sandy grass communities, and oxbows, to shoreline beaches almost without vegetation. Especially worth noting are as many as 11 species of spiders (recorded near the village of Mierzwice), rare at the scale of Poland, known from merely several or ten or so sites dispersed over the country. Ten species of this group have the eastern boundary of their geographical range in the Podlasian Bug section [Zygadło 1993]. They include *Iberina candida* – the species common in southern Europe, and in Poland recorded only from the Karkonosze Mts. and Białowieża Primeval Forest, in addition to Mierzwice [Zygadło 1993]. Also a species new to Poland, *Cheiracanthium campestre*, known as yet only from warm habitats of southern Sweden, was discovered in this area [Próchniewicz 1986]. Moreover, the following rare species were found near Mierzwice: *Agroeca lusatica, Zelotes aeneus, Oxyptila nigrita, Talavera petrensis, Sitticus zimmermanni, Meioneta affinis, Agyneta ramosa, Ceratinopsis stativa, Centromerus aequalis, Baryphyma pratense, Enoplognatha*

mordax and *Tmarus piger* [Staręga 1984, Próchniewicz 1986, Zygadło 1993]. Another area of arachnological investigations was the nature reserve "Kózki", where several species rare in Poland were found. They comprise *Archaeodictyna consecuta, Leptothrix hardyi, Trichopterna cito, Thanatus pictus, Titanoeca quadriguttata, Cheiracanthium campestre, Agrocea lusatica,* and *Meioneta affinis* [Cieciuch 2000].

Butterflies are another group of invertebrates whose species richness, like that of spiders, provides evidence for an unusual faunal diversity of the Bug valley, and for a high rank of this river not only for common but also for rare species. Butterflies were surveyed in the lower Bug valley and along the right side of the Polish-Ukrainian boundary section of the Bug. In 1998–2000, 102 butterfly species were recorded there, accounting for 68% of the butterflies known from Poland. This high species richness was associated with an enormous diversity of well preserved plant communities typical of open habitats. Stenotopic butterflies were mainly associated with fens, or with sandy elevations (called "piaszczyska") and loessic or limestone slopes of the valley. These habitat types were occupied by species reaching their northern range in the Bug valley at the scales of Poland and Europe. Here there are northernmost sites of two species, sloe hairstreak (*Nordmannia acaciae*) and *Poliomuratus tchersites*. In Poland, ten species of butterflies are legally protected, and six of them occur in the Bug valley: swallowtail (*Papilio machaon*), purple emperor *(Apatura iris*), lesser purple emperor *(A. ilia*), dusky large blue (*Maculinea nausithous*), scarce large blue (*M. teleius*), and marsh fritillary (*Euphydryas aurinia*). Six species protected by the Bern Convention inhabit the Bug valley [Pałka *et al*., in press]. Moreover, three species were recorded that are listed in the Red-data Book of European Fauna: *Lyceana dispar,* chequered skipper (*Carterocephalus palaemon*), and large blue (*Maculinea arion*). Of the rare butterflies occurring in Poland and found in the Bug valley, at least the following should be mentioned: *Pollymmatus eroides,* Assmann's fritillary (*Mellicta britomartis*), as many as three of the six sites known from Poland are located in the Bug valley, *Haemaris lucina*, and green-underside blue (*Glaucopsyche alexis*) [Łupiński 1996].

Rather well known, although only from the Podlasian Bug Gap, is the fauna of moths. During 1996–2000, 588 species were recorded from this area, that is, about 53% of the Polish list of moths. Of the three moths species legally protected in Poland, one, *Proserpinus proserpina*, occurs in the Bug valley. Special attention should be paid to a representative of noctuids, *Xylomoia graminea*, so far known only from Poland and Ukraine among European countries. Beyond the Bug valley, this rare in Poland species was noted in the region of Łosice on Roztocze and Polesie Lubelskie. Earlier it was recorded only from the Amur valley in Asia [Łupiński 1996]. Another rarity at the scale of the country is the *Eupithecia cauchiata* occurring near Mielnik, and known in Poland only from the Białowieża Forest. Near the Zabuże, another moth was found, *Odontosia sieversi*, a representative of the Asiatic fauna with the western boundary of its geographical range along the Bug, and near Mielnik, *Pygaera timon,* also the species with the western boundary in eastern Poland. Different researchers emphasize with ever increasing frequency the role of the Bug as an ecological corridor, especially for invasive moths. South-European species move along the Bug valley northwards, and many migrating Mediterranean species were found in the Podlasian Bug Gorge, such as *Autographa gamma*, *Macdunnoughia confusa*, *Mythimna albipuncta*, *Agrotis ipsilon*, and *Prodotis stolida* [Łupiński and Wasiluk, in press].

Also mayflies (*Ephemeroptera*) were investigated in the lower Bug valley. Preliminary surveys conducted between the Brok and Siemiatycze in late spring at the beginning of the 1980s revealed the occurrence of 26 species [Głazaczow 1997]. The fauna of mayflies was represented by species typical of this river section, that is, *Oligoneuriella pallidia,* which is the most abundant species, accounting for over 50% of the specimens collected at that time, numerous species considered to be psammophilous, inhabiting sandy beds of large lowland rivers, represented by *Pseudocentroptiloides shadini, Cercobrachys minutus, Oligoneurisca borysthenica* and *Procloeon nana.* Also relatively rare species were discovered, typical of lower river courses, such as *Isonychia ignota* and *Heptagenia coerulans* [Głazaczow 1997]. More detailed surveys conducted since 1989 showed that the most abundant species in the early 1980s, *O. pallida*, became rare within a period of several years, and *I. ignota* and *H. coerulans* disappeared. Similarly, *O. borysthenica*, a relatively abundant species early in the 1980s, was rarely noted. Moreover, the abundance of *P. shadini* declined [Głazaczow 1997]. Comparing the collection of mayflies from the same study period (June), this author found that the number of species was reduced to 20, with *H. flava* and *L. tricolor* as the only dominants, and he suggests that these substantial changes in the fauna of mayflies in the Bug valley are a consequence of deteriorating water quality. Continuation of this study until 1997 in the Podlasian-Mazovian section (villages of Mierzwice to Barcice) showed the occurrence of 39 mayfly species, accounting for 55% of the lowland fauna of these insects in Poland. With respect to this species richness, the lower reaches of the Bug are thus comparable to such rivers as the Warta or San, where 41–43 mayfly species were recorded [Głazaczow 1989].

Fish belong to better known vertebrates [Danilkiewicz 1985a, 1997]. After a period of 150 years of data collecting, initiated by Wałecki [1864], continued by Zhukow [1965], Danilkiewicz [1997, 1998, and recently by Błachuta et al., in press] it can be stated that the present ichthyofauna of the Bug consists of 44 fish and lamprey species the occurrence of which does not raise doubts, and this number should be supplemented by 8 more species, the occurrence of which has not been confirmed over the recent decade. With this number of species, the Bug belongs to leading rivers in Poland. Of the total number of 77 species of lampreys and freshwater fishes known from Poland [Rolik and Rembiszewski 1987, Witkowski 1992], 57% (or 67% when the species not confirmed in 1990–1999 are included) can be met in the Bug.

Amphibians are represented by 13 species as yet recorded from the Bug valley. In addition to so called green frogs (European green frog *Rana esculenta*, marsh frog (*Rana ridibunda*), and pool frog (*Rana lessonae*) and brown frogs (common frog – *Rana temporaria* and moor frog – *R. arvalis*), also the common toad (*Bufo bufo*) and much rarer green toad (*Bufo viridis*) inhabit this area, as well as locally abundant tree frog (*Hyla arborea*). The fire-bellied toad (*Bombina bombina*), spadefoot toad (*Pelobates fuscus*), smooth newt (*Triturus vulgaris*), and crested newt (*Triturus cristatus*) were regularly recorded from oxbows of the Bug. Especially suitable sites (shallow oxbow lakes, insolated, and partly covered with short vegetation, situated in hay meadows and pastures) support unusually high numbers of fire-bellied toads. Presumably, this is one of the largest populations of this species in Poland. Among the rarest amphibians, natterjack toad (*Bufo calamita*) inhabits the Bug valley.

Reptiles comprise 7 species in the Bug valley. Common are sand-lizards (*Lacerta agilis*) and grass snakes (*Natrix natrix*), but adders (*Vipera berus*) are very rare. Slow-worm (*Anguis fragilis*) and viviparous lizard (*Lacerta vivipara*) were only locally found. The rarest species is smooth snake (*Coronella austriaca*). European pond tortoise (*Emys orbicularis*) was recorded from several sites, for example, near Brześć and in the nature reserve Łęg Dębowy near Janów Podlaski. Searching for this rare reptile should be concentrated in oxbow lakes and mouths of small rivers throughout the Bug and the Krzna valleys, especially that the largest population of pond tortoise occurs near Sobibór. During long-term studies conducted by the Museum of Natural History of the University of Wrocław, pond tortoises were discovered, for example, in the Tarasienka, the Krzemionka, and the Włodawka river valleys, and in oxbow lakes of the middle (Polesian) Bug section [Jabłoński & Jabłońska 1999]. According to these authors, the population of this species in the Bug valley and Łęczyńsko–Włodawskie Lakeland (forest divisions Sobibór and Włodawa) is most abundant (documented and genetically investigated) not only in Poland but also in Europe.

Birds are the best known group of animals across the Bug valley. Breeding avifauna, along with the vegetation, is the most useful indicator of the quality and threats to almost all habitat types occurring in the Bug valley from the source to the mouth of this river. This usefulness is due to a large number of species, their high detectability, especially vocal, and diurnal activity. In contrast to the breeding season, the Bug valley is not an important wintering site for waterbirds. This is rather natural as large numbers of birds are attracted to places of anthropogenic character such as discharges of heated waters that are almost totally absent from the Bug. A detailed description of the avifauna is presented in the next chapter. Here its high species richness should be noted. In the breeding season it comprises 179 species. A high rank of the Bug valley on the international scale is due to large populations of such birds as the corncrake (*Crex crex*), which is a globally threatened species. Moreover, the population of sand martins (*Riparia riparia*) in the Bug valley is among the largest in Europe. Also large are breeding populations of the black-tailed godwit (*Limosa limosa*), black tern (*Chlidonias niger*), kingfisher (*Alcedo atthis*), hoopoe (*Upupa epops*), turtle dove (*Streptopelia turtur*), wryneck (*Jynx torquilla*), and river warbler (*Locustella fluviatilis*). On the Ukrainian and/or Belarussian sides, sparse sites of the ferruginous duck (*Aythya nyroca*), booted eagle (*Hieraaetus pennatus*), short-toed eagle (*Circaetus gallicus*), and white-backed woodpecker (*Dendrocopos leucotos*) were noted at the peripheries of their ranges.

Mammals are a much less known class of vertebrates than birds. Especially desirable is information on the distribution of bats and dormice. Much information on mammals comes from analyses of pellets of the barn owl (*Tyto alba*), long-eared owl (*Asio otus*), and little owl (*Athene noctua*), collected mainly from the lower Bug. So far, 49 mammal species are known from the Bug valley. Among large ungulates, there are elks (*Alces alces*), red deers (*Cervus elaphus*), wild boars (*Sus scrofa*), and roe deers (*Capreolus capreolus*). The presence of the wolf (*Canis lupus*) is worth special attention. This species was heavily decimated in the 1970s and the 1980s. Wolves irregularly appear in large forest complexes. Mammals representing higher trophic levels were not intensively investigated in the Bug valley until 1997. From April 1999 to March 2000, the otter and European beaver were surveyed as they may serve as indicators of habitats valuable to whole groups of semiaquatic

organisms. Their traces were observed along the Bug fragments from the intersection of the river channel and the Ukrainian border to Zegrze Reservoir. Notes were taken every 5–10 km within 1–5 km sections along the main river bank and along selected tributaries up to 5 km from their junction with the Bug [Kloskowski in press]. The otter and beaver populations in the Bug valley are continuous at present. It is difficult to tell how the otter population will be affected by the appearance of the American mink (*Mustela vison*), which is expanding over north-eastern Poland. Mink tracks were found in many places along the Mazovian-Podlasian Bug section, and this mammal is likely to occur much further southwards. Other species of mammals were not so intensively studied, but it is known that the abundance of the raccoon dog (*Nyctereutes procyonoides*) is increasing. This species colonized Poland not so long ago, and became a permanent component of the mammal fauna in many areas. Little known is the group of bats, represented by at least ten species in the Bug valley. A detailed study can yield interesting results. For example, in five forts near Terespol, hibernating northern bats (*Eptesicus nilssoni*) were discovered. In total, seven species were noted in these forts, of which the barbastelle (*Barbastella barbastellus*) was most abundant. The remaining species comprised the serotine (*Eptesicus serotinus*), long-eared bat (*Plecotus auritus*), grey long-eared bat (*Plecotus austriacus*) [Kowalski and Lesiński 1997], Daubenton's bat (*Myotis daubentoni*), and Natterer's bat (*Myotis nattereri*) [Sachanowicz 1995]. It should be emphasized that the sites of the grey long-eared bat discovered near Terespol are located at the northern boundary of its geographical range [Kowalski *et al*. 1997]. Much more important for hibernating bats are forts near Brześć on the Belarussian side. Interesting data have recently been collected in villages situated at the verge of the Bug valley near Sobibór (Lubelskie province) on the Polish side of this boundary river section. Only in the season of 2000, 13 bat species of 16 occurring in the lowland part of Poland were found there [Kowalski, Mazur, and Piskorski, unpubl.).

