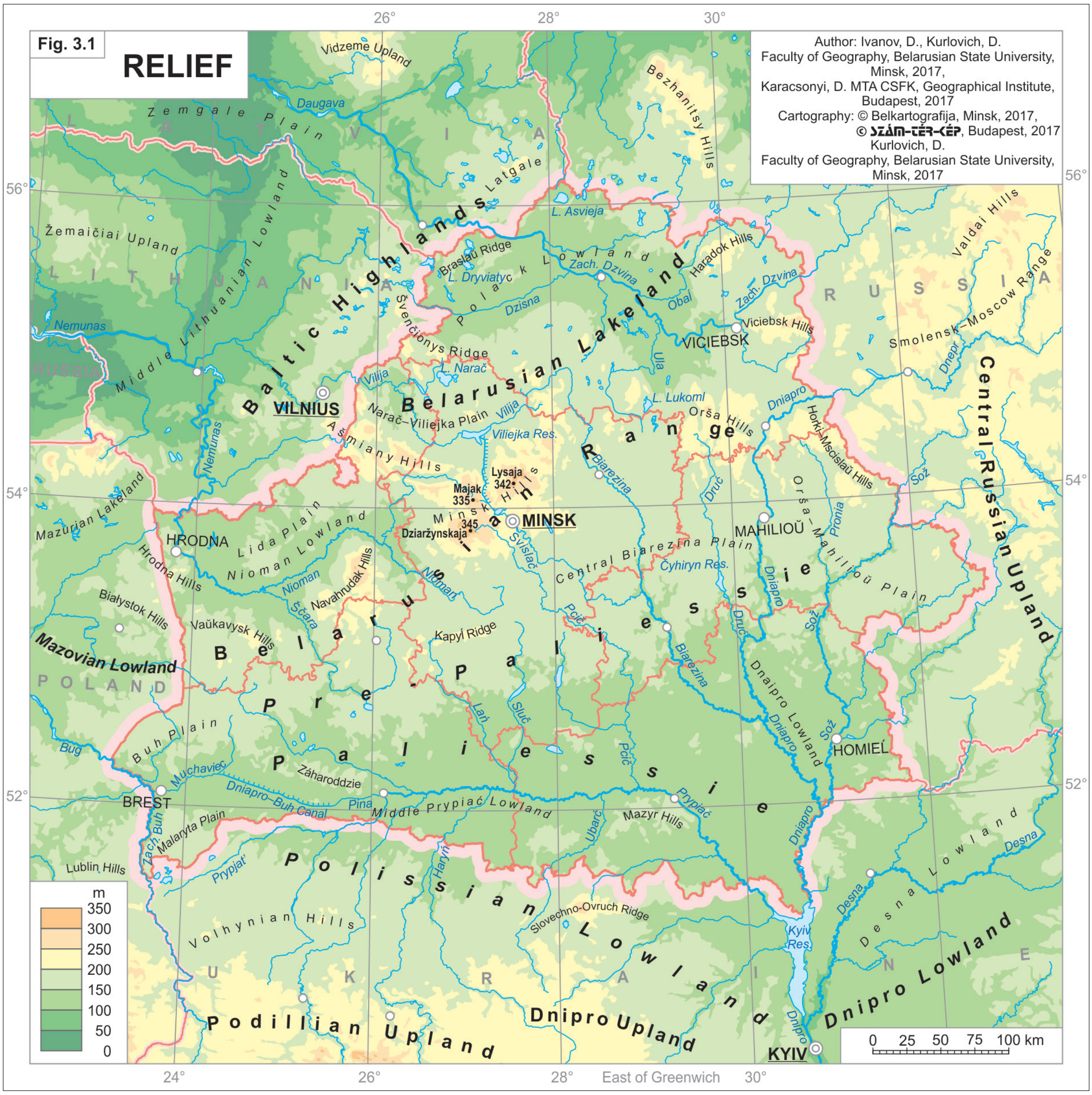
3. NATURAL RESOURCES

Geology, relief

Belarus is located on the East European Plain Europe's most homogenous landscape (*Figure 3.1*). The area often called as East European Platform because it is characterised by a **crystalline rock basement** which has been covered by several thousand meters of sediments (Nemerkényi A. 2007). Major tectonic structures of this basement, so called anteclises (large uplifted structures),



sineclises (large depressions) and troughs influence the thickness of the sediment. In Belarus this old crystalline bedrock is the closest to the present surface in the Belarusian Anteclise, while the depth of the basement surface is greatest within the Prypiać Trough – ranging from 1.5 to 6.2 km. These large subsurface structures also influence the present relief. Above the anteclises we find usually ridges, while the location of the sineclises mostly coincide with the area of lowlands (e.g. the Prypiać Marshes have been preformed by the Prypiać Trough).

The **sedimentary cover** consists of the strata of the Upper Proterozoic and all the geological systems of the Palaeozic, Mesozoic and Cenozoic. Palaeozoic formations include Cambrian, Ordovician and Silurian complexes, which comprise mostly sandstone and clay as well as carbonate strata. The Mesozoic formation also presents all systems. Jurassic formations consisting of limestone, sandstone, clay and other marine sediments are common in the west, east and south-east of Belarus. Cenozoic formations are also widespread. Palaeogene deposits (sandstone, marl and, rarely, clay) are to be found in the Prypiać Trough, the Podlasie-Brest Depression, the Paliessie Saddle and on the southern slopes of the Belarusian Anteclise. Neogene accumulation has given rise to sandy-clay rocks, mainly in the south. Quaternary strata (sands, sandy loams, loams) cover the deposits of older systems and form the surface relief.

The **most important mineral resources** of Belarus, potash, rock salt and some oil are located in this sedimentary cover (*Figure 3.2*). Resources of potash and salt are globally significant. Belarus is the world 3rd largest potash producer.

The landscape has been formed by continental ice sheets during the Pleistocene (Ice Age), the main epoch of the Quaternary. Pleistocene climate was characterised by repeated cooling and warming periods generating glacial cycles in which continental ice sheets pushed to the south and then retreated during the so called interglacials, affecting the entire territory of Belarus. These continental ice sheets when they stopped pushing forward, left at their maximum extension terminal moraines formed by accumulation of glacial debris, mostly sand and rocks. These terminal moraines form a series of hills and ridges, while on the area covered by ice sheets different glacial and fluvioglacial formations emerged, e. g. elongated accumulation embankments and moulds like eskers and kames (*Figure 3.3*). In the territory of Belarus there are two large terminal moraine hill lines, at the limit of the so called Paazierje glaciation

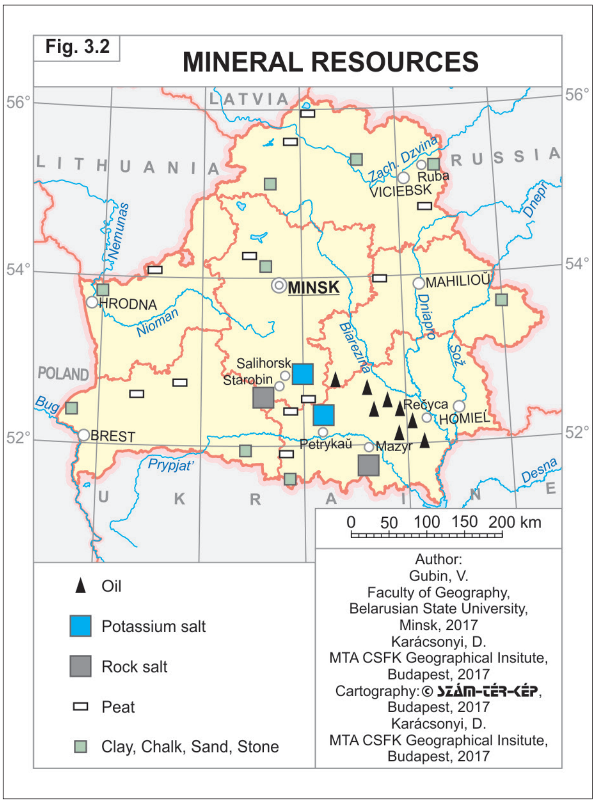


Table 3.1 Glaciation names and ages				
Alpine	Northern European	Russian	Belarusian	1000 years BP
Würm	Weichselian	Valdai	Paazierie	115– 12
Riss	Saalian	Dnepr	Sož/Prypiać/Dniapro	200–130
Mindel	Elsterian	Oka	Biarezina	480–420
Günz	–	–	–	700–600
Source: Székely A. 1978, modified				

