GEOREFERENCED SOIL DATABASE FOR EUROPE

Manual of procedures

Version 1

Edited by
European Soil Bureau
Scientific Committee

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1 PREFACE

In the coming years, a prominent role will be given to agro-environmental instruments to support a sustainable development of rural areas and respond to society's increasing demand for environmental services. This goal has been explicitly set by the *Agenda 2000* of the European Commission. The measures aimed at maintaining and enhancing the quality of the environment shall be reinforced and extended. The European Conference on Rural Development held in Cork, Ireland, from 7th to 9th November 1996, clearly states in its final declaration that sustainable rural development must be put at the top of the agenda of the European Union, and become the fundamental principle which underpins all rural policy in the immediate future and after enlargement. Rural development policy must be multi-disciplinary in concept, and multi-sectoral in application, with a clear territorial dimension. Such policies rely heavily on basic information on the European physical environment and its spatial aspects. The European Community Programme of policy and action in relation to the environment and sustainable development "Towards Sustainability", better known as the 5th EC Environmental Action Programme, clearly identifies the need for harmonised georeferenced information on the European environment. The amended proposal for a European Parliament and Council decision on the review of the 5th EC Environmental Action Programme identifies the need to develop an approach to environmental impact assessment for plans and programmes, and to promote the development of methodologies, training and guidance material for both assessments of projects and of plans and programmes. Further needs for harmonised georeferenced information at EU level have been identified by the EU Ministers responsible for spatial planning in Noordwijk, The Netherlands, the 9th and 10th of June 1997. The European Spatial Development Perspective (ESDP) identifies important gaps in comparable, quantified and georeferenced data. One of the most relevant missing information at an appropriate scale is a georeferenced soil database of Europe.

It is since 1952 that European soil scientists work on the standardisation of mapping methods and soil classification systems in Europe. Main driving force for such a co-operative effort was the need for a soil map of the European continent, and later on, the need for a soil map of the European Communities. Indeed the European Commission has consistently supported the development and harmonisation of European soil information. In 1987, the Commission launched the MARS (Monitoring Agriculture by Remote Sensing) programme. Within this programme there was a clear demand for harmonised soil information as input to agrometeorological modelling of the major European crops. The soil data in the computerised EC soil map were insufficient to supply values to the parameters needed by these models. The Soil and Geographical Information System (GIS) Support Group was thus created to improve this database, first in the framework of the MARS project, and then by enlarging its activities to environmental needs in the framework of the European Agency Task Force of DG XI. Considering the diversity of soil survey coverage in the European countries, and the need for more detailed soil information for environmental studies, the DG XI Task Force commissioned in 1993 a feasibility study on the creation of a soil map of Europe at a scale of 1:250,000. The 1:250,000 scale seems a good intermediate level for linking the data stored in the 1:1,000,000 database with those of small areas covered by national studies. Finally there will be a soil geographical database with three levels of precision: small study areas, 1:250,000 scale and 1:1,000,000 scale. The three levels of information will be stored in a single nested database, and numerical scale-transfer functions will be developed for linking them. The final product will be a truly integrated European Soil Information System (EUSIS), capable of giving general information at a small scale and of comparing soil evolution throughout Europe with a high level of precision. In order to achieve this goal, a working group has been created in 1995 by the European Commission, firstly operating within the Soil Information Focal Point (SIFP) and later integrated within the newly created European Soil Bureau (ESB). The group, formed by European soil mapping experts, was charged with the task of preparing the Procedures Manual for the new Georeferenced Soil Database of Europe. The first draft of this manual has been submitted to the Scientific Committee of the European Soil Bureau for approval and after minor modifications adopted by the European Soil Bureau. This first version of the manual is intended to be further improved and adapted after testing in several pilot areas, that are currently being selected by the European Soil Bureau. Further revisions of the manual are planned as more experience is gained through its application in different environments.

This initiative is expected to give new impetus to the European integration of existing and new georeferenced soil information. Care has been taken to insure that the new *Georeferenced Soil Database of Europe* will be fully compatible with the future European spatial data infrastructure. A new approach to soil mapping has been developed taking into account past experiences by National and European soil mapping programmes. The result is the design of an innovative, highly user oriented database that will be a major tool for future agro-environmental applications at European scale.

L. Montanarella
Secretary of the
European Soil Bureau

1.1 READERS' GUIDE

This manual contains a large number of procedures and formats that can be used to implement a 1:250,000 soil database in pilot areas in Europe. The reader should be aware of the fact, that the most important purpose of this manual is to provide a common framework for different regional groups, to minimise ad postiori harmonisation efforts. It is therefore important that it is clear which procedures, formats and database entries are compulsory to follow, and which are meant predominantly for reference purposes.

The most important chapters for the user to read are the chapters on general concepts (4) and implementation and data acquisition (6), because these chapters introduce the way of thinking and the way of working which are proposed. Chapters 5 and 7 are also important, because these introduce the soil region data layer that is shared by all projects (5) and the data that are actually to be introduced in the database (7). For each database attribute, it is indicated whether it is mandatory or not to put it in the database. The appendices of this manual provide more detailed information on attribute definition.

Chapters 8 and 9 have as main purpose to introduce the reader to existing work that may be relevant for work in pilot areas. It is not compulsary to use these methods. Chapter 8 summarizes some statistical techniques that can help to make sampling designs and to evaluate maps and map units. Chapter 9 gives an overview of applications of soil databases at national and international scales which can be used to identify existing sources of data and potential data users.

2 BACKGROUND

In most European countries systematic soil surveys were started in the 1950s against the background of an urgent need for increased agricultural production. The methodologies, the classification, the scales and the coverage of the surveys varied widely from country to country. It was soon realized that cooperation and correlation would allow for an exchange of experience and know-how and would greatly benefit an overall European approach.

On the initiative of a number of European soil scientists, responsible for soil survey programs in their respective countries, a meeting was held in Ghent, Belgium, in 1952, with the purpose of discussing the possibility of unifying the different systems of soil classification and nomenclature. As a result of this meeting a request was submitted to the Director-General of the Food and Agriculture Organization of the United Nations (FAO) to sponsor this harmonization within the framework of the FAO European Working Party on Land Utilization and Conservation. In response to this request FAO established, in 1955, the Working Party on Soil Classification and Survey, affiliated with the Subcommission on Land and Water Use of the European Commission on Agriculture.

The first session of the Working Party took place in Bonn in 1957. It was felt that the most effective way to harmonize the soil survey activities would be the joint preparation of a unified soil map of Europe. The Working Party opted for the preparation of such a map at scale 1:2,500,000. The choice of this relatively small scale was induced by the uneven density - or even the lack - of soil survey information in certain parts of the continent. It was decided that the map would show major soil groups and include data on terrain type and parent materials. The Working Party nominated a Correlation Committee and decided that the material and information collected in different countries would be centralized in the Soil Survey Center in Ghent. A first draft of the Soil Map of Europe at a scale of 1:2,500,000 was presented at the second meeting of the Working Party held at Oxford in September 1959.

From 1959 through 1964, several drafts of the map and of the text were presented and discussed at successive meetings of the Working Party (Athens 1961, Lisbon 1963, and Florence 1964) and at the seventh and eighth International Congress of Soil Science respectively at Madison, Wisconsin, in 1960, and Bucharest in 1964. The map and its explanatory text were published in 1966 (FAO, 1966). Its main objectives, establishing cooperation at European level and correlating different soil classification systems, had been reached. The project proved to be a stimulus for updating soil surveys at national level. However, the lack of a systematic field correlation was a constraint to achieving satisfactory matching of soil units in different countries.

A further step to a common European inventory was the preparation of the 1:5,000,000 Soil Map of the World, jointly undertaken by FAO and Unesco. The project was initiated in 1961 and publication started in 1971. The two map sheets covering Europe were issued in 1981 (FAO, 1981). The FAO/Unesco Soil Map of the World incorporated the European systems of soil classification into an internationally recognized legend that enhanced cooperation and enabled a harmonized overview of the soil cover, both at continental and global level.

The broad composition of the soil associations at scales of 1:2,500,000 and 1:5,000,000 did not lend themselves as a basis for land use planning. Conscious of its responsibilities with regard to the practical application of soil data, the Working Party on Soil Classification and Survey decided, in 1965, to include the preparation of a Soil Map of Europe at scale 1:1,000,000 in its programme. Four sessions of the Working Party (Montpellier 1967, Varna 1969, Helsinki 1971, Ghent, 1973) were devoted to the construction of the legend, in accord with the FAO/Unesco Soil Map of the World, and to the harmonization of the map units across national boundaries. By 1973 the basic material for the preparation of the 1:1,000,000 Soil Map of Europe had been assembled and correlated (FAO, 1973). However, because of budgetary stringencies, the publication did not immediately materialize.

In 1978 the Land and Water Use Steering Committee of the European Communities (EC) proposed that a soil map of the EC be prepared and published. Advantage was taken of the preparatory work already carried out and of the material assembled in the framework of FAO's European Commission on

Agriculture. The EC Soil Map, at scale 1:1,000,000, was published in 1985 at the initiative and with the support of the Directorate General Agriculture, of the Commission of the European Communities (CEC, 1985).

As a part of the CORINE project the EC Soil Map was digitized in 1986 (Platou et al., 1989) in order to establish a geographical data base for environmental protection work in the EC. In 1987 the Commission launched a programme to Monitor Agriculture by Remote Sensing, MARS (Meyer-Roux, 1987). The programme was entrusted to the Institute for Remote Sensing Applications, Joint Research Centre of the European Communities at Ispra, Italy. In the framework of this project agro-meteorological models were developed, including soil and climatic data. The EC Soil Map of Europe at scale 1:1,000,000 served as a first database. Additional parameters for plant growth and environmental objectives were added, derived from the original material and from updates by national experts.

In 1994 the on-going soils database activity was upgraded to establish a Soils Information Focal Point (SIFP) charged with addressing the broader needs of the European Communities. These efforts led to an improved version of a 1:1,000.000 geographical soil database of Europe. It is at present the only harmonized database at continental scale and allows for satisfying demands for broad information in the domains of agriculture and environmental protection.

With the current application of modelling the need for quantitative soil parameters is increasing. Numerical data with spatial and temporal references and a formalization of methods to process them are now required. The scale and the precision of the 1:1,000,000 database do no longer suffice to ensure the harmonization in methodology between the various soil survey organizations and to meet the needs for specific soils information. The Task Force, European Environment Agency, DG XI of the European Commission initiated a study on the feasibility of the creation of a soil map of Europe, at scale 1:250,000 (Dudal et al., 1993). The study concluded that the preparation of such a map was feasible and desirable. Meetings of the heads of soil surveys of the European Union, which took place at Silsoe in 1989 (Hodgson, 1991) and at Orléans in 1994 (Le Bas and Jamagne, 1996), respectively recommended and endorsed the preparation of a georeferenced soil database for Europe at scale 1:250,000. The implementation of these recommendations was ensured by a Soil Information System Development Working Group (SISD) and subsequently entrusted to the European Soils Bureau which was created within the JRC in 1996 (Montanarella, 1996).

The present Manual sets out the proposed methodology, the concepts, the structure and the implementation of the new soil database. The project will be conducted in an overall framework of the major soil regions of Europe thus establishing a link between the different national inputs and providing an overview of the soil cover of the continent.

3 OBJECTIVES

It is now generally recognized that soil is a natural resource of which the proper management is essential, not only to ensure sustainable agricultural production, but also for the protection of water resources, forests, fisheries and natural ecosystems. It is increasingly realized that soils are strongly influenced by human activities and that relevant policies should promote and stimulate their rational use. Such policies need to be based on accurate soils information, both in space and in time, which can be translated into production potentials for different types of land use, which enables predictions of degradations hazards, and allows the design of protective or remedial measures.

Land use issues are not merely of a local nature but encompass national and regional scopes. Topical issues such as soil erosion, water quality, acidification, set-aside programmes, soil contamination and land use planning cover watersheds and landscapes which often transgress country boundaries. Furthermore measures for efficient land use greatly benefit from international exchanges of experience and information. European Union policies and programmes are already a familiar part of the working environment for land use planners. Hence the need for a comprehensive and harmonized soil data base at European scale (CEC-JRC, 1995).

The existing overviews of the soil cover of Europe, at scales 1:5,000,000, 1:2,500,000 and 1:1,000,000 have greatly contributed to the harmonization of efforts and to the creation of a European partnership. However, with the expanding focus on environmental issues and sustainable development, the needs for precise and quantitative soils information is presently unmet. The objective of the georeferenced soil database, at scale 1:250,000 is to provide the required soil parameters, combined with terrain, climatic, vegetation and lithological data, at a resolution which is suitable for regional planning and in a way which ensures compatibility and comparability of datasets of different national or regional institutions.

A major difference of the present project with previous approaches is that the georeferenced database will not be limited to a representation of data in the form of maps. Cartographic outputs, in order to be readable, have to be simplified which results in a loss of information. The use of soil classification units only, based on a restricted number of taxonomic criteria, limits the interpretation value of maps because certain parameters, needed for currently demanded applications, are not recorded (Vossen and Meyer-Roux, 1995). The georeferenced database will be a computerized structure, allowing for the storage of a maximum amount of soils information, reaching beyond the all-purpose nature of traditional surveys.

It is the objective of the present programme to remedy current shortcomings and to allow for the preparation of thematic outputs that address a broad range of land use issues. The 1:250,000 scale appears to provide for the necessary resolution at regional level. Its suitability has been shown by a number of applications which have already been made in different European countries such as the protection of groundwater quality, the assessment of risks of soil erosion, the assessment of drought hazards, the evaluation of land capability, the delineation of lands vulnerable to nitrate leaching, the assessment of risks of agrochemical pollution, the monitoring of forest ecosystems and desertification abatement.

The purposes of the present Manual are :

- to define the structure and contents of the database
- to describe the methods of georeferencing the data
- to outline suggested procedures for regional mapping and sampling programmes
- to prescribe a format of data storage
- to ensure inter-regional and inter-country harmonization of data acquisition, processing and interpretation.
- to pave the way for the creation of a user friendly soil database which will cater for present and future demands for specific soils information.

The 1:250,000 georeferenced soil database of Europe will provide precise and harmonized soils information for the Directorate Generals of the European Commission, for the European Environment Agency, for interested institutions in member governments and for international organizations. It will allow for an effective exchange of data, for standardization of methodologies of data storage and retrieval, and for establishing cooperation toward rational land use across national boundaries (King and Thomasson, 1996).

4 GENERAL CONCEPTS

4.1 INTRODUCTION

The purpose of this Chapter is to define the concepts and methods required to rationalize the preparation of a georeferenced soil database in Europe at small scale corresponding to 1:250,000. The work will be done by regional groups and so it is very important to use similar procedures to prepare and present the data. The wide variety of European soilscapes, as well as differences in available data from one region to another do not enable a universal procedure to be adopted. In this Chapter, we will stress the basic concepts and final structuring of the data in order to enable subsequent standard utilization (CEC-JRC, 1995).

Small-scale soil maps have already been prepared on the European scale (CEC, 1985). Their digitization and inclusion in a Geographic Information System (GIS) has led to rational management and efficient use of data (Platou et al., 1989); conversely, this approach has also shown its limitations (King et al., 1994). The translation of spatial soil data into a map is limited by the constraints of cartographic representation. In reality, the graphic information has to be limited in order to enable the document to be used easily. This "loss" of information thus has the associated risk of being carried over to databases using soil maps as their support. The European soil map at the scale of 1:1,000,000 is a typical example of the transformation of a map into a database. An extensive program of data enrichment from archives was required to make the base operationally usable in European programs (Burrill and King, 1993).

The aim of the project is to prepare a geographic database by relegating the problem of the cartographic representation of data to a secondary position. This Chapter explains the conceptual data model that is the basis of the computerized structuring of the data. The model is spatial, since the objects composing it are situated in space. Spatial relationships among objects are also described. The model is not strictly a "cartographic" one, since it does not consider the problems of representing data in the form of maps. We will nevertheless detail the inquiry procedures for this type of model, in particular its cartographic translation which remains a priority output.

The focal point of the database is the soil body. The formation of this entity is the result of a multitude of factors (climate, parent rock, vegetation, time, etc.). In a number of cartographic projects or those aimed at preparing geographic databases, these factors sometimes take precedence over the soil itself. In the georeferenced soil database, the soil body is the basic element and is the input key for the information system (Hole, 1978). This soil body is defined principally by soil attributes. Other objects elaborated from the soil body, i.e. the soilscape and soil region, are introduced for a better understanding of the spatial variability of soils and to provide tools for managing and rationalizing data on the continental scale. The criteria for the geographic delimitation of these objects are not necessarily soil variables, but may also be related to characteristics of soil forming factors: parent material, relief, vegetation, climate and human influence.

4.2 SOIL BODY AND SOIL HORIZON

As stated above, the differentiation of soils results from the soil genesis factors (Jenny, 1941). If at different locations all factors would be equal in presence and magnitude, comparable types of soil with comparable characteristics would result. This paradigm is at the origin of the development of a number of soil-classification or mapping systems based on soil formation. We shall retain this principle in order to distinguish the main types of soil in a given region (section 4.2.1), but will also put focus on soil behaviour in its landscape context.

Each soil body is in itself composed of a number of soil horizons and/or layers, which may vary in thickness and properties within one soil body as long as this does not violate the definition of the soil body. Variations in a vertical sense are mainly caused by soil formation or sedimentation processes, while lateral variation may be caused by slope processes such as erosion and deposition and by microvariations in other genetic factors. The physical organization of soil horizons within a soil body thus follows certain rules. These relations between soil horizons within a soil body are described in section 4.2.2.

4.2.1 Criteria for determining a soil body

It has been debated (Cline, 1977) whether the universe of soils comprehends discrete physical bodies, large enough to enable classification into a taxonomic system or whether it should be considered as a continuum (Marbut, 1935). The soil body is here considered as an artificial but recognizeable three-dimensional entity in a soil continuum. Within the soil body we recognize two kinds of variability: (i) *diversity* which results from the possible occurence of different pedotaxa (artificial classes) within the soil body, and (ii) *spatial variability* of soil properties, which is of a more continuous nature. These two kinds of variability are not necessarily positively correlated (high diversity is not always associated with high variability; Ibàñez et al., 1998), and should therefore be separately described. At a scale 1:250,000 and considering the stage of EUSIS, it is not possible to assess the intravariability and intrapedodiversity of all soil bodies, thus for practical purposes we therefore limit ourselves to the following approach:

(i) we use only a few diagnostic criteria to classify soil bodies;
(ii) we describe some tools to deal with diversity within the soil body;
(iii) we prescribe a measure of the intra-soil body variability on the parameter level.

A soil body is thus a portion of the soil cover with diagnostic characteristics resulting from similar processes of soil genesis. The diagnostic criteria used are those of the revised FAO legend (1990), in particular the presence of diagnostic horizons. For the definition of the soil body the classification according to FAO is used until the WRB becomes fully accepted and documented. The FAO-classification should be at the third level. In light of the very general nature of this typology, we added three additional criteria: parent material (according to the nomenclature defined in Chapter 7), soil texture in five fractions with gravel content class (CEC revised FAO triangle; CEC, 1985) and depth to obstacle for roots (defined in appendix 3).

A soil body corresponds to a real portion of the soil cover, but this does not mean that its geometry is precisely known. The first step involves constituting the list of principal soil bodies in a region according to the diagnostic criteria defined. This list will be the reference for general rationalization (see Section 4.4).

The description of each soil body is extended with morphological and analytical attributes of the main horizons, e.g. clay content, type of structure, CEC, organic matter content, etc. Mandatory and free attributes are distinguished (see Chapter 7 for the detailed lists). Whenever possible, these attributes are expressed quantitatively in order to avoid any *a priori* classification. Measurement methods and units are predefined and are referred to in Chapter 6. In contrast to diagnostic criteria, these attributes may possess a degree of variability within the soil body. The modal value, the first quintile and last quintile of each attribute are given for each soil body. These values will generally be obtained from an expert evaluation. The modal value may furnish a false idea of precision, but the difference between the two quintile values will provide an estimation of the spatial variability or, more generally, of the imprecision in our knowledge.

The data are presented in a manner similar to that of Proforma I of the "estimated profiles" of the 1:1,000,000-scale project for European soils. It adds the possibility of describing an intervariability of each body as proposed in the SOTER program (ISRIC, 1993). In addition, a relational table allows to describe the « volumetric pattern » of horizons within a soil body. In order to complete these data, it is important to have access to measured basic data. Like Proforma II of the "measured profiles" of the 1:1,000,000-scale project for European soils, the principle soil bodies will be associated with two or more real soil profiles, including field description results and laboratory analyses.

Table 1 Summary of criteria and guidelines for the definition of soil bodies

Object	Criteria		Guidelines	Delineation
	for definition	**for delineation**		
Soil Body	1 FAO-classification 2 Parent material 3 Depth to obstacle for roots 4 Dominant texture and gravel content class 0-30 cm	not applicable	1 One profile with estimated data in database 2 Two or more profiles with measured data in database 3 More than 90% of the area of a soilscape should be described by soil bodies	Only in small reference areas

4.2.2 Spatial organization of horizons within a soil body

Each soil body is defined by (a.o.) a characteristic combination of parent material and FAO-legend code and horizons within a soil body usually follow a typical vertical sequence. Besides the vertical sequence, also the lateral extension and shape of horizons gives much insight in the behaviour of the soil body, especially with respect to water and solute flow (e.g., Curmi et al., 1997). There are a number of parameters that give usefull additional information on these aspects. Examples are: the volume shape, the vertical and lateral continuity and transition of each horizon etcetera. Chapter 7 describes how the spatial patterns of horizons within each soil body are described qualitatively. The horizons to be described in the "horizon pattern table" are minimally those identified in the "estimated profile".

4.3 SOILSCAPE

The soil body is defined as a portion of land with imprecisely known geographic limits. This does not mean that it is not possible to evaluate its surface area, or even to broadly delimit zones in which one has a good chance of encountering it. This difficulty in representing fairly fine typological units on a commonly large-scale map was resolved in the past by creating soil associations (Simonson, 1989). This method enabled different soil units to be combined in a single mapping unit that could be delimited at a given scale. Although the grouping methods are often insufficiently explained, efforts have been made to better define the objects resulting from these groupings (Hewitt, 1993) and to define the criteria used in their construction (Hudson, 1990).

The difficulty in cartographically representing a soil body at small scale may have two origins: i) data is often lacking to permit the bodies to be delimited; ii) a soil body may be perfectly known but not representable at a small scale such as 1:250,000. In both cases, grouping this soil body with its neighbours results in a loss of spatial information at the same time as remaining compatible with the chosen geographic precision.

On the basis of the principle of grouping soil bodies, it is necessary to define the units obtained, which we call "soilscapes" and to indicate how the soil bodies are organized within these groupings.

4.3.1 Criteria for determining a soilscape

A soilscape is defined as a portion of the soil cover which groups soil bodies having former or present functional relationships, and that can be represented at 1:250,000 scale. The aspects of soil genesis are again given preference, thus defining the "soil catena" within which transfers of water, matter and energy are responsible for the vertical and lateral differentiation of the soils (Huggett, 1975).

Relief is the main diagnostic criterion for delimiting soilscape units. Preference is given to morphological attributes such as altitude, slope intensity, slope length, curvature, landscape dissection, etc. (see Chapter 7). The advantage of these attributes is that they can in principal be extracted from

Digital Elevation Models (DEM), thereby permitting a rigorous and comparative approach from one region to another if commonly accepted algorithms exist and the same datasources can be used. Moreover, an advantage is that the relief is an indicator of the geological material which is also an important diagnostic criterion for soilscape. A common DEM for Europe will be included in the database as an independent layer. These basic data are very useful for example in the automatic delineation of watershed basin. But these basic data or derived data need also to be interpreted according to soil processes. It will be the main task to do by soil surveyors and coordinators for the definition of soilscapes.

Satellite images provide good support for digital data, and also guarantee rigor. For example, DEM can be extracted from satellite data like stereoscopic images of SPOT. Satellite data provide also information on soil cover which useful for delineating soilscapes. However soil cover is the combined result of numerous historical or sociological facts that are difficult to distinguish from causes due to physical factors. For this reason, it is not planned to introduce this attribute as a diagnostic criterion; it will be retained merely as a descriptor of the units defined.

The definition of soilscape units is not only identified with that of soil catena. These units must also be representable at 1:250,000 scale. In GIS, the concept of scale is reflected in terms of geographic precision. Tolerances are adopted to fulfil the mapping objectives : minimum size for a polygon, minimum distance between arcs, etc. (table 2, Chapter 6).

The definition of a soilscape is thus an integration of a pedogenic definition and a geometric definition. It could be possible to consider two different units corresponding to a succession of nested levels (ISRIC, 1993). The disadvantage of this type of structure is that it is difficult to manage and, above all, to use.

Table 2 Summary of criteria and guidelines for the definition and delineation of soilscapes

Object	**Criteria**		**Guidelines**	**Delineation**
	for definition	**for delineation**		
Soilscape	Characteristic physiography or: geomorphology or: parent material or: drainage subbasin	Either: physiography or: geomorphology or: parent material or: drainage subbasin	1 Minimal size polygon: 1.5 km^2 2 Minimal distance on map of two arcs: 1 mm 3 Minimal size soilscape unit: 6 km^2 4 Soilscape= contiguous group of soil bodies	using DTM, geologic and geomorphologic maps etc.

4.3.2 Spatial organization of soil bodies within soilscapes

It was noted above that it is rarely possible to delimit a soil body in the context of the graphic limitations at small scale. Nevertheless, the organization of these units within soilscapes can be described by the use of symbolic attributes of spatial position, e.g. "near", "included in", "above", etc. (King et al., 1994).

The percentage of the soil body included in the soilscape is the first attribute to be assessed for determining a quantitative evaluation of soil resources. The localization of the soil bodies is the second attribute used to indicate the organized or random nature of the soil cover. The shape, pattern, surrounding relationships and boundary contrasts are all data that will lead to a better understanding of the soil systems (see Chapter 7). This leads to criteria of rationalization at European scale for defining soilscapes and for determining the nature of their functions, in particular hydrological. The number of Soil bodies within a Soilscape is not limited. The main point is that more than 90% of the Soilscape must be described by Soil Bodies. Furthermore, small but important Soil Bodies must also be described according to their role in land management or environmental aspects.

On the basis of the stated principles for grouping soil bodies, it is possible to have the same soil body in several soilscapes. Within a GIS, it may be possible to define several soilscapes overlapping in the same area, thereby grouping several units of soil bodies. But, it is evident that an exhaustive subdivision of the land into spatially contiguous soilscapes is preferred in order to prepare usable map outputs.

4.4 SOIL REGION AND REFERENCE AREA

Regardless of the precautions to provide precise definitions of conceptual objects, attributes and their encoding, most operations remain in the field of expert evaluations. This results from the imposed working scale that necessitates processing a vast quantity of information unavailable in formats compatible with digital processing. This fact entails risks of divergence in the interpretation of definitions, as well as drift with time. A structure involving the comparison of methods and rationalization of information thus becomes necessary. There are two possible levels: i) at a smaller scale to establish discussions on the basis of "natural" regional units and ii) at a larger scale in order to process measured data, thus comparable to different methods of preparation of the georeferenced soil database.

4.4.1 Small-scale: the soil region

The criteria used to describe soil bodies and soilscapes are primarily related to relief and parent material. Climate is also included in this approach, even though it is indirectly present in the FAO nomenclature.

Regardless of the criteria adopted, there is possible risk of having soils attributed to a single soil body, while in reality they belong to geographically differentiated soil regions. Experience acquired in coordinating the 1:1,000,000-scale European soil project has clearly shown that rationalization by member states could lead to incompatibilities in defining soil units. It is thus preferable to determine and rationalize soil bodies and soilscapes within large units having the geologic, morphologic and climatic factors that were responsible for the differentiation of soils.

The large units are called SOIL REGIONS. Typical for these areas is a common geologic-paleo-geographic development and therefore a characteristic composition of parent material. But to show the diversity of the soils at european scale the special climatic conditions in the different parts of Europe are very important too. Soil regions therefore are established on the basis of climatic data and parent material associations. And as a next step the FAO names of the dominant soils are added. The results of zoning Europe into soil regions and the acquisition of data necessary for that purpose are described in Chapter 5.

Table 3 Summary of criteria and guidelines for the definition and delineation of soil regions

Object	**Criteria**		**Guidelines**	**Delineation**
	for definition	**for delineation**		
Soil region	1 Climate 2 Parent material association	1 Climate 2 Parent material association	-	concept added to this Manual

4.4.2 Large-scale: reference areas

In order to verify rationalization between defined intra-regional soil bodies and soilscapes, control points in the field must be available. This is done by choosing reference areas of about 1000 hectares that will be finely mapped at approximately 1:50,000 to 1:20,000 scales. These reference areas will be selected to be representative of the regions at the same time as having a high soil variability and taxonomic pedodiversity in a small area.

Within these areas, representative profiles will be selected that will be sampled and analyzed. This sampling procedure is described in Chapter 6. It will be used to characterize soil bodies as well as for inter-region and inter-country comparisons. In the past, this type of work was limited only to soil profiles, implying a vertical and momentary vision of soils. The soil genesis characters of this program, combined with a geomorphologic vision, require a 3-dimensional mapping approach in order to understand the laws of soil distribution within a soilscape. The phase of large-scale cartographic control will be a quality check for verifying work carried out. It will be subsequently applied to small scale work according to procedures remaining to be defined.

4.5 GENERAL STRUCTURE OF THE DATABASE

The data base has a relational structure, being composed of objects: soil bodies (themselves subdivided into soil horizon), soilscapes and soil regions. Soil bodies are the basic element and contain primarily those data describing the nature and properties of soils. Soilscapes and soil regions indicate the spatial organization of soils. Each object appears as a key field in several tables.

Title:
STRUCTUR.EPS
Creator:
Freelance Plus 3.01
Preview:
This EPS picture was not saved
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Figure 1 General structure of the database

Relational tables describe the links among objects. The "organization" tables contains information on the distribution of soil bodies within soilscapes, and on soil horizons within soil bodies. The "limits" table enables the nature of the limits separating the different soilscapes in a soil region to be described. These relational tables are entities isolated from other tables, since they establish the link among the different objects of the database. The input of the "organization" table is composed of a correspondence list indicating the link between a soil body and a soilscape. The attributes describing the organization of soil bodies within soilscapes are linked to this table.

Within the attributes, distinctions are made according to their functions:

The set of attributes describing the nature of soils is the semantic set. Most of these sets are attached to soil bodies and soil horizons. The set of attributes describing the position and shape of the objects is the geometric set, and the attributes describing the organisation of (and within) the objects is the topological dataset. Most of these attributes are attached to soilscapes and soil regions. Chapter 7 and the appendices contains the definition of each attribute, the list of modalities or the measurement units.

Attributes describing soil bodies refer either directly to these bodies, e.g. soil depth, or to sub-units, the horizons. The number of horizons composing a soil body is not limited, but we will nevertheless indicate only the major horizons for the vertical differentiation of soils.
For soil bodies and soil horizons, we distinguish the attributes used as identification criteria and those characterizing objects. The "criteria" are accompanied by a confidence level corresponding to the reliability accorded to the value furnished by that criterion. For "characters" we demand an estimation of the modal value, and the first and last quintile of individuals constituting the soil body or soil horizon.
The values attributed to characters are the result of expert evaluations. These data are complemented by measured values obtained from soil profiles for which a geographic localization can be given.
In order to lighten this procedural load, mandatory variables are distinguished from facultative variables (see Chapter 7 for an extensive list).
Specific encoding is planned for missing data, whether it be a lack of information, nonsense or an omission (Chapter 7).

4.6 RELATIONS TO OTHER SYSTEMS AND DATABASES

4.6.1 Relations to other soil classification and mapping systems

In this section a brief comparison will be made between the concepts developed in this manual and those of the major soil mapping and database construction methods which are applied elsewhere: The USDA-system (Soil Survey Division Staff, 1993), the FAO-system (FAO, 1990) and its successor-to-be WRB, and the SOTER-system (ISRIC, 1993).
In the introduction to FAO-revised legend (FAO, 1990), it is rightfully stated that existing soil classification systems differ most in the concepts on which the subdivision in categories is based: either zonality, evolution, morphology, ecology or geography (including relief). Besides this, important differences ly in the degree to which soil taxonomy and the construction of soil map units coincide. Some of these differences are summarized in Table 4 below. FAO (1990) and SOTER (ISRIC, 1993) are examples of systems in which soil taxonomy and the definition of map units or database entries are strongly interweaved, in USDA and this Manual the connection between soil taxonomy and map unit definition is not so strong (*italic* entries in Table 4 indicate that taxonomic names are commonly used to identify map units).

Table 4 Some characteristics of different soil classification and mapping systems

<table>
<tr><th>Item</th><th>FAO</th><th>SOTER</th><th>USDA</th><th>Manual</th></tr>
<tr><td rowspan="7">Taxonomic hierarchy/
SMU-identification *</td><td rowspan="2">Major Soil Grouping</td><td rowspan="2">Terrain **</td><td>Order</td><td rowspan="3">Soil Region</td></tr>
<tr><td>Suborder</td></tr>
<tr><td>Soil Units</td><td>Terrain Component **</td><td>Great Group</td></tr>
<tr><td rowspan="4">Soil Subunits</td><td rowspan="4">Soil component</td><td>Subgroup</td><td rowspan="3">Soilscape</td></tr>
<tr><td>Family</td></tr>
<tr><td>Soil Series</td></tr>
<tr><td>Polypedon
Pedon</td><td>Soil Body</td></tr>
<tr><td>Purpose of highest level in system</td><td>Taxonomic map legend device</td><td>Map legend and database device</td><td>Taxonomic device</td><td>Map legend and database device</td></tr>
<tr><td>Primary divisive criteria</td><td>geography, evolution</td><td>geography</td><td>morphology, evolution, zonality</td><td>geography, zonality</td></tr>
<tr><td>Name of highest level</td><td>Major Soil Grouping</td><td>Terrain</td><td>Soil Order</td><td>Soil Region</td></tr>
<tr><td>Typical mapping scale</td><td>1:5,000,000</td><td>1:1,000,000</td><td>usually not mapped</td><td>1:5,000,000</td></tr>
</table>

Item	FAO	SOTER	USDA	Manual
Purpose of lowest level in system	Map Unit	Map Unit and Database entry	Link between soil taxonomy and soil mapping	Link between soil functioning and map unit, database entry
Name of lowest level	Soil Subunit	Soil Component (=Soil Subunit FAO)	(Poly)pedon	Soil Body
Typical mapping scale	1:100,000 - 1:1,000,000	1:100,000 - 1:1,000,000	not mapped	not mapped

* SMU=soil map unit
** Objects have no pedological nature

Many other differences exist between the systems, and it is of little value to name them all. In many cases, this manual follows the definitions of FAO and SOTER for soil attributes and diagnostic criteria, in some cases alternative definitions were developed for the purpose of compatibility with existing systems at the European scale or appropriateness.

4.6.2 Structure of the data

The database has an original structure, since it gives preference to an approach that is detached from the limitations of mapping representation and introduces the soil body as a priority input key in the computer system. The proposed approach, involving the establishment of groupings into soilscapes, belongs to the so-called ascending method in which "soil" objects are first defined, which are then grouped into geographic units. Inversely, a descending method first establishes a zoning based on criteria indirectly related to soils (relief, soil occupation, etc.) and then identifies the types of soil present within each zone. This distinction is not systematically clear-cut. The cartographic approach in soil science is often composed of a back-and-forth succession of these two attitudes. This is partially the case in the recommended procedure, since we are proposing: (1) zoning Europe into broad soil regions, (2) determining soil bodies constituting the zones (descending method) and (3) grouping in soilscapes (ascending method).

The procedure is thus different from prior work on the European scale. In particular, we may cite work done for the preparation of the geographic European soils database at 1:1,000,000 scale (CEC, 1985) and the SOTER project (ISRIC, 1993). The former essentially involved obtaining added value from conventional mapping data accompanied by their archives. Updating this database with the assistance of soil scientists from different member states was not sufficient to completely define original conceptual structures, in particular limitations related to cartographic representation. The latter (SOTER project) favoured a descending method using criteria that were more geomorphologic than pedologic. This approach has the advantage of proposing rigorous methods for defining the conceptual objects that are in the database.

In spite of these different concepts, the computer structure of the georeferenced soil database is similar to those of the above-mentioned projects. The soil body corresponds to the Soil Typological Unit (STU) of the 1:1,000,000-scale project and to the "soil component" of the SOTER project. Soilscape has elements of the Soil Mapping Unit (SMU) of the 1:1,000,000-scale project and to the "terrain component" of the SOTER project. The soil region could be related to the "terrain" of the SOTER project. The relational structure of the database is taken from the 1:1,000,000-scale project, as well as the differentiation between estimated and measured variables. The concept of mandatory or facultative variables is taken from the SOTER project. Transfer programs will be implemented in order to assure continuity with these projects.

4.6.3 Nature of variables

The structure of this database is similar to those of the 1:1,000,000-scale and SOTER projects. On the one hand, this implies the search for an ascending compatibility of the modalities of variables. For example, parent materials are described in more detail than in SOTER, at the same time as assuring their equivalence. The corollary to this is a revision of the 1:1,000,000-scale database in order to retain the possibilities of links between the two databases. For example, it is planned to update the 1:1,000,000 database by using the 1990 revised FAO legend and the new list of parental materials.

Some choices were made with respect to the definition of variables. It was chosen not to follow the USDA definition of the soil temperature regime, because measured data lack to make accurate estimates of soil temperature. Instead, climatic data are introduced in the description of the soil regions, and it is advised to incorporate meteorological data if needed by GIS-overlay from wheather station networks rather than to put these data directly in the soil database.

Variability

In addition, the characters describing soil bodies and soil horizon are presented in digital form with the attribution of a modal value and two surrounding values. This presentation is similar to that of SOTER and avoids the *a priori* attribution of classes, which has the disadvantage of setting limits that are not always relevant to all types of soils. Furthermore, this type of classes fixes an identical level of precision that prevents conducting more precise investigations. In particular, the reference areas for controlling the database should use the same database structure for approaches at much larger scales. The proposed encoding is very flexible in order to express different ranges of variation without changing the structure of the data. Finally, this type of method enables data conversion into any national or international system using fixed *a priori* classes, e.g. estimated particle size values can be converted into any texture triangle; soil moisture conditions are characterised by a range of attributes rather than a classification.

Accuracy

The accuracy of data put in the database is an often neglected issue which does however eventually determine the quality of the database as a whole. Accuracy is determined by factors related to the measurement such as (i) the method of analysis, (ii) the laboratory that carried out the analysis, but also to the age of the measurements (depending on the type of analysis). For the current version of this manual, it was chosen to document the accuracy of measurements in the database with information on the laboratory and year in which the analysis were carried out, and a data quality assessment by the provider of the data. For existing data, these data will allow the data analysis method to be reconstructed. For data newly sampled, it is advised to follow ISO-standards.

Completeness

The completeness of the database determines its usefullness for applications. At the spatial scales of the soil horizon, the soil body and the soilscape missing data are allowed at the parameter level as long as a mandatory subset of the data is included. Besides this, also the fraction of the area within a soilscape that is adequately covered by data at the soil body and soil horizon scale is important. It is intended to have minimally 90% of the area of each soilscape covered with adequately described soil bodies and soil horizons. However, since soil databases are usually constructed in a number of approximations, the degree of coverage at the soilscape level is an entry in the database, allowing further sampling efforts to be directed to areas where data are most scarce.

5 SOIL REGIONS OF EUROPE

5.1 INTRODUCTION

On the continent in general, the development of soils depends on the one hand to a high degree on climate and on the other hand on geological conditions. Europe is a continent with very different climatic and geological conditions and very different soils, too. To make the comparison of soils in Europe easier and to achieve finally a soilscape classification it is helpful to subdivide the continent in soil regions. The most appropriate way to start with is to define areas of similar climate. Climate influences the pedogenetic processes and consequently it determines their characteristics and properties. Varying temperatures, precipitation or droughts in the different areas of Europe also determine the potential productive capacity of the soil (FAO 1993) and it may be assumed that areas with similar climate offer the same possibilities for agriculture and forestry production.

Besides climate, geological conditions are the most important soil genetic factor. Therefore, it is necessary to differentiate the climatic areas by geological units. Geology determines e.g. the distinguishing marks of parent material (e.g. soil texture) and the relief as well as the altitude of an area.

Of course the formation of soils as a product of weathering of parent materials is mainly influenced by geological conditions and climate, but the characteristics of soils also depend on water conditions and differences in atmospheric deposition. As a result of the various soil-forming processes we can find in different parts of Europe different dominant soils, too, and the distribution of these dominant soils forms the third basis for the delimitation of soil regions. Therefore soil regions - as areas with similar soil-forming conditions and as the largest units of soil description - are defined as typical associations of dominant soils occurring in areas which are limited by a special climate and/or a special association of parent material. This is why the way of zoning Europe into soil regions is realized in three steps:

i) delimitation of areas with similar climate,
ii) subdivision of these areas by parent material associations with similar geologic-paleogeographic development,
iii) assignment of the occurring dominant soils.

In the description (appendix 9) the parameters used for the definition and delineation are specified. Each single soil region is characterized and described by:

- dominant soil types and regional name
- dominant parent material
- climatic data
- altitudes and major landforms.

To show the diversity of the european soils, a 1:5,000,000 Soil Regions Map for the EU-countries, Norway, Iceland and the countries of east central Europe was prepared containing 172 different soil regions grouped to the major climates of Europe. This map is not a soil map with detailed information about the individual soils with their special characteristics: It only shows a general idea of the soil distribution in the represented part of Europe and their main formation factors. The borders of the soil regions on this map are generalized adequate to the scale 1:5,000,000. Downscaling to larger scales is not advised and proposed. But in case of preparing a map at larger scales, e.g. 1:250,000, which should contain the borders of the soil regions, these borders are to adapt to the respective topography.
Two additional 1:20,000,000 maps show the climatic conditions and the major landforms of Europe.

5.2 DOMINANT SOIL TYPES

The most important objects for the soil regions are the soil associations occurring in these areas. In the description, each soil region is characterized by a combination of mostly three or four soil names of the Revised Legend of the Soil Map of the World (FAO, 1990), but sometimes up to six or seven dominant soils are mentioned if the area is very complex. In the column "soil region and dominant soils" the abbreviations of the soil units (level 2) of the FAO-classification (see appendix 1) are stated in brackets. For the West, South and Middle European countries the soil units are derived from the Soil Geographical Database of Europe at scale 1:1,000,000, version 3.21, and for the North European countries they are taken from the Soil Map of Denmark, Finland, Norway and Sweden (Rasmussen et al. 1989). In spite of comparable soil regions with similar soil forming conditions, e.g. similar climate and parent material, these data and documents show that differences in the distribution of dominant soils may occur and therefore the inclusion of the dominant soils for the definition of soil regions is very important. In all, 75 different soil associations are represented as well in the description as on the soil regions map.

To emphasize the importance of the soil associations, the respective dominant soils are integrated within the name of the soil region, too. These names are a combination of the major soil groupings (level 1) and the name of the regional landscape where these dominant soil associations occur.

5.3 CHARACTERISTIC ASSOCIATIONS OF PARENT MATERIAL

As mentioned above the geological conditions, especially the nature of parent materials, are very important factors for zoning the soils of Europe. Therefore, the description of the soil regions contains a column for the dominant parent materials stating the most important rocks and unconsolidated deposits influencing soil-forming. But the precise type, group or major class of the parent materials list (see appendix 2) is not indicated on the soil regions level. The soil regions are characterized by parent material associations with partly very different rocks and on the soil regions map only summarized geological information can be represented as well. Hence a list of parent material associations was prepared by means of the "International Geological Map of Europe and the Mediterranean Region 1:5,000,000", the "International Quaternary Map of Europe 1:2,500,000", and other geological maps of different types (von Gaertner et al. 1971, Duphorn et al. 1967 / 1989). Table 4 contains a combination of rocks predominantly formed in larger related landscapes with a common geologic-paleogeographic development but also rocks that are placed together by various geological processes. For the investigation area of Europe thirteen characteristic associations of parent material were defined and the special association "prepleistocene surfaces with paleosols" was added as number fourteen. On the Soil Regions Map, these associations of parent material are indicated by different hatchings.

Table 5 Characteristic associations of parent material

CODE	CHARACTERISTIC ASSOCIATIONS OF PARENT MATERIAL
01	quaternary marine deposits, partly with eolian sand
02	fluvial deposits
03	glacial deposits
04	eolian deposits
05	tertiary sedimentary rocks (undifferentiated)
06	sedimentary rocks in tertiary basins, (partly) covered with loess
07	sedimentary rocks in tertiary basins alternating with fluvial deposits
08	mesozoic sedimentary rocks (undifferentiated)
09	mesozoic sedimentary rocks, (partly) covered with glacial deposits
10	calcareous sedimentary rocks
11	igneous and metamorphic rocks
12	alternating igneous, metamorphic and sedimentary rocks
13	alternating igneous, metamorphic and sedimentary rocks, (partly) covered with glacial deposits
14	prepleistocene surfaces with paleosols

5.4 CLIMATIC AREAS OF EUROPE

Dividing Europe in climatic zones is a very important step for the delimitation of soil regions. From Norway and Finland in the north to Spain, Italy and Greece in the south the mean annual temperature increases and this is connected with the change of the length of the frost-free season, the length of the growing period and the seasonal rainfall concentration. Following the different climate classifications (e.g. FAO, 1993, Walther & Lieth 1960 / 1967) we can find four major climates in the investigated area of Europe from north to south:

Boreal climate is characterized by low temperatures (the frost-free season often lasts less than 75 days) and precipitation mostly in the form of snow (partly with a permanent snow cover), and there is only low evaporation. The natural vegetation consists of a tundra and taiga vegetation and because of the low temperatures there is hardly any agricultural land use. The slow decomposition of plant debris results in peat accumulations (Histosols) and by the little chemical weathering of parent materials the soil profiles are scarcely developed (Leptosols).

Boreal to temperate (cold) climate is a transition zone between the boreal and the temperate climate. It is marked by temperatures slightly higher than in the boreal climate but the frost-free season is rather short. Dependent on the season precipitation may fall as rain or snow, but evaporation is negligible. Agricultural production is only possible with frost resistant crops or with a short growing cycle. The natural vegetation consists of pine and oak forests. Typical of the soils of this climate are migration and accumulation of compounds of organic matter with iron and aluminium (Podzols).

T**emperate climate** with warm summers and cool to cold winters takes up the largest part of Europe. In general, the available water capacity, defined by precipitation and evaporation, is sufficient for agricultural cultivation. Precipitation and temperatures allow a very different agricultural production as nearly all - except the typical tropical crops - can be grown. A natural vegetation is deciduous forest with oak, birch, hornbeam and beech, but it hardly exist any more. Under these climatic conditions the soil formation often is connected with the formation, migration and accumulation of clay minerals, combined with a moderate liberation of iron (Luvisols, Cambisols).

Mediterranean climate is characterized by winter rain and droughts in summer, and the high evaporation entails a water deficit. There is hardly any frost risk and accordingly agriculture produces frost-sensitive crops like citrus fruit, olives or grapes. The natural vegetation consists of e.g. evergreen oaks or laurel and coniferous woods with pine, cypress or juniper. Corresponding to the climate, the soil-forming processes are influenced by rainfall and drought and these cause on the one hand migration and accumulation of clay or calcium carbonate (Luvisols, Vertisols, Calcisols) and, in areas with an intense relief, on the other hand erosion (Leptosols).

A further subdivision of these four major climates can be obtained by adding the seasonal and daily equability of humidity and temperature. In general, from Ireland and France in the west to Poland and Romania in the east the maritime influence decreases which can be expressed by the following climatic types describing the climatic balance:

Oceanic or maritime type: Typical are the low daily and annual variations of air temperatures (the mean monthly temperatures, calculated for one year, vary less than seven degrees), day and night and summer and winter are very equable. In general, the mean annual precipitation falls as rain and is higher than in continental climate.

Continental type: Characteristic are the big variations in daily and annual air temperatures (calculated for one year the mean monthly temperatures vary more than 35 degrees), both day and night and summer and winter show big differences. As a rule the summer is warm to hot and the winter is very cold. Usually the sum of the annual precipitation is lower than in oceanic climate and the precipitation in winter falls as snow.

Suboceanic type and **subcontinental type** are transitions to the above mentioned types. But for the description of the single soil regions other combinations of these climatic types were also used.

A special **mountainous climate** (more or less independent from the major climates or the climatic types) we can find in the high mountain areas that are characterized by big differences in altitudes over short distances and therefore steep slopes are common. Corresponding to the relief the climate is typified by a great variability in temperature and rainfall and as a rule the temperature is lower and the rainfall is often higher than in the surroundings. At the highest altitudes permanent snow covers or glaciers may occur. Caused by the relief an intense soil erosion prevails and relatively shallow soils can be found (Leptosols, Regosols). In the lower parts of the high mountain areas Cambisols are present, too, and the land use is determined by forestry but agriculture is not very common.

