Chapter 1
Physical Geography of the Czech Republic

Milan Chytrý

Abstract Geodiversity, climate, hydrology and historical and recent effects of humans on land-cover in the Czech Republic are briefly described. The aim of this chapter is to provide basic information necessary for understanding current and historical patterns in the distribution of the flora and vegetation in this country, their ecology and dynamics.

1.1 Introduction

The Czech Republic (*Česká republika*, also called Czechia, *Česko*) is a land-locked country in Central Europe bordering Germany in the west and north-west, Austria in the south, Slovakia in the east and Poland in the north-east. It stretches from 48°33'09"N to 51°03'33"N and from 12°05'33"E to 18°51'33"E (Fig. 1.1). The country's south-north length is 278 km, west-east length 493 km and area 78,870 km^2 (Czech Statistical Office, www.czso.cz).

Historically the country was divided into three lands (Fig. 1.1, see also Chap. 2, this book). The largest land, Bohemia (*Čechy*), in the western part of the country, was the historical Kingdom of Bohemia with the capital city of Prague (*Praha*) in its centre. Moravia (*Morava*) in the east was a margraviate subject to the Kingdom of Bohemia. Silesia (*Slezsko*) was a duchy, which currently mostly belongs to Poland, with a small part extending to the north-east of present-day Czech Republic (sometimes referred to as Czech Silesia). Currently the country is divided into 14 administrative regions that do not respect the borders of the historical lands; however, these lands are still commonly used in botanical literature and will be referred to throughout this book.

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M. Chytrý et al. (eds.), *Flora and Vegetation of the Czech Republic*, Plant and Vegetation 14, DOI 10.1007/978-3-319-63181-3_1

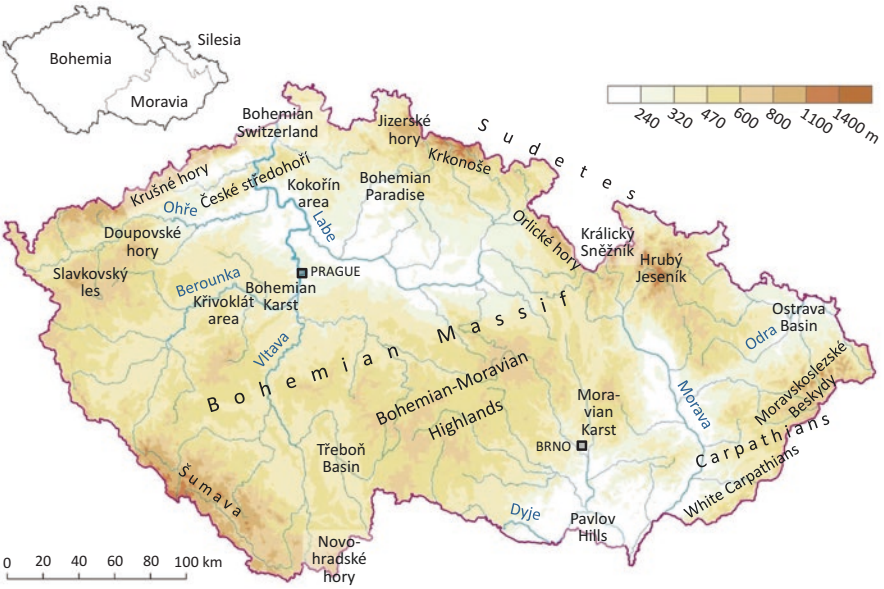

Fig. 1.1 Topographic map of the Czech Republic. See Box 1.1 for a guide to Czech toponyms (all the maps in this chapter were prepared by O. Hájek)

Box 1.1 Czech Topographic Names

Czech belongs to the group of Western Slavic languages, together with Polish and Slovak. Many Czech names of topographic features (e.g. mountain ranges, basins or lowlands) are derived from the names of settlements, to which an adjectival ending is added. For example, the name *Pavlovské vrchy*, literally meaning *Pavlov Hills*, is derived from the village name *Pavlov*. Generic names of topographic features (*vrchy* in this case) are not capitalized in Czech even if they are inseparable part of the toponyms; an exception is the names of towns and villages.

Some better known topographic features in the Czech Republic have established English translations of their Czech names, but most Czech toponyms either have no English equivalent or the equivalent is rarely used and poorly known. In contrast, many Czech toponyms have German equivalents, which for most part are rarely used now, but were routinely used in older botanical literature. The following glossary provides several Czech words that are a common part of topographic names and a list of Czech topographic names frequently used in this book followed by their English and German equivalents. For each name the variant used in this book is set in italics. In most cases, the usage accepted in the recent book *Landscapes and landforms of the Czech Republic* (Pánek and Hradecký 2016) is followed.

(continued)

Box 1.1 (continued)
Frequent Words in Czech Topographic Names

český, -á, -é	1. Czech, 2. Bohemian
dolní	lower
hora, -y	mountain, -s
horní	upper
jezero	lake
jižní	southern
kras	karst
les	forest, woodland, wood
malý, -á, -é	little, small
město	town, city
moravský, -á, -é	Moravian
nížina	lowland
nízký, -á, -é	low
pahorkatina	hilly (colline) landscape
pánev, pánve	basin
potok	brook
řeka	river
rybník	fishpond
severní	northern
skála, -y	rock, -s
slezský	Silesian
údolí	valley
velký, -á, -é	big, great, large
vrch, -y	hill, -s
vrchovina	highland
východní	eastern
západní	western

Historical Lands

Čechy	*Bohemia*	Böhmen
Morava	*Moravia*	Mähren
Slezsko	*Silesia*	Schlesien

Topographic Features

Adršpašsko-teplické skály	*Adršpach-Teplice Rocks*	Adersbach-Weckelsdorfer Felsenstadt
Bílé Karpaty	*White Carpathians*	Weiße Karpaten
České středohoří	n/a	Böhmisches Mittelgebirge

(continued)

Box 1.1 (continued)

České Švýcarsko	*Bohemian Switzerland*	Böhmische Schweiz
Českomoravská vrchovina	*Bohemian-Moravian Highlands*	Böhmisch-Mährische Höhe
Český kras	*Bohemian Karst*	Böhmischer Karst
Český ráj	*Bohemian Paradise*	Böhmisches Paradies
Český masiv	*Bohemian Massif*	Böhmische Masse
Doupovské hory	Doupov Mts	Duppauer Gebirge
Hradčanské stěny	*Hradčany Rocks*	Kummergebirge
Hrubý Jeseník	n/a	Altvatergebirge, Hohes Gesenke
Jizerské hory	Jizera Mts	Isergebirge
Karpaty	*Carpathians*	Karpaten
Kokořínsko	*Kokořín area*	Daubaer Schweiz
Králický Sněžník	n/a	Glatzer Schneeberg
Krkonoše	Giant Mountains	Riesengebirge
Krušné hory	Ore Mts	Erzgebirge
Křivoklátsko	*Křivoklát area*	Pürglitzer Wald
Labské pískovce	*Elbe Sandstones*	Elbsandsteingebirge
Lužické hory	Lusatian Mts	Lausitzer Gebirge
Moravskoslezské Beskydy	Moravian-Silesian Beskids	Mährisch-Schlesische Beskiden
Moravský kras	*Moravian Karst*	Mährischer Karst
Novohradské hory	Nové Hrady Mts	Gratzener Bergland
Orlické hory	Orlice Mts	Adlergebirge
Ostravská pánev	*Ostrava Basin*	Ostrauer Becken
Pavlovské vrchy	*Pavlov Hills*	Pollauer Berge
Praha	*Prague*	Prag
Slavkovský les	Slavkov Forest	Kaiserwald
Sudety	*Sudetes*	Sudeten
Šumava	Bohemian Forest (this term is usually used to include the Šumava Mts, Český les Mts and Bayerischer Wald Mts)	Böhmerwald
Třeboňská pánev	*Třeboň Basin*	Wittingauer Becken
Západní Karpaty	*Western Carpathians*	Westkarpaten

Rivers

Czech names are used for all rivers throughout the text. Large rivers or those shared with other countries are internationally better known under their German names, which are usually used in English-language literature: Dyje – Thaya, Labe – Elbe, Morava – March, Odra – Oder, Ohře – Eger, Vltava – Moldau.

