HIERARCHICAL AND MULTI-SCALE PEDOCLIMATIC ZONATION

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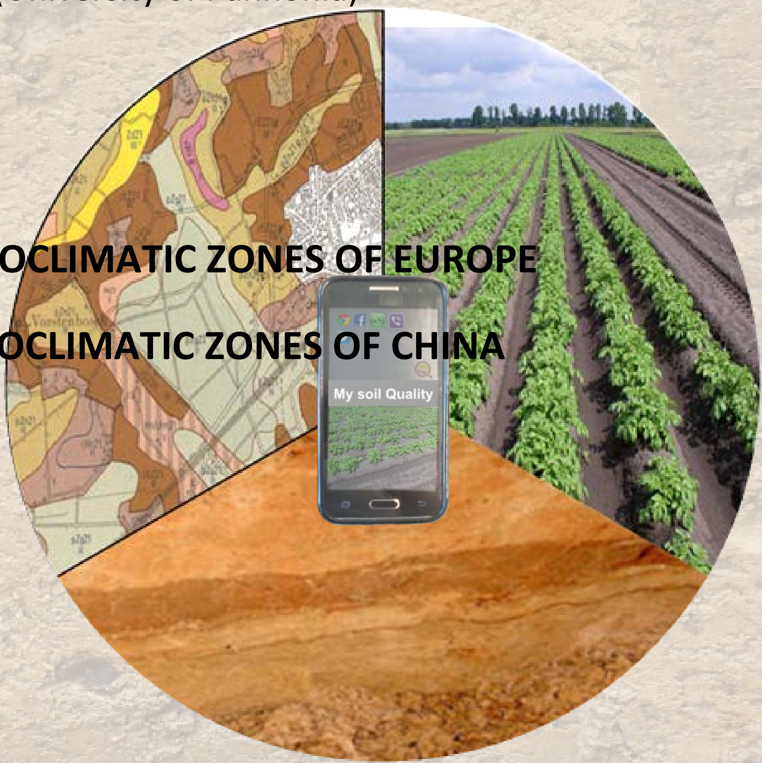

PART A. PEDOCLIMATIC ZONES OF EUROPE

PART B. PEDOCLIMATIC ZONES OF CHINA

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Hierarchical and multi-scale pedo-climatic zonation

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PART A. PEDOCLIMATIC ZONES OF EUROPE

1. Introduction

This report details the data used, methods applied and the results of the assessment which was performed to delineate pedoclimatic zones in Europe.

Soil forms a continuum that comprises many biological, chemical and physical characteristics. A marked spatial and temporal variability of soil characteristics over climatic zones makes building pedoclimatic zonation difficult, even if we consider climatic zones distinct, which is not always the case in reality. In addition, there is a common opinion that different soil classifications result in different pattern of soil representation, namely different soil maps.

The current report overviews soils of European classified in a standard scheme which is the World Reference Base for Soil Resources (WRB; FAO 1998). This system originates from the approach of the FAO to correlate soil resources globally.

The aim of the current pedoclimatic zonation was to support the interpretation of soil resources by providing detailed pedoclimatic data that can be later used for studies on optimizing land use for local climatic and soil condition.

For that aim we analysed the combination of climatic zones with soil information of Europe.

Spatial extent of Reference Soil Groups represent the major units of pedoclimatic zones.

Scale-dependency of different levels of pedo-climatic zones is a key issue. To answer the challenge to provide more information with increasing accuracy when turning to finer scales in the assessment, pedoclimatic zones were subdivided by detailed pedological information. Differentiation was achived by intoducing second level soil qualifyiers within the pedoclimatic zones which hold information on are potentials of soil water and nutrient status and dynamics. This approach secures the basis for the second level of the multiscale assessment. Further semantic details should be introduced based on detailed information based on case studies, including primary data, such as measured nutrient (NPK) levels.

This report provides an in depth summary on the availability of spatial soil information at continental level organized by main climatic and pedoclimatic zones. In order to provide reference to basic soil-forming factors vith a view to consequent soil characteristics an overview is provided by Reference Soil Groups.

2. Data and methods used for delineating pedoclimatic zones

2.1 Climate data: Climatic Areas of Europe (Hartwich et al. 2005)

Europe has diverse climatic conditions, represented by climatic zones and areas (FAO 1990, Köppen 1936, Hartwich et al. 2005). Rainfall characteristics and temperature regime seem to provide sufficient information for continental scale agro-meteorological zonalisation (Bouma 2005). The limiting effect of radiation is less articulated in most of Europe than that of rainfall or temperature. Differences in the radiation intensity can therefore be expressed through the above two factors and through terrain characteristics (slope and its orientation).

Among the available alternative climate zone data layers, the one using the Köppen (1936) classification was found to provide wast areas for one zomne within Eurpe and a few minor zones, which were than not sufficient for meaningful pedological characterization within.

Climatic zonation based on the 35 climatic areas of Hartwich et al. (2005) served as spatial units for the assessments on the continental scale in Europe. Regrouping of the Climatic Areas was performed to create climatic zones for pedoclimatic zonation, as developed by Tóth et al (2013) for the productivity evaluation of European soils (Figure 1). This approach had two main advanatages. First, the final number of zones (eight) sufficiently subdivide the continent for modeling soil-climate interactions and second, this was already proven for soil productivity modeling, which is one of the main subject of the iSQAPER project as well, namely through delineating pedoclimatic zones on the basis of biophysical determinants of net primary productivity.

Figure 1. Climatic zones of Europe

The 35 Climatic Areas of Europe (Hartwich et al. 2005) were arranged into eight climatic groups accordingly (Figure 1). The climatic groups embody regions where the concepts of Boreal to Sub-Boreal (CZ1), Atlantic (CZ2), Sub-oceanic (CZ3) Northern sub-continental (CZ4), Mediterranean semi-arid (CZ5), Southern sub-continental, (CZ6), Mediterranean (temperate and sub-oceanic) (CZ7) and Temperate mountainous (CZ8) soil processes prevail. Pedological assessemnt under different climatic conditions was therefore performed in a spatially explicit manner within these climatic zones.

2.2 Soil data: Soil Geographical Database of Eurasia at scale 1:1,000,000 (SGDBE)

The Soil Geographical Database of Eurasia (SGDBE) has been used as the original source of information for our current pedoclimatic zonation.

The Soil Geographical Database of Eurasia at scale 1:1,000,000 is part of the European Soil Information System (van Liedekerke et al. 2004, Panagos 2006) and is the resulting product of a collaborative project involving soil survey institutions and soil specialists in Europe and neighboring countries.

The SGDBE consists of both a geometrical dataset and a semantic dataset (set of attribute files) which links attribute values to the polygons of the geometrical dataset.

The database contains a list of Soil Typological Units (STU). Besides the higher level soil taxonomic classification units represented by a soil name, these units are described by variables (attributes) specifying the nature and properties of the soils: for example the texture, the water regime, the stoniness, etc. In our current soil mapping exercise we process the soil taxonomic component (first level taxonomic classes: Reference Soil Groups; second level taxonomic classes: soil units, composed by RSGs and qualifiers) included in the STU.

The geographical representation was chosen at a scale corresponding to the 1:1,000,000. At this scale, it is not feasible to delineate the STUs. Therefore they are grouped into Soil Mapping Units (SMU) to form soil associations and to illustrate the functioning of pedological systems within the landscapes. Each SMU corresponds to a part of the mapped territory and as such is represented by one or more polygons in a geometrical dataset.

Harmonization of the soil data from the member countries is based on a dictionary giving the definition for each occurrence of the variables. Considering the scale, the precision of the variables is weak. Furthermore these variables were estimated over large areas by expert judgment rather than measured on local soil samples. This expertise results from synthesis and generalization tasks of national or regional maps published at more detailed scales, for example 1:50,000 or 1:25,000 scales. Delineation of the Soil Mapping Units is also the result of expertise and experience. Heterogeneity can be considerable in European regions.

The spatial variability of soils is very important and is difficult to express at global levels of precision. Quality indices of the information (purity and confidence level) are included with the data in order to guide usage.

The Joint Research Centre (JRC) of the European Commission has developed a CDROM with full documentation of the SGDBE. The detailed documentation contains:

- Brief introduction
- Metadata (general description of the database (purpose, history, etc.).
- Database dictionary (implementation details of the database structure in the ArcInfo GIS software environment)
- Attribute coding (detailed description of the database attribute values)

This detailed documentation can be found on-line in (JRC2008): http://eusoils.jrc.it/ESDB_Archive/ESDBv2/index.htm

Additionally, raster maps have been created with a cell size 10 km x 10 km and 1 km x 1 km. The Raster Library of the European Soil Data Center provides public access and data descriptions to these maps on the EUsoils website: http://esdac.jrc.ec.europa.eu/.

2.3 Nomenclature of soil types

The Soil Geographical Database of Eurasia (SGDBE) contains information on soil name and soil characteristics. The methodology originally used to differentiate and name the main soil types is based on the terminology of the FAO legend for the Soil Map of the World at scale 1:5,000,000 (FAO et al. 1974, 1990). This terminology has been refined and adapted to take account of the specificities of the landscapes in Europe. The FAO legend is itself founded on the distinction of the main pedogenetic processes leading to soil differentiation: brunification, lessivage, podzolisation, hydromorphy, etc.

The Scientific Committee of the European Soil Bureau decided to use both the World Reference Base for Soil Resources (WRB; FAO 1998), as recommended by the International Union of Soil Sciences, and the FAO 1990 Soil Legend (FAO 1990) for defining soil names of the Soil Typological Units of the database.

Since the last update of the SGDBE, a new edition of the WRB has been published (FAO 2006) with structural changes in the designation of Reference Soil Groups and introducing two new Reference Soil Groups (Technosols and Stagnosols), new qualifiers, and changes in the application of qualifiers. The SGDBE holds data based on the correlation of soil types of the national soil inventories according to the 1998 edition of the WRB. Therefore, we present the areal specification of soil units with their name according to the scheme of the 1998 edition of the WRB. Significant feature of the WRB is that it uses two main levels of soil identification. The 'Reference base' is limited to the first level only, having 30 Reference Soil Groups (RSGs). Twenty-three of the thirty Reference Soil Groups of the WRB can be found in the SGDBE with relevance to the European Union.

Soil units in the climatic zones are presented on the second level of the hierarchy. Soil units are composed by the combination of Reference Soil Groups with qualifiers. Qualifiers correspond to special characteristics affecting the primary soil features. Qualifiers are included in the soil name (as prefix or suffix of the RSG) and allow a more accurate description of soil. The WRB is a non-hierarchical system (Krasilnikov 2002), hence, it sets priorities for sequencing qualifiers thus recognizing the different importance of certain soil characteristics within the RSGs. Description of the qualifiers with relevance to the soils of Europe presented in this report.

2.4 Mapping pedoclimatic zones

Map polygons of regrouped climatic areas of Hartwich at el (2005) and the European Soil Database were overlayed to create pedoclimatic zones. Pedoclimatic zones have two attributes: their climate component (the climate zone they belong to) and their soil component (the area of the corresponding Reference Soil Group). This report presents an overview of pedological feautures in each climatic zones. A map of continental coverage is created to provide a synopsis of the main Reference Soil Groups of the EU in their spatial pedoclimatic context. Table 1. dispays the coding system applied when creating pedoclima zones. (Figure 2. in Chapeter 4. of this report shows the pedoclimatic zones in their spatial context.. The supplementing figures and tables in Chapter 5. show detailed information on the extent of each RSG and their soil units in the climate zones. Maps of soil units are available electronically for further use.)

The legend of the Soil Map of the European Union comprises soil units grouped into 23 Reference Soil Groups (of 10 sets). In the case of the overview map a single RSG is shown for each polygon. This approach is based on the methodology used for the original Soil Map of the European Communities (CEC 1985) and the original Soil Map of the World (FAO 1985). The projection of the pedoclimatic map is the "GISCO Lambert System" (GISCO, 2001) which is a metrical Lambert Azimuthal Equal Area system given by the following parameters: Projection: LAMBERT_AZIMUTHAL, Units: METRES, Spheroid: SPHERE, Parameters: radius of the sphere of reference (metres): 6378388.0; longitude of centre of projection: 9° 0' 0.0''; latitude of centre of projection: 48° 0' 0.0''; false easting (metres): 0.0; false northing (metres): 0.0

3. Main features of soils in pedoclimatic zones

Descriptions of the main pedological features is provided in this section, which is largely based on (1.) Soil Map of the European Communities 1:1 000 000 (CEC 1985) (2.) Lecture Notes on the Major Soils of the World (FAO 2001) (3.) World reference base for soil resources (FAO 1998) and (4.) Soils of the European Union (Tóth et al. 2008). Based on the concept of dominant identifiers, i.e. the soil forming factors or processes that most clearly condition the soil formation Reference Soil Groups of the WRB are aggregated in 10 sets (Table 1, based on FAO 2001). Main characteristics of soil formation associated to each set holds information on the soil processes which can be utilized for modeling soil functions and soil use.

Table 1. Sets of Reference Soil Groups based on WRB 1998 (FAO 2001)

SET #	Main feature	Reference Soil Group (RSG)	Code of the RSG
SET #1	Organic soils	HISTOSOLS*	HS
SET #2	Mineral soils whose formation was conditioned by human influences (not confined to any particular region)	ANTHROSOLS*	AT
SET #3	Mineral soils whose formation was conditioned by their parent material	ANDOSOLS*	AN
	- Soils developed in volcanic material	ARENOSOLS*	AR
	- Soils developed in residual and shifting sands	VERTISOLS*	VR
	- Soils developed in expanding clays		
SET #4	Mineral soils whose formation was conditioned by the topography/physiography of the terrain	FLUVISOLS*	FL
	- Soils in lowlands (wetlands) with level topography	GLEYSOLS*	GL
	- Soils in elevated regions with non-level topography	LEPTOSOLS*	LP
		REGOSOLS*	RG
SET #5	Mineral soils whose formation is conditioned by their limited age (not confined to any particular region)	CAMBISOLS*	CM
SET #6	Mineral soils whose formation was conditioned by climate: (sub-)humid tropics	PLINTHOSOLS	PT
		FERRALSOLS	FR
		NITISOLS	NT
		ACRISOLS*	AC
		ALISOLS	AL
		LIXISOLS	LX
SET #7	Mineral soils whose formation was conditioned by climate: arid and semi-arid regions	SOLONCHAKS*	SC
		SOLONETZ*	SN
		GYPSISOLS*	GY
		DURISOLS	DU
		CALCISOLS*	CL
SET #8	Mineral soils whose formation was conditioned by climate: steppes and steppic regions	KASTANOZEMS*	KS
		CHERNOZEMS*	CH
		PHAEOZEMS*	PH
SET #9	Mineral soils whose formation was conditioned by climate: (sub-)humid temperate regions	PODZOLS*	PZ
		PLANOSOLS*	PL
		ALBELUVISOLS*	AB
		LUVISOLS*	LV
		UMBRISOLS*	UM
SET #10	Mineral soils whose formation was conditioned by climate: permafrost regions	CRYOSOLS	CR

* Reference Soil Groups found in Europe.

3.1. Main features of Reference Soil Groups, the pedological determinants of pedoclimatic zones

Spatial extent of Reference Soil Groups represent the major units of pedoclimatic zones. These are further differentiated by the second level soil qualifyiers to enhance pedological information within the pedoclimatic zones. In this chapter an introduction to the major feautres of the Reference Soil Groups is provided. Our current summary builts on previous assessents on the soils of Europe, notably on the reports of the Soil Resources in Europe (Jones et al. 2005), the Soils of The European Union (Tóth et al 2008.) and the Soil Atlas of Europe (ESBN-EC 2005).

Acrisols

Acrisols are highly weathered soils occurring in warm temperate regions and the wetter parts of the tropics and subtropics. Acrisols develop mostly on old land surfaces with hilly or undulating topography with a natural vegetation type of a light forest. Being quite sensitive to erosion, Acrisols are often the dominant soil group on old erosional or depositional surfaces.
There are approximately 10 million km2 of Acrisols world-wide.

Acrisols can be characterized by accumulation of low activity clays in an argic subsurface horizon and by a low base saturation level. The chemical properties of Acrisols are quite poor, containing low level of nutrients and high levels of aluminum. These conditions mean rather limited soil use options.

Most of the European Acrisols are located as associated soils on the Iberian Peninsula and in Greece, but also can be found in Southern England, Denmark and in limited areas in Romania and Bulgaria.

Albeluvisols

Albeluvisols generally develop on flat or undulating plains of unconsolidated glacial till, materials of lacustrine or fluvial origin and of aeolian deposits (loess) under harsh climate with precipitation of 500-1000 mm/year evenly distributed over the year or with a peak in the beginning of the summer. Most Albeluvisols occur under forest.

Profiles of Albeluvisols have a dark, thin ochric surface horizon over an albic subsurface horizon that tongues into an underlying brown clay illuviation horizon. Stagnic soil properties are common in boreal Albeluvisols.
Low nutrient status, acidity, tillage and drainage problems are serious limitations for the use of Albeluvisols, which are extended by the short growing season. Common international names are Podzoluvisols (FAO), Derno-podzolic or Ortho-podzolic soils (Russia) and several suborders of the Alfisols (Soil Taxonomy).

Albeluvisols cover high percentage of land in the Boreal zone in Europe, spanning from the Atlantic coast of France to the Baltic States and further t East, North-East. Distribution of Albiluvisols follows a climatic pattern with cold winters and precipitation evenly spread during the year. While being associated mainly with Luviosls and Podzols in most parts of Western and Northern Europe, Albeluvisols dominate in some regions in south-western France, Belgium and in Lithuania.

Andosols

Andosols are azonal soils developed on volcanic deposits and are found in all climates and at all altitudes in volcanic regions all over the world. The total Andosol area is estimated at some 1.1 million km2 or less than 1 of the global land surface. Andosols are characterised by the presence of either an andic horizon or a vitric horizon. An andic horizon is rich in allophanes (and similar minerals) or aluminium-humus complexes whereas a vitric horizon contains an abundance of volcanic glass.

Andosols typically have a dark humic A horizon on top of a brown B- or C-horizon. Topsoil and subsoil colours are
distinctly different. The average organic matter content of the surface horizon is about 8 but some varieties may contain as much as 30 organic matter. The surface horizon is very porous and the good aggregate stability of Andosols and their high permeability to water make these soils both fertile and relatively resistant to water erosion.

Other international names are Andisols (Soil Taxonomy), Vitrisols (France) and volcanic ash soil.

Large continuous areas with Andosols of Europe are found in the Massif Central of France, in the North-Eastern Carpathians in Romania and in the coastal volcanic areas of Sardinia and continental Italy.

Anthrosols

The Reference Soil Group of the Anthrosols holds soils that were formed or profoundly modified through human activities such as addition of organic materials or household wastes, irrigation or cultivation.
Plaggic Anthrosols have the characteristic horizon plaggic produced by long-continued addition of `pot stable' bedding material, a mixture of organic manure and earth. The man-made character of the plaggic horizon is evident from fragments of brick and pottery and/or from high levels of extractable phosphorus (more than 250 mg P2O5 per kg by 1 citric acid).

The formation of most plaggic horizons started in the medieval times when farmers applied a system of `mixed farming' combining arable cropping with grazing of sheep and cattle on communal pasture land. In places, the system was in use for more than a thousand years evidenced by a plaggic horizon of more than 1 meter in thickness
Plaggic and Terric Anthrosols are well-drained because of their thickened A-horizon

The physical characteristics of plaggic and terric horizons are excellent: penetration resistance is low and permits unhindered rooting, the pores are of various sizes and interconnected and the storage capacity of available soil moisture is high if compared to that of the underlying soil material. Mild organic matter in the surface soil stabilizes the structure of the soil and lowers its susceptibility to slaking. The upper part of a plaggic or terric horizon may become somewhat dense if tillage is done with heavy (vibrating) machinery.

Based on the SGDBE Anthrosols cover land area in Europe predominantly around Belgium, the Netherlands and, to a smaller extent, in north-west Germany. Anthrosols form associations mostly with Podzols, Gleysols and Arenosols.

Arenosols

Arenosols are azonal soils with course texture to a depth of one meter or to a hard layer. They are developed both in residual sands, in situ after weathering of old, usually quartz-rich soil material or rock, and in recently deposited sands as occur in deserts and beach lands. Arenosols are present in all continents and cover around 7 of the earth surface (approximately 9 million km2) thus being one of the most common soil group in the world.
Arenosols in the Temperate Zone show signs of more advanced soil formation than Arenosols in arid regions. They occur predominantly in fluvio-glacial, alluvial, lacustrine, marine or aeolian quartzitic sands of very young to Tertiary age.

Soil formation is limited by low weathering rate and frequent erosion of the surface. If vegetation has not developed, shifting sands dominate. Accumulation of organic matter in the top horizon and/or lamellae of clay, and/or humus and iron complexes, mark periods of stability. Arenosols are easyly erodable with slow weathering rate, low water and nutrient holding capacity and low base saturation. However, the high permeability and easy workability qualifies these soils for high agricultural potential depending on the availability of water and fertilization.

Arenosols cover nearly 5% of the land surface of Europe. Major areas of Arenosols are located on the north-eastern regions of the continent. However, certain regions in Central Europe, the UK, France, Portugal and Spain are also covered by Arenosols.

Calcisols

Calcisols are soil with significant accumulation of secondary calcium carbonates, generally developed in dry areas. Soils belonging to this Reference Soil Group are common on calcareous parent material in regions with distinct dry seasons, as well as in dry areas where carbonate-rich groundwater comes near the surface. The total Calcisol area amounts to some 10 million km2, nearly all of it in the arid and semi-arid (sub)tropics of both hemispheres.

Many Calcisols are old soils if counted in years but their development was slowed down by recurrent periods of drought in which such important soil forming processes as chemical weathering, accumulation of organic matter and translocation of clay came to a virtual standstill. However, most Calcisols have substantial movement and accumulation of calcium-carbonate within the soil profile. The precipitation may occur as pseudomycelium (root channels filled with fine calcite), nodules or even in continuous layers of soft or hard lime (calcrete).

Most Calcisols have a thin (=<10 cm) brown or pale brown surface horizon over a slightly darker subsurface horizon and/or a yellowish brown subsoil that is speckled with white calcite mottles. The organic matter content of the surface soil is low, in line with the sparse vegetation and rapid decomposition of vegetal debris.

Most Calcisols have a medium or fine texture and good water holding properties. Slaking and crust formation may hinder the infiltration of rain and irrigation water, particularly where surface soils are silty. Surface run-off over the bare soil causes sheet wash and gully erosion and, in places, exposure of a petrocalcic horizon.

Vast areas of ‘natural’ Calcisols occur under shrubs, grasses and herbs and are used for extensive grazing. Drought-tolerant crops such as sunflower might be grown rain-fed, preferably after one or a few fallow years, but Calcisols reach their full productive capacity only when carefully irrigated.

Formerly Calcisols were internationally known as Desert Soil and Takyrs.

Calcisols cover less than 10,000 km2 land surface of Europe. Calcisols occur in two countries, being dominant on the islands of Malta and covering about 1.7 of total land area of Spain.

Cambisols

A Cambisol is a young soil. Pedogenic processes are evident from color development and/or structure formation below the surface horizon. Cambisols occur in a wide variety of environments around the world (15M km2 global coverage) and under all kinds of vegetation. Cambiols in the international classifications are referred to as brown soil, Braunerde (Germany), Sols bruns (France) or Brunizems (Russia). The USDA Soil Taxonomy classifies Cambisols as Inceptisols.

Soil types in the Calcisol Reference Soil Group account for the most widespread soils in Europe, covering more then a quarter of its territory. Cambisols can be found nearly all regions of the EU.

Chernozems

Chernozems are typically found in the long-grass steppe regions of the world, especially in Eastern Europe, Ukraine, Russia, Canada and the USA. Chernozem soil has a very dark brown or blackish surface horizon with a significant accumulation of organic matter and a high pH. Calcium carbonate accumulation in the lower part of the surface soil is common (within 50 cm of the lower limit of the humus rich horizon), secondary carbonates occur as pseudo-mycelium and/or nodules in a brownish grey to cinnamon subsoil. The subsurface horizon has blocky or weakly prismatic structure.

The 'typical' Chernozem has formed in uniformly textured, silty parent material (loess), under tall-grass vegetation with vigorous growth. Chernozems show high biological activity. Their soil fauna is very active in wet periods predominantly in the upper 50 cm layer but the animals move to deeper strata at the onset of the dry period.

Chernozems are amongst the most productive soil types in the world and are rather resistant to soil degradation threats.

This Reference Soil Group spans from the Berlin-Budapest axis, on the western end of the Eurasian Chernozem zone to the eastern dges of the continent. Chernozems can be found in Bulgaria, Romania, in four Central-European countries and in Germany Ukraine and Russia.

Fluvisols

Fluvisols are common in periodically flooded areas such as alluvial plains, river fans, valleys and tidal marshes, on all continents and in all climate zones. They occupy some 3.5 million km2 worldwide, of which more than half are in the tropics.

Fluvisols are young soils that have fluvic soil properties. For all practical purposes this means that they receive fresh sediment during regular floods (unless the land was empoldered) and (still) show stratification and/or an irregular organic matter profile. Fluvisols in upstream parts of river systems are normally confined to narrow strips of land adjacent to the actual riverbed. In the middle and lower stretches, the flood plain is wider and has the classical arrangement of levees and basins, with coarsely textured Fluvisols on the levees and more finely textured soils in basin areas further away from the river. Fluvisols show layering of the sediments rather than pedogenic horizons. Their characteristics and fertility depend on the nature and sequence of the sediments and length of periods of soil formation after or between flood events.

Fluvisols cover areas over 5% of the total land area of Europe. Fluvisols are present in nearly all regions, forming dominant soil reference group.

Gleysols

Gleysols are azonal soils and occur in nearly all climates, from perhumid to arid, mainly in lowland areas where the groundwater comes close to the surface and the soil is saturated with groundwater for long periods of time.
Gleysols occupy an estimated 7.2 million km2 world-wide.

Conditioned by excessive wetness at shallow depth, this type of soil develops gleyic colour patterns made up of reddish, brownish or yellowish colours on ped surfaces or in the upper soil layers, in combination with greyish/bluish colours inside the peds or deeper in the soil profile. The main obstacle to utilisation of Gleysols is the necessity to install a drainage system, designed to either lower the groundwater table, or intercept seepage or surface runoff water. Adequately drained Gleysols can be used for arable cropping, dairy farming or horticulture.

Gleysols accounts for approximately 5.3% of the soil resources of the European Union. Gleysosl are abundant north of the Paris-Bucharest line, but can be found in smaller inclusions in the southern countries as well.

Gypsisols

Gypsisols can only be found in arid regions, in level or hilly land and depression areas (e.g. former inland lakes). World-wide extent of Gypsisols is approximately 1 million km2.

Gypsisols have substantial secondary accumulation of gypsum in the subsurface. Most Gypsisols formed when gypsum, dissolved from gypsiferous parent materials, moved through the soil with the soil moisture and precipitated in an accumulation layer. Where soil moisture moves predominantly upward (i.e. where a net evaporation surplus exists for an extended period each year), a gypsic or petrogypsic horizon occurs at shallower depth than a layer with lime accumulation (if present). Gypsum is leached from the surface soil in wet winter seasons. In arid regions with hot, dry summers, gypsum (CaSO4.2H2O) dehydrates to loose, powdery hemihydrate (CaSO4.0.5H2O), which reverts to gypsum during the moist winter. Gypsum precipitates in the soil body as fine, white, powdery crystals in former root channels (gypsum pseudomycelium) or in pockets, or as coarse crystalline gypsum sand, or in strongly cemented petrogypsic horizons. In places it forms pendants below pebbles and stones or rosettes (desert roses).

The natural vegetation is sparse and dominated by xerophytic shrubs and trees and/or ephemeral grasses. However, deep Gypsisols located close to water resources can be planted to a wide range of crops. Yields are severely depressed where a petrogypsic horizon occurs at shallow depth. Nutrient imbalance, stoniness, and uneven subsidence of the land surface upon dissolution of gypsum in percolating (irrigation) water are further limitations. Irrigation canals must be lined to prevent the canal walls from caving in. Most areas of Gypsisols are in use for low volume grazing.

Gypsisols cover just over 4,000 km2 in Europe, which makes up only a one per thousand of its total soil resources. Gypsisols are present only in Spain forming dominant soil reference group in 33 cases.

Histosols

Histosols cover nearly 7% of the land surface of Europea. Histosols have the largest extent in Northern Europe but with the exceptions of Cyprus and Malta all EU Member States have Histosols.

The majority of Histosols are located in the boreal, subarctic and low arctic regions of the Northern Hemisphere. Most of the remaining Histosols occur in temperate lowlands and cool mountain areas; only one-tenth of all Histosols are found in the tropics. Histosols are found at all latitudes, but the vast majority of them occur at low altitudes.
The total extent of Histosols in the world is approximately 3.5 million km2.

Histosols are composed mainly of organic soil material. During development, the organic matter production exceeds the rate of decomposition. The decomposition is retarded mainly by low temperatures or anerobic (low oxygen) conditions which result in high accumulations of partially decomposed organic matter.

A Histosol has a surface or shallow subsurface histic or folic horizon, which consists of partially decomposed plant remains with or without admixed sand, silt and/or clay.

The properties of the organic soil material (botanical composition, stratification, degree of decomposition, packing density, wood content, mineral admixtures, etc.) and the type of peat bog (basin peat, raised bog, etc.) determine the management requirements and use possibilities of Histosols. Northern Histosols are of little use for agriculture but they are part of a unique ecosystem and a habitat for many plant and animal species. Elsewhere more and more bogs are reclaimed for agriculture, horticulture and forestry.

Histosols are also known as peat, muck, bog and organic soil.

Kastanozems

Kastanozems occur mainly in the dry parts of the permanent grassland (steppe) regions of the world (the Great Plains of the USA, Mexico, the pampas of Latin America and the Eurasian short-grass-steppe-belt). The estimated total extent of Kastanozems is at about 4.65 million km2.

Kastanozems have a deep, dark coloured surface horizon with a significant accumulation of organic matter, high pH and an accumulation of calcium carbonate within 100 cm of the soil surface. The morphology of dark Kastanozems is not very different from that of the southern, drier Chernozems whereas the light Kastanozems of the south grade into Calcisols.
Climatic gradients in the Kastanozem belt are visible from pedogenic features. In Russia, the darkest surface horizons occur in the north of the Kastanozem belt (bordering on the Chernozems) whereas soils with shallower and lighter coloured horizons are more abundant in the south. The differentiation between horizons is clearer in the north than in the south in line with decreasing length and intensity of soil formation as conditions become more arid.

The typical arable land use is the production of small grains and irrigated cashcrops and vegetables. Kastanozem are also used for extensive grazing. Kastanozems are threatened by different forms of erosion and are often subjects of desertification processes.

Leptosols

Leptosol is the Reference Soil Group with the most extensive coverage on the global scale, extending over approximately 16.55 million km2. Leptosols are found in all climatic regions and all altitudes and are particularly frequent in mountain areas.

Leptosols are shallow over hard rock and comprise of very gravelly or highly calcareous material. Because of limited pedogenic development, Leptosols do not have much structure and have only weakly expressed horizons. Rendzic and Mollic Leptosols have more pronounced morphological features. The Reference Soil Group of the Leptosols includes a wide variety of soils with greatly differing chemical and physical properties. Leptosols are generally well-drained soils; however they have very few other favorable characteristics for agricultural utilization. The suitability of Leptosols in most areas is limited to forestry.

Lithosols of many international classification systems correlate with the Leptosol Reference Soil Group. Leptosols on limestone are called Rendzinas while those on acid rocks, such as granite, are called Rankers.