The combination of the major climates and the different climatic types has led to nineteen areas with different climatic conditions (Hendel 1991, Rivas-Martinez 1996, Scherhag & Lauer 1982, FAO 1990). Each climatic area is characterized by precipitation, temperatures and in some cases by the vegetation period. The values for these climatic parameters but also for the description of the soil regions in appendix 9 are derived from the "Klimadiagramm Weltatlas" (Walther & Lieth 1960 / 1967) a world atlas of climatic diagrams and maps that forms the basis for a more accurate classification of climates than that given by Köppen (1936). In general, more than 30 partly more than 50 years of climate observation are evaluated and up to nineteen single elements are summarized in diagrams for this atlas. Some of the most important data in the diagrams are:

- altitude of the observation station (in meters)
- number of years of observation (in years and divided for temperature and precipitation)
- mean annual temperature (in degrees centigrade)
- mean annual precipitation (in millimeters)
- mean daily minimum of the coldest month
- absolute minimum
- mean daily maximum of the hottest month
- absolute maximum
- mean range of temperature.

Other data in the diagrams are related to periods of droughts, humid seasons or months with temperatures below zero.

The atlas also contains groups of related climatic diagrams and climatic maps showing the classification of the prevailing climate, the position of the observation stations, and a few specimen diagrams. In this way, the climatic data are available for all parts of Europe and can be evaluated easily for the soil regions.

In the notes below on the nineteen climatic areas (***Table 7***) the amount of precipitation is given in five classes:

Table 6 Precipitation classes

CLASS	MEAN ANNUAL PRECIPITATION (mm per year)
very high	> 1000
high	800 - 1000
medium	500 - 800
low	400 - 500
very low	< 400

The **temperatures** in winter and summer are classified but not exactly defined:

winter	summer
very cold	moderately warm
moderately cold	warm
cold	hot
mild	
very mild	

The **vegetation period** is given by days per year and the periods of drought, classified but not exactly defined as well, are indicated as follows:

without
very short
short
long

For each soil region the precise data for precipitation, temperatures and periods of drought are shown in appendix 9.

Table 7 Climatic types used for the delimitation of soil regions

CODE	CLIMATIC AREA
1	**BOREAL CLIMATE**
11	boreal-oceanic climate, partly subpolar or mountainous climate *high precipitation, moderately cold to cold and snow-rich winter, moderately warm summer, vegetation period 100 to 150 days but often less than 75 days*
12	boreal-continental climate *medium to low precipitation, long and very cold snow-rich winter, relatively warm summer vegetation period 80 to 120 days*
13	boreal-mountainous climate *medium to high precipitation, very cold winter and short summer, partly with glaciers and permanent snow cover*
2	**BOREAL TO TEMPERATE (COLD) CLIMATE**
21	boreal to temperate-oceanic climate, partly mountainous climate *high to very high precipitation, moderately cold winter and moderately warm summer, vegetation period 120 to 180 days*
22	boreal to temperate-suboceanic climate, partly mountainous climate *medium to very high precipitation, cold winter and moderately warm summer, vegetation period 120 to 180 days*
23	boreal to temperate-subcontinental to temperate-continental climate *medium to (partly) low precipitation, cold winter and warm summer, vegetation period 120 to 180 days*
3	**TEMPERATE CLIMATE**
31	temperate to warm-temperate-oceanic climate, partly mountainous climate *medium to (partly) very high precipitation, very mild winter and moderately warm summer, vegetation period 180 to partly more than 210 days*
32	warm-temperate-oceanic to warm-temperate-suboceanic climate, partly submediterranean climate *medium to high precipitation with deficit in summer, mild winter and warm summer, vegetation period 180 to more than 210 days*
33	temperate-suboceanic climate *medium to (partly) high precipitation, moderately cold winter and moderately warm summer, vegetaion period 180 to more than 210 days*
34	temperate-suboceanic to temperate-subcontinental climate, partly mountainous climate *medium to (partly) high precipitation, winter and summer temperatures depend on altitude, vegetation period 150 to more than 180 days*
35	temperate-subcontinental climate *medium to low precipitation, moderately cold to cold winter and moderately warm to warm summer, vegetation period 150 to more than 180 days*
36	temperate-subcontinental to temperate-continental climate, partly mountainous climate *low to medium precipitation, cold to moderately cold winter and warm summer, vegetation period 150 to more than 180 days*
37	warm-temperate-subcontinental climate *medium to high precipitation, temperatures and vegetation period dependent on altitude, cold winter and moderately warm to warm summer, vegetation period 180 to more than 210 days*
38	temperate-mountainous climate *medium to high precipitation, temperatures and vegetation period dependent on altitude (temperate to boreal), cold to very cold winter and moderately cold to moderately warm summer*
4	**MEDITERRANEAN CLIMATE**
41	mediterranean to warm-temperate climate *medium to high precipitation, winter with temperatures below zero, very short dry period in summer, partly without dry period*

42 mediterranean-oceanic to mediterranean-suboceanic climate, partly mountainous climate
medium to high precipitation in autumn, winter and springtime, regional only a short dry period in summer

43 mediterranean-subcontinental to mediterranean-continental climate
medium to very low precipitation in springtime, autumn and winter, long dry period in summer, partly arid, cold winter and hot summer

44 mediterranean to subtropic climate
very low precipitation all over the year, temperate winter and warm summer, partly hot and arid, partly with mountainous climate

45 mediterranean-mountainous climate
medium to partly high precipitation, temperatures and vegetation period dependent on altitude

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On the 1:20,000,000 map "Climatic Areas of Europe" these nineteen climatic areas are represented by different colors: e.g. from blue for the boreal climate over green for temperate climate to orange for the mediterranean climate.

The description of the soil regions (appendix 9) contains not all climatic parameters mentioned before but only the following information:

- mean annual temperature (degrees centigrade, calculated by the average of the observation years)
- mean annual precipitation (millimeters, average overall sum of the observation years)
- months of highest precipitation (names of the months with an average precipitation much higher than in other months of the year)
- months of drought (names of the months with very high evaporation on the land surface and big deficit of precipitation)
- months with temperatures below zero (names of the months when frost is common).

The indicated values are also derived from the before mentioned World Atlas of Climatic Diagrams and Maps (Walther & Lieth 1960 / 1967). All data are based on long-term observations but the given numerical data are average values that may slightly differ in local areas.

5.5 ALTITUDES AND MAJOR LANDFORMS

The physiography gives a first impression of an area and is also a differentiating criterion of the soil regions (van Engelen & Wen 1995). On the level of soil regions only a general characterization of the physiography is necessary. Especially the altitudes and the first level of the landforms, the major landforms, are important for the description of the physiography of a soil region.
The altitudes are stated as intervals in meters above sea level. The larger the interval the more the soil region is subdivided and the more different soil types are to be expected. The interval of the altitudes corresponds also to landforms that are defined mainly by slopes and relief intensity (van Engelen & Wen 1995). According to the first level of the SOTER program the following four major landforms describe the most general features of the morphology of a landscape: level land, sloping land, steep land and land with composite landforms. The distinguishing criteria for these major landforms are given in appendix 7. Because in some soil regions more than one main type of morphology can be found the description contains also combinations of these four major landforms which were used for the characterization:

- level land
- level to sloping land
- sloping land
- sloping to steep land
- steep land
- composite landforms

The 1:20,000,000 map "Major Landforms of Europe" shows where these combinations of major landforms are located. The legend of this map corresponds with the above given list.

5.6 LEGEND OF THE SOIL REGIONS MAP

172 soil regions as combination of 75 different soil associations and fourteen different parent material associations are represented on the Soil Regions Map at scale 1:5,000,000. Each soil region is characterized by an identifying number (see appendix 9), by a typical map color for the most dominant soils and by a defined hatching for the most important parent material association. Also the map legend which is subdivided in two parts represents these distinguishing marks. The first part shows the occurring dominant soil associations of the soil regions. These are grouped in alphabetical order to the four major climates of Europe and marked as well by the mentioned defined map color of the most dominant soils as by the identifying numbers of the soil regions. For a better interpretation these identifying numbers are very helpful. The second part of the legend presents the fourteen parent material associations indicated by hatchings. The parts of Europe that are not included in the map are colored by a uniform pastel.

6 IMPLEMENTATION AND DATA ACQUISITION

This Chapter describes the successive and different steps to be followed for the acquisition of data to be introduced in the database, and to propose a rational coordination for the work. To this purpose, the Chapter is divided in 4 sections: section 6.1 treats the available data resources which are the basic data a regional project needs to get started. Section 6.2 gives a step-by-step summary of the procedure towards a 1:250,000 soils database of Europe. Section 6.3 focuses and elaborates on the work that has to be done in pilot areas to obtain sufficient coverage with data in the pilot area. Finally, section 6.4 describes the framework for the coordination of the work.

6.1 AVAILABLE DATA RESOURCES AT THE EUROPEAN SCALE

This section gives an overview of databases which are available at the European scale with full coverage of Europe. All listed databases are relevant for the preparation of an 1:250,000 soil database. A few words on the relevance of each database are added to the descriptions.

Digital soil region map of Europe 1:5,000,000
This database was made by the BGR in collaboration with the European Soil Bureau, and is described in extenso in Chapter 5 of this Manual. The coverage is freely available through the European Soil Bureau. Its relevance lies in its use to delineate and broadly characterize pilot areas as well as that its provides a general applicable, harmonized data layer valid for the whole of Europe, which makes comparisons between pilot projects easier.

The European soil database of Europe at scale 1:1,000,000
This database comprises (i) the soil geographic database of Europe at 1:1,000,000 scale (version 3.1), and (ii) the soil profile database of Europe for use at 1:1,000,000 scale (version 1.0).
ad (i) The soil geographic database comprises polygon boundaries, polygon attribute tables, soil map unit and soil typological unit tables and a data dictionary describing the structure of the database together with attribute descriptions and definitions. The coverage of the spatial data includes the countries of the European Union and of central and eastern Europe, 18 in total.
ad (ii) The soil profile database comprises soil analytical data (for the whole profile as well as individual horizons) for the main soil types portrayed by the soil geographical database.
An extensive description of both databases is given by King et al. (1995) and Breunig Madsen and Jones (1995). Both databases are available through the European Soil Bureau.
This database is very relevant for use in pilot projects, since it is the only datasource on soils which covers the whole of Europe. It can be used for reference purposes and for stratification of pilot areas in more homogeneous sub-areas.

The European 30 arc-second DEM
A Digital Elevation Model (DEM) of Europe exists which has a spatial resolution of 30 arc seconds, which corresponds to approximately a 1*1 km grid. This grid has been derived from the Level 1 Digital Elevation Data (DTED-1), which contains a spacing of elevations of 3*3 arc seconds for Europe between 0 and 50 N-S (N/S spacing increases with higher latitudes), and covers most of Europe. Missing parts were filled using the digitized chart of the world (DCW). The accuracy specifications are as follows: Horizontal: 130 meters at 90% circular error, and vertical: +/- 30 meters at 90% linear error. The basic data as well as the resulting DEM are extensively described at the internet address: http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html . The DEM is freely available via the internet through anonymous ftp, following the procedure below:

1. FTP to 152.61.128.6 (edcftp.cr.usgs.gov)
2. Enter "anonymous" at the Name prompt.
3. Enter your email address at the Password prompt.
4. Change (cd) to the "pub/data/gtopo30" subdirectory.
5. The files are located under the subdirectories:

EUROPE, NORTH_AMERICA, AFRICA, HAITI, JAPAN and MADAGASCAR

6. Files are named after the image with the following extensions:
   *.bil.gz = compressed image file
   *.blw = world file
   *.hdr = header file
   *.stx = statistics file
   *.tik = coordinate file
   *.ddr = data descriptor record
7. Enter "binary" to set the transfer type
8. Use get or mget to retrieve the desired files.

The names of the files containing the European images are: *eur_30_dem1* for the area between 22W-22.5E longitude and 35N-85N latitude, and *eur_30_dem2* for the area between 22.5E-70E longitude and 35N-85N latitude.

This database is extremely relevant for the current project, because it provides a common base for the delineation of catchments and the larger physiographic features, which is essential when building the data layer with information on soilscapes.

The Joint Operations Graphic (JOG) topographic map 1:250,000, 1501 series

The Joint Operations Graphic (JOG) is a topographic map made for military purposes by the US-Government in collaboration with national governments of NATO-member countries. Feature portrayal includes relief, drainage, vegetation, populated places, cultural features, and coastal hydrography. Linear features are plotted as to their correct orientation and in their true location, wherever scale permits.

The Coordinate Reference System is Polar Stereographic for polar regions and Transverse Mercator (UTM) for other regions.

For technical, ordering, and availability information, contact:

Director
DMA Combat Support Center
6001 MacArthur Boulevard
Bethesda, MD 20816-5001
Telephone: 1-800-826-0342

or the national Ministery of Defense.

A common topographic base is useful in the context of international harmonization programs and for plotting a map. However, for mapping purposes, the scale 1:250,000 of this map is inappropriate, and local topographic maps at higher resolutions should be preferred.

6.2 IMPLEMENTATION PROCEDURE

6.2.1 Soil regions

The first step of the work that has to be done is to delineate the soil regions and to work out a soil regions map of Europe. At European scale the soil regions are grouped firstly by 19 climatic areas which are defined by principal climatic types and climatic balance and secondly by 14 parent material associations. Moreover every single soil region at national or regional scale is characterized by the FAO name of the dominant soils, the parent material group and the regional climate but also by altitudes and major landforms. The combination of dominant soils, parent material associations and climate areas has led to 160 soil regions in Europe. The results of soil regions delineation are presented in Chapter 5 and Appendix 9.

6.2.2 Pilot areas

The main part of the work towards a 1:250,000 soil database for Europe has to be carried out in pilot areas. Pilot areas are areas delineated by soil region boundaries where a number of criteria are met which provide a solid basis to start such a labour-intensive project. An increasing number of pilot areas will provide for an increasing coverage of Europe with the 1:250,000 soils database.

The main aims of having pilot areas are :

(i) To find ways to deal with harmonization problems in an early stage of mapping. This will enable mapping procedures to be adapted and also provides a training for the people involved.

(ii) To solve harmonization problems related to existing data and maps.

(iii) To validate the definition and location of soilscapes and soil bodies.

6.2.2.1 Delineation

This delineation would be made on the basis of the 1:5,000,000 soil regions map in which climate and parent material association are the main distinguishing factors. The Soil Region boundaries are used to delineate pilot zones in the areas of interest. So, this zoning will be a regional working platform which should provide an operational support for the later soil mapping and sampling activities in the pilot areas. The actual delineation should be done at the 1:250,000 scale, and should follow morphometric boundaries as used for the delineation of soilscapes too.

6.2.2.2 Selection

The main criteria for the selection of pilot areas would be:

(i) Representative soilscape must be encountered.

(ii) A representative coverage of EU countries must be established.

(iii) National and/or regional support for this type of work must exist, that means that the best would be combination of pilot areas and present regional important problems of soil conservation requiring soil information, such as environmental/soil degradation research, physical planning research, etc.

(iv) Transboundary and transregion harmonization problems must be also encountered.

(v) Some experience must be gained on unmapped territories.

Some propositions have been made in Finke (1995), which are copied here:
It is proposed to have pilot areas in most EU countries, and regional and national interests should be inventoried by national representatives. A metadatabase will be a help to select the pilot areas in order to have enough data to begin to work. Table 8 gives the possibilities for a first selection.

Table 8 Possible locations of pilot areas

Pilot area	**Countries involved**	**Motivation**
1	Nordic countries	Representative soilscapes (glacial features) Representative coverage of EU Transboundary and transregion harmonization
2	Germany, Denmark	Representative soilscapes (glacial drift) Representative coverage of EU Transboundary and transregion harmonization
3	Germany, Belgium, Netherlands, France	Representative soilscapes (loess, peat, coversand) Representative coverage of EU National/regional support exists Transboundary and transregion harmonization
4	England, Scotland	Representative soilscapes Representative coverage of EU Transboundary and transregion harmonization
5	France (regions)	Representative soilscapes Representative coverage of EU National/regional support exists Transboundary and transregion harmonization Unmapped territory
6	France, Italy	Representative soilscapes Representative coverage of EU National/regional support exists Transboundary and transregion harmonization

Pilot area	Countries involved	Motivation
7	Italy (northeastern regions)	Unmapped territory Representative soilscapes Representative coverage of EU National/regional support exists
8	Spain, Portugal	Transboundary and transregion harmonization Representative soilscapes Representative coverage of EU Transboundary and transregion harmonization
9	Greece	Unmapped territory Representative soilscapes Representative coverage of EU

6.2.2.3 Research phases

The work to be done in pilot areas, after these have been identified and delineated, takes place in a number of successive phases. These phases are based on the reasoning to take maximal advantage of existing relevant information. The work to be done in these phases is described in more detail in the next section.

Phase 1 Construction of a metadatabase of existing information
The first phase is to make an overview of existing information within the pilot area. Semantic and geographic knowledge should exist in each Region. The situation may vary considerably, from the total absence of data to considerable amount of precise mapping data already prepared and accessible in national systems. All intermediate situations may be encountered. In the case where documents already exist, major conversion work may be required later. All existing information should be grouped and made accessible to the members of the regional project team, e.g. by making a computerized metadatabase or a written report.

Phase 2 Screening, aggregation and use of existing data
In the second phase, a closer look is taken at the available information. These data or maps must first be screened on applicability (e.g. do the maps have appropriate scales) and quality (e.g. are the data still up to date). Soil profile data also must fulfil a number of requirements.
Maps that are useable may have to be generalized to the appropriate scale. Also harmonization of the existing map legends to the definitions of soil bodies and soilscapes must be achieved in this phase.

Phase 3 Primary data acquisition
This phase applies only to situations where there is no full coverage of the pilot area with useable existing material, but when it occurs it will take most of the resources. New data will be collected in the following cases:

1. If data are lacking or their accuracy is below the standards defined in the Manual.
2. If the data can not be harmonized with those obtained by methods acceptable by this Manual.
3. If complementary data are needed in addition to the existing data.
4. If new forms of data, such as remote sensed, are desirable.

Primary data acquisition consists of field work for (i) the recognition of soilscapes and soil bodies, (ii) the delineation of soilscapes on field maps and (iii) soil profile sampling.

Phase 4 Definition and delineation
In this phase, the material collected in phases 2 and 3 is combined to define soil bodies and to both define and delineate soilscapes in the pilot area. This phase consists mainly of desk work with some limited field checking.

Phase 5 Filling of the database
During this phase, the geometric part of the database is filled: The delineations of the soilscapes are put into the *soilscape geometry table*. Also, the topological part of the database describing the relations between the objects within the database is filled: The spatial distribution of soil horizons within the soil body is put into the *horizon pattern table*, the spatial distribution and mutual relations between soil bodies within a soilscape are put into the *soil body pattern* and *soil body relations table* and, finally, the

descriptions of the limits between soilscapes is put into the *soilscape limits table*. Furthermore, the semantic part of the database, consisting of several tables, is filled with the properties of soil horizons, soil bodies and soilscapes. For an extensive description of all these tables, reference is made to Chapter 7 of this Manual.

Phase 6 Validation
The purpose of this final phase is to obtain an objective measure of the predictive power of the database. This predictive power is a function of the degree of heterogeneity within and between the distinguished units. The smaller the heterogeneity within the units compared to that between the units, the more successful the classification and the higher the predictive power. Many methods exist to obtain expressions for heterogeneity, a number of which are mentioned in Chapter 8. This validation phase is very important, because the results may be used to improve the basic concepts and methods applied in this Manual. Validation will usually take place in a reference area, or by some kind of random sampling within the pilot area.

Phase 7 Secondary data acquisition
After the database has been filled and checked, the data are still not always fit to be used for all purposes. The description and the evaluation of the performance of soil bodies, under the influence of external factors, and the estimation of the risks soil bodies face upon misuse and degrading impacts are usually accomplished by the use of various models, programmed to simulate specific soil processes. These models require data in addition to those which are normally available in soil survey reports or in the existing data bases. The acquisition of these data is often difficult, costly and time consuming. The problem of the data insufficiency can, in many cases, be overcome by the use of pedotransfer functions (PTF) and pedotransfer rules (PTR). This Manual does not prescribe secondary acquisition, because the types of secondary data needed will vary by pilot area. In Chapter 9, some methods and examples for secondary data acquisition through the development of PTF and PTR are described.

6.3 WORK TO DO IN PILOT AREAS

6.3.1 Development of metadatabase

The metadatabase should describe all existing information relevant to the pilot project. This includes maps, profile databases etc. Types of maps to be included are soil, geologic, topographic, forest, vegetation and geomorphological maps and areal photographs, satellite data etc. It is advised to introduce in the metadatabase only the contours and contents of the existing maps, and not the maps themselves. Metadata to be included are for instance: projection of the available maps, scale of these maps, a reference to the legend used, spatial density of the observations on which the maps were based, references to eventually constructed digital databases with maps and point data, year of survey etc.

Sources for the metadata are to be found at the national level as well as at the regional level. The most recent inventory of national soil data sources in EU-countries has been published in Le Bas and Jamagne (1996). Other relevant data sources at the European scale have been described in section 6.1.

6.3.2 Work in areas with existing soil data

6.3.2.1 Screening, aggregation and use of existing data

The screening of existing data is done by evaluating maps by their scales and the legends by their fitness to be harmonized. Also, soil profile data are to be screened by comparing the data with a number of requirements.

Are existing maps appropriate ?
A soil map may be appropriate for use in building a 1:250,000 database when the map scale is between 1:25,000 and 1:200,000. Also, it is necessary to know which map projection was used, and how the map was made (e.g. the observation density, the survey method). The legend of the map needs to be

checked against the criteria used to define soil bodies and soilscapes. For instance, it is necessary, that the soil typological units within the soil associations on the map, or the map units themselves, can be reclassified into the FAO-revised legend. When the available maps and associated data do not allow for a conversion of the legend into the FAO-revised legend, additional sampling is required. If so, additional sampling schemes should be defined at this stage.

Requirements to existing soil profile data
The reliability and the usefulness of the new data base would largely depend on the quality of the incorporated attributes. Existing data can therefore only be accepted if these satisfy the following requirements:

1. The position (coordinates) of the sampling site is exactly known.
2. The data are descriptive of a whole soil profile down to the depth of 150 cm or to the lithic contact, if shallower. They must refer to all soil horizons or lithological layers thicker than 10 cm, and include also important thinner layers (eg., iron pans).
3. Required attributes are the mandatory attributes described in Chapter 7.
4. Attributes must be coded according to Chapter 7 and Appendices 1-7.
5. Analytical data must have been determined according to acceptable methodologies such as those referred to by Breuning Madsen and Jones (1995) and described by ISO. A list of soil-related analyses for which ISO-formats exist is given in Appendix 8. An updated list can be found at internet site http://www.iso.ch/meme/TC190.html .
6. There must be an acceptable estimate of the accuracy of the data provided by the owner.
7. The sampling sites fit to the definition and are representative of the soil body as defined in this Manual and can be assigned to it.
8. There must be a minimum of 2 sampling sites for each soil body.
9. Data in electronic bases and GIS will be preferable.
10. Time dependent data must be valid otherwise redetermined.
11. The data must be reproducible. Checks must be conducted regularly on the data of the national laboratories by a designated laboratory.

If data are not fit to these requirements, additional sampling schemes must be designed in this phase.

6.3.2.2 Recognition of soil bodies and delineation of soilscapes

When the situation exists, that appropriate soil maps at detailed scales exist, an ascending method can be applied to define and characterize soil bodies and to define and delineate soilscapes. Ascending methods take inventories at high geographical detail as a basis for gradually "zooming out" towards a larger area at less detailed scales. A typical sequence of activities in an ascending method is:

(i) Interpretation of existing maps and reclassification into the revised FAO-legend of the soil map units (in case very detailed maps are available, e.g. 1:10,000 to 1:50,000) or of the soil typological units (in case soil association maps are available, e.g. 1:50,000 to 1:200,000);
(ii) Determination (per map unit or STU) from existing data of the other attributes needed to define a soil body: parent material, topsoil texture and depth to obstacle for roots;
(iii) Grouping of map units (or STU) into soil bodies;
(iv) Usage of existing soil maps in addition to geomorphological maps, DEM etc. to define and delineate soilscapes;
(v) Usage of existing soil profile databases to characterize soil bodies and other data sources to characterize soilscapes resulting from the definition and delineation above.

Some guidelines to be followed are:

1 Each soilscape should be described by such a number of soil bodies that more than 90 % of the area of the soilscape is covered by the descriptions;
2 The minimal size of a soilscape polygon is 1.5 km^2;
3 The minimal distance on a map of two arcs is 1 mm;
4 The minimal size of a soilscape unit is 6 km^2;
5 A soilscape is a contiguous grouping of soil bodies;
6 Criteria for the delineation of soilscapes are to be chosen from: different physiographic or geomorphologic features, differences in parent material or different drainage subbasins.

6.3.3 Work in areas without existing soil data

6.3.3.1 Data acquisition

In areas where no soil maps and databases yet exist, a combination of ascending and descending mapping methods is necessary. A typical sequence of activities would be:

(i) A preliminary phase of basic document consultation, such as: the soil region map 1:5,000,000, topographic, geological, forest and vegetation maps, DEM, areal photographs and satellite data (SPOT, Landsat). These documents allow the establishment of a prezoning of the area in different pedolandscapes;

(ii) Usage of geomorphological maps, DEM etc. in combination with a field survey to define and delineate soilscapes;

(iii) A phase of systematic survey (not soil mapping per se) with surface observations and borings in order to improve the delineation and definition of soilscapes and to investigate which soil bodies occur in a soilscape;

(iv) A phase of information acquisition to characterize soil bodies. In this phase, soil profiles are sampled to a depth of at least 1.50 or to a lithic contact if shallower. Characteristics to be determined are given in Chapter 7.

6.3.3.2 Recognition of soil bodies and delineation of soilscapes

Phases (i) and (ii) correspond to a descending mapping method. In descending methods, information is collected at the target scale to recognize and delineate the spatial units. Delineation of soilscapes should be done in a reproducible manner. One way to achieve this, is to use the 30 arc seconds DEM of Europe as a first reconnaissance of the physiography of the landscape and of the main drainage basins. This reconnaissance can then be improved by a field survey to better locate soilscape limits and can if needed be detailed by adding geomorphological criteria and parent material differences to subdivide units if the scale permits. Phases (iii) and (iv) are ascending methods. Phases (iii) and (iv) may be done in small reference areas, with a soil survey at detailed scales (e.g., 1:25,000). Alternatively, phases (iii) and (iv) may also cover the whole pilot area.

Some guidelines to be followed are:

1 Each soilscape should be described by such a number of soil bodies that more than 90 % of the area of the soilscape is covered by the descriptions;

2 The minimal size of a soilscape polygon is 1.5 km^2;

3 The minimal distance on a map of two arcs is 1 mm;

4 The minimal size of a soilscape unit is 6 km^2;

5 A soilscape is a contiguous grouping of soil bodies;

6 Criteria for the delineation of soilscapes are to be chosen from: different physiographic or geomorphologic features, differences in parent material or different drainage subbasins;

7 Soil borings in phase (iii) should produce the following soil information:

Profile characteristics:
- Origin of excess of water
- Depth of water table
- Parent material
- Field classification into the FAO-revised legend[1]

Horizon characteristics:
- Starting and ending depths
- Texture
- Estimate of organic matter content
- Effervescence ($CaCO_3$ content)
- Presence, nature, size and abundance of coarse elements (stones, gravel)
- Evidence of oxidation-reduction

[1] We are aware of the fact that a field classification into FAO is error-prone because not all necessary data are known. However a rough classification is necessary because otherwise it is not possible to make estimations of the area within a soilscape in which a soil body occurs.

- Notes on toxicity, salinity and impermeability to make the evaluation possible of the "depth to obstacle for roots".

Sample sizes and sampling method
The amount of soil borings in the phase of systematic survey at scale 1:250,000 depends on the variability found. Some rules of thumb are:
(i) field augerings: at high variability, 1 boring per km^2 may be necessary, while at low variability levels, 1 boring per 6 km^2 may be realistic.
(ii) soil sampling: the minimal number of sampled profiles is 2 per soil body. So in case of a pilot area of 7500 km^2, containing 2 soil regions with each 40 soilscapes, with 5 soil bodies per soilscape, about 800 profiles may have to be analyzed.
Advanced statistical methods exist, which can give an estimate of the number of samples needed to obtain an expression of a mean value with fixed precision. These methods have the disadvantage that they only deal with 1 variable at one time. Also, a measure of the variability must exist by way of a standard error or a variogram, which may not be available. Chapter 8 gives some methods.

6.3.4 Filling the database

After the soil bodies and soilscapes have been defined and the soilscapes have also been delineated, the database can be filled. Chapter 7 gives a list of all the mandatory and non-mandatory attributes to be included in the database.

Some guidelines to be followed are:
1 Each soil body should minimally have 1 profile with estimated data in the database, whereby for quantative attributes 3 values must be given: the modal value, the first and the last quintile of the distribution within the soilscape;
2 Each soil body should minimally have 2 or more profiles with measured data in the database;
3 Coding of missing data should be done according to the rules in Chapter 7.

At this stage, when the database partly consists of existing data, it may be necessary to sample complementary data. Complementary data will be collected whenever the existing data are harmonized to the acceptable level but they are not adequate or sufficient. The need for these data will arise either for additional analytical determinations or for more complete soil profile characterization. Complementary determinations can be made for sites previously sampled or individual samples in case of stable soil and land properties such as CEC, carbonates, particle size distribution, parent material, slope, aspect, drainage. New profiles should be located, described and sampled in case, where the existing do no meet the requirements described above.

6.3.5 Validation

The method for validating the database obtained in the pilot area is free for the project team to decide. Chapter 8 gives some methods for validation on the level of the basic data or the map legend. It may be useful to validate the database by looking at soil behaviour rather than individual soil properties. In any case, it is required that the dataset used to validate a soil database has not been used to define soil bodies and soilscapes as well, i.e. the validation set must be independent.

6.4 COORDINATION AND ACTORS

Coordination is provided at 2 main levels:
- the European level;
- a territorial coordination level.
Furthermore, national representation within the territorial level is considered essential. The actual work in pilot areas is done at the project level.

The coordination at the European level is done by the European Soil Bureau, assisted by a working group, and focuses on *process control*:

1 Maintaining the coordination infrastructure at the lower levels;
2 Coordination of fund raising activities;
3 Further development of common procedures such as described in this Manual.

The coordination at the territorial level is done by a supervisor assisted by a team if needed, and focuses on *scientific control*:
1 The verification of the consistency between soil bodies and soilscapes proposed by the operators in the pilot areas within his territory. This means a.o. to control whether a newly proposed soil body or soilscape does not already exist in the database;
2 The development and operation of harmonization and correlation programs in areas where pilot areas border;
3 A regular exchange of data and problems at the European scale in the framework provided by the ESB, to assure that the harmonization will be as good as possible, with everybody working in the same direction and following the same rules.

Table 8 shows, that 4 territories have been distinguished: Northern, Western, Eastern and Mediterranean Europe. An important aspect is, that the coordination at the territorial level has to be done during the work, and not *a posteriori*.

National coordination is also possible, but would automatically require an international attitude towards countries with analogous soil regions. A supra-national supervision at the territorial level is preferred, because it helps to prevent large harmonization efforts at the end of the project. Nevertheless, *national representation* in the territorial group is an essential element to for the project to be successful.

The project, or *operational* level operates within the structure described in Table 9. All operational matters such as field and desk work, financial planning etc. are carried out at this level. Contact with the territorial and central coordination takes place on a regular basis, to facilitate the exchange of knowledge among pilot projects and to improve general concepts such as described in this Manual.

Table 9 Coordination levels

Central coordination level	European Soil Bureau and working group			
territorial correlation level	Northern Europe	Eastern Europe	Western Europe	Mediterranean Europe
National representation level	NOR, SWE, FIN, DNK, EST, LVA, LTU	POL, CHE, SVK, HUN, ex YU, BGR, DEU, ROM	NLD, BEL, FRA, GBR, IRL, LUX, DEU, PRT	ALB, ESP, PRT, ITA, GRC
Project level				Po-valley
Within-soil region correlation level				

7 STRUCTURE OF THE DATABASE

7.1 INTRODUCTION

7.1.1 General structure

The general structure of the database has been described in Chapter 4 of this Manual. A spatial organization model is built with the objects *horizon*, *soil body*, *soilscape* and *soil region*. Since the way of georeferencing differs for each of these components, the database contains 3 types of tables:

1. Tables describing the spatial relations between soil regions, soilscapes, soil bodies and horizons (topological dataset).
2. Tables describing the properties of horizons, soil bodies, soilscapes and soil regions (semantic dataset).
3. Tables describing the geometry of soilscapes and soil regions (geometric dataset).

The actual tables occuring in the database are shown in figure 2, following the general structure introduced in Chapter 4.

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other types of printers.

Figure 2 Tables in the database

7.1.2 Conventions

Missing data
Missing data are allowed in the database only in non-mandatory fields. Three types of missing data are distinguished: (i) lack of information (code -999), (ii) nonsense (code -998) and omission (code -997).

Negative numbers

Negative numbers between 0 and -100 are also allowed in the database, this indicates that actual values are uncertain, but are 'deeper than' the value preceded by the minus sign.

No reference
Some database records may refer to one of the objects horizon, soil body, soilscape of soil region. If there is no adequate reference, the reserved word NIL is applied.

7.2 TOPOLOGICAL DATASET

Within the topological dataset, 4 tables are distinguished:
1. The *horizon pattern table* describes the spatial pattern of the main occuring horizons within a soil body;
2. The *soil body pattern table* describes the spatial pattern of each soil body within a soilscape;
3. The *soil body relation table* describes the mutual relationships between soil bodies within a soilscape;
4. The *soilscape limits table* describes the abruptness of the boundary between two soilscapes.

All these tables contain ordinal or nominal parameters for the simple reason that a quantative characterization of these topological relations boils down to mapping horizons and soil bodies, which is outside the scope of a database at scale 1:250,000. The tables and the parameters used to describe the topological relations are described in the sections 7.2.1 to 7.2.4. Denote, that the topological dataset is entirely non-mandatory.

7.2.1 Horizon pattern table

This table gives some aspects of the spatial distribution of the main horizons within a soil body, meaning the diagnostic horizons of the FAO-legend. All items in this table are non-mandatory. The following items and possible values are distinguished:

Table 10 Items and possible item values in the horizon pattern table

Shaded areas contain non-mandatory attributes

Item	Possible item values	Description
Volume shape	vp	plane shape
	vu	undulating shape
	vi	isolated shapes (pockets, wedges)
Continuity	co	continuous volume
	cl	lateral discontinuous volume
	cv	vertical discontinuous volume
	cs	scattered (lateral and vertical discontinuous)
Scale variability of thickness	sm	maximal variability range: meters
	sd	maximal variability range: decameters
	sw	without or small variability
Lateral transition	lc	laterally continuous with same horizons in neighbouring soil body
	lb	bevelled edge
	lp	progressive lateral transition
	la	abrupt lateral transition
Vertical transition	ta	abrupt vertical transition (cm)
	tg	gradual vertical transition (dm)

An example of the horizon pattern table follows below:

Table 11 Example of horizon pattern table

Soil body	Horizon	Volume shape	Continuity	Scale variability of thickness	Lateral transition	Vertical transition
SB1	SH1	vp	co	sm	lc	ta
	SH2	vu	cl	sd	lc	ta
	SH3	vi	cv	sw	la	ta

7.2.2 Soil body pattern table

The soil body pattern table gives some aspects of the spatial distribution of all individual soil bodies within a soilscape. All items are non-mandatory. The following items and possible item values in the soil body pattern table are distinguished:

Table 12 Items and possible item values in soil body pattern table

Shaded areas contain non-mandatory attributes

Item	Possible item values	Description
Estimated area	(%)	Estimated percentage of the area of the soilscape occupied by the soil body
Characteristic	vm	typical lateral extension of soil body: meter to decameter
dimension	vh	typical lateral extension of soil body: hectometer
	vk	typical lateral extension of soil body: kilometer
Presence	pg	general presence of soil body over the soilscape
	pl	local presence of soil body according to control factors
Aggregation	a1	1 polygon within soilscape
	a2	1-10 polygons within soilscape
	a3	10 polygons within soilscape
Shape	ic	inclusion
	sm	small isolated polygons (patches)
	st	strip contour polygon
	nt	channels network (corridors)

An example of the soil body pattern table follows below:

Table 13 Example of soil body pattern table

Soilscape	Soil body	Area	Characteristic dimension	Presence	Aggregation	Shape
SS1	SB1	60	vh	pl	a2	sm
	SB2	30	vh	pl	a2	st
	SB3	10	vk	pl	a2	st

7.2.3 Soil body relation table

This table describes the topographical relations between soil bodies that form a soilscape. This description is qualitative, and is based on the main soil forming factors (named *controls*) and the transition between soil bodies. Each pair of soil bodies is compared with respect to each control, and the result of this comparison is put in the soil body relation table. None of the fields in this table are mandatory, so `missing values' are allowed. The controls and possible outcomes of the comparison are summarized in Table 14.

Table 14 Items and possible values in the soil body relation table

Shaded areas contain non-mandatory attributes

Item	Possible item values	Description
Topographic control	ph	position soil body A higher than soil body B
	pl	position soil body A lower than soil body B
	ps	position soil bodies A and B similar
	pv	mutual positions vary
Physical organization	ob	organization: A bordering to B
	on	organization: A not bordering to B
Parent material control	ms	parent material A and B similar
	md	parent material A and B different
Vegetation control	vc	vegetation A and B comparable
	vd	vegetation A and B different
Time control	tc	time of formation A and B comparable
	to	time of formation: A older than B
	ty	time of formation: A younger than B
Climate control	ch	climate: mean annual precipitation A higher than B
	cx	climate: mean annual precipitation A comparable to B
	cl	climate: mean annual precipitation A lower than B
	cw	climate: mean annual temperature A warmer than B
	cy	climate: mean annual temperature A comparable to B
	cc	climate: mean annual temperature A colder than B
Transition between soil bodies	ta	transition abrupt (meters)
	tg	transition gradual (decameters)
	tn	transition nonexistent

An example of the organization of soil bodies within one soilscape is given in figure 3. SB1 is a higher (older) terrace level than SB2 in different parent material, and is more exposed to the climate, resulting in more precipitation and colder temperatures. At the terrace level of SB2, locally a different surface texture occurs, resulting in SB3. These relations are expressed in part of the soil body relation table (Table 15).

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Figure 3 Soil bodies in a soilscape consisting of two terrace levels in two parent materials

Table 15 Example of soil body relation table for figure 3

Soil-scape[#] (key)	Soil body A[$] (key)	Soil body B[$] (key)	Organization							Transition
			Topographic control	**Physical organization**	**Parent material control**	**Vegetation control**	**Time control**	**Climate control**		
SS1	SB1	SB2	ph	ob	md	vc	to	ch	cc	ta
	SB1	SB3	ph	on	md	vc	to	ch	cc	tn
	SB2	SB3	ps	ob	ms	vc	tc	cx	cy	tg

[#] Soilscape coding is described in section 7.3.4
[$] Soil body coding is described in 7.3.1 and appendix 5

7.2.4 Soilscape limits table

The soilscape limits table describes the abruptness of the boundary between two adjacent soilscapes. The transition zone between two soilscapes is described by two fields: the abruptness of the transition zone and a field with the soil bodies occuring in the transition zone. All fields are non-mandatory. Possible values of these three fields are described in Table 16.

Table 16 Items and possible values in limits table

Shaded areas contain non-mandatory attributes

Item	Possible value	Description
Abruptness transition zone	ta	transition abrupt
	t1	transition class 1 (0-1 km)
	t2	transition class 2 (1-5 km)
Soil bodies in transition zone	33.2.SBxxx	soil body number xxx in soil region 33.2
	NIL	no transition zone

An example of two soilscapes each describing toposequences in a dissected plateau is given in figure 4. The remains of the dissected plateau are too small or scattered to be delineated as a separate soilscape. Soilscape SS1 in this case consists of the Soil bodies SB1, SB2 and SB3, while Soilscape SS2 consists of SB4, SB5 and SB6. SB1 and SB6 are in fact the same soil body, occuring on either side of the boundary between the two soilscapes. SB1 and SB6 together represent the transition zone. Table 17 gives an example of the limits table for figure 4.

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Figure 4 Two adjacent soilscapes with a transition zone

Table 17 Example of soilscape limits table for figure 4

Soil Region (key)	Soilscape A [#] (key)	Soilscape B [#] (key)	Transition	Limits Soil Bodies [$] in transition zone	
SR1	SS1	SS2	t1	SB1	SB6

[#] Soilscape coding is described in section 7.3.4
[$] Soil body coding is described in section 7.3.1 and appendix 5

7.3 SEMANTIC DATASET

7.3.1 Soil body definition table

The soil body definition table contains the attributes that are used to classify soil profiles into soil bodies. Soil body definitions are results from a field survey. Each soil body is characterized by a unique combination of values of the attributes described in Table 18.

Table 18 Items in the soil body definition table

Identifier	Type	Mandatory	Example	Description
soil_body (key)	char 10	yes	33.2.SB821	Code soil body (SB821) within soil region (33.2)
sb_fao	char 3	yes	GLu	FAO-classification [1]
sb_mat	char 3	yes	900	Parent material [2]
sb_obst	char 1	yes	1	Depth to obstacle for roots [3]
sb_sotex	char 2	yes	mf	Dominant soil texture class 0-30 cm [4]

[1]: see appendix 1: FAO revised legend 1990
[2]: see appendix 2: Hartwich 1995 list of parent materials

[3]: see appendix 3: Determination table for depth to obstacle for roots
[4]: see appendix 4: Texture classes after CEC (1985)

7.3.2 Soil body tables

The soil body tables contain the general characteristics of the soil profile as an entity within its landscape context. Two tables are distinguished:

(i) The table with *measured data* of individual soil profiles which are considered representative for the soil body.

(ii) The table with *spatial estimates and corresponding variability* for the soil body.

The contents and purposes of both tables are described below in some detail.

7.3.2.1 Soil body measurements table

This table contains site characteristics for soil profiles sampled in the field work. The soil profiles put in the database are georeferenced by (X,Y) coordinates and have a limited spatial extent (a few m^2). For this reason no indication of spatial variation is given. Table 19 gives the attributes.

Table 19 Items in the soil body measurements table

Shaded areas contain non-mandatory attributes

Identifier	Type	Mandatory	Example	Description [1]
soil_body (key)	char 10	yes	33.2.SB821	code soil body (SB821) within soil region (33.2)
sbsm_X	num 5	yes	12.10	X-coordinate representative soil profile (eastern latitude)
sbsm_Y	num 4	yes	35.20	Y-coordinate representative soil profile (longitude)
sbsm_alt	num 4	yes	812	Surface altitude (meter a.s.l.)
sbsm_slope	num 2	no	12	Local slope (%)
sbsm_drai	char 1	yes	e	drainage class
sbsm_infl	char 1	yes	y	infiltration rate class
sbsm_capr	char 1	yes	1	summer potential for capillary rise
sbsm_whcp	char 1	yes	1	water holding capacity of the rootable depth
sbsm_rock	char 1	no	n	surface rockiness
sbsm_stone	char 1	no	n	surface stoniness
sbsm_erot	char 1	no	n	type of erosion/deposition
sbsm-erod	char 1	no	s	degree of erosion
sbsm_crus	char 1	no	n	sensitivity to capping
sbsm_root	num 3	yes	100	depth to obstacle for roots (cm)
sbsm_impl	num 3	yes	100	impermeable layer (cm)
sbsm_depr	num 3	yes	5	depth to bedrock (m)
sbsm_watr	char 1	yes	1	water regime
sbsm_depw	num 3	yes	20	average depth to water table (dm)
sbsm_watm	char 1	no	1	type of functioning water management
sbsm_watp	char 1	no	1	purpose water management

[1]: For classification keys see appendix 5

7.3.2.2 Soil body estimates table

This soil body description is not georeferenced by (X,Y) coordinates, but by the soil body as a whole. No precise spatial position can be given, though the soilscape of which the soil body is part is delineated and a landscape model within the soilscape can be constructed through the *soil body relation table.* Also, the sampling sites of each soil body are georeferenced. Modal values can be estimated by expert knowledge or by using statistical methods. We prefer the use of statistical methods if sufficient data are present. A method to obtain a statistical estimate of an average profile is given in Chapter 8. In the table, an indication of spatial variation of each quantitative property must be given by estimates of the modal value as well as the 20% and 80% percentiles of the distribution within the soil body. ***Table 20*** gives the attributes.

Table 20 Items in the soil body estimates table

Shaded areas contain non-mandatory attributes

Identifier	Type[2]	Mandatory	Example	Description[1]
soil_body (key)	char 10	yes	33.2.SB010	code soil body (SB010) within soil region (33.2)
sbse_estm	char 1	yes	s	estimation method
sbse_nopr	num 2	yes	12	number of soil profiles on which estimate is based
sbse_slope	3 num 2	no	12	slope (%)
sbse_drai	char 1	yes	e	drainage class
sbse_infl	char 1	yes	y	infiltration rate class
sbse_capr	char 1	yes	1	summer potential for capillary rise
sbse_whcp	char 1	yes	1	water holding capacity of the rootable depth
sbse_rock	char 1	no	n	surface rockiness
sbse_stone	char 1	no	n	surface stoniness
sbse_erot	char 1	no	n	type of erosion/deposition
sbse_eroa	num 3	no	25	area affected by erosion (%)
sbsm-erod	char 1	no	s	degree of erosion
sbse_crus	char 1	no	n	sensitivity to capping
sbse_root	3 num 3	yes	100	depth to obstacle for roots (cm)
sbse_impl	3 num 3	yes	100	impermeable layer (cm)
sbse_depr	3 num 3	yes	5	depth to bedrock (m)
sbse_dere	3 num 3	no	10	thickness regolith (m)
sbse_watr	char 1	yes	1	water regime
sbse_depw	3 num 3	yes	30	average water table depth (dm)
sbse_watm	char 1	no	1	type of functioning water management
sbse_watp	char 1	no	1	purpose water management

[1]: For classification keys see appendix 5
[2]: <3 num> indicates 3 values: 20% percentile, modal value and 80% percentile

7.3.3 Soil horizon tables

The soil body horizon tables contain the characteristics of each horizon of the soil profile. As with the soil body tables, two tables are distinguished:

(i) The table with *measured horizon data* of individual soil profiles which are considered representative for the soil body.

(ii) The table with *spatial estimates and corresponding variability of horizon data*.

The contents and purposes of both tables are described below in some detail.

7.3.3.1 *Horizon measurements table*

The horizon characteristics for representative soil profiles are characteristically obtained during the field work, and refer to a scale of a few m^2. For this reason no indication of spatial variation is given. Table 21 gives the attributes.