1.2 Geodiversity

The altitudinal range of the Czech Republic is 115–1603 m a.s.l., however, 67% of the area is at altitudes below 500 m and 99% below 1000 m. The mean altitude is 430 m (Czech Statistical Office, www.czso.cz).

The country comprises two major geological units with contrasting topography and landscape features: the Bohemian Massif (*Český masiv*) in the west and the Western Carpathians (*Západní Karpaty*) in the east. The geology of the country is summarized in geological maps (Cháb et al. 2007; mapy.geology.cz) and a reference handbook (Chlupáč et al. 2011), which are used as the main source of the geological information presented in this chapter. Descriptions of the different landscapes in this country are provided by Pánek and Hradecký (2016).

The Bohemian Massif occupies the whole of Bohemia and western and north-western parts of Moravia, extending also to eastern and south-eastern Germany, northern Austria and south-western Poland. It is an old mountain system created by the Variscan (Hercynian) orogeny in the Late Palaeozoic, during which two palaeo-continents, southern Gondwana and northern Laurussia, collided to form the super-continent Pangea. Tectonically the Bohemian Massif is related to other Variscan massifs in France, Belgium and Germany, such as the Armorican Massif, Massif Central, Vosges, Schwarzwald, Ardennes, Rheinisches Schiefergebirge and Harz. Since the Permian the Bohemian Massif has been subject to erosion, which erased its originally rugged mountainous topography and created its current gently undulating landscape (Fig. 1.2a).

The upland areas in the Bohemian Massif are formed mainly of hard, poorly-weathering igneous and metamorphic rocks of Proterozoic and Lower Palaeozoic age, such as granite, granodiorite, gneiss (Fig. 1.2b), schist and granulite, which in places are covered by younger sedimentary or volcanic rocks (Fig. 1.3). Predominant rocks are base-poor and acidic while only small areas of base-rich rocks such as limestone, erlane, amphibolite or serpentinite occur locally. A diverse complex of Proterozoic and Lower Palaeozoic sedimentary and volcanic rocks, called Barrandien, occurs in the area along the Berounka River between the cities of Prague and Plzeň. It is formed mainly of shale and greywacke, with patches of extremely base-poor silicite and quarzite, base-rich volcanic and subvolcanic rocks such as diabase and spilite (Fig. 1.2c), and areas of Silurian and Devonian limestone in the Bohemian Karst between Prague and Beroun. The fine mosaic of base-poor and base-rich, and poorly and easily weathered rocks, supports a highly diverse flora in this region. Another region with a predominance of sedimentary rocks in upland areas occurs along the eastern edge of the Bohemian Massif between the cities of Brno and Opava. Lower Carboniferous base-poor shale and greywacke prevail in this area, though smaller areas of Devonian limestone are also found there, most notably in the Moravian Karst north of Brno (Fig. 1.2d).

The sediments in the Bohemian Massif deposited from the Upper Carboniferous onwards were not influenced by any further orogeny, therefore they are not tilted or folded, still laying horizontally or near-horizontally. Red Permian claystones, sand-

Fig. 1.2 Examples of landforms and bedrocks in the Czech Republic: (**a**) Gently undulating landscape typical of the crystallinic areas of the Bohemian Massif: Pohoří na Šumavě, southern Bohemia; (**b**) Gneiss outcrop at the upper edge of the deep valley of the Dyje River, Podyjí National Park, southern Moravia; (**c**) Outcrop of spilite, a type of Upper Proterozoic basalt, above the Berounka River in the Barrandien zone: Čertova skála near Hracholusky, central Bohemia; (**d**) Pustý žleb, a karst gorge in Devonian limestone in the Moravian Karst, southern Moravia; (**e**) An example of a landscape formed by weathering of Cretaceous sandstone: Prachovské skály, eastern Bohemia. Credits for all photos in this chapter: M. Chytrý

stones and conglomerates, in places calcareous, are present over large areas in central and eastern Bohemia and in the graben *Boskovická brázda* in western Moravia. Triassic and Jurassic rocks are very rare in the Bohemian Massif.

In the Cretaceous period extensive lowland areas in northern, central and eastern Bohemia were flooded by a sea, which left behind two contrasting types of sedi-

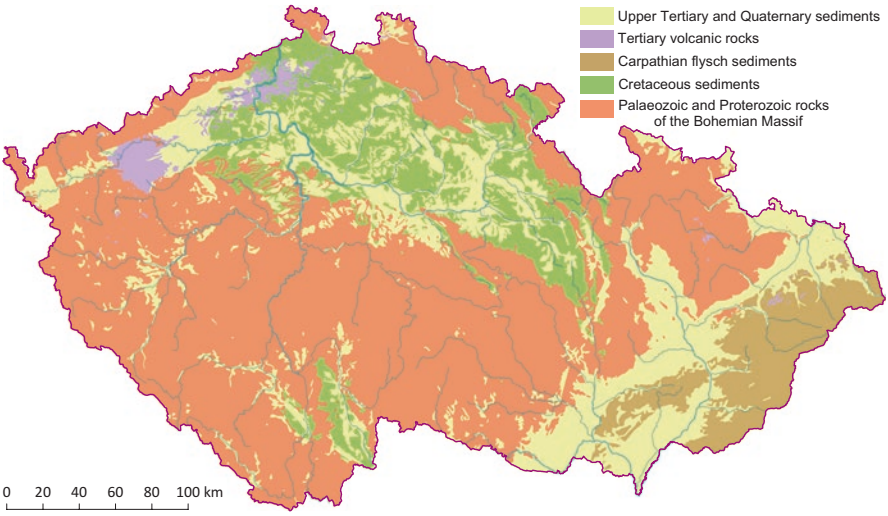

Fig. 1.3 Simplified geological map of the Czech Republic (based on the digital geological map 1:500,000 – GEOČR500 of the Czech Geological Survey 1998)

ments. The first type is acidic siliceous sandstone, which locally forms sandstone pseudokarst areas with deep gorges and isolated rock towers, in Czech called *skalní města*, literally meaning 'rock cities' (Figs. 1.2e and 1.4; Härtel et al. 2007). The second type is a group of soft calcareous sediments, such as marl (Fig. 1.5a), marlite and fine calcareous sandstone, which give rise to gently undulating landforms with fertile base-rich soils. There is a strong contrast between the poor acidophilous flora of vascular plants on the former type and the rich basiphilous flora on the latter type of Cretaceous rocks. Cretaceous sediments also fill two large basins in southern Bohemia, České Budějovice Basin and Třeboň Basin, but here sedimentation occurred in freshwater conditions. The former basin is filled mainly with argillaceous sediments, while base-poor sand prevails in the latter, supporting acidophilous vegetation including peat bogs.