Leptosol is one of the four Reference Soil Groups that occupy more than 10 of the area of the European Union. Leptosols are present throughout Europe. However, they are most typical in the Mediterranean. The majority of the soil types of Cyprus is Leptosols and they cover vast areas in Greece, Spain and France as well.

Luvisols

Luvisols, with nearly 15% share in the area coverage constitute the second largest Reference Soil Group of Europe. Apart from the northernmost regions of Europe, Luviosls can be found in all parts of the continent.

Luvisols extend to approximately 6 million km2 world-wide, for the greater part in temperate regions.

Luvisols show marked textural differences within the profile. The surface horizon is depleted in clay while the subsurface ‘argic’ horizon has accumulated clay. A wide range of parent materials and environmental conditions lead to a great diversity of soils in this Reference Soil Group.

Most Luvisols have favourable physical properties: these are porous and well aerated. Chemical properties and nutrient status varies with parent material and pedogenetic history that also determine the options of land utilization.

Phaeozems

Phaeozems are found in wet steppe (prairie) regions of the world, covering an estimated 1.9 million km2 world-wide.

Phaeozems develop on loess, glacial till and other unconsolidated, predominantly basic materials on flat to undulating topography. These soils are much like Chernozems and Kastanozems but more intensively leached in wet seasons. Consequently, they have a dark, humus-rich surface horizon and have no secondary carbonates in the upper metre of soil.

Soils in this Reference Soil Group are porous, well-aerated soils with moderate to strong, very stable, crumb to blocky structures. The organic matter content of the surface layer of Phaeozems is typically around 5. Phaeozems have good water storage properties but may still be short of water in dry seasons. Phaeozems are fertile soils, making excellent soil for agricultural production.

The main areas of Pheozems in the European Union are found in central and eastern Europe and Spain.

Planosol

Planosols are soils with bleached, light-coloured, eluvial surface horizons that show signs of periodic water stagnation and abruptly overly dense, slowly permeable subsoil with significantly more clay than the surface horizon. They develop mostly on clayey alluvial and colluvial deposits, predominantly in flat lands but can also be found in the lower stretches of slopes, in a strip intermediate between uplands, e.g. with Acrisols or Luvisols, and lowland (plain or basin) areas, e.g. with Vertisols.

Planosols have typically a weakly structured surface horizon over a horizon showing evidence of stagnating water. The texture of these horizons is markedly coarser than that of deeper soil layers; the transition is sharp and conforms to the requirements of an `abrupt textural change'. The finer textured subsurface soil may show signs of clay illuviation; it is only slowly permeable to water.

Most Planosols are poor soils and are therefore not used as cropland but utilized for extensive grazing and forestry.

Planosols were formerly known as pseudogley soils and today are dealt under different levels of classification hierarchies in national and international classification systems.

Despite of their fairly widespread geographical distribution throughout the continent, Planosols have a relatively small share (< 0.5) among the soil types of Europe.

Podzols

The Podzol Reference Soil Group is the third most widespread in the Europe. While vast areas of Podzols are found in the Scandinavian countries, this Reference Soil Group is present in twenty-two Member States of the EU and is only absent in Hungary, Slovenia, Bulgaria, Malta and Cyprus.

Most Podzols develop in humid, well drained areas, particularly, in the Boreal and Temperate Zones, on unconsolidated weathering materials of siliceous rock, prominent on glacial till, and alluvial and aeolian deposits of quartzitic sands. In the boreal zone Podzols occur on almost any rock. Podzols are associated with soils that have evidence of displacement of organic-iron/aluminium complexes but not strong enough to qualify as Podzols.

Main feature of podzol formation is the migration of aluminium, iron and organic compounds from the surface soil down to deeper layers with percolating rainwater. The humus complexes deposit in an accumulation (spodic) horizon while the overlying soil is left behind as a strongly bleached.

Due to the limiting climatic conditions Zonal Podzols generally have low suitability for agricultural production. Azonal podzols can be utilized for agricultural use after amelioration (e.g deep ploughing, liming).

Regosols

Regosol belongs to the major soil types of Europe. Most of the European Regosols are found in the Mediterranean region and the Balkan Peninsula. However, they can be found in nearly all around the continent.

Regosols are present at all climate zones without permafrost and at all elevations. Regosols are particularly common in arid areas, in the dry tropics and in mountain regions. Global coverage of this Reference Soil Group accounts to approximately 2.6 million km2. Regosols are common inclusions in other map units on small-scale maps.

A Regosol is a very weakly developed mineral soil in unconsolidated materials with only a limited surface horizon having formed. Regosols form a taxonomic rest group containing all soil types that cannot be accommodated in any of the other WRB Reference Groups. Regosols are extensive in eroding lands

Limiting factors for the development of Regosols range from low soil temperatures and prolonged dryness to characteristics of the parent material or erosion.

The options for land use and management of these soils vary widely. Some Regosols are used for irrigated farming but generally they are kept for low volume grazing. In mountain areas Regosols are mostly forested.

Solonchaks

Solonchaks are widespread in the arid and semi-arid climatic zones and coastal regions in all climates. The global extent of Solonchaks is estimated to be between 2.6 million and 3.4 million km2. The level of salinity for diagnostic purposes cause the differences in the estimations.

Solonchaks are a strongly saline soil types with high concentration of soluble salts. They occur where saline groundwater comes near to the surface or where the evapo-transpiration is considerably higher than precipitation, at least during a large part of the year. Salts dissolved in the soil moisture remain behind after evaporation of the water and accumulate at or near the surface. Their morphology, characteristics and limitations to plant growth depend on the amount, depth and composition of the salts.

Land use options on Solonchak soils are largely limited by the salt content. The salts magnify drought stress because dissolved electrolytes create an osmotic potential that affects water uptake by plants. A possible way of reclamation is to flush salts out from the soil. However, most Solonchaks can be used for extensive grazing. Solonchak soils in many cases form unique ecosystems worth protecting for their biodiversity and landscape values.

Solonchaks are often cited as saline soil and salt-affected soil in international nomenclatures.

Solonetzes

Solonetz are normally associated with flat lands in a climate with hot, dry summers or with former coastal deposits that contain a high proportion of salt.

Solonetz soils are strongly alkaline with subsurface horizon of clay minerals, well developed columnar structure and high proportion of adsorbed sodium and/or magnesium ions. The presence of free soda in soil is associated with alkaline reaction (field-pH > 8.5). Under such conditions, organic matter has a tendency to dissolve and move through the soil body with moving soil moisture. The remaining mineral soil material is bleached and in the extreme case a clear eluvial horizon may form directly over the dense natric subsurface horizon. Black spots of accumulated organic matter can be seen in many Solonetz, at some depth in the natric horizon. The dense natric (clay) illuviation horizon poses an obstacle to water percolating downward by the dispersion of soil materials.

Land use options of Solonetz soils depend largely on the depth and properties of the surface soil. However, most Solonetzes are Solonetz are problem soils when used for arable agriculture.

Areas of Solonetz soils are similar to those of Solonchaks in Europe. However, the geographic extent is somewhat different: Solonetzes are soils of the Charpatian Basin, Romania and Bulgaria and found in south eastern Europe..

Umbrisols

Umbrisols have one of the smallest share among all Reference Soil Groups of Europe, found in southern part of the continent.

The Umbrisol Reference Soil Group belongs to the set of mineral soils conditioned by a (sub)humid temperate climate. Soils in this Reference Soil Group occur in cool, humid regions, mostly mountainous and with little or no soil moisture deficit, on weathering material of siliceous rock; predominantly in late Pleistocene and Holocene deposits.
Umbriols occupy about 1 million km2 throughout the world.

The central concept of Umbrisols is that of deeply drained, medium-textured soils with a dark, acid surface with high organic matter content as the most distinguishing feature. Vegetation and climate influence the development of an umbric horizon (a dark colored horizon, with low base saturation). In some cases, an umbric horizon may form quite rapidly while concurrent development of an incipient, non-diagnostic, spodic or argic horizon is slow. This explains why umbric horizons are found in young, relatively undeveloped soils that lack any other diagnostic horizon, or have only a weak cambic horizon. Profile development is strongly dependent on deposition of (significant quantities of) organic material with low base saturation at the soil surface.

The organic material that characterises Umbrisols can comprise a variety of humus forms that have been variously described as acid or oligitrophic mull, moder, raw humus and mor. Organic matter could accumulate because of slow biological turnover of organic matter under conditions of acidity, low temperature, surface wetness, or a combination of these. However, Umbrisols were never cold and/or wet for sufficiently long periods to have developed a diagnostic histic horizon.

Many Umbrisols of the world are under a natural or near-natural vegetation cover. Umbriols are predominantly suitable for forestry and extensive grazing. Under adequate management, Umbrisols may also be planted to cash crops such as cereals, root crops, tea and coffee.

Other national and international classification systems classify these soils as Umbrepts and Humitropepts (Soil Taxonomy), Humic Cambisols and Umbric Regosols (FAO), Sombric Brunisols and Humic Regosols (France).

Vertisols

Vertiols develop within depressions, in level to undulating landscapes, mainly in tropical, semi-arid to (sub)humid and Mediterranean climates with an alternation of distinct wet and dry seasons. Sediments that contain a high proportion of smectitic clay or products of rock weathering that have the characteristics of smectitic clay are prerequisite of Vertiol formation.

Vertisols shrink and swell upon drying and wetting. Deep wide cracks form when the soil dries out and swelling in the wet season and creates polished and grooved ped surfaces (slickensides) or wedge-shaped or parallel-sided aggregates in the subsurface vertic horizon. The landscapes of a Vertisol may have a complex micro-topography of micro-knolls and micro-basins called gilgai.

Vertisols with strong pedoturbation have a uniform particle size distribution throughout the profile but texture may change sharply where the substratum is reached. Dry Vertisols can be very hard, while wet Vertisols are very plastic and sticky.

The agricultural use of Vertisols is depending on their physical characteristics, and ranges from very extensive use through smallholder post-rainy season crop production to small-scale and large-scale irrigated agriculture. Cotton is known to perform well on Vertisols. Tree crops are generally less successful because roots find it difficult to establish themselves in the subsoil and are damaged as the soil shrinks and swells.

Vertiols tend to be found in the southern countries of Europe.

3.2 Information content of the WRB (1998) lower level units

Further to the Reference Soil Groups, qualifyers which define the second level of soil units in the WRB classification countain condensed information which can be utilised for soil modelling. In previouse chapters of this report we provided an assessment on the spatial extend of soil units in the different pedoclimatic regions, while this chapter gives full details of the pedological meaning of the quelifyers.

This chapter is based on the 1998 edition of the World Reference Base for Soil Resources (FAO 1998). The information includes definitions of the formative elements (qualifyers) for the second-level units relating to Reference Soil Groups, diagnostic horizons, properties and materials, attributes such as colour, chemical conditions, texture, etc. These formative elements are accepted by the European Soil Bureau Network to be shown at the scale of 1:1 million in the European Geographical Soil Database and provide valuable information for soil function and soil management modelling. General principles for distinguishing lower level units is availéable at FAO (1998).

In the below chapters (3.2.1 to 3.2.5) detailed description of the formative elements to define second level units is provided.

3.2.1 Qualifyers

Albic having an *albic* horizon within 100 cm from the soil surface.

Arenic having a texture of loamy fine sand or coarser throughout the upper 50 cm of the soil.

Aridic having aridic properties without a takyric or yermic horizon.

Calcaric calcareous at least between 20 and 50 cm from the soil surface.

Calcic having a *calcic* horizon or concentrations of secondary carbonates between 50 and 100 cm from the soil surface.

Chromic having a B horizon which in the major part has a Munsell hue of 7.5YR and a chrome, moist, of more than 4, or a hue redder than 7.5YR.

Dystric having a base saturation (by 1 *M* NH_4OAc) of less than 50 percent in at least some part between 20 and 100 cm from the soil surface, or in a layer 5 cm thick directly above a lithic contact in Leptosols.

Eutric having a base saturation (by 1 *M* NH_4OAc) of 50 percent or more at least between 20 and 100 cm from the soil surface, or in a layer 5 cm thick directly above a lithic contact in Leptosols.

Ferric having a *ferric* horizon within 100 cm from the soil surface.

Gelic having *permafrost* within 200 cm from the soil surface.

Gleyic having *gleyic* properties within 100 cm from the soil surface.

Haplic having a typical expression of certain features (typical in the sense that there is no further or meaningful characterization).

Histic having a *histic* horizon within 40 cm from the soil surface.

Humic having a high organic carbon content; in *Ferralsols* and *Nitisols* more than 1.4 percent (by weight) organic carbon in the fine earth fraction as weighted average over a depth of 100 cm from the soil surface, in *Leptosols* more than 2 percent (by weight) organic carbon in the fine earth fraction to a depth of 25 cm from the soil surface, and in other soils more than 1 percent (by weight) organic carbon in the fine earth fraction to a depth of 50 cm from the soil surface.

Leptic having continuous hard rock between 25 and 100 cm from the soil surface.

Lithic having continuous hard rock within 10 cm from the soil surface.

Luvic having an *argic* horizon which has a cation exchange capacity equal to or more than 24 cmolc kg^{-1} clay throughout, and a base saturation by 1 *M* NH_4OAc) of 50 percent or more throughout the horizon to a depth of 100 cm from the soil surface.

Mollic having a *mollic* horizon.

Pellic having in the upper 30 cm of the soil matrix a Munsell value, moist, of 3.5 or less and a chrome of 1.5 or less (*in Vertisols only*).

Placic having within 100 cm from the soil surface a subhorizon of the *spodic* horizon which is 1 cm or more thick and which is continuously cemented by a combination of organic matter and aluminium, with or without iron ("thin iron pan") (*in Podzols only*).

Plaggic having a *plaggic* horizon; in *Anthrosols* 50 cm or more thick, in other soils less than 50 cm thick.

Plinthic having a *plinthic* horizon within 100 cm from the soil surface.

Protic showing no appreciable soil horizon development (*in Arenosols only*).

Rendzic having a *mollic* horizon which contains or immediately overlies calcareous materials containing more than 40 percent calcium carbonate equivalent (*in Leptosols only*).

Sapric having less than one-sixth (by volume) of the *organic* soil material consisting of recognizable plant tissue (after rubbing) (*in Histosols only*).

Sodic having more than 15 percent exchangeable sodium or more than 50 percent exchangeable sodium plus magnesium on the exchange complex within 50 cm from the soil surface.

Takyric having a *takyric* horizon.

Thionic having a *sulfuric* horizon or *sulfidic* soil material within 100 cm from the soil surface.

Umbric having an *umbric* horizon.

Vertic having a *vertic* horizon within 100 cm from the soil surface.

Vitric having a *vitric* horizon within 100 cm from the soil surface and lacking an andic horizon overlying a vitric horizon.

3.2.2. Diagnostic horizons

Albic horizon

General description. The albic horizon (from L. *albus*, white) is a light coloured subsurface horizon from which clay and free iron oxides have been removed, or in which the oxides have been segregated to the extent that the colour of the horizon is determined by the colour of the sand and silt particles rather than by coatings on these particles. It generally has a weakly expressed soil structure or lacks structural development altogether. The upper and lower boundaries are normally abrupt or clear. The morphology of the boundaries is variable and sometimes associated with albeluvic tonguing. Albic horizons usually have coarser textures than the overlying or underlying horizons, although this difference with respect to an underlying spodic horizon may only be slight. Many albic horizons are associated with wetness and contain evidence of gleyic or stagnic properties.

Diagnostic criteria.
An albic horizon must have:

1. Munsell colour, dry:
   a. value of either 7 or 8 and a chrome of 3 or less; or
   b. value of 5 or 6 and a chrome of 2 or less; and
2. Munsell colour, moist:
   a. a value 6, 7 or 8 with a chrome of 4 or less; or
   b. a value of 5 and a chrome of 3 or less[1]; or
   c. a value of 4 and a chrome of 2 or less. A chrome of 3 is permitted if the parent materials have a hue of 5YR or redder, and the chrome is due to the colour of uncoated silt or sand grains; and
3. thickness: at least 1 cm.

Field identification. Identification of albic horizons in the field is based on Munsell soil colours. In addition to the colour determination, checks can be made using a x10 hand-lens to verify if coatings on sand and silt-sized particles are absent.

Additional characteristics. The presence of coatings around sand and silt grains can be determined using an optical microscope for analysing thin sections. Uncoated grains usually show a very thin rim at their surface. Coatings may be of an organic nature, consist of iron oxides, or both, and are dark coloured under translucent light. Iron coatings become reddish in colour under reflected light, while organic coatings remain brownish-black.

Relationships with some other diagnostic horizons. Albic horizons are normally overlain by humus-enriched surface horizons (mollic, umbric or ochric horizons) but may be at the surface due to erosion or artificial removal of the surface layer. They can be considered as an extreme type of eluvial horizon, and usually occur in association with illuvial horizons such as an argic, natric or spodic horizon, which they overlie. In sandy materials albic horizons can reach considerable thickness, up to several metres, especially in humid tropical regions, and associated diagnostic horizons may be hard to establish.

Andic horizon

General description. The andic horizon (from Japanese *An*, dark, and *Do*, soil) is a horizon resulting from moderate weathering of mainly pyroclastic deposits. However, they may also be found in association with non-volcanic materials (e.g. loess, argilites and ferralitic weathering products). Their mineralogy is dominated by short-range-order minerals, and they are part of the weathering sequence in pyroclastic deposits (tephric soil material (r) vitric horizon (r) andic horizon). Andic horizons may be found both at the surface and in the subsurface. They also often occur as layers, separated by non-andic layers. As a surface horizon, andic horizons generally contain a high amount of organic matter (more than 5 percent), are very dark coloured (Munsell value and chrome, moist, is 3 or less), have a

[1] Colour requirements have been slightly changed with respect to those defined in FAO (1988) and Soil Survey Staff (1996) to accommodate albic horizons, which show a considerable shift in chrome upon moistening. Such albic horizons occur frequently in, for example, the southern African region.

fluffy macrostructure and often a smeary consistence. They are light in weight (have a low bulk density), and have mostly silt loam or finer textures. Andic surface horizons rich in organic matter may be very deep, reaching often a thickness of 50 cm or more (pachic characteristic). Andic subsurface horizons are generally somewhat lighter coloured. Andic horizons may have different properties, depending on the type of dominant weathering process acting upon the soil material. They may exhibit thixotropy, i.e. the soil material changes, under pressure or by rubbing, from a plastic solid into a liquified stage and back into the solid condition. In perhumid climates, humus-rich andic horizons may contain more than 100 percent water (by volume) compared to their oven-dry volume (hydric characteristic). Two major types of andic horizons are recognized, one in which allophane and similar minerals are predominant (the sil-andic type), and one in which aluminium complexed by organic acids prevails (the alu-andic type). The sil-andic horizon has an acid to neutral soil reaction, while the alu-andic horizon varies from extremely acid to acid.

Diagnostic criteria. An andic horizon must have the following physical, chemical and mineralogical properties (Shoji et al, 1996; Berding, 1997):

1. bulk density of the soil at field capacity (no prior drying) of less than 0.9 kg dm^{-3}; and
2. 10 percent or more clay and an Al_{ox} + $1/2Fe_{ox}$ [2] value in the fine earth fraction of 2 percent or more; and
3. phosphate retention of 70 percent or more; and
4. volcanic glass content in the fine earth fraction of less than 10 percent; and
5. thickness of at least 30 cm.

Sil-andic horizons have an acid oxalate (pH 3) extractable silica (Si_{ox}) of 0.6 percent or more while alu-andic horizons have a Si_{ox} of less than 0.6 percent (or, alternatively, an Al_{py} [3]/Al_{ox} ratio of less than 0.5 and 0.5 or more, respectively).

Field identification. Andic horizons may be identified using the pH NaF field test developed by Fieldes and Perrott (1966). A pH NaF of more than 9.5 indicates an abundant presence of allophanic products and/or organo-aluminium complexes. The test is indicative for most andic horizons, except for those very rich in organic matter. However, the same reaction occurs in spodic horizons and in certain acid clayey soils, which are rich in aluminium interlayered clay minerals. Sil-andic horizons generally have a field pH (H_2O) of 5 or higher, while alu-andic horizons mainly have a field pH (H_2O) of less than 4.5. If the pH (H_2O) is between 4.5 and 5, additional tests may be necessary to establish the 'alu-' or 'sili-' characteristic of the andic horizon.

Relationships with some other diagnostic horizons. Vitric horizons are distinguished from andic horizons by their lesser rate of weathering. This is evidenced by a higher volcanic glass content in vitric horizons (> 10 percent of the fine earth fraction) and a lower amount of noncrystalline or paracrystalline pedogenetic minerals, as characterized by the moderate amount of acid oxalate (pH 3) extractable aluminium and iron in vitric horizons (Al_{ox} + $1/2Fe_{ox}$ = 0.4-2.0 percent), by a higher bulk density (BD of vitric horizons is between 0.9 and 1.2 kg dm^{-3}), and by a lower phosphate retention (25 -< 70 percent). To separate andic horizons rich in organic matter from histic and folic horizons, andic horizons are not permitted to contain more than 20 percent organic carbon, while histic horizons with an organic carbon content between 12 and 20 percent are not permitted to have properties associated with andic horizons. Spodic horizons, which also contain complexes of sesquioxides and organic substances, can have similar characteristics to andic horizons rich in alumino-organic complexes. Sometimes only analytical tests can discriminate between the two. Spodic horizons have at least twice as much Al_{ox} + $1/2Fe_{ox}$ than an overlying umbric, ochric or albic horizon. This normally does not apply to andic horizons in which the alumino-organic complexes are virtually immobile.

Argic horizon

[2] Al_{ox} and Fe_{ox} are acid oxalate extractable aluminium and iron, respectively (method of Blakemore et al., 1987).

[3] Al_{py}: pyrophosphate extractable aluminium.

General description. The argic horizon (from L. *argilla*, white clay) is a subsurface horizon which has a distinctly higher clay content than the overlying horizon. The textural differentiation may be caused by an illuvial accumulation of clay, by predominant pedogenetic formation of clay in the subsoil or destruction of clay in the surface horizon, by selective surface erosion of clay, by biological activity, or by a combination of two or more of these different processes. Sedimentation of surface materials which are coarser than the subsurface horizon may enhance a pedogenetic textural differentiation. However, a mere lithological discontinuity, such as may occur in alluvial deposits, does not qualify as an argic horizon. Soils with argic horizons often have a specific set of morphological, physico-chemical and mineralogical properties other than a mere clay increase. These properties allow various types of 'argic' horizons to be distinguished and to trace their pathways of development (Sombroek, 1986). Main subtypes are lixi-, luvi-, abrupti- and plan-argic horizons, and natric and nitic horizons. The argic B horizon as defined in the Revised Legend of the Soil Map of the World (FAO, 1988) is taken as a reference, with one modification. The requirement to observe in the field '... at least 1 percent clay skins on ped surfaces and in pores...' is changed into 5 percent. This change is based on the notion that there is no 1:1 correspondence between the amount of clay skins on ped surfaces and in pores, and the percentage of the thin section occupied by oriented clay. Even if 100 percent of the ped surfaces are covered by clay skins, the thin section will in its major part be occupied by the matrix of the soil and voids.

Diagnostic criteria. An argic horizon must have:

1. texture of sandy loam or finer and at least 8 percent clay in the fine earth fraction; and
2. more total clay than an overlying coarser textured horizon (exclusive of differences which result from a lithological discontinuity only) such that:
    a. if the overlying horizon has less than 15 percent total clay in the fine earth fraction, the argic horizon must contain at least 3 percent more clay; or
    b. if the overlying horizon has 15 percent or more and less than 40 percent total clay in the fine earth fraction, the ratio of clay in the argic horizon to that of the overlying horizon must be 1.2 or more; or
    c. if the overlying horizon has 40 percent or more total clay in the fine earth fraction, the argic horizon must contain at least 8 percent more clay; and
3. an increase in clay content within a vertical distance of 30 cm if an argic horizon is formed by clay illuviation. In any other case the increase in clay content between the overlying and the argic horizon must be reached within a vertical distance of 15 cm; and
4. autochthonous rock structure is absent in at least half the volume of the horizon; and
5. thickness of at least one tenth of the sum of the thickness of all overlying horizons and at least 7.5 cm thick. If the argic horizon is entirely composed of lamellae, the lamellae must have a combined thickness of at least 15 cm. The coarser textured horizon overlying the argic horizon must be at least 18 cm thick or 5 cm if the textural transition to the argic horizon is abrupt (see abrupt textural change, in diagnostic properties).

Field identification. Textural differentiation is the main feature for recognition of argic horizons in the field. The illuvial nature may be established in the field using a x10 hand-lens if clear clay skins occur on ped surfaces, in fissures, in pores and in channels. An 'illuvial' argic horizon should at least in some part show clay skins on at least 5 percent of both horizontal and vertical ped faces and in the pores. Clay skins are often difficult to detect in soils with a smectitic mineralogy as these are destroyed regularly by shrink-swell movements. The presence of clay skins in 'protected' positions, e.g. in pores, should be sufficient to meet the requirements for an 'illuvial' argic horizon.

Additional characteristics. The illuvial character of an argic horizon can best be established using thin sections. Diagnostic 'illuvial' argic horizons must show areas with oriented clays that constitute on average at least 1 percent of the entire cross-section. Other tests involved are particle size distribution analysis, to determine the increase in clay content over a specified depth, and the fine clay[4]/total clay analysis. In 'illuvial' argic horizons the fine clay/total clay ratio is larger than in the overlying horizons, caused by preferential eluviation of fine clay particles. If the soil shows a lithological discontinuity

[4] Fine clay: <0.2 µm.

over or within the argic horizon, or if the surface horizon has been removed by erosion, or if only a plough layer overlies the argic horizon, the illuvial nature must be clearly established. A lithological discontinuity, if not clear from the field (data), can be identified by the percentage of coarse sand, fine sand and silt, calculated on a clay-free basis (international particle size distribution or using the additional groupings of the USDA system or other), or by changes in the content of gravel and coarser fractions. A change of at least 20 percent (relative) of any of the major particle size fractions can be regarded as diagnostic for a lithological discontinuity. However, it should only be taken into account if it is located in the section of the profile where the clay increase occurs and if there is evidence that the overlying layer was coarser textured. Although this is a simplified way of treating lithological discontinuities, not much more can be done with the data commonly available. On the other hand, particle size discontinuities are of main interest for the argic horizon and will show if the overlying material was very much different and coarser, even without considering clay loss due to eluviation or other processes. Relationships with some other diagnostic horizons. Argic horizons are normally associated with and situated below eluvial horizons, i.e. horizons from which clay and iron have been removed. Although initially formed as a subsurface horizon, argic horizons may occur at the surface as a result of erosion or removal of the overlying horizons. Some clay-increase horizons may have the set of properties which characterize the ferralic horizon, i.e. a low CEC and ECEC (effective CEC), a low content of water-dispersible clay and a low content of weatherable minerals, all over a depth of 50 cm. In such cases a ferralic horizon has preference over an argic horizon for classification purposes. However, an argic horizon prevails if it overlies a ferralic horizon and it has, in its upper part over a depth of 30 cm, 10 percent or more water-dispersible clay, unless the soil material has geric properties or more than 1.4 percent organic carbon. Argic horizons also lack the structure and sodium saturation characteristics of the natric horizon.

Calcic horizon

General description. The calcic horizon (from L. *calx*, lime) is a horizon in which secondary calcium carbonate ($CaCO_3$) has accumulated either in a diffuse form (calcium carbonate present only in the form of fine particles of 1 mm or less, dispersed in the matrix) or as discontinuous concentrations (pseudomycelia, cutans, soft and hard nodules, or veins). The accumulation may be in the parent material, or in subsurface horizons, but it can also occur in surface horizons as a result of erosion. If the accumulation of soft carbonates becomes such that all or most of the pedological and/or lithological structures disappear and continuous concentrations of calcium carbonate prevail, the horizon is named a hypercalcic horizon (from Gr. hyper, superseding, and L. calxis, lime).

Diagnostic criteria. A calcic horizon must have:

1. calcium carbonate equivalent content in the fine earth fraction of 15 percent or more (for hypercalcic horizons more than 50 percent calcium carbonate equivalent in the fine earth fraction); and
2. thickness at least 15 cm, also for the hypercalcic horizon.

Field identification. The presence of calcium carbonate can be identified in the field using a 10 HCl solution. The degree of effervescence (audible only, visible as individual bubbles, or foam-like) is an indication of the amount of lime present. This test is important if only diffuse distributions are present. Other indications for the presence of a calcic or hypercalcic horizon are:

1. soil colours which are more or less white, pinkish to reddish, or grey; and
2. a low porosity (inter-aggregate porosity in the (hyper-)calcic horizon is usually less than that in the horizon immediately above and possibly also less than in the horizon directly underneath).

Calcium carbonate content may decrease with depth, but this is often difficult to establish, particularly if
the calcic horizon occurs in the deeper subsoil. Accumulation of secondary lime is therefore sufficient to
diagnose a (hyper-)calcic horizon.

Additional characteristics. Determination of the amount of calcium carbonate (by weight) and the changes within the soil profile of the calcium carbonate content are the main analytical criteria for establishing the presence of a calcic horizon. Determination of the pH (H_2O) enables distinction between accumulations with a basic ('calcic') character (pH 8.0 - 8.7) due to the dominance of $CaCO_3$, and those with an ultrabasic ('non-calcic') character (pH > 8.7) because of the presence of $MgCO_3$ or Na_2CO_3. In addition, microscopical analysis of thin sections may reveal the presence of dissolution forms in horizons above or below a calcic horizon, evidence of silicate epigenesis (isomorphous substitution of quartz by calcite), or the presence of other calcium carbonate accumulation structures, while clay mineralogical analyses of calcic horizons often show clays characteristic of confined environments, such as montmorillonites, attapulgites and sepiolites. Relationships with some other diagnostic horizons. When hypercalcic horizons become indurated, transition takes place to the petrocalcic horizon, the expression of which may be massive or as platy structures. In dry regions and in the presence of sulphate-bearing soil- or groundwater solutions, calcic horizons occur associated with gypsic horizons. Calcic and gypsic horizons usually occupy different positions in the soil profile because of the difference in solubility of calcium carbonate and gypsum, and normally they can be clearly distinguished from each other by the difference in morphology. Gypsum crystals tend to be needle-shaped, often visible with the naked eye, whereas pedogenetic calcium carbonate crystalsare much finer in size.

Ferric horizon

General description. The ferric horizon (from L. *ferrum*, iron) is a horizon in which segregation of iron has taken place to such an extent that large mottles or concretions have formed and the inter-mottle/inter-concretionary matrix is largely depleted of iron. Generally, such segregation leads to poor aggregation of the soil particles in iron-depleted areas and compaction of the horizon.

Diagnostic criteria. A ferric horizon must have:

1. many (more than 15 percent of the exposed surface area) coarse mottles with hues redder than 7.5YR and chrome more than 5, or both; or
2. discrete nodules, up to 2 cm in diameter, the exteriors of the nodules being enriched and weakly cemented or indurated with iron and having redder hues or stronger chrome than the interiors; and
3. thickness of at least 15 cm.

Relationships with some other diagnostic horizons. If the amount of nodules reaches 10 percent or more (by volume) and the nodules harden irreversibly to a hardpan or to irregular aggregates on exposure to repeated wetting and drying with free access of oxygen, the horizon is considered to be a plinthic horizon. Therefore, ferric horizons may, in tropical or subtropical regions, grade laterally into plinthic horizons. The transition between the two is often not very clear.