Fig. 3.3

GEOMORPHOLOGY

Author: Gurskij, B., Zernickaja, V., Ilkevich, G., Karabanov, A., Krutous, E., Levchich, V., Levickaja, R., Levkov, E., Moiseenko, V., Matveev, A., Nelipovich, L., Nechiporenko, L., Jakushko, O.
Faculty of Geography, Belarusian State University, Minsk, 2017
Cartography: © Belkartografija, Minsk, 2017,
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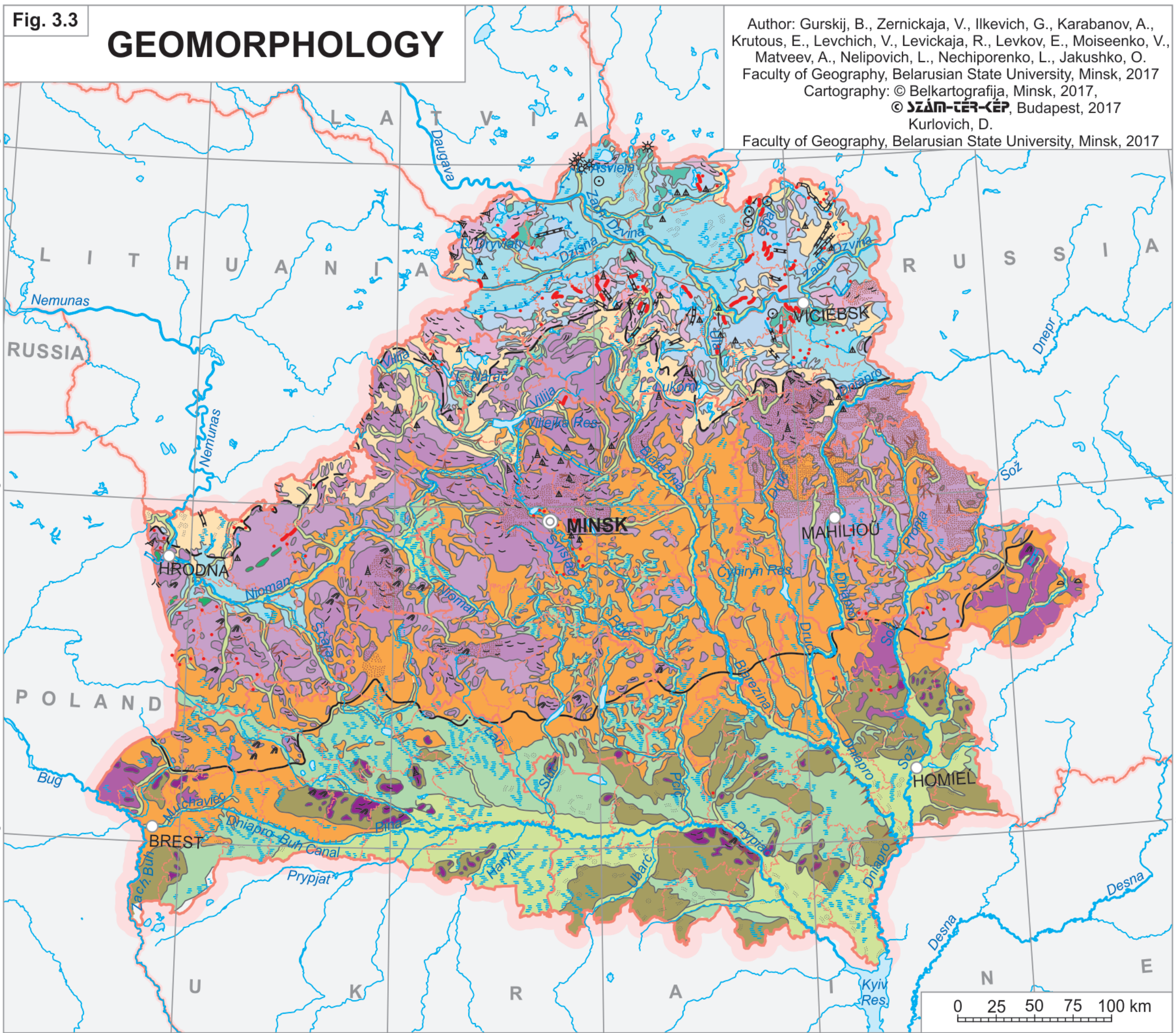
Kurlovich, D.
Faculty of Geography, Belarusian State University, Minsk, 2017



Limit of Paazierje (Weichselian) glaciation

Limit of Sož (Warthe stage of Saalian) glaciation

Relief of the Paazierje (Weichselian) and Holocene age
- Alluvial lowlands and river valleys

Relief of the Paazierje (Weichselian) age
- Lacustrine-alluvial lowlands
- Glacial-lacustrine lowlands
- Kame massifs
- Fluvioglacial plains and lowlands
- Ground moraine plains
- Marginal glacial landforms

Relief of the Sož (Warthe stage of Saalian) age
- Kame massifs
- Fluvioglacial plains and lowlands
- Ground moraine plains
- Marginal glacial landforms

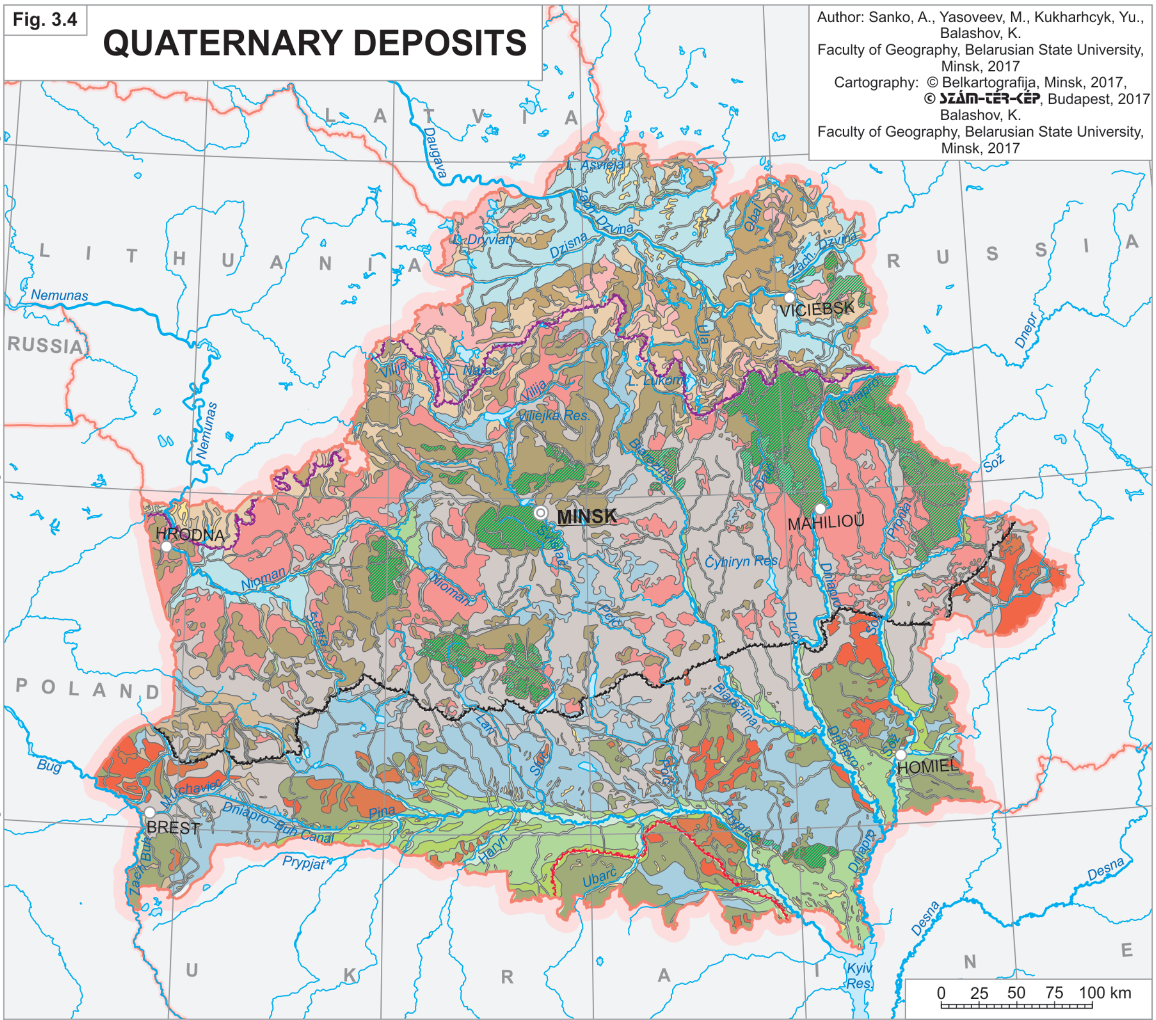
Relief of the Dniapro (Drenthe stage of Saalian) age
- Fluvioglacial plains and lowlands
- Ground moraine plains
- Marginal glacial landforms

- Swamps
- Loess-like deposits
- Eskers
- Kames
- Angular massifs
- Marginal glacial ridges
- Glaciodislocations
- Pingo
- „Mosary"
- „Šalomy"
- Fluvioglacial deltas
- Abrasional cliffs
- Ravines
- „Zvoncy"
- Eolian hills and ridges
- Glacial ravines
- Valleys of ice-melt water discharge

Fig. 3.4

QUATERNARY DEPOSITS

Author: Sanko, A., Yasoveev, M., Kukharhcyk, Yu., Balashov, K.
Faculty of Geography, Belarusian State University, Minsk, 2017
Cartography: © Belkartografija, Minsk, 2017, © Stíefel-Térkép, Budapest, 2017
Balashov, K.
Faculty of Geography, Belarusian State University, Minsk, 2017



Genetic types and ages of the sediments

Holocene. Sudoble Horizon (Q_4sd)

- plQ_4sd — Swamp deposits. Peat
- aQ_4sd_5 — Alluvial deposits of the floodplain. Sand, sandy loam, loam, sand and gravel material
- aQ_4sd_1 — Alluvial deposits of the first terrace (the rivers of the Baltic Sea) and high plains. Sand, sandy loam, loam, sand and gravel material

Upper Pleistocene. Paazierje Horizon (Q_3pz)

- l, aQ_3pz — Lacustrine and alluvial deposits. Sand, slit, sandy loam, loam
- vQ_3pz — Eolian deposits. Sand
- LQ_3pz — Loess and loess deposits. Sandy loam and loam
- a_1Q_3pz — Alluvial deposits of the first terrace (the system of the Dniapro and Prypiać). Sand, sand and gravel deposits
- a_2Q_3pz — Alluvial deposits of the second terrace (the system of the Dniapro and Prypiać). Sand, sand and gravel deposits
- lgQ_3pz^s — Lacustrine–glacial deposits. Varved clays, silts, sands
- fQ_3pz^s — Fluvioglacial deposits. Sand, sand and gravel deposits
- gtQ_3pz — Terminal or frontal or end moraine deposits. Sand, sand and gravel deposits, boulder sandy loam, loam
- gQ_3pz — Moraine deposits. Sandy loam and loam boulder

Middle Pleistocene. Prypiać Horizon (Q_2pr)

- $fQ_2pr_2sž^s$ — Fluvioglacial deposits of Sož stage of Prypiać glaciation. Sand, sand and gravel deposits
- $gtQ_2pr_2sž$ — Terminal or frontal or end of Sož stage of Prypiać glaciation. Sand, sand and gravel deposits, sandy loam, loam
- $gQ_2pr_2sž$ — Moraine deposits of Sož stage of Prypiać glaciation. Boulder sandy loam, loam, clay
- $fQ_2pr_1dn^s$ — Fluvioglacial deposits of Dniapro stage of Prypiać glaciation. Sand, sand and gravel deposits
- gtQ_2pr_1dn — Terminal or frontal or end moraine deposits of Dniapro stage of Prypiać glaciation. Sand, sandy loam, loam
- gQ_2pr_1dn — Moraine deposits of Dniapro stage of Prypiać glaciation. Boulder sandy loam, loam, clay

Borders of ice sheets

- Paazierje
- Sož stage of Prypiać glaciation
- Biarezina

in the North and the Sož glaciation in the South. The southern one is the older, and by expanding from the North to the South it has overwritten all earlier moraine forms. The stages of Pleistocene glaciation have been explored first on the East European Plain because their geomorphological and relief forms are there particularly well-marked on the landscape (Székely A. 1978). The glaciations have usually been named after local rivers, thus they are not the same in different countries. However the stages can be companied to each other (*Table 3.1*).