A more complete valorization of some habitats (oxbows, peatlands, meadows, xeric grass communities) requires detailed studies at the scale of the entire Bug valley. Future faunal investigations should primarily be focused on molluscs, leeches, hymenopterans, orthopterans, and beetles, as well as mammals.

Threats to the fauna of the Bug valley are mainly posed by various forms of human activity, especially over two recent decades. It should be emphasized that most of the treatments could have been planned in a way preventing losses to wildlife and, at the same time, leading to the desired economic effect. For example, reconciliation of flood-control measures with the protection of oxbows, etc. The management practices most harmful to the fauna of the Bug valley incorporate:

1) misplaced location of about 80% of the length of flood embankments,
2) clearing and grazing riparian carrs,
3) drainage of fens and alder swamps,
4) cessation of hay mowing,
5) disappearance of traditional pastoral farming, especially grazing of dry grasslands,
6) afforestation of xeric grasslands and establishment of poplar cultures,
7) regulation of the river channel, especially cutting off meanders,

8) lack of appropriate labels of power lines and poles,
9) lack of passages for small animals under domestic and international roads,
10) conversion of permanent meadows and pastures into arable land,
11) excessive water pollution of the Bug and its tributaries,
12) establishment of sedimentation tanks for industrial waste water near the Bug.

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Chapter VII

Status and threats to avifauna

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Based on the experience during 1984–1990, when field observations were conducted in the Lower Bug Valley (also called the Mazovian Bug section) and in the Podlasian Bug Gap (the Podlasian section), a detailed scheme for ornithological surveys in 1998–2000 along with instructions for data processing were developed and sent off to co-ordinators of ornithological groups in the Lublin province, the Belarus, and the Ukraine. The results of the surveys were mapped using 1:25 000 topographic maps. With this procedure it was possible not only to assess the value of space for birds in different fragments of the valley and in the main habitat types, but also to prepare a spatial analysis of threats and protective measures for their future use in detailed plans.

The basic study in the Polish part was performed during 1998–1999, and it was supplemented in 2000, especially for rails. In the Belarussian and the Ukrainian parts, the main observations were conducted during 1999–2000.

The major goal of the study was to characterize the breeding avifauna of the entire valley, and the wintering fauna of the Bug channel. The importance of the Bug valley to the species diversity of breeding birds was determined at the scale of Europe. Using indicator species, the importance of different habitat types was evaluated

1) in a cross section from the river channel to the valley edge,

and

2) along the river course from the springs to the mouth.

For this purpose, the species that differed in conservation concern (categories from 1 to 4) as defined by Hagemeijer and Blair [1998] were selected. As a result, the international rank of the valorization of this Pan-European ecological corridor was attained.

In 1998, three inventory surveys of the Bug valley were performed on the Polish side. First, the floodplain was surveyed and then a large part of the terrace above

the floodplain. The first survey was conducted during 10 April – 10 May, the next during the second and third ten-day periods of May, and the third survey in June and the first half of July. Similar surveys were performed in the Ukrainian and Belarussian parts in 1999–2000. The objective of the first survey was the valorization of riparian carrs by using indicator species, among others, the green woodpecker (*Picus viridis*), black woodpecker (*Dryocopus martius*), middle spotted woodpecker (*Dendrocopos medius*), bluethroat (*Luscinia svecica*), penduline tit (*Remiz pendulinus*) and the earliest breeders, such as the raven (*Corvus corax*) and great grey shrike (*Lanius excubitor*). The second survey was focused on the valorization of oxbows along with surrounding peatlands, meadows, and xeric grass communities, also beaches by using indicator species, such as the shoveler (*Anas clypeata*), garganey (*Anas querquedula*), marsh harrier (*Circus aeruginosus*), common snipe (*Gallinago gallinago*), black-tailed godwit (*Limosa limosa*), redshank (*Tringa totanus*), black tern (*Chlidonias niger*), crane (*Grus grus*), little ringed plover (*Charadius dubius*), and ringed plover (*Charadrius hiaticula*). Moreover, many species living in riparian carrs were monitored, especially the river warbler, which was also monitored during later, night censuses. During the third survey, the latest breeders were monitored: Montagu's harrier (*Circus pygargus*), white-winged black tern (*Chlidonias leucopterus*), whiskered tern (*Chlidonias hybridus*), and scarlet grosbeak (*Carpodacus erythrinus*). During all surveys, the boundaries of most valuable areas for birds were delineated, and the actual habitat condition was described.

In 1999, on the Polish side of the valley and in 2000 on the Ukrainian side, a night survey was made in open habitats (meadows, peatlands, the largest oxbows) to determine the abundance and distribution of the corncrake (*Crex crex*), which is a globally threatened species. Also the abundances of the quail (*Coturnix coturnix*), spotted crake (*Porzana porzana*), and grasshopper warbler (*Locustella naevia*) were estimated. Nocturnal counts were conducted in the periods of the highest vocal activity of these species, that is, in June, and in the areas inundated for the longest time, early in July (in 1999, the spring overbank flooding of the Bug valley was unusually extensive and prolonged). In addition, four bird species were monitored on largest oxbows and alder swamps in the Bug valley (Mazovian and Podlasian sections): the little grebe (*Tachybaptus ruficollis*), water rail (*Rallus aquaticus*), moorhen (*Gallinula chloropus*), and little corncrake (*Porzana parva*). For this group, playback stimulation was applied during the day. As in 1999 many oxbows, especially below Zgleczewo were flooded until the end of May and probably not inhabited by these species, the stimulation was repeated in 2000. Also because of the high water level, the date of canoeing was shifted from the end of May to the second half of June. During 18–21 June 1999, three two-observer groups in boats flowing in parallel surveyed the Bug section from the confluence of the Krzna river to the village of Kuligów (250 km). They valorized the river course of two physiographic mesoregions, the Podlasian Bug Gap and the Lower Bug valley. The remaining river sections were surveyed from boats at the end of the first 10-day period of June. The abundance and distribution of birds were evaluated in three riparian habitat types:

1) steep escarpments: the sand martin (*Riparia riparia*), kingfisher (*Alcedo atthis*),
2) islands and beaches: the goosander (*Mergus merganser*), common sandpiper (*Actitis hypoleucos*), little ringed plover (*Charadrius dubius*), ringed plover

(*Charadrius hiaticula*), little tern (*Sterna albifrons*), common tern (*Sterna hirundo*), common gull (*Larus canus*), and black-headed gull (*Larus ridibundus*),

3) riparian willow thickets and carrs: the scarlet grosbeak (*Carpodacus erythrinus*), penduline tit (*Remiz pendulinus*), river warbler (*Locustella fluviatilis*), turtle dove (*Streptopelia decaocto*), wryneck (*Jynx torquilla*).

In January 1999, numbers of water birds were estimated along the Lublin section, and in 2000, along the Mazovian-Podlasian and Ukrainian sections to evaluate the role of the Bug for the wintering of these birds.

In total, 179 breeding or probably breeding bird species were recorded from the Bug valley (Tab. 1). The highest species richness of the breeding avifauna in 1998–2000 was noted in the Ukrainian section (167 species), followed by the Belarussian section (160), Mazovian section (158), and Lublin section (142 species).

Table 1. List of breeding and probably breeding birds in the Bug valley in 1998–2000, their conservation priority with reference to the categories (1, 2, 3, 4) of the Species of European Conservation Concern (SPEC), presence on the Red Data Books (RDB) for Poland (P), Belarus (B), and Ukraine (U), and occurrence (+) in different Bug sections: Mazovian-Podlasian (M-P), Lublin (L), Belarussian (B), and Ukrainian (U).

Species	SPEC	RDB	M-P	L	B	U
1	2	3	4	5	6	7
Little grebe (*Tachybaptus ruficollis*)		B	+	+	+	+
Great crested grebe (*Podiceps cristatus*)			+		+	+
Red-necked grebe (*Podiceps grisegena*)		B	+			
Black-necked grebe (*Podiceps nigricollis*)		B	+			
Bittern (*Botaurus stellaris*)	3	P, B	+	+	+	+
Little bittern (*Ixobrychus minutus*)	3	P, B	+	+	+	+
Heron (*Ardea cinerea*)			+	+		+
Black stork (*Ciconia nigra*)	3	B,U	+		+	+
White stork (*Ciconia ciconia*)	2		+	+	+	+
Mute swan (*Cygnus olor*)		B	+	+	+	+
Wigeon (*Anas penelope*)		P		+		
Gadwall (*Anas strepera*)	3		+	+		+
Teal (*Anas crecca*)			+	+	+	+
Mallard (*Anas platyrhynchos*)						
Pintail (*Anas acuta*)	3	P	+			+
Garganey (*Anas querquedula*)	3		+	+	+	+
Shoveler (*Anas clypeata*)			+	+		+
Pochard (*Aythya ferina*)			+	+	+	+
Tufted duck (*Aythya fuligula*)			+	+	+	+
Ferruginous duck (*Aythya nyroca*)	1	P,B,U			+	+
Goldeneye (*Bucephala clangula*)		B,U	+		+	
Goosander (*Mergus merganser*)		B	+			
Honey buzzard (*Pernis apivorus*)	4		+	+	+	+
Short-toed eagle (*Circaetus gallicus*)	3	P				+
Booted eagle (*Hieraaetus pennatus*)	3	P,B,U				+