Table 21 Items in the horizon measurements table

Shaded areas contain non-mandatory attributes

Identifier	Type	Mandatory	Example	Description [1]
soil_body (key)	char 10	yes	33.2.SB821	code soil body
body_hor (key)	char 3	yes	1ap	code soil horizon
sbhm_top	num 3	yes	0	starting depth horizon (cm)

Identifier	Type	Mandatory	Example	Description [1]
sbhm_bot	num 3	yes	20	ending depth horizon (cm)
sbhm_clay	num 2	yes	20	clay content (%)
sbhm_clayQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_clayQ2	char 1	yes	m	quality estimate of analysis
sbhm_silt	num 2	yes	40	silt content (%)
sbhm_siltQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_siltQ2	char 1	yes	m	quality estimate of analysis
sbhm_sand	num 2	yes	40	sand content (%)
sbhm_sandQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_sandQ2	char 1	yes	m	quality estimate of analysis
sbhm_bd	num4.2	no	1.15	bulk density (g cm^{-3})
sbhm_bdQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_bdQ2	char 1	yes	m	quality estimate of analysis
sbhm_stgr	char 2	yes	vv	stone/gravel abundance and size
sbhm_stgrQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_stgrQ2	char 1	yes	m	quality estimate of analysis
sbhm_om	num 4.1	yes	8.1	organic matter content (%)
sbhm_omQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_omQ2	char 1	yes	m	quality estimate of analysis
sbhm_struct	char 3	yes	wfa	grade, size and type of structure
sbhm_mcfc	num 4.2	no	0.29	moisture content at field capacity ($cm^3.cm^{-3}$)
sbhm_mcfcQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_mcfcQ2	char 1	yes	m	quality estimate of analysis
sbhm_mcwp	num 4.2	no	0.02	moisture content at wilting point ($cm^3.cm^{-3}$)
sbhm_mcwpQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_mcwpQ2	char 1	yes	m	quality estimate of analysis
sbhm_hcs	num 6.3	no	88.22	saturated hydraulic conductivity ($cm.d^{-1}$)
sbhm_hcsQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_hcsQ2	char 1	yes	m	quality estimate of analysis
sbhm_CaCO3	num 4.1	no	20.0	carbonates ($g.kg^{-1}$)
sbhm_CaCO3Q1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_CaCO3Q2	char 1	yes	m	quality estimate of analysis
sbhm_CaSO4	num 4.1	no	3.0	gypsum ($g.kg^{-1}$)
sbhm_CaSO4Q1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_CaSO4Q2	char 1	yes	m	quality estimate of analysis
sbhm_pHH2O	num 4.1	yes	4.8	pH-H_2O
sbhm_pHH2OQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_pHH2OQ2	char 1	yes	m	quality estimate of analysis
sbhm_ec	num 4.1	no	4.0	electric conductivity of saturated extract ($dS.m^{-1}$)
sbhm_ecQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_ecQ2	char 1	yes	m	quality estimate of analysis
sbhm_sar	num 4.1	no	3.3	sodium adsorption ratio (-)
sbhm_sarQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_sarQ2	char 1	yes	m	quality estimate of analysis
sbhm_esp	num 2.0	no	10.1	exchangeable sodium percentage (%)
sbhm_espQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_espQ2	char 1	yes	m	quality estimate of analysis
sbhm_Caex	num 4.1	no	14.0	exchangeable Ca^{++} ($cmol+.kg^{-1}$)
sbhm_CaexQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_CaexQ2	char 1	yes	m	quality estimate of analysis
sbhm_Mgex	num 4.1	no	12.0	exchangeable Mg^{++} ($cmol+.kg^{-1}$)
sbhm_MgexQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_MgexQ2	char 1	yes	m	quality estimate of analysis
sbhm_Kex	num 4.1	no	8.8	exchangeable K^{+} ($cmol+.kg^{-1}$)

Identifier	Type	Mandatory	Example	Description [1]
sbhm_KexQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_KexQ2	char 1	yes	m	quality estimate of analysis
sbhm_Alex	num 4.1	no	1.1	exchangeable Al^{+++} (cmol+.kg^{-1})
sbhm_AlexQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_AlexQ2	char 1	yes	m	quality estimate of analysis
sbhm_exac	num 4.1	no	3.3	exchangeable acidity (cmol+.kg^{-1})
sbhm_exacQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_exacQ2	char 1	yes	m	quality estimate of analysis
sbhm_cec	num 5.1	yes	36.0	cation exchange capacity (cmol.kg^{-1})
sbhm_cecQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_cecQ2	char 1	yes	m	quality estimate of analysis
sbhm_C/N	num 4.1	no	8.0	C/N ratio (-)
sbhm_C/NQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_C/NQ2	char 1	yes	m	quality estimate of analysis
sbhm_Feox	num 4.1	no	5	oxalate extractable Fe (%)
sbhm_FeoxQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_FeoxQ2	char 1	yes	m	quality estimate of analysis
sbhm_Alox	num 4.1	no	6	oxalate extractable Al (%)
sbhm_AloxQ1		char yes	NLD01_1988	country, lab and year of analysis
sbhm_AloxQ2	char 1	yes	m	quality estimate of analysis
sbhm_pyr	char 1	no	n	pyrite presence
sbhm_cm	char 2	no	al	clay mineralogy by XRD
sbhm_cmQ1	char 10	yes	NLD01_1988	country, lab and year of analysis
sbhm_cmQ2	char 1	yes	m	quality estimate of analysis

[1]: For classification keys see appendix 6, for methods of analysis see Chapter 6.

7.3.3.2 Horizon estimates table

Estimates of modal values be made by expert knowledge or by using statistical methods. We prefer the use of statistical methods if sufficient data are present. In the horizon estimates table, an indication of spatial variation of each quantitative property must be given by estimates of the modal value as well as the 20% and 80% percentiles of the distribution within the soil body. ***Table 22*** gives the attributes.

Table 22 Items in the horizon estimates table

Shaded areas contain non-mandatory attributes

Identifier	Type [2]	Mandatory	Example	Description [1]
soil_body (key)	char 10	yes	33.2.SB821	code soil body
body_hor (key)	char 3	yes	1Ap	code soil horizon
sbhe_estm	char 1	yes	e	estimation method
sbhe_nopr	num 2	yes	0	number of soil profiles on which estimate is based
sbhe_top	num 3	yes	0	starting depth horizon (cm)
sbhe_bot	num 3	yes	20	ending depth horizon (cm)
sbhe_clay	3 num 2	yes	20	clay content (%)
sbhe_silt	3 num 2	yes	40	silt content (%)
sbhe_sand	3 num 2	yes	40	sand content (%)
sbhe_bd	3 num 4.2	no	1.35	bulk density (g cm^{-3})
sbhe_stgr	char 2	yes	vv	stone/gravel abundance and size
sbhe_om	3 num 4.1	yes	8.1	organic matter content (%)
sbhe_struct	char 3	yes	wfa	grade, size and type of structure
sbhe_mcfc	3 num 4.2	no	0.29	moisture content at field capacity (cm^3.cm^{-3})
sbhe_mcwp	3 num 4.2	no	0.02	moisture content at wilting point

Identifier	Type [2]	Mandatory	Example	Description [1]
				($cm^3.cm^{-3}$)
sbhe_hcs	3 num 6.3	no	88.22	saturated hydraulic conductivity ($cm.d^{-1}$)
sbhe_CaCO3	3 num 4.1	no	10.2	carbonates ($g.kg^{-1}$)
sbhe_CaSO4	3 num 4.1	no	0.6	gypsum ($g.kg^{-1}$)
sbhe_pHH2O	3 num 4.1	yes	5.5	pH-H_2O
sbhe_ec	3 num 4.1	no	2.5	electric conductivity of saturated extract ($dS.m^{-1}$)
sbhe_sar	3 num 4.1	no	4.0	sodium adsorption ratio (-)
sbhe_esp	3 num 2.0	no	2.0	exchangeable sodium percentage (%)
sbhe_Caex	3 num 4.1	no	2.0	exchangeable Ca^{++} ($cmol+.kg^{-1}$)
sbhe_Mgex	3 num 4.1	no	3.0	exchangeable Mg^{++} ($cmol+.kg^{-1}$)
sbhe_Kex	3 num 4.1	no	10.3	exchangeable K^{+} ($cmol+.kg^{-1}$)
sbhe_Alex	3 num 4.1	no	1.8	exchangeable Al^{+++} ($cmol+.kg^{-1}$)
sbhe_exac	3 num 4.1	no	20.0	exchangeable acidity ($cmol+.kg^{-1}$)
sbhe_cec	3 num 5.1	yes	33.3	cation exchange capacity ($cmol.kg^{-1}$)
sbhe_C/N	3 num 4.1	no	15	C/N ratio (-)
sbhe_Feox	3 num 4.1	no	2.5	oxalate extractable Fe (%)
sbhe_Alox	3 num 4.1	no	2.5	oxalate extractable Al (%)
sbhe_pyr	char 1	no	n	pyrite presence
sbhe_cm	char 2	no	al	clay mineralogy

[1]: For classification keys see appendix 6, for methods of analysis see Chapter 6.
[2]: <3 num> indicates three values: 20% percentile, modal and 80% percentile

7.3.4 Soilscape description table

The soilscape description table gives the attributes that describe the landscape setting in which the soil bodies occur. Since physiographic features are used for the delineation of soilscapes during mapping, it follows logically that these features take a large part of the table (***Table 23***).

Table 23 Items in the soilscape description table

Shaded areas contain non-mandatory attributes

Identifier	Type	Mandatory	Example	Description[1,2]
General				
soilscape (key)	char 10	yes	33.2.SS112	Number soilscape (SS112) within soil region (33.2)
ss_aut	char 12	yes	O.B. Bommel	Author name soilscape map unit
ss_yrmap	char 4	yes	2000	Year of mapping
ss_date	char 8	yes	01012000	Date of data processing (day,month,year)
ss_qual	num 1	yes	1	Quality level
ss_doms	char 3	yes	GLu	Dominant soil in soilscape
soil_region (key)	char 4	yes	33.2	Number Soil Region
Physiography				
ss_mlf	char 2	yes	CV	Major landform
ss_resl	char 2	yes	G	Regional slope
ss_hyps	char 2	yes	1	Hypsometry
ss_ddis	char 1	yes	1	Degree of dissection
ss_pws	num 2	yes	10	Permanent water surface (%)
ss_altlo	num 4	yes	800	Minimum altitude (m asl)
ss_althi	num 4	yes	1200	Maximum altitude (m asl)
ss_slint	num 4	yes	900	Relief intensity (m/km)
ss_sllen	num 5	yes	2500	Slope length (m)
ss_ssfr	char 2	yes	U	Dominant slope and surface form

Identifier	Type	Mandatory	Example	Description[1,2]
ss_wetn	num 2	no	12	area with frequent overland flow (%)
Landcover				
ss_lu	char 3	no	312	Dominant Landuse
ss_veg	char 5	no	51138	Dominant natural vegetation
Parent material				
ss_surmat	char 3	yes	611	Parent material surface layer
ss_surtxt	char 2	yes	MF	Texture group surface layer
ss_dmat	num 2	yes	15	Depth to parent material change (dm)
ss_submat	char 3	yes	612	Parent material subsurface layer
ss_subtxt	char 2	yes	MF	Texture group subsurface layer

[1] Attribute coding is described in appendix 7
[2] The keys to natural European vegetation are given in appendix 10

7.3.5 Soil region table

The soil regions are identified by unique combinations of parent material association and climate. The soil region table (***Table 24***) has been created in concept during the writing of this Manual, and is given in full in Appendix 9. Alle climate-related parameters relate to the 30-years climatic period. Alternative values provided during pilot projects should refer to a 20-50 year period.

Table 24 Items in the soil region table

Identifier	Type	Example	Description[1]
soil_region (key)	char 4	33.2	Number Soil Region
code	char 7	34.11.2	Climate, parent material and regional code
sr_name	char 200	Cambisol-Region with Luvisols and Gleysols of West Germany (Westerwald, Vogelsberg, Eifel)	Description of soil region with dominant soil types and regional name
sr-pmas	char 200	basic volcanic rocks and pyroclastic rocks (basalt, pumice), partly covered with loess	Dominant parent material
sr_matlo	num 3	5.5	Mean annual temperature (lower value, ^oC)
sr_mathi	num 3	7.7	Mean annual temperature (higher value, ^oC)
sr_maplo	num 4	760	Mean annual precipitation (lower value, mm)
sr_maphi	num 4	940	Mean annual precipitation (higher value, mm)
sr_hiprec	char 10	NOV,JUL	Months with high precipitation
sr_droug	char 10	-	Months with drought
sr_lowt	char 10	DEC-MAR	Months with temperatures below 0 ^oC
sr_altmin	num 4	550	Minimum altitude (m. asl)
sr_althi	num 4	750	Maximum altitude (m. asl)
sr_mlf	char 75	sloping land	Major landform

[1] Coding of attributes is given in Chapter 5.

7.4 GEOMETRIC DATASET

7.4.1 Soilscape geometry table

The soilscape geometry table shows the geometrical properties of the soilscape polygons, and is formatted according to ARC-INFO conventions.

Table 25 Items in the soilscape geometry table

Column	Item name	Width	Output	Type	Decimals
1	area	4	12	f	3
5	perimeter	4	12	f	3
9	soilscape#	4	5	b	-
13	soilscape-id	4	5	b	-
17	soilscape	9	11	C	-

area in m^2
perimeter in m
soilscape# arc/info internal id polygon
soilscape-id users' id for polygon
soilscape identifier of soilscape to which polygon belongs (key to other tables)

7.4.2 Soil region geometry table

The soil region geometry table shows the geometrical properties of the soil region polygons, and is formatted according to ARC-INFO conventions.

Table 26 Items in the soil region geometry table

Column	Item name	Width	Output	Type	Decimals
1	area	4	12	f	3
5	perimeter	4	12	f	3
9	soilregion#	4	5	b	-
13	soilregion-id	4	5	b	-
17	soil_region	5	7	C	-

area in m^2
perimeter in m
soilregion# arc/info internal id polygon
soilregion-id users' id for polygon
soil_region identifier of soil region to which polygon belongs (key to other tables)

8 SAMPLING AND VALIDATION IN REFERENCE AREAS

This Chapter is meant to introduce some methods that may be useful to better understand variability patterns in a research area, e.g., a pilot area or a smaller reference area. Many textbooks exist on sampling, estimation and classification techniques, and it is not intended to reproduce these texts here, nor to give a complete overview of all available methods. This Chapter does give some practical approaches to problems which may arise during the research in reference areas, without embarking on underlying statistical theorems.

A division in 4 sections is made:

(i) Some methods and parameters are given to describe variability and diversity on the parameter and at the soil type level respectively;

(ii) Some methods are given to determine sample size when sampling for parameter values;

(iii) Some techniques are described to cluster and analyze data at the profile level, with the purpose to assist in the definition of representative profiles for soil bodies or soilscapes;

(iv) Some methods are described to validate a map by evaluating map purity and the maps predictive power.

8.1 ESTIMATES OF VARIABILITY AND DIVERSITY

Two ways of looking at the heterogeneity of soils can be distinguished. These have different focuses on (i) the heterogeneity of soil individuals (taxa) emerging from a classification (diversity), or on (ii) the more or less continuous variation of soil parameters (variability). Both approaches can be considered to yield complementary information, and are therefore briefly reviewed.

8.1.1 Estimation of pedodiversity

Diversity in an ecological context has been defined by Margalef (1958) and Pielou (1966) as *the amount of uncertainty that exists regarding the species (objects) of an individual selected at random from a population*. Ibàñez et al. (1995) applied Shannon's entropy index in the context of soil individuals to estimate pedodiversity:

$$H' = \sum_{i=1}^{n} p_i * \ln(p_i)$$

where H' is the (negative) entropy and p_i is the proportion of soil individual i in the area studied. p_i can be estimated by n_i / N, with n_i = the number of individuals i and N the total number of (randomly collected) samples. An individual can be a defined soil body, or the FAO-classification of a soil profile. The more species there are, and the more they occupy equal areas, the greater the uncertainty and the higher the diversity. Values of the Shannon index are reported between -1.5 and -3.5, and do rarely exceed -4.5. A value of -1.5 corresponds to (e.g.) 4 individuals occupying equal areas, -3.5 correponds to (e.g.) 31 individuals occupying equal areas. The pedodiversity can be calculated with respect to soil bodies within soilscapes. A high pedodiversity (strongly negative H') in a particular soilscape may be a reason to try to split the soilscape into more homogeneous units, if scale permits.

8.1.2 Estimation of population parameters

The simplest way to describe the continuous variation of individual soil properties is making a histogram, which gives the observed frequencies of occurrence of values in a number of equal, successive classes. From this distribution, population characteristics like the mean (average value), the median (the value that is greater than or equal to 50% of the observations) and the modus (the most frequent occurring value) can be estimated. Some characteristics describing the shape of the distribution (using sample data) are:

$$s^2 = \frac{1}{N-1} \sum_{i=1}^{N} (x_i - m)^2$$

where s^2 is the variance, *N* is the sample size, x_i is the *i*th sample and µ is the mean of the samples. The degree of symmetry of the distribution is described by the skewness:

$$g_1 = \frac{m_3}{s^2 s}$$

where m_3 is the third moment about the mean:

$$m_3 = \frac{1}{N}\sum_{i=1}^{N}(x_i - m)^3$$

Distribution characteristics within a soilscape or a soil body give an impression of the uncertainty associated with using one 'representative' value for the soilscape or soil body in an application, e.g., a model. Knowledge on the shape of the distribution is useful to decide whether mean, modal or median values should be used as 'representative' values.

8.1.3 Estimation of the variogram

The spatial variability within the soil body or soilscape can be estimated by variogram analysis. A variogram shows the relation between the distance between two observations points and the squared difference of the observed values at these points. The variogram is usually estimated by (e.g., Cressie, 1991):

$$2\hat{g}(h) = \frac{1}{N(h)}\sum_{N(h)}(Z(x) - Z(x+h))^2$$

where *Z(x)* is the value at sample point *x*, *Z(x+h)* the value at a point at a distance *h* from *x* and *N(h)* is the number of the data pairs with mutual distance (or distance class) *h*. Usually, observations and their coordinates are used to produce either a scatterplot of versus distance *h* or versus distance classes *h*. This is called the experimental variogram. Through this scatterplot, variogram models can be fitted. Figure 5 gives some examples.

Title:
VARMOD.EPS
Creator:
Freelance Plus 3.01
Preview:
This EPS picture was not saved
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Figure 5 Some types of variograms

Three types of variogram models apply to different situations:

(i) Bounded variograms, where reaches a maximum value *C0+C1* at a distances exceeding a certain value *range*; corresponding variogram types are (e.g.) the spherical model:

$$g(h) = \begin{cases} C0 + C1 & if \quad h > range \\ C0 + C1*\left(\dfrac{3h}{2r} - \dfrac{h^3}{2r^3}\right) & if \quad h \le range \end{cases}$$

and the exponential model:

$$g(h) = C0 + c1*(1 - e^{-h/r})$$

(ii) Unbounded variograms show an increasing variability with distance, that extends beyond the area examined and indicates the existence of a trend for continuous variation along certain direction; corresponding variogram types are (e.g.) the power model:

$$g(h) = C*h^p$$

and the linear model, which is a special case of the power model (p=1).

(iii) A special case of the bounded variogram is the pure nugget model ? =*C0*, where maximal variability is reached at very short distances, and a spatial structure has not been detected by the measurements.

Since soil properties may vary anisotropic (the variation in one direction is different than in another direction), it may be useful to estimate and model directional variograms. It is advised to construct variograms on data obtained by nested sampling (Webster, 1977). Variograms can be used to perform interpolations by kriging, e.g., to make contourmaps of soil properties, but are also give useful information when sampling densities are to be chosen (8.2.3). Some literature references with respect to the use of variograms in soil science are: Trangmar et al. (1985) and Oliver and Webster (1991).

8.2 DETERMINATION OF SAMPLE SIZES OF INDIVIDUAL PARAMETERS

Under the circumstance that additional sampling is necessary to obtain a complete dataset, it is efficient to minimize on the sampling costs as much as possible. This section gives some methods to determine sample sizes. A choice between either of these methods can be made on basis of the available existing information.

8.2.1 Sequential sampling

To describe variation, an accurate estimate of the mean is essential. Sequential sampling (Wald, 1947) is a statistical method which can be used during the data acquisition. This method incorporates newly obtained sample values immediately in the estimation of the mean, while testing the accuracy of this estimate against a quality criterion. When this quality criterion is reached, the method advises to stop sampling, thus minimizing the sampling effort, and associated cost. Sequential sampling assumes normally distributed samples.

In a sequential sampling procedure, at first an hypothesis H_0 is formulated on the value of the population mean, using a limited number of observations. This hypothesis is then tested, again using a few observations. The sampling strategy depends on the result of the test:

(i) when H_0 is accepted, sampling can stop as the hypothesized mean is accepted;

(ii) when H_0 is rejected, a new hypothesis on the population mean has to be formulated, e.g. as the average value of all samples taken so far. Some additional samples have to be taken to start testing the new hypothesis;

(iii) when H_0 is accepted nor rejected, more samples need to be taken and the analysis proceeds.

The test value to be calculated is:

$$L_n = \frac{\dfrac{1}{2}\left\{\displaystyle\int_0^\infty \frac{1}{s^n}\exp\left[-\frac{1}{2s^2}\sum_{i=1}^{n}(x_i - m_0 - ds)^2\right]ds + \int_0^\infty \frac{1}{s^n}\exp\left[-\frac{1}{2s^2}\sum_{i=1}^{n}(x_i - m_0 + ds)^2\right]ds\right\}}{\displaystyle\int_0^\infty \frac{1}{s^n}\exp\left[-\frac{1}{2s^2}\sum_{i=1}^{n}(x_i - m_0)^2\right]ds}$$

where L_n is the likelihood-ratio between the hypothesis to be tested (H_0 : $\mu=\mu_0$) and the alternative hypothesis (H_1: $|\mu-\mu_0|/s > d$), s is the sample standard deviation, μ_0 is the hypothesized mean, x_i is the *i*th observation used for testing and *d* is a tolerance factor, depending on what the user determines to be an important deviation from H_0: $\mu=\mu_0$ (for example *d*=1 standard deviation). L_n is calculated by numerically integrating the above equation, while substituting the observations x_i , μ_0 and *d.* Acceptance and rejection criteria are set by the user through a confidence level. An example on application of this method in soil science is given by Finke et al. (1992). A computer program is available from the author.

8.2.2 Sample size estimation from the standard deviation

When an estimate of the standard deviation is available, e.g., from a sampling carried out previously in the same or a comparable area, a rough estimate of the sample size can be made which is needed to obtain an estimate of the mean value with a certain confidence:

$$n = \left(\frac{t s}{r/2} \right)$$

where s is the estimate of the standard deviation, *t* is Students' t at *8* degrees of freedom with a user-defined confidence level and *r* is the desired width of the confidence interval. The estimate of *n* is usually rough, because of the imprecise knowledge on s. It is stressed here, that this way to calculate *n* is only valid when a simple random sampling is to be carried out, and when the parameter to be estimated is normally distributed. When other sampling designs are applied, an approach such as the one in the next section is preferred.

8.2.3 Sample size estimation using variograms

To characterize delineated map units, several sampling designs can be applied. When these sampling designs could be evaluated *a priori*, this would be helpful to limit the number of samples to be taken as much as possible, while maintaining the quality of the estimate of the mean value at a specified level. To this purpose, Domburg *et al.* (1994) developed a method, which uses existing data in the form of digitized maps and information in the standardized forms of variograms to evaluate a variety of sampling designs. The quality of a sampling design is expressed by the standard error of the mean, and can be evaluated relatively easy for two frequently applied sampling designs:

(i) In the case of simple random sampling (i.e. locations are drawn at random in the research area) the expected squared standard error is calculated as a function of the sample size by:

$$\bar{r} = \frac{1}{n} \bar{g}_{A,A}$$

where $\bar{g}_{A,A}$ is the average value from the variogram estimated from a large number of pairs of locations in area *A*.

(ii) In the case of stratified random sampling (i.e. locations are drawn randomly in each of the strata, e.g. map units) the expected squared standard error is calculated as a function of the sample size by:

$$\bar{r}_{St} = \sum_{h=1}^{L} \frac{W_h^2}{n_h} \bar{g}_{Ah,Ah}$$

where $\bar{g}_{Ah,Ah}$ is the average value from the variogram in stratum *h* (each stratum can have its own variogram), n_h is the sample size in stratum *h* and W_h is the weight of stratum *h* (the fraction of the total area *A* taken by stratum *h*).

In each of these cases, the sampling design is simulated by drawing a large number of sampling locations in the area according to design (i) or (ii). In case of design (ii), the digitized codes and boundaries of the soil polygons are used to draw locations in each of the identified strata. From these locations and the variogram(s), the value of $\bar{g}$ is calculated. With this value, standard errors $\sqrt{\bar{r}}$ can be estimated for different values of the sample size. The sample size to be actually chosen for the field sampling is the one at which the standard error corresponds best to a quality criterion set by the user.

8.3 SOME NUMERICAL CLASSIFICATION TECHNIQUES

Numerical classification techniques search to identify clusters of soil individuals which are comparable with respect to a number of properties. Most of these techniques are hierarchical in the sense that they make small groups out of individuals, larger groups out of small groups etc. Classification can be done either upward (by agglomeration of the individuals) or downward (by division of the whole population). For an overview, reference is made to Webster (1977). These techniques lead to attributing a soil individual to one cluster.
Recently, numerical classification techniques have been developed that attribute each soil individual potentially to more than one cluster by assigning each individual memberships to each of these clusters, where the sum of the memberships of one individual to all clusters equals 1. This approach is referred to as fuzzy cluster analysis (e.g., Zadeh, 1965).
In this section some attention is paid to an application of cluster analysis to construct A representative profile for an area, say a soil body. Additionally, attention is paid to a hierarchical agglomerative grouping method called nearest neighbour analysis.

8.3.1 Cluster analysis to obtain a representative profile

This section gives a method that can be applied when a small number (say 5 or more) of soil profiles have been sampled. What the method basically does, is that it constructs a centroid profile from the sampled profiles, using the codes and thicknesses of all horizons of the profiles. Subsequently, one of the actually sampled profiles is chosen on the criterion of minimal distance in property space to this centroid profile. This is the representative profile in the sense of vertical succession of soil horizons and associated thicknesses. For each horizon in this representative profile, the soil characteristics obtained elsewhere for the same horizon are averaged. Thus representative attribute values for all horizons are obtained. When knowledge exist on the degree of dominance of a particular profile in the area, this dominance can be expressed as an area-contribution and given as a weight in the cluster analysis.
A stepwise approach is given hereunder:

1. Take for each soil profile the horizon codes, and extend this code with a character that describes it position in the vertical sequence of horizons. For instance, a Bh-horizon immediately below an Ea horizons gets the code Bh1, while a Bh-horizon immediately below an Ap gets the code Bh2. Harmonize these codes between the profiles, such that Bh1 means the same in any profile.
2. Eventually repeat this to make distinctions in parent material and texture clear.
3. Compile the centroid profile by making a vertical succession of all coded horizons, and give each horizon the average thickness over all sampled profiles. Profiles in which the coded horizon does not appear, have thickness 0 for that horizon. Eventually, weighted averages can be computed, using the estimated area fraction for a profile as a weight.
4. Calculate for each profile for each coded horizon the Euclidian distance to the centroid profile, and sum this for all horizons:

$$D(profile_i) = \sqrt{\sum_{horizon=A1}^{C5} (thickness(horizon, i) - thickness(horizon, centroid))^2}$$

5. Select the profile with the smallest value of D to have the most representative vertical succession of soil horizons.
6. Calculate for each property (say, CEC) the average value for each coded horizon in the representative profile, using all measured values in horizons coded similarly.

8.3.2 Nearest neighbour analysis to calculate simularities between sampling sites

This method measures the degree of similarity between pairs of sampling sites on the basis of selected soil properties. First, the Euclidian distance between two sampling sites in multidimensional property space is calculated:

$$\Delta_{ij} = \sqrt{\frac{1}{p}\left[\sum_{k=1}^{p}(x_{ik} - x_{jk})^2\right]}$$

where p is the number of properties evaluated and x_{ik} is the value of property k at site i. It is recommended that property values are made dimensionless and scaled to equal variances before calculating the distance, e.g. through standardisation to unit variance. Second, $?_{ij}$ is scaled to range between 0 and 1, and the similarity is set to (1-$?_{ij}$), with 1 representing identity and 0 maximum dissimilarity. The similarity values between all pairs of sampling sites that were sampled inside an area (e.g. a soil body) can then be arranged in a similarity-matrix, which would be indicative of the uniformity within the soil body.

Furthermore, such a similarity matrix can be used to group individuals into clusters. First, the pair of individual with the highest similarity is fused into a group. Then, the second highest similarity is sought. If this similarity is between a member of the first group and a third individual, the third individual joins the group. Else, another group is formed by fusion of the two individuals. This process is continued, fusing individuals or groups until only one group remains. The result is a hierarchical grouping of soil individuals. This method is described here because its simplicity makes it attractive to use and it gives insight in comparibility of soil individuals. It should be stated here, that more advanced methods exist and should be applied if a numerical classification scheme is to be developed. A standard work on quantitative classification is Sneath and Sokal (1973).

8.4 TESTING THE PREDICTIVE POWER OF A MAP

This section describes methods and parameters that can be used to estimate the quality of soil maps. The first methods describes how the purity of a soil map can be assessed, the second method describes how the predictive power can be assessed of a soil map for the purpose of translation of attribute values to a region.

8.4.1 Map unit level: map purity

The purity of a soil map unit is the percentage of the area within the soil map unit that matches the definition given in the map legend. It is a relevant property to calculate, because it has been observed (Finke et al., 1996) that extreme behaviour of the soils within a map unit may occur predominantly in the unpure parts of the map units. The purity of a whole soil map is the area-weighted average of the purities of the individual map units, estimated by:

$$Purity = \frac{\sum_{i=1}^{n} A_i * Purity_i}{\sum_{i=1}^{n} A_i}$$

where A_i is the area of the ith map unit. Map purities are preferably estimated by some kind of probability sampling, and not grid sampling. High map purities correspond to a successful delineation of soil bodies (in reference areas only) and soilscapes. Reported values for map unit purities are between 65 and 70%.

8.4.2 Parameter level: (logistic) regression with qualitative predictors

Soil maps are used for many applications. Often a soil map is used to translate point or areal observations on soil properties to larger areas. Alternatively, a soil map may be used to translate soil behaviour, e.g., simulated by a process-model, to a larger area. Part of the validation of a soil map lies therefore in its suitability to use it for the above purposes.

A soil map is well suited for these purposes, when the (i) division into map units explains a large portion of the variability of a soil property within an area, and (ii) when the remaining uncertainty within the map units is at an acceptable level. (i) can be expressed by the percentage of explained variance or deviance of the soil property by the soil map, (ii) is expressed by the prediction error.

When using a soil map to predict the value of a continuous attribute, say the clay percentage in the plough layer, one value is used for each mapping unit. To estimate the percentage of variance explained by the map as well as the prediction error, regression models can be fitted with map units used as qualitative predictor variables. These models take the form:

$$\hat{y} = b_0 + b_1 x_1 + b_2 x_2 + ... + b_n x_n$$

where $\hat{y}$ is the predictor of a variable, $ß_n$ is the regression coefficient of the *nth* mapping unit and x_n is a binary variable that takes the value *1* if the prediction point is located in mapping unit *n*, and *0* otherwise. The percentage of variance explained by this regression equation indicates the predictive power of the map. A high percentage of explained variance corresponds to a high predictive power. The prediction error of this regression equation gives an estimate of the uncertainty which remains (for the whole research area). The prediction error at individual map units can be assessed by the Root Mean Square Error (RMSE), which has the dimension of the measurement:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{m}(y_i - \hat{y})^2}$$

where y_i is the *i*th measured value within the map unit, *m* is the number of measurements taken within the map unit and $\hat{y}$ is the same predictor as above. A low level of the prediction error corresponds to an acceptable degree of uncertainty.

The predictive power of a soil map for a binary variable like *sensitivity to capping = none* can be evaluated by calculating the deviances in a logistic regression model with map units used as qualitative predictors (Dobson, 1990). This model takes the form:

$$\hat{p} = \frac{\exp(b_0 + b_1 x_1 + b_2 x_2 + ... + b_n x_n)}{1 + \exp(b_0 + b_1 x_1 + b_2 x_2 + ... + b_n x_n)}$$

where $\hat{p}$ is the predicted probability that the sensitivity to capping = none. Analogous to the case with continuous variables, a high explained deviance corresponds to a high predictive power. Again, the RMSE can be calculated by:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{m}(p_i - \hat{p})^2}$$

where p_i is the *i*th measured value within the map unit (*p* takes the value *1* when the binary variable is true, and *0* when it does not occur), *m* is the number of measurements taken within the map unit and is the same predictor as above. A low level of the prediction error corresponds to an acceptable degree of uncertainty.

9 APPLICATIONS OF A GEOREFERENCED SOIL DATABASE

9.1 METHODS OF APPLICATION

The systematic collection, storage and retrieval of soil information is a great effort requiring expert skills, enthusiasm and financial means. Nevertheless, building soil databases is never a goal in itself. The database is intended to be used for as great a variety of applications as possible. Speaking in general terms, a georeferenced soil database can be used for two types of applications:

1. To delineate areas in which the soil acts or reacts in a unique manner towards its environment;
2. To quantify the behaviour of soils in a certain area.

Below, these types of applications are described in some detail, relating them to types of questions to be answered.

ad 1 The delineation of areas in which the soil behaviour is unique is done using the geometry tables of the database. Since the flow of water in the soil is the most important factor determining soil behaviour, areas with unique soil behaviour should coincide with hydrologically functioning landscape units (catchments). In case of the 1:250,000 georeferenced soil database this corresponds to the soilscape geometry table. Typical questions to be answered using this type of soil data, are quick evaluations of (e.g.) where environmental hazards are likely to have effect, where drought will cause most damage to crops, which areas may be affected by flooding etc. Typically, these questions can be answered by:

(i) making interpretation tables, using the variables given in the soilscape description table, and

(ii) the subsequent linking of this interpretation to the soilscape geometry table in a GIS.

Some of these interpretations could be called class-pedotransfer functions or pedotransfer rules.

ad 2 The quantification of soil behaviour involves more data, either because the quantification is based on measurements or because a numerical model is used which needs soil data as input. Basically, 4 steps can be envisaged:

(i) A first step in the quantification of soil behaviour is the identification of spatial units with comparable behaviour. This may or may not involve the combination of spatial units (spatial aggregation of soil bodies or soilscapes).

(ii) A second step is to provide the resulting units with the appropriate, representative data, to be able to run the model. This step is called data aggregation. In the georeferenced database 1:250,000, the data aggregation for the smallest spatial unit (the soil body) is done already during the development of the database. The results are stored in the *soil body estimates table* and *horizon estimates table*. It is hardly possible to name relevant soil data when the problem to be studied and the model to be used are undetermined. Dudal *et al.* (1993) describe the types of soil information needed to be able to address a number of environmental issues, using models. These types are reflected in the choices made while the content of the database tables was defined. Besides data, the use of simulation models unavoidedly involves the use of pedotransfer functions, since it is not feasible to measure all possible model parameters for each spatial unit for which simulations are performed. Pedotransfer functions, as currently developed (Bruand *et al.*, in press) and pedotransfer rules (Van Ranst *et al.*, 1995) are therefore necessary extensions to the database.

(iii) The third step is to run the simulation model for the spatial units that have been defined. Postprocessing the output of the model to obtain values representative for soilscapes can be based on the areal contributions of soil bodies within each soilscape, and on spatial relations between soil bodies within the soilscape, as these are documented in the *soil body relation table.*

(iv) Finally, the thus obtained results can be displayed in a GIS using the *soilscape geometry table* or can be presented as statistics.

9.2 STORAGE OF APPLICATION RESULTS

Results of any interpretation of soil in combination with other data could be added to the database in tabular or thematic map form. These data would augment its usefulness and facilitate its application (Bouma, 1988; Proctor et al., 1989). Such tables and maps would refer e.g. to the suitability of soilscapes for major classes of land use, their environmental functions, sensitivity to degrading influxes, hydrological contribution and land capability classification.

Interpretation tables referring to soil bodies would be more specific in evaluating their rating for various uses and management practices such as potential productivity, irrigability, erodibility, suitability for: certain land utilization types, sanitary landfill, dwellings, pond reservoirs, road construction, recreational areas, buidling constructions on soils and others.

These soil interpretation ratings are qualitative and are to be derived through expert systems, available or to be developed for each pilot area on the basis of available research data, pedotransfer functions and rules, and experience.

9.3 DOCUMENTED EXAMPLES AT THE EUROPEAN SCALE

Soil information has been used to support a variety of studies at the European scale. Some examples are:

(i) **The Dobríš Assessment (EEA, 1995).**
The Dobríš Assessment reports on the state of the European environment at the request made in 1991 by the environment ministers for the whole of Europe. The state of the environment includes the assesment of (a.o.) the condition of the soil, inland waters and the landscape. Among the general findings of the report is mentioned the filling of gaps in databases as well as improving the quality of the databases. Furthermore, 12 major environmental problems are recognized, of which 5 (climate change, acidification, the management of fresh waterforest degradation and coastal zone threats and management) can be encountered only if adequate soil and landscape information is available at appropriate scales.
The European Environmental Agency is planning and conducting a number of studies to make assessments like Dobríš every few years. The need for soil data expressed in the Dobríš assessment therefore remains valid.

(ii) **The Crop Growth Monitoring System (CGMS, Burrill *et al.*, 1995).**
The CGMS is developed to forecast crop yields as the season develops, using meteorological, topographic and crop parameter data as well as soils data. The soils data were used in the initial phase to identify areas where a given crop can possible grow. As more soil data have become available, more use is made of soil data, such as available water and rooting depth.

(iii) **The Rine Basin study (Rötter *et al.*, 1994)**
The Rine Basin study was undertaken to analyse possible future land use by biophysical and socio-economic analysis. Soil data were used to analyse the potential economic value of a number of land utilization types, and, conversely, the possible land uses for pieces of land by focusing on crop production.

(iv) **Pedotransferfunctions for hydraulic properties of soils (EU-network HYPRES).**
Pedotransfer functions are mathematical functions that estimate the values of secondary properties from available values of primary data. Such PTF have been developed e.g. by Bouma and Van Lanen (1986). Vereecken (1988) presented an extensive analysis of various models predicting soil hydraulic properties from non-hydraulic soil properties. Wösten et al. (1995) developed pedotransfer functions for hydraulic properties for soil texture classes in the Netherlands. These types of functions are currently under construction for European soils as well (Bruand *et al.*, 1997). It must be stressed, that some PTF are valid only for a restricted number of soils.
Pedotransfer functions have been applied to generate a variety of secondary soil data such as soil fertility parameters, soil erodibility and potential soil productivity.

(v) **Pedotransfer Rules (Van Ranst *et al.*, 1995)**

Pedotransfer Rules (PTR) are based on Boolean or other logic. They are used to predict ranges of classes of not easily determined soil qualities such as soil fertility, vulnerability and potential productivity. These rules are based on data derived from representative profiles and on relationships between soil properties and soil performance. They require the expert judgment of soil scientist and scientists of other related fields (King et al., 1995). The general structure of the PTR was proposed by Van Ranst et al. (1995) using the IF, AND, THEN, ELSE relationships. The primary attributes are fed to the PTR to produce the secondary information, e.g. the range of acidity of a certain soil unit can be derived from its taxonomic class. The rules can be arranged in tables covering a number of logical relations between primary and derived secondary data. The whole system of the relational data base can be linked to a GIS. The reader is referred to King et al. (1994), Jones and Hollis (1996) and Van Ranst et al. (1995) for further explanation and the structure of PTR. Generally these rules are of local applicability and they need validation for the major soil bodies.

An example of a pedotransfer rule is the following :

IF <soil name is Regosol > AND <parent material is Limestone >
THEN < base saturation is 100% >

(vi) **Sampling and modelling programs in European forest soils**

European forest soils have been and are intensively monitored within the context of EU-projects. Models have been developed to assess the impact of acid deposition on pH-change and subsequent mobilization of Al and other metals in forest soils. Examples are the ICP level I and II projects, the DYNAMO-project, the UNCERSDSS-project and the Forest Soil Coordination Panel activities.

9.4 EXAMPLES AT NATIONAL SCALES

Below follow a number of applications of soil information at the national scale. These applications have been made on the basis of expert knowledge, in an empirical way, or through modelling and integration of soils information, site conditions and socio-economic parameters:

(i) Assessment of the groundwater vulnerability of England and Wales in support of a policy and practice for the protection of groundwater. The soils information used in this assessment provided data on the physical properties which affect the downward movement of pollutants (1:1.000.000).

(ii) Assessment of the risk of soil erosion in England and Wales by water on land under winter cereal cropping (1:625.000).

(iii) Assessment of drought hazards in Niedersachsen used for the evaluation of the feasibility of supplementary irrigation (1:200.000).

(iv) Evaluation of the land capability for forestry in South- West Scotland (1:250.000).

(v) Assessment of land suitability for sludge utilisation on agricultural land in Scotland (1:250.000).

(vi) Assessment of the land capability for agricultural use in the region of Madrid (1:625.000).

(vii) Evaluation of the grazing potential of Irish land (1:126.720).

(viii) Delineation of lands vulnerable to nitrate leaching in the Netherlands (1:250.000).

(ix) Planning of landuse and protection of valuable agricultural land around expanding towns and villages in Denmark.

(x) Assessment of the land capability in Southern Portugal (1:250.000).

(xi) Assessment of the soils affected by wetness and of the useable water reserves of soils in France (1:250.000).

(xii) Assessment of the risk of agrochemical pollution in rural landuse in Belgium (1:500.000).

(xiii) Assessment of pesticides leaching potential in region Lombardia (1:250,000).

(xiv) Evaluation of soil erosion risk in province of L'Aquila (1:250,000).

(xv) Evaluation of soil vulnerability and critical loads in Germany (Hennings *et al.*, 1994).

9.5 FUTURE APPLICATIONS AND CONSEQUENCES FOR SOIL DATA COLLECTION AND PRESENTATION

9.5.1 Support to EU-policies

Relevant EU policies of general interest

(i) 5th Environmental Action Programme (DG XI)
(ii) Council resolution 1/2/93 93/C138/01
(iii) Report by the Commission COM (95) 624 (def.)
(iv) 1992 PAC (DG VI)
(v) Regulations n. 2078/92 and n. 2080/92 of 30/6/92
1996 European Spatial Development Perspective (DG XVI)

Specific EU policies and measures of interest

(i) Nitrates Directive (91/676/EEC)
(ii) Pesticides Registration (91/414/EEC)
(iii) Forest Protection against Atmospheric Pollution (3528/86/EEC and amendments)
(iv) Systematic soil survey on 16 x 16 km grid (926/93/EEC)
(v) Risk assessment for chemical substances (793/93/EEC, 67/93/EEC 1488/94/EEC)
(vi) HABITAT Directive (92/43/EEC)
(vii) NATURA 2000 network

9.5.2 Future applications

Further applications of a common database could be envisaged in the following fields:

(i) Suitability of lands of the European Community for different crops, grazing, forestry and horticulture.

(ii) Suitability of lands for ecological habitat creation and intensive recreation.

(iii) Assessment of hazards to the environment in terms of erosion, nitrate leaching, pollution, salinity, compaction and desertification.

(iv) Assessment of soil resilience and buffering capacity towards acidification, desication, sludge acceptance, pesticide toxicity.

(v) Assessment of soil water regimes in terms of drainage and irrigation requirements.

(vi) Evaluation of future strategies with regard to land to be set-aside, climate change, competition for land from different sectors of the economy, water quality control, waste disposal, afforestation.

(vii) General support to the EEA-working programs

GLOSSARY

Term or Acronym	Description or definition (DEF)
ascending method	the agglomerative grouping of (eg) soil bodies into soilscapes
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
DEM	Digital Elevation Model, a georeferenced database containing surface altitudes
descending method	the divisive method used to break down spatial units into smaller entities (eg. determiniation of soilscapes within a soil region)
diversity	DEF the amount of uncertainty regarding the species of an individual selected at random from a population
EUSIS	European Soil Information Systems
metadatabase	an electronic or paper database with descriptive texts on databases, books, maps etc. available elsewhere
PTF	PedoTransfer Functions: mathematical functions which translate basic, easily available soil data to model parameters or, more general, to less easy to obtain soil data
PTR	PedoTransfer Rules: expert rules to derive unknown nominal or ordinal attribute values from combinations of known nominal or ordinal attribute values through logical operators
soil body	DEF a portion of land with imprecisely known geographic limits. An artificial but recognizeable three-dimensional entity in a soil continuum described uniquely by its FAO-classification, parent material, depth to obstacle for roots and dominant surface texture.
soilscape	DEF a portion of the soil cover which groups soil bodies having former or present functional relationships and that can be represented at 1:250,000 scale
soil region	a regionally restricted part of the soil cover characterized by a typical climate and parent material association
SOTER	SOil and TERrain database
STU	Soil Typological Unit: imprecisely georeferenced taxonomic unit within a soil association or map unit

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APPENDIX 1 REVISED LEGEND OF THE SOIL MAP OF THE WORLD

(Soil Units after FAO, 1990b)

Code	Name	Code	Name
Acf	ferric Acrisols	FLc	calcaric Fluvisols
ACg	gleyic Acrisols	FLd	dystric Fluvisols
ACh	haplic Acrisols	FLe	eutric Fluvisols
ACp	plinthic Acrisols	FLm	mollic Fluvisols
ACu	humic Acrisols	FLs	salic Fluvisols
ALf	ferric Alisols	FLt	thionic Fluvisols
ALg	gleyic Alisols	FLu	umbric Fluvisols
ALh	haplic Alisols	FRg	geric Ferralsols
ALj	stagnic Alisols	FRh	haplic Ferralsols
ALp	plinthic Alisols	FRp	plinthic Ferralsols
ALu	humic Alisols	FRr	rhodic Ferralsols
ANg	gleyic Andosols	FRu	humic Ferralsols
ANh	haplic Andosols	FRx	xanthic Ferralsols
ANi	gelic Andosols	GLa	andic Gleysols
ANm	mollic Andosols	GLd	dystric Gleysols
ANu	umbric Andosols	GLe	eutric Gleysols
ANz	vitric Andosols	GLi	gelic Gleysols
ARa	albic Arenosols	GLk	calcic Gleysols
ARb	cambic Arenosols	GLm	mollic Gleysols
ARc	calcaric Arenosols	GLt	thionic Gleysols
ARg	gleyic Arenosols	GLu	umbric Gleysols
ARh	haplic Arenosols	GRg	gleyic Greyzems
ARl	luvic Arenosols	GRh	haplic Greyzems
ARo	ferralic Arenosols	GYh	haplic Gypsisols
ATa	aric Anthrosols	GYk	calcic Gypsisoils
ATc	cumulic Anthrosols	GYl	luvic Gypsisols
ATf	fimic Anthrosols	GYp	Petric Gypsisols
ATu	urbic Anthrosols	HSf	fibric Histosols
CHg	gleyic Chernozems	HSi	gelic Histosols
CHh	haplic Chernozems	HSl	folic Histosols
CHk	calcic Chernozems	HSs	terric Histosols
CHl	luvic Chernozems	HSt	thionic Histosols
CHw	glossic Chernozems	KSh	haplic Kastanozems
CLh	haplic Calcisols	KSk	calcic Kastanozems
CLl	luvic Calcisols	KSl	luvic Kastanozems
CLp	petric Calcisols	KSy	gypsic Kastanozems
CMc	calcaric Cambisols	LPd	dystric Leptosols
CMd	dystric Cambisols	LPe	eutric Leptosols
CMe	eutric Cambisols	LPi	gelic Leptosols
CMg	gleyic Cambisols	LPk	rendzic Leptosols
CMi	gelic Cambisols	LPm	mollic Leptosols
CMo	ferralic Cambisols	LPq	lithic Leptosols
CMu	humic Cambisols	LPu	umbric Leptosols
CMv	vertic Cambisols		
CMx	chromic Cambisols		

Code	Name	Code	Name
LVa	albic Luvisols	SNg	gleyic Solonetz
LVf	ferric Luvisols	SNh	haplic Solonetz
LVg	gleyic Luvisols	SNj	stagnic Solonetz
LVh	haplic Luvisols	SNk	calcic Solonetz
LVj	stagnic Luvisols	SNm	mollic Solonetz
LVk	calcic Luvisols	SNy	gypsic Solonetz
LVv	vertic Luvisols	VRd	dystric Vertisols
LVx	chromic Luvisols	VRe	eutric Vertisols
LXa	albic Lixisols	VRk	calcic Vertisols
LXf	ferric Lixisols	VRy	gypsic Vertisols
LXg	gleyic Lixisols		
LXh	haplic Lixisols		
LXj	stagnic Lixisols		
LXp	plinthic Lixisols		
NTh	haplic Nitisols		
NTr	rhodic Nitisols		
NTu	humic Nitisols		
PDd	dystric Podzoluvisols		
PDe	eutric Podzoluvisols		
PDg	gleyic Podzoluvisols		
PDi	gelic Podzoluvisols		
PDj	stagnic Podzoluvisols		
PHc	calcaric Phaeozems		
PHg	gleyic Phaeozems		
PHh	haplic Phaeozems		
PHj	stagnic Phaeozems		
PHl	luvic Phaeozems		
PLd	dystric Planosols		
PLe	eutric Planosols		
PLi	gelic Planosols		
PLm	mollic Planosols		
PLu	umbric Planosols		
PTa	albic Plinthosols		
PTd	dystric Plinthosols		
PTe	eutric Plinthosols		
PTu	humic Plinthosols		
PZb	cambic Podzols		
PZc	carbic Podzols		
PZf	ferric Podzols		
PZg	gleyic Podzols		
PZh	haplic Podzols		
PZi	gelic Podzols		
RGc	calcaric Regosols		
RGd	dystric Regosols		
RGe	eutric Regosols		
RGi	gelic Regosols		
RGu	umbric Regosols		
RGy	gypsic Regosols		
SCg	gleyic Solonchaks		
SCh	haplic Solonchaks		
SCi	gelic Solonchaks		
SCk	calcic Solonchaks		
SCm	mollic Solonchaks		
SCn	sodic Solonchaks		
SCy	gypsic Solonchaks		

APPENDIX 2 LIST OF PARENT MATERIALS

(modified after Hartwich, 1995)

Major Class	Group		Type	
100 Consolidated clastic sedimentary rocks	110	conglomerate		
	120	breccia		
	130	sandstone	131	calcareous sandstone
			132	ferruginous sandstone
			133	clayey sandstone
			134	quartzitic sandstone
			135	micaceous sandstone
	140	arkose		
	150	greywacke		
	160	calystone/ mudstone		
	170	siltstone		
200 Calcareous, and non clastic siliceous sedimentary rocks and sulphates	210	limestone	211	hard limestone
			212	soft limestone
			213	marly limestone
			214	chalky limestone
			215	detrital limestone
			216	carbonaceous limestone
			217	lacustrine / freshwater limestone
			218	travertine / calcareous sinter
	220	dolomite		
	230	marlstone		
	240	marl	241	chalk marl
			242	gypsyferous marl
	250	chalk		
	260	evaporites	251	gypsum / anhydrite
			252	halite
	270	chert, hornstone, flint		
300 Igneous rocks	310	acid to intermediate plutonic rocks	311	granite / granodiorite
			312	diorite / quartz diorite
			313	syenite
	320	acid to intermediate volcanic rocks	321	rhyolite
			322	andesite
			323	phonolite / trachite
	330	basic plutonic rocks	331	gabbro
	340	basic volcanic rocks	341	basalt / diabase
	350	ultrabasic igneous rocks	351	perodotite / pikrite
			352	pyroxenite
	360	pyroclastic rocks (tephra)	361	volcanic tuff / tuffite
			362	volcanic scoria
			363	volcanic ash
			364	ignimbrite
			365	pumice
400 Metamorphic rocks	410	non calcareaous metamorphic rocks	411	gneiss
			412	mica schist
			413	phyllite
			414	quartzite
			415	greenschist
			416	serpentinite / greenstone
			417	amphibolite
			418	migmatite
			419	slate

Major Class	Group		Type	
	420	calcareous metamorphic rocks	421	marble
			422	calcsilicate rock
			423	calcschist
500 Unconsolidated alluvial deposits	510	marine and estuarine sands	511	pre-quaternary sands (undifferentiated)
			512	quaternary sand (undifferentiated)
	520	marine and estuarine silt to clay and loam	521	pre-quaternary silt to clay (undifferentiated)
			522	quaternary silt to clay
			523	pre-quaternary loam
			524	quaternary loam
	530	fluvial and lacustrine sand to gravel	531	river(-terrace) sand to gravel
			532	lacustrine sand to gravel
	540	fluvial and lacustrine clay and loam	541	pre-quaternary clay
			542	quaternary clay
			543	pre-quaternary loam
			544	quaternary loam
	550	lake deposits	551	lake marl
			552	bog lime
			553	lake silt
600 Unconsolidated glacial deposits / glacial drift	610	glacial deposits / glacial drift	611	glacial till / boulder clay
	620	glaciofluvial deposits	621	outwash sand / glacial sand
			622	outwash gravel / glacial gravel
	630	glaciolacustrine deposits	631	glacial clay
700 Eolian deposits	710	loess	711	loamy loess
			712	sandy loess
	720	eolian sands	721	dune sands
			722	cover sands
800 Residual and redeposited material	810	residual and/or redeposited loam	811	old loam (touyas)
			812	stony loam
			813	clayey loam
	820	residual and/or redeposited clay from calcareous rocks	821	clay with flints
			822	ferrugenous residual loam and clay
			823	calcareous decalcification clay
			824	non-calcareous decalcification clay
			825	calcareous clay / marly clay
	830	slope deposits	841	slope-wash alluvium
			842	colluvial deposits
900 Other rocks or deposits	910	organic material	911	peat
			912	lignite / brown coal
	920	anthropogenic deposits	921	redeposited sediment
			922	rubble / rubbish
			923	industrial ashes and slag

APPENDIX 3 DETERMINATION TABLE FOR DEPTH TO OBSTACLE FOR ROOTS

If

- *toxic* is the depth (cm or class) from the surface to a toxic layer. A toxic layer can result from (e.g.) low pH values and associated high concentrations of Al and heavy metals, a high salt content etc;
- *lowox* is the depth (cm or class) at which there is hardly any oxigen available for plant roots. This can be the result of the presence of permanent (perched) groundwater tables, of the presence of a decomposing peat layer, etc;
- *rock* is the depth (cm or class) at which hard bedrock is found;
- *imper* is the depth (cm or class) to an impermeable layer such as (e.g.) a fragipan, an iron pan, clay layers in sediments or as result of pedogenesis;

then the depth to obstacle for roots is defined as:

Depth to obstacle for roots (cm or class) = MIN(*toxic* , *lowox* , *rock* , *imper*).