The thickness of Quaternary deposits is around 70–80 m, but in some places is as much as 300 m. The deposits of three glacial horizons account for up to 90% of the Quaternary strata (*Figure 3.4*). The Weichselian (*Paazierje*) glaciation reached merely the northern part of the country where this glacial horizon is widespread. The deposits of the *Prypiać* (*Sož* and *Dniapro* – Saalian) and Elsterian (*Biarezina*) glacial horizons prevail in Central and Southern Belarus. Pleistocene interglacial and Lower Pleistocene horizons are of minor importance. Fluvioglacial sands and moraines dominate in the deposits occurring on the surface. Loess and loess loam were formed in the periglacial areas in front of the last (*Paazierje*) ice sheet. Morainic hills, morainic plains, outwash fields, glacial-lacustrine plains emerged in the strip of dead ice blocks. Alluvial, lacustrine and aeolian sands are also widespread.

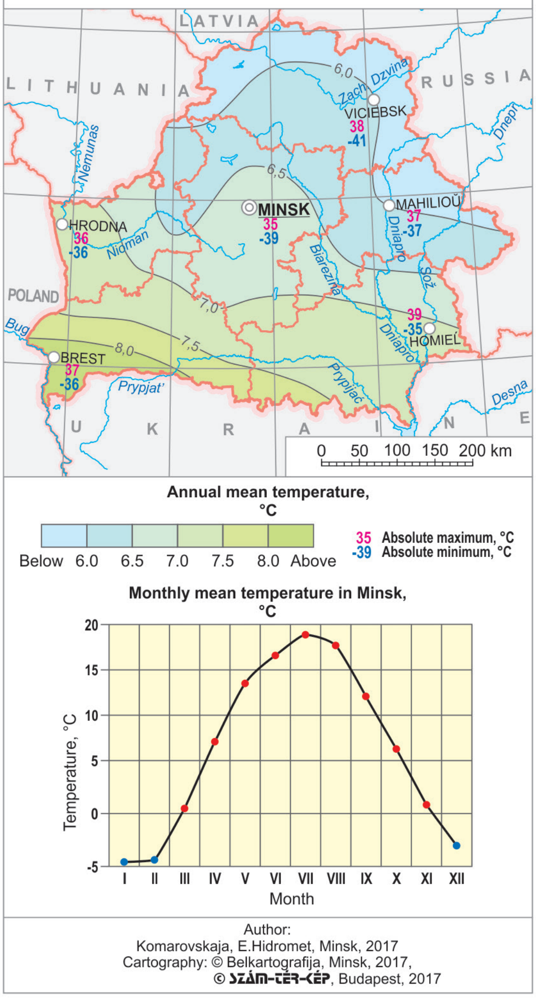
Climate

The climate of Belarus is determined by its location in the forest belt of the northern temperate zone and by the flat or slightly undulating terrain of low elevation. According to the Köppen-Geiger classification system it belongs to the warm-summer humid continental (Dfb) type with severe winters and no dry season. This climate has in Belarus a definitely transitional character: the mild, humid air masses coming from the Atlantic Ocean strongly influence the weather in the western part of the country, while eastward the continental nature of the climate becomes more and more pronounced. This manifests itself mainly in the temperature regime: the harsh winters and relatively warm summers result in higher annual temperature ranges.

The capital city of Minsk, lying close to the geometrical centre of the country and having an almost continuous meteorological record since 1891, lends itself quite well to represent the climate of Belarus. According to the climatological normals of the WMO for the period 1961–1990, the average mean temperature in Minsk was 5.8 °C, while July proved to be the warmest (17.3 °C) and January the coldest month (– 6.9 °C). Vicebsk, lying in the north-eastern corner of the country is a bit colder with particularly severe winters (year: 7.4 °C, July: 17.1 °C, January: –8.2 °C). On the contrary, Brest at the south-western border of Belarus stands out with considerably milder temperatures (year: 7.4 °C, July: 18.0 °C, January: – 4.5 °C).

The 1980s saw the onset of warming in the climate of Belarus that evolved at a pace strongly outperforming the global trend of this pro-

Fig. 3.5 ANNUAL MEAN TEMPERATURE

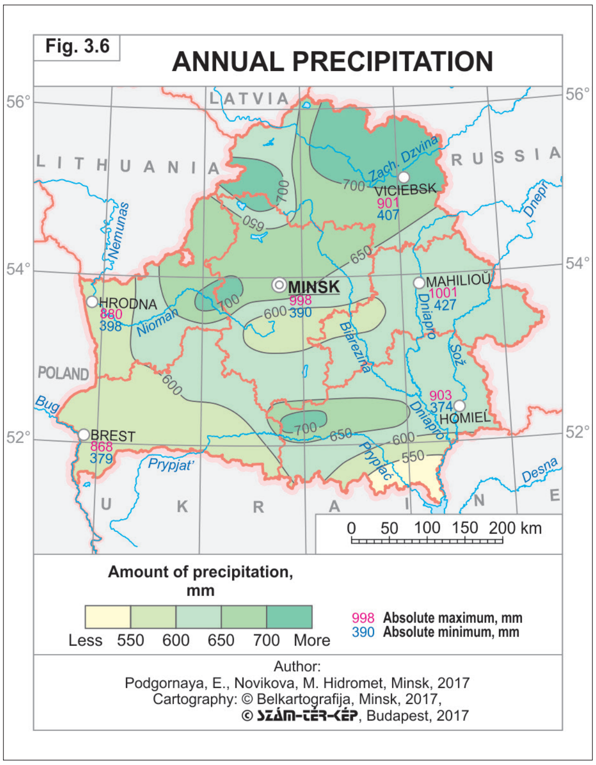


cess. The annual mean temperature of the last three decades (1981–2010) in Minsk increased by 1.3 °C, thus slightly exceeding 7.0 °C. The July mean temperature of this period rose to 18.5 °C. The warming of the winter was even more conspicuous with the average January means rising to – 5.0 °C (*Figure 3.5*). The pattern of the regional differences, however, did not change: the mean annual temperature increases from north-east to south-west. In winter the isotherms run almost exactly in meridional direction, whereas in summer they are guided mainly by the parallels of latitude. The length of the period with daily mean temperatures above 0 °C varies between 240 and 270 days. The growing season (t≥10 °C) is lasting up to 150–170 days after it had witnessed a recent increase of 10–12 days. The sum of active temperatures (degree-days) for the growing season generally amounts to 2100–2600 °C. This is not sufficient for crops demanding more heat (e. g. sunflower, corn) and scarcely enough even for wheat, while it meets the modest requirements of rye, barley, oats and potato. The cultivation of fruits is largely limited to frost-tolerant varieties of pear, apple and berries, quite a few of them being native to the domestic forests.

Wind patterns in Belarus are determined by the general circulation of the atmosphere with light dominance of the westerlies. The average annual wind speed in open areas is close to 4 m/s, in the valleys and flat plains about 3 m/s.

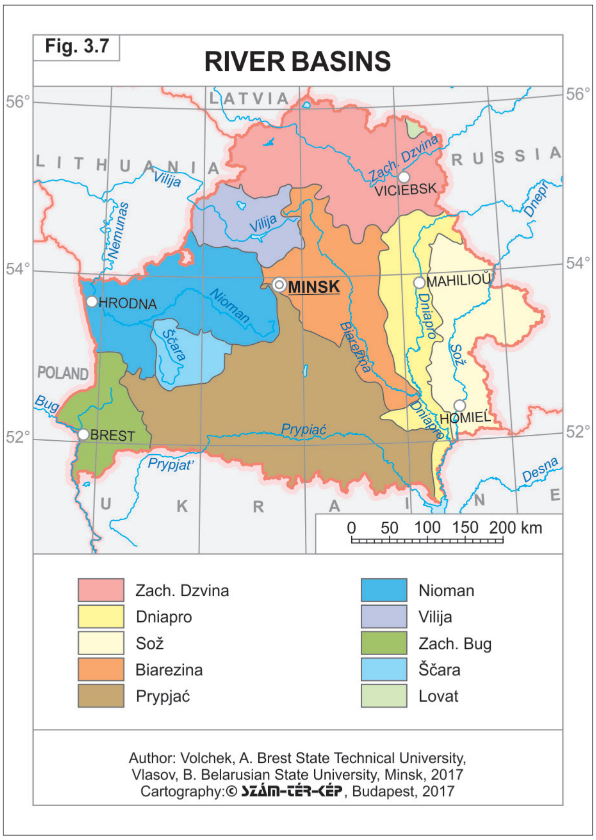
The frequent fogs, the cloudy or often overcast sky and the short daylight add a good deal to the unpleasant features of the Belarusian winter. According to the long-time record of Minsk, in December the inhabitants of the city can enjoy only an average of 48 minutes sunshine, equal merely to 11% of the theoretical length of daylight. The average daily duration of sunshine has its peak in June with 9.5 hours, i.e. 51% of the potential maximum. The annual mean of sunshine hours amounts to 1815, i.e. 41% of the daylight time.