1	2	3	4	5	6	7
Black kite (*Milvus migrans*)	3		+			+
Marsh harrier (*Circus aeruginosus*)			+	+	+	+
Montagu's harrier (*Circus pygargus*)	4		+	+	+	+
Hen harrier (*Circus cyaneus*)	3	P,U			+	
Goshawk (*Accipiter gentilis*)			+	+	+	+
Sparrow hawk (*Accipiter nisus*)			+	+	+	+
Buzzard (*Buteo buteo*)			+	+	+	+
Lesser spotted eagle (*Aquila pomarina*)	3	P,B,U	+	+	+	+
White-tailed eagle (*Haliaeetus albicilla*)	3	P,B,U				+
Kestrel (*Falco tinnunculus*)		B	+	+	+	+
Hobby (*Falco subbuteo*)		B	+	+	+	+
Partridge (*Perdix perdix*)	3		+	+	+	+
Hazel hen (*Bonasa bonasia*)					+	+
Black grouse (*Tetrao tetrix*)	3	P			+	+
Quail (*Coturnix coturnix*)	3		+	+	+	+
Pheasant (*Phasianus colchicus*)			+	+	+	+
Water rail (*Rallus aquaticus*)			+	+	+	+
Spotted crake (*Porzana porzana*)	4		+	+	+	+
Little crake (*Przana parva*)	4	P,B	+	+	+	+
Corncrake (*Crex crex*)	1		+	+	+	+
Moorhen (*Gallinula chloropus*)			+	+	+	+
Coot (*Fulica atra*)			+	+	+	+
Crane (*Grus grus*)	3	B,U	+	+	+	+
Little ringed plover (*Charadrius dubius*)			+	+	+	+
Ringed plover (*Charadrius hiaticula*)		P,U	+		+	+
Lapwing (*Vanellus vanellus*)			+	+	+	+
Common snipe (*Gallinago gallinago*)			+	+	+	+
Great snipe (*Gallinago media*)	2	P		+	+	+
Woodcock (*Cuculus canorus*)	3		+	+	+	+
Black-tailed godwit (*Limosa limosa*)	2		+	+	+	+
Curlew (*Numenius arquata*)	3	B,U	+		+	+
Redshank (*Tringa totanus*)	2		+	+	+	+
Green sandpiper (*Tringa ochropus*)			+	+	+	+
Common sandpiper (*Actitis hypoleucos*)			+	+	+	+
Ruff (*Philomachus pugnax*)	4	P			+	
Black-headed gull (*Larus ridibundus*)			+		+	+
Common gull (*Larus canus*)	2		+		+	
Yellow-legged gull (*Larus cachinnans*)						+
Common tern (*Sterna hirundo*)			+	+	+	+
Little tern (*Sterna albifrons)*	3	P,B	+		+	+
Black tern (*Chlidonias niger*)	3		+	+	+	+
White-winged black tern (*Chlidonias leucopterus*)		P	+	+	+	+
Whiskered tern (*Chlidonias hybridus*)		P		+	+	+
Stock dove (*Columba oenas*)	4		+		+	+
Wood pigeon (*Columba palumbus*)	4		+	+	+	+

1	2	3	4	5	6	7
Turtle dove (*Streptopelia turtur*)	3		+	+	+	+
Collard turtle dove (*Streptopelia decaocto*)			+	+	+	+
Feral pigeon (*Columba livia domestica*)					+	
Cuckoo (*Cuculus canorus*)			+	+	+	+
Barn owl (*Tyto alba*)	3	B,U	+	+	+	+
Eagle owl (*Bubo bubo*)	3	P,B,U	+	+	+	+
Little owl (*Athene noctua*)	3	B	+		+	+
Tawny owl (*Strix aluco*)	4			+	+	+
Long-eared owl (*Asio otus*)			+	+	+	+
Nightjar (*Caprimulgus europaeus*)	2		+		+	+
Swift (*Apus apus*)			+	+	+	+
Kingfisher (*Alcedo atthis*)	3	B	+	+	+	+
Hoopoe (*Upupa epops*)			+	+	+	+
Bee-eater (*Merops apiaster*)	3	P,B	+	+		+
Roller (*Coracias garrulus*)	2	P,B	+		+	
Wryneck (*Jynx torquilla*)	3		+	+	+	+
Grey-headed woodpecker (*Picus canus*)	3	B,U			+	+
Green woodpecker (*Picus viridis*)	2	B	+	+	+	+
Black woodpecker (*Dryocopus martius*)			+	+	+	+
Great spotted woodpecker (*Dendrocopos major*)			+	+	+	+
Syrian woodpecker (*Dendrocopos syriacus*)	4			+	+	+
Middle spotted woodpecker (*Dendrocopos medius*)	4		+	+	+	+
White-backed woodpecker (*Dendrocopos leucotos*)		P			+	+
Lesser spotted woodpecker (*Dendrocopos minor*)			+	+	+	+
Woodlark (*Lullula arborea*)	2		+	+	+	+
Skylark (*Alauda arvensis*)	3					+
Crested lark (*Galerida cristata*)	3					+
Sand martin (*Riparia riparia*)	3		+	+	+	+
Swallow (*Hirundo rustica*)	3		+	+	+	+
House martin (*Delichon urbica*)			+	+	+	+
Tawny pipit (*Anthus campestris*)	3		+	+	+	+
Tree pipit (*Anthus trivialis*)			+	+	+	+
Meadow pipit (*Anthus pratensis*)	4		+	+	+	+
Yellow wagtail (*Motacilla flava*)			+	+	+	+
White wagtail (*Motacilla alba*)			+	+	+	+
Wren (*Troglodytes troglodytes*)			+	+	+	+
Dunnock (*Prunella modularis*)	4		+	+	+	+
Robin (*Erithacus rubecula*)	4		+	+	+	+
Thrush nightingale (*Luscinia luscinia*)	4		+	+	+	+
Nightingale (*Luscinia megarhynchos*)	4		+			
Bluethroat (*Luscinia svecica*)		B	+	+	+	+
Black redstart (*Phoenicurus ochruros*)			+	+	+	+
Redstart (*Phoenicurus phoenicurus*)	2		+	+	+	+
Whinchat (*Saxicola rubetra*)	4		+	+	+	+
Stonechat (*Saxicola torquata*)	3			+	+	+

1	2	3	4	5	6	7
Wheatear (*Oenanthe oenanthe*)			+	+	+	+
Blackbird (*Turdus merula*)	4		+	+	+	+
Fieldfare (*Turdus pilaris*)	4		+	+	+	+
Song thrush (*Turdus philomelos*)	4		+	+	+	+
Redwing (*Turdus iliacus*)	4		+	+	+	+
Mistle thrush (*Turdus viscivorus*)	4		+		+	+
Bearded tit (*Panurus biarmicus*)		P				+
Grasshopper warbler (*Locustella naevia*)	4		+	+	+	+
River warbler (*Locustella fluviatilis*)	4		+	+	+	+
Savi's warbler (*Locustella luscinioides*)	4	B	+	+	+	+
Sedge warbler (*Acrocephalus schoenobaenus*)	4		+	+	+	+
Marsh warbler (*Acrocephalus palustris*)	4		+	+	+	+
Reed warbler (*Acrocephalus scirpaceus*)	4		+	+	+	+
Great reed warbler (*Acrocephalus arundinaceus*)			+	+	+	+
Icterine warbler (*Hippolais icterina*)	4		+	+	+	+
Barred warbler (*Sylvia nisoria*)	4		+	+	+	+
Lesser whitethroat (*Sylvia curruca*)			+	+	+	+
Whitethroat (*Sylvia communis*)	4		+	+	+	+
Garden warbler (*Sylvia borin*)	4		+	+	+	+
Blackcap (*Sylvia atricapilla*)	4		+	+	+	+
Wood warbler (*Phylloscopus sibilatrix*)	4		+	+	+	+
Chiffchaff (*Phylloscopus collybita*)			+	+	+	+
Willow warbler (*Phylloscopus trochilus*)			+	+	+	+
Goldcrest (*Regulus regulus*)	4		+	+	+	+
Spotted flycatcher (*Muscicapa striata*)	3		+	+	+	+
Red-breasted flycatcher (*Ficedula parva*)			+		+	+
Pied flycatcher (*Ficedula hypoleuca*)	4		+	+	+	+
Collard flycatcher (*Ficedula albicollis*)	4			+	+	+
Long-tailed tit (*Aegithalos caudatus*)			+	+	+	+
Marsh tit (*Parus palustris*)			+	+	+	+
Willow tit (*Parus montanus*)			+	+	+	+
Crested tit (*Parus cristatus*)	4		+	+	+	+
Coal tit (*Parus ater*)			+	+	+	+
Blue tit (*Parus caeruleus*)	4		+	+	+	+
Great tit (*Parus major*)			+	+	+	+
Nuthatch (*Sitta europaea*)			+	+	+	+
Tree creeper (*Certhia familiaris*)			+	+	+	+
Short-toed tree creeper (*Certhia brachydactyla*)	4		+			
Penduline tit (*Remiz pendulinus*)		B	+	+	+	+
Golden oriole (*Oriolus oriolus*)			+	+	+	+
Great grey shrike (*Lanius excubitor*)	3	B,U	+	+	+	+
Red-backed shrike (*Lanius collurio*)			+	+	+	+
Jay (*Garrulus glandarius*)			+	+	+	+
Magpie (*Pica pica*)			+	+	+	+
Jackdaw (*Coloeus monedula*)	4		+	+	+	+

1	2	3	4	5	6	7
Rook (*Corvus frugilegus*)			+	+	+	+
Hooded crow (*Corvus corone*)			+	+	+	+
Raven (*Corvus corax*)			+	+	+	+
Starling (*Sturnus vulgaris*)			+	+	+	+
House sparrow (*Passer domesticus*)			+	+	+	+
Tree sparrow (*Passer montanus*)			+	+	+	+
Chaffinch (*Fringilla coelebs*)	4		+	+	+	+
Serin (*Serinus serinus*)	4		+	+	+	+
Siskin (*Carduelis spinus*)	4					+
Greenfinch (*Carduelis chloris*)	4		+	+	+	+
Goldfinch (*Carduelis carduelis*)			+	+	+	+
Linnet (*Carduelis cannabina*)	4		+	+	+	+
Scarlet grosbeak (*Carpodacus erythrinus*)			+	+	+	+
Bullfinch (*Pyrrhula pyrrhula*)			+	+	+	+
Hawfinch (*Coccothraustes coccothraustes*)			+	+	+	+
Yellowhammer (*Emberiza citrinella*)	4		+	+	+	+
Ortolan bunting (*Emberiza hortulana*)	2	B	+	+	+	+
Reed bunting (*Emberiza schoeniclus*)			+	+	+	+
Corn bunting (*Miliaria calandra*)	4	B	+	+	+	+
TOTAL Number of species	97	45	158	142	160	167

Of this total number of species recorded in the Bug valley during 1998–2000, as many as 97 are on the list of the Species of European Conservation Concern (SPECs according to Hagemeijer and Blair 1998), and 82 are not on this list in any of the four categories considered. Most of the SPECs in the Bug valley (47 species, that is, 26% of the avifauna breeding in the Bug valley) are assigned to the lowest category (4) of the Species of European Conservation Concern, 37 (20.7%) species are classified to category 3.11 (6.1%) to category 2, and 2 species (1.1%) to category 1 (Fig. 1).

Special attention should be paid to the high abundance of the corncrake (*Crex crex*), which is categorized as a globally threatened species. The number of territorial males of this species in the years 1999–2000 (extremely favourable for this species) was estimated at 1415–1660, with the largest population in the Mazovian-Podlasian section of the Bug (540–700 males) and in the Lublin section (350–400 males). Especially high corncrake numbers in 1999 could have been due to a prolonged and very high flooding of the meadows and peatlands in the Prypeć valley, where

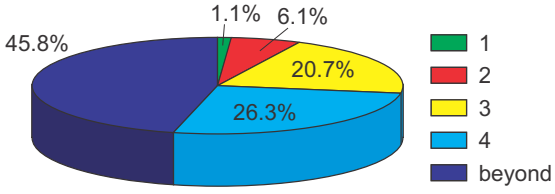

Figure 1. Percentage of bird species in different categories of the European conservation priority (1, 2, 3, 4) termed Species of European Conservation Concern, and beyond this category, breeding in the Bug valley

this species was unusually scarce that year [Nikiforov, unpubl.]. Presumably, some birds could move from the flooded Prypeć valley to neighbouring areas, including the Bug valley.

Another species of category 1 among the Species of European Conservation Concern is the ferruginous duck (*Aythya nyroca*), noted only near Brześć and in the Ukrainian section, where merely 2–4 pairs of this vanishing species occurred. The abundance of most species of categories 2 and 3 was generally low. In category 2, only two species were more abundant, the white stork (*Ciconia ciconia*) and the redshank (*Tringa totanus*). Most abundant among the species classified to category 3 of SPECs was the sand martin (*Riparia riparia*). During the boat surveys in 1999, 32 850 burrows were noted in active colonies, that is, 43 burrows/km of the river, on average. With respect to sand martin numbers, the Bug can be compared to large, lowland rivers in eastern Europe, such as the Dniestr and the Don. For example, the density of this species on the upper Dniestr in 1986 was 87.7 burrows/km [Kogut 1997]. Assuming after Szép [1990] a 60% index of burrow occupation, the sand martin population on the Bug consisted of about 20 000 breeding pairs in the late 1990s. Populations of other species on the Bug were much lower: about 230 pairs of the common sandpiper (*Actitis hypoleucos*), 240 pairs of the kingfisher (*Alcedo atthis*), and 93 pairs of the little ringed plover (*Charadrius dubius*). These numbers should be regarded as high compared with those on central-European rivers.