By the Tertiary the Bohemian Massif had been weathered to a gently undulating peneplain, which was broken into smaller tectonic units during the Alpine orogeny. Some of these units were lifted, forming mountain ranges especially along what are now the national borders with Austria, Germany and Poland. The highest of these ranges are the Sudetes along the Czech-Polish border, consisting of several more or less isolated mountain groups, most notably the Krkonoše (Karkonosze in Polish; 1603 m a.s.l.), Králický Sněžník (Śnieżnik Kłódzki in Polish; 1424 m) and Hrubý Jeseník (1491 m). Other prominent mountain ranges are the Krušné hory Mts (1244 m) on the border with Saxony and Šumava Mts (1456 m) on the border with Bavaria and Upper Austria. Since the upheaval of these mountains occurred with little folding, much of their summit areas are gently undulating plateaus, with peatlands in places. In the Pleistocene local glaciers developed on the eastern slopes of some mountain plateaus and formed cirques, especially in the Krkonoše, Hrubý

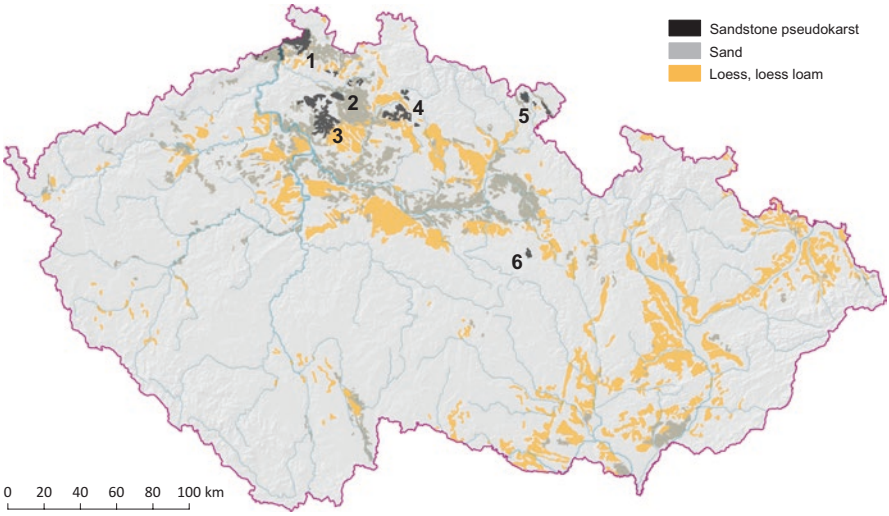

Fig. 1.4 Areas of sandstone pseudokarst (based on topographic maps 1:50,000), sand deposits (based on interpretation of the soil map of the Czech Republic provided by the Czech University of Life Sciences to the Czech National Geoportal at http://geoportal.cenia.cz) and loess accumulations (based on Bajer and Houška 2009). (*1*) Elbe Sandstones (Labské pískovce, including Bohemian Switzerland), (*2*) Hradčany Rocks, (*3*) Kokořín area, (*4*) Bohemian Paradise (Český ráj), (*5*) Broumov area (including the Adršpach-Teplice Rocks), (*6*) Toulovcovy Maštale site

Jeseník and Šumava Mts (Fig. 1.5b). Two valley glaciers developed on the Czech side of the Krkonoše Mts, creating u-shaped elongated troughs of the Labský důl and Obří důl valleys.

In other areas in the Bohemian Massif, most notably in the southern foothills of the Krušné hory Mts, large land masses sank during the Alpine orogeny to form basins that were subsequently filled with Upper Tertiary sediments. Alpine orogeny also caused volcanic activity in the north-western and northern part of the Bohemian Massif, which gave rise to an extensive basalt stratovolcano of the Doupovské hory Mts and a number of isolated volcanic hills in the České středohoří Mts (Fig. 1.5c), which are formed of both base-rich (e.g. basalt) and acidic (e.g. phonolite and trachyte) rocks. These rocks are also typical of the volcanic mountain group of the Lužické hory Mts. Since the Upper Tertiary v-shaped river valleys were deeply cut in hard, poorly weathering rocks in the peneplain landscape in the Bohemian Massif after its upheaval due to the Alpine orogeny. Nowadays these valleys comprise high geodiversity with a broad variety of contrasting vegetation types (e.g. the Vltava, Otava, Lužnice, Berounka, Sázava, Dyje and Jihlava valleys; Fig. 1.6; see also Chap. 7, Sect. 7.4, this book).

Acidic bedrock prevails throughout the Bohemian Massif, especially in the submontane and montane areas. Therefore, local occurrences of limestone or other calcareous rocks (Fig. 1.7) markedly increase local diversity of flora and vegetation. Areas of hard, poorly weathering Silurian and Devonian limestone with well-developed karst features and rendzina soils occur especially in the Bohemian Karst in central Bohemia and Moravian Karst in southern Moravia. Small patches of metamor-

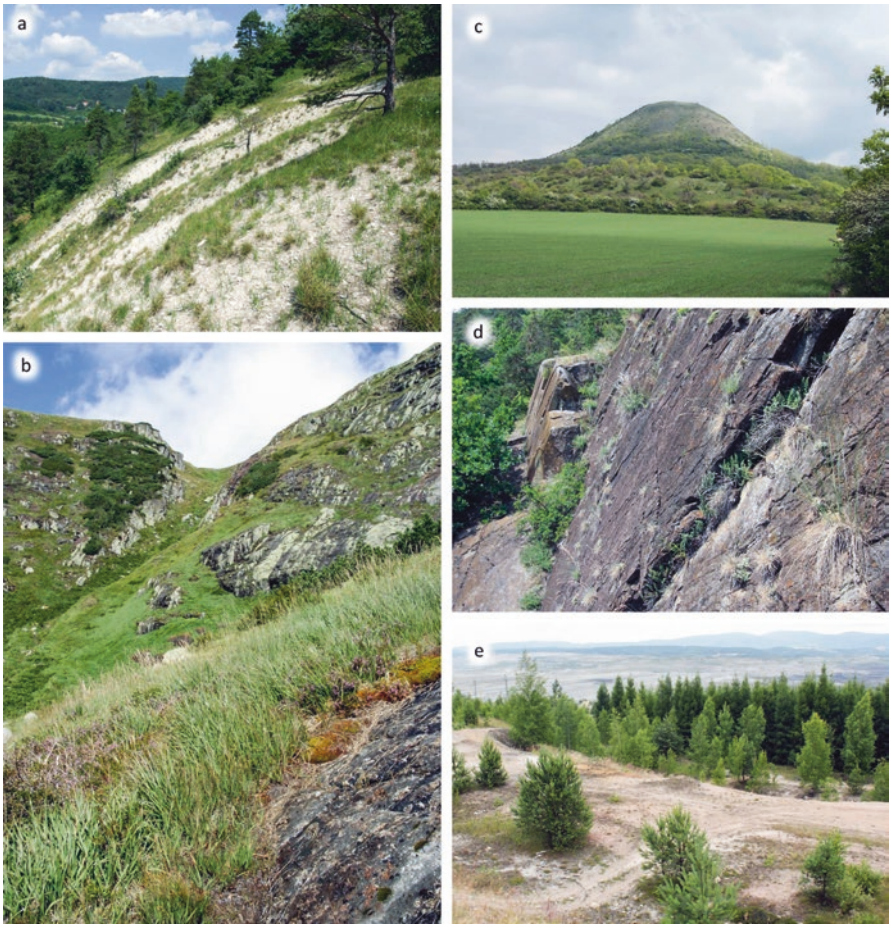

Fig. 1.5 Examples of landforms and bedrocks in the Czech Republic: (**a**) Erosion-prone Cretaceous marl slope near Pokratice, northern Bohemia; (**b**) A glacial cirque in the Velká kotelní jáma in the Krkonoše Mts, eastern Bohemia; (**c**) Oblík, a solitary basalt hill formed as a result of Tertiary volcanism in the České středohoří Mts, northern Bohemia; (**d**) Serpentinite outcrop with the specialist fern *Notholaena marantae* on the slopes of the Jihlava River valley near Mohelno, southern Moravia; (**e**) Landscape in the basins in the foothills of the Krušné hory Mts transformed by open-cast coal mining: Jiří pit near Sokolov, north-western Bohemia

phic limestone (marble), occurring in association with siliceous metamorphic rocks, are found especially in south-western Bohemia (Šumava foothills), north-eastern Bohemia and western Moravia. Other calcareous rocks include sediments of Cretaceous age, which occur mainly in the lowlands in northern, central and eastern Bohemia. Another bedrock type with a strong effect on the local flora and diversity of vegetation is serpentinite, a metamorphic rock rich in magnesium and heavy metals, which is toxic for many plant species. Small patches of serpentinite occur in various areas in the Bohemian Massif, especially in the Slavkovský les Mts in western Bohemia, south-western Bohemia and the Bohemian-Moravian Highlands (Fig. 1.5d).