Histic horizon

General description. The histic horizon (from Gr. *histos,* tissue) is a surface horizon, or a subsurface horizon occurring at shallow depth, which consists of poorly aerated organic soil material. Diagnostic criteria. A histic horizon must have:

1. either - 18 percent (by weight) organic carbon (30 percent organic matter) or more if the mineral fraction comprises 60 percent or more clay;
   or - 12 percent (by weight) organic carbon (20 percent organic matter) or more if the mineral fraction has no clay;
   or - a proportional lower limit of organic carbon content between 12 and 18 percent if the clay content of the mineral fraction is between 0 and 60 percent. If present in materials characteristic for andic horizons, the organic carbon content must be more than 20 percent (35 percent organic matter); and
2. saturation with water for at least one month in most years (unless artificially drained); and
3. thickness of 10 cm or more. A histic horizon less than 20 c

Mollic horizon.

General description. The mollic horizon (from L. *mollis*, soft) is a well structured, dark coloured surface horizon with a high base saturation and a moderate to high content in organic matter.

Diagnostic criteria. A mollic horizon must have:

1. soil structure sufficiently strong that the horizon is not both massive and hard or very hard when dry. Very coarse prisms (prisms larger than 30 cm in diameter) are included in the meaning of massive if there is no secondary structure within the prisms; and
2. both broken and crushed samples have a Munsell chrome of less than 3.5 when moist, a value darker than 3.5 when moist and 5.5 when dry. If there is more than 40 percent finely divided lime, the limits of colour value dry are waived; the colour value, moist, should be 5 or less. The colour value must be at least one unit darker than that of the C horizon (both moist and dry), unless the soil is derived from dark coloured parent material, in which case the colour contrast requirement is waived. If a C horizon is not present, comparison should be made with the horizon immediately underlying the surface horizon; and
3. an organic carbon content of 0.6 percent (1 percent organic matter) or more throughout the thickness of mixed horizon. The organic carbon content is at least 2.5 percent if the colour requirements are waived because of finely divided lime, or 0.6 percent more than the C horizon if the colour requirements are waived because of dark coloured parent materials; and
4. a base saturation (by 1 M NH_4OAc) of 50 percent or more on a weighted average throughout the depth of the horizon; and
5. the following thickness:
    a. 10 cm or more if resting directly on hard rock, a petrocalcic, petroduric or petrogypsic horizon, or overlying a cryic horizon; or
    b. at least 20 cm and more than one-third of the thickness of the solum where the solum is less than 75 cm thick; or
    c. more than 25 cm where the solum is more than 75 cm thick.

The measurement of the thickness of a mollic horizon includes transitional horizons in which the characteristics of the surface horizon are dominant - for example, AB, AE or AC.
The requirements for a mollic horizon must be met after the first 20 cm are mixed, as in ploughing.

Field identification. A mollic horizon can easily be identified by its dark colour, caused by the accumulation of organic matter, well developed structure (usually a granular or fine subangular blocky structure), an indication for high base saturation, and its thickness.

Relationships with some other diagnostic horizons. The base saturation of 50 percent separates themollic horizon from the umbric horizon, which is otherwise similar. The upper limit of organic carbon content varies from 12 percent (20 percent organic matter) to 18 percent organic carbon (30 percent organic matter) which is the lower limit for the histic horizon or 20 percent, the lower limit for a folic horizon. A special type of mollic horizon is the chernic horizon. It has a higher organic carbon content (1.5 percent or more), a specific structure (granular or fine subangular blocky), a very dark colour in its upper part, a high biological activity, and a minimum thickness of 35 cm. Limits with high base-saturated fulvic and melanic horizons are set by the combination of the intense dark colour, the high organic carbon content, the thickness and the characteristics associated with andic horizons in these two horizons. Otherwise, mollic horizons frequently occur in association with andic horizons.

Plaggic horizon

General description. Plaggic horizon (from Dutch *plag*, sod) is one of the Anthropedogenic horizons (from Gr. anthropos, human, and pedogenesis) which result from long-continued cultivation. The characteristics and properties of these horizons depend much on the soil management practices used Anthropedogenic horizons differ from anthropogenic soil materials, which are unconsolidated mineral or organic materials resulting largely from land fills, mine spoil, urban fill, garbage dumps, dredgings, etc., produced by human activities. These materials, however, have not been subject to a sufficiently long period of time to have received significant imprint of pedogenetic processes.

Diagnostic criteria. A plaggic horizon has a uniform texture, usually sand or loamy sand. The weighted average organic carbon content is more than 0.6 percent. The base saturation (by 1 M NH_4OAc) is less than 50 percent while the P_2O_5 content extractable in 1 percent citric acid is high, at least more than 0.025 percent within 20 cm of the surface, but frequently more than 1 percent.

Field identification. The plaggic horizons show evidence of surface raising, which may be inferred either from field observation or from historical records. The horizons are thoroughly mixed and usually contain artifacts such as pottery fragments, cultural debris or refuse, which are often very small (less than 1 cm in diameter) and much abraded. Plaggic horizons are built up gradually from earthy additions (compost, sods or soddy materials mixed with farmyard manure, litter, mud, beach sands, etc.) and may contain stones, randomly sorted and distributed The plaggic horizon has brownish or blackish colours, related to the origin of source materials and its soil reaction is slightly to strongly acid. It shows evidence of agricultural operations such as spade marks as well as old cultivation layers. Plaggic horizons often overlie buried soils although the original surface layers may be mixed. The lower boundary is usually clear.

Plinthic horizon

General description. The plinthic horizon (from Gr. *plinthos*, brick) is a subsurface horizon which constitutes an iron-rich, humus-poor mixture of kaolinitic clay with quartz and other constituents, and which changes irreversibly to a hardpan or to irregular aggregates on exposure to repeated wetting and drying with free access of oxygen.

Diagnostic criteria. The plinthic horizon must have:

1. 25 percent (by volume) or more of an iron-rich, humus-poor mixture of kaolinitic clay with quartz and other diluents, which changes irreversibly to a hardpan or to irregular aggregates on exposure to repeated wetting and drying with free access of oxygen; and
2.
   a. 2.5 percent (by weight) or more citrate-dithionite extractable iron in the fine earth fraction, especially in the upper part of the horizon, or 10[5] percent in the mottles or concretions; and
   b. ratio between acid oxalate (pH 3) extractable iron and citrate-dithionite extractable iron of less than 0.10; and
   c. less than 0.6 percent (by weight) organic carbon; and
   d. thickness of 15 cm or more.

Field identification. A plinthic horizon commonly shows red mottles, usually in platy, polygonal, vesicular or reticulate patterns. In a perennially moist soil, the plinthic material is usually not hard but firm or very firm and can be cut with a spade. The plinthic material does not harden irreversibly as a result of a single cycle of drying and rewetting. Only repeated wetting and drying will change it irreversibly to an ironstone hardpan or to irregular aggregates, especially if it is also exposed to heat from the sun.

Additional criteria. Micromorphological studies may reveal the extent of impregnation of the soil mass by iron. In addition penetration resistance measurements and total amount of iron present may give an indication.

Spodic horizon

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[5] Estimated from data given by Varghese and Byju (1993).

General description. The spodic horizon (from Gr. *spodos*, wood ash) is a dark coloured subsurface horizon which contains illuvial amorphous substances composed of organic matter and aluminium, with or without iron. The illuvial materials are characterized by a high pH-dependent charge, a large surface area and high water retention.

Diagnostic criteria. A spodic horizon must have:

1.
    a. either- a Munsell hue of 7.5YR or redder with value of 5 or less and chrome of 4 or less when moist and crushed; or - a hue of 10YR with value of 3 or less and chrome of 2 or less when moist and crushed; or
    b. a subhorizon which is 2.5 cm or more thick and which is continuously cemented by a combination of organic matter and aluminium, with or without iron ('thin iron pan'); or
    c. distinct organic pellets between sand grains; and
2. 0.6 percent or more organic carbon; and
3. pH (1:1 in water) of 5.9 or less; and
4.
    a. at least 0.50 percent Al_{ox} + ½Fe_{ox}[6] and have two times or more Al_{ox} + ½Fe_{ox} than an overlying umbric, ochric, albic or anthropedogenic horizon; or
    b. an optical density of the oxalate extract (ODOE) value of 0.25 or more, which also is two times or more the value of the overlying horizons; and
5. thickness of at least 2.5 cm and an upper limit below 10 cm of the mineral soil surface, unless permafrost is present within 200 cm depth.

Field identification. A spodic horizon normally underlies an albic horizon and meets the brownish black to reddish brown colours. Spodic horizons can also be characterized by the presence of a thin iron pan, or by the presence of organic pellets when weakly developed.

Relationships with some other diagnostic horizons. Spodic horizons can have similar characteristics as andic horizons rich in alumino-organic complexes. Sometimes only analytical tests can positively discriminate between the two. Spodic horizons have at least twice as much the Alox + ½Feox percentages than an overlying umbric, ochric, albic or anthropedogenic horizon. This criterion normally does not apply to andic horizons in which the alumino-organic complexes are hardly mobile.

Sulfuric horizon

General description. The sulfuric horizon (from L. *sulfur*) is an extremely acid subsurface horizon in which sulphuric acid is formed through oxidation of sulphides.

Diagnostic criteria. A sulfuric horizon must have:

1. pH < 3.5 in a 1:1 water suspension; and
2.
    a. either- yellow/orange jarosite [$KFe_3(SO_4)_2(OH)_6$] or yellowish-brown schwertmannite [$Fe_{16}O_{16}(SO_4)_3(OH)_{10}.10H_2O$] mottles; or - concentrations with a Munsell hue of 2.5Y or more and a chrome of 6 or more; or
    b. superposition on sulfidic soil materials; or
    c. 0.05 percent (by weight) or more water-soluble sulphate; and
3. thickness of 15 cm or more.

Field identification. Sulfuric horizons generally contain yellow/orange jarosite or yellowish brown schwertmannite mottles. Moreover, soil reaction is extremely acid; pH (H_2O) of less than 3.5 is not uncommon.

[6] Al_{ox} and Fe_{ox}: acid oxalate (pH 3) extractable aluminium and iron, respectively.

Relationships with some other diagnostic horizons. The sulfuric horizon often underlies a strongly mottled horizon with pronounced redoximorphic features (reddish to reddish brown iron hydroxide mottles and a light coloured, iron depleted matrix).

Takyric horizon.

General description. A takyric horizon (from Uzbek *takyr*, barren land) is a heavy textured surface horizon comprising a surface crust and a platy structured lower part. It occurs under arid conditions in periodically flooded soils.

Diagnostic criteria. A takyric horizon must have:
1. aridic properties; and
2. a platy or massive structure; and
3.
    a. a surface crust which has all of the following properties: a. enough thickness so that it does not curl entirely upon drying;
    b. polygonal desiccation cracks extending at least 2 cm deep when the soil is dry;
    c. sandy clay loam, clay loam, silty clay loam or finer texture;
    d. very hard dry consistence and very plastic and sticky wet consistence; and
    e. an electrical conductivity (EC) in the saturated paste of less than 4 dS m-1, or less than that of the horizon immediately below the takyric horizon.

Field identification. Takyric horizons are found in depressions in arid regions, where surface water, rich in clay and silt but relatively low in soluble salts, can accumulate and leach the upper soil horizons. Periodic salt leaching causes dispersion of clay and the formation of a thick, compact, fine-textured crust, which forms prominent polygonal cracks upon drying. Clay and silt often make up more than 80 percent of the crust material.

Relationships with some other diagnostic horizons. Takyric horizons occur in association with many diagnostic horizons, the most important ones being the salic, gypsic, calcic and cambic horizons. The low electrical conductivity and low soluble salt content of takyric horizons set them apart from the salic horizon.

Umbric horizon.

General characteristics. The umbric horizon (from L. *umbra*, shade) is a thick, dark coloured, base-desaturated surface horizon rich in organic matter.

Diagnostic criteria. An umbric horizon must have:
1. soil structure sufficiently strong that the horizon is not both massive and hard or very hard when dry. Very coarse prisms larger than 30 cm in diameter are included in the meaning of massive if there is no secondary structure within the prisms; and
2. Munsell colours with a chrome of less than 3.5 when moist, a value darker than 3.5 when moist and 5.5 when dry, both on broken and crushed samples. The colour value is at least one unit darker than that of the C horizon (both moist and dry) unless the C horizon has a colour value darker than 4.0, moist, in which case the colour contrast requirement is waived. If a C horizon is not present, comparison should be made with the horizon immediately underlying the surface horizon; and
3. base saturation (by 1 M NH_4OAc) of less than 50 percent on a weighted average throughout the depth of the horizon; and
4. organic carbon content of 0.6 percent (1 percent organic matter) or more throughout the thickness of mixed horizon (usually it is more than 2 to 5 percent, depending on the clay content). The organic carbon content is at least 0.6 percent more than the C horizon if the colour requirements are waived because of dark coloured parent materials; and

5. the following thickness requirements:
    a. 10 cm or more if resting directly on hard rock, a petroplinthic or petroduric horizon, or overlying a cryic horizon; or
    b. at least 20 cm and more than one-third of the thickness of the solum where the solum is less than 75 cm thick; or
    c. more than 25 cm where the solum is more than 75 cm thick.

The measurement of the thickness includes transitional AB, AE and AC horizons. The requirements for an umbric horizon must be met after the first 20 cm are mixed, as in ploughing.

<u>Field identification.</u> The main field characteristics used to identify the presence of an umbric horizon are its dark colour and its structure. In general, umbric horizons tend to have a lesser grade of soil structure than mollic horizons. As a guide, most umbric horizons have an acid soil reaction (pH (H_2O, 1:2.5) of less than about 5.5) which represents a base saturation of less than 50 percent. An additional indication for the acidity is a rooting pattern in which most of the roots tend to be horizontal, in the absence of a physical root
restricting barrier.

<u>Relationships with some other diagnostic horizons.</u> The base saturation requirement sets the umbric horizon apart from the mollic horizon, which otherwise is very similar. The upper limit of organic carbon content varies from 12 percent (20 percent organic matter) to 18 percent (30 percent organic matter) which is the lower limit for the histic horizon, or 20 percent, the lower limit of a folic horizon. Limits with base-desaturated fulvic and melanic horizons are set by the combination of the intense dark colour, the high organic carbon content, the thickness and the characteristics associated with andic horizons in these two horizons. Otherwise, umbric horizons frequently occur in association with andic horizons. Some thick, dark coloured, organic-rich, base-desaturated surface horizons occur which are formed as a result of human activities such as deep cultivation and manuring, the addition of organic manures, the presence of ancient settlements, kitchen middens, etc. (cf. anthropedogenic horizons). These horizons can usually be recognized in the field by the presence of artifacts, spade marks, contrasting mineral inclusions or stratification indicating the intermittent addition of manurial material, a relative higher position in the landscape, or by checking the agricultural history of the area. If hortic or plaggic horizons are present, either the 0.5 M $NaHCO_3$ P_2O_5 analysis (Gong et al., 1997) or the 1 percent citric acid soluble P_2O_5 analysis may give an indication.

Vertic horizon

<u>General description</u>. The vertic horizon (from L. *vertere*, to turn) is a clayey subsurface horizon which as a result of shrinking and swelling has polished and grooved ped surfaces ('slickensides'), or wedge-shaped or parallelepiped structural aggregates.

<u>Diagnostic criteria.</u> A vertic horizon must have:
1. 30 percent or more clay throughout; and
2. wedge-shaped or parallelepiped structural aggregates with a longitudinal axis tilted between 10° and 60° from the horizontal; and
3. intersecting slickensides[7]; and
4. a thickness of 25 cm or more.

<u>Field identification</u>. Vertic horizons are clayey, and have a hard to very hard consistency. When dry, vertic horizons show cracks of 1 or more centimetre wide. In the field the presence of polished, shiny ped surfaces ("slickensides") which often show sharp angles with each other, is very obvious.
<u>Additional characteristics</u>. The coefficient of linear extensibility (COLE) is a measure for the shrink-swell potential and is defined as the ratio of the difference between the moist length and the dry length of a clod to its dry length: (Lm-Ld)/Ld, in which Lm is the length at 33 kPa tension and Ld the length

[7] Slickensides are polished and grooved ped surfaces which are produced by one soil mass sliding past another.

when dry. In vertic horizons the COLE is more than 0.06. Relationships with some other diagnostic horizons. Several other diagnostic horizons may also have high clay content, viz. the argic, natric and nitic horizons. These horizons lack the characteristic typical for the vertic horizon; however, they may be laterally linked in the landscape with the vertic horizon usually taking up the lowest position.

Vitric horizon

General description. The vitric horizon (from L. *vitrum*, glass) is a surface or subsurface horizon dominated by volcanic glass and other primary minerals derived from volcanic ejecta.

Diagnostic criteria. A vitric horizon must have:

1. 10 percent or more volcanic glass and other primary minerals in the fine earth fraction; and either:
2. less than 10 percent clay in the fine earth fraction; or
3. a bulk density > 0.9 kg dm^3; or
4. Alox + 1/2Feox[8] >0.4 percent; or.
5. phosphate retention > 25 percent; and
6. thickness of at least 30 cm.

Field identification. The vitric horizon can be identified in the field with relative ease. It can occur as a surface horizon, however, it may also occur buried under some tens of centimetres of recent pyroclastic deposits. It has a fair amount of organic matter and a low clay content. The sand and silt fractions are still dominated by unaltered volcanic glass and other primary minerals (may be checked by x 10 hand-lens).

Relationships with some other diagnostic horizons. Vitric horizons are closely linked with andic horizons, into which they may eventually develop. The amount of volcanic glass and other primary minerals, together with the amount of non-crystalline or paracrystalline pedogenetic minerals mainly separates the two horizons.Vitric horizons may overlap with several diagnostic surface horizons, viz. the fulvic, melanic, mollic, umbric and ochric horizons.

Yermic horizon.

General description. The yermic horizon (from Sp. *yermo*, desert) is a surface horizon which usually, but not always, consists of surface accumulations of rock fragments ("desert pavement") embedded in a loamy vesicular crust and covered by a thin aeolian sand or loess layer.

Diagnostic criteria. A yermic horizon must have:

1. aridic properties; and
2.
    a. a pavement which is varnished or includes wind-shaped gravel or stones ("ventifacts"); or
    b. a pavement and a vesicular crust; or c. a vesicular crust above a platy A horizon, without a pavement.

Field identification. A yermic horizon comprises a vesicular crust at the surface and underlying A horizon(s). The crust, which has a loamy texture, shows a polygonal network of desiccation cracks, often filled with inblown material, which extend into the underlying horizons. Crust and the A horizon(s) below have a weak to moderate platy structure.

Relationships with some other diagnostic horizons. Yermic horizons often occur in association with other diagnostic horizons characteristic for desert environments (salic, gypsic, duric, calcic and cambic horizons). In very cold deserts (e.g. Antarctica) they may occur associated with cryic horizons. Under

[8] Al_{ox} and Fe_{ox} are acid oxalate (pH 3) extractable aluminium and iron, respectively (method of Blakemore et al., 1987)

these conditions coarse cryoclastic material dominates and there is little dust to be deflated and deposited by wind. Here a dense pavement with varnish, ventifacts, aeolian sand layers and soluble mineral accumulations may occur directly on loose C horizons, without a vesicular crust and underlying A horizons.

3.2.3. Diagnostic properties

Abrupt textural change

General description. An abrupt textural change is a very sharp increase in clay content within a limited depth range.

Diagnostic criteria. An abrupt textural change requires either:
1. doubling of the clay content within 7.5 cm if the overlying horizon has less than 20 percent clay; or
2. 20 percent (absolute) clay increase within 7.5 cm if the overlying horizon has 20 percent or more clay. In this case some part of the lower horizon should have at least twice the clay content of the upper horizon.

Albeluvic tonguing

General description. The term albeluvic tonguing (from L. *albus*, white, and *eluere*, to wash out) is connotative of penetrations of clay and iron-depleted material into an argic horizon. When peas are present, albeluvic tongues occur along ped surfaces. Redoximorphic characteristics and stagnic properties are not necessarily present.

Diagnostic criteria. Albeluvic tongues must:
1. have the colour of an albic horizon; and
2. have greater depth than width, with the following horizontal dimensions:
   a. 5 mm or more in clayey argic horizons; or
   b. 10 mm or more in clay loamy and silty argic horizons; or
   c. 15 mm or more in coarser (silt loam, loam or sandy loam) argic horizons; and
3. occupy more than 10 percent of the volume in the first 10 cm of the argic horizon, estimated from or measured on both vertical and horizontal sections; and
4. have a particle size distribution matching that of the eluvial horizon overlying the argic horizon.

Aridic properties

General description. The term aridic properties combines a number of properties which are common in surface horizons of soils occurring under arid conditions and where pedogenesis exceeds new accumulation at the soil surface by aeolian or alluvial activity.

Diagnostic criteria. Aridic properties are characterized by all of the following:
1. organic carbon content of less than 0.6 percent[9] if texture is sandy loam or finer, or less than 0.2 percent if texture is coarser than sandy loam, as a weighted average in the upper 20 cm of the soil or down to the top of a B horizon, a cemented horizon, or to rock, whichever is shallower; and
2. evidence of aeolian activity in one or more of the following forms:
   a. the sand fraction in some subhorizon or in inblown material filling cracks contains a noticeable proportion of rounded or subangular sand particles showing a matt surface (use a

[9] The organic carbon content may be higher if the soil is periodically flooded, or if it has an electrical conductivity of the saturated paste extract of 4 dS m-1 or more somewhere within 100 cm of the soil surface.

x 10 hand-lens). These particles make up 10 percent or more of the medium and coarser quartz sand fraction; or
   b. wind-shaped rock fragments ("ventifacts") at the surface; or
   c. aeroturbation (e.g. crossbedding); or
   d. evidence of wind erosion or deposition, or both; and
3. both broken and crushed samples have a Munsell colour value of 3 or more when moist and 4.5 or more when dry, and a chrome of 2 or more when moist; and
4. base saturation (by 1 M NH_4OAc) of more than 75 percent, but normally 100 percent.

Additional remarks. The presence of acicular ("needle-shaped") clay minerals (e.g. palygorskite and sepiolite) in soils is considered connotative of a desert environment, but it has not been reported in all desert soils. This may be due to the fact that under arid conditions acicular clays are not produced but only preserved, provided they exist in the parent material or in the dust that falls on the soil.

Continuous hard rock

Definition. Continuous hard rock is material underlying the soil, exclusive of cemented pedogenetic horizons such as a petrocalcic, petroduric, petrogypsic and petroplinthic horizons, which is sufficiently coherent and hard when moist to make hand digging with a spade impractible. The material is considered continuous if only a few cracks 10 cm or more apart are present and no significant displacement of the rock has taken place.

Geric properties

General description. Geric properties (from Gr. *geraios*, old) refers to mineral soil material which has a very low effective cation exchange capacity or even acts as an anion exchanger.

Diagnostic criteria. Mineral soil material has geric properties if it has either:
1. 1.5 cmolc or less of exchangeable bases (Ca, Mg, K, Na) plus unbuffered 1 M KCl exchangeable acidity per kg clay; or
2. a delta pH (pHKCl minus pH_{water}) of +0.1 or more.

Gleyic properties

General description. Soil materials develop gleyic properties (from the Russian local name *gley*, mucky soil mass) if they are completely saturated with groundwater, unless drained, for a period that allows reducing conditions to occur (this may range from a few days in the tropics to a few weeks in other areas), and show a gleyic colour pattern.

Diagnostic criteria. Reducing conditions[10] are evident by:
1. a value of rH in the soil solution of 19 or less; or
2. the presence of free Fe^{2+} as shown by the appearance of either:
   a. a solid dark blue colour on a freshly broken surface of a field-wet soil sample, after spraying it with a potassium ferric cyanide ($K_3Fe(III)(CN)_6$) solution; or
   b. a strong red colour on a freshly broken surface of a field-wet soil sample after spraying it with a a,a, dipyridyl solution in 10 acetic acid; and
3. a gleyic colour pattern[11] reflecting oxirnorphic[12] and/or reductomorphic[13] properties either:

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[10] The basic measure for reduction in soil materials is the rH. This measure is related to the redox potential (Eh) and corrected for the pH as shown in the following formula:

$$rH = \frac{Eh(mV)}{29} + 2pH$$

a. in more than 50 percent of the soil mass; or
b. in 100 percent of the soil mass below any surface horizon.

Field identification. Iron and manganese (hydr)oxides in soils with gleyic properties are redistributed to the outside of the peas and towards the soil surface from where oxygen is derived. The resulting colour pattern (reddish, brownish or yellowish colours near the ped surface or in the upper part of the profile, together with grayish/bluish colours in the inside of the peas or deeper in the soil) indicates if gleyic conditions occur. Also, the dipyridyl test often gives a good indication if ferric iron is present in the soil solution.

Permafrost

Definition. Permafrost is a layer in which the temperature is perennially at or below 0°C for at least two consecutive years.

Secondary carbonates

General description. The term secondary carbonates refers to translocated lime, soft enough to be cut readily with a finger nail, precipitated in place from the soil solution rather than inherited from a soil parent material. As a diagnostic property it should be present in significant quantities.

Field identification. Secondary carbonates must have some relation to the soil structure or fabric. Secondary carbonate accumulations may disrupt the fabric to form spheroidal aggregates or 'white eyes', that are soft and powdery when dry, or lime may be present as soft coatings in pores or on structural faces. If present as coatings, secondary carbonates cover 50 percent or more of the structural faces and are thick enough to be visible when moist. If present as soft nodules, they occupy 5 percent or more of the soil volume. Filaments (pseudomycelia), which come and go with changing moisture conditions, are not included in the definition of secondary carbonates.

Stagnic properties

General description. Soil material has stagnic properties (from L. *stagnare*, to flood) if it is, at least temporarily, completely saturated with surface water, unless drained, for a period long enough to allow

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[11] A gleyic colour pattern results from a redox gradient between the groundwater and capillary fringe causing an uneven distribution of iron and manganese (hydr)oxides. In the lower part of the soil and/or inside the peas the oxides are either transformed into insoluble Fe/Mn(II) compounds or they are translocated both processes leading to the absence of colours with a Munsell hue redder than 2.5Y. Translocated iron and manganese compounds can be concentrated in oxidized form (Fe(III) Mn(lV)) recognizable by a 10% H_2O_2 test in the field on ped surfaces or in (bio)pores ("rusty root channels"), and towards the surface even in the matrix.

[12] Oximorphic properties reflect alternating reducing and oxidizing conditions as is the case in the capillary fringe and in the surface horizon(s) of soils with fluctuating groundwater levels. Oximorphic properties are expressed by reddish brown (ferrihydrite) or bright yellowish brown (goethite) mottles or as bright yellow (jarosite) mottles in acid sulphate soils. In loamy and clayey soils the iron (hydr)oxides are concentrated on aggregate surfaces and the walls of larger pores (e.g. old root channels).

[13] Reductomorphic properties reflect permanently wet conditions and are expressed by neutral (white to black: N1/ to N8/) or bluish to greenish (2.5Y, 5Y, 5G, 5B) colours in more than 95 percent of the soil matrix. In loamy and clayey material blue-green colours dominate due to Fe (II,III) hydroxy salts (green rust). If the material is rich in sulphur blackish colours prevail due to iron sulphides. In calcareous material whitish colours are dominant due to calcite and/or siderite. Sands are usually light grey to white in colour and often also impoverished in iron and manganese. The upper part of a reductomorphic horizon may show up to 5 percent rusty colours mainly around channels of burrowing animals or plant roots.

reducing conditions to occur (this may range from a few days in the tropics to a few weeks in other areas), and show a stagnic colour pattern[14].

Diagnostic criteria. Reducing conditions are evident by:

1. a value of rH in the soil solution of 19 or less; or
2. the presence of free $Fe2^+$ as shown by the appearance of either:
   a. a solid dark blue colour on a freshly broken surface of a field-wet soil sample, after spraying it with a 1 potassium ferric cyanide ($K_3Fe(III)(CN)_6$) solution; or
   b. a strong red colour on a freshly broken surface of a field-wet soil sample after spraying it with a 0.2 a,a, dipyridyl solution in 10 acetic acid; and
3. an albic horizon or a stagnic colour pattern either:
   a. in more than 50 percent of the soil volume if the soil is undisturbed; or
   b. in 100 percent of the soil volume if the surface horizon is disturbed by ploughing.

Field identification. The distribution pattern of the redoximorphic features, with iron and manganese oxides concentrated in the inside of peas (or in the matrix if peas are absent) gives a good indication of stagnic properties.

3.2.4. Diagnostic materials

Anthropogeomorphic soil material

General description. Anthropogeomorphic soil material (from Gr. *anthropos*, human) refers to unconsolidated mineral or organic material resulting largely from land fills, mine spoil, urban fill, garbage dumps, dredgings, etc., produced by human activities. It has, however, not been subject to a sufficiently long period of time to find significant expression of pedogenetic processes.

Calcaric (calcareous) soil material

Definition. Calcaric soil material (from En. *calcareous*) shows strong effervescence with 10 percent HCl
in most of the fine earth. It applies to material which contains more than 2 percent calcium carbonate equivalent.

Organic soil material

General description. Organic soil material consists of organic debris which accumulates at the surface under either wet or dry conditions and in which the mineral component does not significantly influence the soil properties.

Diagnostic criteria. Organic soil material must have one of the two following:

1. if saturated with water for long periods (unless artificially drained), and excluding live roots, either:
   a. 18 percent organic carbon (30 percent organic matter) or more if the mineral fraction comprises 60 percent or more clay; or

[14] A stagnic colour pattern shows mottling in such a way that the surfaces of the peas (or part of the soil matrix) are lighter (one Munsell value unit or more) and paler (one chrome unit or less) coloured, and the interior of the peas (or parts of the soil matrix) are more reddish (one hue unit or more) and brighter (one chrome unit or more) coloured than the non-redoximorphic parts of the layer, or of its mixed average. This mottling pattern may occur directly below the surface horizon or plough layer, or below an albic horizon.

   b. 12 percent organic carbon (20 percent organic matter) or more if the mineral fraction has no clay; or
   c. a proportional lower limit of organic carbon content between 12 and 18 percent if the clay content of the mineral fraction is between 0 and 60 percent;or
2. if never saturated with water for more than a few days, 20 percent or more organic carbon.

Sulfidic soil material

General description. Sulfidic soil material (from E. *sulphide*) is waterlogged deposit containing sulphur, mostly in the form of sulphides, and only moderate amounts of calcium carbonate.

Diagnostic criteria. Sulfidic soil material must have:

1. 0.75 percent or more sulphur (dry weight) and less than three times as much calcium carbonate equivalent as sulphur; and
2. pH (H_2O) of more than 3.5.

Field identification. Deposits containing sulphides often show in moist or wet condition a golden shine, the colour of pyrite. Forced oxidation with a 30 percent hydrogen peroxide solution lowers the pH by 0.5 unit or more. Oxidation also gives rise to the smell of rotten eggs.

3.2.5 Other diagnostic criterion

Cation exchange capacity

The cation exchange capacity (CEC), used as a criterion in the definition of diagnostic horizons or properties as well as in the key to the reference soil groups, is essentially meant to reflect the nature of the mineral component of the exchange complex. However, the CEC determined on the total earth fraction is also influenced by the amount and kind of organic matter present. Where low clay activity is a diagnostic property, it may be desirable to deduct CEC linked to the organic matter, using a graphical method[15] for individual profiles (Bennema and Camargo, 1979; Brinkman, 1979; Klamt and Sombroek, 1988).

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[15] The method involves regressing the amount of organic C (expressed in g) against the measured CEC (pH 7) expressed in cmolc kg-1 clay. With the resultant equation tile contribution of the organic C to tile CEC can be calculated, and the corrected CEC of the clay be determined. Uniform clay mineralogy throughout tile profile should be assumed.