Valorization of breeding habitats for birds

The Bug valley supports a wide spectrum of diverse habitats. In addition to the action of natural factors, mainly fluvial processes (spring flooding, deposition of sediments, or removal of material from river channel sides), also human activity (livestock grazing and mowing of grasslands, forest clearing) exerted a strong impact. Despite a long agricultural use, the transverse zonation is still retained, and some habitats are surprisingly little transformed. Centuries of both these kinds of activity created specific mosaics of open, semi-open (park type), and forest habitats. The natural river course produces alternating depositional and abrasive landforms: low sandy beaches (prime nesting habitat of plovers and terns) and steep escarpments (breeding sites of sand martins and kingfishers). These habitats are in close proximity along almost the entire river course. In long sections of the river, the channel has never been regulated, and only below Wyszków and within the zone influenced by Zegrzyński Reservoir the river was barred with concrete spurs.

Riparian willow-poplar carrs *Salici populetum* occupy only a small area, except for the section along the state boundary. A much larger area is occupied by younger, initial stages of riparian carrs, that is, by wicker thickets *Salicetum triandro-viminalis* growing on islands and deposition sites along river banks. Areas located further from the river, where coarse sediments are deposited, support elm-ash carrs with a large proportion of oaks. These carrs were cleared most rapidly and now they occur only in the form of isolated patches. At outlets of smaller streams, retained are so called riparian alder-ash carrs, and along the margins of the valley, at the

foot of the escarpment, last sites of currant bush. Steep valley sides support oak-hornbeam forests unique to the Bug valley.

The areas originally covered with elm-ash and alder-ash carrs, now support vast meadow complexes or small patches of arable land. The sites of cleared willow-poplar carrs were converted into beaches, xeric grass communities, and extensive pastures. When hay making and grazing were ceased, patches of willow regrowth appeared rapidly, followed by willow-poplar carrs. But recently, processes of spontaneous secondary succession have been rare in the lower Bug valley, except for higher islets. Low moors are almost nonexistent, and only locally in the lowest meadow complexes, especially at the outlets of small tributaries to the Bug, patches of these habitats are not rare. The largest complexes of low moors are preserved only in lower reaches of the Kosówka and the Ugoszcz rivers, and near Marianów.

Oxbows called "bużyska" are a characteristic component of the lower floodplain zone. Most attractive to birds are extensive, shallow oxbow lakes partly overgrown with vegetation, and surrounded by meadows and pastures. In contrast, narrow and deep oxbows situated in woods are of minor importance to breeding birds.

The habitats described above were subjected to ornithological valorization with respect to the species richness and the abundance of priority species. Priority species were identified based on the classification to one of the four categories of the Species of European Conservation Concern proposed by Hagemeijer and Blair [1998], and this confers an international rank to the present valorization. Each species was assigned to a single habitat type supporting the major part (above 80%) of its population. In total, 71 species of breeding birds were selected as priority species for the valorization of different habitat types (zones) of the lower Bug valley. The river-channel zone consisted of beaches, open islands with no vegetation (sand dunes), high islands, and steep escarpments. The zone of willow-poplar carrs comprised mature (the oldest) tree stands and also pioneer stages (willow thickets), including their patches on islands. The scores of individual habitat types represent the sum of the scores for individual species according to the following criteria for the Species of European Conservation Concern:

1) category 1 – 8 points,
2) category 2 – 5 points,
3) category 3 – 3 points,
4) category 4 – 1 point.

Using this system, the highest avifaunal rank was assigned to willow-poplar carrs, where 44% of the key (priority) species were noted, which had 30% of all the scores (Tab. 2). The species allocated to high categories (2 and 3) and those with largest breeding populations at the scale of the country merit special attention. These are, for example, the green woodpecker, wryneck, and turtle dove.

Oxbow lakes received a high avifaunal rank with 18% of the priority species. It should be emphasized that they are inhabited by the redshank and black-tailed godwit, the species allocated to category 2 on the SPEC list, and also by the black tern and garganey with category 3. The populations of these species in the Bug valley represent an important part of their populations at the scale of Poland and central Europe.

Complexes of wet meadows and peatlands with short willow clumps are important breeding habitats for 12 bird species, accounting for 17% of the key species. Especially associated with this habitat is the corncrake, the SPEC category 1 species. Also the population of the curlew is fairly large, especially along outlet sections of the Bug tributaries: the Ugoszcz, the Kosówka, and the Buczynka rivers.

Elm-ash carrs, alder-ash carrs, and alder swamps represent the most important refuge for 11 (15%) of the SPECs, placing these habitats on the fourth position in the ranking (Tab. 2). Among them, especially the black stork, lesser spotted eagle, crane (*Grus grus*), eagle owl, and middle spotted woodpecker should be noted.

Table 2. Avifaunal valorization of major habitat types (according to zones from the river channel to the valley edge) inhabited by a large proportion of breeding pairs (over 80% of the Bug valley population) for the species assigned to one of the four categories of the Species of European Conservation Concern, and ranks of these habitats

Habitat (zone)	Number of species	Scores	Rank
River channel	4 (6%)	14 (9%)	V
Oxbows	13 (18%)	33 (9%)	II
Willow-poplar carrs	29 (41%)	45 (30%)	I
Elm-ash carrs, alder-ash carrs, alder swamps	11 (15%)	21 (14%)	IV
Pastures, xeric grasslands, not afforested dunes	2 (3%)	8 (5%)	VI
Meadows, fens, willow thickets	12 (17%)	31 (20%)	III
Total	71 (100%)	152 (100%)	I-VI

The birds associated with the river channel included four priority species: the little tern, kingfisher, sand martin, and common gull. The last species belongs to category 2 of the SPECs, and the remaining species to category 3. It should be emphasized, however, that the sand martin population on the Bug is the largest population of this species in Poland, and the little tern population is the second largest (after the Vistula population) in Poland and one of the largest in central Europe. Also the kingfisher population is large, whereas the common gull started spreading on the lower Bug. Extensive complexes of xeric grasslands and pastures, and not afforested dunes are the stronghold of the woodlark and skylark.

Avifaunal valorization of the Bug from the springs to the mouth

This valorization is based on densities of the key bird species nesting in the zone of the river channel along successive river sections: Volynian-Podolian, Polesian--Volynian, Podlasian, and Mazovian. The density of sand martins showed marked differences among these sections (Fig. 2): it was lowest in the upper section

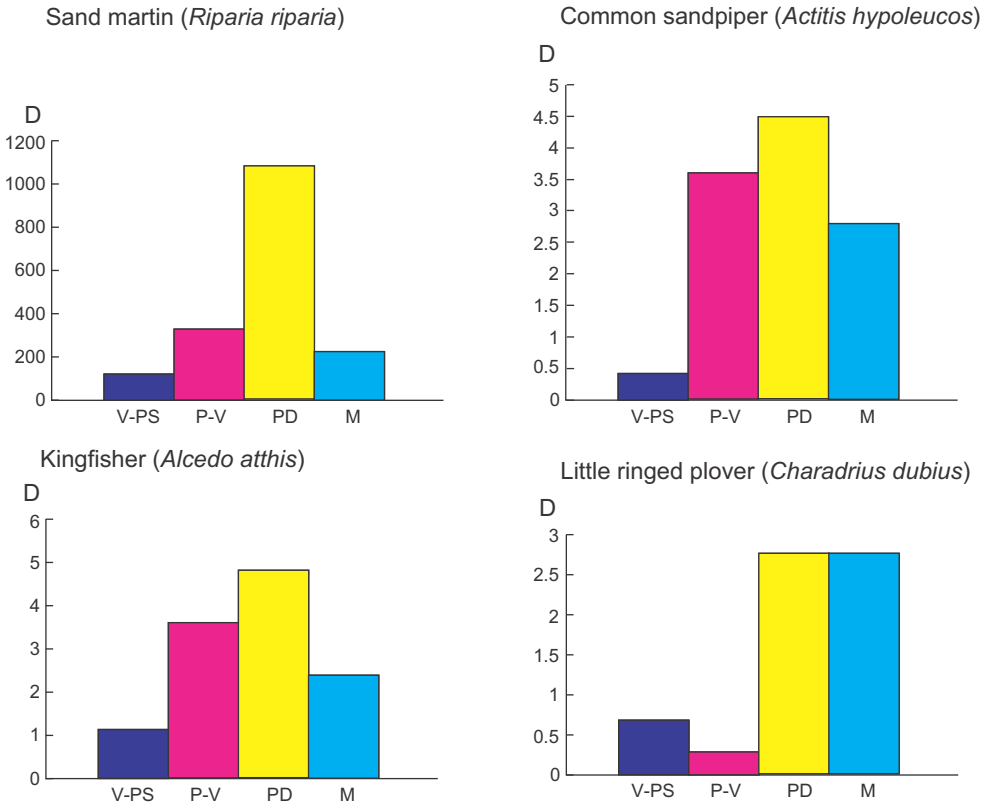

Figure 2. Densities (D) of four bird species nesting in the zone of the river channel (number of burrows per 10 km for the sand martin, or pairs for the other species) along different river sections from headwaters to the mouth: V-PS – Volynian-Podolian section, PV – Polesian-Volynian section, PD – Podlasian section, and M – Mazovian section; in 1999

(Volynian-Podolian) where 126 burrows/10 km were noted, as compared with 1 090 burrows/10 km in the Podlasian section and 220 in the Mazovian section. This last section was affected by earlier river regulation works and backwaters of the Zegrze impoundment reservoir. But the general downstream increasing tendency in the sand martin population is conspicuous. Also densities of the other species increased in the same direction. This was especially the case of the common sandpiper with a density of merely 0.4 pairs/10 km in the Wolynian-Podolian section, as compared with 3.6 pairs in the Polesian-Volynian section, 4.5 pairs in the Podlasian section, and 2.8 pairs in the Mazovian section. Similar tendencies, that is, a gradual downstream increase followed by a decline along the outlet section were also observed for the kingfisher. In contrast, the little ringed plover occurred in highest densities along the lower course, that is, in the Podlasian and Mazovian sections (2.8 pairs/10 km in each of them), and surprisingly low densities were recorded in the Polesian-Volynian section (Fig. 2).

Also the distribution of breeding sites of many species not associated with the river channel but nesting in the valley varied along the river course. The corncrake was relatively evenly distributed along the valley (Fig. 3), with most abundant