The following classes are distinguished in the soil body definition table:

Code	Description
1	Depth to obstacle for roots 0 - 30 cm
2	Depth to obstacle for roots 30 - 60 cm
3	Depth to obstacle for roots > 60 cm

APPENDIX 4 TEXTURE CLASSES

(after CEC, 1985)

The following texture classes are used:

Class	Description	
0	No texture	Peat soils
1	Coarse	18% = clay and >65% sand
2	Medium	18% = clay < 35% and 15% sand, or 18% = clay and 15% = sand <65%
3	Medium fine	<35% clay and <15% sand
4	Fine	35% = clay < 60%
5	Very fine	= 60% clay

where sand=fraction between 50 and 2000 µmeter;
silt=fraction between 2 and 50 µmeter;
clay= fraction smaller than 2 µmeter;

Gravel content classes are:

Class	Description	
1	Low gravel content	= 15% gravel
2	High gravel content	> 15% gravel

where gravel=fraction < 2000 µmeter

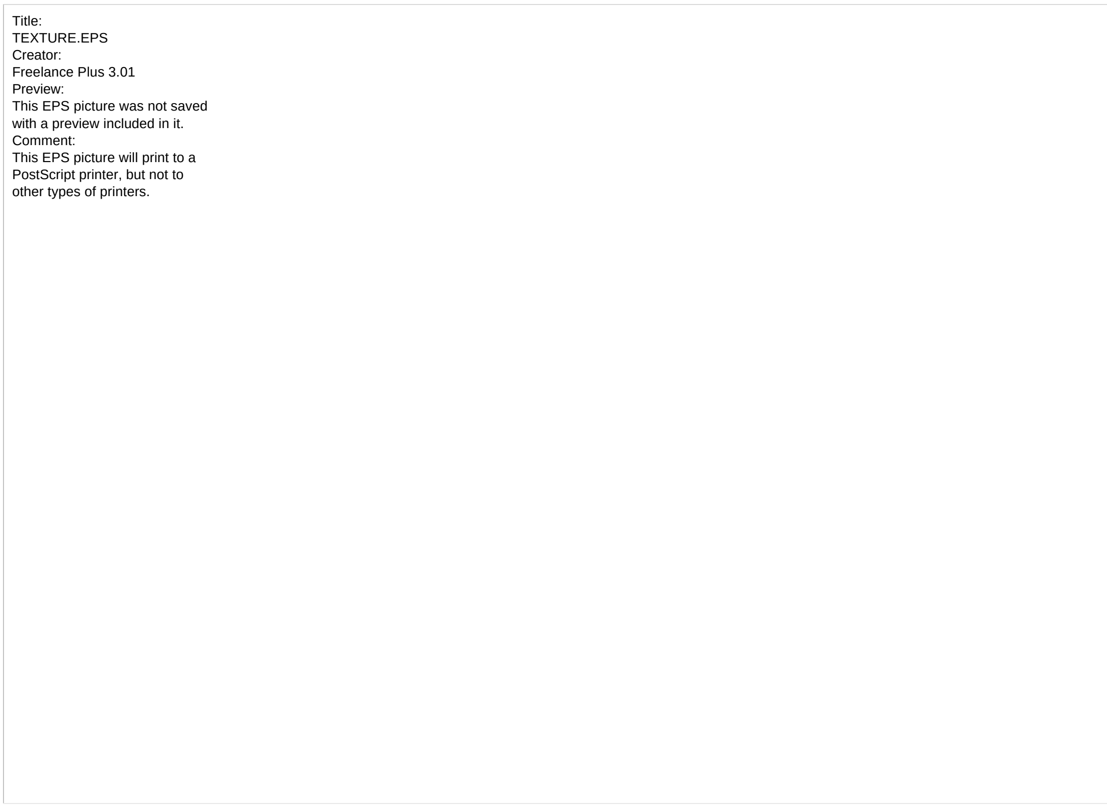


Figure 6 Texture classes (after CEC, 1985)

APPENDIX 5 CODING OF SOIL BODY ATTRIBUTES

soil_body
Each soil body is uniquely coded by attaching a 3-digit number preceded by *SB* to the code of the soil region. Soil body 210 within soil region 33.2 is thus coded in a 10 character format as 33.2.*SB210*. The same soil body occuring in two adjacent soilscapes thus occurs only once in the sematic dataset. It is of course possible to attach more measured profiles to the same soil body, so that in each soilscape where a soil body occurs a soil body description is available.

sbse_estm
The estimation method of the data at the soil body scale. Options are:

Code	Description
s	statistical estimate
e	experts' guess

sbse_nopr
The number of profiles on which the statistical estimate is based.

sbsm_X, sbsm_Y
These fields contain the X- and Y-coordinates of the described profile. Units are degrees.centidegrees longitude and latitude.

sbsm_alt
The surface altitude in meters above sealevel.

sbsm_slope, sbse_slope
The slope (%) at the location of the soil profile or modal, 20% and 80% percentile values for the slope in the soil body.

sbsm_drai, sbse_drai
The drainage of the soil profile is described according to the FAO-guidelines (FAO, 1990a) for soil profile description:

Code	Description	
E	excessively drained	Water is removed from the soil very rapidly
S	somewhat excessively drained	Water is removed from the soil profile rapidly
W	well drained	Water is removed from the soil readily but not rapidly
M	moderately well drained	Water is removed from the soil somewhat slowly during some periods of the year. The soils are wet for short periods within rooting depth.
I	imperfectly drained	Water is removed slowly so that the soils are wet at shallow depth (<40 cm) for a considerable period
P	poorly drained	Water is removed so slowly that the soils are commonly wet for considerable periods. The soils have commonly a shallow (<40 cm) water table.
V	very poorly drained	Water is removed so slowly that the soils are wet at shallow depth for long periods. The soils have a very shallow (<40 cm) water table.

sbsm_infl, sbse_infl
The infiltration rate is indicated according to the categories distinguished by BAI (1991):

Code	Description	
E	very slow	< 0.1 cm/h
S	slow	0.1 - 0.5 cm/h
D	moderately slow	0.5 - 2.0 cm/h
M	moderate	2.0 - 6.0 cm/h
R	rapid	6.0 - 12.5 cm/h

Code	Description	
Y	very rapid	12.5 - 25.0 cm/h
X	extremely rapid	= 25 cm/h

sbsm_capr, sbse_capr

The summer potential for capillary rise is the amount of water which rises to the bottom of the rooted zone during the growing season by capillary rise from relatively shallow groundwater tables. The following categories are distinguished (the bottom of the root zone is assumedly fixed at 40 cm depth, the length of the growing season depends on the climate):

Code	Description	
E	extremely low	0 - 25 mm
L	low	25 - 50 mm
M	moderate	50 - 100 mm
H	high	100 - 200 mm
Y	extremely high	> 200 mm

sbsm_whcp, sbse_whcp

The water holding capacity is defined as the difference between the moisture content at field capacity and at the permanent wilting point, summed up for the rootable depth.

Code	Description	
E	extremely low	< 50 mm
L	low	50 - 100 mm
M	moderate	100 - 200 mm
H	high	200 - 300 mm
Y	extremely high	> 300 mm

An example for a two layer profile (0-20: Ap coarse texture; 20-120: C medium texture; rootable depth 80 cm):

Ap: an estimated $?_{fc}$ =0.27 cm^3 .cm^{-3} and $?_{wp}$=0.08 cm^3 .cm^{-3} give an estimated capacity of (0.27-0.08)*(20-0)= 42 mm

C: an estimated $?_{fc}$ =0.40 cm^3 .cm^{-3} and $?_{wp}$=0.10 cm^3 .cm^{-3} give an estimated capacity of (0.40-0.10)*(80-20)= 180 mm

The water holding capacity is thus estimated as (180+42)=222 mm (class H).

sbsm_rock, sbse_rock

The surface rockiness is the percentage of rock outcrops according to the FAO-guidelines (FAO, 1990a):

Code	Description	
N	none	0%
V	very few	0 - 2 %
F	few	2 - 5 %
C	common	5 - 15 %
M	many	15 - 40 %
A	abundant	40 - 80 %
D	dominant	= 80 %

sbsm_stone, sbse_stone

The surface stoniness is the percentage of coarse fragments (> 2 mm diameter) at the soil surface, described according to the FAO-guidelines (FAO, 1990a):

Code	Description	
N	none	0%
V	very few	0 - 2 %
F	few	2 - 5 %
C	common	5 - 15 %
M	many	15 - 40 %
A	abundant	40 - 80 %
D	dominant	= 80 %

sbsm_erot, sbse_erot

The type of erosion/deposition is characterized according to the FAO-guidelines (FAO, 1990a):

Code	Description	Code	Description
N	no visible evidence of erosion	W	water and wind erosion
S	sheet erosion	L	wind wind deposition
R	rill erosion	A	wind erosion and deposition
G	gully erosion	D	shifting sand
T	tunnel erosion	Z	salt deposition
P	deposition by water		

sbsm_eroa, sbse_eroa
The area affected by the erosion type, according to ISRIC-UNEP (1988):

Code	Area (%)
1	0 - 5 %
2	5 - 10 %
3	10 - 25 %
4	25 - 50 %
5	=50 %

sbsm_erod, sbse_erod
The degree of erosion is described according to the FAO-guidelines (FAO, 1990a):

Code	Description	
S	slight	Some evidence of loss of surface horizons. Original biofunctions largely intact
M	moderate	Clear evidence of removal or coverage of surface horizons. Original biofunctions partly destroyed.
V	severe	Surface horions completely removed (with subsurface horizons exposed) or covered up by sedimentation of material from upslope. Original biofunctions largely destroyed.
E	extreme	Substantial removal of deeper subsurface horizons (badlands). Complete destruction of original biofunctions.

sbsm_crus, sbse_crus
The magnitude in which surface crusts tend to form is described according to the FAO-guidelines (FAO, 1990a):

Code	Description	
N	none	no capping or sealing observed
W	weak	the soil surface has a slight sensitivity to capping. Soft or slightly hard crust less than 0.5 cm thick
M	moderate	the soil has a moderate sensitivity to capping. Soft or slightly hard crust more than 0.5 cm thick, or hard crust less than 0.5 cm thick
S	strong	the soil surface has a strong sensitivity to capping. Hard crust more than 0.5 cm thick

sbsm_root, sbsm_root
The rootable depth is the depth to obstacle for roots in cm as defined in appendix 3.

sbsm_impl, sbsm_impl
The depth to an impermeable layer in cm.

sbsm_depr, sbse_depr
The depth to bedrock in m. For depths more than 10 m it can be given to the nearest 5 m.
Unknown depth but deeper than 50 meter is coded by -50; unknown but deeper than 100 is coded by -99.

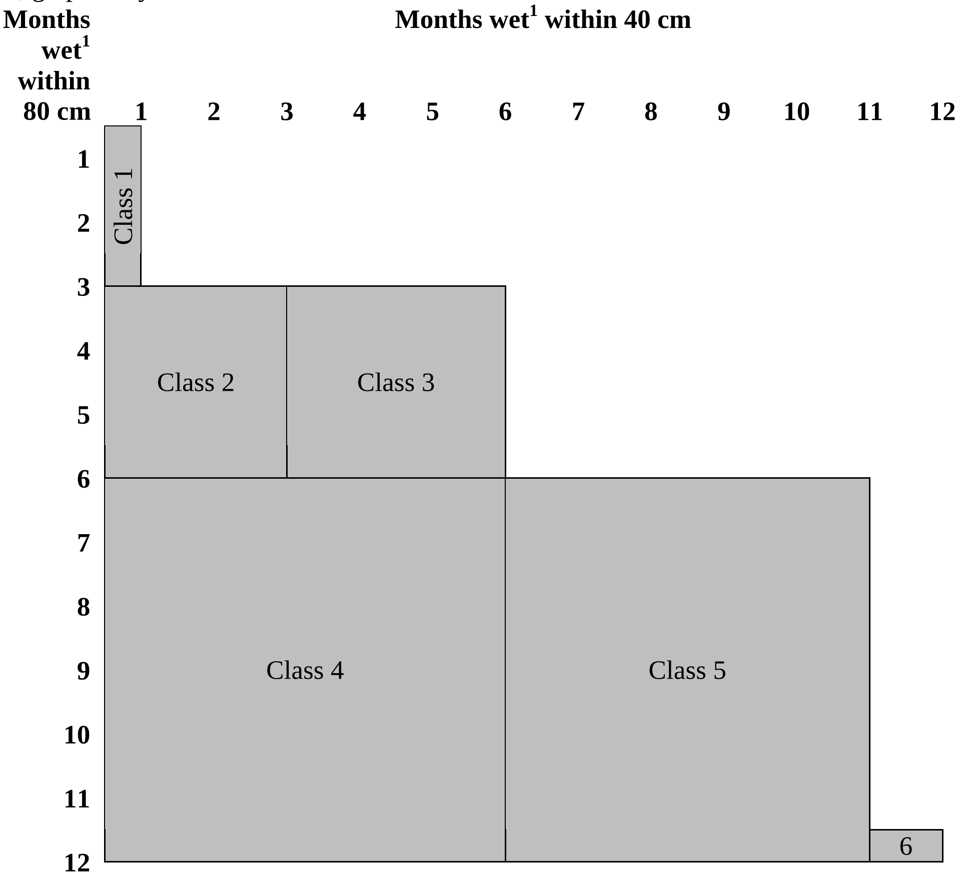
sbse_dere
The thickness of the regolith in m. For depths more than 10 m it can be given to the nearest 5 m.
Unknown depth but deeper than 50 meter is coded by -50; unknown but deeper than 100 is coded by -99.

sbsm_watr, sbse_watr

The annual soil water regime is an estimation of the within-year fluctuations in moisture conditions, which is based on time series of matric suction profiles, of groundwatertables, or morphological attributes or a combination of these. The annual soil water regime is expressed in hydrological terms, and is a refinement of the definition of Daroussin et al. (1995). Time is counted in cumulative, not per se consecutive, days.

Code	Description
1	The soil profile is not wet[1] within 80 cm for more than 3 months, nor wet within 40 cm depth for more than 1 month
2	The soil profile is wet[1] within 80 cm for 3 to 6 months but not wet within 40 cm for more than 3 months
3	The soil profile is wet[1] within 80 cm for 3 to 6 months and wet within 40 cm for more than 3 months
4	The soil profile is wet[1] within 80 cm for more than 6 months and wet within 40 cm for less than 6 months
5	The soil profile is wet[1] within 80 cm for more than 6 months and wet within 40 cm for more than 6 months but less than 11 months
6	The soil profile is wet[1] within 40 cm depth for more than 11 months

or, graphically:



[1] wet ˜ water saturated, defined as: a matric suction of < 10 cm, or a matric potential of > -1 kPa.

sbsm_depw, sbse_depw

The annual average water table depth in decimeters. Unknown depths or absence of a water table is indicated by a minus sign: a - sign preceding any number between 1 and 99 indicates a depth *deeper than* the number (example: -35 indicates a water table depth deeper than 3.5 meter); -99 indicates absence of a water table.

sbsm_watm, sbse_watm

This attribute concerns only ***functioning water management***. The type of water management is described according to Daroussin et al. (1995):

Code	Description	Code	Description
1	pumping	6	"bed" system
2	ditches	7	permanent flood irrigation
3	pipe underdrainage	8	permanent overhead sprinkler
4	mole drainage	9	permanent trickle irrigation
5	deep loosening		

sbsm_watp, sbse_watp

The purpose of the water management system is described according to Daroussin et al. (1995):

Code	Description	Code	Description
1	to alleviate waterlogging (drainage)	4	to alleviate both waterlogging and drought stress
2	to alleviate drought stress (irrigation)	5	to alleviate both waterlogging and salinity
3	to alleviate salinity (drainage)		

APPENDIX 6 CODING OF HORIZON ATTRIBUTES

Quality assessments: <attribute>Q1 and <attribute>Q2
Each soil horizon attribute which has to be determined in the laboratory gets two auxilary attributes:
Q1: 10-digit code composed from:

- 3-digit ISO-code of country of the laboratory (e.g. NLD for Netherlands)
- 2-digit number referring to laboratory within the country (e.g. 01 for "bedrijfslaboratorium voor Grond- en gewasonderzoek, Oosterbeek, Netherlands", national list is yet to be compiled)
- _ (underscore-mark)
- year in which analysis was done (e.g. 1988).

Q2: 1-digit code expressing the data providers assessment of the data quality:

Quality assessment Q2	Meaning
l	low quality (e.g., measurement method obscure)
m	medium quality
h	high quality (laboratory of excellent reputation, measurement according ISO-described method)

sbhm_stgr, sbhe_strgr
The stone/gravel abundance (volume% classes in soil matrix) and size (diameter classes) are both described using the FAO-guidelines (FAO, 1990a). The first character of _stgr comes from the abundance class, the second character from the size class.

Abundance class	Description	Size class	Description
N	0 %	0	Not applicable
V	0 - 2%	V	< 2 mm
F	2 - 5 %	F	2 - 6 mm
C	5 - 15 %	M	6 - 20 mm
M	15 - 40 %	C	20 mm
A	40 - 80 %		
D	80 %		

sbhm_struct, sbhe_struct
The grade, size and type of structure are defined according to the FAO-guidelines (FAO, 1990a). Each of these structure descriptors contributes a single character to the three-character code.

Grade of structure	Description	
N	structureless	no observable aggregation or no orderly arrangement of natural planes of weakness (massive or single grain)
W	weak	soil with poorly formed indistinct peds, that are barely observable in place even in dry soil, breaks up into very few intact peds, many broken peds and much apedal material
M	moderate	soil with well-formed distinct peds, durable and evident in disturbed soil which produces many entire peds, some broken peds and little apedal material
S	strong	soil with durable peds that are clearly evident in undisturbed (dry) soil, which breaks up mainly into entire peds

Size classes		Ranges of size of structure elements (mm)				
		platy	prismatic/columnar	(sub)angular blocky	granular	crumb
V	very fine	< 1	< 10	< 5	< 1	< 1
F	fine	1 - 2	10 - 20	5 - 10	1 - 2	1 - 2
M	medium	2 - 5	20 - 50	10 - 20	2 - 5	2 - 5
C	coarse	5 - 10	50 - 100	20 - 50	5 - 10	
X	very coarse	> 10	> 100	> 50	> 10	

Type of structure	Description	
P	platy	particles arranged around a generally horizontal plane
R	prismatic	prisms with rounded upper end
C	columnar	prisms with rounded caps
A	angular blocky	bounded by plains intersecting at largely sharp angles
S	subangular blocky	mixed rounded and plane faces with vertices mostly rounded
G	granular	spheroidical or polyhedral, relatively non-porous
B	crumb	spheroidical or polyhedral, porous
M	massive	no structure
N	single grain	no structure, individual grains
W	wedge shaped	structure in horizons with slickensides

sbhm_cm
The dominant mineral in the clay fraction, as determined by XRD (X-ray diffraction) (codes according to SOTER, 1993):

Code	mineral	Code	Mineral
AL	allophane	KA	kaolinitic
CH	chloritic	MO	montmorillonitic
IL	illitic	SE	sesquioxidic
IN	interstratified or mixed	VE	vermiculitic

sbhe_cm
The minerals which dominate the clay fraction, as determined by expert judgement based on parent material, soil genesis, etc.

Code	mineral group
LO	low CEC clay minerals such as Kaolinites and Illites are dominant
HI	high CEC clay minerals such as Montmorillonites and Vermiculites are dominant
MX	mixed group

APPENDIX 7 CODING OF SOILSCAPE ATTRIBUTES

soilscape (key)
The unique code of the soilscape, of which the number of the soil region forms part. For example, soilscape 422 within soil region 112 is numbered as 112.SS422.

ss_aut
The name of the author of the soilscape map unit.

ss_yrmap
The year of mapping.

ss_date
The date of data processing (day,month,year).

ss_qual
The quality level of the description of the soilscape by soil bodies. The following levels have been defined:

Code	Description
1	> 90% of the area of the soilscape is sufficiently * described by soil bodies
2	40-90% of the area of the soilscape is sufficiently described by soil bodies
3	< 40% of the area of the soilscape is sufficiently described by soil bodies

* sufficiently = in the soil body estimates and soil horizon estimates table all mandatory attributes are filled

ss_doms
The dominant soil in the soilscape according to the FAO-classification.

soil_region (key)
The unique identification of the soil region in which the soilscape is found.

ss_mlf
The major landform is described by the general features of the morphology of the landscape according to 2nd level in SOTER (1993):

1st level		2nd level		gradient (%)	relief intensity
L	level land	LP	plain	<8	<100 m/km
		LL	plateau	<8	<100 m/km
		LD	depression	<8	<100 m/km
		LF	low-gradient footslope	<8	<100 m/km
		LV	valley floor	<8	<100 m/km
S	sloping land	SM	medium-gradient mountain	15-30	>600m/2km
		SH	medium-gradient hill	8-30	>50m/slope unit
		SE	medium-gradient escarpment zone	15-30	<600m/2km
		SR	ridges	8-30	>50m/slope unit
		SU	mountainous highland	8-30	>600m/2km
		SP	dissected plain	8-30	<50m/slope unit
T	steep land	TM	high-gradient mountain	>30	>600m/2km
		TH	high-gradient hill	>30	<600m/2km
		TE	high-gradient escarpment zone	>30	>600m/2km
		TV	high-gradient valleys	>30	variable
C	land with	CV	valley	>8	variable
	composite	CL	narrow plateau	>8	variable
	landforms	CD	major depression	>8	variable

ss_resl

The regional slope describes the landform in more detail. Classes are inferred from SOTER.

Simple landforms	Description		Complex landforms	Description [**]
W0	0-2%	flat, wet[*]	CU	cuestashaped
F0	0-2%	flat	DO	dome-shaped
G0	2-5%	gently undulating	RI	ridged
U0	5-8%	undulating	TE	terraced
R0	8-15%	rolling	IN	inselberg covered (occupying 1%)
S0	15-30%	moderately steep	DU	dune-shaped
T0	30-60%	steep	IM	with intermontane plains (occupying 15%)
V0	= 60%	very steep	WE	with wetlands (occupying 15%)
			KA	strong karst

[*] wet is defined as 50-90 permanent water surface

[**] complex landforms apply (with exception of IM) to level landforms

ss_hyps

The hypsometric level is the height of the local base level above the sea level for flat of slightly sloping lands, and the height above the local base level in case of lands with a high relief intensity. The SOTER-manual defines 12 classes (class 12 does not occur in Europe):

Code	Description		Code	Description	
Level and sloping lands[1]			*Sloping lands*[2]		
1	< 300m	very low level	6	< 200m	low
2	300-600m	low level	7	200-400m	medium
3	600-1500m	medium level	8	400m	high
4	1500-3000m	high level	*Steep and sloping lands*[3]		
5	= 3000m	very high level	9	600-1500m	low
			10	1500-3000	medium
			11	3000-5000m	high
			12	= 5000m	very high

[1] relief intensity < 50m/slope unit

[2] relief intensity > 50m/slope unit

[3] relief intensity > 600m/2km

ss_ddis

The degree of dissection is described according to SOTER, based on the use of morphometric data:

Code	Description [1]
1	< 10 km km^{-2}
2	10-25 km km^{-2}
3	= 25 km km^{-2}

[1] expressed in average length of drainage channels per unit area of land, km km^{-2}

ss_pws

The percentage of the soilscape that is permanently covered with water.

ss_altlo

Minimum altitude in the soilscape (m above sea level).

ss_althi

Maximum altitude in the soilscape (m above sea level).

ss_slint

The relief intensity is the median difference between highest and lowest point within the soilscape per horizontal km (m km^{-1}).

ss_sllen
The slope length is the estimated dominant length of the slope in m.

ss_ssfr
The slope and local surface form describe the dominant slope and the meso-relief occuring in the soilscape. The ss_ssfr attribute value is the concatenation of the codes for slope form and local surface form. The classifications proposed by SOTER are used:

Code slope form	**Description**	**Code local surface form**	**Description** **
0	slope 2%	0	flat
U	uniform slope	H	hummocky
C	concave slope	M	mounded
V	convex slope	T	towered
I	irregular slope	R	ridged
		T	terraced
		G	gullied
		S	strongly dissected
		D	dissected
		L	slightly dissected

** See the SOTER-manual for a morphometric definition

ss_wetn
The wetness index, estimated as the percentage of the area of the soilscape with frequent overland flow.

ss_lu
The dominant landuse in the soilscape according to (minimally) the level 2 classification (*italic* names) of CORINE:

Corine level			**Name**	**Definition**
1	**2**	**3**		
1.			ARTIFICIAL SURFACES	
1.	*1.*		*Urban fabric*	
1.	1.	1.	Continuous urban fabric	Buildings, roads and artificially surfaced area cover almost all the ground. Non-linear areas of vegetation and bare soil are exceptional.
1.	1.	2.	Discontinuous urban fabric	Most of the land is covered by structures. Buildings, roads and artificially surfaced areas associated with vegetated areas and bare soil, which occupy discontinuous but significant surfaces.
1.	*2.*		*Industrial, commercial and transport*	
1.	2.	1.	Industrial or commercial units	Artificially surfaced areas (with concrete, asphalt, tamacadam, or stabilised, e.g. beaten earth) devoid of vegetation, occupy most of the area in question, which also contains buildings and/or vegetated areas
1.	2.	2.	Road and rail networks and associated land	Motorways, railways, including associated installations (stations, platforms, embankments). Minimum width to include: 100 m.
1.	2.	3.	Port areas	Infrastructure of port areas, including quays, dockyards and marinas.
1.	2.	4.	Airports	Airport installations: runways, buildings and associated land.
1.	*3.*		*Mine, dump and construction sites*	

Corine level 1	2	3	Name	Definition
1.	3.	1.	Mineral extraction sites	Areas with open-pit extraction of industrial minerals (sandpits, quarries) or other minerals (opencast mines). Includes flooded gravel pits, except for river-bed extraction.
1.	3.	2.	Dump sites	Landfill or mine dump sites, industrial or public.
1.	3.	3.	Construction sites	Spaces under construction development, soil or bedrock excavations, earthworks.
1.	*4.*		*Artificial, non-agricultural vegetated areas*	
1.	4.	1.	Green urban areas	Areas with vegetation within urban fabric. Includes parks and cemeteries with vegetation.
1.	4.	2.	Sport and leisure facilities	Camping grounds, sports grounds, leisure parks, golf courses, racecourses, etc. Includes formal parks not surrounded by urban zones
2.			AGRICULTURAL AREAS	
2.	*1.*		*Arable land*	*Cultivated areas regularly ploughed and generally under a rotation system.*
2.	1.	1.	Non-irrigated arable land	Cereals, legumes, fodder crops, root crops and fallow land. Includes flower and tree (nurseries) cultivation and vegetables, whether open field, under plastic or glass (includes market gardening). Includes aromatic, medicinal and culinary plants. Excludes permanent pastures.
2.	1.	2.	Permanently irrigated land	Crops irrigated permanently and periodically, using a permanent infrastructure (irrigation channels, drainage network). Most of these crops could not be cultivated without an artificial water supply. Does not include sporadically irrigated land.
2.	1.	3.	Rice fields	Land developed for rice cultivation. Flat surfaces with irrigation channels. Surfaces regularly flooded.
2.	*2.*		*Permanent crops*	*Crops not under a rotation system which provide repeated harvests and occupy the land for a long period before it is ploughed and replanted: mainly plantations of woody crops. Excludes pastures, grazing lands and forests.*
2.	2.	1.	Vineyards	Areas planted with vines.
2.	2.	2.	Fruit trees and berry plantations	Parcels planted with fruit trees or shrubs: single or mixed fruit species, fruit trees associated with permanently grassed surfaces. Includes chestnut and walnut groves.
2.	2.	3.	Olive groves	Areas planted with olive trees, including mixed occurrence of olive trees and vines on the same parcel.
2.	*3.*		*Pastures*	
2.	3.	1.	Pastures	Dense, predominantly graminoid grass cover, of floral composition, not under a rotation system. Mainly used for grazing, but the fodder may be harvested mechanically. Includes areas with hedges (bocage).
2.	*4.*		*Heterogeneous agricultural areas*	
2.	4.	1.	Annual crops associated with permanent crops	Non-permanent crops (arable lands or pasture) associated with permanent crops on the same parcel.
2.	4.	2.	Complex cultivation	Juxtaposition of small parcels of diverse annual crops, pasture and/or permanent crops.

Corine level 1	2	3	Name	Definition
		3.	Land principally occupied by agriculture, with significant areas of natural vegetation	Areas principally occupied by agriculture, interspersed with significant natural areas.
		4.	Agro-forestry areas	Annual crops or grazing land under the wooded cover of forestry species.
3.			FORESTS AND SEMI-NATURAL AREAS	
3.	*1.*		*Forests*	
3.	1.	1.	Broad-leaved forest	Vegetation formation composed principally of trees, including shrub and bush understories, where broad-leaved species predominate.
3.	1.	2.	Conifereous forest	Vegetation formation composed principally of trees, including shrub and bush understories, where coniferous species predominate.
3.	1.	3.	Mixed forest	Vegetation formation composed principally of trees, including shrub and bush understories, where broad-leaved and coniferous species co-dominate.
3.	*2.*		*Shrub and/or herbaceous vegetation associations*	
3.	2.	1.	Natural grassland	Low productivity grassland. Often situated in areas of rough uneven ground. Frequently includes rocky areas, briars, and heathland.
3.	2.	2.	Moors and heathland	Vegetation with low and closed cover, dominated by bushes, shrubs and herbaceous plants (heath, briars, broom, gorse, laburnum, etc.).
3.	2.	3.	Sclerophyllous vegetation	Bushy sclerophyllous vegetation. Includes *maquis and garrige.* *Maquis:* a dense vegetation association composed of numerous shrubs associated with siliceous soils in the Mediterranean environment. *Garrigue:* discontinuous bushy associations of Mediterranean calcareous plateaus. Generally composed of kermes oak, arbutus, lavender, thyme, cistus, etc. May include a few isolated trees.
3.	2.	4.	Transitional woodland/shrub	Bushy or herbaceous vegetation with scattered trees. Can represent either woodland degradation or forest regeneration/colonisation.
3.	*3.*		*Open spaces with little or no vegetation*	
3.	3.	1.	Beaches, dunes, and sand plains	Beaches, dunes and expanses of sand or pebbles in coastal or continental , including beds of stream channels with torrential regime.
3.	3.	2.	Bare rock	Scree, cliffs, rocks and outcrops.
3.	3.	3.	Sparsely vegetated areas	Includes steppes, tundra and badlands. Scattered high-attitude vegetation.
3.	3.	4.	Burnt areas	Areas affected by recent fires, still mainly black.
3.	3.	5.	Glaciers and perpetual snow	Land covered by glaciers or permanent snowfields.
4.			WETLANDS	
4.	*1.*		*Inland wetlands*	*Non-forested areas either partially, seasonally or permanently waterlogged. The water may be stagnant or circulating.*
4.	1.	1.	Inland marshes	Low-lying land usually flooded in winter, and more or less saturated by water all year round.

Corine level 1	2	3	Name	Definition
4.	1.	2.	Peatbogs	Peatland consisting mainly of decomposed moss and vegetable matter. May or may not be exploited.
4.	*2.*		*Coastal wetlands*	*Non-wooded areas either tidally, seasonally or permanently waterlogged with brackish or saline water.*
4.	2.	1.	Salt marshes	Vegetated low-lying areas, above the high-tide line, susceptible to flooding by sea water. Often in the process of filling in, gradually being colonised by halophilic plants.
4.	2.	2.	Salines	Salt-pans, active or in process of structuring. Sections of salt marsh exploited for the production of salt by evaporation. They are clearly distinguishable from the rest of the marsh by their segmentation and embankment systems.
4.	2.	3.	Intertidal flats	Generally unvegetated expanses of mud, sand or rock lying between high and low water-marks. On contour on maps.
5.			WATER BODIES	
5.	*1.*		*Inland waters*	
5.	1.	1.	Water courses	Natural or artificial water-courses serving as water drainage channels. Includes canals. Minimum width to include: 100 m.
5.	1.	2.	Water bodies	Natural or artificial stretches of water.
5.	*2.*		*Marine waters*	
5.	2.	1.	Coastal lagoons	Unvegetated stretches of salt or brackish waters separated from the sea by a tongue of land or other similar topography. These water bodies can be connected with the sea at limited points, either permanently or for parts of the year only.
5.	2.	2.	Estuaries	The mouth of a river within which the tide ebbs and flows.
5.	2.	3.	Sea and ocean	Zone seaward of the lowest tide limit.

ss_veg
The dominant natural vegetation is described according to the classification given in appendix 10.

ss_surmat
The parent material of the surface layer is described according to the Hartwich list of parent materials (the TYPE-level). See the list provided in appendix 2.

ss_surtxt
Texture group surface layer. See the texture groups provided in appendix 4.

ss_dmat
Depth to parent material change (dm). If the parent material does not change with depth, then ss_dmat should have the value 0, and ss_submat should be equal to ss_surmat.

ss_submat
The parent material of the subsurface layer is described according to the Hartwich list of parent materials (the TYPE-level). See the list provided in appendix 2.

ss_subtxt
Texture group subsurface layer. See the texture groups provided in appendix 4.

APPENDIX 8 ISO-FORMATS RELATED TO SOIL ANALYSES

ISO-code:year	Subject
Soil chemical analyses	
ISO 10390:1994	Determination of pH
ISO 10693:1995	Determination of carbonate content -- Volumetric method
ISO 10694:1995	Determination of organic and total carbon after dry combustion (elementary analysis)
ISO/DIS 14235	Determination of organic carbon by sulfochromic oxidation
ISO/DIS 11047	Determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc -- Flame and electrothermal atomic absorption spectrometric methods
ISO 11466:1995	Extraction of trace elements soluble in aqua regia
ISO 11048:1995	Determination of water-soluble and acid-soluble sulfate
ISO 13536:1995	Determination of the potential cation exchange capacity and exchangeable cations using barium chloride solution buffered at pH = 8,1
ISO 11260:1994	Determination of effective cation exchange capacity and base saturation level using barium chloride solution
ISO/DIS 14254	Determination of exchangeable acidity of barium chloride extract
ISO 11261:1995	Determination of total nitrogen -- Modified Kjeldahl method
ISO/DIS 14255	Determination of soluble nitrogen fractions
ISO/DIS 14256-1	Determination of nitrate, nitrite and ammonium in field moist soils by extraction with potassium chloride solution -- Part 1: Manual method
ISO/DIS 13878	Determination of total nitrogen content after dry combustion ("elemental analysis")
ISO 11263:1994	Determination of phosphorus -- Spectrometric determination of phosphorus soluble in sodium hydrogen carbonate solution
ISO 11265:1994	Determination of the specific electrical conductivity
ISO/DIS 11271	Determination of redox potential -- Field method
Soil physical analyses	
ISO/DIS 11272	Determination of dry bulk density
ISO/DIS 11508	Determination of particle density
ISO/DIS 11273-1	Determination of aggregate strength -- Part 1: Tensile strength measurement (crushing test)
ISO/DIS 11274	Determination of the water retention characteristic -- Laboratory methods
ISO/DIS 11275	Determination of unsaturated hydraulic conductivity and water retention characteristic -- Wind's evaporation method
ISO 11276:1995	Determination of pore water pressure -- Tensiometer method
ISO/DIS 11277	Determination of particle size distribution in mineral soil material -- Method by sieving and sedimentation following removal of soluble salts, organic matter and carbonates
ISO/DIS 11461	Determination of soil water content as a volume fraction using coring sleeves -- Gravimetric method
ISO 11465:1993	Determination of dry matter and water content on a mass basis -- Gravimetric method
ISO 10573:1995	Determination of water content in the unsaturated zone -- Neutron depth probe method

APPENDIX 9 DESCRIPTION OF SOIL REGIONS OF EUROPE

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
SOIL REGIONS WITH BOREAL CLIMATE				
1.	**Histosol - Podzol Region**			
1.1	Histosol-, Podzol-Region of North- and Middle-Finland (HSf, HSl, PZh)	loamy glacial deposits (ground moraine)	mean annual temperature: 0.5 - 1.5°C mean annual precipitation: 400 - 510 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Oct. - Apr.	100 - 400 m level land
2.	**Leptosol - Podzol Regions**			
2.1	Leptosol-Region, with Podzols, of Middle- and North-Norway and North-Sweden (LPq, LPu, PZh)	igneous and metamorphic rocks (schist, granite)	mean annual temperature: 1.8 - 5.2°C mean annual precipitation: 760 - 1050 mm months of highest precipitation: Sept. - Nov. months of drought: -- months with temperatures below zero: (Oct.) Nov. - Apr.	0 - 2100 m steep land
2.2	Leptosol-Region, with glaciers, or permanent snow cover, of Southwest-Norway (LPq, LPu, PZh)	igneous and metamorphic rocks alternating with paleozoic sedimentary rocks, and partly covered with glacial deposits (ground moraine)	mean annual temperature: -0.3 - 1.5°C mean annual precipitation: 570 - 880 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: (Sept.) Oct. - May	1600 - 2500 m steep land
2.3	Leptosol-, Podzol-Region, partly with Histosols, of East-Iceland	igneous rocks, partly with thin and patchy morainal deposits	mean annual temperature: 0.0 - 3,5°C mean annual precipitation: 1200 - 1900 mm	0 - 1200 m sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(LPq, LPu, PZh, HSf)		months of highest precipitation: -- months of drought: -- months with temperatures below zero: Dec. - Febr.	
2.4	Leptosol-Region, rarely with Andosols, Podzols, Cambisols and two glacier areas, of Central Iceland (LPq, ANh, PZh, CMd)	Basic igneous rocks, mainly effusive (basalt) or pyroclastic (tuff), of quaternary age, partly covered with a thin layer of eolian sand	mean annual temperature: in the western part: 2.0 - 4.0°C in the northern part: -0.1 - 2.0°C mean annual precipitation: in the western part: 870 - 1040 mm in the northern part: 320 - 400 mm months of highest precipitation: -- months of drought: -- months with temperatures below zero: in the western part: Dec. - Mar. in the northern part: Oct. - Apr.	0 - 1800 m sloping land
3.	**Podzol - Cambisol Regions**			
3.1	Podzol-Region, partly with Cambisols, of North-Sweden (PZh, PZg, CMd)	loamy, partly sandy glacial deposits (ground moraine, outwash sand) overlying igneous and metamorphic rocks	mean annual temperature: 1.0 - 2.7°C mean annual precipitation: 450 - 570 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: Oct. - Apr.	0 - 800 m level to sloping land
3.2	Podzol-Region, with Cambisols and Histosols of Middle-Finland (PZh, CMd, HSf)	loamy glacial deposits (ground moraine), overlying igneous and metamorphic rocks	mean annual temperature: 1.6 - 2.1°C mean annual precipitation: 540 - 600 mm months of highest precipitation: July - Aug.	0 - 300 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
			months of drought: -- months with temperatures below zero: Oct. - Apr.	
3.3	Podzol-, Regosol-Region, with Histosols and partly with Cambisols, of South-Iceland (PZh, RGd, HSf, CMd)	glacifluvial and fluvial deposits and eolian sands, partly loess with intercalations of tuff	mean annual temperature: 3.7 - 4.4^{o}C mean annual precipitation: 1100 - 1400 mm months of highest precipitation: -- months of drought: -- months with temperatures below zero: Dec. - Febr.	0 - 150 m level land
4.	**Podzol - Leptosol Regions**			
4.1	Podzol-Region, with Leptosols and Histosols, of Middle-Norway (PZh, LPq, LPu, HSf)	igneous and metamorphic rocks (schist, granite), partly covered by loamy glacial deposits	mean annual temperature: 4.7 - 5.2^{o}C mean annual precipitation: 870 - 1100 mm months of highest precipitation: Sept. - Nov. months of drought: -- months with temperatures below zero: Oct. - Apr.	0 - 1400 m steep to sloping land
4.2	Podzol-, Leptosol-Region of North-Norway and North-Finland (PZh, PZg, LPq, LPu)	loamy glacial deposits (ground moraine) overlying paleozoic sedimentary rocks, partly permafrost	mean annual temperature: -2.0 - -0.4^{o}C mean annual precipitation: 370 - 410 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Sept. - May	400 - 600 m level land
4.3	Podzol-, Leptosol-Region, with Andosols, partly with Cambisols, and with two glacier areas, of Northeast-Iceland (PZh, LPq, ANh, CMd)	igneous rocks, partly covered with ground moraine and partly with thin and patchy morainal deposits	mean annual temperature: 0.3 - 2.8^{o}C mean annual precipitation: in the western part: 750 - 850 mm in the northern part: 330 - 500 mm months of highest precipitation: Jan., Oct. months of drought: partly with deficit in June and July in the northern part months with temperatures below zero: Nov. - Mar.	0 - 1000 m sloping alnd

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM

SOIL REGIONS WITH BOREAL TO TEMPERATE CLIMATE

5. Cambisol - Gleysol - Luvisol Region

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
5.1	Cambisol-, Gleysol-, Luvisol-Region of Northeast Poland and the southern part of the Kaliningrad area of Russia (CMe, GLe, LVj)	loamy glacial deposits (ground moraine)	mean annual temperature: 6.5 - 6.8^{o}C mean annual precipitation: 640 - 680 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Dec. - Mar.	0 - 200 m level, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
6.	**Gleysol - Luvisol - Podzol Regions**			
6.1	Gleysol-, Luvisol-, Podzol-Region of Northeast-Poland (GLe, LVj, PZg)	loamy to sandy glacial deposits (ground moraine, outwash sand)	mean annual temperature: 5.8 - 6.7^{o}C mean annual precipitation: 540 - 620 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Nov. - Mar.	100 - 250 m level, partly sloping land
6.2	Gleysol-, Fluvisol-Region, with Regosols, Podzols and Histosols, of the estuary of Nemunas (Neman) in the border zone of Lithuania and the Kaliningrad area of Russia (GLe, FLe, RGd, PZh, HSf)	Fluvial deposits, partly eolian sand	mean annual temperature: 6.4 - 6.7^{o}C mean annual precipitation: 630 - 720 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: Nov. - Mar.	0 - 30 m level land
6.3	Luvisol-, Gleysol-, Podzoluvisol-Region, partly with Arenosols, of the Baltic countries and the Russian area of Kliningrad (LVg, LVh, GLe, PDg, ARb)	glacial deposits (ground moraine) and glaciolacustrine, glaciofluvial and fluvial sands and loam	mean annual temperature: 4.7 - 6.5^{o}C mean annual precipitation: 550 - 650 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: Nov. - Mar. (Apr.)	30 - 220 m level, partly sloping land
6.4	Luvisol-, Gleysol-, Arenosol-Region, with Fluvisols-, Podzoluvisols and Podzols, of	Glaciolacustrine, glaciofluvial and fluvial sands and loam, glacial deposits (ground moraine) and partly eolian sands	mean annual temperature: 6.0 - 6.5^{o}C mean annual precipitation: 570 - 630 mm months of highest precipitation: Aug.	50 - 150 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	South-Lithuania and the northwest part of the Russian area of Kaliningrad (LVj, GLe, ARb, FLe, PDg, PZg)		months of drought: -- months with temperatures below zero: Nov. - Mar.	