4. Overview spatial assessment of pedoclimatic zones

A great variety of climatic, topographical and geological conditions, together with the diverse anthropogenic influences has resulted in a diverse soil cover in Europe. The fact that twenty-three out of the total of thirty Reference Soil Groups (WRB 1998) of the world have representative in the the continent shows the magnitude of this diversity. However, not all soil types have the same share in the soil coverage. While the most widespread Reference Soil Group – Cambisols – has a proportion up to 56 % of the total area in the Sub-Oceanic belt, Solonetz soil can be found on very limited areas in two climatic zones. Table 2 shows the summarized extent of pedoclimatic zones as defined by Reference Soil Groups in the continent by climate zones. There are 133 different pedoclimatic zones in Europe.

Table 2 Spatial share of pedoclimatic zones (by Reference Soil Groups; WRB 1998) under different climates in Europe

Reference Soil Group	Boreal to Sub-Boreal	Atlantic	Sub-oceanic	Northern sub-continental	Southern sub-continental	Mediterranean semi-arid	Mediterranean (temperate and sub-oceanic)	Temperate mountainous
	%							
Acrisols			0.01		0.07	1.68	0.11	0.05
Albeluvisols	28.61	4.53	1.81	13.87	11.13			1.61
Andosols			0.85			0.09	0.37	0.62
Arenosols	0.15	1.29	0.04	3.77	0.38	0.53	0.28	0.03
Calcisols						2.07	1.18	
Cambisols	1.24	27.07	56.02	11.43	11.04	39.48	47.02	43.06
Chernozems		0.01	0.01	24.94	17.98			0.28
Cryosol	2.88							
Fluvisols	2.81	7.37	4.11	6.24	8.38	7.78	5.81	4.23
Gleysols	1.47	9.08	1.23	3.06	3.48	0.06	0.07	1.09
Gypsisols						0.99	0.03	
Histosols	12.52	4.53	0.44	3.22	1.69	0.02	0.15	0.07
Kastanozems				1.04		0.02		
Leptosols	2.70	8.56	12.68	1.78	3.00	8.53	24.47	29.10
Luvisols	1.04	19.79	15.09	9.92	14.25	13.88	6.97	10.95
Phaeozems	1.21	0.02	0.87	8.89	22.06		0.35	0.85
Planosols	0.01	0.07	0.16	0.19	1.30	0.07	0.01	0.81
Podzols	41.55	16.71	2.93	10.27	1.04	0.38	2.25	5.77
Regosols	3.66	0.71	3.69	1.19	0.52	21.25	10.14	0.58
Solonchaks		0.23		0.06	0.15	0.51	0.33	
Solonetzes				0.05	0.72			0.01
Umbrisols	0.15				0.07		0.15	
Vertisols		0.03	0.07	0.09	2.75	2.65	0.31	0.89

Following the Cambisols Reference Soil Group the second most widespread is that of Luvisols, Podzols and Leptosols. Luvisols, like Cambisols, can be found in all parts of the continent in associations with other Reference Soil Groups. Podzols have similar area to Luvisols. However, this Reference Soil Group is mainly concentrated in northern Europe. Leptosols, the forth largest Reference Soil Group, on the contrary, have smaller shares in the northern regions. Spatial extent of Histosols, Regosols, Fluviols, Gleysols and Arenosols ranges around 5 within the EU. However, while Histosols, Gleysols and Arenosols are predominantly soils of the Northern regions, most of Regolols can be found in the southern parts of Europe. Fluvisols are predominant in the river basins in all parts of the continent. Albeluvisols have similar areal coverage (~ 2) with Chernozems and Phaeozems, however fundamentally different pedological features. Reference Soil Groups with smaller areal extent (< 1) include soils with special abilities for performing important soil functions.

Each Reference Soil Group in climatic zones of Europe can be furher subdivided by their main qualyfyers, which enhance the information base for soil modeling. In Tables 2 and 3 the list of Reference Soil Groups and qualifyers are presented, together with the mapping codes which are applied during the pedoclimatic zonation. Figure 3 displayes the map of pedoclimatic zones showing the distribution of Reference Soil Groups within the climate zones. Further subdivision of soils within the pedoclima zones has been perfortmed on the second level taxonomy by the qualifyiers applied in the classification. Detailed information on the results of this assessment is provided in chapter 5.

Figure 2 Pedoclimatic zones of Europe (The first digit of the code in the legend represents the climate zone and the second code represents the RSG as given in Table 3.)

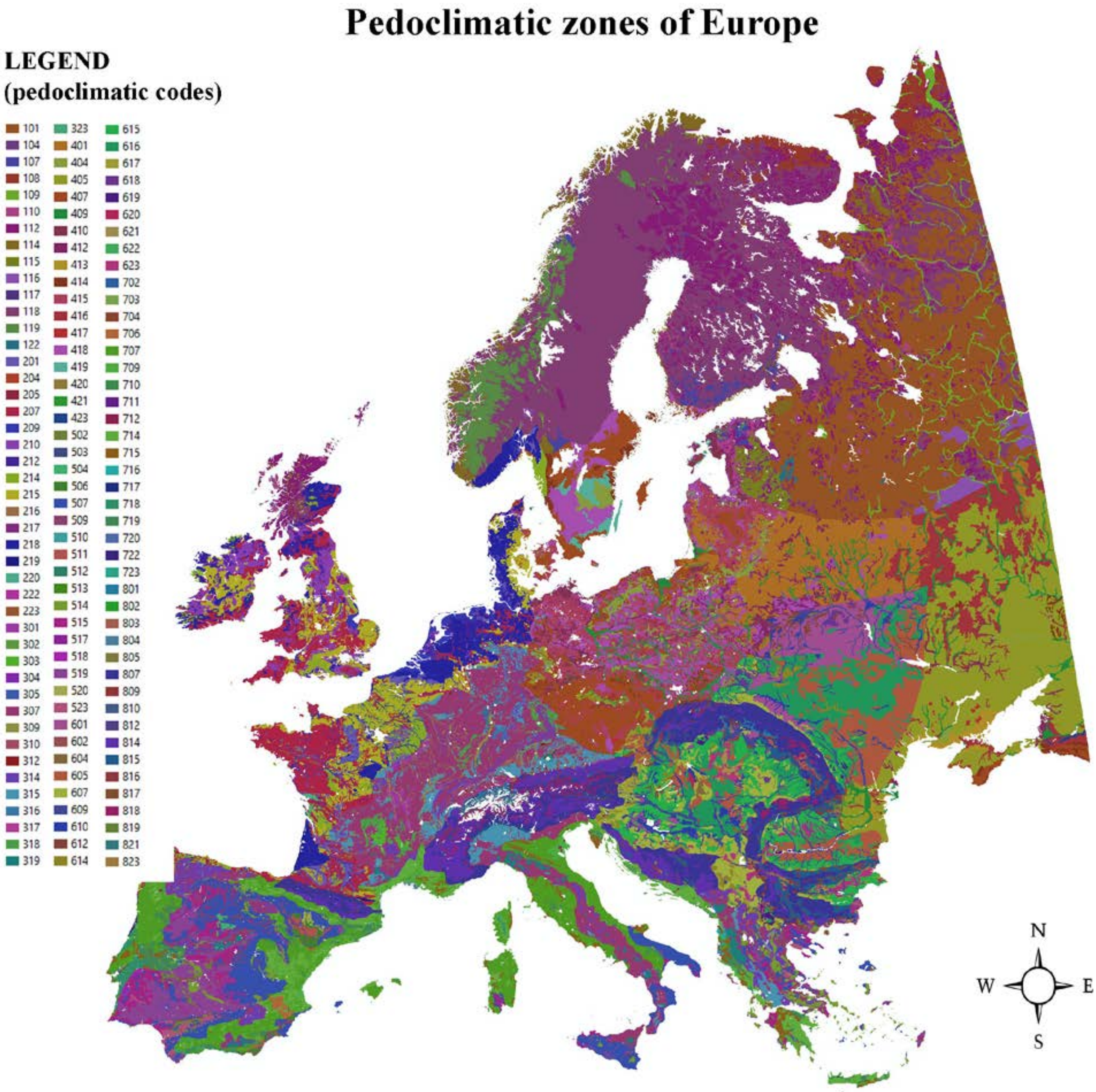


Table 3. Codes of pedoclimatic zones of Europe

Reference Soil Group (RSG)	RSG soil acronym	Code of pedoclimatic zone in climate zone* 1	Code of pedoclimatic zone in climate zone 2	Code of pedoclimatic zone in climate zone 3	Code of pedoclimatic zone in climate zone 4	Code of pedoclimatic zone in climate zone 5	Code of pedoclimatic zone in climate zone 6	Code of pedoclimatic zones in climate zone 7	Code of pedoclimatic zone in climate zone 8)
Acrisols	AC	n.a.	n.a.	301	n.a.	501	601	701	801
Albeluvisols	AB	102	202	302	402	n.a.	602	n.a.	802
Andosols	AN	n.a.	n.a.	303	n.a.	503	n.a.	703	803
Arenosols	AR	104	204	304	404	504	604	704	804
Chernozems	CH	n.a.	205	305	405	n.a.	605	n.a.	805
Calcisols	CL	n.a.	n.a.	n.a.	n.a.	506	n.a.	706	n.a.
Cambisols	CM	107	207	307	407	507	607	707	807
Cryosol	CR	108	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Fluvisols	FL	109	209	309	409	509	609	709	809
Gleysols	GL	110	210	310	410	510	610	710	810
Gypsisols	GY	n.a.	n.a.	n.a.	n.a.	511	n.a.	711	n.a.
Histosols	HS	112	212	312	412	512	612	712	812
Kastanozems	KS	n.a.	n.a.	n.a.	413	513	n.a.	n.a.	n.a.
Leptosols	LP	114	214	314	414	514	614	714	814
Luvisols	LV	115	215	315	415	515	615	715	815
Phaeozems	PH	116	216	316	416	n.a.	616	716	816
Planosols	PL	117	217	317	417	517	617	717	817
Podzols	PZ	118	218	318	418	518	618	718	818
Regosols	RG	119	219	319	419	519	619	719	819
Solonchaks	SC	n.a.	220	n.a.	420	520	620	720	n.a.
Solonetzes	SN	n.a.	n.a.	n.a.	421	n.a.	621	n.a.	821
Umbrisols	UM	122	n.a.	n.a.	n.a.	n.a.	622	722	n.a.
Vertisols	VR	n.a.	223	323	423	523	623	723	823

*Climate zones: 1 - Boreal to Sub-Borea, 2 - Atlantic, 3 - Sub-Oceanic, 4 - Northern sub-continental, 5 - Mediterranean semi-arid, 6 - Southern sub-continental, 7 - Mediterranean (temperate and sub-oceanic), 8 -Temperate mountainous

5. Spatial distribution of soils in the pedoclimatic zones

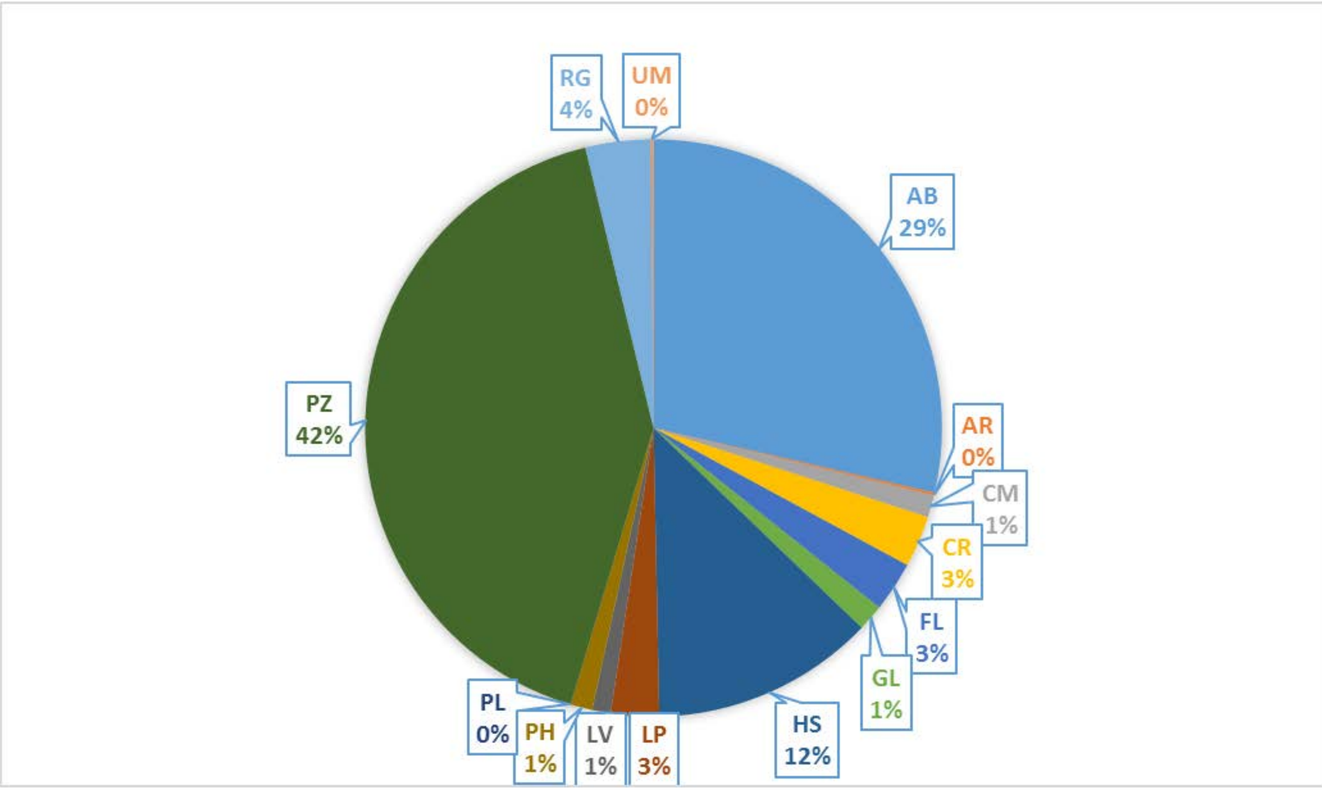
5.1 Boreal climate and its pedoclimatic zones

Fourteen different Reference Soil Groups can be found in the boreal climatic zone of Europe, resulting fourteen pedoclimatice zones under this climate.

Podzols and Albeluvisols are the predominat Reference Soil Groups and histosolos have also areal share above 10%. While Histosols have little agricultural relevance in this zone, the other two major soil group can be in the prime focus of soil assessment in the Boreal zone.

Share of the pedoclimatic zones under Boreal climate are given in figure 3.

Figure 3. Areal share of pedoclimatic zones under Boreal climate by Reference Soil Groups



Details of soil conditions within the pedoclimatic zones are given in tables 4.-17.

Table 4. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Albeluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Endoeutric Albeluvisol	ABeun	11,6%
Gleyic Albeluvisol	ABgl	9,4%
Haplic Albeluvisol	ABha	0,7%
Histic Albeluvisol	ABhi	16,3%
Stagnic Albeluvisol	ABst	3,4%
Umbric Albeluvisol	ABum	58,6%

Table 5. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Arenosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Arenosol	ARha	94,1%
Protic Arenosol	ARpr	5,9%

Table 6. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Cambisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Cambisol	CMca	12,8%
Dystric Cambisol	CMdy	51,7%
Eutric Cambisol	CMeu	7,5%
Gleyic Cambisol	CMgl	0,8%
Vertic Cambisol	CMvr	27,2%

Table 67 Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Cryosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Cryosol	CRha	2,2%
Histic Cryosol	CRhi	46,8%
Turbic Cryosol	CRtu	36,9%
Umbric Cryosol	CRum	14,1%

Table 8. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Fluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Fluvisol	FLdy	66,5%
Eutric Fluvisol	FLeu	21,7%
Histic Fluvisol	FLhi	8,7%
Thionic Fluvisol	FLti	2,8%
Umbric Fluvisol	FLum	0,3%

Table 9. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Gleysol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Gleysol	GLdy	36,5%
Eutric Gleysol	GLeu	32,7%
Histic Gleysol	GLhi	14,8%
Humic Gleysol	GLhu	16,1%

Table 10. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Histosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Histosol	HSdy	40,0%
Eutric Histosol	HSeu	2,5%
Fibric Histosol	HSfi	24,4%
Gelic Histosol	HSge	31,2%
Sapric Histosol	HSsa	2,0%

Table 11. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Leptosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Leptosol	LPdy	8,4%
Haplic Leptosol	LPha	70,7%
Lithic Leptosol	LPli	0,3%
Rendzic Leptosol	LPrz	20,7%

Table 12. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Luvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcic Luvisol	LVcc	5,0%
Gleyic Luvisol	LVgl	91,3%
Haplic Luvisol	LVha	3,7%

Table 13. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Phaeozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Albic Phaeozem	PHab	86,8%
Haplic Phaeozem	PHha	3,6%
Luvic Phaeozem	PHlv	9,5%

Table 14. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Planosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Eutric Planosol	PLeu	100,0%

Table 15. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Podzol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Carbic Podzol	PZcb	5,3%
Entic Podzol	PZet	9,0%
Gleyic Podzol	PZgl	0,1%
Haplic Podzol	PZha	75,6%
Leptic Podzol	PZle	0,1%
Placic Podzol	PZpi	0,3%
Rustic Podzol	PZrs	9,3%
Umbric Podzol	PZum	0,2%

Table 16. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Regosol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Calcaric Regosol	RGca	1,3%
Dystric Regosol	RGdy	98,7%

Table 17. Share of second level soil units in the pedoclimatic zone (Boreal to Sub-Boreal, Umbrisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Gleyic Umbrisol	UMgl	100,0%

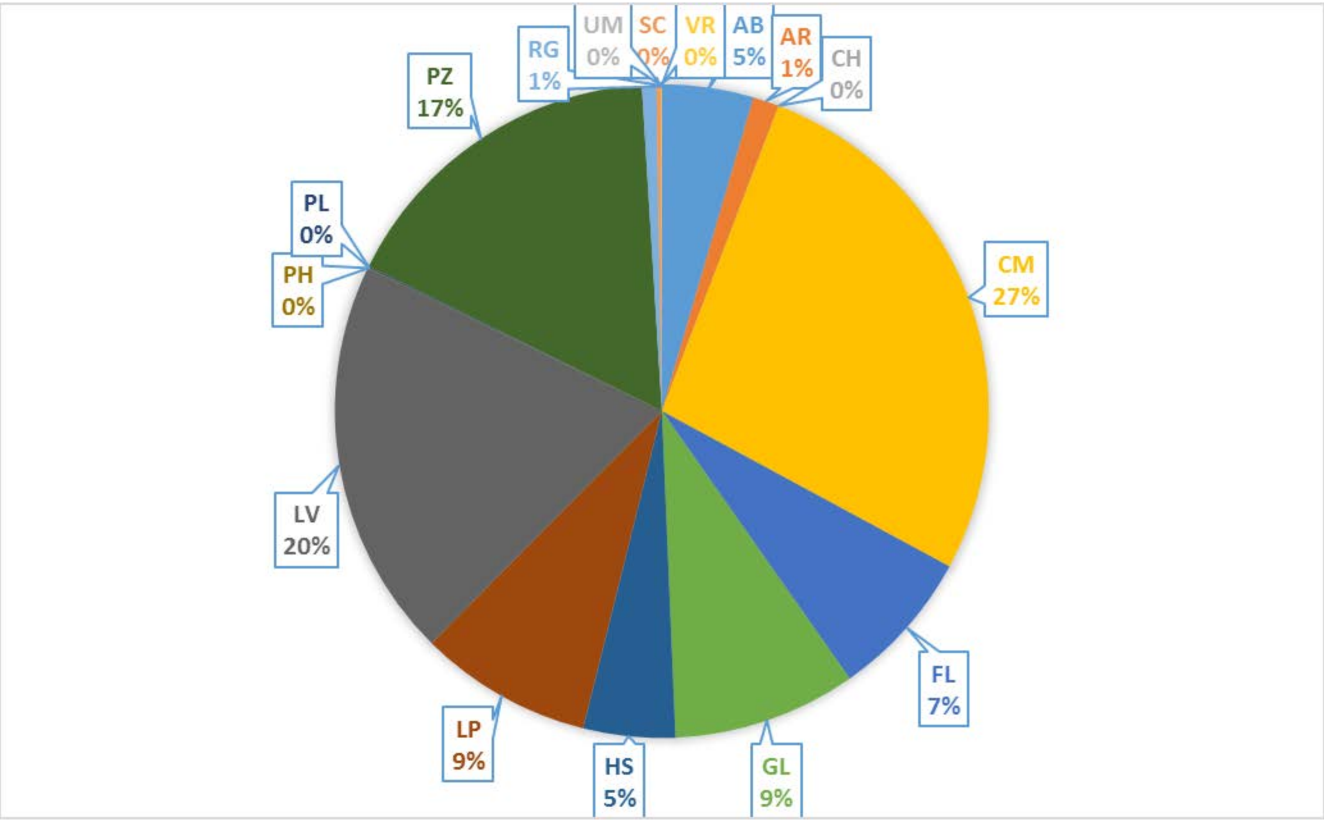
5.2 Atlantic climate and its pedoclimatic zones

Sixteen different Reference Soil Groups can be found in the Atlantic climatic zone of Europe, resulting sixteen pedoclimatice zones under this climate.

Cambisols, Luvisols and Podzols the predominat Reference Soil Groups and Leptosols, Fluvisols and Histosols have also areal share above 5%.

Share of the pedoclimatic zones under Atlantic climate are given in figure 4.

Figure 4. Areal share of pedoclimatic zones under Atlantic climate by Reference Soil Groups



Details of soil conditions within the pedoclimatic zones are given in tables 18.-33.

Table 18. Share of second level soil units in the pedoclimatic zone (Atlantic, Albeluvisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Endoeutric Albeluvisol	ABeun	23,7%
Gleyic Albeluvisol	ABgl	6,4%

Haplic Albeluvisol	ABha	69,9%

Table 19. Share of second level soil units in the pedoclimatic zone (Atlantic, Arenosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Arenosol	ARha	100,0%

Table 20. Share of second level soil units in the pedoclimatic zone (Atlantic, Chernozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Chernozem	CHha	100,0%

Table 21. Share of second level soil units in the pedoclimatic zone (Atlantic, Cambisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Cambisol	CMca	11,7%
Chromic Cambisol	CMcr	3,3%
Dystric Cambisol	CMdy	43,3%
Eutric Cambisol	CMeu	25,9%
Gleyic Cambisol	CMgl	8,9%
Mollic Cambisol	CMmo	6,8%
Vertic Cambisol	CMvr	0,1%

Table 22. Share of second level soil units in the pedoclimatic zone (Atlantic, Fluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Fluvisol	FLca	43,0%
Dystric Fluvisol	FLdy	3,1%
Eutric Fluvisol	FLeu	54,0%

Table 23. Share of second level soil units in the pedoclimatic zone (Atlantic, Gleysol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Gleysol	GLca	1,8%
Dystric Gleysol	GLdy	43,6%
Eutric Gleysol	GLeu	33,8%
Haplic Gleysol	GLha	0,7%
Humic Gleysol	GLhu	14,1%
Mollic Gleysol	GLmo	5,9%
Thionic Gleysol	GLti	0,1%

Table 24. Share of second level soil units in the pedoclimatic zone (Atlantic, Histosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Histosol	HSdy	73,9%
Eutric Histosol	HSeu	26,1%

Table 25. Share of second level soil units in the pedoclimatic zone (Atlantic, Leptosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Leptosol	LPca	0,8%
Dystric Leptosol	LPdy	15,9%
Eutric Leptosol	LPeu	0,2%
Haplic Leptosol	LPha	18,0%
Rendzic Leptosol	LPrz	65,1%

Table 26. Share of second level soil units in the pedoclimatic zone (Atlantic, Luvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Albic Luvisol	LVab	0,3%
Arenic Luvisol	LVar	1,5%
Chromic Luvisol	LVcr	5,8%
Gleyic Luvisol	LVgl	25,4%
Haplic Luvisol	LVha	67,0%

Table 27. Share of second level soil units in the pedoclimatic zone (Atlantic, Phaeozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Luvic Phaeozem	PHlv	100,0%

Table 28. Share of second level soil units in the pedoclimatic zone (Atlantic, Planosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Planosol	PLdy	100,0%

Table 29. Share of second level soil units in the pedoclimatic zone (Atlantic, Podzol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Gleyic Podzol	PZgl	14,4%

Haplic Podzol	PZha	60,7%
Leptic Podzol	PZle	6,8%
Placic Podzol	PZpi	13,2%
Umbric Podzol	PZum	4,9%

Table 30. Share of second level soil units in the pedoclimatic zone (Atlantic, Regosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Regosol	RGca	8,6%
Dystric Regosol	RGdy	66,0%
Eutric Regosol	RGeu	25,4%

Table 31. Share of second level soil units in the pedoclimatic zone (Atlantic, Solonchak areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Gleyic Solonchak	SCgl	100,0%

Table 32. Share of second level soil units in the pedoclimatic zone (Atlantic, Umbrisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Arenic Umbrisol	UMar	100,0%

Table 33. Share of second level soil units in the pedoclimatic zone (Atlantic, Vertisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Pellic Vertisol	VRpe	100,0%

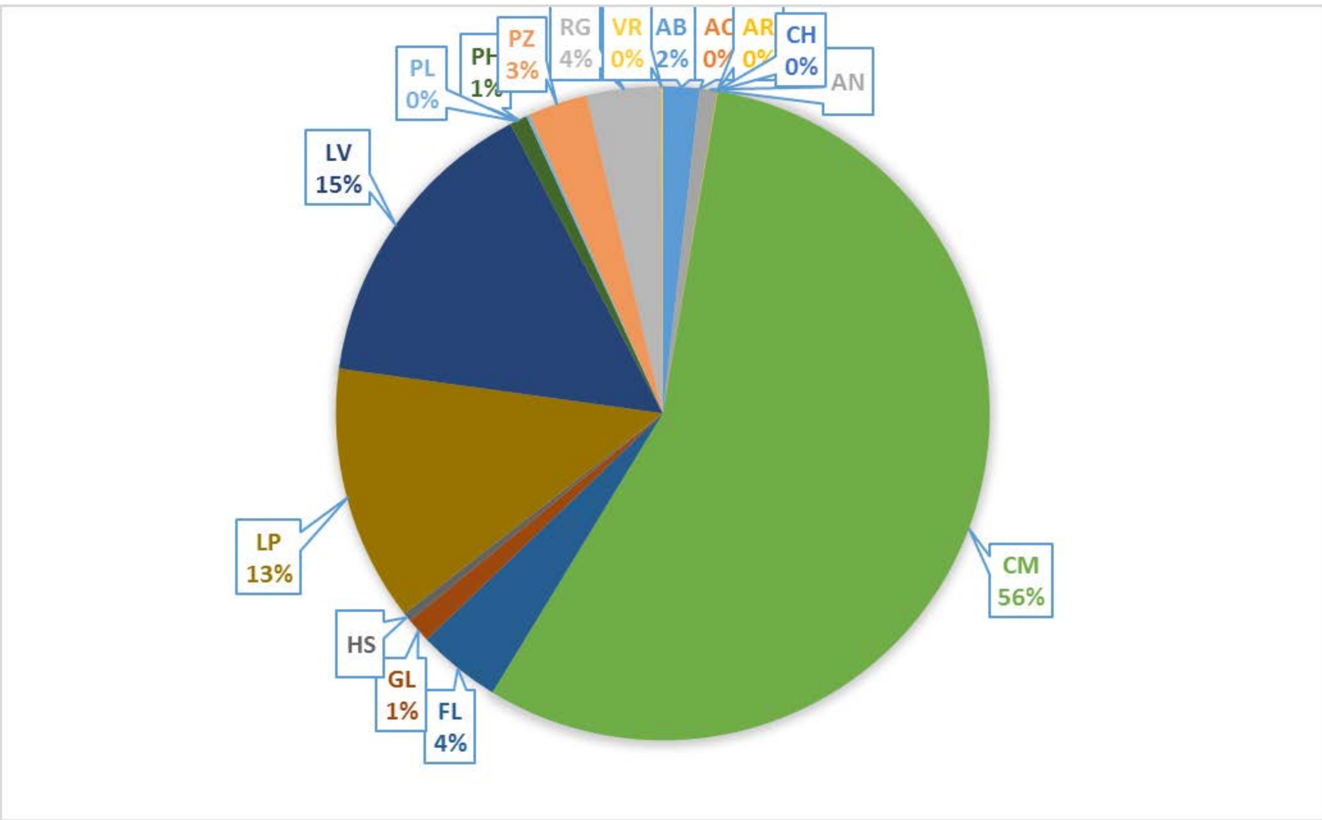
5.3 Sub-Oceanic climate and its pedoclimatic zones

Sixteen different Reference Soil Groups can be found in the Sub-Oceanic climatic zone of Europe, resulting sixteen pedoclimatice zones under this climate.

Cambisols dominate this climate zone but Leptosols and Luvisols have important shares on its land too.

Share of the pedoclimatic zones under Sub-Oceanic climate climate are given in figure 5.

Figure 5. Areal share of pedoclimatic zones under Sub-Oceanic climate by Reference Soil Groups



Details of soil conditions within the pedoclimatic zones are given in tables 34.-49.