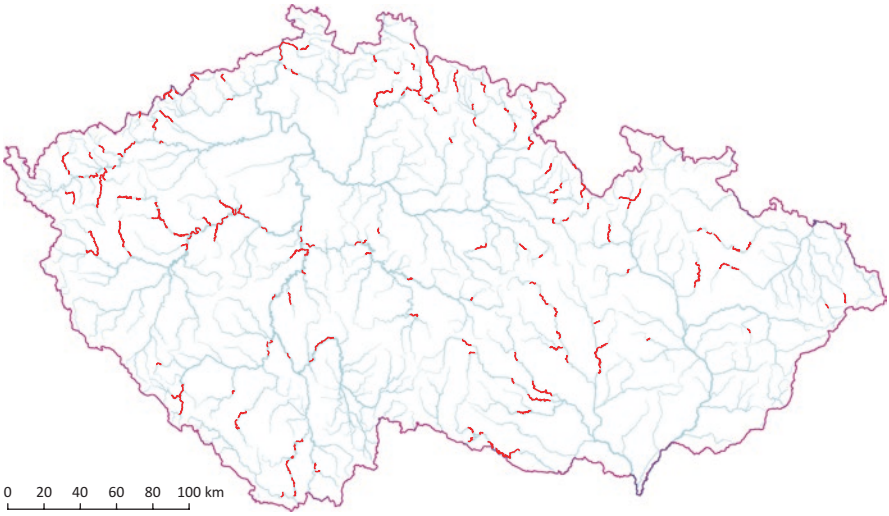

Fig. 1.6 Deep river valleys, defined as areas with altitudinal difference of more than 60 m within 300 m on both sides of the river

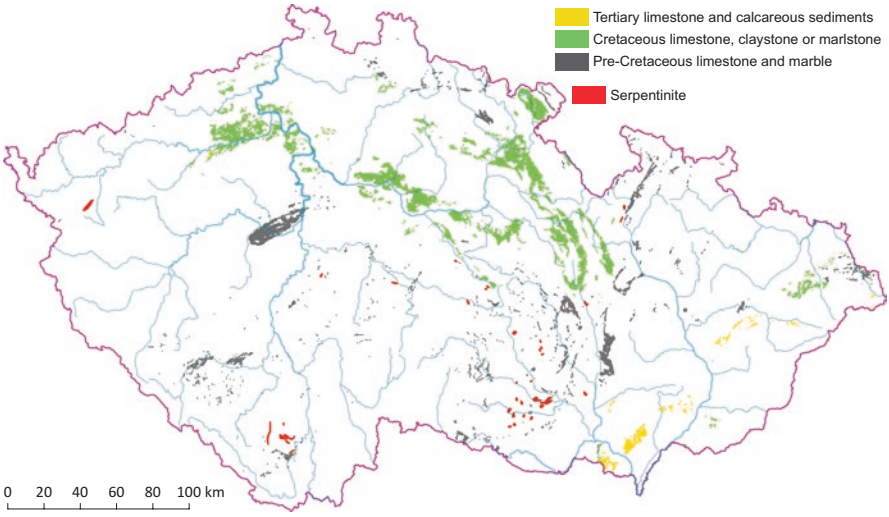

Fig. 1.7 Areas of limestone, related calcareous bedrock and serpentinite (based on the digital geological map of the Czech Republic 1 : 50,000 of the Czech Geological Survey 2004). The map shows all limestone and serpentinite occurrences, including those covered by superficial deposits. (*1*) Bohemian Karst, (*2*) Moravian Karst

Ore has been mined in the Bohemian Massif since prehistory. A massive landscape transformation was caused by open-cast brown coal mining in the second half of the twentieth century, particularly in the 1970s–1980s in the basins at the foot of the Krušné hory Mts in northern and north-western Bohemia. Mining still occurs there, though with lower intensity, leaving large pits and waste dumps, partly rehabilitated, in an area larger than 1000 km^2 (Fig. 1.5e).

The Western Carpathians were formed by the closure of the Tethys Ocean during the Alpine orogeny in the Cretaceous and Tertiary, when oceanic crust was subducted under the African plate and the Western Carpathian rocks were thrust over the margin of the Eurasian plate. Only the Outer Western Carpathians, formed of flysch, are present in the Czech territory (in eastern and southern Moravia; Fig. 1.3). Flysch is a deep-ocean sedimentary sequence of alternating sandstones and claystones deposited by turbidity currents in the foreland basin of the developing Carpathian orogen in the Cretaceous and Palaeogene. With the progressive closure of the Tethys Ocean, the flysch layers were thrust over the margin of the Bohemian Massif, forming a series of nappes (thrust sheets). The highest flysch nappes in the Carpathian part of the Czech Republic are in the Moravskoslezské Beskydy Mts, reaching an altitude of 1323 m.

Flysch is a soft and erosion-prone rock, forming landscapes with gentle slopes and broad valleys. Rock outcrops are very rare in the flysch Carpathians, but fairly common in the Bohemian Massif. Still the topography of the flysch Carpathians, with their nappe structure forming deep valleys and relatively narrow crests (most of them running in a WSW–ENE direction) is more rugged at a coarser scale than that of the Bohemian Massif (Fig. 1.8a, b). Some flysch facies are calcareous (especially in the southern Moravian lowlands and upland fringes including the White Carpathians) while others are acidic (especially in the Moravskoslezské Beskydy Mts in north-eastern Moravia). As the sandstone layers of flysch are water-permeable while the claystone layers hold water, springs and small-scale landslides often occur on slopes of the Outer Western Carpathians. A combination of calcareous and relatively wet soils, otherwise rare in the Czech Republic, occurs on the calcareous flysch facies, supporting species-rich plant communities. Isolated remnant parts of eroded nappes, called klippes, occur at the outer edges of the Western Carpathians. The most prominent klippes are the Pavlov Hills in southern Moravia (Fig. 1.8c) and hills near the town of Štramberk in north-eastern Moravia, both formed of Jurassic and Lower Cretaceous limestone. These limestone klippes are important stepping stones for basiphilous and thermophilous flora.

The Western Carpathians are separated from the Bohemian Massif by the broad elongated Carpathian foreland basin, running in a SW–NE direction across Moravia, which is filled with molasse sediments of Neogene and Quaternary age, e.g. gravel, sand, loam and clay, both acidic and calcareous. The boundary between the Western Carpathians and the Eastern Alps is the Vienna Basin, also filled with Neogene and Quaternary sediments. While its main part is situated in eastern Austria and western Slovakia, it also reaches southern Moravia along the lower Dyje and Morava rivers. The soils developed in these lowland areas are among the most fertile in the country, therefore they were mostly converted to arable land.