7. Gleysol - Podzol - Histosol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
7.1	Gleysol-, Podzol-, Histosol-Region of East-Poland (GLd, PZg, PZb, HSf, HSl)	loamy to sandy fluvial deposits	mean annual temperature: 5.8 - 6.5^{o}C mean annual precipitation: 550 - 660 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Nov. - Mar.	100 - 200 m level land
7.2	Gleysol-, Podzol-, Histosol-Region, partly with Arenosols, in West-Latvia and in the coastal area of Estonia (GLe, PZh, HSf, ARb)	glaciolacustrine sands and loam, glacial deposits (ground moraine), marine and estuarine alluvium and organic material	mean annual temperature: 5.0 - 6.0^{o}C mean annual precipitation: 510 - 600 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: Nov. - Mar.	0 - 50 m level land

8. Histosol - Podzol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
8.1	Histosol-, Podzol-Region of Northwest-Scottland (HSf, HSl, PZh)	cristalline rocks and migmatites, schists and volcanic rocks, and organic material, often covered with glacial deposits (ground moraine)	mean annual temperature: 7.7 - 8.5^{o}C mean annual precipitation: 960 - 1300 mm Months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: (Dec. - Febr.)	0 - 1100 m sloping to steep land
8.2	Histosols-, Podzol-, Cambisol-Region, with Gleysols, of North-Estonia	glacial deposits (ground moraine), glaciolacustrine and fluvial sands and loam, often covered by organic material and	mean annual temperature: 4.7 - 5.0^{o}C mean annual precipitation: 510 - 590 mm months of highest precipitation: Aug.	0 - 120 m level, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(HSf, PZh, CMc, GLe)	partly overlying limestone	months of drought: -- months with temperatures below zero: Nov. - Apr.	
8.3	Histosol-, Podzol-, Luvisol-Region of East-Latvia (HSf, PZg, LVg)	glaciolacustrine sands and loam and glacial deposits (ground moraine), often covered by organic material	mean annual temperature: 5.0 - 5.5 ^{o}C mean annual precipitation: 580 - 650 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: Nov. - Mar. (Apr.)	30 - 120 m level land
9.	**Podzol - Cambisol Regions**			
9.1	Podzol-, Cambisol-Region of South-Norway (PZh, CMd, CMg)	quaternary marine deposits	mean annual temperature: 5.4 - 6.1^{o}C mean annual precipitation: 740 - 900 mm months of highest precipitation: Aug., Oct. months of drought: -- months with temperatures below zero: Nov. - Mar.	0 - 80 m level, partly sloping land
9.2	Podzol-, Cambisol-Region of South-Finland (PZh, CMd, CMv)	loamy to sandy glacial deposits (ground moraine, outwash sand)	mean annual temperature: 3.4 - 4.5^{o}C mean annual precipitation: 500 - 620 mm months of highest precipitation: Aug. - Oct. months of drought: -- months with temperatures below zero: (Oct.) Nov. - Apr.	0 - 250 m level land
9.3	Podzol-, Cambisol-Region of Middle-Sweden (PZh, PZg, CMd)	loamy glacial deposits (ground moraine), partly overying igneous and metamorphic rocks	mean annual temperature: 3.9 - 5.8^{o}C mean annual precipitation: 480 - 600 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: (Oct.) Nov. - Apr.	0 - 800 m level to sloping land
9.4	Podzol-Region, with Gleysols	glaciolacustrine, glaciofluviatile and	mean annual temperature: 5.8 - 6.6^{o}C	0 - 50 m

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	and partly with Cambisols, Histosols and Arenosols, of the coastal area of Latvia (PZh, PZg, GLe, CMe)	fluviatile sands and loam, and organic material	mean annual precipitation: 550 - 660 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: Dec. - Mar.	level land
10.	**Podzol - Cambisol - Histosol Region**			
10.1	Podzol-, Cambisol-, Histosol-Region of Southwest-Norway (PZh, CMd, HSf)	igneous and metamorphic rocks partly covered with glacial deposits(ground moraine), and organic material	mean annual temperature: 4.4 - 7.2°C mean annual precipitation: 1100 - 1600 mm months of highest precipitation: Sept. - Jan. months of drought: -- months with temperatures below zero: Nov. - Mar.	0 - 1600 m steep land
11.	**Podzol - Cambisol - Leptosol Region**			
11.1	Podzol-, Cambisol-, Leptosol-Region of South-Norway (PZh, CMd, LPu, LPq)	igneous and metamorphic rocks alternating with paleozoic sedimentary rocks, partly covered with glacial deposits (ground moraine)	mean annual temperature: 6.8 - 7.6°C mean annual precipitation: 1100 - 1700 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: Dec. - Mar.	0 - 600 m sloping land
12.	**Podzol - Histosol - Leptosol Regions**			
12.1	Podzol-Region, with Histosols and partly with Leptosols, of Northeast-Scottland (PZh, PZb, HSf, HSl, LPu)	cristalline rocks and migmatites, schists and volcanic rocks, often covered with glacial deposits, and organic material	mean annual temperature: 7.7 - 8.2°C mean annual precipitation: 850 - 980 mm Months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: (Dec. - Febr.)	0 - 1300 m sloping, partly steep land
12.2	Podzol-Region, with Histosols and partly with Leptosols, of Middle-Sweden and South-Norway	loamy glacial deposits (ground moraine), partly overlying igneous and metamorphic rocks	mean annual temperature: 2.8 - 5.2°C mean annual precipitation: 520 - 710 mm months of highest precipitation: Aug. months of drought: --	200 - 1000 m level to sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(PZh, PZg, HSf, LPu)		months with temperatures below zero: (Oct.) Nov. - Apr.	
12.3	Podzol-, Histosol-, Leptosol-Region of Southeast-Norway (PZh, PZg, HSf, LPu, LPq)	igneous and metamorphic rocks alternating with paleozoic sedimentary rocks, partly covered with glacial deposits	mean annual temperature: 2.8 - 4.4^{o}C mean annual precipitation: 680 - 880 mm months of highest precipitation: Aug., (Oct.) months of drought: -- months with temperatures below zero: Oct. - Apr.	500 - 1300 m sloping, partly steep land

SOIL REGIONS WITH TEMPERATE CLIMATE

13. Arenosol - Podzol - Cambisol Region

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
13.1	Arenosol-, Podzol-, Cambisol-Region of the younger glacial drift area in Northeast-Germany and Northwest Poland (ARb, ARl, PZh, CMe, CMd)	sandy sediments (outwash sand, cover sand) and partly loamy glacial deposits (ground moraine)	mean annual temperature: 7.0 - 8.0^{o}C mean annual precipitation: 540 - 650 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Mar.	30 - 160 m level, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
14.	**Cambisol - Andosol Region**			
14.1	Cambisol-, Andosol-Region, with Podzols, of West-Carpathian Mts. in Romania (CMd, ANh, PZb)	igneous and metamorphic rocks (granite, basalt, andesite, tuff, gneiss) alternating with flysh deposits	mean annual temperature: 4.8 - 8.2°C mean annual precipitation: 580 - 750 mm months of highest precipitation: June - July months of drought: -- months with temperatures below zero: Nov. - Mar.	450 - 2100 m steep, partly sloping land
15.	**Cambisol - Gleysol - Podzol Regions**			
15.1	Cambisol-, Gleysol-, Podzol-Region of Wales (Cambrian Mountains) (CMd, CMe, GLd, PZh)	very different rocks (slate, greywacke, sandstone, siltstone limestone, igneous rocks)	mean annual temperature: 8.1 - 9.6°C mean annual precipitation: 900 - 1200 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: --	0 - 900 m sloping, partly steep land
15.2	Cambisol-, Gleysol-Region of Southwest England (Cornwall, Devon) (CMd, GLd)	paleozoic sedimentary rocks alternating with ingneous rocks	mean annual temperature: 10.4 - 11.4°C mean annual precipitation: 850 - 1050 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: --	0 - 600 m sloping land
16.	**Cambisol - Leptosol Regions**			
16.1	Cambisol-, Leptosol-Region of North-Portugal (CMu, CMe, LPq, LPu)	acid intrusive igneous rocks(granite), paleozoic and precambrian slates	mean annual temperature: 10.2 - 13.5°C mean annual precipitation: 950 - 1100 mm months of highest precipitation: Oct., Mar. months of drought: (July - Aug.)	0 - 1900 m sloping, partly steep

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
			months with temperatures below zero: --	
16.2	Cambisol-, Leptosol-Region of Southeast-Poland (Beskidy) (CMd, LPu, LPq)	cretaceous and tertiary flysh, marl, sandstone and limestone	mean annual temperature: 5.0 - 5.8^{o}C mean annual precipitation: 900 - 1200 mm months of highest precipitation: June - Aug. months of drought: -- months with temperatures below zero: Nov. - Mar.	480 - 1600 m sloping to steep land
16.3	Cambisol-, Leptosol-Region with Luvisols and Regosols, of "former Yugoslavia" (CMd, LPu, LPq, LVh, RGd)	igneous and metamorphic rocks (granite, peridotite, schist) and sandstone	mean annual temperature: 7.8 - 9.6^{o}C mean annual precipitation: 1000 - 1450 mm months of highest precipitation: Oct. - Nov. months of drought: -- months with temperatures below zero: Dec.- Mar.	450 - 2100 m steep land
17.	**Cambisol - Leptosol - Podzol Regions**			
17.1	Cambisol-, Leptosol-, Podzol-Region of South-Ireland (CMd, CMe, LPq, PZh)	paleozoic sedimentary rocks alternating with igneous and metamorphic rocks	mean annual temperature: 8.9 - 10.3^{o}C mean annual precipitation: 980 - 1200 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: --	0 - 900 m composite land- forms (level to steep but mostly sloping land)
17.2	Cambisol-, Leptosol-, Podzol-Region of East-France (Lorraine) and West-Germany (Pfälzer Wald) (CMe, CMk, LPk, PZh, PZb)	triassic and lower jurassic clayey to sandy sedimentary rocks (claystone, sandstone), and marl and limestone	mean annual temperature: 8.8 - 9.6^{o}C mean annual precipitation: 750 - 870 mm months of highest precipitation: Nov., July months of drought: -- months with temperatures below zero: Dec. - Febr.	250 - 550 m sloping to level land
17.3	Cambisol-, Leptosol, Podzol-Region of South-Germany (Schwäbisch-Fränkisches Keuperbergland and Albvorland)	clayey to sandy triassic, jurassic and cretaceous sedimentary rocks (claystone, sandstone)	mean annual temperature: 7.4 - 8.4^{o}C mean annual precipitation: 680 - 780 mm months of highest precipitation: July months of drought: --	350 - 550 m sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(CMe, CMv, CMd, LPu, PZh)		months with temperatures below zero: Dec. - Febr.	
18.	**Cambisol - Luvisol Regions**			
18.1	Cambisol-Region, with Luvisols of West-France (Bretagne, West Normandie) (CMd, CMe, LVh)	igneous and metamorphic rocks (granite, slate, schist), partly covered with loess	mean annual temperature: 11.3 - 12.0^{o}C mean annual precipitation: 650 - 850 mm months of highest precipitation: Oct. - Dec. months of drought: -- months with temperatures below zero: --	0 - 300 m level, partly sloping land
18.2	Cambisol-Region, with Luvisols and partly wiht Gleysols, of West-Germany (Westerwald, Vogelsberg, Eifel) (CMd, CMe, LVh, GLe)	basic volcanic rocks and pyroclastic rocks (basalt, pumice), partly covered with loess	mean annual temperature: 5.5 - 7.7^{o}C mean annual precipitation: 760 - 940 mm months of highest precipitation: Nov., July months of drought: -- months with temperatures below zero: Dec. - Mar.	550 - 750 m sloping land
18.3	Cambisol-Region, with Luvisols, of South-Sweden (CMe, CMv, LVh)	loamy glacial and partly glcciolacustrine deposits (ground moraine, glcial clay)	mean annual temperature: 7.1 - 7.5^{o}C mean annual precipitation: 580 - 620 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: Jan. - Febr.	0 - 120 m level land
18.4	Cambisol-, Luvisol-Region, partly with Podzols, of Southeast-Germany and Czech Republik (Thüringer Wald, Erzgebirge, Bohemian massif) (CMd, LVg, PZh)	igneous and metamorphic rocks rocks (granite, rhyolite, gneiss, schist, slate), and paleozoic sedimentary rocks (sandstone, greywacke), partly covered with loess	mean annual temperature: 4.5 - 5.8 (7.5)^{o}C mean annual precipitation: 950 - 1100 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Nov. - Mar.	550 - 1400 m sloping, partly steep land
19.	**Cambisol - Luvisol - Gleysol Region**			
19.1	Cambisol-, Luvisol-Region, with	flysch and molasse, partial covered with	mean annual temperature: 7.5 - 8.2^{o}C	380 - 520 m

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	Gleysols, of the Alpine Foreland in Germany and Austria (CMe, LVh, GLe)	loess or with glaciofluvial gravel, and fluvial quaternary deposits	mean annual precipitation: 670 - 770 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Nov. - Mar.	level to sloping land

20. Cambisol - Luvisol - Leptosol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
20.1	Cambisol-, Leptosol-Region, with Luvisols, of North Spain (Pais vasco, Cantabria) (CMe, CMu, LPk, LVh)	cretaceous, partly jurassic and tertiary calcareous deposits (flysch, limestone)	mean annual temperature: 13.6 - 14.5^{o}C mean annual precipitation: 900 - 1300 mm months of highest precipitation: Nov. - Jan. months of drought: ((Aug.)) months with temperatures below zero: --	0 - 1800 m sloping, partly steep land
20.2	Cambisol-Region, with Lepto-sols, Luvisols and Podzoluvisols of Central-France (parts of Nivernais, Bourgogne and Lorraine) (CMe, LPk, LVh, PDe)	jurassic and cretaceous limestone, marl and residual loam	mean annual temperature: 8.9 - 9.6^{o}C mean annual precipitation: 810 - 900 mm months of highest precipitation: Oct. months of drought: -- months with temperatures below zero: Dec. - Febr.	250 - 600 m sloping to level land
20.3	Cambisol-, Luvisol-, Leptosol-Region of Central-Germany (Weser-Leine Bergland, Hessisch-Thüringisches Bergland) (CMe, LVh, LPk)	triassic clayey to sandy sedimentary rocks (claystone, sandstone), and marl and limestone, partly covered with loess	mean annual temperature: 7.9 - 8.4^{o}C mean annual precipitation: 520 - 600 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Febr.	250 - 600 m sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
21.	**Cambisol - Podzol Regions**			
21.1	Cambisol-Region, with Podzols, of East-France (Vosges) (CMd, PZb, PZh)	igneous and metamorphic rocks (granite, gneiss, schist), and partly sandstone	mean annual temperature: 8.8 - 9.3°C mean annual precipitation: 900 - 980 mm months of highest precipitation: Oct. - Dec. months of drought: -- months with temperatures below zero: Dec. - Febr.	600 - 1300 m sloping to steep land
21.2	Cambisol-Region, with Podzols, of Southwest Germany (Schwarz-wald, West-Odenwald, West-Spessart) (CMd, PZh PZb)	acid igneous and metamorphic rocks (granite, gneiss, schist), and partly sandstone	mean annual temperature: 5.8 - 7.5°C mean annual precipitation: 1000 - 1400 mm months of highest precipitation: -- months of drought: -- months with temperatures below zero: Nov. - Mar.	500 - 1400 m sloping to steep land
21.3	Cambisol-Region, with Podzols of West Germany (Pfälzer Bergland) (CMd, PZh)	upper cretaceous and lower permian clastic sedimentary rocks (sandstone, conglome-rate, siltstone) alternating with effusive igneous rocks (andesite, basalt)	mean annual temperature: 8.8 - 9.2°C mean annual precipitation: 600 - 700 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Febr.	350 - 550 m sloping land
22.	**Cambisol - Podzol - Andosol Region**			
22.1	Cambisol-, Podzol-, Andosol-Region, with Luvisols and Leptosols, of Central France (Marche, Limousin, Auvergne, Lyonnais, Bourgogne, Massif Central)	igneous and metamorphic rocks (granite, basalt, migmatite, gneiss, schist)	mean annual temperature: 9.6 - 11.5°C mean annual precipitation: 800 - 1200 mm months of highest precipitation: Oct. - Dec. months of drought: -- months with temperatures below zero: (Dec.) Jan. - Febr.	550 - 1880 m sloping to steep land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(CMd, PZb, ANh, LVh, LPu)			

23. Cambisol - Podzol - Leptosol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
23.1	Cambisol-, Podzol-, Leptosol-Region, with Gleysols and Histosols, of North-Ireland (CMd, PZh, LPq, GLu, HSf)	igneous and metamorphic rocks (basalt, granite, schist) alternating with paleozoic sedimentary rocks, partly covered with glacial deposits (ground moraine)	mean annual temperature: 8.9 - 9.4^{o}C mean annual precipitation: 1000 - 1250 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: --	0 - 650 m sloping land
23.2	Cambisol-Region, with Podzols and Leptosols, of East-Belgium, West-Germany and North-Luxembourg (Ardennes, Rheinisches Schiefergebirge, Hunsrück) (CMe, CMd, PZh, LPu)	devonian and carboniferous sedimentary and metamorphic rocks (slate, siltstone, sandstone, quartzite, limestone), and effusive igneous rocks (diabase, keratophyre), partly covered with loess	mean annual temperature: 7.1 - 9.0^{o}C mean annual precipitation: 880 - 1150 mm months of highest precipitation: Dec. - Jan. months of drought: -- months with temperatures below zero: Dec. - Febr.	400 - 800 m sloping, partly steep land
23.3	Cambisol-Region, with Podzols and Gleysols, of Central-Germany (Harz) (CMd, CMe, PZh, GLe)	very different paleozoic sedimentary and metamorphic rocks (siltstone, sandstone, greywacke, limestone, slate, schist), and igneous rocks (granite, rhyolite)	mean annual temperature: 5.8 - 7.4^{o}C mean annual precipitation: 820 - 1300 mm months of highest precipitation: July, Dec. months of drought: -- months with temperatures below zero: Dec. - Mar.	350 - 1100 m sloping land
23.4	Cambisol-Region, with Podzols, Leptosols and Luvisols, of the Carpathian Mts. in East-Romania (CMe, PZb, LPq, LVh)	calcareous and clastic flysh deposits (limestone, marl, sandstone)	mean annual temperature: 5.2 - 8.2^{o}C mean annual precipitation: 580 - 720 mm months of highest precipitation: June - July months of drought: -- months with temperatures below zero: Nov. - Febr.	500 - 1600 m steep, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
23.5	Cambisol-, Podzol-, Leptosol-Region, with Luvisol, of the high mountains in Romania, "former Yugoslavia" and Bulgaria (Carpati Meridionali, Stara Planina, Rila Mts., Pirin Mts., Rhodopi Planina) (CMd, PZb, LPq, LPu, LVh)	igneous and metamorphic rocks (tuff, granite, gneiss) and flysh deposits, partly covered with residual loam	mean annual temperature: 6.2 - 7.8^{o}C mean annual precipitation: 780 - 900 mm months of highest precipitation: June, Nov. months of drought: -- months with temperatures below zero: Nov. - Mar.	450 - 2900 m steep, partly sloping land
24.	**Cambisol - Podzoluvisol - Leptosol Region**			
24.1	Cambisol-, Podzoluvisol-Region, with Luvisols, of Southwest-France (Gascogne) (CMk, CMx, PDe, LVh)	tertiary deposits (flysch and molasse, marl) and fluvial quaternary sediments	mean annual temperature: 12.0 - 13.4^{o}C mean annual precipitation: 740 - 850 mm months of highest precipitation: May, Dec. months of drought: (July) months with temperatures below zero: --	100 - 600 m sloping, partly level land
25.	**Chernozem - Kastanozem - Phaeozem Region**			
25.1	Chernozem-, Kastanozem-, Phaeozem-Region, with Luvisols and partly Vertisols, of South- and East-Romania and North-Bulgaria (CHh, KSh, PHh, LVh, VRe)	eolian deposits (loamy loess, partly sandy loess)	mean annual temperature: 10.8 - 11.2^{o}C mean annual precipitation: 510 - 580 mm months of highest precipitation: May - June months of drought: (deficite in August) months with temperatures below zero: (Jan. - Febr.)	80 - 200 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
26.	**Chernozem - Luvisol Region**			
26.1	Chernozem-Region, with Luvisols, of the central German low-rainfall area (CHh, LVh)	eolian deposits (loess)	mean annual temperature: 7.9 - 9.1^{o}C mean annual precipitation: 460 - 540 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Febr.	80 - 220 m level, partly sloping land
27.	**Fluvisol - Gleysol Regions**			
27.1	Fluvisol-Region, with Gleysols, of the Lower Elbe area in Northwest-Germany (FLe, GLe)	loamy to clayey river deposits	mean annual temperature: 8.0 - 8.5^{o}C mean annual precipitation: 580 - 730 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Dez. - Febr. (Mar.)	0 - 30 m level land
27.2	Fluvisol-Region of Wisla valley in Central-and North-Poland (FLe)	sandy to loamy river deposits	mean annual temperature: 7.3 - 7.8^{o}C mean annual precipitation: 510 - 550 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Dec. - Mar.	0 - 80 m level land
27.3	Fluvisol-Region of Upper Elbe area in Czech Republic (FLe)	sandy to loamy river deposits	mean annual temperature: 8.4 - 8.9^{o}C mean annual precipitation: 530 - 550 mm months of highest precipitation: July, (Oct.) months of drought: -- months with temperatures below zero: Dez. - Febr.	140 - 220 m level land
27.4	Fluvisol-Region, with Gleysols, of the Middle Elbe area in Germany (FLe, GLe)	sandy to loamy, partly clayey river deposits	mean annual temperature: 8.5 - 9.2^{o}C mean annual precipitation: 500 - 580 mm months of highest precipitation: July months of drought: --	50 - 70 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
			months with temperatures below zero: Dez. - Febr.	
27.5	Fluvisol-Region of the Danube valley in Romania (FLe)	sandy to loamy river deposits	mean annual temperature: 10.8 - 11.2°C mean annual precipitation: 410 - 550 mm months of highest precipitation: June months of drought: (Aug.- Sept.) months with temperatures below zero: Dec. - Febr.	0 - 60 m level land
28.	**Fluvisol - Luvisol Region**			
28.1	Fluvisol-Region, with Luvisols, of the Upper Rhine valley in France and Germany (FLc, FLe, FLd, LVx)	loamy to sandy river deposits	mean annual temperature: 9.7 - 10.2°C mean annual precipitation: 670 - 750 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Febr.	90 - 200 m level land
29.	**Fluvisol - Luvisol - Solonchak - Solonetz Region**			
29.1	Fluvisol-, Luvisol-Region, partly with Solonchaks and Solonetz, of the large fluvial plains in Hungary and"former Yugoslavia" (FLe, LVh, SCh, SNh)	sandy to loamy river deposits	mean annual temperature: 10.0 - 11.1°C mean annual precipitation: 540 - 650 mm months of highest precipitation: June months of drought: (deficite in August) months with temperatures below zero: Dec. - Febr.	70 - 140 m level land
30.	**Fluvisol - Podzol Regions**			
30.1	Fluvisol-Region, with Cambisols and Podzols, of the Lower Rhine area in The Netherlands and Germany (FLc, CMc, PZh, PZg, PZc)	loamy to sandy river deposits, and eolian deposits (eolian sand)	mean annual temperature: 9.0 - 9.7°C mean annual precipitation: 660 - 770 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Jan. - Febr.	0 - 40 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
30.2	Fluvisol-, Podzol-Region of Wisla and San valley in Southeast-Poland (Fle, PZb)	sandy to loamy river deposits and sandy glaciofluvial deposits	mean annual temperature: 7.4 - 7.7^{o}C mean annual precipitation: 520 - 560 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Nov. - Mar.	120 - 160 m level land

31. Fluvisol - Regosol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
31.1	Fluvisol-, Regosol-Region of the North Sea coast in Belgium, Netherlands and Germany (FLc, FLd, FLe, RGc, RGd)	holocene marine or estuarine sediments (sand, clay) and dunes	mean annual temperature: 8.0 - 9.7^{o}C mean annual precipitation: 740 - 800 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: Dec. - Febr.	0 - 30 m level land
31.2	Fluvisol-Region of East-England (Lincoln, Norfolk) (FLd)	holocene marine or estuarine sediments	mean annual temperature: 9.3 - 9.8^{o}C mean annual precipitation: 550 - 570 months of highest precipitation: (Nov.) months of drought: -- months with temperatures below zero: --	0 - 30 m level land

32. Gleysol - Cambisol - Luvisol Region

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
32.1	Gleysol-, Cambisol-Region, with Luvisols and Podzols, of South-Scotland and North-England (GLd, GLu, CMe, CMd, LVg, PZh)	different paleozoic rocks (schist, sandstone, limestone), and effusive igneous rocks, often covered with glacial deposits (ground moraine)	mean annual temperature: 8.6 - 9.1^{o}C mean annual precipitation: 870 - 950 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: (Jan. - Febr.)	0 - 80 m sloping, partly level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
33.	**Gleysol - Leptosol - Podzol Region**			
33.1	Gleysol-, Leptosol-, Podzol-Region, with Histosols, of West-Ireland (GLd, LPu, PZb, HSf)	igneous and metamorphic rocks alternating with paleozoic sedimentary rocks, partly covered with glacial deposits (ground moraine)	mean annual temperature: 8.7 - 9.7^{o}C mean annual precipitation: 980 - 1300 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: --	0 - 700 m composite land- forms (level to steep but mostly sloping to level land)
34.	**Leptosol - Regions**			
34.1	Leptosol-Region of the Champagne (France) (LPk)	calcareous sedimentary rocks of cretaceous age (secondary chalk)	mean annual temperature: 9.7 - 10.0^{o}C mean annual precipitation: 730 - 800 mm months of highest precipitation: Oct. - Dec. months of drought: -- months with temperatures below zero: Jan. - Febr.	150 - 280 m level, partly sloping land
34.2	Leptosol-Region of the Northern and Western Alps, partly with permanent snow cover or glaciers (LPk, LPq)	mesozoic calcareous rocks (limestone)	mean annual temperature: 5.2 - 6.3^{o}C mean annual precipitation: 900 - 1300 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Nov. - Mar.	750 - 3100 m steep land
34.3	Leptosol-Region of the Southern Alps (LPk, LPq)	mesozoic calcareous rocks (dolomite, limestone)	mean annual temperature: 7.5 - 9.5 (12.0)^{o}C mean annual precipitation: 600 - 1000 mm months of highest precipitation: May, Oct. months of drought: -- months with temperatures below zero: Dec. - Febr.	750 - 3300 m steep land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM

35. Leptosol - Cambisol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
35.1	Leptosol-, Cambisol-Region, with Luvisols and Podzols, of Northwest-Spain (Galicia, Asturia) (LPu, LPk, CMu, LVh)	igneous and metamorphic rocks (granite, gneiss,schist), partly jurassic limestone	mean annual temperature: (9.5) 12.0 - 13.6°C mean annual precipitation: 760 - 1400 mm months of highest precipitation: Oct. - Mar. (Apr.) months of drought: -- months with temperatures below zero: (Jan. - Febr.)	0 - 2100 m steep to sloping land
35.2	Leptosol-, Cambisol-Region, partly with Luvisols, of South-Germany (Schwäbische and Fränkische Alb) (LPk, CMe, CMx, LVh)	jurassic limestone and redeposited loam	mean annual temperature: 6.4 - 7.4°C mean annual precipitation: 680 - 750 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Mar.	550 - 950 m sloping, partly steep land
35.3	Leptosol-, Cambisol-Region, partly with Luvisols, of Jura in East-France and West-Switzerland (LPk, CMk, LVk)	jurassic and cretaceous limestone	mean annual temperature: 4.5 - 6.7°C mean annual precipitation: 1100 - 1500 mm months of highest precipitation: -- months of drought: -- months with temperatures below zero: Nov. - Mar.	600 - 1300 m steep, partly sloping land
35.4	Leptosol-, Cambisol-Region, with Regosols and Luvisols, of "former Yugoslavia" (LPq, LPk, CMe, RGe, LVh)	flysh, limestone, dolomite, marl, partly residual loam to clay	mean annual temperature: 8.7 - 9.4°C mean annual precipitation: 1150 - 1450 mm months of highest precipitation: Oct. - Nov. months of drought: -- months with temperatures below zero: Dec. - Mar.	450 - 2000 m steep land
35.5	Leptosol-Region, with Cambisols and Podzols of the Pyrenees (LPq, LPu, LPk, CMu, CMe, PZh)	frequently alternating igneous and metamorphic rocks (granite, gneiss, schist, slate), and sedimentary rocks (limestone, sandstone)	mean annual temperature: 6.0 - 10.5°C mean annual precipitation: 880 - 1200 mm months of highest precipitation: May, Nov. months of drought: -- months with temperatures below zero: Nov. - Mar (Apr.)	600 - 3400 m steep land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
36.	**Leptosol - Cambisol - Luvisol Regions**			
36.1	Leptosol-, Cambisol-Region, with Luvisols and Regosols, of West-France (Dordogne) (LPk, CMx, LVk, RGc)	jurassic and cretaceous clayey to sandy deposits, and chalk and limestone	mean annual temperature: 12,2 - 12.7^{o}C mean annual precipitation: 770 - 820 mm months of highest precipitation: Oct. - Nov. months of drought: -- months with temperatures below zero: --	0 - 350 m level to sloping land
36.2	Leptosol, Cambisol-,Luvisol-Region, with Gleysols and Podzols, of South-England (LPk, CMe, CMg, LVg, LVh, GLe, PZh)	jurassic, cretaceous and tertiary sedimentary rocks (frequently alternating clayey, sandy and calcareous deposits)	mean annual temperature: 9.2 - 10.1^{o}C mean annual precipitation: 650 - 720 mm months of highest precipitation: Oct. - Nov. months of drought: -- months with temperatures below zero: --	0 - 300 m level to sloping land
36.3	Leptosol-, Cambisol-, Luvisol-Region of Central-Germany (Fränkische Platten) (LPk, CMx, CMe, LVh)	middle triassic limestone, partly covered with loess	mean annual temperature: 7.8 - 8.2^{o}C mean annual precipitation: 710 - 750 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Febr.	280 - 600 m sloping, partly level land
36.4	Leptosol-Region, with Luvisols and Cambisols of the Bakony Mts. in Hungary (LPk, LVh, CMe)	triassic and cretaceous limestone and marl, partly tertiary volcanic rocks	mean annual temperature: 9.4 - 10.6^{o}C mean annual precipitation: 670 - 710 mm months of highest precipitation: May, Aug. months of drought: -- months with temperatures below zero: Dec. - Febr.	120 - 500 m sloping land
37.	**Leptosol - Podzol - Cambisol Regions**			
37.1	Leptosol-Region, with Podzols and Cambisols of the Central Alps, partly with glaciers or permanent snow cover	igneous and metamorphic rocks (granite, gneiss, schist)	mean annual temperature: 4.5 - 5.7^{o}C mean annual precipitation: 1000 - 1250 mm months of highest precipitation: May - Oct. months of drought: --	750 - 4800 m steep land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(LPu, LPq, PZb, CMd)		months with temperatures below zero: Nov. - Mar. (Apr.)	
37.2	Leptosol-, Cambisol-Region, with Podzols, of Slovakia (Tatry, Fatra) (LPq, LPu, CMd, PZb)	igneous rocks (volcanic tuff, granite), partly metamorphic rocks (gneiss, schist)	mean annual temperature: 4.8 - 5.8^{o}C mean annual precipitation: 900 - 1100 mm months of highest precipitation: May - Aug. months of drought: -- months with temperatures below zero: Nov. - Mar.	750 - 2600 m steep, partly sloping land

38. Luvisol - Cambisol - Gleysol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
38.1	Luvisol-Region, with Cambisols and Gleysols, of East-Denmark and North-Germany (East-Schleswig-Holstein) (LVh, LVg, CMe, GLe)	loamy glacial deposits (ground moraine)	mean annual temperature: 7.4 - 7.9^{o}C mean annual precipitation: 570 - 660 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: (Dec.) Jan. - Febr.	0 - 120 m level, partly sloping land
38.2	Luvisol-, Cambisol-Region, with Gleysols, of "Middle"-England (LVg, LVh, CMg, GLe)	triassic sedimentary rocks (continental series: sandstone, claystone) and jurassic to cretaceous limestone and marl; often covered with glacial deposits (ground moraine)	mean annual temperature: 8.3 - 9.7^{o}C mean annual precipitation: 740 - 900 mm months of highest precipitation: Aug., Oct. months of drought: -- months with temperatures below zero: --	0 - 350 m level to sloping land
38.3	Luvisol-, Cambisol-Region, with Gleysols, in the North of The Alps (Switzerland, Germany and Austria) (LVh, CMe, GLe)	calcareous loamy and sandy to gravelly morainic deposits, partly mixed with loess	mean annual temperature: 6.8 - 7.7^{o}C mean annual precipitation: 860 - 1000 mm months of highest precipitation: May - Aug. months of drought: -- months with temperatures below zero: Nov. - Mar.	500 - 850 m level to sloping land
38.4	Luvisol-Region, with Cambisols and partly with Gleysols, two areas in the southwest of Czech Republic	loess of different thickness overlying igneous and metamorphic rocks	mean annual temperature: 7.6 - 8.4^{o}C mean annual precipitation: 550 - 590 mm months of highest precipitation: May, Aug. months of drought: --	350 - 480 m level to sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(LVh, CMe, GLe)		months with temperatures below zero: Dec. - Febr.	
39.	**Luvisol - Chernozem Regions**			
39.1	Luvisol-, Chernosem-Region, partly with Leptosols, of the Upper Rhine valley (Germany) (LVh, CHh, LPk)	loess overlying various rocks	mean annual temperature: 8.9 - 9.5°C mean annual precipitation: 540 - 680 mm months of highest precipitation: (July) months of drought: -- months with temperatures below zero: Dec- - Febr.	250 - 300 m level to sloping land
39.2	Luvisol-, Chernozem-Region, partly with Podzols and Cambisols, in the central part of Czech Republik (LVh, CHh, PZh, CMe)	loess of different thickness overlying cretaceous sandstone and marl, and igneous and metamorphic rocks	mean annual temperature: 8.5 - 9.4°C mean annual precipitation: 420 - 530 mm months of highest precipitation: July, Oct. months of drought: -- months with temperatures below zero: Dec. - Febr.	160 - 280 m level, partly sloping land
40.	**Luvisol - Gleysol Regions**			
40.1	Luvisol-, Gleysol-Region, with Histosols, of Central-Ireland (LVh, GLd, HSf)	paleozoic sedimentary rocks alternating with igneous and metamorphic rocks, partly covered with glacial deposits (ground moraine)	mean annual temperature: 8.7 - 9.7°C mean annual precipitation: 900 - 1150 mm months of highest precipitation: Oct. - Jan. months of drought: -- months with temperatures below zero: --	0 - 500 m level to sloping land
40.2	Luvisol-Region, partly with Gleysols in the North of the highlands of Lower Saxony (Germany) (LVh, GLe)	loess of different thickness overlying various rocks	mean annual temperature: 8.6 - 8.8°C mean annual precipitation: 690 - 720 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: Dec. - Febr.	80 - 300 m level to sloping land
40.3	Luvisol-, Gleysol-Region, partly with Podzols and Histosols, of	loamy glacial sediments (ground moraine)	mean annual temperature: 7.0 - 8.2°C mean annual precipitation: 580 - 650 mm	0 - 140 m level, partly

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	the undulating younger glacial drift area in Northeast-Germany and Northwest Poland (LVh, GLe, PZh, HSf)		months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Mar.	sloping land

41. Luvisol - Leptosol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
41.1	Luvisol-Region, with Leptosols and Cambisols, of Northwest-France (Normandie, Picardie, Artois, Flandre) (LVh, LPk, CMe, CMc)	loess and loessic loam overlying cretaceous and tertiary sedimentary rocks, partly residual loam from calcareous rocks	mean annual temperature: 9.9 - 10.6^{o}C mean annual precipitation: 750 - 840 mm months of highest precipitation: Oct. - Nov. months of drought: -- months with temperatures below zero: (Jan. - Febr.)	0 - 250 m level land
41.2	Luvisol-Region, with Leptosols and Planosols, of North-Bulgaria (LVv, LPq, PLe)	cretaceous flysh deposits, partly covered with loess and residual loam	mean annual temperature: 10.0 - 11.3^{o}C mean annual precipitation: 680 - 880 mm months of highest precipitation: June - July months of drought: -- months with temperatures below zero: (Jan.)	200 - 450 m sloping, partly level land

42. Luvisol - Phaeozem - Vertisol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
42.1	Luvisol-, Phaeozem-Region, with Cambisols, of Central-Romania (Transylvania) (LVh, LVv, PHh, CMe)	frequently neogene marl, clay, sand, and loess and redeposited quaternary deposits	mean annual temperature: 8.1 - 8.9^{o}C mean annual precipitation: 680 - 800 mm months of highest precipitation: June - July months of drought: -- months with temperatures below zero: Jan. - Febr.	280 - 400 m level, partly sloping land
42.2	Luvisol-Region, with Vertisols,	tertiary marl, limesstone, detrital	mean annual temperature: 10.9 - 11.3^{o}C	150 - 450 m

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	Phaeozems and Cambisols, of West-Romania (LVh, VRe, PHh, CMe)	formations, clayey deposits	mean annual precipitation: 560 - 650 mm months of highest precipitation: June months of drought: (deficite in Aug.- Sept.) months with temperatures below zero: Dec. - Febr.	sloping, partly level land
42.3	Luvisol-, Phaeozem-Region, with Cambisol and Vertisol, of East-Romania (LVv, PHh, CMe, VRe)	tertiary marl, limestone, detrital formations, clayey to loamy deposits	mean annual temperature: 9.2 - 10.3^{o}C mean annual precipitation: 500 - 550 mm months of highest precipitation: June months of drought: (deficite in Aug.) months with temperatures below zero: Dec. - Febr.	150 - 450 m level to sloping land
43.	**Luvisol - Podzol Region**			
43.1	Luvisol-, Podzol-Region, with Cambisols and Gleysols, of central polish low-rainfall area (LVh, PZb, CMe, GLe)	loamy glacial deposits (ground moraine), often with cover sand, and sandy glaciofluvial deposits	mean annual temperature: 7.3 - 8.2^{o}C mean annual precipitation: 450 - 520 mm months of highest precipitation: July months of drought: (deficit in Aug. - Sept.) months with temperatures below zero: Dec. - Mar.	40 - 150 m level, partly sloping land
44.	**Luvisol - Podzoluvisol Regions**			
44.1	Luvisol-, Podzoluvisol-Region, with Cambisols and Leptosols, of North-France (Ile de France) (LVh, PDe, CMe, LPk)	eolian deposits (loess) overlying tertiary and cretaceous sedimentary rocks, partly residual loam from calcareous rocks	mean annual temperature:10.4 - 11.0^{o}C mean annual precipitation: 560 - 700 mm months of highest precipitation: Oct. -Dec. months of drought: -- months with temperatures below zero: (Jan., Febr.)	80 - 250 m level, partly sloping land
44.2	Luvisol-, Podzoluvisol-Region, with Cambisol, of Central-France (Touraine) (LVg, PDg, CMe)	jurassic and cretaceous clayey to sandy deposits, and limestone and marl, partly tertiary deposits	mean annual temperature: 10.5 - 11.5^{o}C mean annual precipitation: 650 - 830 mm months of highest precipitation: Oct. - Dec. months of drought: -- months with temperatures below zero: --	100 - 250 m level, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
44.3	Luvisol-, Podzoluvisol-Region, with Gleysols, in the North of Ardenne and Rheinisches Schiefergebirge in Belgium and Germany (LVh, PDe, GLe)	eolian sediments (loess) overlying various rocks, partly residual or redeposited loam	mean annual temperature: 9.1 - 10.0°C mean annual precipitation: 720 - 860 mm months of highest precipitation: Dec., July months of drought: -- months with temperatures below zero: (Jan., Febr.)	80 - 350 m level to sloping land
44.4	Luvisol-Region, with Planosols, Podzoluvisols, Cambisols and Phaeozems, of East-Austria and Northern parts of "former Yugoslavia" (LVv, PLe, PDg, CMe, PHv)	tertiary marl and clay, partly covered with loess and loamy pleistocene deposits	mean annual temperature: 10.2 - 11.3°C mean annual precipitation: 700 - 880 mm months of highest precipitation: May - June months of drought: -- months with temperatures below zero: Dec - Jan.	120 - 450 m level, partly sloping land

45. Phaeozem - Chernozem - Arenosol Region

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
45.1	Phaeozem-, Chernozem-Region with Cambisols, Arenosols, Regosols, and partly Vertisols and Solonetz of Pannonia basin in Hungary and "former Yugoslavia" (PHc, PHg, CHk, CMu, ARb, RGd, VRe, SNh)	eolian deposits (sandy and loamy loess), overlying neogene deposits, partly with outcrops of different mesozoic rocks	mean annual temperature: 10.0 - 11.1°C mean annual precipitation: 540 - 650 mm months of highest precipitation: June months of drought: (deficite in August) months with temperatures below zero: Dec. - Febr.	100 - 200 m (900 m) level, partly sloping to steep land

46. Podzol - Arenosol - Regosol Region

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
46.1	Podzol-, Arenosol-Region, with Regosols and Gleysols, of North-Denmark (PZh, ARh, RGd, GLe)	quaternary marine deposits	mean annual temperature: 7.0 - 8.0°C mean annual precipitation: 580 - 670 mm months of highest precipitation: August months of drought: -- months with temperatures below zero: Jan. - Febr.	0 - 50 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
47.	**Podzol - Cambisol Region**			
47.1	Podsol-, Cambisol-Region of South-Sweden (PZh, PZg, CMd, CMe)	Loamy glacial deposits (ground moraine)	mean annual temperature: 5.6 - 7.4^{o}C mean annual precipitation: 550 - 880 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: (Nov.) Dec. - Mar.	0 - 280 m level, partly sloping land
47.2	Podzol-, Cambisol-Region, with Leptosols, of East-Sweden (Stockholm area) (PZh, PZg, CMv, CMd, LPq)	Glaciolucustrine, glaciofluviatile and glacial deposits, partly with outcrops of acid to intermediate igneous and metamorphic rocks	mean annual temperature: 4.9 - 6.3^{o}C mean annual precipitation: 520 - 510 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: (Nov.) Dec. - Mar.	0 - 150 m level land
48.	**Podzol - Gleysol Regions**			
48.1	Podzol-, Gleysol-Region, with Cambisols, Luvisols and Histosols, of West-Denmark, Northwest-Germany and East-Netherlands (PZh, PZg, PZb, GLd, GLe, GLm, CMe, LVe, HSf)	sandy to loamy glacial deposits (ground moraine, outwash sand) often with sandy cover sediments, partly sandy loess	mean annual temperature: 7.8 - 8.4^{o}C mean annual precipitation: 680 - 790 mm months of highest precipitation: July - Aug. months of drought: -- months with temperatures below zero: (Dec.) Jan. - Febr.	0 - 80 m level land
48.2	Podzol-Region of South-Netherlands and North-Belgium (PZg, PZc, PZh)	eolian deposits (eolian sand), partly glaciofluvial deposits	mean annual temperature: 9.2 - 10.0^{o}C mean annual precipitation: 720 - 860 mm months of highest precipitation: July months of drought: --	30 - 80 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
			months with temperatures below zero: Jan. - Febr.	
48.3	Podsol-Region, with Gleysols and Histosols, of South-Sweden (PZh, PZg, GLd, HSf)	sandy glaciofluvial and loamy glacial deposits	mean annual temperature: 5.6 - 6.2°C mean annual precipitation: 540 - 790 mm months of highest precipitation: Aug. months of drought: -- months with temperatures below zero: (Nov.) Dec. - Mar.	80 - 130 m level, partly sloping land
49.	**Podzol - Luvisol Region**			
49.1	Podzol-, Luvisol-Region, with Leptosols, of Central-France (Orleanais) (PZh, LVg, LPk)	tertiary deposits (detrital formations) and fluvial sediments, partly covered with loess	mean annual temperature: 10.8 - 11.5°C mean annual precipitation: 630 - 670 mm months of highest precipitation: Oct. months of drought: -- months with temperatures below zero: --	100 - 250 m level, partly sloping land
50.	**Podzol - Podzoluvisol - Gleysol Region**			
50.1	Podzol-, Podzoluvisol-, Gleysol-Region, with Cambisols, of the older glacial drift area in North-east-Germany and Northwest-Poland (PZb, PDj, GLe, CMe)	sandy and loamy glacial deposits, often with cover sand	mean annual temperature: 7.8 - 8.5°C mean annual precipitation: 550 - 650 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Mar.	30 - 180 m level, partly sloping land
51.	**Podzol - Regosol Region**			
51.1	Podzol-,Regosol-Region of Southwest France (Medoc, Landes) (PZh, PZc, RGd)	eolian sand (overlying neogene deposits)	mean annual temperature: 12.7 - 13.8°C mean annual precipitation: 880 mm months of highest precipitation: Oct. - Nov.	0 - 120 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
			months of drought: -- months with temperatures below zero: --	
52.	**Podzoluviusol - Luvisol - Gleysol Regions**			
52.1	Podzoluvisol-, Luvisol-Region, with Leptosols and Fluvisols, of the Saone valley and of the Bourbonnais between Allier and Loire (France) (PDg, LVh, LPk, FLe)	tertiary deposits (detrital formations), and fluvial quaternary sediments, partly with eolian deposits	mean annual temperature: 10.3 - 10.9°C mean annual precipitation: 670 - 780 mm months of highest precipitation: June, Oct. months of drought: -- months with temperatures below zero: Jan. - Febr.	180 - 450 m level to sloping land
52.2	Podzoluvisol-, Luvisol-, Gleysol-Region of the loess belt in the North of the east-german and polish highlands (PDe, LVh, GLe)	loess of different thickness overlying various rocks	mean annual temperature: 8.0 - 8.8°C mean annual precipitation: 480 - 640 mm months of highest precipitation: July months of drought: -- months with temperatures below zero: Dec. - Mar.	180 - 300 m level, partly sloping land
53.	**Vertisol Region**			
53.1	Vertisol-Region of Central-Bulgaria (VRe)	clayey deposits and residual loam	mean annual temperature: 10.8 - 12.4°C mean annual precipitation: 480 - 550 mm months of highest precipitation: May, Nov. months of drought: (deficite in Aug. - Sept.) months with temperatures below zero: (Jan.)	0 - 250 m level, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM

Soil Regions With Mediterranean Climate

54. Acrisol - Planosol Region

54.1	Acrisol-, Planosol-Region, with Fluvisols, of West-Spain	oligocene and miocene sedimentary deposits (detrital formations, rañas) and	mean annual temperature: 15.9 - 16.5°C mean annual precipitation: 380 - 450 mm	180 - 450 m level to sloping

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(Badajoz, Mérida) (ACh, PLe, FLc)	fluvial deposits	months of highest precipitation: Nov., Mar. months of drought: June - Sept. months with temperatures below zero: --	land
55.	**Calcisol - Solonchak - Cambisol Regions**			
55.1	Calcisol-Region, with Solonchaks, Cambisols and Fluvisols, of Northeast-Spain (Zaragoza, Lérida, Cataluña, Aragon) (CLh, SCh, CMk, FLc)	oligocene and miocene sedimentary deposits (marl) and quaternary fluvial deposits	mean annual temperature: 13.5 - 14.0^{o}C mean annual precipitation: 340 - 450 mm months of highest precipitation: May, Oct. months of drought: (June), July - Aug. months with temperatures below zero: (Jan)	120 - 750 m sloping, partly level land
55.2	Calcisol-Region, with Leptosols, of Southeast-Spain (Alicante, Albacete) (CLh, LPk, LPq)	mesozoic and tertiary sedimentary rocks (marl, limestone, sandstone)	mean annual temperature: 12.5 - 15.0^{o}C mean annual precipitation: 330 - 430 mm months of highest precipitation: May, Nov. months of drought: June - Sept. months with temperatures below zero: ((Jan.))	680 - 950 m sloping land
56.	**Cambisol - Andosol - Regosol Region**			
56.1	Cambisol-, Andosol-Region, with Regosols, of Central-Italy (Lazio, Mt. Vesuvio) (CMe, ANh, RGd)	effusive igneous rocks (e.g. tuff)	mean annual temperature: 12.7 - 15.2^{o}C mean annual precipitation: 900 - 1100 mm months of highest precipitation: Nov. months of drought: July - Aug. months with temperatures below zero: --	0 - 1200 m sloping to steep land
57.	**Cambisol - Calcisol - Vertisol Region**			
57.1	Cambisol-Region, with Calcisols and Vertisols, of Southeast-Spain (Andalucia) (CMk, CMu, CLh, VRk)	very different paleozoic to tertiary rocks (marl, limestone, sandstone, flysch)	mean annual temperature: 16.3 - 18.5^{o}C mean annual precipitation: 360 - 450 mm months of highest precipitation: Nov., May months of drought: June - Sept. months with temperatures below zero: --	0 - 850 m sloping, partly steep land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
58.	**Cambisol - Fluvisol - Arenosol Regions**			
58.1	Cambisol-Region, with Fluvisols and Arenosols, of North-Spain (Valladolid, Castilla y Leon) (CMk, CMe, FLc, ARc)	neogene marl, limestone, detrital formations, and fluvial quaternary sediments	mean annual temperature: 9.8 - 11.7^{o}C mean annual precipitation: 340 - 420 mm months of highest precipitation: May, Oct.-Nov. months of drought: July - Sept. months with temperatures below zero: Jan., (Febr.)	700 - 850 m level, partly sloping land
58.2	Cambisol-, Fluvisol-Region of North-Spain (Zaragoza Aragón) (CMk, FLc)	tertiary marl, limestone, detrital formations, and fluvial quaternary sediments	mean annual temperature: 11.6 - 14.1^{o}C mean annual precipitation: 310 - 380 mm months of highest precipitation: May, Oct. months of drought: June - Sept. months with temperatures below zero: --	150 - 750 m sloping, partly level land
59.	**Cambisol - Leptosol Regions**			
59.1	Cambisol-, Leptosol-Region of Northeast-Spain (Cataluñia) (CMx, CMe, LPq, LPk)	very different triassic to tertiary sedimentary rocks (sandstone, marl, limestone)	mean annual temperature: 14.9 - 16.0^{o}C mean annual precipitation: 510 - 600 mm months of highest precipitation: Nov., May months of drought: (June), July - Aug. months with temperatures below zero: --	0 - 1700 m sloping, partly steep land
59.2	Cambisol-, Leptosol-Region, with Podzols, Andosols and Luvisols, of Sardegna and Corse (Italy, France) (CMd, CMx, LPq, PZb, ANh, LVh)	acid igneous rocks (granite, tuff)	mean annual temperature: 13.6 - 15.9^{o}C mean annual precipitation: 800 - 1250 mm months of highest precipitation: Oct. - Nov. months of drought: (May), June - Aug. months with temperatures below zero: --	0 - 2700 m steep, partly sloping land
59.3	Cambisol-, Leptosol-Region, partly with Fluvisols, of North-Spain (Soria, Sierra de la Virgen,	very different rocks (marl, limestone, sandstone, flysch, river alluvium) of triassic to quaternary age, partly paleozoic	mean annual temperature: (9.0) 10.5 - 11.6^{o}C mean annual temperature: 10.5 - 11.6^{o}C mean annual precipitation: 420 - 550 mm	750 - 2100 m sloping, partly steep land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	Sierra de Vicort, Sierra de Santa Cruz, Sierra Cebollera) (CMk, CMe, LPq, FLc)	sedimentary rocks	months of highest precipitation: May, Oct. months of drought: July - Aug. months with temperatures below zero: Jan. - Febr.	
59.4	Cambisol-Region, with Leptosols and Luvisols, of Southeast Portugal, West Spain (Extremadura) (CMe, CMd, CMk, LPq, LVh, LVv)	frequently alternating igneous and meta-morphic rocks (granite, gneiss, gneiss, schist, slate), partly covered with mesozoic and tertiary sedimentary rocks	mean annual temperature: 14.8 - 15.3°C mean annual precipitation: 560 - 640 mm months of highest precipitation: Oct. - Nov. months of drought: June - Sept. months with temperatures below zero: --	150 - 1100 m sloping, partly level land
59.5	Cambisol-, Leptosol-Region of Central-Spain (Cuenca) (CMk, LPk, LPq)	oligocene and miocene sedimentary deposits (detrital formations, marl)	mean annual temperature: 13.5 - 14.3°C mean annual precipitation: 480 - 510 mm months of highest precipitation: May, Nov. months of drought: June - Sept. months with temperatures below zero: --	850 - 1000 m sloping, partly level land
59.6	Cambisol-, Leptosol-Region of East-Spain (Valencia, Cataluñia, Balearic Islands) (East Spain) (CMk, LPk, LPq)	very different triassic to tertiary Rocks (sandstone, marl, limestone)	mean annual temperature: 15.0 - 16.3°C mean annual precipitation: 410 - 580 mm months of highest precipitation: Nov., May months of drought: (June), July - Aug. months with temperatures below zero: --	0 - 1400 m sdloping, partly steep land
59.7	Cambisol-, Leptosol-Region, with Luvisols, of the Appennino Mts. (Italy) (CMe, CMd, CMk, CMx, LPk,	mesozoic and tertiary sedimentary rocks (limestone, marl, sandstone)	mean annual temperature: 7.7 - 13.0°C mean annual precipitation: 850 - 1100 mm months of highest precipitation: May, Oct. months of drought: (July)	650 - 2900 m steep, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	LVh, LVg)		months with temperatures below zero: (Jan.)	