Table 34. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Albeluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Endoeutric Albeluvisol	ABeun	1,7%
Gleyic Albeluvisol	ABgl	64,5%
Haplic Albeluvisol	ABha	33,9%

Table 35. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Acrisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Gleyic Acrisol	ACgl	100,0%

Table 36. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Andosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Andosol	ANdy	89,1%
Humic Andosol	ANhu	10,3%
Mollic Andosol	ANmo	0,6%

Table 37. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Arenosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Arenosol	ARha	100,0%

Table 38. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Chernozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Chernozem	CHha	100,0%

Table 39. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Cambisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Cambisol	CMca	8,9%
Chromic Cambisol	CMcr	5,0%
Dystric Cambisol	CMdy	42,4%
Eutric Cambisol	CMeu	31,1%
Gleyic Cambisol	CMgl	1,8%
Mollic Cambisol	CMmo	6,1%
Vertic Cambisol	CMvr	4,9%

Table 40. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Fluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Fluvisol	FLca	37,5%
Dystric Fluvisol	FLdy	3,1%
Eutric Fluvisol	FLeu	59,4%

Table 41. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Gleysol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Gleysol	GLca	17,0%

Dystric Gleysol	GLdy	4,3%
Eutric Gleysol	GLeu	10,6%
Haplic Gleysol	GLha	60,0%
Humic Gleysol	GLhu	6,0%
Mollic Gleysol	GLmo	2,2%

Table 42. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Histosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Histosol	HSdy	33,3%
Eutric Histosol	HSeu	66,7%

Table 43. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Leptosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Leptosol	LPca	16,7%
Dystric Leptosol	LPdy	7,7%
Eutric Leptosol	LPeu	3,5%
Haplic Leptosol	LPha	21,4%
Rendzic Leptosol	LPrz	50,7%

Table 44. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Luvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Albic Luvisol	LVar	1,1%
Calcic Luvisol	LVcc	0,0%
Chromic Luvisol	LVcr	10,8%
Gleyic Luvisol	LVgl	22,9%
Haplic Luvisol	LVha	65,0%
Vertic Luvisol	LVvr	0,2%

Table 45. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Phaeozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Phaeozem	PHca	5,9%
Haplic Phaeozem	PHha	5,5%
Luvic Phaeozem	PHlv	88,6%

Table 46. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Planosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)

Dystric Planosol	PLdy	100,0%

Table 47. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Podzol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Gleyic Podzol	PZgl	0,0%
Haplic Podzol	PZha	39,0%
Leptic Podzol	PZle	58,8%
Umbric Podzol	PZum	2,2%

Table 48. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Regosol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Calcaric Regosol	RGca	42,6%
Dystric Regosol	RGdy	13,8%
Eutric Regosol	RGeu	43,6%

Table 49. Share of second level soil units in the pedoclimatic zone (Sub-oceanic, Vertisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Chromic Vertisol	VRcr	35,7%
Pellic Vertisol	VRpe	64,3%

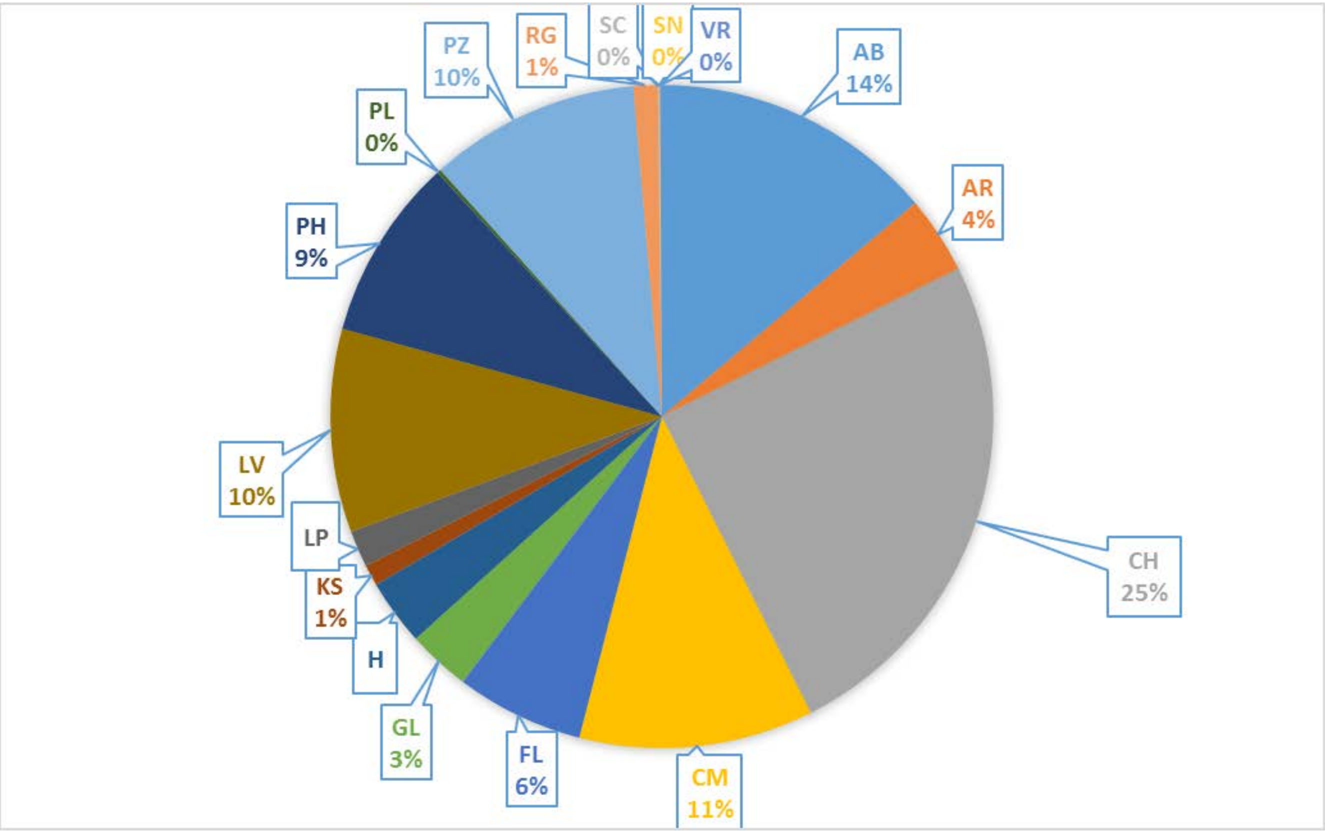
5.4 Northern Sub-Continental climate and its pedoclimatic zones

Seventeen different Reference Soil Groups can be found in the Northern Sub-Continental climatic zone of Europe, resulting seventeen pedoclimatice zones under this climate.

Chernozem has the highest share under this climate with Albeluvisols, Cambisols, Luvisols and Phaeozems having important parts too.

Share of the pedoclimatic zones under Northern Sub-Continental climate are given in figure 6.

Figure 6. Areal share of pedoclimatic zones under Northern Sub-Continental climate by Reference Soil Groups



Details of soil conditions within the pedoclimatic zones are given in tables 50.-66.

Table 50. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Albeluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Endoeutric Albeluvisol	ABeun	4,5%
Gleyic Albeluvisol	ABgl	8,7%
Haplic Albeluvisol	ABha	4,3%
Stagnic Albeluvisol	ABst	2,4%
Umbric Albeluvisol	ABum	80,1%

Table 51. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Arenosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Albic Arenosol	ARab	2,1%
Haplic Arenosol	ARha	86,8%
Protic Arenosol	ARpr	11,1%

Table 52. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Chernozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcic Chernozem	CHcc	31,0%
Chernic Chernozem	CHch	51,7%
Haplic Chernozem	CHha	2,2%
Luvic Chernozem	CHlv	15,1%

Table 53. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Cambisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Cambisol	CMca	6,9%
Chromic Cambisol	CMcr	0,7%
Dystric Cambisol	CMdy	55,7%
Eutric Cambisol	CMeu	29,9%
Gleyic Cambisol	CMgl	5,4%
Vertic Cambisol	CMvr	1,5%

Table 54. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Fluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Fluvisol	FLca	10,5%
Dystric Fluvisol	FLdy	7,1%
Eutric Fluvisol	FLeu	57,1%
Gleyic Fluvisol	FLgl	10,4%

Histic Fluvisol	FLhi	14,7%
Mollic Fluvisol	FLmo	0,2%

Table 55. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Gleysol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Gleysol	GLca	0,1%
Dystric Gleysol	GLdy	25,1%
Eutric Gleysol	GLeu	28,3%
Haplic Gleysol	GLha	3,6%
Histic Gleysol	GLhi	4,1%
Humic Gleysol	GLhu	15,9%
Mollic Gleysol	GLmo	6,3%
Sodic Gleysol	GLso	16,7%

Table 56. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Histosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Histosol	HSdy	4,4%
Eutric Histosol	HSeu	48,6%
Fibric Histosol	HSfi	11,8%
Gelic Histosol	HSge	3,7%
Sapric Histosol	HSsa	30,0%
Salic Histosol	HSsz	1,6%

Table 57. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Kastanozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcic Kastanozem	KScc	16,1%
Haplic Kastanozem	KSha	64,0%
Luvic Kastanozem	KSlv	19,9%

Table 58. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Leptosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Leptosol	LPca	0,6%
Dystric Leptosol	LPdy	43,6%
Haplic Leptosol	LPha	6,5%
Mollic Leptosol	LPmo	15,1%
Rendzic Leptosol	LPrz	34,3%

Table 59. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Luvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Albic Luvisol	LVab	1,3%
Arenic Luvisol	LVar	10,9%

Calcic Luvisol	LVcc	3,8%
Chromic Luvisol	LVcr	0,5%
Gleyic Luvisol	LVgl	34,9%
Haplic Luvisol	LVha	48,6%

Table 60. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Phaeozem areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Albic Phaeozem	PHab	43,6%
Gleyic Phaeozem	PHgl	0,9%
Haplic Phaeozem	PHha	25,7%
Luvic Phaeozem	PHlv	26,0%
Sodic Phaeozem	PHso	3,8%

Table 61. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Planosol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Dystric Planosol	PLdy	30,7%
Eutric Planosol	PLeu	12,9%
Mollic Planosol	PLmo	56,4%

Table 62. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Podzol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Entic Podzol	PZet	5,9%
Gleyic Podzol	PZgl	3,1%
Haplic Podzol	PZha	64,5%
Leptic Podzol	PZle	23,6%
Rustic Podzol	PZrs	2,3%
Umbric Podzol	PZum	0,6%

Table 63. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Regosol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Calcaric Regosol	RGca	22,4%
Dystric Regosol	RGdy	77,6%

Table 64. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Solonchak areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Gleyic Solonchak	SCgl	35,7%

Haplic Solonchak	SCha	64,3%

Table 65. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Solonetz areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Gleyic Solonetz	SNgl	50,8%
Haplic Solonetz	SNha	49,2%

Table 66. Share of second level soil units in the pedoclimatic zone (Northern sub-continental, Vertisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Pellic Vertisol	VRpe	100,0%

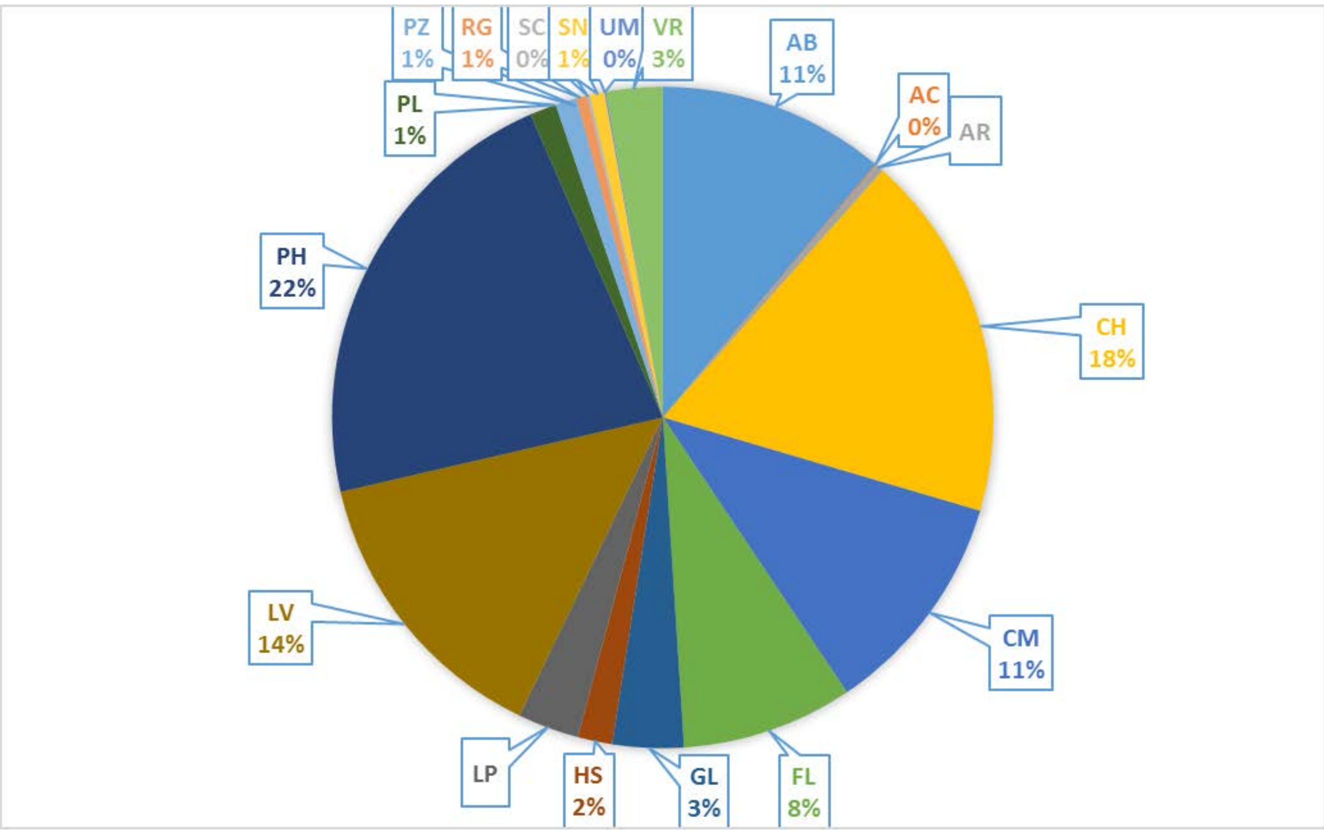
5.5 Southern Sub-Continental climate and its pedoclimatic zones

Eighteen different Reference Soil Groups can be found in the Southern Sub-Continental climatic zone of Europe, resulting seventeen pedoclimatice zones under this climate.

Chernozem has the highest share under this climate with Albeluvisols, Cambisols, Luvisols and Phaeozems having important parts too.

Share of the pedoclimatic zones under Southern Sub-Continental climate are given in figure 7.

Figure 7. Areal share of pedoclimatic zones under Southern Sub-Continental climate by Reference Soil Groups



Details of soil conditions within the pedoclimatic zones are given in tables 67.-84.

Table 67. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Albeluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Gleyic Albeluvisol	ABgl	37,9%
Stagnic Albeluvisol	ABst	8,3%
Umbric Albeluvisol	ABum	53,8%

Table 68. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Acrisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Acrisol	ACha	100,0%

Table 69. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Arenosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)

Haplic Arenosol	ARha	100,0%

Table 70. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Chernozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcic Chernozem	CHcc	33,8%
Chernic Chernozem	CHch	50,8%
Haplic Chernozem	CHha	10,3%
Luvic Chernozem	CHlv	5,1%

Table 71. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Cambisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Cambisol	CMca	0,0%
Chromic Cambisol	CMcr	13,4%
Dystric Cambisol	CMdy	49,6%
Eutric Cambisol	CMeu	29,5%
Gleyic Cambisol	CMgl	1,8%
Mollic Cambisol	CMmo	5,6%

Table 72. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Fluvisol)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Fluvisol	FLca	48,8%
Dystric Fluvisol	FLdy	5,3%
Eutric Fluvisol	FLeu	27,3%
Gleyic Fluvisol	FLgl	1,6%
Histic Fluvisol	FLhi	14,5%
Mollic Fluvisol	FLmo	0,8%
Salic Fluvisol	FLsz	1,8%

Table 73. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Gleysol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Gleysol	GLdy	12,7%
Eutric Gleysol	GLeu	15,5%
Histic Gleysol	GLhi	5,6%
Humic Gleysol	GLhu	28,4%
Mollic Gleysol	GLmo	30,9%
Sodic Gleysol	GLso	7,0%

Table 74. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Histosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Eutric Histosol	HSeu	21,9%
Fibric Histosol	HSfi	25,9%
Sapric Histosol	HSsa	38,5%
Salic Histosol	HSsz	13,6%

Table 75. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Leptosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Leptosol	LPca	8,0%
Dystric Leptosol	LPdy	1,2%
Eutric Leptosol	LPeu	1,3%
Haplic Leptosol	LPha	16,3%
Rendzic Leptosol	LPrz	73,2%

Table 76. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Luvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Albic Luvisol	LVab	0,3%
Arenic Luvisol	LVar	6,2%
Chromic Luvisol	LVcr	24,7%
Dystric Luvisol	LVdy	0,7%
Gleyic Luvisol	LVgl	32,7%
Haplic Luvisol	LVha	35,5%

Table 77. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Phaeozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Albic Phaeozem	PHab	35,2%
Calcaric Phaeozem	PHca	11,3%
Gleyic Phaeozem	PHgl	8,4%
Haplic Phaeozem	PHha	9,5%
Luvic Phaeozem	PHlv	33,2%
Sodic Phaeozem	PHso	2,4%

Table 78. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Planosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Planosol	PLdy	58,4%
Eutric Planosol	PLeu	41,6%

Table 79. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Podzol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Entic Podzol	PZet	7,5%
Haplic Podzol	PZha	27,9%
Leptic Podzol	PZle	29,9%
Rustic Podzol	PZrs	34,7%

Table 80. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Regosol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Calcaric Regosol	RGca	88,3%
Eutric Regosol	RGeu	11,7%

Table 81. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Solonchak areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Gleyic Solonchak	SCgl	80,8%
Haplic Solonchak	SCha	19,2%

Table 82. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Solonetz areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Gleyic Solonetz	SNgl	16,6%
Haplic Solonetz	SNha	37,7%
Mollic Solonetz	SNmo	45,7%

Table 83. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Umbrisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Gleyic Umbrisol	UMgl	100,0%

Table 84. Share of second level soil units in the pedoclimatic zone (Southern sub-continental, Vertisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Pellic Vertisol	VRpe	100,0%

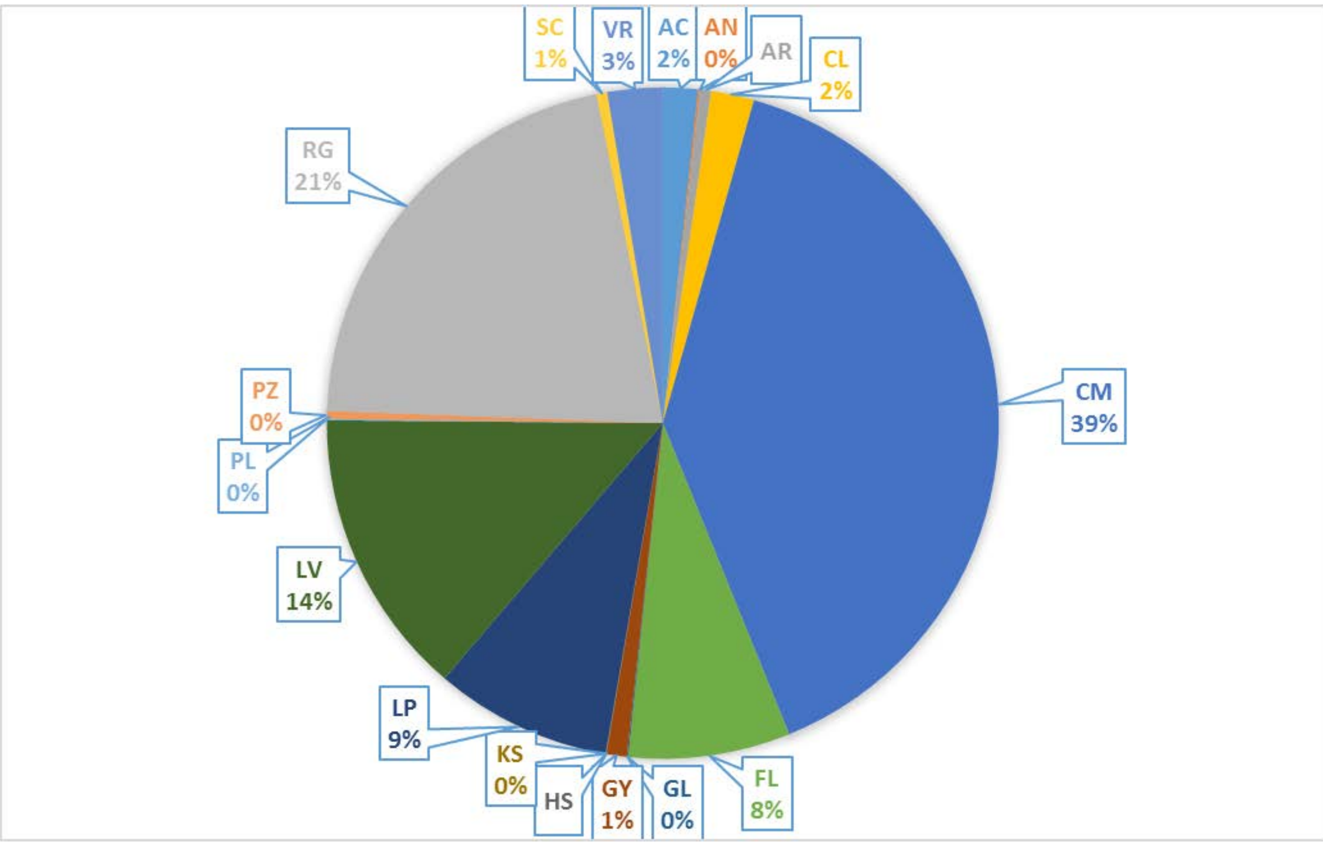
5.6 Mediterranean Semi-Arid climate and its pedoclimatic zones

Seventeen different Reference Soil Groups can be found in the Mediterranean Semi-Arid climatic zone of Europe, resulting seventeen pedoclimatice zones under this climate.

Cambisols dominate the land under this climate with Regosols, Luvisols, Leptosols and Fluvisols taking important shares too.

Share of the pedoclimatic zones under Mediterranean Semi-Arid climate are given in figure 8.

Figure 8. Areal share of pedoclimatic zones under Mediterranean (semi-arid) climate by Reference Soil Groups



Details of soil conditions within the pedoclimatic zones are given in tables 85.-101.

Table 85. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Acrisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Gleyic Acrisol	ACgl	100,0%

Table 86. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Andosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Mollic Andosol	ANmo	100,0%

Table 87. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Arenosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Arenosol	ARha	100,0%

Table 88. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Calcisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Aridic Calcisol	CLad	100,0%

Table 89. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Cambisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Cambisol	CMca	62,8%
Chromic Cambisol	CMcr	1,6%
Dystric Cambisol	CMdy	2,1%
Eutric Cambisol	CMeu	16,5%
Mollic Cambisol	CMmo	6,1%
Vertic Cambisol	CMvr	10,9%

Table 90. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Fluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Fluvisol	FLca	97,5%
Eutric Fluvisol	FLeu	2,5%

Table 91. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Gleysol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Mollic Gleysol	GLmo	100,0%

Table 92. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Gypsisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Aridic Gypsisol	GYad	100,0%

Table 93. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Histosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Eutric Histosol	HSeu	100,0%

Table 94. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Kastanozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcic Kastanozem	KScc	100,0%

Table 95. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Leptosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Leptosol	LPca	55,9%
Dystric Leptosol	LPdy	15,2%
Eutric Leptosol	LPeu	22,3%
Haplic Leptosol	LPha	1,2%
Rendzic Leptosol	LPrz	5,5%

Table 96. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Luvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Arenic Luvisol	LVar	3,6%
Calcic Luvisol	LVcc	3,8%
Chromic Luvisol	LVcr	51,0%
Ferric Luvisol	LVfr	5,3%
Gleyic Luvisol	LVgl	8,2%
Haplic Luvisol	LVha	10,5%
Vertic Luvisol	LVvr	17,7%

Table 97. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Planosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Eutric Planosol	PLeu	100,0%

Table 98. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Podzol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Haplic Podzol	PZha	97,5%
Umbric Podzol	PZum	2,5%

Table 99. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Regosol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Calcaric Regosol	RGca	13,7%
Dystric Regosol	RGdy	42,1%
Eutric Regosol	RGeu	44,2%

Table 100. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Solonchak areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Gleyic Solonchak	SCgl	9,3%
Haplic Solonchak	SCha	90,7%

Table 101. Share of second level soil units in the pedoclimatic zone (Mediterranean semi-arid, Vertisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Chromic Vertisol	VRcr	61,3%
Pellic Vertisol	VRpe	38,7%

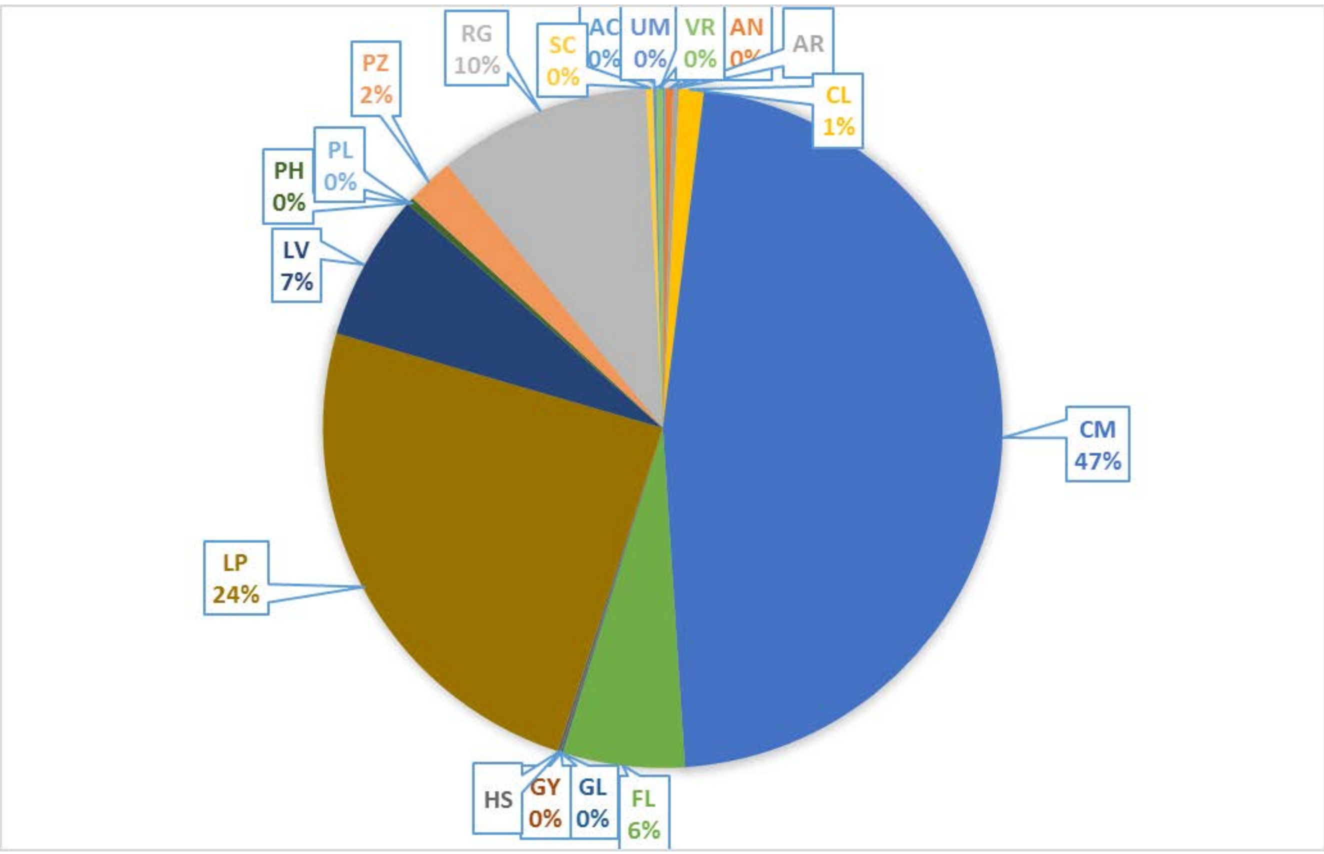
5.7 Mediterranean (temperate and sub-oceanic) climate and its pedoclimatic zones

Eighteen different Reference Soil Groups can be found in the Mediterranean (temperate and sub-oceanic) climatic zone of Europe, resulting seventeen pedoclimatice zones under this climate.

Cambisols dominate the land under this climate as well, with Regosols and Luvisols having above 10% and Fluvisols and Luvisols above 5% shares.

Share of the pedoclimatic zones under Mediterranean (temperate and sub-oceanic) climate are given in figure 9.

Figure 9. Areal share of pedoclimatic zones under Mediterranean (temperate and sub oceanic) climate by Reference Soil Groups



Details of soil conditions within the pedoclimatic zones are given in tables 102.-119.

Table 102. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Acrisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Gleyic Acrisol	ACgl	100,0%

Table 103. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Andosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Andosol	ANdy	7,9%
Mollic Andosol	ANmo	92,1%

Table 104. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Arenosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Arenosol	ARha	100,0%

Table 105. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Calcisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Aridic Calcisol	CLad	100,0%

Table 106. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Cambisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Calcaric Cambisol	CMca	33,5%
Chromic Cambisol	CMcr	7,8%
Dystric Cambisol	CMdy	6,0%
Eutric Cambisol	CMeu	30,7%
Mollic Cambisol	CMmo	14,4%
Vertic Cambisol	CMvr	7,7%

Table 107. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Fluvisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Calcaric Fluvisol	FLca	66,0%
Dystric Fluvisol	FLdy	1,6%
Eutric Fluvisol	FLeu	32,4%

Table 108. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Gleysol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Eutric Gleysol	GLeu	48,4%
Humic Gleysol	GLhu	5,3%
Mollic Gleysol	GLmo	46,3%

Table 109. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Gypsisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Aridic Gypsisol	GYad	100,0%

Table 110. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Histosol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Dystric Histosol	HSdy	15,3%

Eutric Histosol	HSeu	84,7%

Table 111. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Leptosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Leptosol	LPca	59,2%
Dystric Leptosol	LPdy	5,1%
Eutric Leptosol	LPeu	6,0%
Haplic Leptosol	LPha	6,3%
Rendzic Leptosol	LPrz	23,5%

Table 112. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Luvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcic Luvisol	LVcc	11,0%
Chromic Luvisol	LVcr	49,8%
Ferric Luvisol	LVfr	1,2%
Gleyic Luvisol	LVgl	13,7%
Haplic Luvisol	LVha	22,8%
Vertic Luvisol	LVvr	1,6%

Table 113. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Phaeozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Phaeozem	PHha	95,5%
Luvic Phaeozem	PHlv	4,5%

Table 114. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Planosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Eutric Planosol	PLeu	100,0%

Table 115. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Podzol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Podzol	PZha	88,6%
Leptic Podzol	PZle	9,9%
Umbric Podzol	PZum	1,5%

Table 116. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Regosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Regosol	RGca	33,1%
Dystric Regosol	RGdy	43,0%
Eutric Regosol	RGeu	23,9%

Table 117. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Solonchak areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Solonchak	SC	8,6%
Gleyic Solonchak	SCgl	36,0%
Haplic Solonchak	SCha	55,4%

Table 118. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Umbrisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Arenic Umbrisol	UMar	100,0%

Table 119. Share of second level soil units in the pedoclimatic zone (Mediterranean (temperate and sub-oceanic), Vertisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Chromic Vertisol	VRcr	78,3%
Pellic Vertisol	VRpe	21,7%

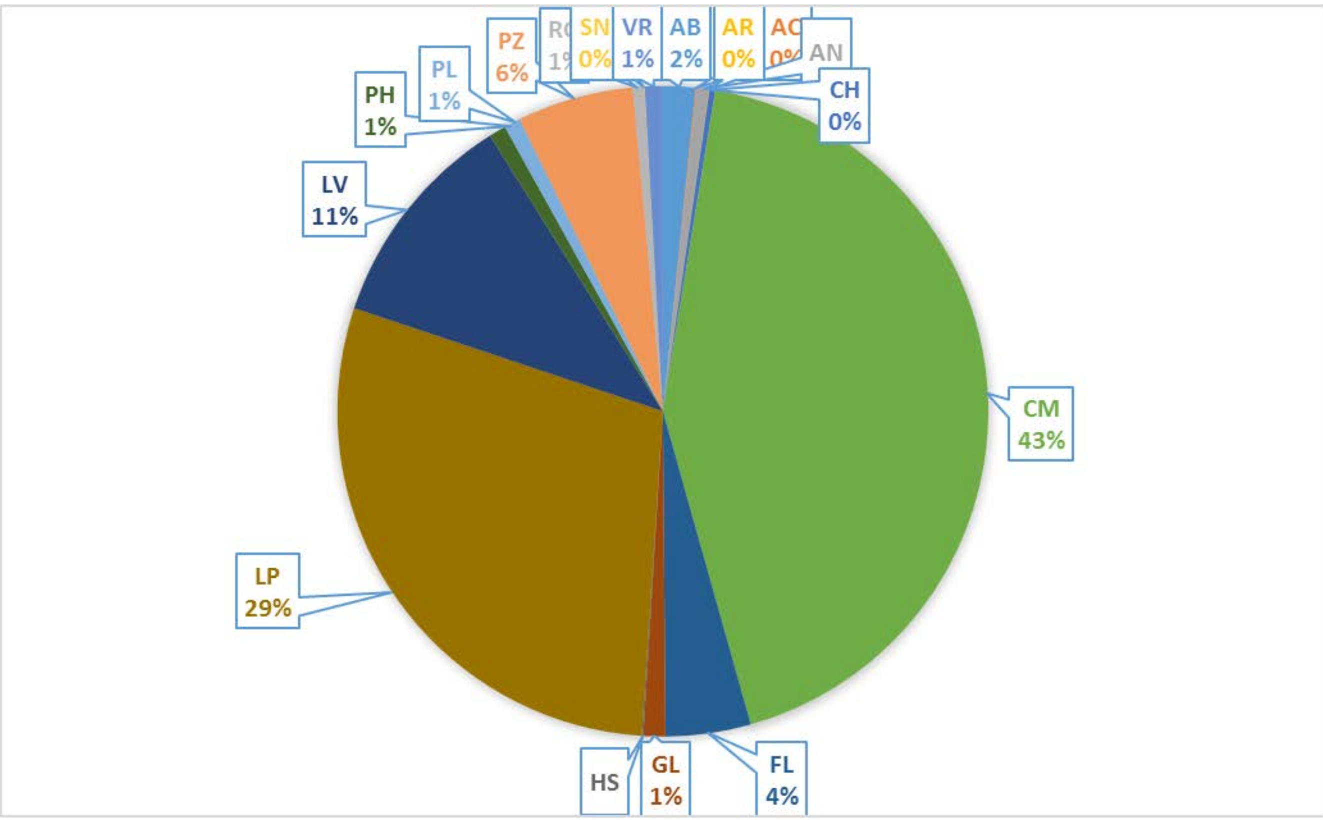
5.8 Temperate mountainous climate and its pedoclimatic zones

Seventeen different Reference Soil Groups can be found in the Temperate mountainous climatic zone of Europe, resulting seventeen pedoclimatice zones under this climate.