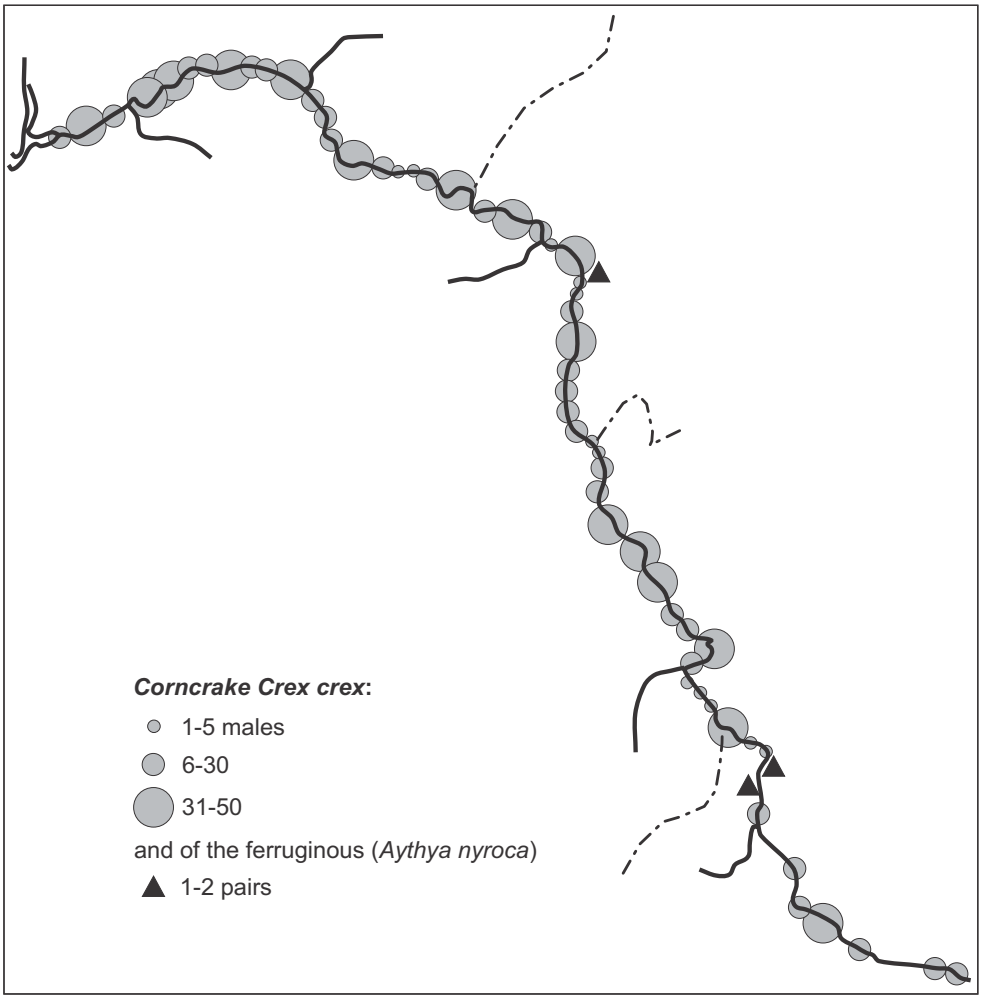

Figure 3. Distribution of the corncrake (*Crex crex*) and ferruginous duck (*Aythya nyroca*) in the Bug river valley

aggregations of lekking males in the Mazovian section (the Lower Bug valley), where the floodplain was the widest and moist meadows most extensive. An opposite distribution was documented for a group of rare species nesting in open habitats such as oxbows, meadows, and escarpments without shrub cover. In general, the highest concentrations of the sites of these birds were found in the upper part of the Bug valley. This was especially the case of species disappearing from central and western Europe and still more abundant in the eastern part of their European range. They include the little bittern (*Ixobrychus minutus*), an extremely evenly distributed species along the entire upper (Ukrainian) section, whereas almost totally absent from the middle and lower Bug valley (Fig. 4). Also the bee-eater *(Merops apiaster*), stonechat (*Saxicola torquata*), and whiskered tern (*Chlidonias hybridus*) were more abundant along the Upper Bug. As these are south-European species recently expanding their ranges northwards [Hagemeijer, Blair 1998], their populations are traditionally higher in the Upper Bug valley.

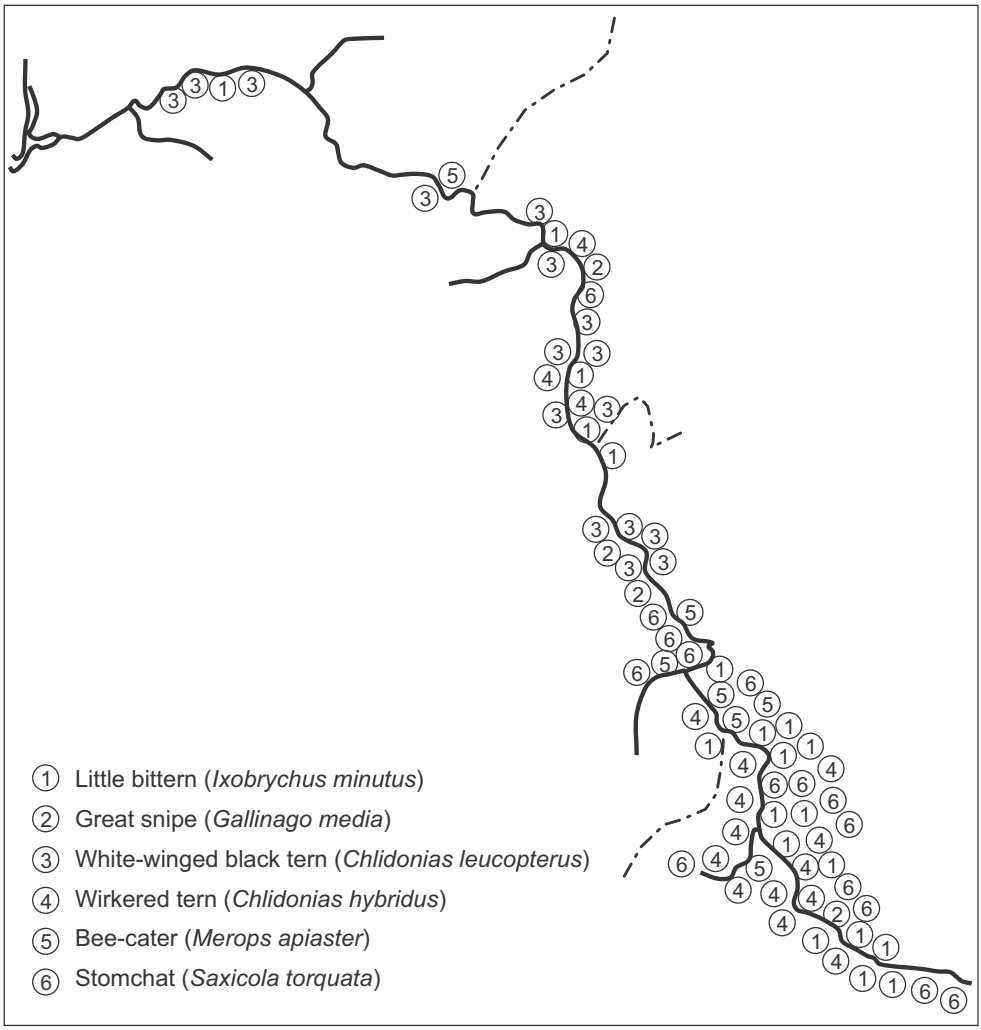

Figure 4. Distribution of breeding sites of selected bird species nesting in open habitats in the 1998–2000

Most sites of some species associated with forests and riparian carrs were located in the Ukrainian and Belarussian parts of the middle Bug valley. This is certainly an effect of the occurrence of less disturbed willow-poplar carrs on the eastern side of the boundary Bug section. Moreover, the fragmentation of these carrs is much more advanced on the western (Polish) side, where agricultural management reaches the river bank, thus, interrupting the originally continuous stretches of the carrs. These relationships are clearly illustrated by the distribution of the white-backed woodpecker (*Dendrocopos leucotos*) (Fig. 5). It was surprising that the black stork (*Ciconia nigra*) and lesser spotted eagle (*Aquila pomarina*) were relatively abundant not only on the eastern side of the boundary (Polish-Ukrainian Bug section) but also along the whole Ukrainian section (Fig. 5). Interesting is the distribution of the collard flycatcher (*Ficedula albicollis*), inhabiting a short headwater section in Ukraine and almost totally absent lower in the valley. This species was,

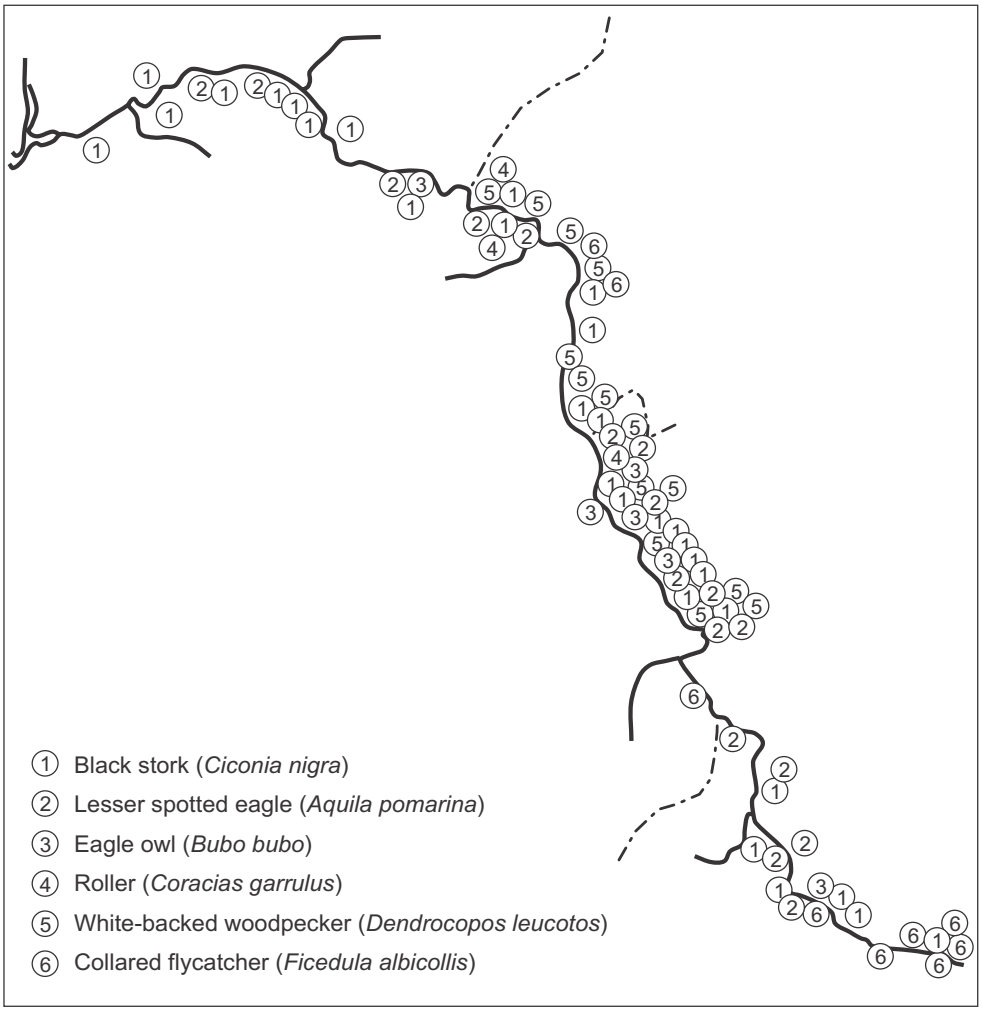

Figure 5. Distribution of breeding sites of selected bird species nesting in riparian carrs in the 1998–2000

however, rather abundant locally outside the Bug valley, for example in Strzeleckie Forests on the Polish side [Wójciak, unpubl.].

To sum up, it may be suggested that the Bug valley is an ecological corridor serving as an expansion route for many bird species associated with different habitat types, both under forests and open.

The surveys conducted in January of 1999 (Polesian-Volynian section) and in 2000 (the remaining sections) along a 600 km route in both years jointly revealed the wintering of 8 036 individuals representing 19 waterbirds and waders (Tab. 3). The most abundant species was the mallard (*Anas platyrhynchos*), accounting for over 90% of all the birds of this group. The mute swan (*Cygnus olor*), goosander (*Mergus merganser*), goldeneye (*Bucephala clangula*), and herring gull (*Larus argentatus*) wintered mainly in the lower course of the river, clearly influenced by the Zegrzyński reservoir.