The mean annual precipitation is usually sufficient, with the climatic normal of Minsk amounting to 677 mm. There are no great regional differences in this figure: the lowlands receive about 600–650 mm precipitation which increases to 650–700 mm in the hills (*Figure 3.6).* The maximum annual precipitation registered during the entire observation period at most stations is between 850 and 1000 mm, while in extremely dry years it may decrease to 350–450 mm. About 70% of the annual precipitation comes in the form of rain during the warmer months with a slight maximum in July (Minsk: 88 mm). In the summer months there are 15–16, in winter 19–20 days with precipitation of more than 0.1 mm. In an average year there are 3–4 periods with no rain for 10 consecutive days, while drought periods lasting 20–25 days occur every second year. Although the amount of precipitation has not shown any significant change during the last decades, drought became more frequent and the drop of humidity due to the higher temperatures has caused perceptible damage to the spruce forests in the northern regions of the country.



Snow lies on the ground for at least a month, typically from early December in the north-east of the country and from the end of December in the south-east. The snow cover can melt several times and then appear again, especially at the beginning and toward the end of winter. According to the meteorological record of Minsk from the recent decades (1990–2012), chances of finding snow cover on the ground are highest at the end of January (65%). Snow depth ranges from 6–7 cm in the south-west to 20–30 cm in the central and north-eastern parts of the country with the maximum usually observed in the first days of March. The mean depth of the snow in Minsk reaches then about 22 cm, but in every tenth year it exceeds even 42 cm. The sudden transition from winter to an extremely warm spring and the rapid melting of snow often induce extensive floods inundating the flat lowlands along the rivers.

The long-term estimates based on the regional downscaling of the general circulation model HadCM2 (Hadley Centre, United Kingdom) indicate the continuation of the recent warming tendencies of the climate which would rise the temperatures by 1.6–4.8 °C above the climate normals of the previous decades till the end of the 21st century. At the same time the amount of precipitation would only slightly increase, mainly in the cold season. While the expected warming seems to be favourable, the adaptation to the drier conditions of the growing season may present a challenge for the agriculture of Belarus.



Waters

The **rivers** of Belarus lie in the catchment area of the Black and Baltic Seas. The Black Sea drainage basin covers about 57% of Belarusian territory and accounts for 50.3% of water courses. Meanwhile, the Baltic Sea basin covers 43% of the territory and accounts for 49.7% of water courses. The hydrographic network is dense, with 20.8 thousand mostly small rivers (total length: approx. 90.6 thousand km) flowing across the country. The river network density for the whole territory of Belarus is about 0.44 km/km^2. In the higher northern part of the country this figure increases to 0.60–0.80 km/km^2, while in the low southern part it decreases to 0.23–0.30 km/km^2.

The main rivers are: Zachodniaja Dzvina, Dniapro, Sož, Biarezina, Prypiać, Nioman, Vilija and Zachodni Buh. Most of them are transboundary rivers, usually coming from abroad, and after crossing Belarus their courses continue in other countries again. Dniapro, (Black Sea drainage basin), the the biggest river has a length of 700 km in Belarus and a catchment area of 63,700 km^2 (*Figure 3.7*). Prypiać, the main tributary of Dniapro, originates in the Volyn Region of Ukraine; it flows in a latitudinal direction through the southern part of Belarus and then re-enters Ukraine. The length of this river in Belarus is 500 km, and its water catchment area covers 53,000 km^2.

The biggest river in the Baltic Sea drainage basin is the Zach. Dzvina, with a length of 1,020 km and a catchment area of 87,900 km^2. The Belarusian part of the river is 328 km long and has a water catchment area of 33,200 km^2. The Nioman, and its tributary the Vilija, are major rivers in the Baltic Sea drainage basin; both originate in Belarus and flow to Lithuania. The length of the Nioman in Belarus is 459 km, while the length of the Vilija is 264 km.

In terms of the availability of **water resources**, the situation in Belarus is relatively favourable. The mean annual discharge of all rivers is about 57.9 km^3 with 34.0 km^3 of this amount coming from the territory of Belarus. The average annual runoff in Belarus ranges from 8.5 l/s/km^2 in the northern part of the country to 3.5 l/s/km^2 in the south (*Figure 3.8*).

In Belarus there are around 10,780 **lakes** with a total surface area of 1,500 km^2 and total water volume of 5,874±341 million km^3. The geological

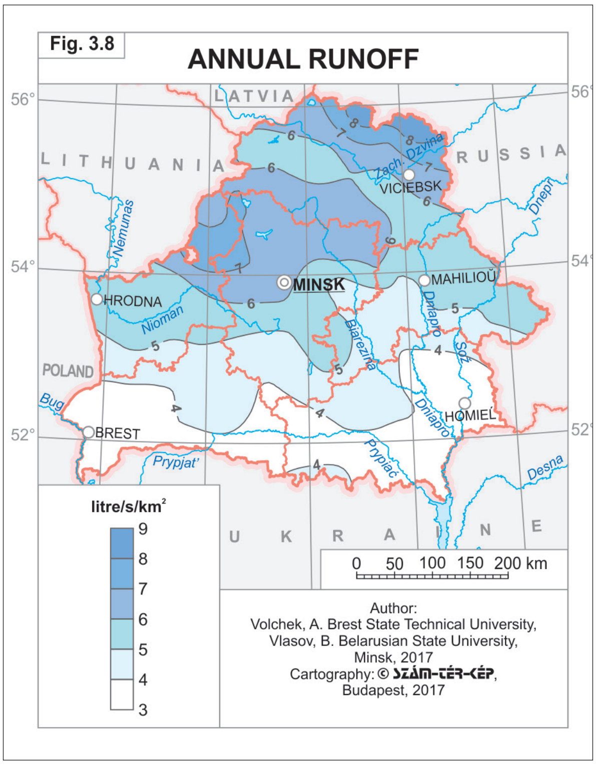


Fig. 3.8 ANNUAL RUNOFF

formation of lakes was associated with the glaciation (till 12–13,000 years ago), to much less extent by karst processes, and the generally high water content of the soil. Most of the lakes are concentrated in the Belarusian Lakeland (*Paazierje*) in the north of the country and in Belarusian Paliessie in the south. Lakes of small surface area (less than 0.01 km^2) prevail. The biggest lake is Narač in the Miadzieĺ district (79.8 km^2), while the deepest is Doŭhaje in the Hlybokaje district (53 m).

Wetlands originally covered 19.9% of the country (4.13 million ha). Most of the wetland comprised peatlands, which occupy 14.2% (2.9 million ha) of the total area of Belarus. There are three types of wetlands which are classified on the base of mineral nutrient supply and vegetation: mires (fen, low-moor; eutrophic), transitional (poor fen; mesotrophic) and bog (high-moor, raised bogs; oligotrophic). Mires account for 77% of the total wetland area of Belarus (*Figure 3.9*); the share of bogs is about 19%, and that of the transitional type is about 4%. By now only 860 thousand ha of wetlands remained in their natural state. One of the largest bogs is Jeĺnja (20 thousand ha), which lies in the northern part of Belarus.

Wetlands in a natural state are important for the conservation of biological and landscape diversity and for the regulation of the hydrological and biochemical cycles. Each year, peatlands remove about 900 thousand tonnes of carbon dioxide from the atmosphere and produce 630 thousand t of oxygen. About 500 million tonnes of carbon has been accumulated in the peatlands of Belarus. Drained **peatlands** are widely used in agriculture and forestry. For many years, peatlands were used for peat extraction for combustion or as organic fertilizers. Over the past five years, the annual production of peat was 1.7–3.2 million tonnes, which is used mainly as fuel. Around 500 thousand ha of peatlands have been degraded, owing to drainage, peat extraction and intensive agricultural use.

Soils

The soils of Belarus were formed through the interaction of soil forming factors in a temperate and moderately humid climate with mostly high groundwater levels. The soils of Belarus developed on a base of glacial deposits and alluvial, aeolian and peat sediments. The most common soil-forming processes are humus-accumulation, podzolization, gleying, and peat accumulation.

Belarusian soil cover is highly heterogeneous. In general, one can find the following main types of the soils in the country (*Figure 3.10*): retisols – about 45%, luvisols –19%, histosols –15%, fluvisols –9%, gleysols and stagnosols –9%, as well as some podsols and leptosols. There is a clear predominance of semi-hydromorphic soils over auto-amorphic soils. The fertility of the soils is mostly moderate. The conditions for biomass production vary significantly. The generally favourable agro-ecological potential is limited principally by soil degradation processes, acidification, an extreme moisture regime, and unfavourable changes in the biogeochemical cycles of elements.