Fig. 1.8 Examples of landforms and bedrocks in the Czech Republic: (**a**) A typical topography at higher altitudes in the flysch Carpathians with long valleys and relatively narrow crests, some of them historically used as summer pastures: Mionší, Moravskoslezské Beskydy Mts, Silesia; (**b**) A typical topography at low altitudes in the flysch Carpathians with broad valleys and gentle slopes: Hustopeče, southern Moravia; (**c**) A klippe of Jurassic limestone in a marginal area of the Western Carpathians: Soutěska in the Pavlov Hills, southern Moravia; (**d**) Loess, aeolian sediment deposited in Pleistocene full glacials: Dolní Věstonice, southern Moravia; (**e**) Eroded chernozem below the Pavlov Hills in southern Moravia

Many areas in the Czech Republic below 300 m a.s.l. (or below 400 m in the driest regions) are covered by loess (Figs. 1.4 and 1.8d), a wind-blown calcareous sediment of Pleistocene age (Cilek 2001). Chernozems, black soils with a thick organo-mineral horizon containing charred organic matter, often develop on loess (Fig. 1.8e; Vysloužilová et al. 2014). Also these soils are very fertile and mostly used for agriculture.

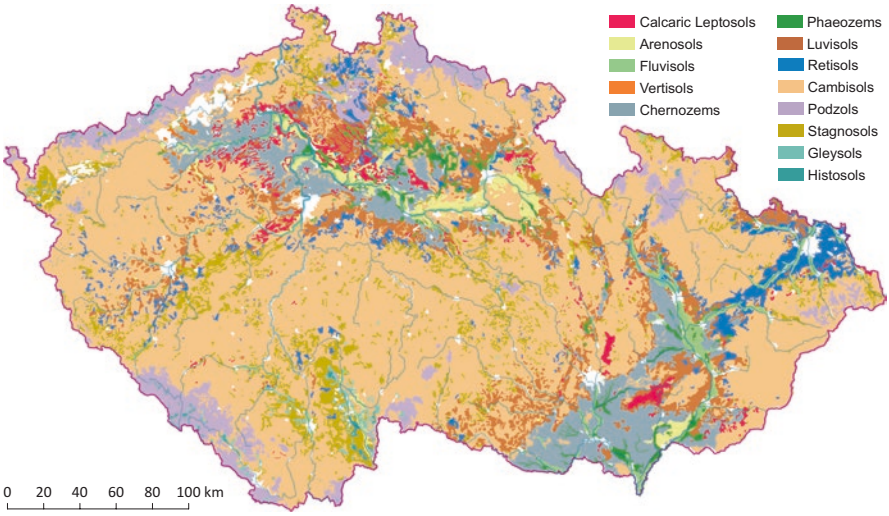

Fig. 1.9 Soil types in the Czech Republic (based on the digital soil map provided by the Czech University of Life Sciences to the Czech National Geoportal at http://geoportal.cenia.cz). Soil types follow the typology and nomenclature of the IUSS Working Group WRB (2015)

The main soil types are chernozems and luvisols in the lowlands, cambisols at middle altitudes and podzols in the mountains (Kozák and Němeček 2010; Vavříček and Pancová Šimková 2014; Fig. 1.9). In general the fertility of soils depends on their richness in mineral nutrients, which decreases from chernozems on loess in the lowlands towards higher altitudes, being lowest in the mountain areas in the Bohemian Massif. In the flysch Carpathians nutrient-rich soils reach on average to higher altitudes than in the Bohemian Massif due to the high sorption capacity of soils developed on flysch sediments (Fig. 1.10; Bajer and Houška 2009). Poor soils also occur on lowland sandy plains, which develop especially along the Labe River in eastern and northern Bohemia, lower Vltava in central Bohemia, Lužnice in southern Bohemia and on the terraces of the Morava and Dyje rivers in southern Moravia (Fig. 1.4).

1.3 Climate

According to the Köppen-Geiger global classification, the climate in the Czech Republic is cold, with warm summers and no dry seasons (Peel et al. 2007). In the bioclimatic classification of Rivas-Martínez et al. (2004), this country has a transitional climate between temperate oceanic in the west (Bohemian Massif) and temperate continental in the east (Carpathians). The climate is seasonal with warm summers, cold winters and two distinct transitional seasons.

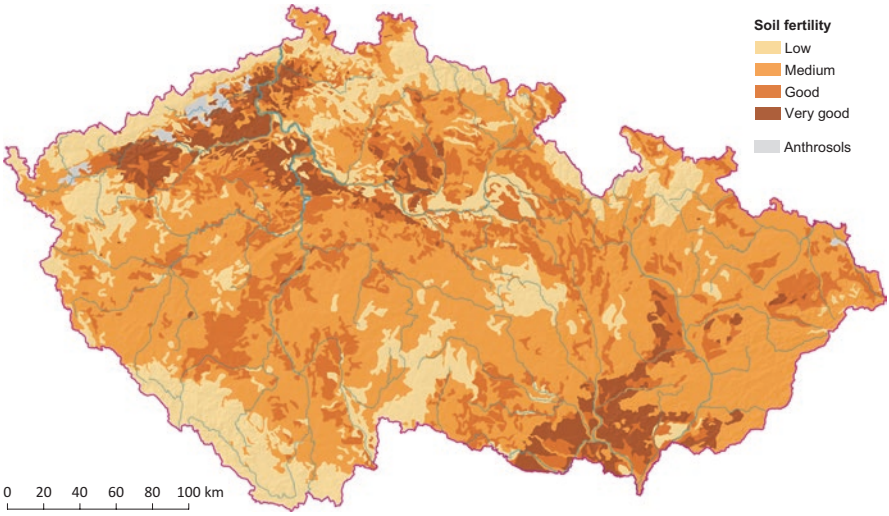

Fig. 1.10 Soil fertility defined by the content of mineral nutrients (based on Bajer and Houška 2009)

Generally, temperature decreases and precipitation increases with altitude in the Czech Republic (Fig. 1.11). Summer and winter temperatures are positively correlated and so is summer and winter precipitation. Both temperature and precipitation peak in July. Lowlands are warm and dry, with a mean annual temperature of 8–9.5 °C (January mean −2 to 0 °C, July mean 18–20 °C) and annual precipitation of 400–600 mm. In contrast, the highest areas in the mountains have a mean annual temperature of about 1–2 °C (January mean about −7 to −6 °C, July mean about 8–10 °C) and annual precipitation of 1200–1400 mm (Tolasz et al. 2007).

Precipitation is brought predominantly by frontal systems originating over the northern part of the Atlantic Ocean. Cool summers and mild wet winters occur in years when there is a large difference in atmospheric pressure between the two major stable pressure areas in the North Atlantic Oscillation (the Icelandic Low and Azores High), which strengthens the westerly wind flow. In contrast, in the years with little difference in pressure westerlies are weaker, which results in hot and dry summers and winters with distinct frosty periods caused by the easy penetration of cold air from North-eastern Europe. These events account for the absence in the Czech Republic of several frost-sensitive species that are widespread at the same latitudes in Western Europe.

The average number of days with snow cover each year ranges from about 30 in the lowlands in Bohemia and southern Moravia up to more than 160 days on the summits of the highest mountains. The average seasonal maximum snow cover depth is less than 15 cm in the lowlands and more than 150 cm in the mountains (Tolasz et al. 2007). In the lowlands snow tends to melt soon after it falls, leaving the landscape without snow cover for most of the winter. Since the periods with temperatures below and above 0 °C alternate frequently in winter, plants in the lowlands are often not protected from frost by an insulating layer of snow.