60. Cambisol - Luvisol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
60.1	Cambisol-Region, with Luvisols, of Piemonte in Northwest Italy (CMe, CMd, LVk)	miocene calcareous rocks (marl, marly siltstone, limestone, molasse) and partly sandstone	mean annual temperature: 11.7 - 12.0°C mean annual precipitation: 660 - 740 mm months of highest precipitation: Oct. - Nov. months of drought: July, (Aug.) months with temperatures below zero: Dec. - Jan.	150 - 280 m sloping, partly level land
60.2	Cambisol-, Luvisol-Region of Sardegna (Italy) (LMv, LVg)	neogene calcareous deposits (marl, limestone) partly covered with quaternary sediments	mean annual temperature: 15.0 - 16.7°C mean annual precipitation: 750 - 1100 mm months of highest precipitation: Dec. - Jan. months of drought: June - Sept. months with temperatures below zero: --	0 - 250 m level to sloping land
60.3	Cambisol-, Luvisol-, Regosol-Region of West-Portugal (Estremadura) (CMk, CMe, LVk, RGc)	jurassic and cretaceous limestone, marl, sandstone	mean annual temperature: 14.6 - 15.9°C mean annual precipitation: 650 - 9oo mm months of highest precipitation: Nov. - Jan. months of drought: June - Aug. months with temperatures below zero: --	0 -600 m sloping land
60.4	Cambisol-Region, with Luvisols, of West-Italy (Liguria, Toscana, Lazio) (CMx, CMe, LVv)	jurassic, cretaceous and tertiary marl, limestone, sandstone and detrital formations	mean annual temperature: 13.0 - 14.7°C mean annual precipitation: 820 - 1060 mm months of highest precipitation: Apr., Nov. months of drought: July - Aug. months with temperatures below zero: --	0 - 1700 m sloping, partly steep land
60.5	Cambisol-, Luvisol-Region of Northeast Corse (France) (CMd, LVh)	mesozoic metamorphic rocks, ophiolites and flysch	mean annual temperature: 15.4 - 16.0°C mean annual precipitation: 520 - 580 mm months of highest precipitation: Oct.	0 - 1300 m sloping, partly steep land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
			months of drought: (May) June - Aug. months with temperatures below zero: --	
60.6	Cambisol-, Luvisol-Region, with Leptosols, of South-Italy (Calabria) (CMe, CMd, CMx, LVh, LPq)	igneous and metamorphic rocks (granite, basalt, tuff, schist, slate) and tertiary sedimentary rocks (limestone, marl)	mean annual temperature: 14.0 - 16.2°C mean annual precipitation: 750 - 1100 mm months of highest precipitation: Dec. - Jan. months of drought: June - Aug. months with temperatures below zero: --	0 - 1900 m steep, partly sloping land

61. Cambisol - Regosol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
61.1	Cambisol-, Regosol-Region, with Luvisols and Vertisols, of East-Italy (East part of Appenino Umbre Marchigiano and Appenino Abruzzese) (CMe, RGe, LVe, VRe)	miocene flysch, marl, limestone and clayey to sandy deposits	mean annual temperature:13.5 - 14.8°C mean annual precipitation: 760 - 840 mm months of highest precipitation: Nov. - Dec. months of drought: July, (Aug.) months with temperatures below zero: --	0 - 650 m sloping, partly level land
61.2	Cambisol-, Regosol-Region of Northeast-Spain (Northeast-Cataluña) (CMd, RGd)	acid igneous rocks (e.g. granite)	mean annual temperature: 13.7 - 15.0°C mean annual precipitation: 580 - 650 mm months of highest precipitation: May, Oct. months of drought: (June), July - Aug. months with temperatures below zero: --	0 - 1700 m sloping to steep land

62. Cambisol - Vertisol - Luvisol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
62.1	Cambisol-, Vertisol-, Luvisol-Region, with Fluvisols, of the coast of Golfo di Taranto (Tavoliere della Puglia) in South-Italy (CMc, VRk, LVv, FLe)	pleistocene marine, partial fluvial deposits	mean annual temperature: 15.7 - 17.0°C mean annual precipitation: 470 - 480 mm months of highest precipitation: Nov. - Dec. months of drought: May - Sept. months with temperatures below zero: --	0 - 100 m level, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
62.2	Cambisol-, Luvisol-Region, with Leptosols, Andosols and Vertisols, of Sicilia (Italy) (CMv, CMe, LVx, LPk, ANh, VRk)	tertiary, partly cretaceous and jurassic clayey deposits, calcareous rocks, flysch	mean annual temperature: 16.4 - 18.6^{o}C mean annual precipitation: 500 - 850 mm months of highest precipitation: Dec. - Jan. months of drought: May - Sept. months with temperatures below zero: --	0 - 1900 m sloping to steep land

63. Cambisol - Vertisol - Solonchak Region

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
63.1	Cambisol-, Vertisol-Region, with Fluvisols and Solonchaks of Central-Spain (Madrid, Castilla) (CMk, CMe, VRk, FLc, SCk)	neogene marl, limestone, detrital formations, and fluvial quaternary sediments	mean annual temperature: 12.8 - 14.3^{o}C mean annual precipitation:380 - 440 mm months of highest precipitation: Nov. months of drought: June - Sept. months with temperatures below zero: (Jan.)	540 - 750 m level, partly sloping land

64. Fluvisol - Cambisol - Luvisol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
64.1	Fluvisol-, Cambisol-Region, with Luvisols, of the Po river plain in North-Italy (FLe, FLc, CMe, LVk)	loamy to sandy river deposits	mean annual temperature: 12.7 - 13.2^{o}C mean annual precipitation: 670 - 800 mm months of highest precipitation: Sept. months of drought: July- Aug. months with temperatures below zero: Jan. - (Febr.)	0 - 150 m level land
64.2	Fluvisol-Region, with Vertisols of the Pinios river in Thessalia (Greece) (FLc, VRk)	fluvial quaternary sediments overlying cretaceous and tertiary flysch deposits	mean annual temperature: 16.1 - 16.9^{o}C mean annual precipitation: 510 - 540 mm months of highest precipitation: Nov. months of drought: June - Sept. months with temperatures below zero: --	60 - 120 m level land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
64.3	Fluvisol-Region of the Axios, Strimon and Nestos river in Makedhonia (Greece) (FLc)	fluvial quaternary sediments	mean annual temperature: 15.5 - 15.9°C mean annual precipitation: 450 - 500 mm months of highest precipitation: Nov. months of drought: June - Sept. months with temperatures below zero: --	0 - 80 m level land
65.	**Fluvisol - Solonchak Regions**			
65.1	Fluvisol-, Solonchak-Region, with Cambisols, of the Rhone delta in South-France (FLc, SCh, CMx)	loamy to sandy river deposits, and partly marine and estuarine sediments	mean annual temperature: 14.5°C mean annual precipitation: 550 - 600 mm months of highest precipitation: Oct. months of drought: June - Aug. months with temperatures below zero: --	0 - 50 m level land
65.2	Fluvisol-Region, with Solonchaks, of East-Spain (mouth of Ebro and other rivers in Valencia) (FLc, SCh)	loamy to sandy river deposits, and partly marine deposits	mean annual temperature: 16.5 - 17.5°C mean annual precipitation: 410 - 450 mm months of highest precipitation: Nov., April months of drought: May - Sept. months with temperatures below zero: --	0 - 80 m level land
66.	**Leptosol - Cambisol Regions**			
66.1	Leptosol-Region, with Cambi-sols, of Central-and East-Spain (Sierra de Cuenca, Sierra de Javalambre, Sierra de Gudar, Sierra de San Just) (LPq, LPk, CMk)	mesozoic sedimentary rocks (limestone, marl, sandstone)	mean annual temperature: 7.5 - 10.2°C mean annual precipitation: 810 - 1000 mm months of highest precipitation: Nov., Febr. months of drought: July - Aug. months with temperatures below zero: Jan. - Mar.	750 - 2000 m steep, partly sloping land
66.2	Leptosol-, Cambisol-Region of South-Spain (Andalucia: Sierra Nevada, Sierra de Los Filabres,	mesozoic sedimentary rocks (limestone, marl, sandstone) and partly paleozoic metamorphic rocks (slate)	mean annual temperature: 8.5 - 12.5°C mean annual precipitation: 500 - 600 mm months of highest precipitation: Oct.	700 - 3400 m steep, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	Sierra de Segura, Sierra de Alcaraz) (LPq, LPk, CMk)		months of drought: June - Aug. (Sept.) months with temperatures below zero: Jan. - Mar.	
66.3	Leptosol-Region, with Cambisols, of Central-Spain (Sierra de Gredos, Sierra de Guadarrama) (LPq, CMd, CMu)	acid igneous rocks (granite) and metamorphic rocks (schist, slate)	mean annual temperature: 9.0 - 10.5°C mean annual precipitation: 780 - 900 mm months of highest precipitation: Nov., Febr. months of drought: July - Aug. months with temperatures below zero: Jan. - Mar.	650 - 2500 m steep, partly sloping land
66.4	Leptosol-, Cambisol-Region of Mt. Etna (Sicilia, Italy) (LPq, LPu, CMd)	volcanic rocks	mean annual temperature: 12.0 - 14.5°C mean annual precipitation: 1050 - 1150 mm months of highest precipitation: Nov. - Jan. months of drought: May - Aug. months with temperatures below zero: --	0 - 3300 m steep, partly sloping land
67.	**Leptosol - Cambisol - Luvisol Regions**			
67.1	Leptosol-, Cambisol-Region, with Luvisols, of Southeast France (Provence) (LPk, LPq, CMk, LVk)	jurassic and cretaceous limestone	mean annual temperature: 7.6 - 9.7°C mean annual precipitation: 830 - 1100 mm months of highest precipitation: Oct. - Dec. months of drought: (July) months with temperatures below zero: Dec. - Mar.	0 - 1600 m sloping to steep land
67.2	Leptosol-, Cambisol-Region, with Luvisols, of the adriatic coast of "former Yugoslavia", Albania and Greece	Jurassic, cretaceous and tertiary limestone, dolomite, marl and flysh	mean annual temperature: 13.1 - 16.3°C mean annual precipitation: 900 - 1500 mm months of highest precipitation: Oct. - Nov. months of drought: June - Aug. (Sept.)	0 - 2100 m sloping to steep land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(LPq, LPk, CMc, LVv)		months with temperatures below zero: --	
67.3	Leptosol-Region, with Cambisols and Luvisols, of South-Greece (Peloponnisos) (LPq, LPk, CMc, LVv)	cretaceous and tertiary limestone and marl, partly igneous rocks	mean annual temperature: 15.3 - 16.9^{o}C mean annual precipitation: 380 - 580 mm months of highest precipitation: Nov. months of drought: June - Sept. months with temperatures below zero: --	0 - 2400 m steep, partly sloping land
67.4	Leptosol-, Cambisol-Region, with Luvisols, of Southeast-France (Massif des Maures) (LPu, CMd, LVh)	metamorphic rocks (amphibolite, schist)	mean annual temperature: 13.7 - 14.8^{o}C mean annual precipitation: 720 - 800 mm months of highest precipitation: Oct. months of drought: June - Aug. months with temperatures below zero: --	0 - 550 m sloping land
67.5	Leptosol-, Cambisol-Region, with Luvisols, of the southern part of La Mancha (Spain) (LPq, CMc, LVv)	triassic and jurassic marl, limestone, partly sandstone and siltstone	mean annual temperature: 14.4 - 14.8^{o}C mean annual precipitation: 580 - 600 mm months of highest precipitation: Mar., Dec. months of drought: June - Sept. months with temperatures below zero: --	780 - 900 m level to sloping land
67.6	Leptosol-Region, with Luvisols, Cambisols, Andosols and Regosols, of Crete and other Greece Islands (LPq, LPk, LVv, CMx, ANh, RGc)	mesozoic to tertiary sedimentary rocks (marl, limestone) and different igneous rocks (volcanic rocks)	mean annual temperature: 16.3 - 18.5^{o}C mean annual precipitation: 530 - 640 mm months of highest precipitation: Dec. - Jan. months of drought: Apr. - Sept. months with temperatures below zero: --	0 - 2400 m sloping to steep land
67.7	Leptosol-, Luvisol-Region, with Cambisols, of Central-Greece, East-Albania and South of	frequently alternating sedimentary rocks (limestone, flysch, molasse) and igneous and metamorphic rocks (granite, migmatite,	mean annual temperature: 10.8^{o}C mean annual precipitation: 620 - 750 mm months of highest precipitation: Nov. - Jan.	0 - 2700 m steep, partly sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	"former Yugoslavia" (LPq, LPk, LVx, CMx)	gneiss, schist)	months of drought: July - Sept. months with temperatures below zero: --	

68. Leptosol - Luvisol - Vertisol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
68.1	Leptosol-Region, with Luvisols, Cambisols, Vertisols and Andosols, of East-Greece (East-Makedhonia and Thrakia) (LPk, LVh, CMc, VRe, ANh)	mesozoic and tertiary limestone and marl, and partly volcanic rocks	mean annual temperature: 15.5 -16.2^{o}C mean annual precipitation: 480 - 600 mm months of highest precipitation: Nov. months of drought: June - Sept. months with temperatures below zero: --	0 - 1500 m sloping to steep land
68.2	Leptosol-, Luvisol-, Cambisol-Region, partly with Vertisols, of North-Greece and South of "former Yugoslavia" (LPu, LVh, CMe, VRe)	igneous rocks and metamorphic rocks (granite, schist) alternating with paleozoic and mesozoic sedimentary rocks (marl, limestone) and clayey deposits	mean annual temperature: 11.4 - 16.5^{o}C mean annual precipitation: 480 - 700 mm months of highest precipitation: Nov. months of drought: July - Sept. (Oct.) months with temperatures below zero: --	0 - 2900 m steep, partly sloping land

69. Luvisol - Planosol - Acrisol Regions

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
69.1	Luvisol-Region, with Planosols, Acrisols and Fluvisols, of Central-Spain (LVv, PLe, ACh, FLc)	miocene sedimentary rocks (detrital formations, rañas), and fluvial deposits	mean annual temperature: 13.8 -15.0^{o}C mean annual precipitation: 450 - 510 mm months of highest precipitation: Mar., Nov. months of drought: (May), June - Sept. months with temperatures below zero: --	350 - 1200 m sloping land
69.2	Luvisol-, Acrisol-Region, with Planosols and Cambisol, of	paleogene and miocene sedimentary deposits (detrital formations) partly covered	mean annual temperature: 12.3 - 13.0^{o}C mean annual precipitation: 280 - 320 mm	800 - 950 m sloping, partly

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	West-Spain (Salamanca) (LVv, LVh, ACh, PLe, CMk, CMe)	with river alluvium	months of highest precipitation: (Nov) months of drought: (May), June - Sept. months with temperatures below zero: (Jan.)	level land
70.	**Luvisol - Cambisol - Gleysol Region**			
70.1	Luvisol-, Cambisol-Region, with Gleysols, of the glacial drift area in the south of The Alps (Italy) (LVh, LVg, CMc, GLe)	glacial deposits (glaciofluvial deposits, glacial drift)	mean annual temperature: 12.2 - 13.0^{o}C mean annual precipitation: 700 - 980 mm months of highest precipitation: May, Oct. months of drought: July months with temperatures below zero: Dec. - Febr.	150 - 600 m sloping land
71.	**Luvisol - Leptosol Region**			
71.1	Luvisol-, Leptosol-Region, with Fluvisols and Cambisols, of the Rhone and Aude valley in Southeast-France (LVh, LPq, LPk, FLc, CMe)	neogene marl and limestone, partial covered with fluvial quaternary deposits	mean annual temperature: 10.7 - 12.0^{o}C mean annual precipitation: 780 - 900 mm months of highest precipitation: Oct. months of drought: -- months with temperatures below zero: Jan. - Febr.	0 - 300 m level to sloping land
72.	**Luvisol - Regosol - Cambisol Regions**			
72.1	Luvisol-, Regosol-, Cambisol-Region of Northern Peleponnes (Greece) (LVx, RGe, CMx)	neogene deposits (detrital formations), partly coverd with marine and fluvial quaternary sediments	mean annual temperature: 17.7 - 18.1^{o}C mean annual precipitation: 570 - 700 mm months of highest precipitation: Nov. - Dec. months of drought: May - Sept. months with temperatures below zero: --	0 - 450 m sloping, partly level land
72.2	Luvisol-, Regosol-, Cambisol-Region of Southeast-Italy	cretaceous limestone and marl	mean annual temperature: 15.7 - 17.0^{o}C	0 - 550 m level to sloping

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM
	(Puglia) (LVx, RGe, CMe, CMx)		mean annual precipitation: 460 - 480 mm months of highest precipitation: Nov. - Dec. months of drought: June - Aug. (Sept.) months with temperatures below zero: --	land
73.	**Podzol - Regosol Regions**			
73.1	Podzol-Region, with Regosols, of the Coast of the Atlantic Ocean in Westportugal (PZh, RGd)	quaternary marine deposits and dunesand overlying tertiary sediments (detrital formatons)	mean annual temperature: 14.6 - 15.0^{o}C mean annual precipitation: 980 - 1150 mm months of highest precipitation: Nov. - Jan. months of drought: July - Aug. months with temperatures below zero: --	0 - 120 m level land
73.2	Podzol-Region, with Regosols, of West-Portugal (Setubal / Ribatejo) (PZh, RGe)	neogene sandy deposits, partly covered with fluvial quaternary sediments	mean annual temperature: 14.8 - 15.3^{o}C mean annual precipitation: 570 - 630 mm months of highest precipitation: Nov., Mar. months of drought: June - Sept. months with temperatures below zero: --	0 - 250 m level, partly sloping land
74.	**Regosol - Cambisol Region**			
74.1	Regosol-, Cambisol-Region of the Coast of the Adriatic Sea in Central Italy (RGc, RGe, CMc, CMe)	quaternary marine deposits, partial with eolian and fluvial deposits	mean annual temperature: 15.3^{o}C mean annual precipitation: 720 - 760 mm months of highest precipitation: Oct. months of drought: July - August months with temperatures below zero: --	0 - 140 m level, partly sloping land
75.	**Vertisol - Acrisol Region**			
75.1	Vertisol-, Acrisol-Region, with Arenosols and Fluvisols, of Southwest-Spain (Sevilla / Cordoba, Andalucia) (VRe, ACh, ARl, FLc)	tertiary deposits (marl, limestone, detrital formations, rañas), and fluvial quaternary sediments	mean annual temperature: 15.8 - 19.6^{o}C mean annual precipitation: 500 - 640 mm months of highest precipitation: Nov., Mar. months of drought: June - Sept. months with temperatures below zero: --	0 - 350 m level to sloping land

No.	SOIL REGION AND DOMINANT SOILS	DOMINANT PARENT MATERIAL	CLIMATIC DATA	ALTITUDE AND MAJOR LANDFORM

APPENDIX 10 KEYS TO EUROPEAN VEGETATION

Introduction

The EU 1:250,000 Soil Database is seeking to draw up a soil resource inventory on a European level which will be useful for addressing present and future agricultural and environmental problems. A suitable understanding of European soilscapes also calls for a compilation of information on soil forming factors. Vegetation is one of these. Whilst the methodology presented in this Manual has not embodied phytocenotic criteria, it is obvious that any Soil Survey and Soil Database would be incomplete if the pedological information of a certain geographic area were not in some way related to that of the natural or agricultural ecosystems with which it interacts. Likewise, integrating information of soil forming factors into a SDB enables spatial relations between soils, or certain properties thereof, and the environmental factors most important to their forming and dynamics to be analyzed.

In addition, this enriching of the future EU 1:250,000 Soil Database information may be of great strategic importance for the future of pedology at a European level, as well as for the prestige of those practising it. There are currently very few pan-European initiatives of an environmental interest which address the importance of soil resources in the conservation of the natural heritage with the rigour that pedologists would like. This situation may be partially explained by the traditional dependence of pedology on agronomical research. However, both the new CAP directives and the interests of citizens and governments are increasingly concentrated on an endeavour to mitigate the serious environmental problems affecting the EU. A European Soil Database, enabling the inter-relations between soilscapes and natural ecosystems to be analyzed will demonstrate the importance of conserving soil resources to preserve biodiversity and the health of natural and semi-natural habitats. It will thus be easier for conservationist movements, citizens and national and Community institutions to become concerned about the importance of strengthening and financing activities which the ESB intends to conduct. In parallel fashion, soil surveyors could again recover the recognition and social and scientific protagonism their activity, which has been declining for some years, deserves.

The Keys to European Vegetation here presented have been drawn up by Members of the Working Group[2] bearing in mind the aims pursued in a SDB. The criteria used are presented hereafter. The first step consisted in selecting a widely accepted European vegetation Manual translated into several languages, so as to be available to most of the potential EU 1:250,000 Soil database users. The methodology chosen was also required to come from a regionalization of the types of vegetation by climate. The reasons are obvious inasmuch as this type of approximation facilitates a user's direct access to plant landscape information of the geographical area where he works without his first having to face technical nomenclatures alien to him. In other words, in our opinion this is more user friendly than other alternatives. Both requisites are extensively covered by Polunin & Walters' monograph (1985). However, like any publication earmarked to wide dissemination amongst readers with highly heterogeneous training, certain deficiencies were detected and an attempt made to correct them. Firstly, the due improvements were made to provide as globalizing a view of Europe's vegetation as possible. Accordingly, some more innovating criteria on eco-regionalization were incorporated and, more specifically, proposals as put forth by Schultz (1995) and Tallis (1991) for vegetation in the arctic, boreal and temperate-steppic environment were taken into account. Secondly, new types of communities were also introduced, such as the primeval forest of Europe (Schnitzler-Lenoble 1996; Blanco *et al.* 1997), the industrial forest (Schultz 1995), certain plant structures typical of traditional European farming systems such as the Atlantic hedges and “bocages”, or the Mediterranean “dehesas”, “montados” and “sotos” (Blanco *et al.* 1997)., etc. Finally, several of the lowest ranked units as described by Polunin & Waters were modified, taking the vegetation's repercussions on soil more into account, wherever possible, than the floristic composition of the plant communities.

In the second step, we endeavoured to have these keys to European Vegetation take into account the recent initiatives in the field of nature conservation at EU level. With this in mind, a study was carried out on the possibility of making them compatible with the proposals as developed in other projects, such as the hierarchical classification of European Habitats developed by the CORINE biotopes project (1991),

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the Natura 2000 (a network of special areas of conservation) and Annex I of the Habitats Directive (more specifically, with the habitat type in danger of disappearance within the territory of the European Union) (EU, 1992; Habitat 1996). The CORINE Biotopes (1991) (It is to be expected that, from time to time, revisions of this manual will take place to take account of scientific developments in our understanding of habitats) seemed the most viable solution. However, this classified the European landscape into almost 3000 types. Such a level of detail seemed excessive to us for the purpose of this Manual.

All the initiatives mentioned, though conducted by different specialists asynchronously and often from different perspectives, have connections worth mentioning. Since the framework between these and other activities is highly complex, we shall quote only some of them. Thus, for example, the CORINE classification (1991 version) provides the main basis for a description of the Annex I habitat types (EU, 1992); the 1991 CORINE classification was extended in 1993 to the whole Palaearctic region (due to the incorporation of Austria, Finland and Sweden into the EU); recently, the Habitat EUR15 version (1996) updates the definitions of those habitat types for which the CORINE 1991 has been used, on the basis of the information contained in what is called the PHYSIS computer database; in parallel fashion, the CORINE codes are also replaced by the 'Palaearctic codes' in the Habitat EUR15 Document.

It should not be surprising, therefore, that certain problems of terminological confusion and only partial compatibleness between the different products (highly criticized by many ecologists and conservationist movements) are currently arising despite various efforts towards coordination as sponsored by different Community institutions. Thus, for example, when conserving highly valuable natural areas and/or areas with a risk of disappearing, different documents speak of biotopes, habitats, ecosystems, biocenoses, etc., using different terms for one and the same concept and/or the same term with a different meaning. This is why we considered that the simplest solution consisted in implementing the information drawn up in step one with that from Habitat EUR15. However, we have also seen that, with the aid of specialists, it would not be too difficult to make the Keys presented here compatible with the much more complex CORINE Biotopes classification.

Unfortunately, the climatic boundaries drawn up both by Polunin & Walters (1985), Schultz (1995), and Habitat (1996) only very approximately coincide with the climatic units used for drawing up the Soil-Regions Map of Europe (***Table 27***). It must be borne in mind that, even though the classification of biological organisms is sustained on sound bases (though not free from controversy either), the classification of ecosystem and biomes, awakens as much passion and heated debate amongst specialists as soil taxonomies do amongst pedologists. It should be of no surprise, then, that the Habitat EUR15 Document explicitly states that: "*the fact that many of the habitat types of Annex I are qualified by biogeographical terms such as Mediterranean, Alpine, Medio-European, etc., meaning that they have their main occurrence in a given biogeographical region, does not exclude the possibility of finding the same habitat types in other biogeographical regions. In fact, these often isolated occurrences have a major scientific and conservation value. The users of the manual will need to employ a certain flexibility of interpretation, particularly in those areas where the habitat types are very fragmentary and influenced by human activities*" (Habitat, 1996). This is why assignments of the different plant communities to the different climatic regions are also approximate, and it may transpire that one and the same phytocenosis belongs to different climate types, according to the four types of criteria used. Therefore, once plant communities have been identified, they should be primarily assigned to the climate units as established by this Working Group (BGR/ESB).

On the other hand, ***Table 28*** shows the bioclimatic belts of western Europe, as in the Habitat EUR15 Document. This is a latitudinal-altitudinal zonation based on drawing up bioclimatic indices, which differentiate different bioclimates and vegetation communities very well, using climatic data (Rivas-Martínez, 1991).

Finally, it must be added that the phytocenoses, habitats and climatic belts of the Macaronesian Region (Canary and Azores Islands) have not been included in the ESB-Vegetation Keys, inasmuch as the current European Soil Database does not contain any information on the soils in these island systems.

Table 27 Relations between the climate units of this Manual, the climate regions of Polunin & Walters, the Ecoregions of Schultz and the Habitat regions.

BGR/ESB (1997)	**Polunin/ Walters (1985)**	**Schultz (1995)**	**Habitat Biogeographical Regions (1996)[1]**	
			Holarctic Empire Euro-Siberian Region	
1. Boreal	1. Arctic 2. Boreal	1. Ice deserts 2. Frost debris zone 3. Tundra 4. Boreal zone	1.1. Boreal province[2]	Boreal region
2. Boreal to temperate	2. Boreal	4. Boreal zone	1.1. Boreal province[2]	Boreal region
	3. Atlantic	5. Humid Mid-Latitudes	1.2. Atlantic province	Atlantic region
			1.3. Coastal province	Atlantic
3. Temperate	3. Atlantic	5. Humid Mid-Latitudes	1.2. Atlantic province	Atlantic region
	4. Central European	6. Mediterranean Subtropics	1.3. Coastal province	Atlantic region
	5. Mediterranean		1.4. Midle European province[3]	Continental region
	6. Pannonic		1.5. High mountain province	Alpine region
			Mediterranean Region	
4. Mediterranean	3. Atlantic	5. Humid Mid-Latitudes	1.3. Coastal province	Euro-Siberian region
	5. Mediterranean	6. Mediterranean subtropics	Mediterranean region	Mediterranean region
			1.5. High mountain province[3]	Alpine Region

(1) As stipulated in Article 1 of Council Directive 92/43/EEC are identified with an asterisk (*);
(2) Includes hemiboreal region;
(3) Includes subalpine and alpine levels. Macarronesian region of Habitat (1996) is not included here.

Table 28 European Altitudinal Bioclimatic Belts[1]

Vegetation levels for the Euro-Siberian region[2] After Habitat 2000 (1996)
- marine and coastal level - hill level (white oak, sessile oak, common oak, beech, Scots pine, etc.) - montane level (beech, fir, spruce, Scots pine) - subalpine level (fir, spruce, mountain pine, larch, arolla pine) - alpine level (not forested by definition) - snow level
Vegetation levels for the Mediterranean region:

Five basic vegetation levels are distinguished which are (in order of increasing altitude):
- thermo-Mediterranean level (thermophile conifer forests, olive, carob and mastic formations in association with oaks)
- meso-Mediterranean level (forests dominated by sclerophyllous oaks)
- supra-Mediterranean level (deciduous oak forests)
- montane-Mediterranean level (montane conifer forests: cedar, black pine, etc.)
- oro-Mediterranean level (occupied at least in part by sparse, high-altitude juniper forests)

(Delpech, R., Dumé, G., Galmiche, P. (1985) Typologie des stations forestières - Vocabulaire. Institut pour le Développement Forestier (IDF).2). In most of the Atlantic Region it is only possible to distinguish these vegetation levels on the basis of the overhall ecological affinities of its non-woodland habitats to the habitats found in the more clearly characterized vegetation levels of the Continental and Alpine Regions (Habitat 2000, pp. 6).

Finally, it should be mentioned that there will be a Document available in the ESB where each unit's most relevant structure, geographical distribution and ecological properties are described in detail, together with their relationships with soils, physiographies, parent materials, land use, etc.

1. Artic Climate zone

Vegetation belts

a. Low artic tundra (> 80% plant cover)
b. High artic tundra (10-80% plant cover)
c. Polar desert (< 10% plant cover)

Small-scale patterns

1.1. Barren ground
1.2. Moss tundra
1.3. Lichen tundra
1.4. Dwarf-heath tundra
  1.4.1 Variant of dwarf birch
  1.4.2 Variant of Dryas heaths (Habitat 31.48)
1.5. Artic alpine tundra (Habitat 31.48; 36.32)
1.6. Grassland tundra
1.7. Polar/subpolar mires (mainly palsa mires) (see also mires of the Boreal Climate Zone) (Habitat 54.9; 54.9)
1.8. Forest tundra (mineral soils and peaty soils sub-types must be taken into consideration)
  1.8.1. Forest tundra with coniferous trees
  1.8.2.Forest tundra with deciduous trees
1.9. Freshwater communities (standing and running waters)
1.10. Rocky habitats communities (screes, cliff, rock fissures, etc.)
1.11. Permanent glaciers (rock and true glaciers) (Habitat no code)
1.12. Fields of lava (Habitat no code; Natura 2000 8320)

2. Boreal Climate Zone

2.1 Coniferous forest (Taiga); Natural or semi-natural coniferous woodlands (Habitat 42C) (sub-types: (a) nudum -litter layer only-; (b) mosses and lichen layer; © shrub and herbaceous layer; (d) Primeval (old) stands; (e) succesional post-burn stands on natural forest; (f) Industrial stands -afforestation-, must be taken into consideration)
  2.1.1. Spruce (*Picea abies*) woods
  2.1.2. Scots Pine (*Pinus sylvestris*) woods
  2.1.3. Spruce (*Picea abies*) & scots pine (*Pinus sylvestris*) mixed woods
2.2. Mires
  2.2.1. Bogs
    2.2.1.1 Blanket bogs. Active -Habitat 52.1- and degraded -Habitat 52.2- sub-types must be taken into consideration
    2.2.1.2 Raised bogs. Active -Habitat 51.1- and degraded -Habitat 51.2- sub-types must be taken into consideration
    2.2.1.3 Aapa or string mires and palsa mires. Active and degraded sub-types must be taken into consideration
      2.2.1.3.1. Aapa mires (Habitat 54.8)
      2.2.1.3.2. Palsa mires (Habitat 54.9)
    2.2.1.4. Bog woodland. Active and degraded sub-types must be taken into consideration
      2.2.1.4.1. Sphagnum birch woods (Habitat 44.A1)
      2.2.1.4.2. Scots pine mire woods (Habitat 44.A2)
      2.2.1.4.3. Mire spruce woods (Habitat 44.A4)
    2.2.1.5. Transitional and Intermediate mires (Habitat 54.5 & partly correspond with Habitat 37.31)
  2.2.2. Fen communities (Habitat 54.2)
    2.2.2.1. Marsh fen communities (Habitat 53.3)
    2.2.2.2. Carr fen communities
    2.2.2.3. Pioneer formations of *Caricion bicoloris-atrofuscae* (Habitat 54.3)

2.2.3. Petrifying springs with tufa formation; Calcareous flushes, (*Cratoneurion commutati*) (Habitat 54.12)

2.3. Deciduous forest

2.3.1 Birch woods (Habitat 42C). Sub-types: (a) primeval; (b) intensive forestry; (c) recently post-burn forest on natural stands; (d) industrial -afforestation-, must be taken into consideration

2.3.1.1. Downy birch (*Betula pubescens* = *B. alba*) woods

2.3.1.2. Silver birch (*Betula pendula*)

2.3.1.3. Wet birch woods

2.3.2. Willows thickets. Mineral soils and peaty soils sub-types must be taken into consideration

2.3.3. Alder woods or carrs. Mineral soils and peaty soils sub-types must be taken into consideration (Habitat 44.3; 44.2)

2.3.3.1. Grey alder (*Alnus incana*) woods (Habitat 44.2)

2.3.3.2. Grey alder (*Alnus incana*) & ash (*Fraxinus*) alluvial mixed woods (Habitat 44.2)

2.3.3.3. Common alder (*Alnus glutinosa*) woods (Habitat 44.3?)

2.3.3.4. *Alnus glutinosa, A. incana, Betula pubescens, Ulmus laevis*, etc. mixed woods (Habitat 44.3)

2.3.4. Other mixed or pure deciduous woods

2.4. Heatlands

2.4.1. Alpine heaths (Habitat 31.45)

2.4.2. Lowland maritime heaths (Habitat 31.25)

2.4.3. Heaths on dry inland dunes with *Calluna* and *Genista* (Habitat 64.1x31.223)

2.4.4. Heaths on dry inland dunes with *Calluna* and *Empetrum nigrum* (Habitat 64.1x31.227)

2.5. Grasslands and meadows

2.5.1. Natural (alpine) grasslands and hay meadows (partly corresponds with Habitat 38.3)

2.5.1.1. Calcareous grasslands

2.5.1.2. Siliceous grasslands (Habitat 36.32)

2.5.2. Semi-natural grasslands

2.5.3. *Molinia* meadows on chalk and clay (*Eu-Molinion*) (Habitat 37.31)

2.5.3.1. On neutro-alkaline to calcareous soils (sometimes peaty) *(Eu-Molinion*) (Habitat 37.311)

2.5.3.2. On acid soils (*Junco-Molinion; Juncion acutiflory)* (Habitat 37.312; 54.2)

2.5.4. Hygrophilous-eutrophic tall herbs communities (along water courses) (Habitat 37.7)

2.5.5. Artificial (planted) grasslands

2.5.6. Other Boreal grasslands

2.6 Boreal coastal plant communities (see also Atlantic and Central Europe Region)

2.6.1. Mudflats sandflats, saltmarhes and salt meadows (halophytic communities, including estuaries communities) (partly corresponds with Habitat: 13.2; 14. 11; 15.11; 15.13, etc.,)

2.6.1.1. Coastal saltmarsh-grass meadows (*Puccinellia* species, commonly common saltmarsh-grass *Puccinellia maritima*) communities (*Glauco-Puccinellietalia*) (Habitat 15.31; 15.32; 15.33; 15.34; 15.35; 15.36). Sub-types: (a) most flooded (Habitat 15.31); (b) less flooded with *Festuca rubra*, must be taken into consideration (Habitat 15.33)

2.6.1.2 Sea-pearlworth annual pioneers communities (*Saginion maritimae*) (variable salinity) (Habitat 15.13)

2.6.1.3. Saltmarsh rush (*Juncus gerardii*) communities (Habitat 15.33)

2.6.1.4. Salt rush (*Juncus maritimus*) with *Atriplex hastata*, etc. communities (partly corresponds with Habitat 15.15; 15.36)

2.6.1.5. Sea wormwood (*Artemisia maritima*) (On light sandy soils) (Habitat 15.33)

2.6.2. Sand dune and shingle communities

2.6.2.1 Annual vegetation of drift lines (open, short-lived communities of beach, drift material and gravel with *Salsola kali, Cakile maritima, etc*. (Habitat 17.2)

2.6.2.2. Embryonic shifting dunes with *Elymus farctus, Elymus arenarius* (Habitat 16.211)

2.6.2.3. Primary shifting dunes along the shoreline (white dunes); communities of marram grass (*Ammophila arenaria*) (low dunes with disperse vegetation) (Habitat 16.212)

2.6.2.4. Plant communities on grey (fixed) dunes (stabilized, with willows, rushes, grasses, closed turf of mossses and lichens) (Habitat 16.221 to 16.227) (see sub-tyes in the sand dunes communities of the Atlantic region)

2.6.2.5. Decalcified fixed dunes with *Empetrum nigrum* (Habitat 16.23)

2.6.2.6. Dune-slacks communities (hollows left between the dune ridges). The following sub-types must be taken into consideration: (a) water table below the surface with *Salix arenaria* (Habitat 16.26); (b) damp hollows with pondweeds (*Potamogeton species*), horned pondweed (*Zannichellia palustris*) and mosses. (Habitat 16.31 to 16.35); © pioneer swards (*Juncenion bufonii* p.: *Gentiano-Erythraetum littoralis, Hydrocotylo-Baldellion*) (Habitat 16.32); (d) acidic and calcareous fens, often invaded by creeping willow (Habitat 16.33 & 54.2); (e) humid grasslands and rushbeds, often with reeping willows (Habitat 16.34); (f) reedbeds, sedgebeds and canebeds (Habitat 16.35)

2.6.2.7. Boreal wooded dunes with several posssibles assamblages of trees (*Alnus, Pinus,* etc.) (Habitat 16.29)

2.6.3. Perennial vegetation of stony banks: sea kale communities (*Elymo-Crambetum,* etc.) (Habitat 17.31)

2.6.4. Vegetated sea steepest cliff of the Baltic coasts (*Crithmo-Armerietalia, Silenion maritimae*) (Habitat 18.21)

2.7. Freshwater habitats (frequently pioneer of land interface zones of lakes or rivers, sometimes on peaty soils). Only Habitat EUR15 communities are included here

2.7.1. Standing waters

2.7.1.1. Oligotrophic waters of sandy plains with amphibious vegetation: *Lobelia, Littorella* and *Isoetes* (Habitat 22.11x22.31)

2.7.1.2. Oligotrophic waters in medio-European area with amphibious vegetation (Habitat 22.11 x22.31; 22.32). Sub-types (a) aquatic to amphibious short perennial vegetation, oligotrophic to mesotrophic, of lake, pond and pool banks and water-land interfaces belonging to the *Littorelletalia uniflorae* order; (b) Amphibious short annual vegetation, pioneer of land interface zones of lakes, pools and ponds with nutrient poor soils, or which grows during periodic drying of these standing waters. *Isoeto-Nanojuncetea* class must be taken into consideration.

2.7.1.3. Natural dystrophic lakes and ponds generally on peaty soils in bogs or in heaths (Habitat 22.14)

2.7.1.4. Other standing waters communities

2.7.2. Running water

2.7.2.1. Herbaceous and suffrutescent communities along of the gravel river banks (*Epilobion fleischeri* p.) (Habitat 24.221)

2.7.2.2. Ligneous vegetation of *Myricaria germanica* along gravel river banks (*Salici-Myricarietum*) (Habitat 24.223)

2.7.2.3. Thickets or woods with *Salix eleagnos, Salix* spp., *Alnus, Betula,* etc. along gravel river banks (Habitat 24.224)

2.7.2.4. Other running water communities

2.8. Rocky habitats communities

2.8.1. Scree communities

2.8.1.1. Montane cryoclastic siliceous scree (*Androsacetalia alpinae & Galeopsietalia ladani*) (Habitat 61.1)

2.8.1.2. Other scree communities

2.8.2. Chasmophytic vegetation (cliff fissures) on rocky slopes

2.8.2.1. Chasmophytic vegetation of calcareous rocky slopes with *Asplenium viride & Woodsia glabella* (Habitat 62.1C)

2.8.2.2. Chasmophytic vegetation on siliceous rocky slopes (rapakivi cliffs) (Habitat 62.2A)

2.8.2.3. Other chasmophytic vegetation

2.8.3. Pioneer vegetation on siliceous rock or colonising superficial soils of siliceous rock surfaces (*Sedo-Scleranthion, Sedo albi-Veronicion dillenii*) (Habitat 62.3). This habitat is associated with Habitat 62.2 (vegetation colonising siliceous rocks); vegetation colonising calcareous rocks is included under Habitat 34.11 "Karstic calcareous grasslands" and Habitat 62.4 "Limestone pavements"

2.8.4. Nordic limestone pavements. They are very complex patterns of micro-topography, microclimates, soils and plant communities (Habitat 62.4). The rock exposures could be covered by bryophytes or a thin soil. The surface is covered by *Sedum album, Cerastium pumilum,* lichens, etc. The vegetation in the cracks contains *Gymnocarpium robertianum*, *Asplenium ruta-muraria*, and occasionally bushes such as *Prunus spinosa, Fraxinus excelsior*, *Cotoneaster* spp., *Rosa* spp.

2.8.5. Permanent glaciers (rock and true glaciers) (Habitat no code)

2.8.6. Other rocky habitats communities

3. Atlantic Climate Zone

3.1. Atlantic deciduous, semi-evergreen and evergreen broadfeaf woods

3.1.1. Deciduous oak woods

3.1.1.1. Pedunculate oak (*Quercus robur*) woods

3.1.1.2. Sessile oak (*Quercus petraea*) woods. The following sub-types must be taken into consideration: (a) on hydromorphic soils; (b) on dry soils

3.1.1.3. *Quercus robur & Quercus petraea* mixed woods

3.1.1.4. Other assamblages with *Quercus petraea and/or Q. robur,* with some of these taxa: *Betula pendula, B. pubescens, Ilex, Carpinus,* etc. as co-dominant trees (Habitat 41.51; 41.53; 41.54; 41.24)

3.1.2. Semi-deciduous and evergreen oak Woods (partly sub-Mediterranean)

3.1.2.1. Pyrenean oak (*Quercus pyrenaica*) and *Q. robur* mixed woods. The following sub-types must be taken into consideration: (a) French pyrenean oak forests with *Betula pendula* (Habitat 41.65); (b) Cantabrian pyrenean oak forests (Habitat 41.62)

3.1.2.2. *Quercus petraea & Quercus pyrenaica* mixed woods

3.1.2.3. *Quercus pyrenaica & Fagus sylvatica* mixed woods

3.1.2.4. Thermic moist-holm oak (*Quercus ilex* ssp. ilex) evergreen woods (partly sub-mediterranean) with *Laurus nobilis* and many climber species)

3.1.2.5. Thermic dry-holm oak (*Q. ilex* ssp. *rotundifolia*) evergreen woods (partly sub-mediterranean)

3.1.2.6. Old acidophillous oak woods with *Quercus robur, Q. pyrenaica, Betula pendula, Betula pubescens, etc.* (Habitat 41.54?)

3.1.3. Atlantic beech woods. Sub-types: (a) nudum; (b) shrub and/or ground layer must be taken into consideration

3.1.3.1. On acid soils

3.1.3.1.1. *Luzulo-Fagetum* beech forests (Habitat 41.11)

3.1.3.1.2. Beech forest with *Ilex* and/or Taxus (*Ilici-Fagion*) (partly sub-Mediterranean) Habitat 41.12). The following sub-types must be taken into consideration: (a) Atlantic beech-oak forests with *Ilex* (plains & hilly levels); (b) pure beech forest or beech-fir forest with Ilex (montane level)

3.1.3.2. On neutrophile soils (*Asperulo-Fagetum* beech forests) (abundant herb layer) (Habitat 41.131; 41.132). The following sub-types must be taken into consideration: (a) Medio-European collinar nitrophilous beech forests (Habitat 41.131); b: Atlantic neutrophiile beech forest (Habitat 41.132)

3.1.3.3. Dry calcareous beech forest (*Cephalantero-Fagion*) (north western Iberia) (Habitat 41.162)

3.1.3.4. Other asamblages with *Fagus sylvatica* as dominant or codominant tree with some of these taxa: *Quercus robur, Q. petraea, Fraxinus excelsior, Carpinus betulus,* etc. (partly corresponds withHabitat 41.12; 41.131; 41.132)

3.1.4. Ash woods (ash is dominat species but other trees also occur). The following sub-types must be taken into consideration: (a) on hydromorphic soils (Habitat 44.3?); (b) on dry soils

3.1.5. Alder woods, or *Carr*, with *Alnus glutinosa* as dominant with ash on hydromorphic or peaty soils (Habitat 44.3)

- 3.1.6. Birch woods. The following sub-types must be taken into consideration: (a) with a dense and rich herbaceous layer; (b) with bilberry (*Vaccinium myrtillus*) and other shrubs in a dense shrub layer
- 3.1.7. Primeval deciduous forest (multilayered with many non-codominant deciduous and coniferous trees) (Habitat 41.4)
- 3.1.8. Thermophyllous mixed forest (with deciduous & evergreen broadleaf trees such as *Laurus nobilis*) (partly sub-Mediterranean)
- 3.1.9. Other deciduous, semi-deciduous and evergreen broadleaf woods
- 3.1.10. Riparian oak-elm-ash mixed forests (Habitat 44.4)

3.2. Atlantic coniferous woodland

- 3.2.1. Scots pine (*Pinus sylvestris*) woods. The following sub-types must be taken into consideration: (a) natural-relicts including *P. sylvestris* var. *Scotia, Betula,* etc. forests (Scotland) (Habitat 42.51); (b) Semi-natural; © industrial (afforestation)
- 3.2.2. Maritime pine (*Pinus pinaster*) woods. The following sub-types must be taken into consideration: (a) natural; (b) semi-natural (commonly with *Quercus robur and/or, Q. pyrenaica*); © industrial.
- 3.2.3. Yew (*Taxus bacatta*) woods with *Sorbus aria* , *Betula,* etc. (Habitat 42.A71)
- 3.2.4. Other Atlantic coniferous forests plantations (e.g. *P. radiata, Chamaecyparis,* etc.).