Cambisols and Leptosols together cover more than 70% of the land under this climate. Luvisols, Fluvisols and Podzolt are abundant with areal shares of 11%, 4% and 6% respectively.

Share of the pedoclimatic zones under Temperate mountainous climate are given in figure 10.

Figure 10. Areal share of pedoclimatic zones under Temperate montainous climate by Reference Soil Groups



Details of soil conditions within the pedoclimatic zones are given in tables 120.-136.

Table 120. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Albeluvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Endoeutric Albeluvisol	ABeun	0,1%
Gleyic Albeluvisol	ABgl	17,2%
Haplic Albeluvisol	ABha	56,9%
Stagnic Albeluvisol	ABst	0,3%
Umbric Albeluvisol	ABum	25,6%

Table 121. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Acrisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Acrisol	ACha	100,0%

Table 122. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Andosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Humic Andosol	ANhu	100,0%

Table 123. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Arenosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Arenosol	ARha	100,0%

Table 124. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Chernozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcic Chernozem	CHcc	53,1%
Haplic Chernozem	CHha	46,9%

Table 125. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Cambisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Cambisol	CMca	4,1%
Chromic Cambisol	CMcr	5,7%
Dystric Cambisol	CMdy	64,2%
Eutric Cambisol	CMeu	21,2%
Gleyic Cambisol	CMgl	0,3%
Mollic Cambisol	CMmo	4,5%
Vertic Cambisol	CMvr	0,1%

Table 126. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Fluvisol areas)

Soil units in the pedoclimatic zone	**Code of soil unit**	**Area share in the pedoclima zone (%)**
Calcaric Fluvisol	FLca	67,1%
Dystric Fluvisol	FLdy	0,9%
Eutric Fluvisol	FLeu	31,3%
Mollic Fluvisol	FLmo	0,6%

Table 127. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Gleysol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Gleysol	GLca	66,4%
Dystric Gleysol	GLdy	0,7%
Eutric Gleysol	GLeu	18,7%
Histic Gleysol	GLhi	0,2%
Humic Gleysol	GLhu	14,0%

Table 128. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Histosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Histosol	HSdy	45,8%
Eutric Histosol	HSeu	54,2%

Table 129. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Leptosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Leptosol	LPca	21,8%
Dystric Leptosol	LPdy	9,4%
Eutric Leptosol	LPeu	0,3%
Haplic Leptosol	LPha	10,5%
Humic Leptosol	LPhu	0,5%
Rendzic Leptosol	LPrz	57,5%

Table 130. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Luvisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Albic Luvisol	LVab	0,1%
Chromic Luvisol	LVcr	37,9%
Dystric Luvisol	LVdy	2,6%
Gleyic Luvisol	LVgl	17,2%
Haplic Luvisol	LVha	42,2%

Table 131. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Phaeozem areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Phaeozem	PHca	23,4%
Gleyic Phaeozem	PHgl	11,9%
Haplic Phaeozem	PHha	53,7%
Luvic Phaeozem	PHlv	11,0%

Table 132. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Planosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Dystric Planosol	PLdy	41,1%
Eutric Planosol	PLeu	58,9%

Table 133. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Podzol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Gleyic Podzol	PZgl	1,6%
Haplic Podzol	PZha	42,7%
Leptic Podzol	PZle	55,7%

Table 134. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Regosol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Calcaric Regosol	RGca	80,1%
Dystric Regosol	RGdy	16,7%
Eutric Regosol	RGeu	3,1%

Table 135. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Solonetz areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Haplic Solonetz	SNha	100,0%

Table 136. Share of second level soil units in the pedoclimatic zone (Temperate mountainous, Vertisol areas)

Soil units in the pedoclimatic zone	Code of soil unit	Area share in the pedoclima zone (%)
Chromic Vertisol	VRcr	8,5%
Pellic Vertisol	VRpe	91,5%

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PART B – PEDOCLIMATIC ZONES OF CHINA

1. Introduction

China has a vast territory, a unique natural environment, complex historical and economic process, and a variety of soil types. There are great differences in the soil characteristics and distribution, and production region of agriculture, animal husbandry and animal husbandry. Coupled with China's large population and fast growth rate, the contradictions of population demand and supply of resources are becoming increasingly acute because of the relative shortage of the arable land and water resources, and ecological environment degradation. Therefore, how to ensure the food security and sustainable development of China is particularly important. In order to facilitate the production of local conditions of agricultural production, district planning, classification guidance, and classification implementation are conducted. From the last century 50's until now, the Chinese pedoclimatic zones delineation has been listed as an important national long-term research task, and constantly open up.

Soil type and pedoclimatic zones can both be used as the space unit of soil management. Both of them are related and different, where soil types are often be used as the basis for pedoclimatic zones delineation. Soil type focuses on revealing the soil behaviour characteristics and generalizing the generality of regional soil, whose analysis object is the pedon and soil individual. It is note that the regional spatial continuity is not taken into account. Whereas pedoclimatic zones delineating is used to reveal the soil group characteristics and its spatial distribution, based on the features of the soil combination in a range of areas and many natural elements to distinguish. The regional characteristics is emphasized, the surface is not repetitive, and the space is connected to a piece.

The pedoclimatic zones delineation is based on the regional differentiation rules of soil, as far as possible to objectively in China are classified into several with internal and external difference in regional similarity. According to the subordination of regional level, a hierarchical system is established to better understand the basic situation of soil resources, and analyze the status quo and potential. Furthermore it is necessary to point out reasonable utilization and improvement measures of the unfavorable conditions so as to make full use of the soil resources, give full play to the comparative advantages of the regions, improve adverse soil properties and natural conditions, and provide scientific feasible bases for the State Environmental Planning and Management and regional sustainable development. This helps to strengthen the guidance of agricultural and non-agricultural production initiative, and in turn reduce blindness.

2. Data Used and Delineation Principle

2.1. Climate data

The climate zone map of China (Figure 1, 1:8,000,000) was provided by the China Meteorological Administration (CMA, 2011). Generally speaking, this partition is similar to the Chinese geomorphological zones (Figure 2).

The warmest areas in winter are to be found in the South and Southwest, such as Sichuan, Banna in Yunnan, and Hainan Island. In summer the coolest spots are in the far northeast. China has a climate dominated by dry seasons and wet monsoons, which leads to clear temperature differences in winter and summer. In winter, northern winds coming from high latitude areas are cold and dry; in summer, southern winds from sea areas at lower latitude are warm and moist.

China climates differ from region to region because of the country's extensive and complex topography. In the south of the Nanling Mountains, rains are prolific and the temperature is high all year round. In the Yangtze and Huaihe river valleys in the central part of China, there are four distinctive seasons. In northeast China, summer is short but there is much sunshine, while winter is long and cold. Precipitation is limited in northwest China where it is cold in winter and hot in summer. In southwest China of low latitudes, the land is elevated high, and has characteristically vertical seasonal zones. The main difference of climate zones regarding the orientation is as follows:

North

Northern winters, from December to March, can be extremely cold. Beijing may experience temperature of -20 °C at night, dry and no sun. During the summer, from May to August, temperatures in Beijing can hit 38 °C (100F), coinciding with the rainy season for the city.

Central

The Yangtze River valley has long and humid summer with high temperatures from April to October. Winters there, with temperatures dropping well below freezing, can be as cold as in Beijing, particularly as there is no heating in public buildings to the south of the Yangtze River.

South

Near Guangzhou, the summer is a season of typhoons between July and September. Temperatures can rise to around 38 °C. Winters are short, between January and March. Precipitation averages 76 cm (30 inches) per year.

Northwest

It gets hot in summer, dry and sunny. The desert regions can be scorching in the daytime. Turphan, which sits in a depression 150 m below sea level, is referred to as the 'hottest place in China' with maximums of around 47 °C. In winter this region is as severely cold as the rest of northern China. Temperatures in Turphan during Winter are only slightly more favorable to human existence. This area of China climate experiences little rain, and as a consequence, the air is very dry. Summers, however, can exceed 40 °C, while winters may drop to -10 °C. Precipitation averages less than 10 cm (4 inches) per year.

Southwest (Tibet)

Tibet is one of the harshest places for human existence. It is cool in summer but freezing cold in winter. In Lhasa, the mildest city in Tibet, temperature may exceed 29 °C in summer while plummeting to -16 °C in winter. Sun radiation is extremely strong in Tibet. The thin air can neither block off nor retain heat so that the temperature extremes can be met in daytime and the same night respectively in Tibet. The average temperature in north Tibet is subzero and winter arrives in October until the following May or June. May, June and September is the tourist season in east Tibet. In winter, roads are all blocked by heavy snow.

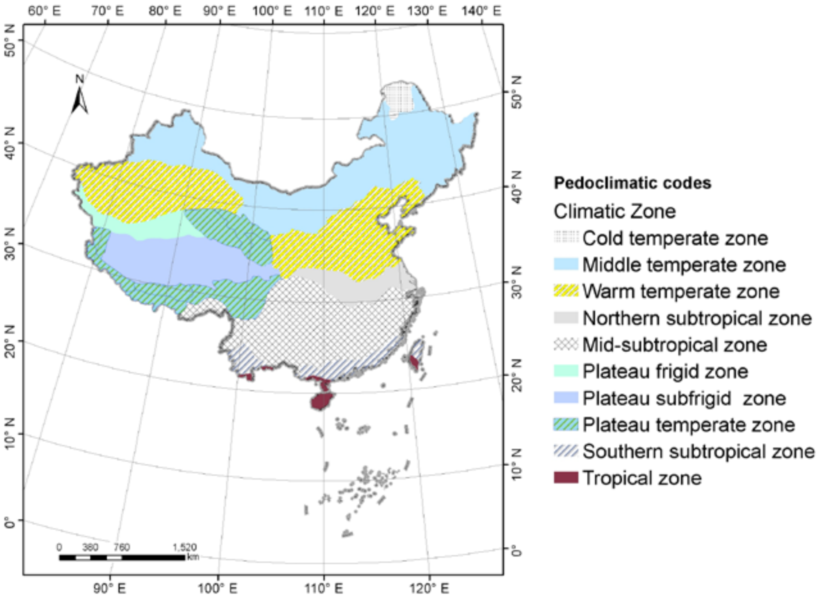


Figure 1. Climatic zones of China

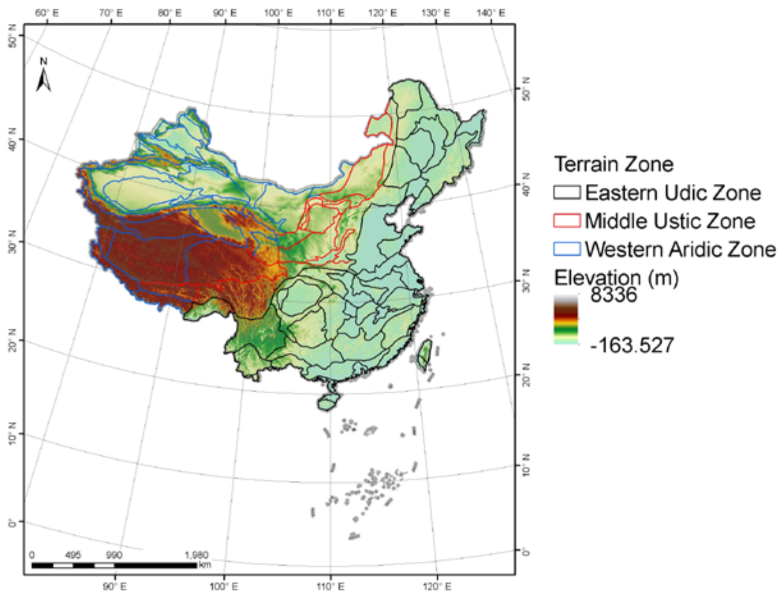


Figure 2. Chinese geomorphological zones

2.2. Soil map and soil type updating

The update of current HWSD involves mainly the use of the new version of WRB soil classification system and supplementing existing polygons with new pedon data as available. The level of update is cross-border integration of national updates over the entire China. The maps and databases will be merged by ISSCAS.

2.2.1. Data for translations

According to Harmonized World Soil Database (version 1.1), the framework of soil mapping data on HWSD was established and divided into three blocks for the purpose of interpreting soil information which are (1) general information on the soil mapping unit composition, (2) information related to phrases and (3) physical and chemical characteristics of topsoil (0~30cm) and subsoil (30~100cm). In order to cross-reference soil types effectively, the first and third block of data play important roles in this work. The first block involving soil type information on soil unit symbols (FAO-74, FAO-85 and FAO-90) is mainly used for reference while the third block which contains soil physical and chemical characteristics of topsoil (0~30cm) and subsoil (30~100cm) is considered as main basis.

1) Soil physical and chemical properties

In this block, soil physical and chemical information of each pixel in the digital map are expressed in the form of two tiers which are topsoil and subsoil. Series of fields as parts of data framework for each tier, respectively, were added concerned with mechanical composition, content of organic materials, calcium carbonate and gypsum, value of CEC in clay, base saturation and ESP, and so on.

2) Information of FAO-74/85/90

Compared with the above block, fields of the first block containing soil type information on FAO-74, FAO-85 and FAO-90 (FAO/UNESCO legends used in the map of world soil) are referred to as key reference. The details about these three soil symbols standing for spatial major soil groups are provided in Harmonized World Soil Database (version 1.1). In this database, for each pixel, soil symbol information is provided in terms of at least one of the three symbols for descripting soil types. In other words, this information is useful for cross-reference in practice.

3) Harmonization of the three FAO legends and WRB

As one of the most influential soil classification standards, World Reference Base for Soil Resources (WRB, 2006) has become the official reference soil nomenclature and classification for the European Commission and has been widely adopted by the West. It is WRB that originated from FAO/UNESCO legends used in the soil map of the world and was developed on the basis of the International Reference Base of Soil Classification (IRB). So it is obvious that using WRB is much easier than using others in cross-referencing soil types from FAO/UNESCO legends.

2.2.2. Units of the legacy soil map

(1) Format

Although the HWSD is provided to modellers as a raster on a 30” grid, we prefer to build that grid from source polygon maps. In that way we can more easily adjust boundaries at national borders, and assure that map units conform to scale specifications.

Please provide a polygon map as an ArcGIS Shapefile, preferably unprojected (i.e., coordinates are longitude and latitude) on the WGS84 ellipsoid and datum. Shapefiles can be exported from many geoprocessing programs; for example, the R package rgdal includes a function to write shapefiles. Note: if your coverage is in another coordinate system, we can transform it, provided that the projection information is correct in the shapefile metadata.

Each polygon should have only one attribute: its soil map unit ID; this corresponds to field MU_SOURCE1 in the attribute database. The relation is many-to-one: many polygons can have the same soil map unit ID. If you can not provide a polygon map, or shapefiles, please contact us for alternatives.

(2) Cartographic conventions

The nominal map scale is 1:1M. Using the common cartographic convention that the minimum legible delineation (MLD) is 0.25 cm2 (i.e., 0.5 x 0.5 cm), this implies a minimum legible area (MLA) of 25 km^2. No polygon should have a smaller area. If necessary, dissolve smaller polygons into neighbours and record the proportion of the soils as components.

Another cartographic convention is that the minimum legible width (MLW) is 3 mm (0.03 cm); this implies a minimum width of 3 km on the ground at the nominal scale of HWSD. Any narrower polygons or portions of them must be merged with surrounding map units. This is common with long, relatively narrow valleys.

2.2.3. Brief in keys to WRB and rules for soil naming

Although there is something in common between FAO/UNESCO legends and WRB, it is still unacceptable that cross-referencing soil types directly from legends to reference soil groups (RSGs) without any change. Compared with FAO/UNESCO legends, WRB is independent and systematic classification with concrete diagnostic criteria rather than legends for mapping. When it comes to quantifiable soil classification systems, soil scholars in growing number have come to believe that only rely on a standardized framework of keys and diagnosed criteria can they hope to descript soils scientifically and exchange understandable achievements. Consequently, principles in WRB should be followed.

Principles and utilization in WRB

The framework of soil types defined in WRB comprises two tiers which are reference soil groups (RSG) and qualifier level. The former tier was conceived to a group of major soils with a certain sequence, by which the central concepts of the major soils would come out by series of criteria, referring to as diagnostic horizons, properties or materials. Concurrently, the latter tier, based on the former one, is composed of lists of qualifiers which are prefix and suffix qualifiers, detailing the characteristics of RSGs to make them distinct, even unique types.

All the details about learning and using WRB correctly are provided in the book named World Reference Base for Soil Resources (2006) elaborately.

2.2.4. Cross-reference for translating soil types from FAO legends to WRB

According to the principles of classification and nomenclature in WRB, based on the data tables of HWSD, 7 fields representing RSGs and qualifier levels were added, including 1ST PREFIX, 2ND PREFIX, 3RD PREFIX, REFERENCE_SOIL_GROUP, 1ST SUFFIX, 2ND SUFFIX and 3RD

SUFFIX mentioned above. In addition, it is worth mentioning that there is no necessary for each of 7 fields in one pixel to be filled up except REFERENCE_SOIL_GROUP for the reason that there might not so many confirmed qualifiers for naming. The procedures of cross-reference generally can be illustrated in the following three steps.

(1) Diagnose and confirm the RSGs

Diagnose and confirm the RSGs by means of specified criteria which are diagnostic horizons, properties or materials and the sequence of searching 32 RSGs one by one. In practice, because of existence of FAO legends in database, the fields of SU_SYM74, SU_SYM85 and SU_SYM90 can provide valuable and direct information. Besides, the soil physical and chemistry date can be used for check. The confirmed names of RSGs were filled up in REFERENCE_SOIL_GROUP.

(2) Determine the combination of RSGs with qualifiers

For detailing the properties of RSGs, prefix and suffix qualifiers are provided for each RSG in WRB. Prefix qualifiers represent the typically associated qualifiers and intergrade qualifiers while the suffix qualifiers applied information on other qualifiers which generally express universal soil features rather than distinct ones. For prefix and suffix qualifiers to be confirmed, primary information is on basis of existing FAO/UNESCO legends (FAO-74, FAO-85 and FAO-90) due to the lack of concrete morphology information in database while the mechanical composition and base saturation, and so on, can be diagnosed directly by database. In addition, for each RSG, qualifiers are mostly chosen from the list of it. The intact lists of qualifiers for 32 RSGs are introduced in World Reference Base for Soil Resources (2006).

(3) Proofread the combination of RSGs with qualifiers

In practice, proofreading the combination of RSGs with qualifiers is the last but most important. For many qualifiers, even RSGs, only rely on the soil physical and chemistry characteristics from the database can they not be confirmed for lack of the limitation of the data. The main aspects are reflected as followed:

1) Soil morphology features

Taking Gleyic, Albic, Calcic, Plinthic and Greyic as examples, these qualifiers are basically diagnosed on basis of concrete morphological description of profiles, such as color, volume of soil newgrouths, existence and specified features of some horizons, and so on, which are not provided in the database.

2) Climatic information

It is widely known that climatic conditions are not considered as the most important factors compared with Soil Taxonomy (USDA). So they are not contained in the database. But some qualifiers, such as Gelic, still need concrete information on climate to be confirmed.

To insure the completeness of soil information during the cross-reference, for some qualifiers which cannot be determined only rely on the database of HWSD, it is acceptable that taking into count the information on FAO legends in the database as basis.

2.2.5. Soil map units of the production

(1) Source databases

The source databases used to reference WRB 2006 soil type include version 1.21 of the HWSD, the 1:1 million soil map of China.

(2) Database contents

The soil database of southeastern Asia is composed of a vector file (shapefile format) linked to an attribute database in Microsoft Access format (version 2010). While these two components are separate data files, they can be linked through a commercial GIS system.

The HWSD attribute database provides information on the soil unit composition for each of the 100118 soil mapping units. After a dissolution operation, soil mapping units that own a same soil type are merged into one polygon feature. Finally, there are 1368 records in the attribute table of the vector file. A soil mapping unit can have up to 9 soil unit/topsoil texture combination records in the database.

The old core fields for identifying a soil mapping unit are:

- MU_GLOBAL - the harmonized soil mapping unit identifier of HWSD providing the link to the GIS layer;
- MU_SOURCE1 and MU_SOURCE2- the mapping unit identifiers in the source database;
- SEQ – the sequence of the soil unit in the soil mapping unit composition;
- SHARE - % of the soil unit/topsoil texture combination in the soil mapping unit; and the
- Soil unit symbol using the FAO-74 classification system or the FAO-90 classification system (SU_SYM74 resp. SU_SYM90) or FAO-85 interim system (SU_SYM85).

The full descriptions of the old fields can be found in the Harmonized World Soil Database Version 1.0.

Furthermore, seven new attributes of the database are added in each soil mapping unit including 1ST PREFIX, 2ND PREFIX, 3RD PREFIX, REFERENCE_SOIL_GROUP, 1ST SUFFIX, 2ND SUFFIX, and 3RD SUFFIX. The framework of soil types defined in WRB comprises two tiers which are reference soil groups (RSG) and qualifier level. The former tier was conceived to a group of major soils with a certain sequence, by which the central concepts of the major soils would come out by series of criteria, referring to as diagnostic horizons, properties or materials. Concurrently, the latter tier, based on the former one, is composed of lists of qualifiers named as prefix and suffix qualifiers, detailing the characteristics of RSGs to make them distinct, even unique types. Prefix qualifiers representing typical soil forming processes comprise two kinds of qualifiers listed in a certain sequence which are typically associated qualifiers and intergrade qualifiers. In comparison to prefix qualifiers, as a whole, suffix ones differ from the following aspects: (1) de-emphasize the processes of soil forming ; (2) focus on the concrete characteristics in a defined sequence in WRB evolved as other qualifiers. It is typically associated qualifiers, intergrade qualifiers and other qualifiers that evolve as the basis for soil naming in qualifier level.

According to the principles of classification and nomenclature in WRB, based on the data tables of HWSD, 7 fields representing RSGs and qualifier levels were added, viz.: 1ST PREFIX, 2ND PREFIX, 3RD PREFIX, REFERENCE_SOIL_GROUP, 1ST SUFFIX, 2ND SUFFIX and 3RD SUFFIX mentioned above. To be specified in these fields, the confirmed soil types among 32 RSGs were filled up in REFERENCE_SOIL_GROUP while the prefix and suffix qualifiers corresponding to RSGs were filled up in 1ST PREFIX, 2ND PREFIX, 3RD PREFIX and 1ST SUFFIX, 2ND SUFFIX and 3RD SUFFIX, respectively. In addition, it is worth mentioning that there is no necessary for each of 7 fields in one pixel to be filled up except REFERENCE_SOIL_GROUP for the reason that there might not so many confirmed qualifiers for naming.

All the details about learning and using WRB correctly are provided in the book named World Reference Base for Soil Resources (2006) elaborately.
There are mainly two field within the shapefile:

- NUGLOBAL: The foreign key of this relationship table, which links the soil information of excel file named WRB_SE_ASIA.
- Count_ASIA: the country of each polygon.

2.2.6. Soil mapping units merge

As the soil maps are provided by each country, the soil mapping units ought to be merged in to an integrated file. There are two steps to merge these soil mapping units, including union and field update. All the operations are conducted in the commercial software ARCGIS 9.3.

(1) Map units union

The function of “UNION” in the tool OVERLAY module of ARCGIS 9.3 was used to merge the soil mapping units into an integrated file.

In the dialogue of Union tool, input features should be given and a target directory and name of output features should be provided by user. Meanwhile, the new name of output file should accord with the naming convention of ESRI software.

As the boundaries of each country might not be consistent with the each other, the XY Tolerance should be inputted. This operation can move the minimum distance separating all feature coordinates (nodes and vertices) as well as the distance a coordinate in X or Y (or both). The higher the value set to data, the less coordinate accuracy will be achieve. In other words, the high value could obtain an extremely high accuracy.

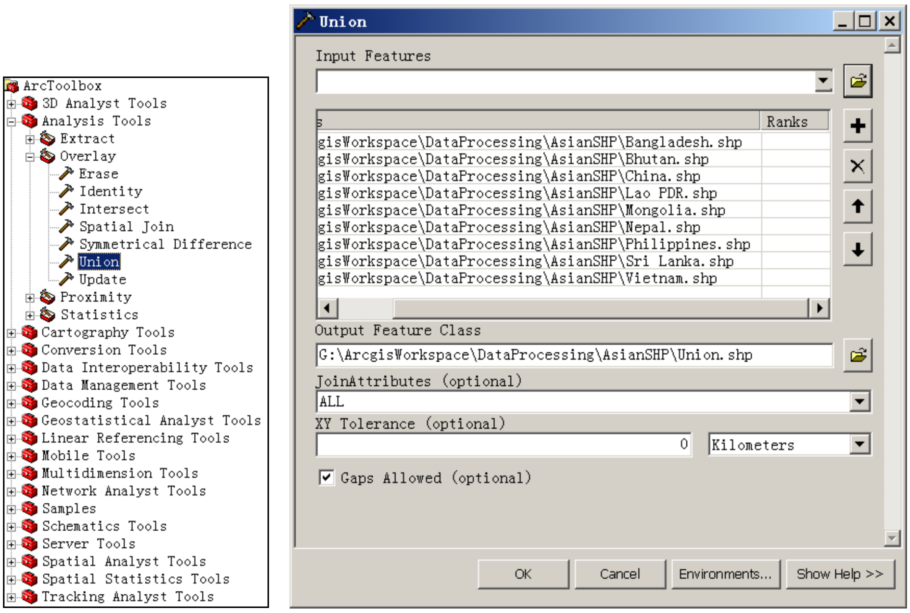
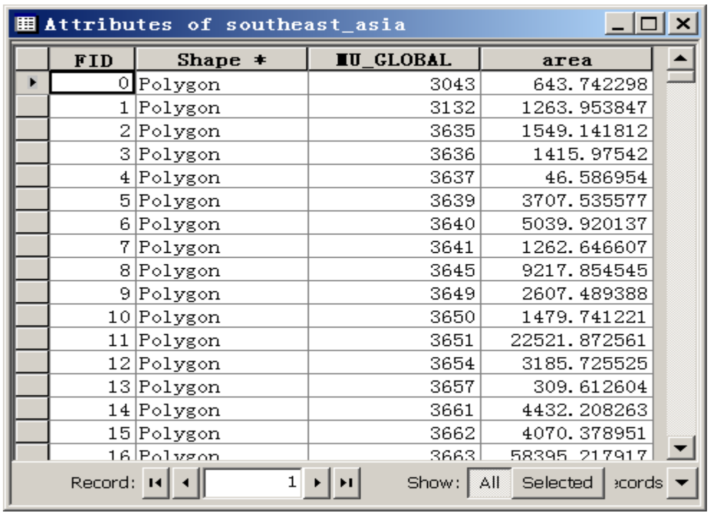


Figure 3. Union function in the directory of toolbox (left) and the dialogue of Union (right)

(2) Field update

This “UNION” function only computes a geometric intersection of the input features, and all features will written to the out put feature class with the attributes from the input features, which it may overlaps. Hence, there will be multiple fields named with raw field name of each input feature. In other words, each country has one field of MU_GLOBAL whose name is independent, and this field is filled with values when the soil mapping unit is of this country and will be non-value for other countries.

A new filed named “MU_GLOBAL” was created for unity and its value of each polygon was assigned by the raw filed that has a same value with MU_GLOBAL.



Attributes of southeast_asia

FID	Shape *	MU_GLOBAL	area
0	Polygon	3043	643.742298
1	Polygon	3132	1263.953847
2	Polygon	3635	1549.141812
3	Polygon	3636	1415.97542
4	Polygon	3637	46.586954
5	Polygon	3639	3707.535577
6	Polygon	3640	5039.920137
7	Polygon	3641	1262.646607
8	Polygon	3645	9217.854545
9	Polygon	3649	2607.489388
10	Polygon	3650	1479.741221
11	Polygon	3651	22521.872561
12	Polygon	3654	3185.725525
13	Polygon	3657	309.612604
14	Polygon	3661	4432.208263
15	Polygon	3662	4070.378951
16	Polygon	3663	58395.217917

Record: 1 Show: All Selected ecords

Figure 4. Attributes of soil maps after field update

(3) Database consistency testing

Consistency is one of the four guarantees that define ACID transactions. Furthermore, all the attributes in this new database has been checked after the soil mapping units merging, so that there is an one-to-one correlation between the ID of any record in the database and one polygon in the soil map.