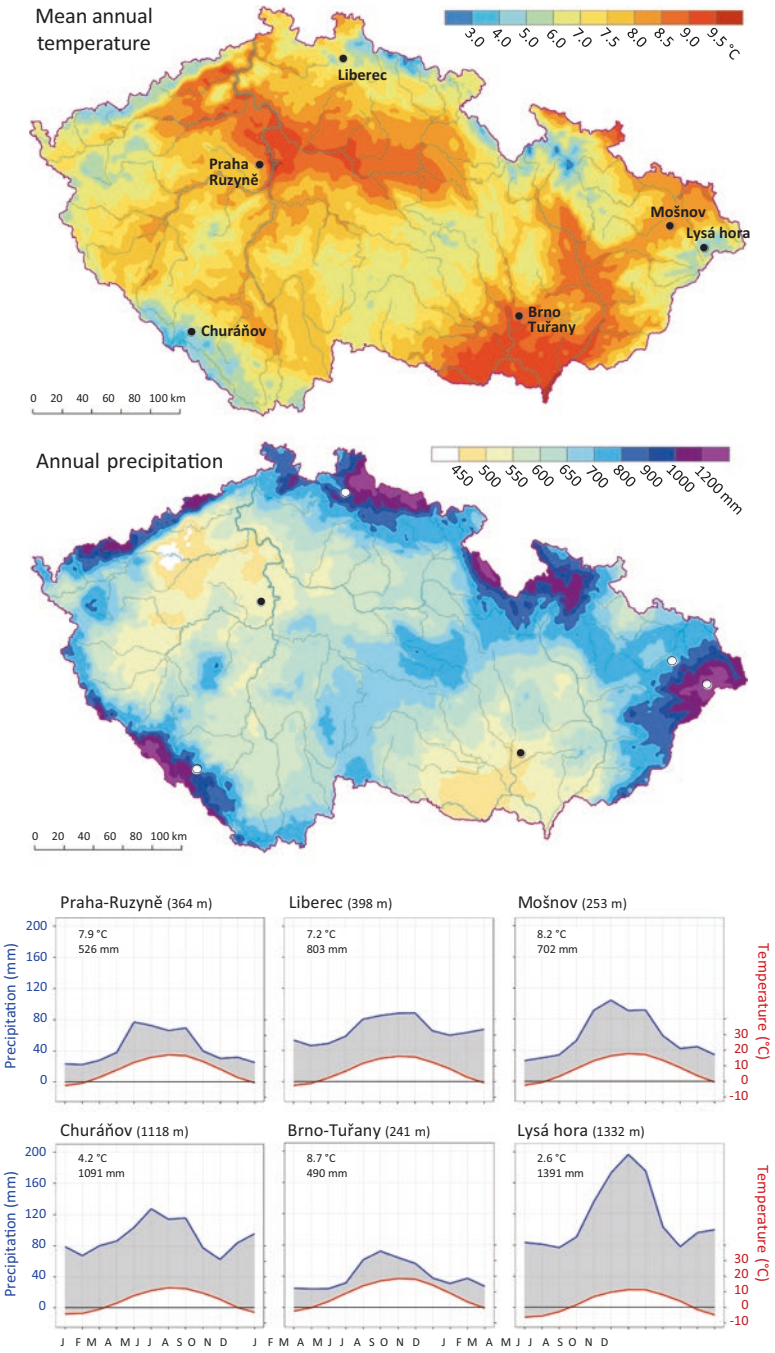

Fig. 1.11 Mean annual temperature and annual precipitation in the Czech Republic (based on the source data for the Climate atlas of Czechia, Tolasz et al. 2007, provided by the Czech Hydrometeorological Institute) and climate diagrams for selected stations based on the measurements from 1961–1990 (data from www.chmu.cz). Locations of the climate stations are shown in the maps

The distribution of precipitation is strongly dependent on topography. The north-western slopes in the mountain systems, facing the moisture-laden westerlies, receive relatively high amounts of precipitation, whereas lowland areas in the lee of these mountain systems are dry due to the rain-shadow effect. The driest area in the Czech Republic is the middle Ohře valley in northern Bohemia, located in the lee of the Krušné hory Mts, which receives less than 450 mm of rain per year, which corresponds to a forest-steppe climate at this latitude. Relatively low amounts of precipitation (below 550 mm) are also typical of the lowland and low hilly areas adjacent to the south and south-east, up to the city of Plzeň in western Bohemia and Prague in central Bohemia (Fig. 1.11: Praha-Ruzyně). Another dry area (with less than 500 mm of precipitation per year) is the lowland part of southern Moravia (Fig. 1.11: Brno-Tuřany), situated to the south-east of the Bohemian-Moravian Highlands. This is not a very high (837 m a.s.l.), but extensive highland system, which also creates a rain-shadow effect. All of these dry areas host numerous species of the continental steppe, some of them at the western limit of their broad temperate Eurasian distribution.

Another lowland area in the Czech Republic, the Ostrava Basin in north-eastern Moravia and adjacent margins of the Silesian Lowlands (Fig. 1.11: Mošnov), is much wetter than the lowlands in northern Bohemia and southern Moravia because of its location at the foot of a windward front ridge in the Moravskoslezské Beskydy Mts. Being relatively warm, this area receives 650–800 mm of precipitation per year, which makes it an exception from the general negative correlation between temperature and precipitation across the remaining area of the Czech Republic.

1.4 Hydrology

The Czech Republic is situated on the continental divide of Europe, with the Labe (Elbe) River draining most of the area of Bohemia into the North Sea, the Odra (Oder) River draining Silesia and a part of northern Moravia into the Baltic Sea and the Morava (March) River draining most of Moravia through the Danube to the Black Sea. All the major Czech rivers originate in this country or in the borderland mountains. For most Czech rivers the peaks in discharge occur in March and April due to snow melt in the mountains, while the period of low discharge generally lasts from June to November. Only in the rivers belonging to the Odra catchment, which receives a higher mean precipitation than other catchment areas in the country, the period of relatively high discharge lasts until July (Tyl 2009; Vlnas 2009).

Natural lakes are very rare in the Czech Republic, except for small lakes in river floodplains and mire complexes (Vondrák et al. 2015). The general lack of lakes is in marked contrast to that in nearby areas that were glaciated in the Pleistocene including the Alps, their foothills, and northern German and Polish lowlands. Only five lakes of glacial origin occur in cirques in the Šumava Mts, the largest being

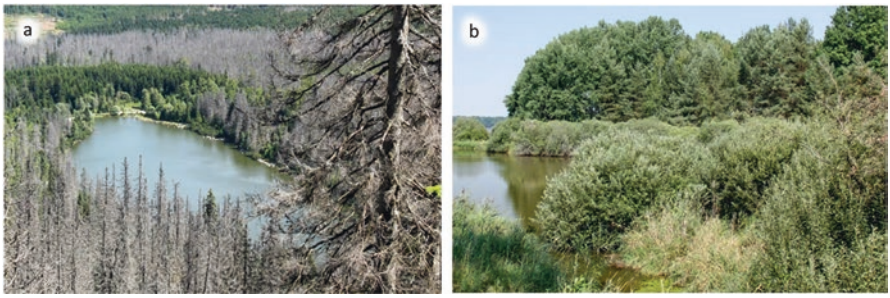

Fig. 1.12 Examples of water bodies in the Czech Republic: (**a**) Plešné Lake in a glacial cirque in the Šumava Mts is one of six recently still existing glacial lakes in the Czech Republic. Natural spruce forest around this lake was damaged by a bark beetle outbreak; (**b**) The shore of Rožmberk, the largest Czech fishpond, built in the sixteenth century, is fringed with marshes and willow and alder carrs: Třeboň, southern Bohemia