3.3. Deciduous bush communities

- 3.3.1. Successional bush communities
- 3.3.2. Bush communities of hedges and bocages (traditional farming structures)

3.4. Atlantic heaths and scrubs

- 3.4.1. Northern wet heaths (ericaceous species dominants and *Erica tetralix* as characteristic taxa) (Habitat 31.11)
- 3.4.2. Oceanic wet heaths (ericaceous and gorse species) (Habitat 31.12)
- 3.4.3. Northern dry heaths (Habitat 31.25 & 31.21)
- 3.4.4. Oceanic dry heaths (Habitat 31.23 & 31.234)
- 3.4.5 Subcontinental dry heats (ericaceous and leguminous shubs species) (including Habitat 31.22)
- 3.4.6. Southern dry heaths (dominated by taller ericaceous and *Cistus* shrubs) (Habitat 31.24)
- 3.4.7. Atlantic stable *Buxus sempervivens* formations on calcareous rock slopes (*Berberidion* p.) (Habitat 31.82)
- 3.4.8. Atlantic *Juniperus communis* formations on calcareous heaths or grasslands (Habitat 31.88)
- 3.4.9. Heaths on dry inland dunes with *Calluna* and *Genista* (Habitat 64.1x31.223)
- 3.4.10. Heaths on dry inland dunes with *Calluna* and *Empetrum nigrum* (Habitat 64.1x31.227)

3.5. Atlantic mires (active and and degraded sub-types must be taken into consideration)

- 3.5.1. Blanket bogs (Habitat 52.1; 52.2; also partly correspond with Habitat 37.31)
- 3.5.2. Raised bogs (Habitat 51.1; 51.2)
- 3.5.3. Transitional and Intermediate mires (Habitat 54.5 & partly correspond with Habitat 37.31)
- 3.5.4. Depressions on peat substrates (*Rhynchosporion*) (Habitat 54.6)
- 3.5.5. Fen communities (Habitat 54.2)
  - 3.5.5.1. Poor fens (slighly acid or neutral peats)
  - 3.5.5.2. True or rich fens; Marsh fen communities (neutral or alkaline peats)(Habitat 53.3)
  - 3.5.5.3. Rich fens in transition to carr
  - 3.5.5.4. Pioneer formations of *Caricion bicoloris-atrofuscae* (Habitat 54.3)
- 3.5.6. Petrifying springs with tufa formation: calcareous flushes, (*Cratoneurion commutati*) (Habitat 54.12)
- 3.5.7. Bog woodland
  - 3.5.7.1. Sphagnum birch woods (Habitat 44.A1)
  - 3.5.7.2. Scots pine mire woods (Habitat 44.A2)
  - 3.5.7.3. Mountain pine bog woods (Habitat 44.A3)

3.6. Atlantic grasslands and meadows (natural and semi-natural)

- 3.6.1. Neutral grasslands and meadows (with *Lolium perenne & Dactylis glomerata*)
  - 3.6.1.1. Neutral grasslands with open, bocage or hedge structures (Habitat 38.2)
  - 3.6.1.2. Montane hay meadows (Habitat 38.3)

3.6.1.3. Artificial grasslands
3.6.1.4. Other neutral grasslands and meadows
3.6.2. Calcareous grasslands.
3.6.2.1. Grasslands dominated by fescue grasses and *Avenula pratensis* (Habitat 34.32 & 34.33)
3.6.2.2. Grasslands dominated by *Bromus erectus* and *Brachypodium pinnatum; Mesobromion* (Atlantic and sub-Mediterranean) (Habitat 34.32; 34.33)
3.6.2.3. Natural karstic calcareous grasslands (*Alysso-Sedion albi*) (Habitat 34.11). The vegetation colonising calcareous rocks is included here
3.6.2.4. Natural, xeric, sandy calcareous grasslands (*Koelerium glaucae*) (Habitat 34.12)
3.6.2.5. Thermophile, forest fringe, abandonment fields variants (*Trifolio-Geranietea*) (Atlantic, sub-continental)
3.6.2.6. Artificial grasslands
3.6.2.7. Other calcareous grasslands
3.6.3. Acid grasslands
3.6.3.1. Perennial grasslands very rich in species of *Agrostis* genera
3.6.3.2. Perennial grasslands dominated by *Nardus stricta* (Habitat 35.1)
3.6.3.3. Annual grasslands
3.6.3.4. Damper grasslands with *Molinia* and *Juncus* (on acid soils) (*Junco-Molinion; Juncion acutiflory)* (Habitat 37.312; 54.2)
3.6.3.5. Open grassland on continental dunes with *Corynephorus* and *Agrostis* (partly sub-Mediterraean) (Habitat 64.1x35.2)
3.6.3.6. Artificial grasslands
3.6.3.7. Other acid grasslands
3.6.4. Inland salt meadows -halophytic communities- (*Puccinellietalia distalis*) (Habitat 15.14)
3.6.5. Atlantic coastal saltmarsh-grass meadows (*Puccinellia* species, commonly common saltmarsh-grass, *Puccinellia maritima*) communities (*Glauco-Puccinellietalia*) (Habitat 15.31; 15.32; 15.33; 15.34; 15.35; 15.36). Sub-types: (a) most flooded (Habitat 15.31); (b) less flooded with *Festuca rubra* (Habitat 15.33), must be taken into consideration
3.6.6. Hygrophilous-eutrophic tall herbs communities (along water courses) (Habitat 37.7)
3.6.7. Dune meadows of *Poa pratensis*, and *Festuca rubra*) (Scotish & Ireland Machairs) (sandy calcareous soils) (Habitat 1A)
3.6.8. Other grasslands and meadows
3.7. Atlantic coastal plant communities. See also thermo-Atlantic saltmarshes and salt meadows in Mediterranean region (Habitat 15.15).
3.7.1. Mudflats, sandflats, saltmarhes and salt meadows (halophytic communities, including estuaries communities) (partly corresponds with Habitat 13.2; 14; 11.3)
3.7.1.1. Thermo-Atlantic halophilous scrubs of dwarf shrubby perennial glassworts (*Arthrocnemetalia fruticosae*) (Habitat 15.16)
3.7.1.2. Spartina swards (*Spartinion*). Perennial pioneer flat-leaved cordgrass swards (high salinity)*(Spartina townsendii, S. maritima, S. anglica, S. alterniflora*) (Habitat 15.11; 15.21, and partly also corresponds with 13.2). The following sub-types must be taken into consideration: (a) natural *Spartina* swards on salt muds; (b) planted *Spartina* swards
3.7.1.3. Variant of Gassworts (*Salicornia species*) (annuals) (low fleshy plants, often growing in close proximity) (Habitat 15.11)
3.7.1.4. Saltmarsh rush (*Juncus gerardii*) communities (Habitat 15.33)
3.7.1.5. Salt rush (*Juncus maritimus*) with *Atriplex hastata*, etc. communities (partly corresponds with Habitat 15.15; 15.36)
3.7.1.6. Sea wormwood (*Artemisia maritima*) (On light sandy soils) (Habitat 15.33)
3.7.1.7. Creeping bent (*Agrostis stolonifera*) community (estuaries) (intensively grazed) (salinity lesser than 1%) (Habitat 15.33)
3.7.1.8. Common reed (*Phragmites australis*) community (similar conditions to 3.7.1.7 in the absence of grazing or cutting)
3.7.1.9. Atlantic sea-pearlworth annual pioneers communities(*Saginion maritimae*) (variable salinity on salltmarshes & dunes) (Habitat 15.13)
3.7.1.10. Other mudflats, sandflats, saltmarhes and salt meadows

3.7.2. Sand dune and single communities

3.7.2.1. Atlantic foreshore communities of beach, drift material and gravel rich in nitrogenous organic matter. Open and short-lived communities of *Cakiletea maritimae* p. with *Polygonum aviculare, Rumex crispus,* etc. (Habitat 17.2)

3.7.2.2. Mobile dunes communities (primary, embryonic or white shifting low dunes along the shoreline) with disperse grasses such as *Agropyron junceum, Elymus arenarius, Polygonum aviculare, Rumex crispus, Atriplex hastata, Cakile maritima* (high salinity) (Habitat 16.211)

3.7.2.3. Primary, shifting dunes (white dunes) communities of marram grass (*Ammophila arenaria*) (Habitat 16.212)

3.7.2.4. Plant communities on grey (fixed) dunes (with willows, rushes, grasses, closed turf of mossses and lichens) (Habitat 16.221 to 16.227). The next sub-types must be taken into consideration: (a) northern grey dunes with grass communities (Habitat 16.221); (b) Biscay gery dunes (*Euphorbio-Helichrysion stoechadis*) (Habitat 16.222); © thermo-Atlantic grey dunes (*Crucianellion maritimae*) (Habitat 16.223); (d) Atlantic dune grasslands (*Mesobromion*) (Habitat 16.225); (e) Atlantic dune thermophile fringes (*Trifolio-Geranietea sanguinei, Galio maritimi-Geranion sanguinei, Geranium sanguineum* formations (Habitat 16.226); (e) dune fine-grass annual communities (*Thero-Airion* p., *Nardo-Galion saxatile* p.,*Tuberarion guttatae* p.) (Habitat 16.227)

3.7.2.5. Plant communities on brown (frequently decalcified dunes) (high dunes with heaths, woods, meadows and peats). The following sub-types must be taken into consideration: (a) descalcified fixed dunes with *Empetrum nigrum*, sometimes on acid peats (Habitat 16.23); (b) decalcified fixed dunes of *Calluno-Ulicetea* (commonly on acid peats); (Habitat 16.24); © brown dunes with *Hippophae rhamnoides* and willows (Habitat 16.25); (d) other brown dune with shrubs (*Rubus* spp., *Ulex europaeus*, etc.); (e) wooded brown dunes with many assamblages of tree species (Habitat 16.29)

3.7.2.6. Dune-slacks communities (hollows left between the dune ridges). The following sub-types must be taken into consideration: (a) water table below the surface with *Salix arenaria* (Habitat 16.26) (b); damp hollows with pondweeds (*Potamogeton species*), horned pondweed (*Zannichellia palustris*) and mosses (Habitat 16.31 to 16.35); © pioneer swards (*Juncenion bufonii* p.: *Gentiano-Erythraeetum littoralis*, *Hydrocotylo-Baldellion*) (Habitat 16.32); (d) calcareous and acidic fens, often invaded by creeping willow (Habitat 16.33 & 54.2); (e) humid grasslands and rushbeds, often with reeping willows (Habitat 16.34); (f) reedbeds, sedgebeds and canebeds communities (Habitat 16.35)

3.7.2.7. Other sand dune and single communities

3.7.3. Perennial vegetation of stony banks: sea kale communities (*Lathyro-Crambetum; Crithmo-Crambetum* , etc.) (Habitat 17.32)

3.7.4. Vegetated Sea cliffs of the Atlantic coasts (Habitat, 18.21)

3.8. Freshwater habitats (frequently pioneer of land interface zones of lakes or rivers, sometimes on peaty soils). Only Habitat EUR15 communities are included here

3.8.1. Standing waters

3.8.1.1. Oligotrophic waters of sandy plains with amphibious vegetation: *Lobelia, Littorella* and *Isoetes* (Habitat 22.11x22.31)

3.8.1.2. Oligotrophic waters of the sub-continental area with amphibious vegetation (Habitat 22.11 x 22.31; 22.32). Sub-types: (a) aquatic to amphibious short perennial vegetation, oligotrophic to mesotrophic, of lake, pond and pool banks and water-land interfaces belonging to the *Littorelletalia uniflorae* order; (b) amphibious short annual vegetation, pioneer of land interface zones of lakes, pools and ponds with nutrient poor soils, or which grows during periodic drying of these standing waters. *Isoeto-Nanojuncetea* class must be taken into consideration

3.8.1.3. Natural dystrophic communities of lakes and ponds, generally on peaty soils in bogs or heaths (Habitat 22.14)

3.8.1.4. Sub-Mediterranean temporary ponds rich in therophytic and geophytic species (Habitat 24.34)

3.8.1.5. Turloughs (Ireland and possibly other countries) (Habitat no code; Natura 2000 code 3180)
3.8.1.6. Other standing waters communities
3.8.2. Running waters
3.8.2.1. Annual pioneeer nitrophilous vegetation (*Chenopodietum rubri, Bidention* p.p.) on muddy river banks (Habitat 24.52)
3.8.2.2. Other communities of running waters
3.9. Rocky habitats communities
3.9.1. Scree communities
3.9.1.1. Montane to snow level cryoclastic siliceous scree, (*Androsacetalia alpinae & Galeopsietalia ladani*) (Habitat 61.1)
3.9.1.2. Eutric scree of the montane to alpine levels (*Thlaspietea rotundifolii*) (Habitat 61.2). Sub-types: (a) calcshist screes (*Dabrion hoppeanae*); (b) calcerous screes (*Thlaspion rotundifolii*); (c) marl screes (*Petasition paradoxi*), must be taken into consideration
3.9.1.3. Upland siliceous scree with *Epilobium collinum & Cryptogramma crispa* (Habitat 61.5)
3.9.1.4. Other scree communities
3.9.2. Chasmophytic vegetation (cliff fissures) on rocky slopes
3.9.2.1. Chasmophytic vegetation of calcareous rocky slopes (*Potentilletalia caulescentis*) (Habitat 62.15 and 62.1B)
3.9.2.2. Chasmophytic vegetation of siliceous rocky slopes (Habitat 62.2). The following sub-types must be taken into consideration: (a) Hercynian system and its periphery (*Androsacion vandellii*) (Habitat 62.21); (b) communities of montane level of Cevennes (*Asarinion procumbentis*) (Habitat 62.26); © communities of the plain level (*Asplenion billotii-Umbilicarion rupestre* (Habitat 62.29 is included); (d) Hercynian serpentine cliffs (*Asplenion cuneifolii*)
3.9.2.3. Other chasmophytic communities
3.9.3. Pioneer vegetation on siliceous rock or colonising superficial soils of siliceous rock surfaces (*Sedo-Scleranthion*, *Sedo albi-Veronicion dillenii*) (Habitat 62.3) This habitat is associated with Habitat 62.2. Vegetation colonising calcareous rocks is included under Habitat 34.11 "Karstic calcareous grasslands" and Habitat 62.4 "Limestone pavements"
3.9.4. Limestone pavements with very complex patterns of micro-topography, microclimates, soils and plant communities. In British Isles the following sub-types must be taken into consideration: (a) *Seslerio-Mesobromenion*; (b) pockets of shade-tolerant plants such as *Geranium robertianum* and *Ceterach officinale*; © heath and scrub of *Corylo-Fraxinetum*; (d) dense scrubs of *Prunetalia spinosae* or *Dryas octopetala*; (e) open *Taxus-Juniperus* scrub; (f) ancient woodland containing *Tilia cordata* ; (Habitat 62.4); (f) Calaminarian grasslands (*Violetalia calaminariae*) occur on rock outcrops rich in heavy metals including mines (Habitat 34.2 & 36.44)

4. Central European Climate Zone

4.1. Deciduous forests
4.1.1. Beech (*Fagus sylvatica*) woods. Sub-types: (a) nudum; (b) shrub and/or herbaceous layer must be taken into consideration
4.1.1.1. Dry slope limestone variant rich in orchids & sedges (*Cephalantero-Fagion*) (Habitat 41.161)
4.1.1.2. Calcareous mountain variant with *Sesleria coerulea* (partly subcontinental, partly continental)
4.1.1.3. Variant with yew (*Taxus baccata*) (partly oceanic, partly sub-oceanic) (Habitat 41.12)
4.1.1.4. Variant with *Melica uniflora* (partly sub-Mediterranean)
4.1.1.5. Variant with fir and/or spruce (montane sub-oceanic) (Habitat 41.133; 41.134)
4.1.1.6. Variant with sycamore and *Rumex arifolius* (lower sub-alpine belt of the southwest of Central Europe) (Habitat 41.15)

4.1.1.7. Wood-rush *Luzulo-Fagetum* forests (dystric soils, lowlands and montane belts) (Habitat 41.11)

4.1.1.8. Collinar and montane nitrophilous beech forests (Habitat 41.131; 41.133)

4.1.1.9. Other beech woods with codominant tree species (elms, ahs, maples, etc.)

4.1.2. Oriental beech (*Fagus orientalis*) woods, commonly associated with other trees such as *Juglans regia, Quercus cerris, Q. fraginetto,* ashes, etc.)

4.1.3. Oak-horbeam woods (*Quercus robur* and *Q. petraea* with *Carpinus betulus* as codominant species)

4.1.3.1. Variant associated with different combinations of other trees such as spruce, fir, beech, lime, ash, etc. (Habitat 41.24)

4.1.3.2. Sub-continental variant of *Q. petraea*, frequently with fir, and/or beech, and/or *Q. robur* (*Galio-Carpinetum*) (Habitat 41.26)

4.1.3.3. Eastern and Carpathian types of *Q. petraea* (sometimes with *Q. robur* and/or beech, and/or elm, and/or maple) (Habitat 41.2B)

4.1.3.4. Other oak-horbeam forests

4.1.4. Oak forests

4.1.4.1. *Quercus robur* woods

4.1.4.2. *Quercus petraea* woods (mainly on acid soils, foothills of the main mountain ranges)

4.1.4.3. *Quercus robur* woods with *Populus tremula, Sorbus aucuparia, Betula pendula, B. pubescens* (Habitat 41.51)

4.1.4.4. *Quercus petraea & Pinus sylvestris* mixed woods (frequently with birch, aspen, limes and pedunculate oak)

4.1.4.5. *Quercus Robur & Q. petraea* mixed woods

4.1.4.6. *Quercus petraea & Castanea sativa* mixed woods (southern of Central Europe, partly sub-mediterranean, frequently with ash, black poplar, lime and elm) (corresponds partly with Habitat 41.9)

4.1.4.7. *Quercus frainetto* with *Quercus cerris* woods (frequently with *Carpinus orientalis, Quercus pubescens, Tilia tomentosa* and *Fraxinus ornus,* etc.)

4.1.4.8. Steppe oak woods (*Quercus robur, Q. cerris, Q. pubescens,Q. petraea,* etc.) (Habitat 41.7A)

4.2. Central Europe coniferous forest

4.2.1. Pine forests

4.2.1.1. Scots pine (*Pinus sylvestris*) woods. The following sub-types must be taken into consideration: (a) lowland pure stands; (b) mixed forests with pedunculate oak; © semi-natural variant woods; (d) afforestation; (e) sub-Alpine forests

4.2.1.2. Arolla pine (*Pinus cembra*) woods (Alps and Carpathians) (Habitat 42.31 to 42.32)

4.2.1.2.1. Eastern allora pine woods (siliceous and calcicolous sub-types must be taken into consideration) (Habitat 42.31; 42.32)

4.2.1.2.2. Eastern Alpine *Pinus cembra* & larch (*Laris decidua*) woods (siliceous and calcicolous sub-types must be taken into consideration) (Habitat 42.31; 41.32)

4.2.1.3. Black pine (*Pinus nigra*) woods (sub-Mediterranean) (natural, semi-natural and industrial sub-types must be taken into consideration). The following sub-types must be taken into consideration: (a) *Pinus nigra* ssp. *nigra* woods; (b) *Pinus nigra* ssp. *pallasiana* woods

4.2.1.4. Dwarf mountain pine (*Pinus mugo*) bushes with hairy alpenrose (*Rhododendron hirsutum*) and the spring heath (*Erica carnea*) (mountain belts, partlly submediterranean)

4.2.1.5. *Pinus uncinata* woods (partly sunmediterranean) (Habitat 42.4). The following sub-types must be taken into consideration: (a) sub-Alpine pure stands (Habitat 42.41; 42.42); (b) with scots pine mixed forests (Pyrenees) (Habitat 42.41; 42.42); © with larch and arolla pine mixed forests (Habitat 42.41; 42.42); (d) on bogs (Habitat 44.A); (e) with *Pinus mugo* scrub (Habitat 31.5)

4.2.2. Spruce (*Picea abies, P. orientalis, P. omorika*), fir (*Abies alba*) and larch (*Larix decidua*) woods

4.2.2.1. Spruce woods

4.2.2.1.1. Spruce woods (Habitat 42.21 to 42.23). Natural, semi-natural and industrial sub-types must be taken into consideration. The following biogeographical variants must be taken into account: (a) Carpatian sub-Alpine spruce forests *Piceetum subalpinum* (Habitat 42.21); (b) montane spruce forests *Picetum montanum* (Habitat 42.22); © Hercynian sub-alpine spruce forests (Habitat 42.23); (d) other spruce forests

4.2.2.1.2. Spruce & scots pine woods

4.2.2.1.3. Spruce & beech woods

4.2.2.1.4. Spruce & with fir woods

4.2.2.2. Fir woods. The following sub-types must be taken into consideration: (a) fir & beech forests; (b) fir & spruce forests

4.2.2.3. Eastern Alpine larch forests (siliceous and calcicolous types must be taken into consideration) (Habitat 42.31; 42.32)

4.3. Wet Woodlands

4.3.1. Alder woods (*Alnus glutinosa* and/or *Alnus incana*) (Habitat 44.3)

4.3.1.1. *Alnus glutinosa* woods with birch and ash

4.3.1.2. *Alnus incana* woods

4.3.1.3. Alder woods on bogs

4.3.2. Willow woods (with poplars, ash and alders) (Habitat 44.3). The following sub-types must be taken into consideration: (a) lowland woods (partly corresponds with Habitat 44.17); (b) high montane and sub-alpine woods

4.3.3. Wet mixed forest (several tree species co-dominants) (when they are Riparian corresponds with Habitat 44.4)

4.3.3.1. Oak-hornbeam of river valleys on hydromorphic soils (Habitat 41.24)

4.3.3.2. Oak-ash-elm-maples (several species) mixed woods (major river valleys) (Habitat 44.4; 41.4?)

4.3.3.3. Elm-maples (several species)-ash-lime mixed woods (Habitat 41.4)

4.3.3.4. Other wet mixed woods

4.3.4. Industrial poplar (*Populus* species) woods

4.4. Mires

4.4.1. Raised bogs

4.4.1.1. Sub-oceanic, subcontinental and continental very wet variants (active and degraded sub-types must be taken into consideration) (Habitat 51.1; 51.2)

4.4.1.2. Continental non-very wet variant with scots pine and heaths (active and degraded sub-types must be taken into consideration) (Habitat 51.1; 51.2)

4.4.2. Transitional and Intermediate mires (Habitat 54.5 & partly correspond with Habitat 37.31)

4.4.3. Depressions on peat substrates (*Rhynchosporion*) (Habitat 54.6)

4.4.4. Fens (Habitat 54.2)

4.4.4.1. Wet variant (which may be transitional to swamps); Marsh fen communities (neutral or alkaline) (Habitat 53.3)

4.4.4.2. Dry variant (partly correnponds with Habitat 37.31). The following sub-types must be taken into consideration: (a) acid dry fens; (b) calcareous dry fens; (c) poor fens

4.4.5. Petrifying springs with tufa formation; Calcareous flushes, (*Cratoneurion commutati*) (Habitat 54.12)

4.4.6. Bog woodland

4.4.6.1. Scots pine mire woods (Habitat 44.A2)

4.4.6.2. Mire spruce woods (Habitat 44.A4)

4.4.6.3. Mountain pine bog woods (Habitat 44.A3)

4.5. Heathlands

4.5.1. Sub-oceanic variant (with similar florisrtic assambleges of Atlantic heathlands) (Habitat 31.22; 31.21)

4.5.2. Heather-broom variant (mainly subcontinental) (Habitat 31.22?)

4.5.3. Montane heaths variant on dry peats (partly sub-continental, partly continental) (Habitat 31.21?)

4.5.4. Montane grass-heath variant (partly sub-continental, partly continental) (Habitat 31.21?)

4.5.5. Sclerophyllous scrubs of *Juniperus communis* on calcareous heaths or grasslands (Habitat 31.88)
4.5.6. Heaths on dry inland dunes with *Calluna* and *Genista* (Habitat 64.1x31.223)
4.5.7. Heaths on dry inland dunes with *Calluna* and *Empetrum nigrum* (Habitat 64.1x31.227)

4.6. Grasslands (all of them semi-natural with the exception of alpine and very dry sites steppe-like grasslands)

4.6.1. Dry grasslands and Steppe-like grasslands (mainly in correspondence with *Festucetalia valesiacae*) (Habitat 34.31; 34.34)
4.6.1.1. Natural and semi-natural feather-fescue communities (*Festuca* spp. & *Stipa* spp.) (on very dry sites) (Habitat 34.31)
4.6.1.2. Natural karstic calcareous grasslands (*Alysso-Sedion albi*) (Habitat 34.11)
4.6.1.3. Natural, xeric, sandy calcareous grasslands (*Koelerium glaucae*) (Habitat 34.12)
4.6.1.4. Semi-natural tor-grass or brome-tor grass communities (*Brachypodium pinnatum & Bromus inermis*) (*Mesobromion*) (Habitat 34.31; 34.34)
4.6.1.5. Semi-natural fescue grasslands (*F. glauca & Sesleria albicans*) (on calcareous parent materials)
4.6.1.6. Semi-natural southwestern grasslands of brome (*Bromus erectus*) (partly sub-mediterranean) (*Xerobromion*)
4.6.1.7. Calcareous-siliceous grasslands on hyperxerothermophile sands (*Koelerio macranthae-Phleion phloeidis*) (Habitat 34.34)
4.6.1.8. Open grassland with *Corynephorus* and *Agrostis* on continental dunes (Habitat 64.1x35.2)
4.6.1.9. Artificial grasslands

4.6.2. Meadows and pastures (natural, semi-natural or artificial and commonly flooded periodically)
4.6.2.1. Wet meadows and pastures (with *Molinea caerulea* dominant) (partly also corresponds with Habitat 54.2). The following sub-types must be taken into consideration: (a) poor variant (Habitat 37.311); (b) rich variant (Habitat 37.312)
4.6.2.2. Fresh meadows and pastures. The following sub-types must be taken into consideration: (a) hay-meadows with false oat-grass (*Arrhenatherum elatius*) (Habitat 38.2); (b) montane hay meadows of yelow oat-grass (*Trisetum flavescens*) (Habitat 38.3); © rye-grass grassland (*Lolium perenne*) (lowland and hills); (d) *Festuca nigresscens* grasslands (sub-montane or montane)
4.6.2.3. Poor meadows and pastures of mat-grass (*Nardus stricta*) (Habitat 35.1)
4.6.2.4. Inland salt meadows -halophytic communities- (*Puccinellietalia distalis*) (Habitat: 15.14)
4.6.2.5. Dry pioneer *Sedum* meadows (*Sedo-Scleranthea*) (partly corresponds with Habitat 62.3)
4.6.2.6. Alluvial meadows of flooding sites in river valleys (*Cnidion dubii*) (Habitat no code; Natura 2000 code 6440)
4.6.2.7. Semi-natural hygrophilous-eutrophic tall herbs communities (along water courses) (Habitat 37.7)

4.7. Central European coastal plant communities (see also Atlantic Region)

4.7.1. Mudflats, sandflats, saltmarhes & salt meadows (halophytic, including estuaries) (Habitat 13.2; 14; 11.3; 15.21, etc.)
4.7.1.1. Spartina swards (*Spartinion*). Perennial pioneer flat-leaved cordgrass swards *(Spartina townsendii, S. maritima, S. anglica, S. alterniflora*) (Habitat 15.11; 15.21). Natural and planted sub-types must be taken into consideration
4.7.1.2. Variant of Gassworts (*Salicornia species*) (annuals) (low fleshy plants, often growing in close proximity) (Habitat 15.11)
4.7.1.3. Coastal saltmarsh-grass meadows (*Puccinellia* species, commonly, *Puccinellia maritima*) communities (*Glauco-Puccinellietalia*) (Habitat 15.31; 15.32; 15.33; 15.34; 15.35; 15.36). Sub-types: (a) most flooded (Habitat 15.31) and (b) less flooded with *Festuca rubra*, must be taken into consideration (Habitat 15.33)

4.7.1.4. Salt marshes and Salt Meadows (*Saginion maritimae*) (Habitat 15.13)
4.7.1.5. Saltmarsh rush (*Juncus gerardii*) communities (Habitat 15.33)
4.7.1.6. Salt rush (*Juncus maritimus*) with *Atriplex hastata*, etc. communities (partly corresponds with Habitat 15.15; 15.36)
4.7.1.7. Sea wormwood (*Artemisia maritima*) (On light sandy soils) (Habitat 15.33)
4.7.1.8. Creeping bent (*Agrostis stolonifera*) community (estuaries) (intensively grazed) (salinity lesser than 1%) (Habitat 15.33)
4.7.1.9. Common reed (*Phragmites australis*) community (similar conditions to 4.7.1.8 in the absence of grazing or cutting)
4.7.1.10. Perennial vegetation of stony banks: sea kale communities with *Crambe maritima* (Habitat 17.3?)

4.7.2. Sand dune and shingle communities

4.7.2.1. Foreshore communities of beach, drift material and gravel rich in nitrogenous organic matter. Open and short-lived communities with of *Cakiletea matitimae* p. (Habitat 17.2)
4.7.2.2. Mobile dunes communities (embryonic or white shifting low dunes along the shoreline) with disperse grasses such as *Elymus farctus, Elymus arenarius* (Habitat 16.211)
4.7.2.3. Shifting or white dunes communities along the shoreline with marram grass (*Ammophila arenaria*) (Habitat 16.212)
4.7.2.4. Plant communities on grey (fixed) dunes (stabilized, with willows, rushes, grasses, closed turf of mossses and lichens) (Habitat 16.221 to 16.227) (see sub-tyes in the sand dunes communities of the Atlantic region)
4.7.2.5. Plant communities on brown, frequently decalcified dunes (high dunes with heaths, woods, meadows and peats)
4.7.2.6. Decalcified fixed dunes with *Empetrum nigrum* (Habitat 16.23)
4.7.2.7. Wooded dunes with several posssibles assamblages of trees (Habitat 16.29)
4.7.2.8. Dune-slacks communities (hollows left between the dune ridges). The following sub-types must be taken into consideration: (a) water table below the surface with *Salix arenaria* (Habitat 16.26); (b) damp hollows with *Potamogeton species*, *Zannichellia palustris* and mosses (Habitat 16.31 to 16.35); © pioneer swards communities (*Juncenion bufonii* p.: *Gentiano-Erythraeetum littoralis, Hydrocotylo-Baldellion*) (Habitat 16.32); (d) calcareous and acidic fens, often invaded by creeping willow (Habitat 16.33 & 54.2); (e) humid grasslands and rushbeds, often with reeping willows (Habitat 16.34); (f) reedbeds, sedgebeds and canebeds communities (Habitat 16.35)

4.7.3. Perennial vegetation of stony banks: sea kale communities (*Lathyro-Crambetum; Crithmo-Crambetum* , etc.) (Habitat 17.32)

4.7.4. Vegetated Sea cliffs of the Central Europe coasts (Habitat, 18..21)

4.8. Freshwater habitats (frequently pioneer of land interface zones of lakes or rivers, sometimes on peaty soils). Only Habitat EUR15 communities are included here

4.8.1. Standing waters

4.8.1.1. Oligotrophic waters of sandy plains with amphibious vegetation: *Lobelia, Littorella* and *Isoetes* (Habitat 22.11x22.31)
4.8.1.2. Oligotrophic waters in medio-European area with amphibious vegetation (Habitat 22.11 x 22.31; 22.32). Sub-types (a) aquatic to amphibious short perennial vegetation, oligotrophic to mesotrophic, of lake, pond and pool banks and water-land interfaces belonging to the *Littorelletalia uniflorae* order; (b) amphibious short annual vegetation, pioneer of land interface zones of lakes, pools and ponds with nutrient poor soils, or which grows during periodic drying of these standing waters: *Isoeto-Nanojuncetea* class, must be taken into consideration.
4.8.1.3. Natural dystrophic lakes and ponds generally on peaty soils in bogs or in heaths (Habitat 22.14)
4.8.1.4. Other standing waters communities

4.8.2. Running waters

4.8.2.1. Annual pioneeer nitrophilous vegetation (*Chenopodietum rubri, Bidention* p.p.) on muddy river banks (Habitat 24.52)
4.8.2.2. Other communities of running waters

4.9. Rocky habitats communities

4.9.1. Scree communities

4.9.1.1. Montane to snow level cryoclastic siliceous scree (*Androsacetalia alpinae & Galeopsietalia ladani*) (Habitat 61.1)

4.9.1.2. Eutric scree of the montane to alpine levels (*Thlaspietea rotundifolii*) (Habitat 61.2). Sub-types: (a): calcshist screes (*Dabrion hoppeanae*); (b) calcerous screes (*Thlaspion rotundifolii*); (c) marl screes (*Petasition paradoxi*), must be taken into consideration

4.9.1.3. Central Europe thermophillous scree (Habitat 61.3) and peri-Alpine thermophilous screes (*Stipion calamagrostidis, Leontodontion hyoseroidis*) (Habitat 61.31)

4.9.1.4. Upland siliceous scree with *Epilobium collinum & Cryptogramma crispa* (Habitat 61.5)

4.9.1.5. Calcreous or marly screes of hill and montane levels, often in dry, warm stations in associations with *Stipetalia calamagrostis.* Calcareous screes of the Paris Basin *Leontodontion hyoseroidis* are included (Habitat 61.6)

4.9.2. Chasmophytic vegetation (cliff fissures) on rocky slopes

4.9.2.1. Chasmophytic vegetation of calcareous rocky slopes (*Potentilletalia caulescentis*) (Habitat 62.15; 62.1B)

4.9.2.2. Chasmophytic vegetation of siliceous rocky slopes (Habitat 62.2). Saxicolous communities of the plain to hill levels under Middle European climate (*Asplenion septentrionalis*) (Habitat 62.29)

4.9.3. Pioneer vegetation on siliceous rock or colonising superficial soils of siliceous rock surfaces (*Sedo-Scleranthion, Sedo albi-Veronicion dillenii*) (Habitat 62.3) This habitat is associated with Habitat 62.2. Vegetation colonising calcareous rocks is included under Habitat 34.11 "Karstic calcareous grasslands” and Habitat 62.4 "Limestone pavements"

4.9.4. Limestone pavements (see Atlantic Region: 3.9.4)

5. Mediterranean climate zone

5.1. Evergreen and semi-evergreen oaks forests

5.1.1. Evergreen oak woods

5.1.1.1. Holm oak (*Quercus ilex* ssp. *ballota* = *Quercus rotundifolia*) woods (xeric and continental environments) (Habitat 45.34)

5.1.1.1.1. Holm oak closed woods

5.1.1.1.2. Sclerophillous grazed forests of Holm oak (Spanish Dehesas) (Habitat 32.11)

5.1.1.1.3. Holm oak with cork oak (*Q. suber*) mixed woods (subcontinental)

5.1.1.1.4. Holm oak with Portuguese oak (*Quecus faginea*) woods(western Mediterranean)

5.1.1.1.5. Holm oak with Spanish juniper (J*uniperus thurifera*) mixed woods (western Mediterranean, very continental climate)

5.1.1.1.6. Other Holm oak mixed woods or brush (Habitat 45.3)

5.1.1.2. Holm oak (*Quercus ilex* ssp. *ilex* = *Quercus ilex*) woods (coastal, sub-humid)

5.1.1.2.1. Thermo-meso-Mediterranean maritime and sub-continental woods of holm oak (Habitat 45.31)

5.1.1.2.2. Moist-thermic woods of Holm oak with laurel and other semi-evergreen trees and climbers

5.1.1.2.3. Holm oak with white oak (*Quercus pubescens*) mixed woods (Habitat 45.32)

5.1.1.2.4. Eastern holm oak with white oak and aleppo pine (*Pinus halepensis* or *Pinus brutia*)

5.1.1.2.5. Holm oak with & cork oak woods (occassionally wih *Q. faginea*) (Habitat 45.32)

5.1.1.2.6. Holm oak with other semi-deciduous or deciduous trees (*Quercus humilis, Q.canariensis*, etc.) (Habitat 45.31)

5.1.1.2.7. Holm oak with *Pinus sylvestris* woods (montane sub-humid)
5.1.1.2.8. Other holm oak mixed woods or brush (Habitat 45.3)
5.1.1.2.9. Cretan *Quercus brachyphyla* with *Q. ilex* woods (Habitat 41.7C)
5.1.1.3. Cork oak (*Quecus suber*) woods (western Mediterranean) (Habitat 45.2)
5.1.1.3.1. Cork oak pure stand woods (Habitat 45.21)
5.1.1.3.2. Sclerophillous grazed forests of cork oak (Spanish Dehesas) (Habitat 32.11)
5.1.1.3.3. Moist-thermic cork oak woods with laurel and many climber species
5.1.1.3.4. Cork oak-holm oak (*Q. rotundifolia*) mixed woods
5.1.1.3.5. Cork oak-holm oak (*Q. ilex*) mixed woods
5.1.1.3.6. Cork oak with white oak (*Q. pubescens* = *Q. humilis*) mixed woods
5.1.1.3.7. Cork oak with *Q. canariensis* or *Q. faginea* mixed woods (Habitat 45.22)
5.1.1.3.8. Cork oak with pyrenean oak mixed forests (Habitat 45.23)
5.1.1.3.9. Aquitanian cork-oak woodland as a facies of dunal pine-cork oak forests (Habitat 45.24)
5.1.1.3.10. Cork oak brush or arborescent matorral (Habitat 45.21)
5.1.1.3.11. Industrial cork oak woods
5.1.1.3.11. Other cork oak mixed woods
5.1.1.4. Kermes oak woods or bushes (*Quercus coccifera*)
5.1.2. Other evergreen woods
5.1.2.1. Wild olive & carob forests (Habitat 45.1). The following sub-types must be taken into consideration: (a) wild olive & carob mixed forests; (b) wild olive woods with carob (Habitat 45.11); (c) carob woods with wild olive and *Pistacia lentiscus* (Habitat 45.12)
5.1.2.2. Palm groves of *Phoenix* (*Phoenix theophrasti*) (Crete) (Habitat 45.7)
5.1.2.3. Woods of *Ilex aquifolium* (Sub-Mediterranean) (Habitat 45.8) sometimes with *Taxus baccata* (Habitat 42.A7)
5.1.3. Semi-evergreen, sub-xeric oak woods & bushes (Habitat 45.5)
5.1.3.1. Natural and semi-natural valonia oak (*Quercus macrolepsis*) woods (Habitat 41. 791; 41.792)
5.1.3.2. Valonia oak & funeral cypress mixed woods (with kermes oak & *Ceratonia siliqua*)
5.1.3.3. Dwarf semi-evergreen oak (*Q. fruticosa*) woods (Southwestern Iberia)
5.1.3.4. Cretan *Quercus brachyphyla* with *Q. macrolepsis* woods (Habitat 41.7C)
5.1.3.5. Other semi-evergreen, sub-xeric oak woods & bushes
5.2. Sub-Mediterranean montane and sub-humid-Mediterranean semi-evergreeen oak forests and bushes
5.2.1. White oak woods with many other deciduous trees (e.g. oriental hornbeam, hop-hornbeam, sweet chesnut, *Celtis australis*, *Pyrus* spp., *Sorbus* spp., *Prunus mahaleb*, *Ceris siliquastrum*, *Acer* spp., ahs, etc.) (Habitat 41.24?)
5.2.1.1. White oak & turkey oak (*Quercus cerris*) (Balkan peninsula) mixed forests
5.2.1.2. White oak & hungarian oak (*Quercus frainetto*) mixed forests (Balkan peninsula)
5.2.1.3. Other pure or mixed white oak woods or brush
5.2.2. Pyrenean oak (*Q. pyrenaica*) forests
5.2.2.1. Pyrenean oak pure stand woods (mainly in Iberia, sub-Mediterranean) (Habitat 41.61; 41.63; 41.64)
5.2.2.2. Pyrenean oak & holm oak (*Quercus rotundifolia*) mixed forests
5.2.2.3. Baetic pyrenean oak forests with *Fraxinus angustifolius* and *Hacer granatense* (Habiat 41.64)
5.5.2.4. Pyrenean oak thickets or brush (Spanish “monte bajo”)
5.2.2.5. Other pure or mixed pyrenean oak woods
5.2.3 Lusitanian oak (*Quercus faginea*) woods (mainly in Iberia) (Habitat 41.771; 41.772; 41.775)
5.2.4. Turkey oak (*Quercus cerris*) woods (Balkan peninsula)

5.2.5. Hungarian oak (*Quercus frainetto*) woods (Balkan peninsula) (corresponds partly with Habitat 41.1B)
5.2.6. *Quercus infectoria* shrubs (Aegean region)
5.2.7. *Quercus canariensis* woods (Iberia) (Habitat 41.773; 41.774)
5.2.8. *Quercus dalechampii* woods (southeastern Europe)
5.2.9. *Quercus polycarpa* woods (southeastern Europe)
5.2.10. *Quercus pedunuliflora* woods (southeastern Europe)
5.2.11. *Quercus mas* woods (western Mediterranean)
5.2.12. *Quercus sicula* woods (Sicily, southern France, and Sardinia)
5.2.13. Trojan oak *Quercus trojana* woods (Habitat 41.85). The following sub-types must be taken into consideration: (a) Helleno-Balkanic trojan oak woods or brush (with juniper or maples) (Habitat 41.781); (b) Apulian trojan oak woods (with white oak and holm oak) (Habitat 41.782)
5.2.14. Other semi-evergreen oak mixed woods (Habitat 41.4?)

5.3. Sub-Mediterranean humid-mixed deciduous and semi-evergreen forest with many species and with non-dominant trees

5.3.1 Eastern mixed humid-deciduous oak woods with *Quercus cerris, Q. frainetto* and other deciduous trees (e.g. *Q. pubescens, Q. patraea, Q. robur, Q. ilex, Sorbus* spp., *Castanea sativa, Carpinus orientalis, Ostrya carpinifolia, Acer* spp., *Fraxinus* spp., (also occur in the eastern Central European Region and in the Pannonic Region) (Habitat 41.4?)
5.3.1.1. Turkey oak & hungarian oak mixed forest on lowlands
5.3.1.2. Mountainous deciduous oaks woods with *Quercus petraea*
5.3.1.3. Mixed deciduous woods with macedonian oak (*Quercus trojana*)
5.3.1.4. Other eastern mixed humid-deciduous oak woods
5.3.2. Western mixed deciduous oaks woods with other trees (e.g. *Hacer* spp., *Celtis australis, Pinus* spp., *Quercus* spp., *Castanea sativa, Fraxinus* spp., etc.)
5.3.3. Western mixed deciduous oaks woods with many deciduous trees (20-30 species) (e.g. *Quercus* spp., *Fagus sylvatica, Castanea sativa, Betula alba, B. pendula, Prunus,* spp., *Acer* spp., *Sorbus* spp., *Tilia* spp., *Prunus* spp., *Carpinus betulus, Pyrus,* spp., *Alnus glutinosa, Populus* spp., *Ulmus* spp.,) and evergreen species (e.g. *Ilex aquifolium, Laurus nobilis, Abies alba, Taxus baccata,* etc.) (partly atlantic) (Habitat 41.4?)

5.4. Laurel (*Laurus nobilis*) pure and mixed woods and other relicts woods of the Arcto-tertiary flora

5.4.1. Pure and mixed laurel woods
5.4.2. Other Arcto-tertiary relicts woods (e.g. *Arbutus unedo* woods, *Prunus lusitanica* woods, *Celtis australis* woods)

5.5. Other deciduous and semi-evergreen woods

5.5.1. Sweet chesnut (*Castanea sativa*) woods (Habitat 41.9)
5.5.1.1. Pure sweet chesnut variant
5.5.1.2. Planted sweet chesnut variant (traditional Mediterranean practice)
5.5.1.3. Sweet chesnut variant with some associated tree species (white oak, birch, walnut, etc.)
5.5.1.4. Sweet chesnut variant with many associated tree species (e.g. *Juglans regia, Carpinus betulus, C. orientalis, Fagus sylvatica, Ostrya carpinifolia, Acer* spp., *Tilia tormentosa*, *Fraxinus ornus*, *Quercus* spp., etc.)
5.5.2. Horse chesnut (*Aesculus hippocastanum*) woods, commonly associated with many other tree species (e.g. *Junglans regia, Alnus glutinosa, Carpinus betulus, Fagus sylvatica, Quercus* spp., *Acer* spp., *Tilia* spp., *Populus* spp., *Fraxinus* spp., etc.) (natural in the eastern mediterranean region and semi-natural for the whole of the Mediterranean region)
5.5.3. Walnut (*Juglans regia*) woods, commonly associated with other many tree species
5.5.4. Sub-Mediterranean beech forests
5.5.4.1. Thermophilous beech forests with *Taxus* and *Ilex* (Habitat 41.181)
5.5.4.2. Mesophilous beech forest with *Abies alba* or *A. nebrodensis* (Habitat 41.184)
5.5.4.3. *Fagus sylvatica* or *Fagus moesiaca* thermohile forests with *Quecus frainetto* (Habitat 41.1B)
5.5.4.4. Other Mediterranean beech forests

5.6. Mediterranean coniferous woods

5.6.1. True Mediterranean pine woods

5.6.1.1 Aleppo pine (*Pinus halepensis*) woods Sub-types: (a) close- canopy; (b) open cannopy-maquis shrub layer; (c) open cannopy-garigue shrub layer, must be taken into consideration)

5.6.1.1.1. Natural or long-stablished formations of Aleppo pine (Habitat 42.84). Biogeographical variants: Habitat 42.841; 42.842; 42.843; 42.844; 42.845; 42.846; 42.847; 42.848, must be specified

5.6.1.1.2. Industrial variant

5.6.1.2 Aegean pine forests (*Pinus brutia, P. pityusa, P. stankewiczii, P. eldarica*) Sub-types: close-canopy; (b) open cannopy-maquis shrub layer; (c) open canopy-garigue shrub layer, must be taken into consideration. Sometimes Aegean pine is mixed with *P. pallasiana*, *Cupressus sempervirens* or other tree taxa. Biogeographical variants Habitat 42.851; 42.852; 42.853; 42.854; 42.855; 42.856; 42.857; 42.858; 42.859, must be specified

5.6.1.3. Maritime pine (*Pinus pinaster*) forests (Habitat 42.81; 42.82)

5.6.1.3.1. Natural and semi-natural pure and mixed (evergreen oaks, etc.) stands

5.6.1.3.1.1. Natural or plantations of Maritime of *P. pinaster* ssp. *atlantica* (Habitat 42.81)

5.6.1.3.1.2. Mesogean pine forest of *P. pinaster* ssp.*pinaster* (*P. mesogensis*) (Habitat 42.82). Biogeographial variants: Habitat 42..821; 42.822; 42.823; 42.824; 42.825; 42.826, must be specified.

5.6.1.3.2. Maritime pine forests on sand dunes of south Atlantic coast (Habitat 16.29; 16.29 x 42.8)

5.6.1.3.3. Industrial variants

5.6.1.3.4. Other maritime pine woods

5.6.1.4. Umbrella or stone pine (*Pinus pinea*) forests

5.6.1.4.1. Natural forests or naturalized plantations of stone pine. Sub-types: (a) grass rich habaceous layer; (b) dense maquis shrub layer; (c) continental or littoral sand dunes; (d) damped soils; (e) dehesa, must be taken into consideration (Habitat 48.83; 16.29 X 42.8); Biogeographical variants: Habitat 48.831; 48.832; 48.833; 48.834; 48.835; 48.836; 48.837; 48.838, must be specified

5.6.1.4.2. Recent plantations stone pine forest

5.6.1.4.3. Other stone pine woods

5.6.2. Sub-Mediterranean and Mediterranean-montane pine woods

5.6.2.1. Black pine (*Pinus nigra*) woods (Habitat 42.6)

5.6.2.1.1. Western Balkanic austrian pine (*Pinus nigra* ssp. *nigra*) forests (Habitat 42.62). The next sub-types must be taken into consideration: (a) montane woods with scots pine, silver fir, and beech; (b) sub-montane woods with white oak, hop-hornbean, etc.; (c) wet woods with sessile oak, aspen, etc. (partly temperate-subcontinental)

5.6.2.1.2. Alpino Apennine dalmation pine (*P. nigra* ssp. *dalmatica*) (Habitat 42.61). The next sub-types must be taken into consideration: (a) woods with maquis type shub layer (sub-montane); (b) montane woods with *Juniperus communis* ssp. *nana*

5.6.2.1.3. Crimean pine (*Pinus nigra* ssp. *pallasiana*) montane forests (Habitat 42.66). The next sub-types must be taken into consideration: (a) montane woods with Beech, fir, yew, hop hornbeam, etc.; (b) northern woods with white oak, birch, aspen, hop-hornbeam, anna ash, etc.; (c) hilly sub-montane woods with maquis shrub layer

5.6.2.1.4. Pyrenean pine (*Pinus nigra* ssp. *salzmannii*) woods (Iberia and Causses) (Habitat 42.63). The next sub-types must be taken into consideration: (a) pure stands (or pyrenean pine as dominant tree); (b) with montpellier maple; (c) with maritime pine; (d) with spanish juniper woods (dry-continental, Iberia); (e) dry woods with maquis shrub layer; (f) industrial variant

5.6.2.1.5. Corsican pine (*Pinus nigra* subpsp. *laricio*) forests (Habitat 42.64). The next sub-types must be taken into consideration: (a) pure stands; (b) with fir and/or silver beech

5.6.2.1.6. Calabrian laricio pine forests *Pinus nigra* subpsp. *laricio* var. *calabrica* forests (Habitat 42.65)

5.6.2.1.7. Bosnian pine (*Pinus leucodermis*) woods (central Balkans) (Habitat 42.8). The next sub-types must be taken into consideration: (a) montane of pure stands; (b) montane woods with fir, beech, juniper, *Pinus leucodermis*; (c) sub-alpine woods with *Juniperus communis* ssp. *nana, J. sabina* & *P. mugo*

5.6.2.2. White-barked pine (*Pinus heldreichii*) woods (mountains of Balkans, Italy)

5.6.2.3. Macedonian pine (*Pinus peuce*) woods (mountains of Balkan Peninsula). Sub-Alpine pure stands and montane mixed stands with other tress (e.g. spruce, beech, fir), must be taken into consideration

5.6.3. Fir woods

5.6.3.1 Greek fir (*Abies cephalonica*) woods. Upper montane pure stands and lower montane stands with white oak and *Juniperus oxycedrus* sub-types, must be taken into consideration

5.6.3.2 *Abies borisii-regis* woods with beech and/or Crimean pine (eastern Mediterranean) (Habitat 41.1Ax 42.17; see 5.5.4)

5.6.3.3. *Abies nebrodensis* woods (endemic fir of Sicily)

5.6.3.4 Pinsapo fir (*Abies pinsapo*) woods (southern Spain) (Habitat 42.19). Sub-types on calcicolous and ultra-basic serpentine, must be taken into consideration (Habitat 42.191; 42.192)

5.6.3.5 Montane silver fir (*Abies alba*) forests. Common and Relict Apennine *Abies alba* and *Picea excelsa* forests sub-types, must be taken into consideration) (Habitat 42.14)

5.6.3.6. Other fir woods

5.6.4. Cypress, juniper and other coniferous woods of dry-Mediterranean environments

5.6.4.1. Funeral cypress (*Cupressus sempervivens, C. atlantica, C. dupreziana*) woods (eastern Mediterranean) (Habitat 42A1)

5.6.4.1.1. Natural and semi-natural pure stands woods. Sub-types: (a) *nudum*; (b) open forest; (c) stands with maquis shrub layer must be taken into consideration.