Table 3. Abundance of waterbirds wintering on the Bug in January 1999 along the Polesian--Volhynian section (P-V) and in January 2000 along the remaining sections: Mazovian-Podlasian (M-PD) and Volynian-Podolian (V-PS)

Species	Number of species			
	M-PD	P-V	V-PS	Total
Mallard (*Anas platyrhynchos*)	3087	2201	2017	7035
Mute swan (*Cygnus olor*)	231	6	43	280
Goosander (*Mergus merganser*)	116	21	4	141
Goldeneye (*Bucephala clangula*)	70	29	3	102
Herring gull (*Larus argentatus*)	64		12	76
Black-headed gull (*Larus ridibundus*)	20		25	45
Common gull (*Larus canus*)	17		4	21
Kingfisher (*Alcedo atthis*)	7		3	10
White-tailed eagle (*Haliaeetus albicilla*)	4	1	1	6
Smew (*Mergus albellus*)	3		5	8
Heron (*Ardea cinerea*)	2	1		3
Tufted duck (*Aythya fuligula*)	1		3	4
Wigeon (*Anas penelope*)	1	2		3
Whooper swan (*Cygnus cygnus*)	1			1
Great crested grebe (*Podiceps cristatus*)			8	8
Bittern (*Botaurus stellaris*)			1	1
Coot (*Fulica atra*)			12	12
Pochard (*Aythya ferina*)			8	8
Teal (*Anas crecca*)		2		2
Total	**3624**	**2263**	**2149**	**8036**
Length of survey section (km)	**M-PD=240**	**P-V=225**	**V-PS=135**	**Total=600**

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Chapter VIII

Strategy for the protection of natural values of the Bug valley

Objectives and implementation of the protection of natural values of the Bug valley – *Andrzej Dombrowski*

Objectives

Pan-European Strategy for Biological and Landscape Diversity that defines various actions promoting the implementation of the Convention on Biological Diversity includes a chapter on ecosystems of running waters and riparian wetlands. This chapter lists the following actions: removal of the consequences caused by river regulation, power-plant activity, river pollution, excavation of sand and clay, agricultural activity, and disturbance to water regime in the catchment basin. These works are thought to maintain the natural value of the habitat itself and also its function as an ecological corridor – the role performed by valleys of large European rivers. The principal function of all ecological corridors is to ensure a free dispersal of organisms, which allows a free exchange of genes between populations, and thus maintains the diversity of gene pools and, consequently, a long-term population persistence. The present state of knowledge is insufficient to characterize in detail the mechanisms of the functioning of the Bug valley as an ecological corridor, but there is no doubt that the Bug is an ecological corridor. If the Bug valley is to continue this specific function, the following strategic objectives should be attained:

1) Restoration of natural flooding in all the habitats whose functioning is dependent on regular inundation year after year, which in practice concerns fragments of the floodplain with flood embankments.
2) Restoration of the natural continuity of different habitats along the Bug and its valley, and counteracting their further fragmentation.
3) Sustaining traditional extensive agriculture, especially livestock grazing.

4) Maintaining a high diversity of natural structures in the Bug valley, including physiographical characteristics, plant cover, and animal communities across the valley.
5) Removal of all kinds of barriers obstructing dispersal on the Bug and its tributaries, as well as in the valley, including the terrace above the floodplain. This concerns transverse barriers hindering dispersal along the river and the valley and longitudinal obstacles making difficult movements of organisms from the valley edge to the river channel.

Recommendations

These strategic objectives will be implemented through actions that can be categorized into long-term and current administrative actions that are very urgent. Institutions responsible for the implementation of actions listed below should be indicated by the state and local administrations involved in nature conservation (with a special role of the headquarters of landscape parks).

Long-term actions (in order of their importance) regarding:

1) Withdrawal of embankments towards the edge of the floodplain to restore the natural flooding of oxbows and meadows (in the first stage along the sections Morzyczyn-Płatkownica and Przewóz Nurski – the Cetynia river outlet).
2) Abandonment of all agricultural treatments (mowing, ploughing, grazing) in the riparian zone from 50 to 200 m wide, depending on local conditions in order to trigger spontaneous secondary succession leading to the regrowth of riparian carrs (willow-poplar) along the Bug valley (in the first step along the most degraded section in the Mazovian Province from Białobrzegi, commune Sterdyń to Wilczogęby, commune Sadowne).
3) Re-establishment of mowing or grazing on abandoned meadows, except for the riparian zone mentioned above.
4) Restoration of water quality through constructing sewage treatment plants across the Bug basin (with the use of funds such as PHARE, ISPA, SAPARD, as well as NFOŚ and GW) – also worth support are the activities initiated by the Association of Powiat Administrative Districts and Communes of the Bug region (13 powiats and 58 communes and towns).
5) Treatment of industrial and communal sewage localized in the Bug valley, especially in the largest sedimentation tanks near Brześć (Belarus), and in the Ukraine spirit works at Stronybaba, sewage sedimentation tanks near Lviv and Sokal, and tanks of mining water near Czerwonograd.
6) Establishment of the Bug National Park at the junction of the Lublin, Podlasian, and Mazovian Provinces (Pratulin – Mielnik), where riparian forests are most diverse, and breeding avifauna unusually rich.
7) Designation of a coherent system of landscape parks at the scale of the entire Bug valley, primarily in refuge 199 (the Lower Bug river valley) as defined in

CORINE-base according to the directives of the European system of protected areas NATURA 2000.

8) Restoration of drained alder swamps and fens.

Currant administrative and legal actions regarding:

1) Protection of the river channel:
   - resignation of the governments of Poland, Belarus, and Ukraine from the concept of the East-West Waterway;
   - prohibition of the construction of large reservoirs on the Bug, especially of the reservoir Granne, and also of small reservoirs across the Bug valley; small reservoirs should be constructed in upper and middle reaches of the Bug tributaries, especially in places of former mill streams that functioned at 65 sites in the Bug basin until the late 1960s;
   - prohibition of permanent fences up to 30 m from the banks of the Bug and to 10 m from the banks of the other rivers and all oxbows.
2) Protection of oxbows and wetlands:
   - prohibition of converting oxbows and local depressions into storage reservoirs, recreational grounds, sewage disposal tanks, and dumps of solid wastes;
   - prohibition of any changes in water regime of alder swamps and fens across the Bug valley;
   - execution of the interdiction concerning the dumping of wrappings of pesticides and fertilizers in local depressions, ditches and streams as being extremely harmful to the reproductive cycle of amphibians;
   - prohibition of the disposal of liquid manure across the Bug valley and adjacent areas off the valley in all communes on the Bug;
   - development of the legislation concerning reduction of the frequency of desludging drainage ditches (every 10 years) across the Bug valley and reduction of the depth of desludging to 15–20 cm (optimally to 5–10 cm).
3) Protection of forests:
   - prohibition of the clearing of forests and carrs to a distance of 50–200 m from the river channel;
   - conferring a status of protective forests (soil- and water-protecting) on all forests in the Bug valley, including the edge of the valley;
   - prohibition of the removal of dead trees with hollows and old trees, irrespective of whether they satisfy the criteria of a nature monument;
   - legal protection as nature reserves of all old patches of elm-ash and willow-poplar carrs – the habitats most severely threatened with clearing and/or wood stealing (primarily near Pratulin).
4) Building industry and economic activities:
   - prohibition of constructions of any kind in the floodplain; on higher terraces of the Bug valley constructions can be allowed only within the already existing settlements;

- prohibition of resource exploitation at the edges of the Bug valley, and cessation of the present activities as soon as possible;
- supervision of the execution of the prohibition of exploiting dunes and peatlands in legally protected areas, and extension of this prohibition to the remaining parts of the Bug valley, so far not protected by law;
- prohibition of the application of pesticides of toxicity classes 1–3 in all communities inhabiting the Bug valley, and attempts to remove highly productive orchards and intensive vegetable-growing areas from the Bug valley;
- prohibition of converting meadows and pastures into arable land, along with bringing to an end the existing arable land through returning to meadows or pastures across the Bug floodplain by 2010;
- prohibition of the afforestation of vast sandy grass communities, although they were man-made;
- counteracting the attempts at intensifying agriculture across the Bug valley, by developing, for example, a system of financial compensation to sustain extensive agriculture – agri-environmental programmes of the European Community;
- encouraging ecological farming on fertile soils (classes I–IV), mainly in the areas adjacent to the Bug valley.

5) Legally protected areas:
   - designing plans for the protection of landscape parks (taking into consideration the postulates of the strategy presented in this volume) in co-operation with research workers conducting detailed studies in the Bug valley for many years; starting the work in the opposite order, because planning protection measures within the present boundaries of landscape parks would lead to a waste of public money that should be used for supporting protection plans within the target boundaries of landscape parks;
   - appointment of botanists and zoologists involved in long-term research and protection of the Bug valley to be members of the Voivodeship Commissions for Nature Protection in Warsaw, Lublin, and Białystok;
   - abandoning the concept of ecological utility areas in favour of legal protection of all oxbows, dunes, and still existing patches of fens through respective directives in landscape park protection plans and through broad educational activities in local populations by the authorities of landscape parks;
   - all restoration projects should be preceded by a thorough wildlife expertise considering the present state, as well as all negative consequences;
   - protection plans of nature reserves and landscape parks should be reviewed.

6) Wildlife monitoring:
   - the Bug valley, like the middle Vistula reaches, should be put on the list of priority areas for the monitoring of breeding avifauna as proposed in the Monitoring of Natural Resources of Poland (see: Dombrowski *et al*. 1998 "Ornitologiczna ranga największych rzek dorzecza Wisły Środkowej"

[Ornithological rank of the largest rivers in the Middle-Vistula basin], Not. Orn. 39, 2:61–75); Assessment of unique floristic and ornithological values of the Bug valley in the integrated system of nature monitoring issues from the Convention on Biological Diversity and from some directives of the European Communities (Council Directives 92/43 on the conservation of natural habitats and of wild fauna and flora, and 79/409/EEC on the conservation of wild birds);

- implementation of the Programme for Nature Monitoring in the Bug valley, co-ordinated by different scientific centres in co-operation with Laboratories of Nature Monitoring that should be created for this purpose at the authorities of the landscape parks; monitoring of the status of and threats to the natural values at ten year intervals (the first in the period 2008–2010) across the valley to determine long-term tendencies, and year-to-year monitoring on the sites typified in the mid-1980s to assess current tendencies.

Priority uses of the Bug valley can be summarized as follows:

1) The Bug valley as an area of the protection of natural environment performing the role of an ecological corridor.
2) The Bug valley as an area of basic scientific research on the structure and function of ecosystems and physiocenoses of a large lowland river on mineral substratum.
3) The Bug valley as a priority area for the monitoring of flora and breeding avifauna in the programme for the Monitoring of Natural Resources of Poland.
4) The Bug valley as an important area for ecotourism and ecological education at all levels (green schools, field training courses for students of biology and environmental conservation). Channelling of tourism – zoning the areas for various kinds of tourism or tourism ban in the most fragile areas.
5) Priority of agri-tourism over recreational centres and land sale for recreational lots.
6) Priority of extensive agriculture:
   - extensive grazing of grasslands instead of their afforestation,
   - moderate breeding of slaughter cattle and milk production in place of breeding pigs, cultivating cereals, root crops, vegetables, and orchards.

These objectives and priorities should be implemented by the largest non-governmental ecological organizations active within the Bug basin. Here should be mentioned those already working on the protection of natural values of the Bug valley and surface waters in the Bug basin:

1) Lion Association from Lviv,
2) West-Ukrainian Ornithological Society,
3) Belarussian Ornithological Society,
4) Lublin Ornithological Society,

5) Mazovian Society for the Protection of Fauna,
6) Polish Society for Bat Protection,
7) Polish Society of Friends of Nature proNatura,
8) Podlasian Association of Communes,
9) Association of Powiats and Communes on the Bug,
10) Association of Friends of Wyszków, Biała Forest and Kamieniecka Forest,
11) Association of Communes Sokołów Podlaski,
12) Cultural-Wildlife Nature Society "Żuraw",
13) Ecological Club of UNESCO.

Activists of these non-governmental organizations should more closely cooperate with local and governmental authorities responsible for nature protection at the commune, powiat, and province levels, also at the country level, including the State Fish Guard and administration of State Forests in the Bug forest divisions. To detect mistakes in conservation programmes, they should be implemented in close co-operation with scientists from leading centres conducting field studies on selected groups of plants and animals:

1) University of Lviv,
2) Belarussian Academy of Sciences,
3) Adam Mickiewicz University in Poznań,
4) University of Warsaw,
5) Warsaw Agricultural University,
6) University of Wrocław
7) Maria Curie-Skłodowska University,
8) Agricultural University of Lublin,
9) Podlasian University of Siedlce.