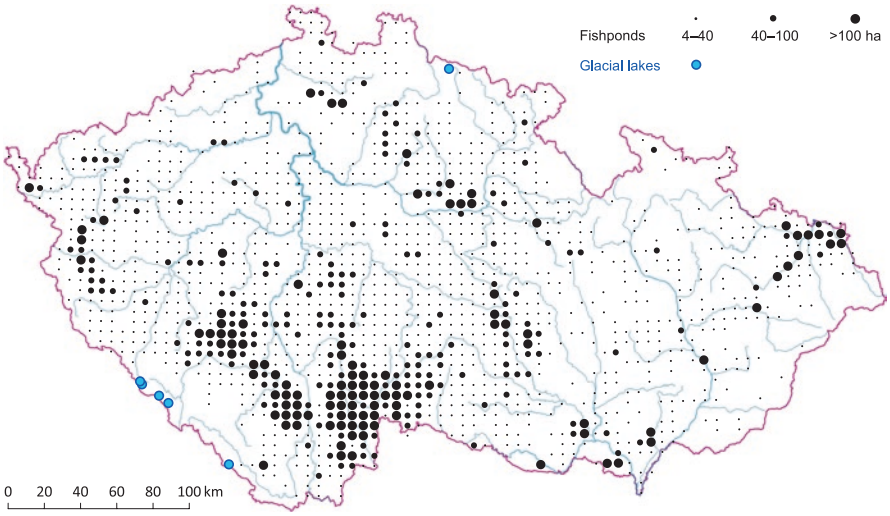

Fig. 1.13 Distribution of fishponds and glacial lakes. Dot sizes for fishponds indicate summed hectarage of fishponds per grid square of 3 × 5 geographical minutes. Blue dots for glacial lakes indicate their exact position

Černé Lake (18 ha), followed by the lakes Čertovo, Plešné (Fig. 1.12a), Prášilské and Laka (Fig. 1.13). The Krkonoše Mts have large glacial lakes on the Polish side, whereas a large lake on the Czech side of these mountains disappeared due to terrestrialization in the Early Holocene (Engel et al. 2010). Currently only one very small glacial lake (~470 m^2) remains on the Czech side (Engel et al. 2003). Several natural lakes occurred also in the lowlands, most of them originating in the Late Glacial period. Saline lakes existed in southern Moravia near the villages Měnín,

Čejč and Kobylí. These lowland lakes vanished due to either natural terrestrialization in the Holocene or draining by humans, mainly in the nineteenth century (Břízová 2009; Jankovská and Pokorný 2013; Vondrák et al. 2015).

A typical feature of the Czech landscape is fishponds, shallow water reservoirs built from the eleventh century onwards for fish farming. The main species farmed has always been common carp (*Cyprinus carpio*), which requires warm and shallow water. Therefore, most of the fishponds were built in the lowlands or mid-altitude basins and are on average about 2 m deep. In the heydays of fish farming at the turn of the seventeenth century there were about 70,000 fishponds in the Bohemian lands. Later on, many of them, especially those in the lowlands, were drained to obtain agricultural land, and currently there are about 25,000 fishponds (Čítek et al. 1998). The largest extant fishpond, Rožmberk near Třeboň in southern Bohemia, has an area of almost 500 ha (Fig. 1.12b). The fishponds are concentrated mainly in the basins of southern Bohemia around Blatná, České Budějovice and Třeboň, in the Ostrava Basin in north-eastern Moravia and Silesia and in flat areas in the Bohemian-Moravian Highlands (Fig. 1.13). Further artificial lakes were built by damming deep river valleys, most notably on the Vltava River, during the twentieth century, for hydroelectricity production and flood protection. Unlike the fishponds, these water reservoirs are deep, with steep shores that provide few opportunities for the development of wetland habitats. A large system of shallow artificial lakes with a total area of 32 km^2 was built on the Dyje River in the lowland area of southern Moravia in the 1970s–1980s, destroying unique floodplain ecosystems.

1.5 Human Effects on Land-Cover

The territory of the current Czech Republic was inhabited by humans already in the Palaeolithic, but more significant effects of humans on land-cover probably only occurred in the Neolithic, which started here ~7600 years before present. Until the Early Middle Ages, human settlements and agriculture were concentrated in the warm and dry lowlands along the lower Ohře and Labe rivers in northern, central and eastern Bohemia, and in the Moravian lowlands along the Dyje, Jihlava, Svratka, Morava and Odra rivers. This old-settlement area occupied less than 30% of the total area of the country (Boháč 1987; Nováková 2009). In some periods, most notably in the Bronze and Iron Ages, isolated areas were settled also at lower altitudes in western or southern Bohemia, namely in the Plzeň region and the Vltava and Otava valleys (Čížecký and Dreslerová in Pokorný 2011). Boháč (1987) estimated the population in the territory of the current Czech Republic at ~100,000 people in the Roman Period and ~680,000 people in the Early Middle Ages (AD 1000).

Long-term agricultural activities and collection of firewood contributed to landscape openness in the old-settlement area, whereas higher altitudes both in the Bohemian Massif and the Carpathians were covered by pristine forest until the Early Middle Ages. A dramatic change occurred between the late twelfth and late

fourteenth centuries, when many new villages and towns were founded and the mid-altitude areas were deforested and colonized, partly by a German-speaking population coming from other areas of Central Europe (Klápště 2012). By the end of fourteenth century, the population reached ~3 millions and the previously isolated deforested areas in Bohemia and Moravia were connected (Boháč 1987). Only the highest areas in the mountains remained continuously forested. However, because of wars and plague outbreaks, population numbers subsequently declined and remained below two million between the fifteenth and seventeenth centuries (Fialová 2007).

While the colonization of the higher altitudes on the topographically relatively gentle Bohemian Massif was proceeding by gradual extension of the deforested area, creating a matrix of open land with patches of woodland, in the more rugged landscapes of the higher altitudes of the flysch Carpathians the settlements remained concentrated in the lower parts of the valleys. During the so-called Wallachian colonization in the sixteenth and early seventeenth centuries, a livestock grazing system using mountain summer pastures was introduced in the Moravian Carpathians, resulting in deforestation of the summit areas, which were used as summer pastures for livestock (Futák 2008). However, forest was generally preserved in the belt between the valley bottoms and range summits. The highest mountain ranges in the Bohemian Massif were colonized even later. In the Krkonoše Mts summer or permanent chalets were established near or above the timberline in the seventeenth and eighteenth centuries, supporting mountain pastoralism and hay making (Krahulec et al. 1997). The Šumava Mts, forming the state border between Bohemia and Bavaria, had a very sparse network of settlements even in the Modern Period, with most of them along trade trails. Unlike other mountain areas in Central Europe, it escaped pastoral colonization, probably because of the lack of an alpine zone. Its central part was colonized only in the eighteenth century (Beneš 1996).