The main **soil degradation** process is erosion. Eroded soils account for about 10% of arable land, while around 40% are at risk of erosion. Eroded soils are confined mainly to the hills. Deflation is a major danger in the southern part of Belarus, where sand and drained peat soils predominate. Permanent soil acidification is caused by washout with average losses of 300 kg/ha $CaCO_3$. Half a century of liming in Belarus has significantly reduced soil acidity: the average pH has increased from 4.9 to 5.9 on arable soils. Now only 5% of the

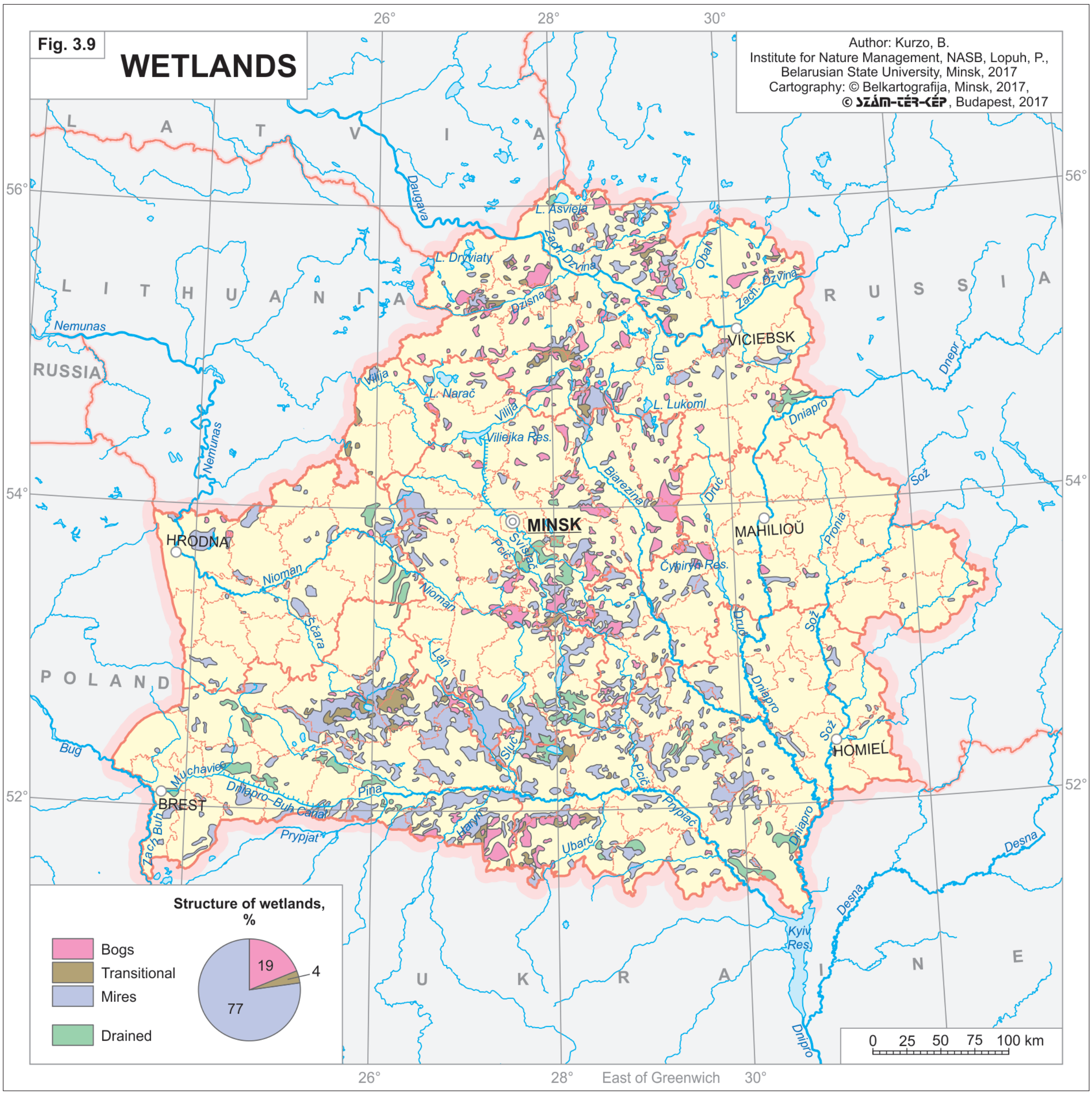
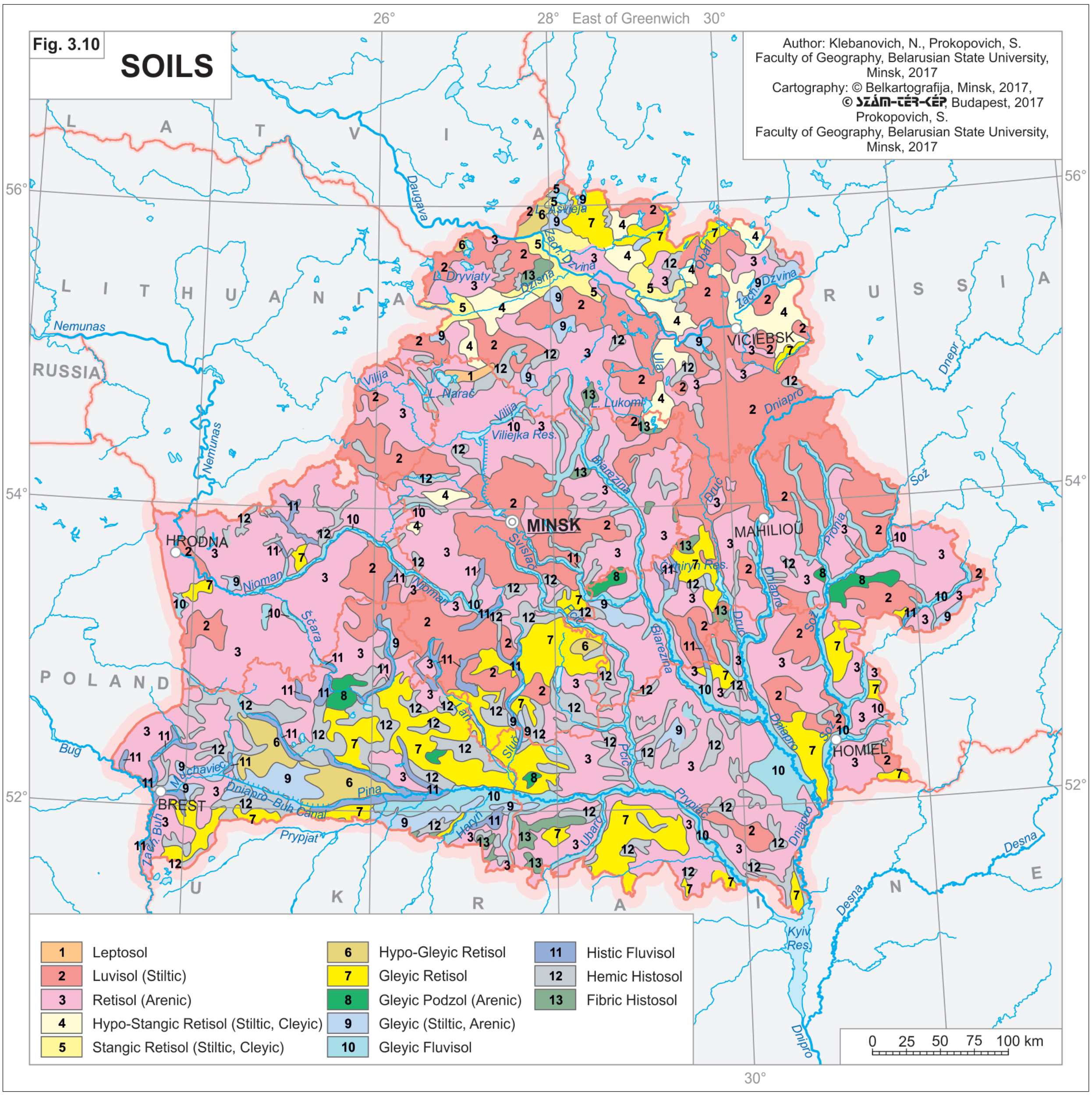


Fig. 3.9 WETLANDS

arable soils have a pH of less than 5.0. The soils of Belarus have a low humus content. Over the past two decades, the average content of humus in arable soils has steadied at 2.2%, an increase over the previous 30 years of 0.5%. Belarus has a relatively high proportion of peat soils.

Vegetation

Two biomes meet on the territory of Belarus: the Eurasian taiga and the European deciduous forest. The proximity of the forest-steppe zone and the complex history of evolution have resulted in a wide variety of flora and vegetation. Natural vegetation covers 66% of the territory of Belarus, comprising forest, meadow, wet shrubs and aquatic vegetation. Forest vegetation is predominant, accounting for 8.2 million ha or 39.4% of the total area (*Figure 3.11*). Belarusian forests are very diverse, with 111 types of forest and more than 800 plant associations. In terms of tree species, the forests are divided into coniferous, mixed, broad-leaved and secondary types. The main forest-forming species is pine, accounting for 50.6% of forested lands. Birch makes up



23.2% of forested lands, spruce – 9.3%, black alder – 8.6%, and oak – 3.4%. Intrazonal meadow vegetation covers 3.2 million ha or 15.6% of the territory of Belarus. Only 873 thousand ha or 2.3% of the territory of the country comprises azonal vegetation of natural swamps, while water vegetation accounts for 470 thousand ha.

Land use

According to the State Land Cadaster of January 1, 2015, the total land area in Belarus is 20.76 million ha, including 8.4 million ha (41.4%) of agricultural land, 9.4 million ha (45.3%) of forest land, 540.0 thousand ha (2.6%) of meadows, 859.2 thousand ha (4.1%) of bogs, 469.2 thousand ha (2.3%) of water areas, 504.2 thousand ha of built-up areas and 396.0 thousand ha of transport and communication areas (*Figure 3.12*).

During the period 1950–2015, substantial changes were seen in the structure of land use. There was a steady fall in the amount of agricultural land, with a decrease of about 2.2 million ha in the 65-year period. At the same time forests and land with shrub vegetation increased by 3.1 million ha.

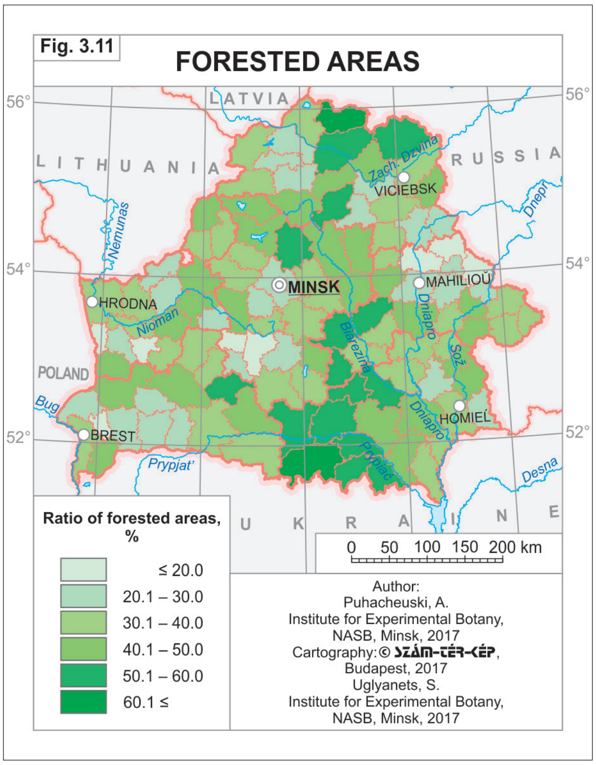


Fig. 3.11 FORESTED AREAS

About 5.5 million ha or 2/3 of agricultural land is arable land. Thus, there are 0.92 hectares of agricultural land per person in Belarus and 0.56 hectares of arable land. Much of the drained land is used by the agriculture. The drained agricultural land area includes 1.8 million ha of mineral soils and 1.1 million ha of peat soils.