Optimization of management for conservation of the vegetation – *Zygmunt Głowacki, Marek Wierzba, Paweł Marciniuk*

Table 1. Management measures recommended in order to protect habitats and floristic values in Bug river valley

Habitat; plant communities	Main threats	Optimum use (management)
Flora of ephemeral islets and bars in river channel; *Ass. Limosello-Cyperetum fusci* *All. Chenopodion fluviatile*	Regulation of river channel	Abandoning hydrotechnical works to maintain natural character of the river
Willow-poplar carrs and riparian osiers; *Ass. Salici-Populetum* *Ass. salicetum triandro-viminalis*	Deforestation, grazing, tree monocultures (mainly pines and cultivars of poplars alien to this habitat), flood embankments, regulation of river channel	Strict protection of best preserved fragments to maintain or restore the structure of these communities threatened in Europe
Aquatic plants, rushes; *All. Potamogetonion* *All. Nymphaeion* *All. Phragmition* *All. Magnocaricion*	Drainage, water eutrophication, soil erosion in local basins, excessive impact of tourism, flood embankments	Conservation of existing and construction of new land reclamation facilities to maintain high water level; restorations of riparian shrubberies and woods as biological filters retaining nutrient runoff from catchment basin; prohibition of pesticide use to eliminate aquatic plants and rushes in oxbows (only mechanical methods are allowed)
Vegetation of peatlands, moist meadows, forbs; *Class Scheuchzerio-Caricetea fuscae* *O. Molinietalia* *All. Senecion fluviatilis*	Drainage, flood embankments, addition of so called „noble" grasses	Maintenance of traditional (sporadic or one-two-swath use without fertilizing and sowing so called „noble" grass species
Economically used forests; *Ass. Ribo-nigri-Alnetum* *Ass. Sphagno squarrosi-Alnetum* *Ass. Salicetum pentadro-Cinerae* *Ass. Circaeo-Alnetum* *Ass. Ficario-Ulmetum* *Ass. Tilio-Carpinetum* *All. Dicrano-Pinion*	Inappropriate forest management in river valley and its edges	Designation of all forests in the Bug valley and its edges as protective forests (soil and water protecting), management conforming to recommendations for this forest category, prohibition of pine monocultures; confer a status of strict protection to forest reserves

Psammophilous grasslands and poor pastures; *All. Armerion elongatae* *All. Koelerion glaucae* *Class Molinio-Arrhenatheretea*	Abandonment of traditional management (grazing and sporadic mowing), introduction of pines	Continuation of traditional use, prohibition of afforestation
Xerothermic grasslands, thermophilous shrubberies and marginal vegetation; *Class Festuco-Brometea* *Class Trifolio-Geranietea* *O. Prunetalia*	Abandonment of grazing	Active protection of best preserved patches – grazing, sporadic mowing
Crop fields; *Class Rudero-Secalietea*	Intensification of agriculture	Promotion of modern ecological agriculture on more fertile soils, system of integrated agriculture on the remaining areas

Recommendations for active protection of fauna – *Andrzej Dombrowski*

Actions that can reduce the mortality of different animal groups

ENTOMOFAUNA:

1) mowing (after 20 August) and removal of tree and shrub seedlings from ungrazed and unmown xeric grasslands;
2) education against grass burning that damages developmental stages of many insects;
3) active measures against the application of insecticides in the entire Bug valley;
4) inventory and protection from removal of old, rotting trees.

ICHTHYOFAUNA:

1) construction of fish ladders at the weir in Terespol and at two weirs in the upper Bug course, also at dams on the Bug tributaries to enable fish migration;
2) elimination of fishes of the group of „ecological pollutants" from the Bug, especially the abundant German carp and catfish, also nine other alien fishes; introduction of fry of indigenous species, especially of progressively rarer rheophilous species such as the barbel, undermouth, and vimba.

HERPETOFAUNA:

1) construction of passages and their maintenance in the permeative state under roads with the heaviest traffic (highways, state and provincial roads) crossing the Bug valley to reduce casualties among amphibians, reptiles, and also mammals;
2) catching and carrying amphibians, and fencing the roadside sections where collisions of these animals with vehicles are most frequent in the period of migrations to breeding sites (March – April);
3) restoration of the meandering channel along channelized sections of the Bug tributaries, primarily on the Kosówka and the Cetynia.

AVIFAUNA:

1) labelling power lines with silhouettes of birds of prey or bright balloons to counteract the mortality of migrating birds;
2) exposing silhouettes of birds of prey or other signs deterring small bird species from collisions on road sections at bridges in Nur, Brok, Kózki and Wyszków where the highest mortality rate of passerine birds was recorded;
3) regular shooting of stray cats, dogs, and foxes, and also elimination of the American mink because of a high rate of their predation on ground nests of birds;
4) shifting the first hay making until mid-June, and until the third ten-day period of June in late springs;
5) starting mowing from central part of the meadow towards peripheries, that is, in opposite direction to the traditional one;

6) application of alternate (every two years) mowing of meadow fragments with high densities of the corncrake, as the only method enabling successful breeding of this globally threatened species;
7) removal of shrubs from abandoned meadows and unmown fens;
8) removal of alders from threatened sites of the curlew near Jakubiki and Morzyczyn;
9) shifting the beginning of the hunting season from mid-August to mid-September because of late nesting of many duck and tern species, including rare species;
10) providing nest boxes for the barn owl on all church towers at the edges of the Bug valley. In 1990, a nest of this species was found in only one church at the scale of the entire valley, the other potential nest sites being unavailable because of filling in the tower walls.

THERIOFAUNA:

1) construction of foot-bridges across international transition roads, primarily near Terespol, Brześć, and Chełm, and also above the roads crossing the largest forest complexes to make possible the dispersal of large mammals (elks, deers, and wild boars);
2) safeguarding and permanent monitoring of bats in roosting sites located in underground corridors of the fortifications of the former Brześć Fortified Area on the Polish and Belarussian sites; the same actions in bunkers near Drohiczyn and Siemiatycze, Podlasian Province;
3) restriction of poaching otters and beavers, trapping and relocation of beavers in the case of an excessive increase in numbers.

Also basic rules of active protection of species and habitats should be observed, as formulated in „The strategy for conservation of birds in the Mazovian Lowland" [Dombrowski A. 2001, In: Strategy for the conservation of fauna in the Mazovian Lowland, Ed. MTOF], that refer not only to the Mazovian-Podlasian Bug section. When developing a programme for active protection of individual species, the principal rule of „not doing harm" should be kept in mind. Examples illustrating harmful activities of home-bred ecologists have a long tradition. Already in the 1960s, it was proposed to increase mallard populations by placing nesting baskets on fish ponds. Unfortunately, many of these artificial nest sites were placed in shrubs or small trees where they were easy to spot by predators. At the same time, dikes were intensively mown, reedbeds were removed, and marshlands were drained, thus eliminating natural and safer breeding habitats of different duck species, including mallards. There are also examples of providing defective nest boxes: with entrance holes placed too low, or having diameter of the entrance hole too large and necessarily provided with a perch that served martens or magpies immediately spotting such „larders" as a support when robbing a nest. Nesting baskets or boxes were also recommended for kestrels and long-eared owls. Apparently, such places are readily discovered by many predators, including people, until leaves of trees are fully grown. Goosanders colonized only some of the very abundant islands on the Bug, and they do not need artificial nesting sites – such sites would be even undesirable for reasons given above. Also goldeneyes, that spontaneously colonized the Bug valley, though not in such large numbers as goosanders, do not need nest boxes as the number of tree holes made by black and green woodpeckers, as well as other nesting places much safer than nest boxes visible from large distances are plentiful. Before developing a programme for active protection, the key reason for species disappearance or low numbers should be recognized.

Moreover, the purpose of supporting the „rescue" of the species not threatened at present should be reconsidered in face of the enormous need to save a large number of disappearing species or potentially threatened with extinction.

The rules described above concern not only single species but also disappearing habitats. Before implementing any naturalization programme, the natural value of an area should be carefully assessed, and possible negative effects of all technical treatments should be listed, as it may appear that the balance of profits and losses will be disadvantageous to the natural habitat although profitable to firms performing technical works. All programmes of habitat protection should consider the degree of threat to different habitat types, that is, the hierarchy of real needs at the scale of the Bug valley where now the most vulnerable habitats are riparian carrs, fens, alder swamps, and xeric grasslands, whereas least vulnerable are oxbows.

Concept of an Ecological Network of Protected Areas – *Andrzej Dombrowski, Zygmunt Głowacki, Igor Gorban, Paweł Marciniuk, Michail Nikiforov, Danuta Urban, Marek Wierzba*

Bug River National Park

A serious gap on the map of national parks is the absence of this high rank protection of ecosystems characteristic of large lowland rivers. Some of the national parks established so far protect riparian carrs in peatland river valleys. But riparian carrs in valleys on mineral substrate are quite different. Moreover, willow-poplar carrs associated with this kind of substrate occupy now much smaller areas than alder-ash carrs so characteristic of smaller rivers and covering large stretches, for example, in the Biebrza River National Park and Białowieża National Park. An unusually high concentration of willow-poplar and ulm-ash carrs was noted during counts of the breeding avifauna in the lower Bug valley in 1984–1987 [Dombrowski, Chmielewski 2001: Unique values of the breeding avifauna in the lower Bug valley – threats and protection postulates. In: Strategy for fauna conservation in the Mazovian Lowland. Edited by MTOF]. The cited authors presented the concept of the Bug National Park at a conference on the avifauna of the lower Narew and lower Bug basins that was held in Łomża in October 1994. The area delimited at that time with respect to its ornithological value, and proposed for protection in the rank of a national park is located between Wygoda near Janów Podlaski and Pratulin [Chapter: "Status, threats, and concept of avifauna protection in the lower Bug valley"]. A detailed floristic study in the 1990s showed, however, that an area located north-west of that proposed by ornithologists should be protected as a national park, that is, the region near Mielnik, Serpelice, and Gnojno. With respect to the high floristic value of the Bug valley near Mielnik and its unique faunistic value near Janów Podlaski, we propose to establish a national park between Pratulin (Janów Podlaski Commune, Lublin Province), Zabuże (Sarnaki Commune, Mazovian Province) and Mielnik, Podlasian Province. The boundaries of the proposed Bug River National Park will be delimited later, during detailed studies conducted to gather the documentation needed to create the park. At present only a small part of this unique area is protected by law (nature reserve "Łęg Dębowy").

Nature reserves

Based on the faunistic and floristic research, 32 areas jointly covering 4793 ha were proposed for protection as nature reserves. Nearly half of them was proposed by both botanists and zoologists. These are mostly the oldest fragments of riparian carrs or oak-hornbeam forests, and only occasionally other habitat types such as oxbows and xeric grass communities. The experience gained so far indicate that only nature reserves can effectively protect the remains of old carr forests from logging which is destructive to these stands already unique at the scale of European forests. For this reason, forest habitats are best represented in the proposed form of protection (Tab. 1 and 2). Total clearing or removal of old trees are also documented in the Ukrainian part of the Bug valley. Legal protection of forests is urgently needed in Belarus. It should be emphasized that the continuity of willow-poplar carrs is best retained along the Belarussian section of the Bug valley, and this section needs special legal protection.

Priority protection in the form of nature reserve for forests seems to be apparent, but this form of protection should be avoided in semi-natural habitats developed as a result of extensive agriculture (moist mown meadows, extensively grazed xeric grass communities). These secondary habitats would be reasonably protected in the form of nature-landscape complexes or areas of ecological utility, thus areas where the economic activity should be continued to prevent spontaneous secondary succession gradually eliminating these specific habitats.

All kinds of legal protection should be implemented with caution, especially those of the lowest rank, that is, protection in the form of areas of ecological utility and nature-landscape complexes. These forms should not be frequently applied in the Bug valley not only because they are implemented in farmland (pastures and hay meadows) but also for some other reason. Namely, the rank of an area of ecological utility is assigned to over 600 objects and areas. Such a large number of areas of ecological utility should not exist in the Bug valley for at least three reasons:

1) The final goal is to protect the entire Bug valley in the rank of a national park where protective regimes are more rigorous, and at least not more permissible than the corresponding regulations concerning areas of ecological utility.
2) Creation of an area of ecological utility or a nature-landscape complex in a landscape park is inadvisable for the same reasons as the creation of an area of ecological utility within a nature reserve.
3) Development of regulations for optimum management at the scale of the entire Bug valley seems to be a better form of protection than formal establishment of an area of ecological utility.