Rapid population growth in Bohemia and Moravia started after the end of Thirty Year's War in 1648, continuing until World War II. Increasing deforestation led Empress Maria Theresa to issue the forest regulation orders for Bohemia (1754), Moravia (1756) and Silesia (1769), which prevented forest grazing, leading to separation of forests from grasslands and reversing the trend of forest decline (Nožička 1957). Previous diffuse transitions between forests and grasslands were replaced by sharp borders in the first half of the nineteenth century when the so-called stable cadastre was established for the purpose of the calculation of land taxes, in which strictly defined land-use was assigned to each plot (Brůna et al. 2005). Forests were further markedly changed due the advent of plantation forestry at the turn of nineteenth century, based mainly on monocultures of spruce and pine (*Picea abies* and *Pinus sylvestris*, both native trees of this country; Nožička 1957). In spite of large qualitative changes in forests, their total area and spatial pattern in the country has been relatively stable from the mid-nineteenth century to the present, covering about one third of the territory (Bičík and Krupková 2009a; Fig. 1.14a). Grasslands also changed considerably between mid-eighteenth and mid-nineteenth century.

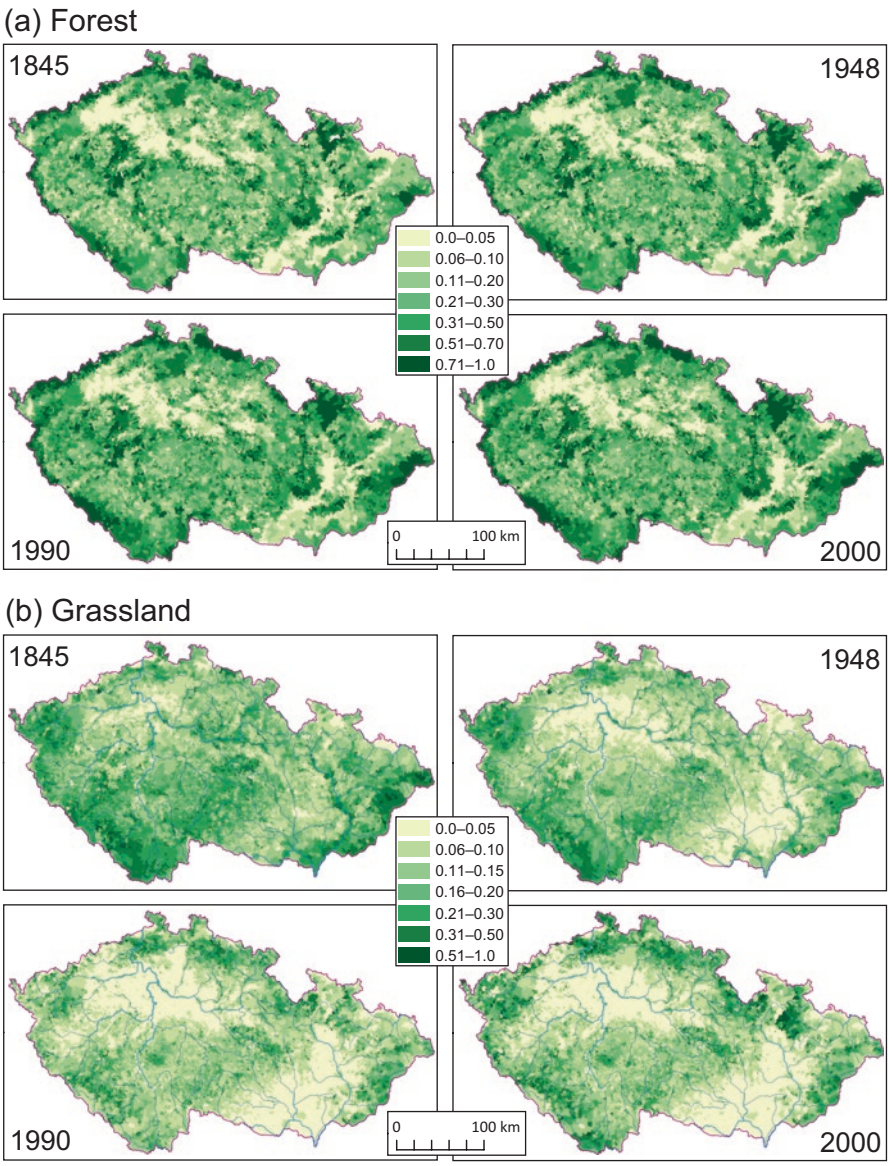

Fig. 1.14 Changes in the area of forest and grassland between 1845 and 2000. Numbers are proportions of forest and grassland areas in territorial administrative units (based on the data provided by LUCC Czechia, Charles University; http://web.natur.cuni.cz/ksgrrsek/lucc)

The growing population required an increase in agricultural production, which was achieved partly by extension of arable land, partly by intensification through the application of farmyard manure. Livestock was therefore increasingly moved from free ranging to enclosures, and required additional feeding by hay. As a result, grasslands were separated into pastures and hay meadows (Hejcman et al. 2013).

In 1930 the area of the current Czech Republic reached a population of 10.7 million (Czech Statistical Office, http://bit.ly/2pn3jDp), corresponding to 135 people per km^2. This was historically the highest count of all population censuses (the 2011 census reported 10.4 million people). The decline to 8.9 million in 1950 was partly due to war casualties and partly due to forced emigration of citizens of German nationality after World War II. Before the war, ethnic Germans were the prevailing nationality in the areas adjacent to the national borders with Germany (including German Silesia, currently in Poland) and Austria. Some of these areas were repopulated by Czechs, others were depopulated and abandoned. Some of them were converted into military training areas, the largest one (332 km^2) being in the Doupovské hory Mts in north-western Bohemia. Others became a part of the so-called Iron Curtain, a prohibited strip of land on the border between communist Czechoslovakia and Western Germany or Austria. Large-scale spontaneous succession towards woodland occurred on former arable land, grasslands and even at the sites of abandoned villages in these areas (Kopecký and Vojta 2009).

Huge changes in agricultural landscapes occurred across the whole country in the 1950s as a result of the introduction of collective farming enforced by the communist government. Small private fields were united, forming large uniform areas of arable land that replaced the heterogeneous environment of previous farmland. Agricultural intensification with heavy machinery, artificial fertilizers and pesticides was supported by government subsidies to the cooperative farms. Intensive management was increasingly applied not only to arable land, but also to grasslands. In contrast, remote, poorly accessible or less productive areas of agricultural land were gradually abandoned and left to spontaneous succession towards scrub and forest. Post-war agricultural intensification was associated with a decline in the number of people involved in agriculture (in 2015 less than 3% of Czech employees worked in agriculture and forestry; Czech Statistical Office, http://bit.ly/2pDiLum). Consequently, the heterogeneous agricultural landscape typical of the period between 1850 and 1950, which was maintained by various activities of numerous small land owners, was replaced by a coarse mosaic consisting of large patches with homogenized management. This landscape transformation is associated with the loss of valuable natural or semi-natural habitats, especially grasslands (Bičík and Krupková 2009b; Fig. 1.14b), and a decline in quality and biodiversity of most habitat types. Further changes in land-cover occurred after the break-up of the communist regime in 1989, when both arable farming and animal husbandry became unprofitable in many areas after the cessation of governmental subsidies to cooperative and state-run farms. Large areas of arable land, especially at higher altitudes, were converted into grasslands, but at the same time many grasslands were abandoned because of the decrease in demand for pasture land and hay (Bičík and Krupková 2009b; Fig. 1.14b).

Acknowledgements I thank Jiří Danihelka, Handrij Härtel, Zdeněk Kaplan, Zdeněk Palice and Marinus Werger for comments on this text, Ondřej Hájek for preparing the maps, Kryštof Chytrý for preparing an R script for climate diagrams and technical processing of photographic plates, Pavel Dřevojan and Zuzana Sixtová for editing the list of references, Tony Dixon for English proofreading and Irena Axmanová for her help with proof correcting. The work was supported by the Czech Science Foundation (project no. 14-36079G, Centre of Excellence Pladias).

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