5.6.4.1.2. Variant with semi-evergreen maple (*Acer sempervivens*)

5.6.4.1.3. Other funeral cypress woods

5.6.4.2. Endemic Mediterranean juniper forests (*J. brevifolia, J. drupacea, J. excelsa, J. foetidissima, J. oxycedrus, J. phoenicea, J. thurifera*) woods

5.6.4.2.1. Spanish juniper (*Juniperus thurifera*) woods (western Mediterranean) (Habitat 42.A2)

5.6.4.2.1.1. Pure stands woods. Sub-types: (a) *nudum*; (b) open forest; (c) with maquis shrub layer; (d) with herbaceous layer, must be taken into consideration (dry-continental; supramediterranean)

5.6.4.2.1.2. Variant with holm oak, and lusitanian oak (meso-supramediterranean)

5.6.4.2.1.3. Variant with maritime pine

5.6.4.2.1.4. Supramediterranean variant with black pine and/or scots pine

5.6.4.2.1.5. Cantabric variant with *J. nana, J. sabina, Berberis vulgaris* ssp. *cantabrica*

5.6.4.2.1.6. Gypsiferous variant with *Rhamnus lyciodes*

5.6.4.2.1.7. Corsica variant, sometimes with *Pinus laricio*

5.6.4.2.1.8. Other spanish juniper mixed woods

5.6.4.2.2. Phoenician juniper (*Juniperus phoenicea*) woods (central and western Mediterranean): The next sub-types must be taken into consideration: (a) pure stands variant (ssp. *phoenicea*) (continental); (b) variant (ssp. *phoenicea*) with Savin (J*uniperus* *sabina*) (continental); © pure stands variant (ssp. *turbinata*) (thermic-dry coast); (d) Variant (ssp. *turbinata*) with other trees (thermic-dry coast)

5.6.4.2.3. Greek juniper (*Juniperus excelsa*) woods (eastern Mediterranean) (Habitat 42.A3)

5.6.4.2.4. Syrian juniper (*Juniperus drupacea*) woods (eastern Mediterranean) (Habitat 42.A5) Pure and mixed priclky juniper (*Juniperus oxycedrus*) woods (sometimes with holm oak, lusitanian oak, etc)

5.6.4.2.6. Stinking juniper (*Juniperus foetidissima*) woods (supra-Mediterranean, Greece) (Habitat 42.A4)

5.6.4.2.7. Other juniper forests pure or mixed with jupiner dominants

5.6.4.3. Barbary arbor-vitae (*Tetraclinis articulata*). Open stands with a maquis shrub layer in very dry sites of Malta and southeastern Spain. (Habitat 42.A6)

5.6.4.4. Mediterranean *Taxus baccata* woods (Habitat 42.A7). Sub-tyes: (a) Corsican, with *Ilex aquifolium* & *Buxus sempervivens*; (b) Sardinian, with *Ilex* only, must be taken into consideration (Habitat 42.A72; 42.A73)

5.7. Sub-Mediterranean and Mediterranean wet woods

5.7.1. Mixed deciduous and semi-deciduous oak woods with alder, hornbeam, willows, elm (*Ulmus minor*), ash (*Fraxinus angustifolia*), poplars (*P. alba, P. nigra, P. tremula, P. canescens*) etc. (partly corresponds with Habitat 44.4 in riparian corridors)

5.7.2. Alder (*Alnus glutinosa*) woods with ash (*Fraxinus angustifolia*), willows, poplars, elms, etc.

5.7.2.1. Alder woods partly (partly Atlantic, partly temperate continental)

5.7.2.2. Alder woods of sub-Mediterranean thermic climates with *Rododendron ponticum* ssp. *baeticum* (Habitat 44.52)

5.7.3. Mixed willow woods with poplars, elms, etc. “galleries forest” (with many possible species of willows) (Habitat 44.17)

5.7.4. Poplar woods (several possible species combinations). Natural forests (several possible combinations) with willows, elms, ash, elders, etc. (Habitat 44.17) and Industrial planations, must be taken into consideration

5.7.5. Elm (commonly *Ulmus minor*) mixed forests with poplars, elms and ash (Habitat 44.17?)

5.7.6. Ahs (commonly *Fraxinus* angustifolia) forests

5.7.6.1 Ash mixed woods on hydromorphic soils with elms, poplars maples and alders, etc.

5.7.6.2. Ash & pyrenean oak or white oak mixed forests (Habitat 41.86)

5.7.7. Oriental plane (*Platanus orientalis*) woods or bushes (Balkan peninsula) (Habitat 44.7). Biogeographical variants (a) Helleno-Balkanic riparian plane forests (Habitat 44.711; (b) Hellenic slope plane woods (Habitat 44.712); © Sicilian plane tree canyons (Habitat 44.713), must be taken into consideration. In addition oriental plane dominant and oriental plane & walnut (*Junglans regia*) sub-types must be taken into consideration

5.7.8. Sweet gum gallery forests (Tertiary relict) (*Liquidambar orientalis*) (Assia Minor & Rhodes) (Habitat 44.721)

5.8. Thermo-Mediterranean riparian galleries (with halophyte vegetation, rich in sclerephillous evergreen species and commonly, “tetic climates” and dry valleys) (Spanish Ramblas) (e.g. SE Spain) (Habitat 44.81; 44.82)

5.8.1. Tamarisk communities (Spanish Tarayales) (Habitat 44.81)

5.8.1.1. Non or weak-halophyte communities of tamarisk (*Tamarix gallica, T. africana*) (Habitat 44.811)

5.8.1.2. Halophyte communities of Tamarisk (*Tamarix boreana, T. canariensis*) (Habitat 44.811)

5.8.2. Oleander; riparian galleries (*Nerium oleander*) and/or Chaste tree (*Vitex agnus-castus*) communities (Habitat 44.81). The following sub-types must be taken into consideration: (a) oleander riparian galleries (Spanish Adelfares) (Habitat 44.811); (b) oleander-tamarisk riparian galleries (Habitat 44.811); © pure or mixed chaste tree riparian galleries (Habitat 44.812)

5.8.3. South western Iberian riparian galleries (*Securinega tinctoria*) (Spanish Tamujares) (Habitat 44.82)

5.8.4. Oretanian lauriphyllous galleries (*Prunus lusitanica* & *Viburnum tinus*) (Habitat 44.83)

5.8.5. Oretanian bog-myrtle willow scrub communities (*Frangula alnus, Salix sps., Myrica gale*) (Habitat 44.84)

5.9. Mediterranean bush, shrubs and dwarf shrubs communities (shrublands)

5.9.1. Maquis

5.9.1.1. Maquis of the olive (*Olea auropaea*) & carob (*Ceratonia siliqua*) (dry-coastal climates) (Habitat 35.12)

5.9.1.2. Maquis of oak taxa

5.9.1.2.1. Maquis with kermes oak dominant (Spanish coscojal)

5.9.1.2.2. Other types of the evergreen oak zone (e.g. Habitat 32.11 with cork oak or Habitat 45.3 with *Q. ilex*)

5.9.1.3. Pseudomaquis (maquis of the sub-montane and montane belts with semi-evergreen or deciduous trees as potential vegetation) with kermes oak, box, pricky juniper, etc.

5.9.1.3.1. Pseudomaquis with evergreen shrub species dominants (other than Box)

5.9.1.3.2. Mediterranean *Buxus sempervivens* shubs (calcareous rock slopes) (*Berberidion* p.) (Habitat 31.82)

5.9.1.3.3. Pseudomaquis with dedicuous shrub species dominants (partly corresponds with Habitat 44.84)

5.9.1.4. Deciduous bush communities or *Sibljak* (sub-Mediterranean)

5.9.1.5. Mediterranean arborescent matorral

5.9.1.5.1. Juniper formations

5.9.1.5.1.1. *Juniperus oxycedrus* arborescent matorral (Habitat 32.131)

5.9.1.5.1.2. *Juniperus phoenicea* arborescent matorral (Habitat 32.132)

5.9.1.5.1.3. *Juniperus excelsa* or *J. foetidissima* arborescent matorral (Anatolia & Near East) (Habitat 32.133)

5.9.1.5.1.4. *Juniperus communis* arborescent matorral (Habitat 32.134)

5.9.1.5.1.5. *Juniperus drupacea* arborescent matorral (Eastern Mediterranean) (Habitat 32.135)

5.9.1.5.1.6. *Juniperus thurifera* arborescent matorral (Habitat 32.136)

5.9.1.5.2. Matorral with *Zyziphus lotus* (South-western Iberia) (Habitat 32.17)

5.9.1.5.3. Matorral with *Laurus nobilis* (Habitat 32.18)

5.9.2. Garigue (Greek Phrygana) (Spanish Matorral). Dwarf shrub communities, disperse vegetation with patches of bare soil

5.9.2.1. Kermes oak garigue (mainly on calcareous soils). Sub-types: (a) coastal sub-humid, thermic; (b) costal xeric garigue; © mainland continental; (d) mountain sub-humid, must be taken into consideration

5.9.2.2. *Cistus* garigue (Spanish jaral) (mainly on acid soils) (several species and combinations). Sub-types: (a) coastal, thermic; (b) mainland continental; © mountain sub-humid; (d) *Cistus palhinhae* formations on maritime wet heaths (Habitat 31.89), must be taken into consideration

5.9.2.3. *Euphorbia garigue*. Sub-types: (a) spiny purge (*Euphorbia spinosa*) (near of western coastal shores); greek spiny spurge (*E. acanthothamnos*) (near of eastern shores) (Habitat 33.4); © tree spurge garigue (*Euphorbia dendroides*) (Tertiary relict in the olive-carob zone) (Habitat 32.22), must be taken into consideration

5.9.2.4. Rosemary garigue (*Rosmarynus officinalis*) (Spanish romeral) (calcareous soils). Sub-tyypes: (a) xeric & sub-humid with many *Cistus* species and some heaths species; (b) sub-humid & humid with many heaths species and some *Cistus* species, must be taken into consideration

5.9.2.5. Genista-*Erica manipuliflora* montane garigue (coastall hills of Yugoslavia) with dalmatian pine
5.9.2.6. Thyme garigue (Spanish tomillar). Western (*Thymus vulgaris*), Continental-Iberia (*Thymus zygis*) and Eastern (*Thymus capitatus*) sub-types, must be taken into consideration
5.9.2.7. Lavander (commonly *Lavandula stoechas*) garigue (Spanish espliegar) (neutral or acid soils)
5.9.2.8. Tree heath (*Erica arborea*) garigue (with other heaths and *Cistus* species) (sub-Mediterranean)
5.9.2.9. Eastern Thorny garigue (Greek phrygana) (with *Sarcopoterium spinosum, Anthyllis hermanniae,* and *Genistas* & *Cistus* species) (Habitat 33.3)
5.9.2.10. Palmetto brush (*Chamaerops humilis)* (western Mediterranean on dry coastal sites) (Habitat 32.24)
5.9.2.11. Christ’s thorn (*Paliurus spina-christi*) garigue (with *Rhamnus intermedius, Juniperus oxycedrus* and *Carpinus orientalis*) (eastern Mediterranean)
5.9.2.12. Sege (*Salvia, officinalis, S. lavandulifolia, S. argentea & S. triloba*) garigue
5.9.2.13. Gypsum steppes-Garrigue (*Gypsophiletalia*) (Iberia) (Habitat 15.19). The following sub-types must be taken into consideration: (a) vegetation of low topographic level (*Sarcocornetea*); (b) vegetation of high topographic levels (*Limoniletalia confusi*)
5.9.2.14. Thermo-Mediterranean laurel thickets or brush (Habitat 32.216)
5.9.2.15. Thermo-Mediterranean low formations of *Euphorbia* close to sea cliffs (western Mediterranean) (Habitat 32.217)
5.9.2.16. Diss-dominated garrigues (*Ampelodesmos maauritanica*) (thermo-meso-Mediterranean) (Habitat 32.23)
5.9.2.17. Mediterranean pre-desert scrub (*Periplocion angustifoliae, Anthyllidetalia terniflorae*) (South Iberia) Habitat 32.25)
5.9.2.18. Thermo-Mediterranean broom fields (*Lygos* spp.) (western Mediterranean) (Habitat 32.26)
5.9.2.19. Cretan phryganas (*Euphorbio-verbascion*). Sub-types: (a) *Hypericum* (Aegean Isles) (Habitat 33.5); Italian *Sarcopoterium* (Habitat 33.6); © Sardinian *Genista acanthoclada* (Habitat 33.7); (d) Balearic cliff top (Habitat 33.8); (e) Cyrno-Sardian *Genista corsica* or *G. morisii* (Habitat 33.9); (d) (*Helichrysum saxile* ssp. *errerae*) (Habitat 33A), must be taken into consideration
5.9.2.20. Other types of Garigue

5.10. Mediterranean and sub-Mediterranean grasslands

5.10.1. Meso and thermo-Mediterranean natural and semi-natural grasslands, and pseudo-steppe with grasses and annuals (peremnial Communities of *Thero Brachypodietea* and annual communities of *Tuberarietea guttatae*) (Habitat 34.5)

5.10.1.1. Arid and semi-arid grasslands and steppe-grasslands
5.10.1.1.1 Feather-grasses (*Stipa*) species steppe-grasslands (Spanish Espartales). Sub-types: (a) *Stipa tenacissima* (eastern Iberia); (b) *Stipa capensis & Stipa offnery* (Sicily & Sardinia); (c) *Stipa capensis & Lamarckia aurea* (southern Italy); (d) *Stipa capensis & Brachypodium retusum* (eastern Mediterranean); (e) other Feather-grass, must be taken into consideration
5.10.1.1.2. Albardine-steppe (*Lygeum spartum*) grassland (slighhtly salty soils) (Spain & Italy)
5.10.1.1.3. Salt Steppes (*Limonietalia*) (Mediterranean coasts and Iberia), (Habitat 15.18)
5.10.1.1.4. Other arid and semi-arid grasslands and steppe-grasslands

5.10.1.2. Xeric and sub-humid Mediterranean grasslands
5.10.1.2.1. *Brachypodium retusum* grasslands (eutric/calcareous soils)
5.10.1.2.2. *Brachypodium phoenicoides* grasslands (calcareous soils, abandoned cultivated lands)
5.10.1.2.3. *Vulpia ciliata* grasslands (dry sandy, acid soils, easterm Mediterranean)

5.10.1.2.4. Steppe-like grasslands of *Chrysopogon gryllus* (eastern mediterranean)
5.10.1.2.5. Steppe-like grasslands of *Festuca rupicola* (eastern Mediterranean)
5.10.1.2.6. Other calcareous grasslands
5.10.1.2.7. Western Iberia forested grasslands on acid soils ("Dehesa") (see also Habitat 32.11). Sub-types: (a) grasslands of therophytes with *Vulpia & Trifolium*; (b) dry *Poa bulbosa & Trifolium subterraneum* grasslands ("Majadal seco)"; © moist *P. bulbosa & T. subterraneum* grasslands ("Majadal húmedo"); (d) moist grasslands of *Agrostis castellana* (hemicryptophytes) ("Vallicar húmedo"); (e) poor grasslands of *A. castellana* ("Vallicar pobres"); (f) *Agrostis castellana* hay meadows("vallicar de siega"); (g) hay meadows on hydromorphic soils ("Bonales"), must be taken into account
5.10.1.2.8. Other xeric and sub-humid grasslands
5.10.1.2.9. Artificial grasslands

5.10.2. Sub-humid semi-natural grasslands (serial stages of deciduous & semi-evergreen woods)
5.10.2.1. *Sesleria caerulea* grasslands (western Mediterranean)
5.10.2.2. *Koeleria vallesiana -Festuca ovina* grasslands (western Mediterranean)
5.10.2.3. Western, sub-Mediterranean steppe-like grassland with *Stipa pennata* (Alps, Pyrenees)
5.10.2.4. *Festuca lemanii, F. valesiaca* & *Koeleria splendens* grasslands (lowland Dalmatia)
5.10.2.5. *Bromus erectus* & *Koeleria splendens* grasslands (coastal mountains of Croatia)
5.10.2.6. Greek montane grasslands of *Stipa pulcherrima*, *Melica ciliata* & *Festuca varia*
5.10.2.7. Other western grasslands of sub-Mediterranean lowlands. Sub-types (a) on calcareous soils; (b) on siliceous soils, must be taken into consideration
5.10.2.8. Other eastern grasslands of sub-Mediterranean lowlands. Sub-types on siliceous soils; (b) on calcareous soils, must be taken into consideration

5.10.3. Iberia halo-nitrophilous scrubs (*Pegano Salsoletea*) (Habitat 15.17)
5.10.4. Natural karstic calcareous grasslands (*Alysso-Sedion albi*) (Habitat 34.11)
5.10.5. Tall-herb and rush meadows (*Molinio-Holoschoenion*) (Habitat 37.4)
5.10.6. Mediterranean coastal salt meadows (Habitat 15.15)
5.10.6.1. Tall rush saltmarshes dominated by *Juncus maritimus* and/or *J. acutus*, etc. (Habitat 15.51)
5.10.6.2. Short rush, sedge and clover saltmarshes (*Juncion maritimi*) (Habitat 15.52)
5.10.6.3. Mediterranean halo-psammophile meadows (*Plantaginion crassifoliae*) (Habitat 15.53)
5.10.6.4. Iberian salt meadows (*Puccinellion fasciculatae*) (Habitat 15.54)
5.10.6.5. Halophilous marshes along the coast and coastal lagoons (*Puccinellion festuciformis*) (Habitat 15.55)
5.10.6.6. Humid halophilous moors with shrubby stratum (*Agropyro- Artemision coerulescentis*) (Habitat 15.57)
5.10.6.7. Medium-tall *Juncus subulatus* beds, often forming facies with *Arthrocnemum* scrubs (Habitat 15.58)

5.11. Alkaline fens (Habitat 54.2)
5.12. Mediterranean coastal plant communities (see also Atlantic region)
5.12.1. Mudflats, sandflats, saltmarhes and salt meadows (halophytic communities, including estuaries) (partly corresponds with Habitat 13.2; 14; 11.3; etc.)
5.12.1.1. Halo-nitrophilous pionner communities (*Frankenion pulverulentae*) (Habitat 15.12)
5.12.1.2. Mediterranean and thermo-Atlantic halophilous scrubs of dwarf shrubby perennial glassworts (*Arthrocnemetalia fruticosae*) (Habitat 15.16)
5.12.1.3. Southern Iberia *Spartina* swards with *Spartina densiflora* halophytic communities (Habitat 15.22)

5.12.2. Sand dune and shingle communities

5.12.2.1. Mediaterranean open and short-lived communities of beach, drift material and gravel with *Salsola kali, Cakile maritima*, etc. (Habitat 17.2)
5.12.2.2. Movile dunes communities (primary, embryonic or white shifting low dunes along the shoreline) with disperse grasses such as *Agropyron junceum, Elymus farctus Elymus arenarius* (Habitat 16.211)
5.12.2.3. Shifting or white dunes along the shoreline; communities of marram grass (*Ammophila arenaria*) (Habitat 16.212)
5.12.2.4. Plant communities on grey (fixed) dunes (stabilized, with camephytes rushes, grasses, closed turf of mossses and lichens). The following sub-types must be taken into consideration (a): *Crucianellion maritimae* (Habitat 16.223); (b) communities of *Euphorbia terracina* (Habitat 16.224); (c) *Malcolmietalia* grasslands (Habitat 16.228); (d) *Brachypodietalia* annual grasslands (Habitat 16.229)
5.12.2.5. Thermo-Atlantic communities on grey dunes with *Crucianella maritima, Pancration maritimum* (Habitat 16.223)
5.12.2.6. Plant communities on brown (frequently decalcified dunes) (high dunes with shrubs, woods, meadows and peats) (Habitat 16.29 x 42.8 and 16.29). The following sub-tyes must be taken into consideration: (a) juniper thickets (*Juniperus spp.*) (Habitat 16.27); (b) sclerophyllous scrubs (*Cisto-Lavanduletalia*) (Habitat 16.28); (c) evergreen oak woods (Mediterranean, sub-Mediterranean); (d) wooded dunes of southern atlantic coast with trees other than pines

5.12.3. Vegetated Sea cliffs of the Mediterranean coast with endemic *Limonium* spp. (Habitat 18.22)

5.13. Freshwater habitats (frequently pioneer of land interface zones of lakes or rivers, sometimes on peaty soils). Only Habitat EUR15 communities are included here

5.13.1. Standing waters
5.13.1.1. Oligotrophic waters of sandy plains with amphibious vegetation: *Lobelia, Littorella* & *Isoetes* (Habitat 22.11x22.31)
5.13.1.2. Oligotrophic waters of western Mediterranean sandy plains with *Isoetes* (Habitat 22.11 x 22.34)
5.13.1.3. Natural dystrophic lakes and ponds generally on peaty soils in bogs or heaths (Habitat 22.14)
5.13.1.4. Mediterranean temporary ponds rich in therophytic and geophytic species (Habitat 24.34)
5.13.1.5. Other standing waters communities

5.13.2. Running waters
5.13.2.1. Constantly flowing Mediterranean rivers with *Glaucium flavum* and *Myricaria germanica* (Habitat 24.225)
5.13.2.2. Annual pioneer nitrophilous vegetation (*Chenopodietum rubri, Bidention* p.p.) on muddy river banks (Habitat 24.52)
5.13.2.3. Constantly flowing Mediterranean rivers with *Paspalo-Agrostidion* and hanging curtains of *Salix* and *Populus Alba* (Habitat 24.53)
5.13.2.4. Intermittently flowing Mediterranean rivers (*Paspalo-Agrostidion*) (Habitat no code; Natura 2000 code 3290)
5.13.2.5. Other communities of running waters

5.14. Rocky habitats communities

5.14.1. Scree communities
5.14.1.1. Western Mediterranean thermophillous scree (party also corresponds to warm, sunny middle European upland or lowlans sites) (Habitat 61.3). The following sub-types must be taken into consideration: (a) ProvenÇal screes (*Pimpinello-Gouffeion*) (Habitat 61.32); (b) Pyrenean calcareous screes (*Iberidion spathulatae*) (Habitat 61.34); ©; Iberian fern screes (*Dryopteridion oreadis, Dryopteridion submontanae*) (Habitat 61.37); (d) Carpetano-Iberian siliceous srees (*Linario-Senecion carpetani*) (Habitat 61.38); (e) southern Iberian calcareous screes (*Platycapno-Iberidion granatensis, Scrophularion sciaphilae*) (Habitat 61.3A); (f) central Mediterranean screes (Habitat 61.3B)
5.14.1.2. Balkan screes communities of *Drypetalia spinosae* (Habitat 61.4); Sub-types: (a) limestone screes (*Drypion spinosae; Silenion caesiae*) (Habitat

61.41); (b) serpentine screes (*Campanulion hawkinsonianae*) (Habitat 61.42), must be taken into consideration

5.14.2. Chasmophytic vegetation (cliff fissures) on rocky slopes

5.14.2.1. Chasmophytic vegetation of calcareous rocky slopes (Habitat 62.1; 62.1A)

5.14.2.1.1. Communities of *Potentilletalia caulescentis* (Habitat 62.15 and 62.1A).

5.14.2.1.2. Western Mediterranean communities of *Asplenion petrarchae* and mesotherm shady fern groups of the supra-Mediterranean level of *Polypodion australis* (Habitat 62.11) (included the Corsican subtypes of the *Brassicion insularis* Habitat 62.1C).

5.14.2.1.3. Central Pyrenean communities (*Saxifragion mediae*) (Habitat 62.12)

5.14.2.1.4. Liguro-Apennine cliffs communities (*Saxifragion lingulatae*) (Habitat 62.13)

5.14.2.1.5. Southern Italian communities of *Dianthion rupicolae* (Habitat 62.14)

5.14.2.1.6. Greek & southern Italian calcareous cliff communities (*Campanulion versicoloris, Cirsietalia chamaepeucis, Silenion auriculatae, Ramondion nathaliae*) (Habitat 62.16, 62.17; 62.18; 62.19; 62.1A)

5.14.2.2. Chasmophytic vegetation of siliceous rocky slopes.

5.14.2.2.1. Montane communities of pyrenees and Alps. The following sub-types must be taken into account: (a) Hercynian system and its periphery (*Androsacion vandellii*) (Habitat 62.21); (b) Communities of montane level of Pyrenees and Cevennes (*Asarinion procumbentis*: includes Habitat 62.26); © Hercynian serpentine cliffs (*Asplenion cuneifolii*)

5.14.2.2.2. High altitude siliceous cliff vegetation of Central Iberian mountains (*Saxifragion willkommianae*) and Sierra Nevada (*Saxifragion nevadensis*) (Habitat 62.22)

5.14.2.2.3. Cyrno-Sardian siliceous montane cliff vegetation (*Potentillion crassinerviae*) (Habitat 62.24)

5.14.2.2.4. Northern Greek siliceous cliff vegetation (*Silenion lerchenfeldianae*) (Habitat 62.25)

5.14.2.2.5. Western Iberian submontane siliceous cliff vegetation (*Cheilanthion hispanicae*) (Habitat 62.27)

5.14.2.2.6. Provenço-Iberian siliceous cliff vegetation on rock faces rich in basic silicates, of the thermo to meso-Mediterranean levels (*Phagnalo saxatilis-Cheilanthion maderensis*) (Habitat 62.28)

5.14.3. Pioneer vegetation on siliceous rock or colonising superficial soils of siliceous rock surfaces (*Sedo-Scleranthion*, *Sedo albi-Veronicion dillenii*) (Habitat 62.3). This habitat is associated with Habitat 62.2 (vegetation colonising siliceous rocks). Vegetation colonising calcareous rocks is included under Habitat 34.11 and Habitat 62.4

5.14.4. Fields of lava: Sites and products of recent volcanic activity harbouring distinct biological communities (Habitat 65) *(Viola cheiranthifolia, Silene nocteolens, Argyranthemum teneriffae*; lichens: *Stereocaulon vesubianum*). The following sub-types must be taken into consideration: (a) Barren lava fields (e.g. *Stereocaulon vesubianum*) (Habitat 66.3); (b) Volcanic ash, lapilli fields, lava tubes and fumaroles (Habitat 66.4, 66.5, 66.6)

6. Semi-arid and arid temperate continental climate zone

(Western of the European Pannonic Region)[3]

6.1. Steppe-woods (commonly oak species) (mainly natural and semi-natural)

6.1.1. Turkey oak (*Quercus cerris*) woods. The following sub-types must be taken into account: (a) turkey oak pure stands; (b) turkey oaks with white oak, sessile oak and

[3] Alpine, coastal, freshwater and rocky habitats are not included in consulted texts.

hornbean woods (Habitat 41.2B, 41.7374, 417A); (c) turkey oak with hungarian oak woods; (d) other woods with turkey oak as dominant species (Habitat 41.7A)

6.1.2. White oak (*Quercus pubescens*) woods. The following sub-types must be taken into account: (a) white oak pure stand (Habitat 41.7374); (b) white oak with pedunculate oak woods; (c) white oak, pedunculate oak, oriental hornbean & manna ash woods; (d) other woods with white oak as dominant species (Habitat 41.7374)

6.1.3. Hungarian oak (*Quercus frainetto*) woods (partly sub-Mediterranean) (partly corresponds with Habitat 41.1B)

6.1.4. *Quercus pedunculiflora* woods. The following sub-types must be taken into account: (a) with *Quercus pedunculiflora* dominant; (b) with hungarian oak and other tree species

6.1.5. *Quercus polycarpa* woods

6.1.6. *Quercus dalechampii* woods

6.1.7. Pedunculate oak & sessile oak woods (moister sites in river valleys, and at higher altitudes). The following sub-types must be taken into account: (a) pedunculate oak dominant with *Q. pubescens, Q. cerris, Q.petraea & Ulmus minor,* etc. (Habitat 44.4 in riparian sites); (b) sessile oak dominant

6.1.8. Neutrophile beech forest (Habitat 41.135; Habitat 41.1B?)

6.1.9. Other deciduous oaks mixed woods (*Tilia tomentosa, Carpinus betulus, C. orientalis, Acer tartaricum,* etc.)

6.1.10. Primeval and/or mixed woods with several tree species co-dominants (Habitat 41.4?)

6.1.11. Transitional temperate-continental & grass-steppe woods with oaks and/or beech

6.1.12. Coniferous woods and pine-oak woods.

6.1.12.1. Sub-Mediterranean natural and semi-natural steppe woods with coniferous trees

6.1.12.2. Sub-Central Eurppean natural and semi-natural steppe woods with coniferous trees

6.1.12.3. Pine forests on poor sands (frequently mainland dunes)

6.1.12.4. Pine-oak forests

6.1.12.5. Industrial coniferous forests

6.1.13. Other Pannonic forests

6.2. Wet woodlands (commonly in the major rivers)

6.2.1. Mixed woods with willows (*Salix* spp.) as dominants species with poplars, elms, ash & climbers (*Vitis vinifera, Humulus lupulus*) (Habitat 44.17)

6.2.2. Willows and poplars (e.g. *Populus nigra, Populus alba*) mixed woods with oaks and ash (Habitat 44.17?)

6.2.3. Oaks mixed woods (e.g. sessile and pedunculate oaks) with ash, poplars, willows and climbers (Habitat 44.4)

6.3. Bush communities

6.3.1. Ground cherry (*Prunus fruticosa*) bushes

6.3.2. Pseudo-*sibjak* bushes with oriental hornbeam, common lilae (*Syringa vulgaris*) and white oak

6.3.3. White oak bushes

6.3.4. Other bush communities

6.4. Steppe-grasslands (Habitat 34.31; 34.91 with the exception of 6.4.2.3)

6.4.1. Natural steppe-grasslands of feather-grasses (*Stipa* spp.) (with *Festuca* spp., *Poa bulbosa, Bromus* spp., etc.) (driest areas)

6.4.2. *Puszta* (semi-natural or secondary steppe-grasslands with traditional management)

6.4.2.1. Moist secondary grasslands with *Chrysopogon gryllus, Agrostis capillaris,* etc.

6.4.2.2. Grasslands of fescue grass (*Festuca rupicola*) & feather-grass (*Stipa joannis*) (degraded soils, lower altitudes)

6.4.2.3. Sand dunes steppe-grasslands (Habitat 34.A1)

6.4.2.3.1. Pioneer steppe-grasslands on sand dunes (annuals dominants) (Habitat 64.71)

6.4.2.3.2. Brome-grasslands (*Bromus tectorum, B. hordeaceus, Secale sylvestre,* etc.)

6.4.2.3.3. Steppe-grasslands of stabilized dunes (with *Festuca vaginata* & *Koeleria glauca*)

6.4.2.4. Rich meadows (replace river-valleys woodlands)

6.4.2.4.1. Wet rich meadows (*Deschampsia cespitosa, Agrostis stolonifera*, etc.) (partly corresponds with Habitat 37.4)

6.4.2.4.2. Dry rich meadows (with *Poa pratensis, Dactylis glomerata* & *Arrhenatherum elatius*)

6.4.2.5. Other secondary steppe-grasslands and meadows

6.5. Salt steppes (Inland halophytic communities) (partly corresponds with Habitat 15.A1)

6.5.1. Highly saline communities usually dominated by short-lived and succulent taxa with *Salicornia europaea* abundant

6.5.2. Communities on soils very rich in soda (pH 8.5 and pH 11) with *Puccinellia distans* and *Crypis aculeata*

6.5.3. Communities on sandy, damped, moderately saline soils with *Puccinella festuciformis, Agrostis stolonifera,* etc. Sub-types with or without *Festuca pseudovina* must be taken into consideration

6.5.4. Halophytic communities on early flooded, sandy soils with *Cyperus pannonicus* dominant

6.5.5. Salty meadows dominated by rushes such as *Juncus compresus* and *Juncus gerardii*

6.5.6. Dry salt steppes (intermediate between dry grasslands and steppe) with *Festuca pseudovina* dominant

6.5.7. Salt steppes and salt marshes on local geological deposits or ephemeral saline lakes (Habitat 15.A1). Dry (*Lepidium cartilagineum, Salicornia europaea, Suaeda maritima* ssp. *pannonica*, etc.) and moist (*Aster tripolium* ssp. *pannonicus*) sub-types, must be taken into consideration

6.5.8. Salt meadows, moist, poorly saline, with *Juncus geradii* & *Plantago maritima* (geological deposits, ephemeral saline lakes)

6.6. Other salt steppes and meadows

6.7. Alkaline fens (Habitat 54.2)

6.8. Freshwaters communities (standing and running waters)

6.9. Rocky habitats communities (screes, cliff, rock fissures, pioneer vegetation on rock surfaces, rock pavements, etc.)

7. Sub-Alpine and alpine belts in Europe

7.1. Bush and/or tall-herb communities above the tree line

7.1.1. Sub-alpine bushes

7.1.1.1. Sub-alpine pine (*Pinus mugo*) bushes on calcareous soils (sub-alpine belts of Central Europe

7.1.1.1.1. Alpide bearberry heaths of *Mugo-Rhododendretum hirsuty* p., *Juniperus nanae* i.a. (Habitat 31.47)

7.1.1.1.2. Hairy alpenrose-erica heaths of *Mugo-Rhododendretum hirsuty* p. (Habitat 31.48)

7.1.1.1.3. Scrub with *Pinus mugo* and *Rodhodendron hirsutum* (*Mugo-Rodhodendretum hirsuti*) (Habitat 31.5)

7.1.1.2. Green alder (*Alnus viridis*) sub-alpine bushes with tall-herbs on siliceous soils (moister sites of the Alps and other ranges of southeastern Central Region)

7.1.1.3. Sub-alpine Shrubby willow communities

7.1.1.3.1. Central Europe communities with many possible willows species

7.1.1.3.2. Boreal communities with *Salix glauca, Salix lanata* and *Salix lapponum* (Habitat 31.662)

7.1.2. Sub-alpine tall-herb communities

7.1.2.1. Temperate-continental communities of *Adenostyles alliariae* and *Cicerbita alpina* (Habitat 37.8)

7.1.2.2. Atlantic communities (Habitat 37.8)

7.2. Sub-alpine and alpine heaths and pseudo-heaths

7.2.1. Sub-alpine and alpine heaths

7.2.1.1. Alpenrose heaths (*Rhododendron ferrugineum*) (temperate continental & sub-Mediterranean) (Habitat 31.42)

- 7.2.1.2. Crowberry heaths (*Empetrum nigrun* ssp. *hermaphroditum*) (temperate-continental & sub- Mediterranean) (Habitat 31.44)
- 7.2.1.3. Dwarf azalea (*Loiseleuria procumbens*) -lichen heaths (temperate-continental & sub-Mediterranean) (Habitat 31.41)
- 7.2.1.4. Sub-alpine heath of spike-heath (*Bruckenthalia spiculifolia*) (temperate continental & sub-Mediterranean) (Habitat 31.46)
- 7.2.1.5. Dwarf juniper (*Juniperus communis* ssp. *nana*) heaths (sub-mediterranean, Atlantic, temperate continental) (Habitat 31.43)
- 7.2.1.6. Spike-heath & dwarf juniper community (with *Genista tinctoria, Vaccinium* spp. (temperate continental) (Habitat 31.41)
- 7.2.1.7. High mountain dwarf bilberry heaths; Sub-alpine belts of southeastern mountains (Habitat 31.4A)
- 7.2.1.8. Greenweed heaths (*Chamaecystus spp.*) montane and sub-alpine belts of southeastern mountains (Habitat 31.4B)
- 7.2.1.9. Other Sub-alpine and alpine heaths

7.2.2. Oro-Mediterranean hedgehog heaths or cushion heaths (dry Mediterranean)

- 7.2.2.1. Iberian hedgehog heaths with spiny shrublets (e.g. *Berberis hispanica, Erinacea anthyllis, Genista*, spp. etc.) (western Mediterranean). Biogeographical Sub-types: (a) Pyrenean hedgehog-heaths of *Junipero-Genistetum horridae* (Habitat 31.71); (b) Cordilleran hedgehog-heaths (Habitat 31.72); © Nevadan hedgehog-heaths of *Erinacetalia* p., *Lavandulo-genistion boissieri* p. (Habitat 31.73); (d) Franco-Iberian hedgehog-heaths (Habitat 31.74), must be taken into account
- 7.2.2.2. Italian hedgehog heaths with spiny shrublets. Biogeographical sub-types: (a) spiny shrublet community of *Anthyllis hermanniae*; (b) Mount Etna Spiny shrublet community of *Astragaletum*. *Siculi* (Habitat 31.76); © Madonie and Apennine hedgehog-heaths with *Astragalus* spp. or *Genista* spp. (Habitat 31.77), must be taken into consideration
- 7.2.2.3. Hedgehog-heaths with *Prunus prostrata*. Biogeogrphical sub-types: (a) Cyrno-Sardinian (Habitat 31.75); (b) Cretan with *Saturejetea spinosae* (Habitat 31.7B), must be taken into consideration
- 7.2.2.4. Hedgehog heaths communities of juniper (*Juniperus communis* ssp. *hemisphaerica, Astragalus creticus* ssp. *rumelicus* & *Eryngium amethystinum* (partly corresponds with Habitat 31.88?)
- 7.2.2.5. Eastern hedgehog heaths (many of them with the spiny cushion *Astragalus angustifolius*)
- 7.2.2.6. Biogeographical sub-types: (a) with *Box*; (b) Aegean summital hedgehog-heaths (Habitat 31.7C); (c) Helleno-Balkanic sylvatic *Astragalus* hedgehog-heaths (Habitat 31.78); (d) Hellenic oro-Mediterranean hedgehog-heaths (*Daphno-Festucetea: Eryngio-Bromion* p.) (Habitat 31.79); (e) Hellenic alti-Mediterranean hedgehog-heaths (*Daphno-Festucetea: Astragalo-Seslerrion*) (Habitat 317A); (e) Southern Hellenic *Genista acanthoclada* hedgehog heaths (Habitat 31.7D); (e) *Astragalus sempervirens* hedgehog-heaths (Habitat 31.7E), must be taken into consideration.
- 7.2.2.7. Mountain *Genista purgans* formations (France & Spain) (Habitat 31.842)
- 7.2.2.8. Other western Mediterranean hedgehog heaths or cushion heaths
- 7.2.2.9. Other eastern Mediterranean hedgehog heaths or cushion heaths

7.3. Snow-patch communities

- 7.3.1. Communities with willows. Sub-types: (a) *Salix herbacia* on acid soils; (b) *Salix reticulata* & *Salix retusa* on calcareous soils; © *Salix polaris*- (Boreal region), must be taken into consideration
- 7.3.2. Communities dominated by the wood-rush (*Luzula alpinopilosa*) on acid soils
- 7.3.3. Communities of *Ranunculus alpestris, Arabis caerulea, Saxifraga androsacea,* etc. on calcareous soils
- 7.3.4. Communities of mosses (snow-free period is less than eight weeks long)
- 7.3.5. Other snow-patch communities

7.4. Alpine grasslands

7.4.1. Acid alpine grasslands (natural and seminatural)

- 7.4.1.1. Mat-grass (*Nardus stricta*) moist communities (Habitat 35.1)

7.4.1.2. Communities of alpine sedge (*Carex curvula*) (termperate-continental & sub-Mediterranean)

7.4.1.3. Communities dominated by fescue species. Sub-types: (a) *Festuca airoidis*; (b) *Festuca eskia* on siliceous soils (Habitat 36.314); © *Festuca paniculata*; (d) *Festuca indigesta* on sicileous soils (Habitat 36.36), must be taken into consideration

7.4.1.4. Communities with rushes. Sub-types: (a) three-leaved rush (*Juncus trifidus*) with *Oreochloa disticha* (Central Europe); (b) Boreo-alpine with *Juncus trifidus and Carex bigelowii* (Habitat 36.32), must be taken into consideration

7.4.1.5. Other acid alpine and subalpine grasslands

7.4.2. Alpine and subalpine calcareous grasslands and hay meadows (natural and semi-natural)

7.4.2.1. Mesophile closed calciphile alpine grasslands (*Dryas, Gentiana*) (Habitat 36.41)

7.4.2.2. Meso-xerophile wind edge naked-rush swards (*Kobresia myosuroides*) (Habitat 36.42)

7.4.2.3. Xero-thermophile calciphilous stepped and garland grassland (Habitat 36.43)

7.4.2.4. Oro-Corsican grasslands (*Plantago subulata* spp. *insularis*) (Habitat 36.37)

7.4.2.5. Oro-Apennine closed grasslands (*Festuca violacea* spp. *macrathera*) (Habitat 36.38)

7.4.2.6. Sub-alpine rich mesophile hay meadows (*Geranium sylvaticum*) (Habitat 38.3)

7.4.2.7. Calaminarian grasslands (*Violetalia calaminariae*) on outcrops rich is heavy metals (Habitat 36.44)

7.4.2.8. Other alpine and subalpine calcareous grasslands

7.5. Alpine wet communities

7.5.1. Alpine and sub-alpine peats (acid, neutral, or alkaline)

7.5.1.1. Sub-alpine bogs

7.5.1.1.1. Raised bogs. Actived (Habitat 51.1) and degraded (Habitat 51.2) sub-types, must be taken into consideration

7.5.1.1.2. Depressions on peat substrates (*Rhynchosporion*) (Habitat 54.6)

7.5.1.2. Alpine fens

7.5.1.2.1. Poor fens of sedges (*Carex nigra* commonly dominant) (Habitat 54.2)

7.5.1.2.2. Alpine poor fens of cottongrass (*Eriophorum scheuchzeri*), sedges and rushes

7.5.1.2.3. Alpine calcareous fens of the sedge, *Carex frigida* (Habitat 54.2)

7.5.1.3. Alpine pioneer formations of *Caricion bicoloris-atrofuscae* (Habitat 54.3)

7.5.2. Flush communities with mosses, and such hygrophilous flowering plants as saxifrages, butterworts, and willowherbs (parlty corresponds with Habitat 54.2?). Sub-types: (a) acid with *Saxifraga stellaris*, *Epilobium nutans* and mosses; (b) calcareous, commonly with the dominant moss *Cratoneuron commutatum* (Habitat 54.12), must be taken into consideration

7.5.3. Bog woodland

7.5.3.1. Sphagnum birch woods (Habitat 44.A1)

7.5.3.2. Scots pine mire woods (Habitat 44.A2)

7.5.3.3. Mountain pine bog woods (Habitat 44.A3)

7.5.3.4. Mire fir woods

7.6. Freshwater habitats (frequently pioneer of land interface zones of lakes or rivers, sometimes on peaty soils). Only Habitat EUR15 communities are included here

7.6.1. Standing waters

7.6.1.1. Oligotrophic waters in perialpine area with amphibious vegetation (Habitat 22.11x22.31; 22.32). Sub-types (a) aquatic to amphibious short perennial vegetation, oligotrophic to mesotrophic, of lake, pond and pool banks and water-land interfaces belonging to the *Littorelletalia uniflorae* order; (b) amphibious short annual vegetation, pioneer of land interface zones of lakes, pools and ponds with nutrient poor soils, or which grows during periodic drying of these standing waters. *Isoeto-Nanojuncetea* class, must be taken into consideration.

7.6.1.2. Other standing waters communities

7.6.2. Running water (see also Habitat 24.222)

7.6.2.1. Herbaceous and suffrutescent communities along of the boreal gravel river banks (*Epilobion fleischeri* p.) (Habitat 24.221)

7.6.2.2. Ligneous vegetation of *Myricaria germanica* along alpine gravel river banks (*Salici-Myricarietum*) (Habitat 24.223)

7.6.2.3. Thickets or woods with *Salix eleagnos, Salix* spp., *Alnus, Betula,* etc. along alpine and peri-Alpine gravel river banks (Habitat 24.224)

7.6.2.4. Other running water communities

7.7. Rocky habitats communities

7.7.1. Scree communities

7.7.1.1. Montane to snow level cryoclastic siliceous scree (*Androsacetalia alpinae & Galeopsietalia ladani*) (Habitat 61.1)

7.7.1.2. Eutric scree from the montane to alpine levels (*Thlaspietea rotundifolii*) (Habitat 61.2). Sub-types: (a): calcshist screes (*Dabrion hoppeanae*); (b) calcerous screes (*Thlaspion rotundifolii*); (c) marl screes (*Petasition paradoxi*), must be taken into consideration

7.7.1.3. Western Mediterranean and alpine thermophillous scree (party also corresponds to non-alpine, warm, sunny Central Europe) (Habitat 61.3). The following sub-types must be taken into consideration: (a) Peri-alpine thermophilous screes (*Stipion calamagrostidis, Leontodontion hyoseroidis*) (Habitat 61.31); (b) Pyreneo-Alpine thermo-siliceous screes (*Senecion leucophyllae, Taraxacion pyrenaici*) (Habitat 61.33); (c) Pyrenean calcareous screes (*Iberidion spathulatae*) (Habitat 61.34); (d) Oro-Cantabrian calcareous screes (*Linarion filicaulis, Saxifragion praetermissae*) (Habitat 61.35); (e) Oro-cantabrian siliceous screes (*Linarion filicaulis* p., *Linario-Senecio carpetani* p.) (Habitat 61.36); (f) Iberian fern screes (*Dryopteridion oreadis, Dryopteridion submontanae*) (Habitat 61.37); (g) Carpetano-Iberian siliceous srees (*Linario-Senecion carpetani*) (Habitat 61.38); (h) Nevadan siliceous screes (*Holcion caespitosae*) (Habitat 61.39); (i) Central Mediterranean screes (Habitat 61.11)

7.7.1.4. Calcreous or marly screes of subalpine and alpine belts, often in dry, warm stations in associations with (*Stipetalia calamagrostis*) (Habitat 61.6)

7.7.1.5. Other scree communities

7.7.2. Chasmophytic vegetation (cliff fissures) on rocky slopes

7.7.2.1. Chasmophytic vegetation of calcareous rocky slopes (Habitat 62.1; 62.1A). The following sub-types must be taken into consideration: (a) communities of *Potentilletalia caulescentis* (Habitat 62.15; 62.1A); (b) Pyrenean communities (*Saxifragion mediae*) (Habitat 62.12); (c) Liguro-Apennine cliffs communities (*Saxifragion lingulatae*) (Habitat 62.13) (d) other chasmophytic vegetation of calcareous rocky slopes

7.7.2.2. Chasmophytic vegetation of siliceous rocky slopes (Habitat 62.2). The following sub-types must be taken into consideration: (a) Pyrenees and Alps (*Androsacion vandellii*) (Habitat 62.21); (b) Iberian mountains (*Saxifragion willkommianae*) and Sierra Nevada (*Saxifragion nevadensis*) (Habitat 62.22); (c) South-western Alps (*Saxifragion pedemontanae*) (Habitat 62.23); (d) Cyrno-Sardian *Potentillion crassinerviae* (Habitat 62.24); (e) other chasmophytic vegetation of siliceous rocky slopes

7.7.3. Pioneer vegetation on siliceous and calcareous rocks or colonising superficial soils of rock surfaces (*Sedo-Scleranthion, Sedo albi-Veronicion dillenii*) (Habitat 62.3). This habitat is associated with 7.7.2.1 and 7.7.2.2. Vegetation colonising calcareous rocks is included under Habitat 34.11 "Karstic calcareous grasslands" and Habitat 62.4 "Limestone pavements"

7.7.4. Fields of lava. Sites and products of recent volcanic activity with*Viola cheiranthifolia, Silene nocteolens, Argyranthemum teneriffae* and lichens (e.g. *Stereocaulon vesubianum*) (Habitat 65). The following sub-types must be taken into consideration: (a) Etna summital communities (Habitat 66.2); (b) Barren lava fields (colonized, for example, by *Stereocaulon vesubianum*) (Habitat 66.3); © Volcanic ash and lapilli fields, lava tubes and fumaroles (Habitat 66.4, 66.5, 66.6)

7.7.5. Permanent glaciers (rock and true glaciers) (Habitat no code)