The areas affected by Chernobyl radioactive fallout are generally agricultural or forested. More than 1.8 million ha of agricultural land in Belarus (about 20% of its total area) was affected by Cs-137 contamination. Owing to high density contamination, 265.4 thousand ha of agricultural land was withdrawn from use. Over the 30-year post-accident period, the area of agricultural land contaminated by caesium decreased by 35.7%.

Landscapes and physical geographical subdivisions

Two kinds of **landscapes** are dominant in Belarus, covering about 35% of the country: fluvioglacial and secondary-moraine types (*Figure 3.1*). Fluvioglacial landscapes with mixed forests (coniferous and deciduous) on soddy-podzolic sandy soils are widespread at elevations of 140–190 m. These landscapes are mostly uncultivated with a high percentage of forest coverage (up to 40%). Secondary-moraine landscapes with mixed forests on soddy-podzolic sandy-loam soils have arisen on the plains with underlying deposits of moraine with an elevation of 150–180 m.

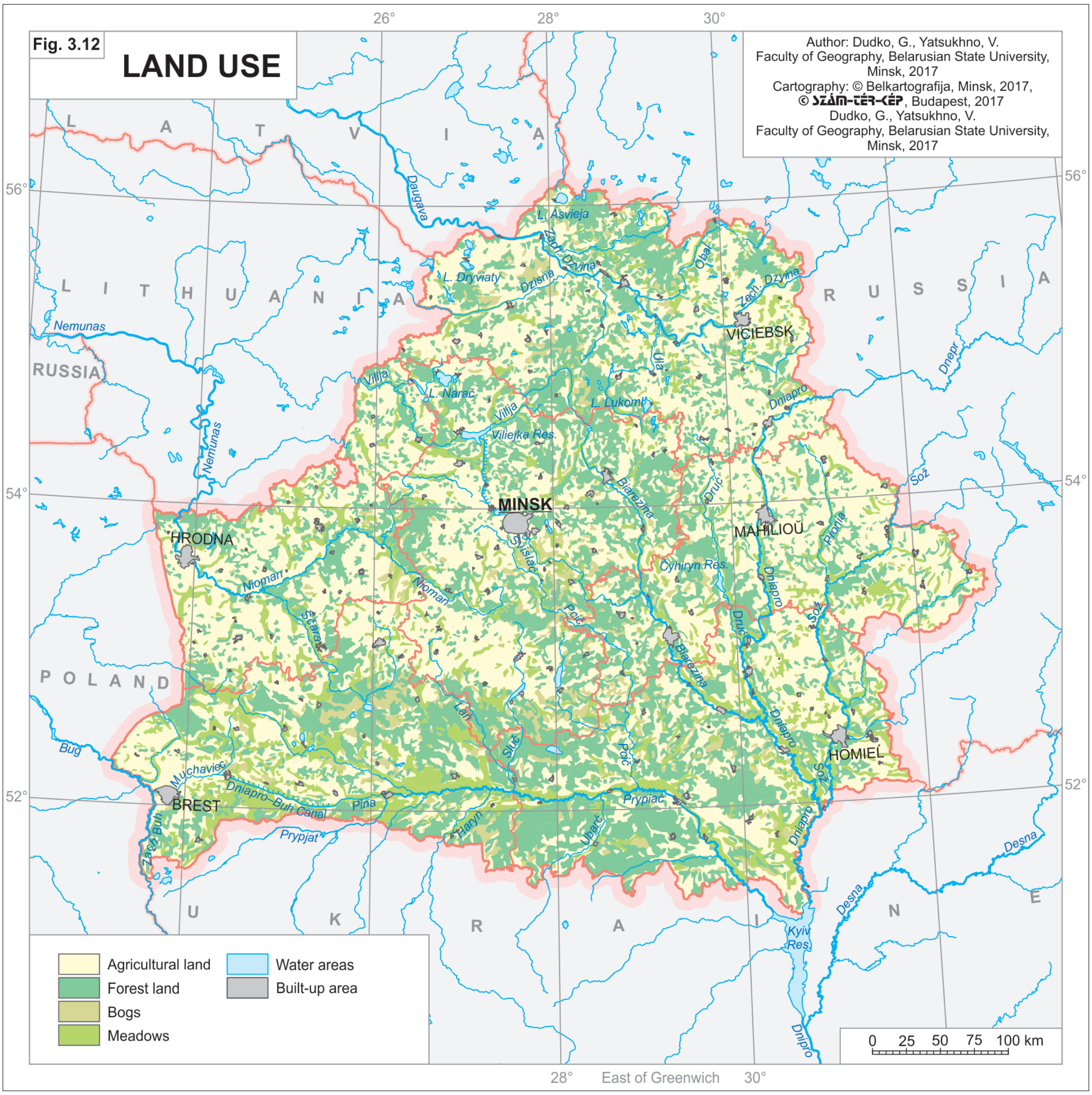
In terms of denudation and geomorphology, conditions change in Belarus from north to south, resulting in latitudinal zoning. The **Belarusian Lakeland** (*Bielaruskaje Paazierje*) in the North is characterized by young geological features that were formed predominantly through the glacial accumulation of the Weichselian (*Paazierje*) glaciation. The main genetic types of relief include marginal glacial uplands and escarpments, as well as ground-moraine plains, which are surrounded by vast areas of flat glacial-lacustrine lowlands and plains with numerous lakes.

The predominantly glacial-accumulative and significantly denuded relief of the Warthe stage of the Saalian (*Sož*) glaciation prevails in the region of hills and ridges of Central Belarus. As a unique geomorphological feature, the WSW-ENE stretching hills of the **Belarusian Range** (*Bielaruskaja hrada*) form the watershed between the drainage basins of the Black and Baltic Seas.

The main relief feature of the **Pre-Paliessie** (*Peradpaliessie*) region are the gently undulating plains, the elevation of which decreases gradually from north to south. In terms of their origin, fluvioglacial (outwash) and moraine-fluvioglacial plains prevail.

The **Belarusian Paliessie** (*Bielaruskaje Paliessie*) includes vast flat and swampy plains with the ancient and flattened relief of the Drenthe stage of the Saalian (*Dniapro*) glaciation, including remnant fragments of marginal glacial formations. In terms of relief genesis, heavily swamped alluvial, lacustrine and lacustrine-alluvial lowlands predominate. Landforms of aeolian accumulation, as well as lake hollows of the remnant and oxbow types, are widespread and various.

The complex **physical-geographical subdivision** developed by Belarusian geographers reflects the structure, diversity and hierarchy of the studied entities. The taxonomic units of the subdivision are as follows: country – province – region (voblasć)- district (*Figure 3.13*). The provinces were established based on their orographic characteristics and elevation. The borders of the



physical-geographical provinces and districts tend to reflect geological or geological-geomorphologic factors.

Environmental quality

The ecological situation of Belarus has been relatively stable in recent years. The national environmental management system, coupled with a high proportion of natural ecosystems (63.6% of the country), provides an acceptable level of environmental quality. Belarus does suffer, however, from environmental problems relating to radiation (see the chapter on Chernobyl), air pollution, pollution of surface and ground water, soil degradation, and waste accumulation.

Air pollution in Belarus is determined by emissions and pollutants from local and transboundary sources. According to research conducted under the auspices of the EMEP Program (Cooperative Program for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe), the following pollut-

Fig. 3.13

PHYSICAL–GEOGRAPHICAL SUBDIVISIONS

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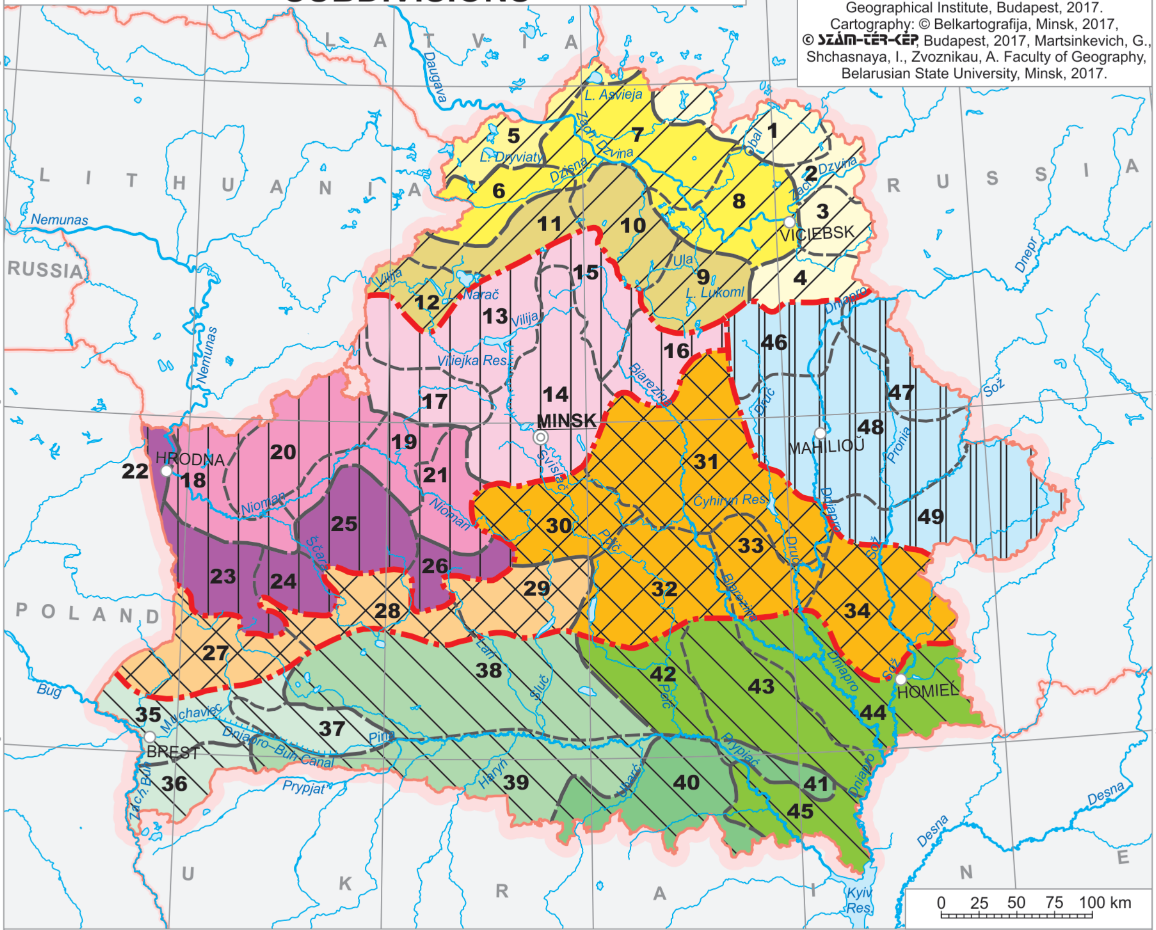