There are four steps to do this checking:

a) Copy all the major keys into an excel file by columns, and sort the IDs from small to large so that the column will be ordered by IDs;

b) Use the function "EXACT" to check the IDs of adjacent cells, and set this result to one new column;

1	MU_GLOBAL	uniqueness?	SHARE	integrity ?
30	3641	TRUE	40	=C30+C31+C32+C33+C34
31	3641	TRUE	30	
32	3641	TRUE	10	
33	3641	TRUE	10	
34	3641	FALSE	10	
35	3645	TRUE	30	100
36	3645	TRUE	20	
37	3645	TRUE	20	
38	3645	TRUE	10	
39	3645	TRUE	10	
40	3645	FALSE	10	
41	3649	TRUE	60	100
42	3649	TRUE	20	
43	3649	FALSE	20	
44	3650	TRUE	60	100
45	3650	TRUE	20	
46	3650	FALSE	20	

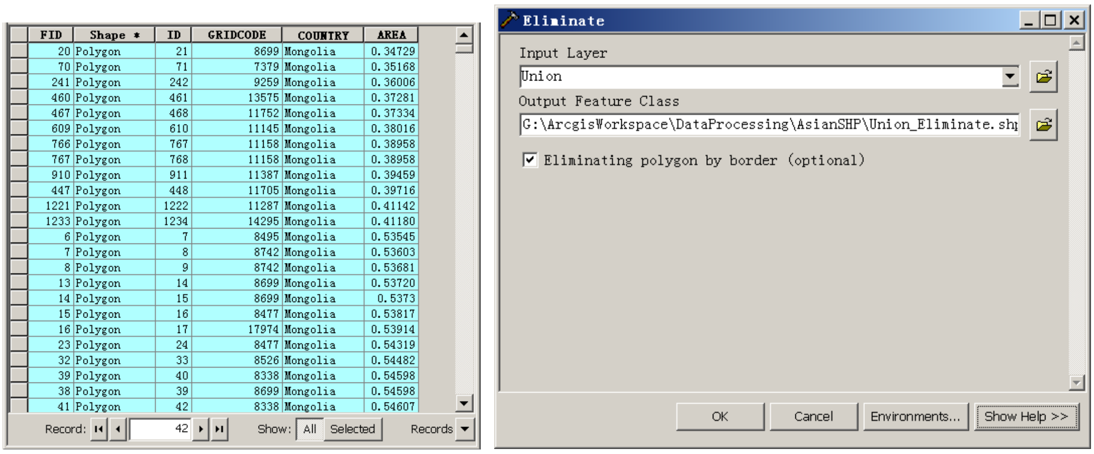
Figure 5. An illustration of the consistency testing

c) By the uniqueness testing, we can conclude how many rows and which rows belong to one independent soil map unit.

d) The last step is to check whether all the soil unites are integrated. In other words, the sum of share values within one soil unit should be 100.

(4) Eliminating of small polygons

As some updated soil unites might be too small, we need to calculate their area and merge them to the nearby larger polygon. Here, the eliminate function of ArcGIS software is carried out so as to merges the selected polygons with neighboring polygons with the largest shared border or the largest area.



FID	Shape *	ID	GRIDCODE	COUNTRY	AREA
20	Polygon	21	8699	Mongolia	0.34729
70	Polygon	71	7379	Mongolia	0.35168
241	Polygon	242	9259	Mongolia	0.36006
460	Polygon	461	13575	Mongolia	0.37281
467	Polygon	468	11752	Mongolia	0.37334
609	Polygon	610	11145	Mongolia	0.38016
766	Polygon	767	11158	Mongolia	0.38958
767	Polygon	768	11158	Mongolia	0.38958
910	Polygon	911	11387	Mongolia	0.39459
447	Polygon	448	11705	Mongolia	0.39716
1221	Polygon	1222	11287	Mongolia	0.41142
1233	Polygon	1234	14295	Mongolia	0.41180
6	Polygon	7	8495	Mongolia	0.53545
7	Polygon	8	8742	Mongolia	0.53603
8	Polygon	9	8742	Mongolia	0.53681
13	Polygon	14	8699	Mongolia	0.53720
14	Polygon	15	8699	Mongolia	0.5373
15	Polygon	16	8477	Mongolia	0.53817
16	Polygon	17	17974	Mongolia	0.53914
23	Polygon	24	8477	Mongolia	0.54319
32	Polygon	33	8526	Mongolia	0.54482
39	Polygon	40	8338	Mongolia	0.54598
38	Polygon	39	8699	Mongolia	0.54598
41	Polygon	42	8338	Mongolia	0.54607

Figure 6. The eliminate function

2.3. Generation of the Chinese pedoclimatic zones

According to regional differentiation of soil type and climate type, the main soil types of each climatic zone were summarized. The main procedures can be found as follows:

(1) Selection of the main soil type within one unit of soil map

The compounded soil types were stored in the updated soil map, that is, there might be two or more soil types within one unit. Therefore, the distinguished soil types were employed.

(2) Selection of the main soil types within one climatic zone

As the climate map was with smaller scale than that of soil map (1:8,000,000 V.S. 1:1,000,000), the climatic zones (Figure 1) were classified further according to the boundary of main soil types (Figure 2).

(3) Update of the boundary and legend of climatic zone

After the previous step, the shape of climatic zone would be changed with detailed information including the boundary of soil type within one polygon. Then the legend should be updated by adding the soil type name to each polygon.

2.4. Main features of the pedoclimatic zones

Regional differentiation of soil genesis and processes is mainly considered. It refers not only to the soil and the climate, vegetation, topography, and parent material for a long time and integrated effects, but also contains soil processes and behavior characteristics of the soil itself. Therefore, when to delineate the soil zones, it cannot simply adopt the soil conditions zonality, or the geology and geomorphology, but should pay close attention to the soil formation, development of natural geographical and historical background.

The eastern part of Inner Mongolia, Southeast of the Loess Plateau and the Tibetan Plateau are designated as a level of soil zone, which is according to our understanding of the principle of consideration. This vast region has similar conditions in terms of the soil, the development of regional natural historical background. In the eastern monsoon region to the northwest inland arid area of the transition zone, main vegetation types are the forest, forest steppe and steppe where geomorphology is since Tertiary uplift of the Tibetan Plateau and mountain. In this area the loess and loose materials are widely distributed. The dryness is more than or equal to 1.0 and smaller than 3.5, equivalent to the ustic moisture condition. The soil types are mainly Ustic Cambosols and Ustic Argosols. For the agricultural management, dry land is used for the basic farmland. Here a business oriented management system of water-saving agriculture is developed. Therefore, it is appropriate to separate this area for the soil and agricultural production planning.

Table 1 Summary of each pedoclimatic zone

Primary zone	Secondary zone	Accumulated annual air temperature larger than 10°C	The lowest monthly air temperature (°C)	Dryness (K)	vegetation	Agriculture Type
I Eastern Udic Soil Moisture Zones	I.1: Cold temperate zone – Podzols, Umbrisols, Gleysols	<1600	<-30	0.4~1.0	Coniferous forest	One season, Very early crop
	I.2: Middle temperate zone – Cambisols, Phaeozems	1600~3200	-30~-12	<1.0 (part 1.0~2.0)	Mixed broadleaf-conifer forest	One year one crop, mainly spring wheat
	I.3: Warm temperate zone – Luvisols, Cambisols	3200~4500	-12~0	1.0~2.0	Deciduous forest	Two years three crops, mainly winter wheat
	I.4: Northern subtropical zone – Anthrosols, Lixisols	4500~5100	0~4	0.4~1.0	Evergreen and deciduous broad-leaved forest	One year two crops, mainly rice and wheat
	I.5: Mid-subtropical zone – Acrisols, Lixisols	5100~6900	4~10	0.4~10 (part<0.4)	Evergreen broad-leaved forest	two year five crops, double cropping rice
	I.6: Southern subtropical zone – Acrisols, Ferralsols	6900~8000	10~15	0.4~10 (part <0.4)	Monsoon forest, Evergreen broad-leaved forest	One year three crops, double cropping rice
	I.7: Tropical zone – Ferralsols, Acrisols	>8000	>15	0.4~1.0	Rainforest, Monsoon forest	Thermophilic crops, Annual growth
II Middle Ustic Soil Moisture Zones	II.1: Middle temperate zone – Phaeozems, Arenosols	1600~3200	-30~-12	1.0~3.5	Steppe	One year one crop, chimonophilous crops
	II.2: Warm temperate zone – Cambisols, Umbrisols, Luvisols	3200~4500	-12~0	1.0~3.0	Forest steppe	Two year three crops or one year two crops
	II.3: Plateau temperate zone – Cambisols, Luvisols,	—	-10~0	0.4~2.0	Coniferous forest, Valley shrub	One year one or two crops

	Leptosols				grassland	
	II.4: Plateau subfrigid zone – Leptosols, Histosols, Gleysols	—	-10~-6	1.0~2.0	Alpine meadow	Animal Husbandry
III Northwestern Arid Zones	III.1: Middle temperate zone – Calcisols, Arenosols	—	-30~-12	3.5~14	Steppe, desert	One year one crop, mainly winter wheat and cotton
	III.2: Warm temperate zone - Gypsisols, Solonchaks	—	-12~0	>14	Shrub and desert	Two year three crops or one year two crops
	III.3: Plateau temperate zone – Calcisols, Chernozems, Solonchaks	—	-10~0	2.0~14	Alpine grasslands, meadows local coniferous forest	Animal Husbandry
	III.4: Plateau temperate zone - Umbrisols, Cambisols	—	-10~0	1.0~3.5	Alpine grassland	Alpine agriculture
	III.5: Plateau subfrigid zone – Cambisols, Calcisols	—	-10~-6	2.0~3.5	Alpine grassland	Animal Husbandry
	III.6: Plateau frigid zone – Cambisols, Arenosols, Solonchaks	—	-18~-10	2.0~3.5	Alpine desert	No man's land

3. Category of Pedoclimatic Zones

3.1. Primary zone

The first level of national soil zoning system is mainly based on the classification of soil composition of Chinese Soil Taxonomy and combined with the most important differences of natural conditions. In the same soil region, the biological and climatic conditions, the combination of soil series, the basic form of farmland, production technology and management system are similar.

3.2. Secondary zone

The second level is based on the soil composition and its spatial distribution in the soil region, in which the difference of geographical position and topography are highlighted. In the same soil region, there are similar hydrothermal conditions, soil type combinations of components and structures, ways and key measures for soil improvement and ecological environment protection, farming system and agriculture, forestry, animal husbandry and production layout.

3.2. Tertiary zone

The third level is mainly decided by the Chinese Soil Taxonomy. This level is classified by the soil composition proportion and spatial distribution, combined with bio climatic conditions and geographical factors, such as topography, parent material, hydrology and other differences caused by geographic region. Within each patch, the water and heat conditions with the situation, and morphological structure are very similar. In addition, the soil fertility, land use patterns and production levels, improved governance approaches and measures are more consistent.

4. Spatial distribution of the Chinese Pedoclimatic Zones

4.1. Summary

China is divided into 3 soil regions, 17 soil areas and 82 soil zones (Figure 7), corresponding to the first, second and third levels. The soil regions are named by the combination of geographical location and soil moisture condition. The soil areas are named by the temperature zones and soil types. The soil zones are named by the geographical names, geomorphology and main soil types avoiding a repetition.

4.2. Legends of Chinese Pedoclimatic Zones

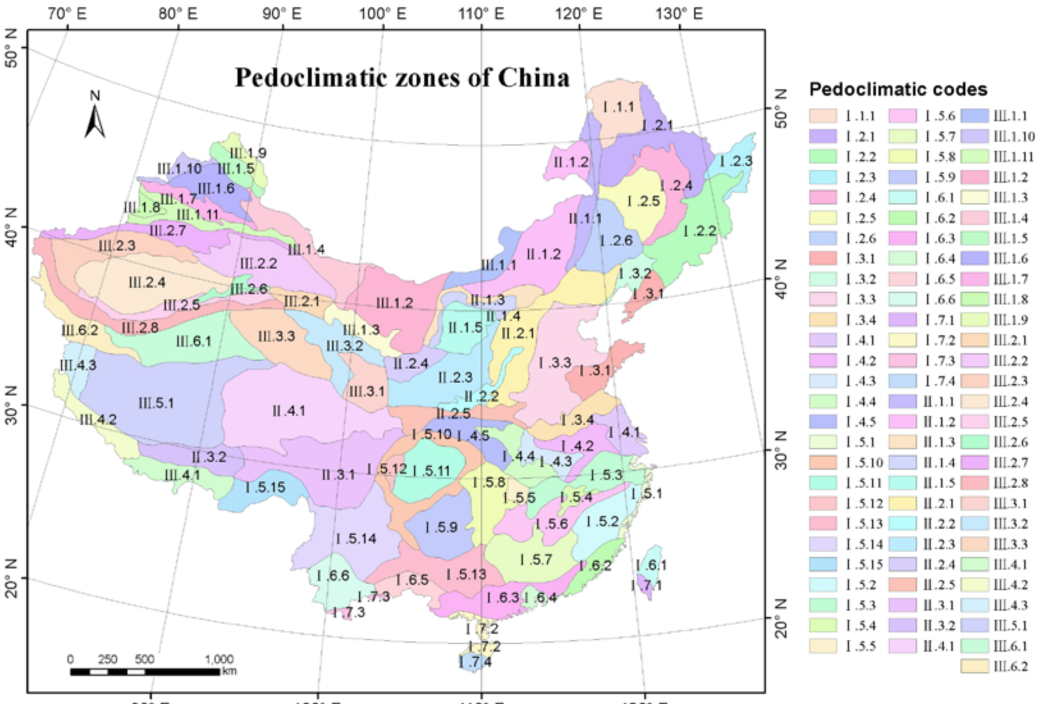


Figure 7. Chinese Pedoclimatic Zones

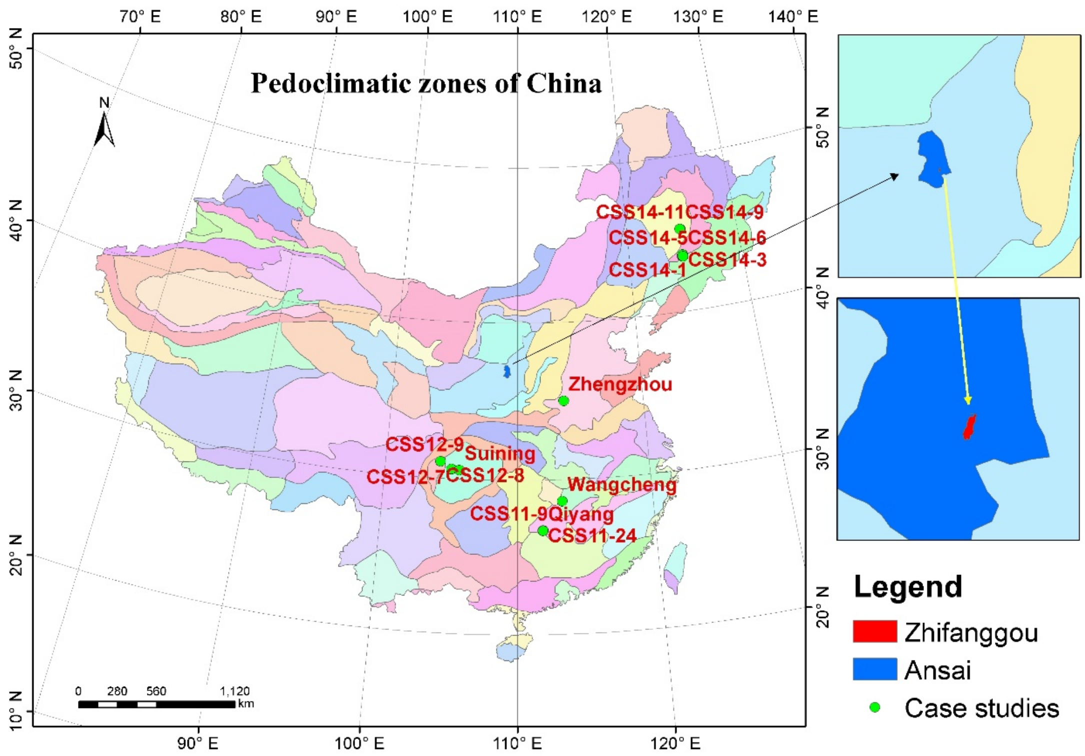


Figure 8. Chinese Pedoclimatic Zones with Chinese case studies

Table 1 Information of the codes in Chinese Pedoclimatic Zones map

Codes	Area (%)	Area	Climatic zone	Geographical regions	Soiltype (WRB, 2006)
I.1.1	1.29	Eastern Udic Zone	Cold temperate zone	Northern Greater Khingan	Haplic Podzols (Gelic), Folic Cambic Umbrisols (Gelic), Histic Gleysols (Gelistagnic)
I.2.1	2.15	Eastern Udic Zone	Middle temperate zone	Greater Khingan, Lesser Khingan Mountains	Folic Cambisols (Gelic), Haplic Phaeozems
I.2.2	2.21	Eastern Udic Zone	Middle temperate zone	Changbai Mountains	Folic Cambisols, Folic Endogleyic Umbrisols (Pachic), Albic Luvisols (Arenic)
I.2.3	0.69	Eastern Udic Zone	Middle temperate zone	Sanjing Plain	Haplic Endogleyic Umbrisols (Pachic), Albic Luvisols (Arenic), Histic Gleysols
I.2.4	1.23	Eastern Udic Zone	Middle temperate zone	Eastern Songnen Plain	Haplic Phaeozems, Haplic Endogleyic Umbrisols (Pachic)
I.2.5	1.37	Eastern Udic Zone	Middle temperate zone	Western Songnen Plain	Haplic Phaeozems (Pachic), Endogleyic Umbrisols (Pachic), Haplic Solonchaks (Takyric)
I.2.6	1.37	Eastern Udic Zone	Middle temperate zone	Western Liaohe Plain	Haplic Arenosols, Endogleyic Cambisols (Eutric), Calcic Chernozems
I.3.1	1.26	Eastern Udic Zone	Warm temperate zone	Liaodong Peninsula, Shandong Peninsular	Cutanic Luvisols, Haplic Cambisols (Eutric), Haplic Luvisols
I.3.2	0.46	Eastern Udic Zone	Warm temperate zone	The lower reaches of the Liaohe Plain	Endogleyic Cambisols (Eutric), Hydragric Anthrosols
I.3.3	2.98	Eastern Udic Zone	Warm temperate zone	North China Plain	Endogleyic Cambisols (Eutric), Haplic Luvisols, Haplic Arenosols
I.3.4	0.85	Eastern Udic Zone	Warm temperate zone	Huaibei Plain	Endogleyic Cambisols (Eutric), Gleyic Calcic Vertisols
I.4.1	0.69	Eastern Udic Zone	Northern subtropical zone	The lower reaches of the Yangtze River	Hydragric Anthrosols, Gleyic Solonchaks
I.4.2	0.87	Eastern Udic Zone	Northern subtropical zone	Jianghuai Hilly Plain	Cutanic Lixisols (Ferric, Chromic), Hydragric Anthrosols
I.4.3	0.57	Eastern Udic Zone	Northern subtropical zone	Dabie Mountains, Tongbai Mountains	Folic Cambisols (Ferric, Chromic), Hydragric Anthrosols
I.4.4	0.83	Eastern Udic Zone	Northern subtropical zone	Nanxiang Basin, Jianghan Plain	Luvic Planosols (Eutric, Clayic), Hydragric Anthrosols, Endogleyic Cambisols (Eutric)
I.4.5	0.96	Eastern Udic Zone	Northern subtropical zone	Qin-ba Mountain areas	Luvic Planosols (Eutric, Clayic), Folic Cambisols (Ferric, Chromic),

Codes	Area (%)	Area	Climatic zone	Geographical regions	Soiltype (WRB, 2006)
					Hydragric Anthrosols
I.5.1	0.25	Eastern Udic Zone	Mid-subtropical zone	Coastal Hills in the Fujian and Zhejiang Provinces	Plinthic Acrisols (Chromic), Hydragric Anthrosols
I.5.10	1.50	Eastern Udic Zone	Mid-subtropical zone	Hills around the Sichuan Basin	Haplic Lixisols, Haplic Cambisols (Calcaric), Haplic Cambisols (ferric, Chromic)
I.5.11	1.45	Eastern Udic Zone	Mid-subtropical zone	Hills in the Sichuan Basin	Haplic Cambisols, Haplic Lixisols (oxyaquic, Alumic), Hydragric Anthrosols
I.5.12	0.20	Eastern Udic Zone	Mid-subtropical zone	Chengdu Plain	Hydragric Anthrosols, Endogleyic Cambisols (Eutric), Haplic Lixisols (Oxyaquic, Alumic)
I.5.13	1.76	Eastern Udic Zone	Mid-subtropical zone	Hilly Basin in the Yunan, Sichuan and Guangxi Provinces	Haplic Luvisols (Hypereutric), Hydragric Anthrosols
I.5.14	2.72	Eastern Udic Zone	Mid-subtropical zone	Yunnan Plateau	Haplic Acrisols (Alumic, Clayic, Chromic), Hydragric Anthrosols
I.5.15	1.02	Eastern Udic Zone	Mid-subtropical zone	Alpine Canyon of the Northern Himalaya	Folic Cambisols (Alumic), Haplic Cambisols (Alumic)
I.5.2	1.27	Eastern Udic Zone	Mid-subtropical zone	Mountains in the Fujian and Zhejiang Provinces	Plinthic Acrisols (Chromic), Folic Ferralic Cambisols (Alumic)
I.5.3	1.34	Eastern Udic Zone	Mid-subtropical zone	Jiangnan Hilly areas	Haplic Acrisols (Ferric, Chromic), Haplic Lixisols, Hydragric Anthrosols
I.5.4	0.22	Eastern Udic Zone	Mid-subtropical zone	Poyang Lake Plain	Hydragric Anthrosols, Endogleyic Cambisols (Eutric), Haplic Acrisols (Ferric, Chromic)
I.5.5	0.22	Eastern Udic Zone	Mid-subtropical zone	Dongting Lake Plain	Hydragric Anthrosols, Haplic Acrisols (Ferric, Chromic)
I.5.6	1.32	Eastern Udic Zone	Mid-subtropical zone	Hilly Basin in the Hunan and Jiangxi Provinces, Jinqu Basin	Haplic Acrisols (Ferric, Chromic), Hydragric Anthrosols, Folic Cambisols
I.5.7	1.71	Eastern Udic Zone	Mid-subtropical zone	Nanling Mountains	Folic Acrisols (Ferric, Chromic), Haplic Lixisols,
I.5.8	1.29	Eastern Udic Zone	Mid-subtropical zone	Hilly areas in the Hunan and Hubei Provinces	Folic Cambisols (Alumic), Folic Cambisols (Alumic)
I.5.9	1.54	Eastern Udic Zone	Mid-subtropical zone	Guizhou Plateau	Haplic Lixisols, Haplic Cambisols (Calcaric), Hydragric Anthrosols
I.6.1	0.27	Eastern Udic Zone	Southern subtropical zone	North Central Taiwan Mountains	Haplic Acrisols (Alumic), Hydragric Anthrosols
I.6.2	0.53	Eastern Udic Zone	Southern subtropical zone	Coastal Hills in the Fujian and Southeastern Guangdong Provinces	Plinthic Acrisols (Hyperdystric, Chromic), Haplic Vertisols, Hydragric Anthrosols
I.6.3	1.40	Eastern Udic Zone	Southern subtropical zone	Hilly areas in the Guangdong and Guangxi Provinces	Plinthic Acrisols (Hyperdystric, Chromic), Haplic Ferralsols,

Codes	Area (%)	Area	Climatic zone	Geographical regions	Soiltype (WRB, 2006)
					Hydragric Anthrosols
I.6.4	0.19	Eastern Udic Zone	Southern subtropical zone	Pearl River delta	Hydragric Anthrosols, Terric Anthrosols (Eutric), Haplic Ferralsols
I.6.5	0.60	Eastern Udic Zone	Southern subtropical zone	Karst Mountains in the Yunnan and Guangxi Provinces	Haplic Luvisols (Hypereutric), Mollic Umbrisols, Umbric Acrisols (Alumic)
I.6.6	1.10	Eastern Udic Zone	Southern subtropical zone	Mountains in the Southern Yunan Provinces	Haplic Acrisols (Chromic), Haplic Cambisols (Ferric, Chromic), Hydragric Anthrosols
I.7.1	0.11	Eastern Udic Zone	Tropical zone	Hilly Plain in the Southern Taiwan	Haplic Ferralsols (Dystric), Hydragric Anthrosols
I.7.2	0.34	Eastern Udic Zone	Tropical zone	Terrace Plain in the Leizhou Peninsula and Hainan Island	Haplic Ferralsols (Ferric, Dystric), Hydragric Anthrosols
I.7.3	0.11	Eastern Udic Zone	Tropical zone	Low Valley Dam in the Southern Yunnan Province	Haplic Ferralsols (Dystric, Oxyaquic), Haplic Ferralsols (Alumic, Dystric)
I.7.4	0.20	Eastern Udic Zone	Tropical zone	Hilly areas in the South-central Hainan Province	Folic Ferralsols (Dystric), Haplic Acrisols, Haplic Cambisols
II.1.1	0.95	Middle Ustic Zone	Middle temperate zone	Western Greater Khingan	Haplic Phaeozems (Pachic), Haplic Phaeozems (Clayic)
II.1.2	2.97	Middle Ustic Zone	Middle temperate zone	Eastern Inner Mongolian Plateau	Rendzic Calcic Phaeozems, Haplic Arenosols
II.1.3	0.60	Middle Ustic Zone	Middle temperate zone	Yinshan Mountains, Helan Mountains	Haplic Calcisols (Aridic), Rendzic Umbrisols, Haplic Luvisols
II.1.4	0.49	Middle Ustic Zone	Middle temperate zone	Hetao Plain	Irragric Anthrosols (Eutric), Gleyic Solonchaks
II.1.5	1.01	Middle Ustic Zone	Middle temperate zone	Ordos Plateau	Rubic Arenosols, Calcic Chernozems, Haplic Calcisols (Aridic)
II.2.1	2.65	Middle Ustic Zone	Warm temperate zone	Mountains in the North China	Folic Luvisols, Haplic Regosols, Haplic Cambisols
II.2.2	0.46	Middle Ustic Zone	Warm temperate zone	Fenhe River Plain, Weihe Plain	Endogleyic Cambisols (Eutric), Terric Anthrosols (Eutric), Haplic Luvisols
II.2.3	1.98	Middle Ustic Zone	Warm temperate zone	Middle Loess Plateau	Haplic Regosols (Calcaric), Terric Umbrisols
II.2.4	0.61	Middle Ustic Zone	Warm temperate zone	Northwestern Loess Plateau	Haplic Calcisols (Aridic), Haplic Regosols (Calcaric)
II.2.5	0.89	Middle Ustic Zone	Warm temperate zone	Qinling Mountains, Northern slope of Funiu Mountains	Haplic Luvisols, Fobic Cambisols
II.3.1	3.38	Middle Ustic Zone	Plateau temperate zone	Western Sichuan Province and Eastern Tibet	Folic Cambisols (Calcaric), Haplic Luvisols, Lithic Leptosols (Humic, Gelic)
II.3.2	1.05	Middle Ustic Zone	Plateau temperate zone	Middle Reaches of theYarlung Zangbo River	Mollic Umbrisols (Gelic), Irragric Anthrosols
II.4.1	4.66	Middle Ustic Zone	Plateau subfrigid zone	Three River Source areas	Lithic Leptosols (Humic, Gelic), Cryic Histosols, Histic Gleysols

Codes	Area (%)	Area	Climatic zone	Geographical regions	Soiltype (WRB, 2006)
III.1.1	0.68	Western Aridic Zone	Middle temperate zone	Western Inner Mongolian Plateau	Haplic Calcisols (Aridic), Haplic Arenosols (Aridic)
III.1.10	0.29	Western Aridic Zone	Middle temperate zone	Western Mountains in the Dzungaria	Haplic Regosols (Aridic), Calcic Chernozems
III.1.11	0.96	Western Aridic Zone	Middle temperate zone	Northern Slope of the Tianshan Mountains	Haplic Calcisols (Aridic), Calcic Chernozems, Lithic Leptosols (Humic, Gelic)
III.1.2	2.44	Western Aridic Zone	Middle temperate zone	Alashan High Plain	Haplic Arenosols (Aridic), Haplic Calcisols (Aridic)
III.1.3	0.68	Western Aridic Zone	Middle temperate zone	East-central Hexi Corridor	Haplic Calcisols (Aridic), Irragric Cambisols (Aridic)
III.1.4	1.54	Western Aridic Zone	Middle temperate zone	Gobi Nuomin	Haplic Gypsisols (Aridic), Haplic Regosols (Aridic)
III.1.5	0.50	Western Aridic Zone	Middle temperate zone	Northern Xinjiang	Haplic Calcisols (Aridic), Calcic Chernozems
III.1.6	1.07	Western Aridic Zone	Middle temperate zone	Northern Junggar Basin	Haplic Arenosols (Aridic), Haplic Gypsisols (Aridic)
III.1.7	0.64	Western Aridic Zone	Middle temperate zone	Southern Junggar Basin	Haplic Luvisols, Irragric Cambisols (Aridic), Haplic Solonchaks (Aridic)
III.1.8	0.21	Western Aridic Zone	Middle temperate zone	Yili Valley	Haplic Calcisols (Aridic), Calcic Chernozems, Irragric Cambisols (Aridic)
III.1.9	0.39	Western Aridic Zone	Middle temperate zone	Altai Mountains	Calcic Chernozems, Albic Luvisols, Lithic Leptosols (Humic, Gelic)
III.2.1	0.51	Western Aridic Zone	Warm temperate zone	Western Hexi Corridor	Haplic Gypsisols (Aridic), Irragric Cambisols (Aridic)
III.2.2	2.15	Western Aridic Zone	Warm temperate zone	Basin in the Eastern Xinjiang	Haplic Gypsisols (Aridic), Haplic Solonchaks (Aridic), Irragric Cambisols (Aridic)
III.2.3	1.68	Western Aridic Zone	Warm temperate zone	Northern Tarim Basin	Haplic Regosols (Aridic), Irragric Anthrosols (Eutric), Haplic Solonchaks (Aridic)
III.2.4	2.98	Western Aridic Zone	Warm temperate zone	Central Tarim Basin	Haplic Arenosols (Aridic)
III.2.5	0.82	Western Aridic Zone	Warm temperate zone	Southern Tarim Basin	Petrogypsic Solonchaks (Sodic, Aridic), Irragric Anthrosols (Eutric)
III.2.6	0.29	Western Aridic Zone	Warm temperate zone	Lop Nor Plain	Haplic Solonchaks (Aridic)
III.2.7	1.31	Western Aridic Zone	Warm temperate zone	Northern Slope of the Tianshan Mountains	Haplic Gypsisols (Aridic), Calcic Chernozems, Lithic Leptosols (Calcaric, Humic, Gelic)
III.2.8	1.63	Western Aridic Zone	Warm temperate zone	Kunlun Mountains, Northern Slope of the Altun Mountains	Haplic Gypsisols (Aridic), Haplic Calcisols (Aridic)
III.3.1	0.94	Western Aridic Zone	Plateau temperate zone	Southeastern Qinghai Province	Haplic Calcisols (Aridic), Calcic Chernozems, Irragric Cambisols

Codes	Area (%)	Area	Climatic zone	Geographical regions	Soiltype (WRB, 2006)
					(Aridic)
III.3.2	1.33	Western Aridic Zone	Plateau temperate zone	Qilian Mountains	Haplic Calcisols (Aridic), Calcic Chernozems, Lithic Leptosols (Humic, Gelic)
III.3.3	1.83	Western Aridic Zone	Plateau temperate zone	Qaidam Basin	Haplic Gypsisols (Aridic), Haplic Solonchaks (Aridic), Histic Gleysols
III.4.1	0.94	Western Aridic Zone	Plateau temperate zone	Southern Tibetan Plateau	Mollic Umbrisols (Gelic), Haplic Cambisols (Gelic), Irragric Cambisols (Aridic)
III.4.2	0.84	Western Aridic Zone	Plateau temperate zone	Southwestern Tibetan Plateau	Haplic Cambisols (Gelic), Irragric Anthrosols (Eutric)
III.4.3	0.56	Western Aridic Zone	Plateau temperate zone	Western Tibetan Plateau	Haplic Calcisols (Aridic), Haplic Cambisols (Gelic), Irragric Cambisols (Aridic)
III.5.1	5.39	Western Aridic Zone	Plateau subfrigid zone	Qiangtang Plateau	Haplic Cambisols (Gelic), Haplic Calcisols (Aridic)
III.6.1	2.26	Western Aridic Zone	Plateau frigid zone	Southern Kunlun Mountains	Haplic Cambisols (Gelic), Haplic Arenosols (Gelic), Haplic Solonchaks (Aridic)
III.6.2	1.01	Western Aridic Zone	Plateau frigid zone	Karakorum Mountains	Haplic Calcisols (Aridic), Leptic Gelistagnic Cambisols

5. Spatial distribution of soils in the pedoclimatic zones

5.1. Cold temperate climate and its pedoclimatic zones

Six different Reference Soil Groups can be found in the cold temperate climatic zone of China, resulting six pedoclimatice zones under this climate.