Areas of ecological utility should be created only in face of a direct threat such as conversion of a meadow to a crop field, afforestation of a xeric grass community, a threat of conversion to a golf course, or recreational developments at an oxbow lake. This form of nature protection can also be promoted when the chance to create a nature reserve on the threatened areas is small, whereas it is relatively easy to create an area of ecological utility or a nature-landscape complex. For these reasons, Chapters IV and V propose creation of these local forms of nature protection in already existing or planned landscape parks. Their location is shown on CD 1:50 000 maps.

Accounting for all the restrictions above, the proposed nature reserves are set in Tables 1 and 2.

Table 1. The projected nature reserves (with documentation) in Poland

Name of reserve	Type of reserve	Area (ha)	Object of protection	Commune
Kacapski Canal	Faunistic	209	Breeding sites for a few bird species vulnerable to extinction in Poland and Europe	Sadowne
Podjabłońskie	Floristic	38.5	Biochores of open oak forests and continental mixed coniferous forest with numerous rare and protected plant species	Ceranów
Kępa Drażniewska	Landscape	380	Natural landscape of Bug valley with mosaics of habitats and plant communities	Platerów
Adolfów	Forest	56	Oak-hornbeam forests and carrs with rare and protected plant species	Ceranów
Trojan	Landscape	208	Fragment of Bug valley with mosaics of habitats rich in flora and fauna	Sarnaki
Kalinik	Landscape	330	Natural landscape of Bug valley with mosaics of habitats and plant communities	Janów Podlaski
Prostyń	Faunistic	150	Breeding aggregations of birds in oxbows	Małkinia Górna

Table 2. Proposed nature reserves (with no scientific documentation)

Name of reserve	Type of reserve	Area (ha)	Object of protection	Commune
1	2	3	4	5
Poland				
Bug outlet	Landscape	225	Landscape between the Bug and the Narew rivers with retained plant communities typical of oxbows, meadows differing in wetness, xeric grass communities, forests, and shrubberies with rich flora	Dąbrówka
Noski	Faunistic	300	Old alder swamps, alder carrs rich in birds	Ceranów
Fidest	Faunistic	160	Community of breeding birds associated with alder swamps and carr forests	Wyszków
Las Parowy	Faunistic	70	Breeding sites of birds threatened and strongly threatened with habitat loss in carrs and oak-hornbeam forests	Łochów
Brzuza	Landscape	550	Fragment of Bug valley with diverse landscape, flora and fauna	Łochów
Cypel	Landscape	140	Fragment of Bug valley with retained plant communities typical of oxbows, meadows of different wetness, xeric grass communities, forests and shrubberies with rich flora and fauna	Sarnaki
Ujście Czyżówki (Czyżówka river outlet)	Landscape	170	Fragment of Bug valley at Czyżówka river confluence, rich in birds and flora	Janów Podlaski
Skorzyna	Landscape	59	Fragment of river valley with retained complexes of carrs and oak-hornbeam forests, also with oxbows and meadows	Janów Podlaski and Rokitno

1	2	3	4	5
Łęg Pratuliński	Landscape	87	Fragment of river valley with a well retained complex of carrs, meadows and oxbows	Rokitno
Bużny Most	Landscape	150	Fragment of Bug valley with mosaics of forests, shrubberies, meadows, xeric grass communities, and wetlands	Terespol
Leonów	Faunistic	100	Unusually rich breeding aggregation of birds	Korczew
Łokieć	Faunistic	25	High densities of some hole-nesting birds	Ciechanowiec
Łęg Frankopolski	Faunistic	20	High richness of breeding birds	Repki
Łęgi Natolin	Faunistic	20	Breeding bird communities typical of ulm-ash carrs	Ceranów, Sterdyń
Olsy Budy	Faunistic	120	Concentration of sites of a few rare bird species	Brańszczyk
Ols Osiny	Faunistic	10	Nesting site of a few rare bird species, rich herpetofauna	Somianka
Czumów-Gródek	Floristic	50	Well retained xeric grass communities on steep slopes and floodplain of Bug valley	Hrubieszów
Marcze-Zagórnik	Floristic	50	Aquatic communities, shrubberies and forests; rare species, e.g., *Iris sibirica.*	Dubienka
Dołhobrody	Faunistic	20	Colony of heron	Dubienka
Belarus				
Tomaszewski	Faunistic	200	Nesting sites of 29 species of waterbirds	
Orchowo-Komarówka	Faunistic	100	Abundant waterbirds, otters and beavers	
Domaczewo-Kopajówka	Faunistic	150	Nesting sites of 25 species of waterbirds	
Bug-Leśna	Faunistic	150	Well retained willow-poplar carrs with rich breeding avifauna	
Smolnicki Las	Faunistic	35	High species richness of breeding avifauna and migrants – 60 species jointly	
Ukraine				
Dieriewljany	Land	1000	High faunistic and floristic values	
Gajek	Land	25	High faunistic and floristic values	
Potorica	Land	120	High faunistic and floristic values	
Skomorochy	Land	250	High faunistic and floristic values	
Dobrotwor	Faunistic	1000	High values of breeding avifauna	
Gorniak	Faunistic	52	High values of breeding avifauna	
Szichtari	Faunistic	60	High values of breeding avifauna	
Litowierz	Faunistic	12	High values of breeding avifauna	
Tadany	Faunistic	300	High values of breeding avifauna	
Gromosz	Floristic	12	High floristic values	

Landscape parks

Based on comprehensive field studies conducted in 1998–2000 under the IUCN programme, it can unequivocally be stated that the entire Bug valley within its physiographic boundaries should be protected in the rank of a landscape park. It was postulated long ago that the boundaries of the Bug Landscape Park be expanded and the Bug Protected Landscape Area transformed into the Landscape

Park “Podlaski Przełom Bugu”, which would also include the Bug valley section within the boundaries of the Podlasian Province, according to Czerwiński [1995] concept: “Delimitation of the boundaries of the planned Landscape Park “Bug valley".

The boundaries and names of the proposed parks should refer to physiographic units. For example, the Landscape Park of the Podlasian Bug Gap should cover a vast area from the Krzna outlet to the Kosówka outlet. The Landscape Park of the Lower Bug valley will extend between the Kosówka outlet and the Bug outlet to Zegrzyński Reservoir at the height of Kuligów and Popowo Kościelne. The largest landscape parks at the scale of the Bug valley will be located in its lower reaches. The management of these large areas will not be easy. The structure and rules of the future administration should thus be carefully designed. This work should be performed not only by the governmental and local administration responsible for nature protection but also by research scientists conducting intensive field studies. One of he basic issues will be the location of the headquarters of landscape parks and a proper selection of the Social-Scientific Councils of landscape parks. It is extremely important to appoint directors of landscape parks exclusively by open competition. The current practice in this field creates potential threats to natural values taking into account that predisposition to effective management should be combined with a minimum of knowledge on the structure and function of nature at the levels of ecosystems and physiocenoses.

Creation of landscape parks has also been proposed in the remaining parts of the Bug valley. In recent years, a concept has emerged of the Dołhobrodzko-Kodeński Landscape Park that will cover a vast area of the Bug valley west of the road “Nadbużanka“, extending to Okczyn in the north and to Stawki in the south.

Possibility of using structural funds of the European Community to retain extensive agriculture in the Bug valley – *Andrzej Dombrowski*

In 1999, the Council Regulation (EC) No. 1257/1999 on the support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF) was issued. It replaced the Regulation 2078/92 concerning "agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside". Article 22 in Chapter VI (Agri-environment) of the actual Regulation defines five major objectives regarding agriculture and the environment that will be promoted:

1) ways of using agricultural land which are compatible with the protection and improvement of the environment, the landscape and its features, natural resources, the soil and genetic diversity;
2) an environmentally-favourable extensification of farming and management of low-intensity pasture systems;
3) the conservation of high nature-value farmed environments which are under threat;
4) the upkeep of the landscape and historical features on agricultural land;
5) the use of environmental planning in farming practice.

With reference to these objectives, the following actions should be implemented by farmers in the Bug valley:

1) cessation of chemical plant protection and the replacement of mineral fertilizers with organic fertilizers;
2) delaying agricultural works, especially hay making, until the end of the nesting period in birds, and starting mowing from central parts of meadows towards the edges;
3) maintaining the livestock at the present level and running the animals in pastures after the termination of the first brood in birds;
4) mowing unused meadows every two-three years (every year at best) to prevent succession that is leading towards conversion of open areas to forests; this concerns moist meadows as well as xeric grass communities;

5) converting arable land into permanent green areas, and cessation of converting existing meadows and pastures into arable land;
6) establishing buffer green areas along streams;
7) restoring and maintaining a high level of meadow wetness.

Some kinds of the recommended actions are not advisable under the conditions of the Bug valley, though desirable in the typical agricultural landscape beyond the valley of this river. They include, for example, fallowing fragments of cropland, introducing balks, planting trees along pathways in cropland, or reducing livestock. But the establishment of buffer green areas (see point 6) perfectly corroborates the postulated restoration of the continuity of riparian carrs along the Bug and its tributaries. Point 3, referring to the maintenance of the livestock at the present level, becomes increasingly important in the Bug valley in face of a growing tendency towards the disappearance of the traditional pastoral land-use. This process primarily affected xeric grassy communities at the valley edges and also moist meadows at Góry and other sites. But livestock grazing should even be increased in nature reserves "Wydma Mołożewska" and "Kózki", also around oxbows between Treblinka and Płatkownica, at Borsuki, and on moist meadows in the valleys of the Kosówka and the Ugoszcz because of their unique avifaunal value which may vanish as they are threatened with the expansion of self-sowing pines. Unique xeric grass communities at the edges of the valley where grazing or mowing was abandoned urgently require re-establishment of one of these forms of extensive landuse.

Furthermore, it should be emphasized that the restoration of small depressions with water, postulated in environmental programmes for a typical, intensively used agricultural landscape, in the Bug valley can concern only small oxbows, illegally filled with wastes, located in peripheral parts of the valley. The majority of oxbows retained their high biological value, and the main threat to them is their cutting off from flood waters by an improper location of flood embankments. This threat should be taken into account in the future agri-environmental programmes.

Pre-accession support is also required for the education and training of farmers in the field of different kinds of agricultural development conforming to the environmental protection and management of rural areas. In Poland, about 120 consultants will be educated for a direct co-operation with farmers. The implementation of agri-environmental programmes can be financed after the acceptance of the national programme for agri-environmental funds. Moreover, a preliminary programme must be implemented in the Biebrza and the Narew river valleys, also in the surroundings of the reserve "Słońsk". Presumably, only after the implementation of this programme it will be possible to announce detailed rules of the competition for the implementation of agri-environmental projects in three categories:

1) Protection of biological diversity in farmland,
2) Protection of the environment and agricultural landscape,
3) Development of ecological agriculture.

The potential programmes designed for the Bug valley belong to the first category. Projects of groups 2 and 3 should be proposed in surroundings of the Bug valley. Farmers submitting approved proposals will sign contracts assuming two phases of project implementation: initial phase (for two years) financed by PHARE and

the proper phase financed by SAPARD. The application of strict management rules will be financed according to the formula (based on Article 24, Chapter VI of the Council Regulation No. 1257/1999 of 17 May 1999):

COMPENSATION = LOST INCOME + COSTS + PREMIUM

Premiums are paid by the EC only in part, to 50% of the programme costs or to 75% in the countries of objective no 1.

To illustrate the funds provided by the **EU** for the implementation of agri-environmental programmes: the mean annual premium was 117 ECUs/ha/year and the lowest one was 60 ECUs/ha/year where about 17% of the farmland was under the programme. The premiums in programmes currently implemented in Poland in the Mazurian-Warmian and East-Carpathian Provinces can reach even 140 ECUs/ha/year.

An example of the potential use of the subsidies in the Bug valley can be the area covered with xeric grass communities near Mielnik, characterized by high floristic and entomological values. After the cessation of livestock grazing and mowing, pines started spreading over these areas. Over the recent 4–5 years, similar processes occur in the reserve "Wydma Mołożewska". Compensation for owners of unmown meadows should concern payment for mowing and/or grazing on dates and at frequencies agreed with botanists and zoologists conducting long-term research in this unique habitat type. Those interested in this subject can get detailed information at the Ministry of Agriculture and Rural Development, Department of Preaccession Support and Structural Funds (00–430 Warsaw, Wspólna 30).

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