Provinces

- Lakeland
- Western Belarus
- Pre-Paliessie
- Paliessie
- Eastern Belarus

Regions

- Viciebsk Lakeland
- Braslaŭ Lakeland
- Dzvina
- Narač–Ušacy Lakeland
- Central Belarusian Ridge
- Nioman
- Southwestern Belarusian Ridge
- Western Pre-Paliessie
- Eastern Pre-Paliessie
- Bresckae Paliessie
- Prypiackae Paliessie
- Mazyrskae Paliessie
- Homieĺskae Paliessie
- Dniapro

Boundaries

- Provinces
- Regions
- Districts

Districts

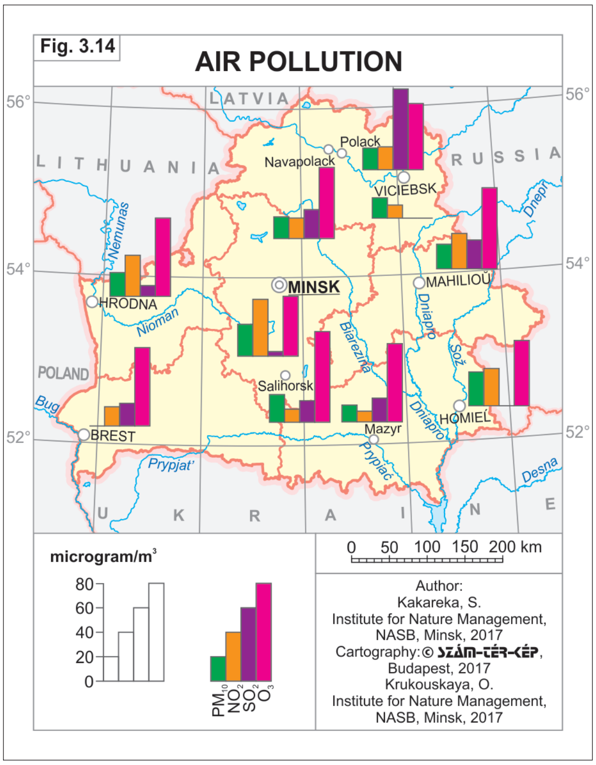
1 Nieščarda–Haradok Upland
2 Suraž Lowland
3 Viciebsk Upland
4 Lučosa Lowland
5 Asveia–Braslaŭ Ridge
6 Dzisna Lowland
7 Polack Lowland
8 Šumilina Plain
9 Čašniki Plain
10 Ušacy–Liepieĺ Upland
11 Švenčionys Ridge
12 Narač Plain
13 Viliejka Plain
14 Ašmiany Upland
15 Minsk Upland
16 Upper Biarezina Lowland
17 Barysaŭ Plain
18 Middle Nioman Lowland
19 Upper Nioman Lowland
20 Lida Plain
21 Stoŭbcy Plain
22 Hrodna Upland
23 Vaŭkavysk Upland
24 Slonim Plain
25 Navahrudak Plain
26 Kapyĺ Ridge
27 Pružany Plain
28 Baranavičy Plain
29 Sluck Plain
30 Puchavičy Plain
31 Central Biarezina Plain
32 Babruisk Plain
33 Ola Plain
34 Čačersk Plain
35 Vysokae Plain
36 Malaryta Plain
37 Zaharadze Plain
38 Jasieĺda–Sluck Lowland
39 Middle Prypiać Lowland
40 Mazyr–Lieĺčycy Plain
41 Chojniki–Brahin Plain
42 Kapatkievičy Plain
43 Vasilievičy Lowland
44 Rečyca–Sož Lowland
45 Kamaryn Lowland
46 Orša Upland
47 Horki–Mscislaŭ Upland
48 Orša–Mahilioŭ Plain
49 Kastiukovičy Plain

ants were annually deposited on the territory of Belarus (2012): 92.9 thousand tonnes of oxidized sulphur, 58.6 thousand tonnes of oxidized nitrogen, 96.0 thousand tonnes of reduced nitrogen. In 2013, annual emissions from local sources amounted to 51.3 thousand tonnes of sulphur dioxide (main sources: power stations, oil refineries), 162.5 thousand tonnes of nitrogen oxide (main sources: road and off-road transport, power stations), and 150.1 thousand tonnes of ammonium (main source: livestock). Since 1990, the national emissions of sulphur dioxide and nitrogen oxide dropped by more than 90% and 63% respectively.

The reduction of ammonium emissions was less significant. In combination with a decreased transboundary flows of sulphur, these developments have resulted in a substantial reduction of acidification loads and a slight decline of eutrophication loads. Since 1980, Belarus has experienced a 79% reduction in total sulphur deposition and a 38% reduction in oxidized nitrogen deposition.

Air pollution levels in Belarus's urban areas are monitored under the National System of Environmental Monitoring. Regular monitoring covers an area inhabited by 87% of the national population. There are 14 automatic and 66 manual monitoring stations (The State of Environment…, 2014). In 2013, the average annual concentration of particulate matter (PM10) in most cities was in the range of 14–31 μg/m^3 (*Figure 3.14*); in most cases, the concentration does not exceed 60% of the annual mean Maximum Permissible Level (MPL), but in Minsk the concentration is 70–90% of the MPL. In several cities, the maximum daily average concentration of PM10 in the air exceeded the MPL by a factor of 1.5 to 3. In 2013, the PM10 daily average exceeded the double of MPL on 17.8% of all days in Minsk and on 11% of all days in Homieĺ (The State of Environment…, 2014).

In 2013, the annual average concentration of nitrogen dioxide in the urban air of Belarus ranged from 11 μg/m^3 to 58 μg/m^3. The daily MPL of nitrogen dioxide was sometimes exceeded in Minsk and Mahilioŭ. Sulphur dioxide usually did not exceed 40–50% of MPL; the daily MPL of sulphur dioxide was sometimes exceeded in Polack and Navapolack. In 2013, in all monitored cities, the daily MPL of ground-level



ozone concentration was exceeded on some days. The number of days with excessive ozone concentration ranged from 14 (in Polack) to 115 (in Salihorsk) and from 6 to 19 in Minsk, depending on the monitoring station.

Surface water quality in Belarus is negatively affected by waste water getting into rivers or lakes. The total amount of waste water entering such bodies of water is approximately 950 million cubic metres per year. The largest amount of waste water is produced by the residential sector and by the power plants. The largest volume of waste water (617 million cubic metres or 69%) is produced in the cities, especially in Minsk, which accounts for around 30% of petroleum products discharged into rivers with sewage, 24% of suspended solids and 21% of organic substances.

Agriculture is the main source of the diffuse pollution of surface and groundwater. The widespread use of inorganic nitrogen and phosphate fertilizers leads to excessive levels of nitrates and phosphates in the groundwater and the eutrophication of surface water.

In this regard, the major pollutants of surface waters are nutrients (ammonium-nitrate, nitrites and phosphates) and organic matter.

According to an assessment using a water pollution index (WPI), the status of surface water in Belarus is satisfactory. In the assessment, most rivers (91% of the observation points) were deemed to be in Quality Class I or Class II (“clean” and “relatively clean”). Some sections of certain rivers (including the Muchaviec and Svislač rivers below Minsk and the River Sož below Homieĺ) were placed in Class III (“moderately polluted”).

The water resources of Belarus are sufficient to provide for current and future water needs for different purposes. The water exploitation index in Belarus (2.8–3.0%) indicates that the total water supply for all sectors of economic activity does not significantly affect the quantitative parameters of the country’s water resources. Domestic water consumption per capita in Belarus is in line with the level of water consumption in most European countries.

Drinking water in Belarus comes mainly from groundwater. In 2013, the Ministry of Health reported that 19.3% of the samples failed to meet health standards based on the sanitary-chemical indicators and 1.4% of the samples failed to accord with standards of microbiological indicators.

The main reason for the poor quality of the groundwater used in the central water supply is the high content of iron and, to a lesser extent, manganese, which is caused by natural factors. In some instances, however, groundwater is polluted by nitrates, ammonium, chloride and other chemicals due to human activities.

Soil pollution. The problem of the chemical contamination of soil is less acute in Belarus than in Western Europe. This reflects a less intense and less prolonged anthropogenic impact on the environment. However, chemical contamination of soils can be observed in certain urban and industrial areas and near major transport routes, municipal and industrial waste dumps, gas and oil facilities, former military bases, mining and other excavation areas.

In urban areas, the major soil pollutants are petroleum products, heavy metals and – to a lesser extent – sulphates and nitrates. Lead and zinc are the principal metal pollutants. The National Environmental Monitoring System revealed that, in one of two of the surveyed settlements, the oil content of the soil exceeds the maximum permissible concentration by a factor of five to fifteen. Meanwhile, zinc exceeds the permissible level by a factor of two or more in 14 cities, as does lead in 9 cities.