Share of the pedoclimatic zones under cold temperate climate are given in figure 9.

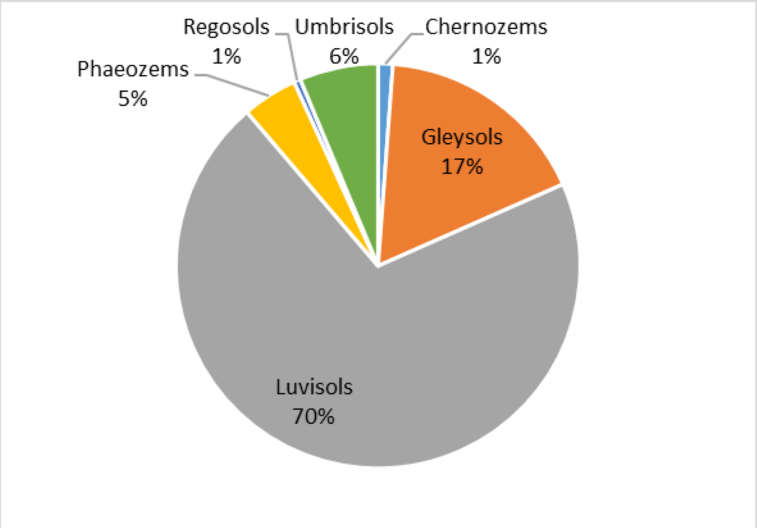


Figure 9. Areal share of pedoclimatic zones under cold temperate climate by Reference Soil Groups

Table 2. Share of second level soil units in the pedoclimatic zone (cold temperate climate, Chernozems areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Chernozems	99.17
Luvic Chernozems	0.83

Table 3. Share of second level soil units in the pedoclimatic zone (cold temperate climate, Gleysols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Mollic Gleysols	100.00

Table 4. Share of second level soil units in the pedoclimatic zone (cold temperate climate, Luvisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Albic Luvisols	0.26
Haplic Luvisols	98.86
Stagnic Luvisols	0.88

Table 5. Share of second level soil units in the pedoclimatic zone (cold temperate climate, Phaeozems areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Phaeozems	72.53
Gleyic Phaeozems	27.47

Table 6. Share of second level soil units in the pedoclimatic zone (cold temperate climate, Regosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Regosols	100.00

Table 7. Share of second level soil units in the pedoclimatic zone (cold temperate climate, Umbrisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Umbrisols	100.00

5.2. Middle temperate climate and its pedoclimatic zones

Nineteen different Reference Soil Groups can be found in the middle temperate climatic zone of China, resulting nineteen pedoclimatice zones under this climate.

Share of the pedoclimatic zones under middle temperate climate are given in figure 10.

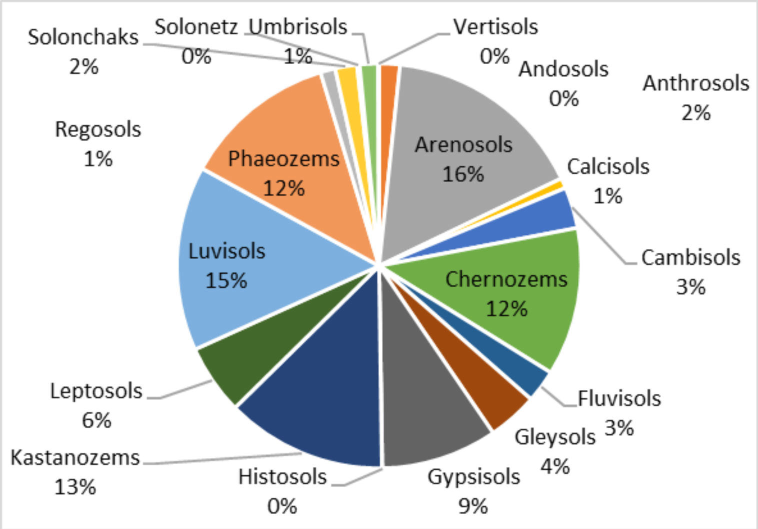


Figure 10. Areal share of pedoclimatic zones under middle temperate climate by Reference Soil Groups

Table 8. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Andosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Andosols	93.96
Umbric Andosols	6.04

Table 9. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Anthrosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Anthrosols	32.25
Plaggic Anthrosols	67.75

Table 10. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Anthrosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Arenosols	11.17
Cambic Arenosols	19.30
Haplic Arenosols	69.54

Table 11. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Calcisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Calcisols	80.38
Luvic Calcisols	0.20
Petric Calcisols	19.42

Table 12. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Cambisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Gleyic Cambisols	2.43
Haplic Cambisols	97.57

Table 13. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Chernozems areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Chernozems	19.37
Gleyic Chernozems	5.81
Haplic Chernozems	21.84
Luvic Chernozems	52.98

Table 14. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Fluvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Fluvisols	66.10
Mollic Fluvisols	0.15
Salic Fluvisols	33.75

Table 15. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Gleysols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Gleysols	37.74
Haplic Gleysols	0.45
Mollic Gleysols	61.82

Table 16. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Gypsisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Gypsisols	35.78
Haplic Gypsisols	22.62
Luvic Gypsisols	39.64
Petric Gypsisols	1.96

Table 17. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Histosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Fibric Histosols	17.90
Haplic Histosols	82.10

Table 18. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Kastanozems areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Kastanozems	24.31
Haplic Kastanozems	37.56
Luvic Kastanozems	38.13

Table 19. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Leptosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Lithic Leptosols	93.95
Rendzic Leptosols	6.05

Table 20. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Luvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Albic Luvisols	12.39
Albiv Luvisols	0.02
Calcic Luvisols	0.80
Gleyic Luvisols	5.35
Haplic Luvisols	81.20

Stagnic Luvisols	0.24

Table 21. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Phaeozems areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Gleyic Phaeozems	25.33
Haplic Phaeozems	72.98
Stagnic Phaeozems	1.69

Table 22. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Regosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Regosols	100.00

Table 23. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Solonchaks areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Solonchaks	19.95
Gleyic Solonchaks	5.59
Gypsic Solonchaks	21.51
Haplic Solonchaks	0.81
Mollic Solonchaks	52.14

Table 24. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Solonetz areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Solonetz	4.54
Gleyic Solonetz	80.78
Haplic Solonetz	14.68

Table 25. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Umbrisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Umbrisols	100.00

Table 26. Share of second level soil units in the pedoclimatic zone (middle temperate climate, Vertisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Vertisols	100.00

5.3. Mid-subtropical climate and its pedoclimatic zones

Sixteen different Reference Soil Groups can be found in the mid-subtropical climatic zone of China, resulting sixteen pedoclimatice zones under this climate.

Share of the pedoclimatic zones under mid-subtropical climate are given in figure 11.

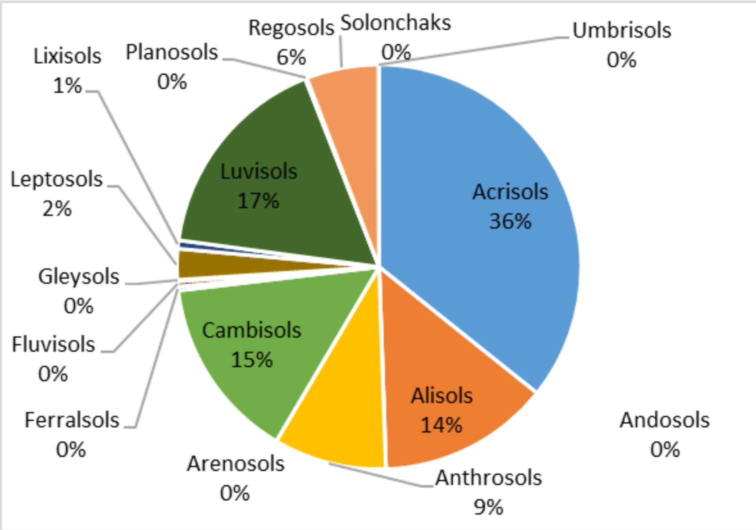


Figure 11. Areal share of pedoclimatic zones under mid-subtropical climate by Reference Soil Groups

Table 27. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Acrisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Acrisols	99.66
Plinthic Acrisols	0.34

Table 28. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Alisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Alisols	99.02
Plinthic Alisols	0.98

Table 29. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Andosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Andosols	100.00

Table 30. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Anthrosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Anthrosols	0.05
Plaggic Anthrosols	99.95

Table 31. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Arenosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Arenosols	100.00

Table 32. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Cambisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Ferralic Cambisols	1.36
Haplic Cambisols	98.64

Table 33. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Ferralsols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Ferralsols	100.00

Table 34. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Fluvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Fluvisols	100.00

Table 35. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Gleysols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Gleysols	26.81
Haplic Gleysols	57.93
Mollic Gleysols	15.26

Table 36. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Leptosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Lithic Leptosols	59.09
Rendzic Leptosols	40.91

Table 37. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Lixisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Albic Lixisols	2.70
Haplic Lixisols	97.30

Table 38. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Luvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Albic Luvisols	0.04
Albiv Luvisols	0.10
Gleyic Luvisols	0.01
Haplic Luvisols	99.85

Table 39. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Planosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Planosols	100.00

Table 40. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Regosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Regosols	100.00

Table 41. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Solonchaks areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Solonchaks	100.00

Table 42. Share of second level soil units in the pedoclimatic zone (mid-subtropical climate, Umbrisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Umbrisols	100.00

5.4. Northern subtropical climate and its pedoclimatic zones

Fourteen different Reference Soil Groups can be found in the northern subtropical climatic zone of China, resulting fourteen pedoclimatice zones under this climate.

Share of the pedoclimatic zones under northern subtropical climate are given in figure 12.

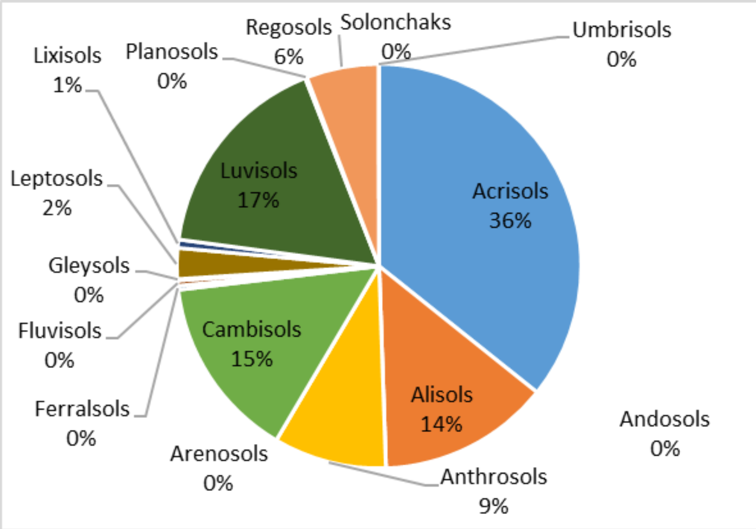


Figure 12. Areal share of pedoclimatic zones under northern subtropical climate by Reference Soil Groups

Table 43. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Acrisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Acrisols	46.98
Plinthic Acrisols	53.02

Table 44. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Alisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Alisols	70.16
Plinthic Alisols	29.84

Table 45. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Andosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Andosols	100.00

Table 46. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Anthrosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Plaggic Anthrosols	100.00

Table 47. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Cambisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Cambisols	100.00

Table 48. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Fluvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Fluvisols	93.39
Salic Fluvisols	6.61

Table 49. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Gleysols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Gleysols	2.00

Haplic Gleysols	88.63
Mollic Gleysols	9.37

Table 50. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Leptosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Lithic Leptosols	77.52
Rendzic Leptosols	22.48

Table 51. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Lixisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Lixisols	100.00

Table 52. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Luvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Albic Luvisols	1.41
Haplic Luvisols	98.59

Table 53. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Planosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Planosols	100.00

Table 54. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Regosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Regosols	100.00

Table 55. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Solonchaks areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Gleyic Solonchaks	21.15
Haplic Solonchaks	78.85

Table 56. Share of second level soil units in the pedoclimatic zone (northern subtropical climate, Vertisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Vertisols	100.00

5.5. Plateau frigid climate and its pedoclimatic zones

Eleven different Reference Soil Groups can be found in the plateau frigid climatic zone of China, resulting eleven pedoclimatice zones under this climate.

Share of the pedoclimatic zones under plateau frigid climate are given in figure 13.

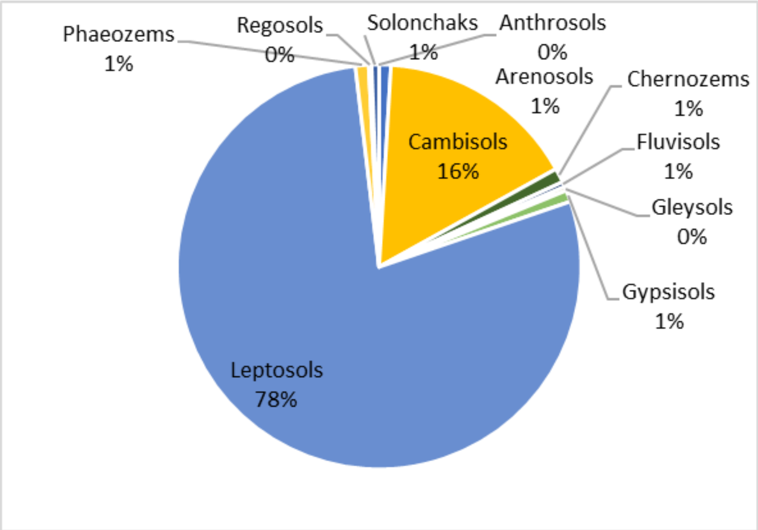


Figure 13. Areal share of pedoclimatic zones under plateau frigid climate by Reference Soil Groups

Table 57. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Anthrosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Anthrosols	100.00

Table 58. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Arenosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Arenosols	3.19
Cambic Arenosols	9.27
Haplic Arenosols	87.55

Table 59. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Cambisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Cambisols	100.00

Table 60. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Chernozems areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Luvic Chernozems	100.00

Table 61. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Fluvisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Fluvisols	100.00

Table 62. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Gleysols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Mollic Gleysols	100.00

Table 63. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Gypsisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Gypsisols	25.48
Petric Gypsisols	74.52

Table 64. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Leptosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Leptosols	3.16
Lithic Leptosols	93.53
Rendzic Leptosols	3.31

Table 65. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Phaeozems areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Gleyic Phaeozems	20.07
Haplic Phaeozems	79.93

Table 66. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Regosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Regosols	100.00

Table 67. Share of second level soil units in the pedoclimatic zone (plateau frigid climate, Solonchaks areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Solonchaks	21.84
Gleyic Solonchaks	4.42
Gypsic Solonchaks	14.09
Haplic Solonchaks	59.65

5.6. Plateau subfrigid climate and its pedoclimatic zones

Twelve different Reference Soil Groups can be found in the plateau subfrigid climatic zone of China, resulting twelve pedoclimatice zones under this climate.

Share of the pedoclimatic zones under plateau subfrigid climate are given in figure 14.

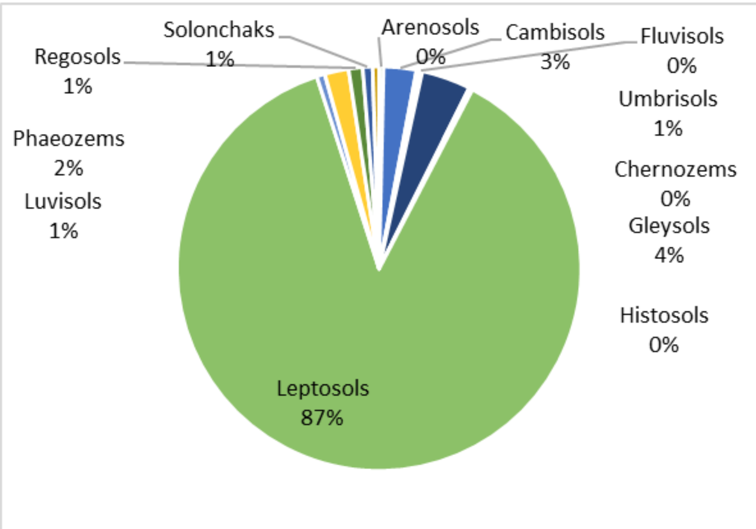


Figure 14. Areal share of pedoclimatic zones under plateau subfrigid climate by Reference Soil Groups

Table 68. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Arenosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Arenosols	62.06
Cambic Arenosols	9.68
Haplic Arenosols	28.27

Table 69. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Cambisols areas)

Soil units in the	Area share in the

pedoclimatic zone	pedoclima zone (%)
Haplic Cambisols	100.00

Table 70. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Chernozems areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Chernozems	25.53
Luvic Chernozems	74.47

Table 71. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Fluvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Fluvisols	27.43
Umbric Fluvisols	72.57

Table 72. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Gleysols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Gleysols	15.89
Mollic Gleysols	84.11

Table 73. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Histosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Histosols	100.00

Table 74. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Leptosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Leptosols	16.03
Lithic Leptosols	82.92
Rendzic Leptosols	1.04

Table 75. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Luvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Luvisols	0.33
Haplic Luvisols	99.67

Table 76. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Phaeozems areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Gleyic Phaeozems	36.46
Haplic Phaeozems	63.54

Table 77. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Regosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Regosols	100.00

Table 78. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Solonchaks areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Solonchaks	38.12
Gleyic Solonchaks	22.50
Haplic Solonchaks	39.38

Table 79. Share of second level soil units in the pedoclimatic zone (plateau subfrigid climate, Umbrisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Umbrisols	100.00

5.7. Plateau temperate climate and its pedoclimatic zones

Twenty different Reference Soil Groups can be found in the plateau temperate climatic zone of China, resulting twenty pedoclimatice zones under this climate.

Share of the pedoclimatic zones under plateau temperate climate are given in figure 15.

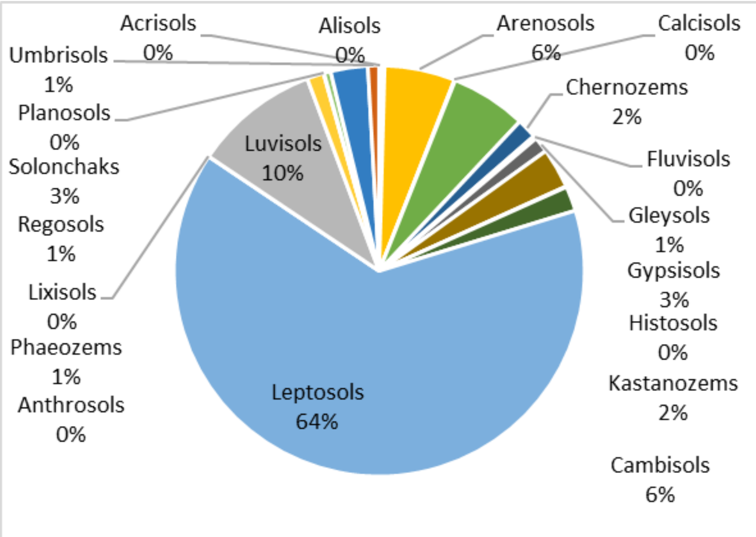


Figure 15. Areal share of pedoclimatic zones under plateau temperate climate by Reference Soil Groups

Table 80. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Acrisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Acrisols	100.00

Table 81. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Alisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Alisols	100.00

Table 82. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Anthrosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Anthrosols	92.52
Plaggic Anthrosols	7.48

Table 83. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Arenosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Arenosols	1.80
Cambic Arenosols	5.44
Haplic Arenosols	92.76

Table 84. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Calcisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Calcisols	94.42
Petric Calcisols	5.58

Table 85. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Cambisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Ferralic Cambisols	0.07
Gleyic Cambisols	0.57
Haplic Cambisols	99.36

Table 86. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Chernozems areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Chernozems	23.16
Haplic Chernozems	22.30
Luvic Chernozems	54.54

Table 87. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Fluvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Fluvisols	98.55
Salic Fluvisols	1.45

Table 88. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Gleysols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Gleysols	10.83
Haplic Gleysols	10.79
Mollic Gleysols	78.37

Table 89. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Gypsisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Gypsisols	51.99
Luvic Gypsisols	10.89
Petric Gypsisols	37.12

Table 90. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Histosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Fibric Histosols	27.81
Haplic Histosols	72.19

Table 91. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Kastanozems areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Kastanozems	8.83
Haplic Kastanozems	56.09
Luvic Kastanozems	35.08

Table 92. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Leptosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Leptosols	1.98
Lithic Leptosols	97.33
Rendzic Leptosols	0.69

Table 93. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Lixisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Lixisols	100.00

Table 94. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Luvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Albic Luvisols	2.65
Albiv Luvisols	0.89
Calcic Luvisols	3.55
Gleyic Luvisols	0.08
Haplic Luvisols	92.83

Table 95. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Phaeozems areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Gleyic Phaeozems	26.58
Haplic Phaeozems	73.42

Table 96. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Planosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Planosols	100.00

Table 97. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Regosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Regosols	100.00

Table 98. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Solonchaks areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Calcic Solonchaks	19.57
Gleyic Solonchaks	30.86
Haplic Solonchaks	2.19
Mollic Solonchaks	47.37

Table 99. Share of second level soil units in the pedoclimatic zone (plateau temperate climate, Umbrisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Umbrisols	100.00

5.8. Southern subtropical climate and its pedoclimatic zones

Fourteen different Reference Soil Groups can be found in the southern subtropical climatic zone of China, resulting fourteen pedoclimatice zones under this climate.

Share of the pedoclimatic zones under southern subtropical climate are given in figure 16.

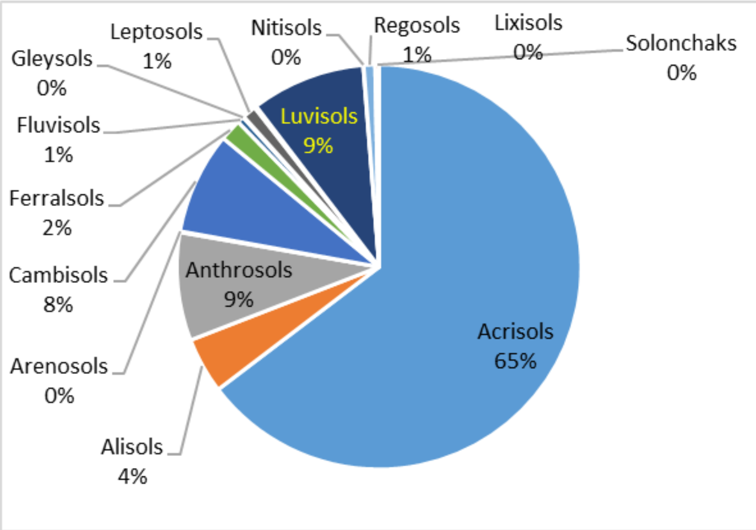


Figure 16. Areal share of pedoclimatic zones under southern subtropical climate by Reference Soil Groups

Table 100. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Acrisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Acrisols	99.94
Plinthic Acrisols	0.06

Table 101. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Alisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Alisols	100.00

Table 102. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Anthrosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Plaggic Anthrosols	100.00

Table 103. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Arenosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Arenosols	100.00

Table 104. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Cambisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Ferralic Cambisols	14.64
Haplic Cambisols	85.36

Table 105. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Ferralsols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Ferralsols	100.00

Table 106. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Fluvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Fluvisols	100.00

Table 107. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Gleysols areas)

Soil units in the	Area share in the

pedoclimatic zone	pedoclima zone (%)
Haplic Gleysols	100.00

Table 108. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Leptosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Lithic Leptosols	58.34
Rendzic Leptosols	41.66

Table 109. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Lixisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Lixisols	100.00

Table 110. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Luvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Luvisols	100.00

Table 111. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Nitisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Nitisols	100.00

Table 112. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Regosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Regosols	100.00

Table 113. Share of second level soil units in the pedoclimatic zone (southern subtropical climate, Solonchaks areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Solonchaks	100.00

5.8. Tropical climate and its pedoclimatic zones

Fifteen different Reference Soil Groups can be found in the tropical climatic zone of China, resulting fifteen pedoclimatice zones under this climate.

Share of the pedoclimatic zones under tropical climate are given in figure 17.

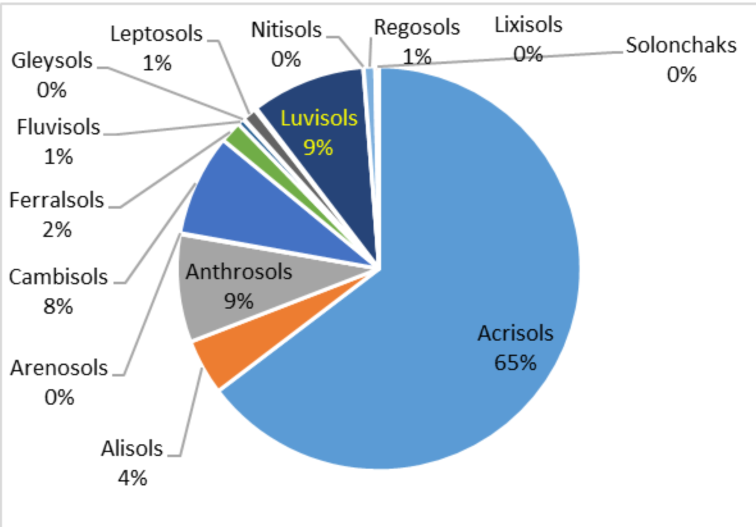


Figure 17. Areal share of pedoclimatic zones under tropical climate by Reference Soil Groups

Table 114. Share of second level soil units in the pedoclimatic zone (tropical climate, Acrisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Acrisols	100.00

Table 115. Share of second level soil units in the pedoclimatic zone (tropical climate, Alisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Alisols	100.00

Table 116. Share of second level soil units in the pedoclimatic zone (tropical climate, Andosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Andosols	100.00

Table 117. Share of second level soil units in the pedoclimatic zone (tropical climate, Anthrosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Plaggic Anthrosols	100.00

Table 118. Share of second level soil units in the pedoclimatic zone (tropical climate, Arenosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Arenosols	100.00

Table 119. Share of second level soil units in the pedoclimatic zone (tropical climate, Cambisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Ferralic Cambisols	67.12
Haplic Cambisols	32.88

Table 120. Share of second level soil units in the pedoclimatic zone (tropical climate, Ferralsols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Ferralsols	100.00

Table 121. Share of second level soil units in the pedoclimatic zone (tropical climate, Fluvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Fluvisols	100.00

Table 122. Share of second level soil units in the pedoclimatic zone (tropical climate, Gleysols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Gleysols	100.00

Table 123. Share of second level soil units in the pedoclimatic zone (tropical climate, Leptosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Lithic Leptosols	88.82
Rendzic Leptosols	11.18

Table 124. Share of second level soil units in the pedoclimatic zone (tropical climate, Luvisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Luvisols	100.00

Table 125. Share of second level soil units in the pedoclimatic zone (tropical climate, Nitisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Nitisols	100.00

Table 126. Share of second level soil units in the pedoclimatic zone (tropical climate, Regosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Regosols	100.00

Table 127. Share of second level soil units in the pedoclimatic zone (tropical climate, Solonchaks areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Solonchaks	100.00

Table 128. Share of second level soil units in the pedoclimatic zone (tropical climate, Vertisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Haplic Vertisols	100.00

5.9. Warm temperate climate and its pedoclimatic zones

Twenty different Reference Soil Groups can be found in the warm temperate climatic zone of China, resulting twenty pedoclimatice zones under this climate.

Share of the pedoclimatic zones under warm temperate climate are given in figure 18.

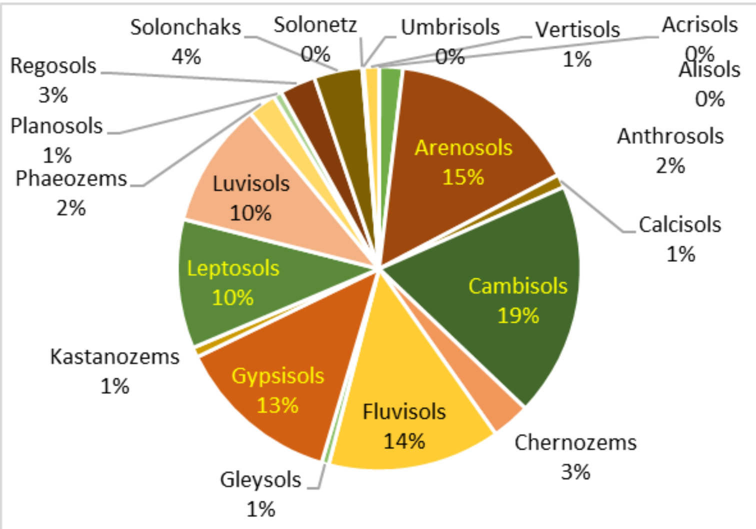


Figure 18. Areal share of pedoclimatic zones under warm temperate climate by Reference Soil Groups

Table 129. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Acrisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Plinthic Acrisols	100.00

Table 130. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Alisols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)
Plinthic Alisols	100.00

Table 131. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Anthrosols areas)

Soil units in the pedoclimatic zone	Area share in the pedoclima zone (%)

Haplic Anthrosols	7.81
Plaggic Anthrosols	92.19

Table 132. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Arenosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Albic Arenosols	0.35
Calcic Arenosols	0.39
Cambic Arenosols	19.25
Haplic Arenosols	80.01

Table 133. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Calcisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Calcisols	100.00

Table 134. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Cambisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Gleyic Cambisols	6.93
Haplic Cambisols	93.04

Table 135. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Chernozems areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Chernozems	9.77
Haplic Chernozems	3.38
Luvic Chernozems	86.85

Table 136. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Fluvisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Fluvisols	82.88
Salic Fluvisols	17.12

Table 137. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Gleysols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Gleysols	58.33
Haplic Gleysols	2.93
Mollic Gleysols	38.74

Table 138. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Gypsisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Gypsisols	18.42
Haplic Gypsisols	0.16
Luvic Gypsisols	11.09
Petric Gypsisols	70.33

Table 139. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Kastanozems areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Kastanozems	70.45
Haplic Kastanozems	27.44
Luvic Kastanozems	2.11

Table 140. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Leptosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Lithic Leptosols	93.36
Rendzic Leptosols	6.64

Table 141. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Luvisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Albic Luvisols	2.28
Calcic Luvisols	29.44
Gleyic Luvisols	22.01
Haplic Luvisols	46.27

Table 142. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Phaeozems areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Gleyic Phaeozems	46.57
Haplic Phaeozems	53.43

Table 143. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Planosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Planosols	100.00

Table 144. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Regosols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Regosols	100.00

Table 145. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Solonchaks areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Solonchaks	15.69
Gleyic Solonchaks	2.67
Gypsic Solonchaks	44.40
Haplic Solonchaks	12.64
Mollic Solonchaks	24.60

Table 146. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Solonetz areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Gleyic Solonetz	100.00

Table 147. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Umbrisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Haplic Umbrisols	100.00

Table 148. Share of second level soil units in the pedoclimatic zone (warm temperate climate, Vertisols areas)

Soil units in the pedoclimatic zone	**Area share in the pedoclima zone (%)**
Calcic Vertisols	13.52
Haplic Vertisols	86.48

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