The share of zinc-contaminated soil varies from 2.9% in Mazyr to 56.8% in Minsk (2013). The main pollutants in soils near mechanical engineering plants are zinc, cadmium, and – to a lesser extent – copper, nickel, lead and chromium. Soil contamination by polycyclic aromatic hydrocarbons, petroleum products and polychlorinated biphenyls are typical near energy, chemical and petrochemical industrial plants. In general, the chemical contamination of soils in Belarus is local and has no significant impact on the ecological state of the environment at the regional level.

Solid waste. In 2013, about 40 million tonnes of industrial waste and 4 million tonnes of municipal waste were produced in Belarus. The share of halite (rock salt) waste and sludge resulting from the extraction of ore and the production of potash makes up for 50% of the total amount of solid waste. To date, near the town of Salihorsk, about 1 billion tonnes of salt waste have been accumulated. The other type of waste is phosphogypsum, which arises at the Homieĺ Chemical Plant (657.5 thousand tonnes in 2013).

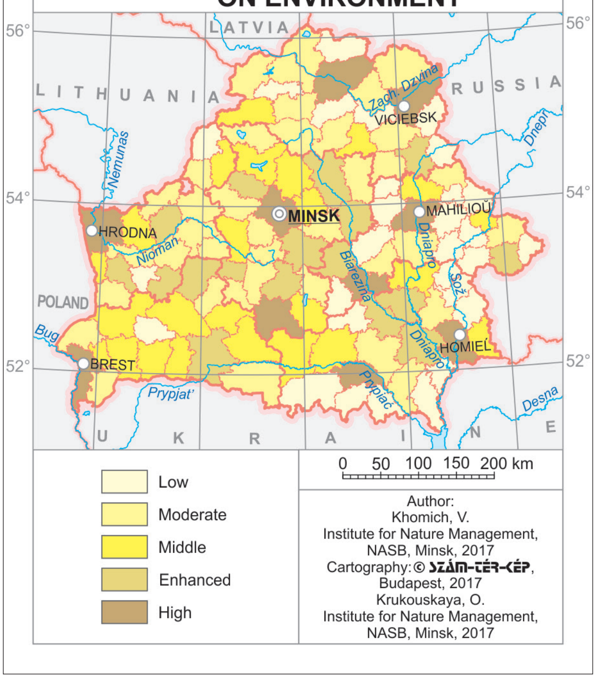


Fig. 3.15 TECHNOGENIC INFLUENCE ON ENVIRONMENT

Almost half of the waste generated in 2013 was recycled; this is the highest value in recent years. The recovery of secondary materials from municipal waste amounted to 8.8%. The accumulation of waste in Belarus is uneven. More than half of the waste is generated in the Minsk region. Unused waste is disposed at more than 200 landfills. Most of these sites have natural or artificial barriers preventing the spread of contamination. However, high concentrations of pollutants exceeding the limit values are observed in the groundwater of many landfills.

Technogenic loads. The extent of the anthropogenic impact on the environment of Belarus (based on the volumes of industrial and municipal waste, the discharge of waste water and emissions into the atmosphere) is shown in *Figure 3.15*. The anthropogenic impact on the environment is most severe in the administrative districts of the major cities and near industrial enterprises: Minsk, Viciebsk, Brest, Homieĺ, Mahilioŭ, Hrodna, Babrujsk, Mazyr, Polack and Salihorsk.

Nature conservation areas

To preserve the landscapes and biological diversity of Belarus, a system of protected areas has been established, including 1 reserve, 4 national parks, 85 nature reserves of national significance, 267 local reserves and 874 nature monuments (*Figure 3.16*). The protected natural areas in Belarus constitute a part of the pan-European ecological network, thereby facilitating the diversity of fauna and flora. In total, the protected areas cover 1,723 thousand hectares, or 8.2% of the national territory. Forests (about 58%), wetlands (about 20%), meadows (about 17%), river valleys and lakes (about 5%) are comprised by the protected natural areas.

The Biarezina Biosphere Reserve, the Bielaviežskaja Pušča (Bielavieža Forest) National Park and the Prybuhskaje Paliessie (literally Palessie along the River Buh) reserve have been recognized by UNESCO as Biosphere Reserves. The Western Paliessie biosphere reserve, which straddles three countries (Belarus, Poland and Ukraine), arose out of the Prybuhskaje Paliessie biosphere reserve. The Bielaviežskaja Pušča National Park features on the UNESCO World Heritage List. Some of the reserves are used by birds during migration and are included on the list of Wetlands of International Importance (Ramsar sites).

The Biarezina Biosphere Reserve was created to preserve large-scale forest-marshes in their natural condition. Such areas used to be common in the zone of mixed forests in Eastern Europe. The Bielaviežskaja Pušča National Park is the oldest

"Mountains" (mine dumps) emerged by human activity on the flat Pre-Paliessie near Salihorsk, one of the largest potash deposits in the world. (Photo: Karácsonyi, D. 2011)

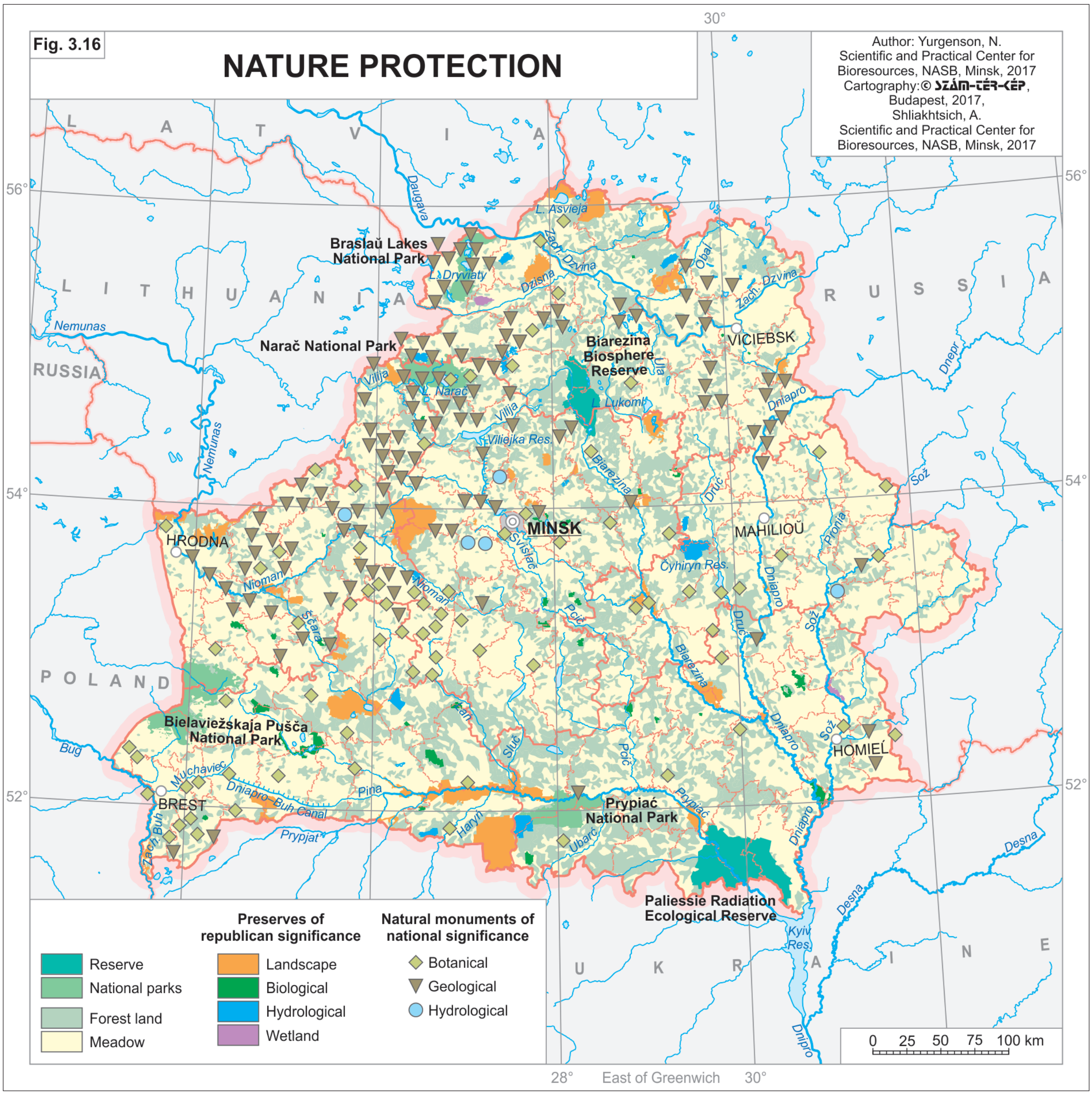


Fig. 3.16 NATURE PROTECTION

reserve in Europe; it was first mentioned in the early 15th century and declared as a royal hunting reserve in 1543. Bielaviežskaja Pušča extends westward also across the border to the territory of Poland and consists of preserved primeval forest areas where many of the trees are 200–300 years old and some oaks are up to 600 years old. The forest is famous for the world's largest wild-ranging herd of the European bison. This species was hunted to complete extinction by the early 20th century, but it survived in some zoos and thus could be reintroduced in the wilderness. Wolves, deer, elk and wild boar appear also in the national park's fauna.

The Braslaŭ Lakes (*Braslaŭskija aziory*) National Park is situated in the north of Belarus. The largest health resort and tourist centre in Belarus arose at the site of the Narač National Park.

The Paliessie Radiation Ecological Reserve lies in the south-east of the country, near the border with Ukraine. The area was exposed to radioactive contamination at the time of the Chernobyl disaster. In a legal sense, it is not one of Belarus's protected areas. Even so, it is a large nature reserve and a unique scientific testing ground for the study of the dynamics of the post-anthropogenic restoration of natural ecosystems.