SPADE-2: Soil Profile Analytical Database for Europe
Version 2.0 Beta Version March 2009

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Abstract

This report describes the development of the Soil Profile Analytical Database for Europe (SPADE-2), Version 2.0. It is an update of the SPADE-2 Version 1.0 report (EUR 22127 EN, 2006) that describes the compilation of soil profile data for nine EU Member States. Both versions of the SPADE 2.0 Database have been funded by the European Crop Protection Association (ECPA) and this latest version (2.0) contains data for a further eight EU Member States & Switzerland. The report describes the background to the development of SPADE-2, the method of its derivation and the harmonisation procedures adopted. Some guidance on use of SPADE-2 in association with the 1:1,000,000 scale Soil Geographical Database of Europe is also provided. A third phase of data collection is anticipated that will aim to provide soil profile data for the whole of the enlarged European Union in the not too distant future.

More detailed analyses and descriptions will be added to this report (V1.1) as the SPADE-2 database is updated through further validation and acquisition of additional material. The database referred to in this report (SPADE2v11) is a beta version of the final database.

Introduction

The European Soil Database (SDBE version 1.0) has been developed over the last two decades through the efforts of the European Soil Bureau Network and its predecessors, co-ordinated since 1990 through the Secretariat of the European Soil Bureau, Institute of Environment and Sustainability, European Commission Joint Research Centre, Ispra, Italy.

The database has four main components:

- The 1:1,000,000 Soil Geographic Database of Europe (SGDBE v. 3.2.8.0
- The European Soil Profile Analytical database, SPADE-1 (v 2.1.0.0).
- The European Pedo-Transfer Rules database 2.0.
- The HYPRES pedo-transfer functions v 1.0.

Soil Geographic Database of Europe SGDBE

This database can be used both with in ArcView™ (v 3.2, 8.3) and with ArcGIS™ (v 8.2, 8.3). The database is a digital version of the 1:1,000,000 Soil Map of Europe (CEC 1985), which was compiled in the 1970's but considerably updated in the 1990s through the efforts of the European Soil Bureau Network, under institutional funding of the Joint Research Centre. The database has geometric and semantic components, soil information being presented in the form of Soil Map Units (SMUs) with each polygon (geometric or spatial) unit on the map being assigned to a single SMU. Each SMU comprises a number of soil types or Soil Typological Units (STU) which are associated together within the SMU landscape but cannot be separated spatially at the 1:1,000,000 map scale.

The digital data cover all the Member States (25) of the Enlarged EU, former EFTA nations (Norway & Switzerland), Candidate Countries (Bulgaria, Croatia & Romania), and Neighbouring Countries of the Western Balkans.

Included within the database are four data tables in DBase (.dbf) format:

- SOIL.PAT – Specifies the perimeter length, area, etc. of each polygon.
- SMU – Specifies the area and number of polygons for each SMU.
- STU.ORG – Specifies the code and percentage cover of each STU in each SMU.
- STU – Defines a range of attributes for each STU.

SPADE-2 database

The original SPADE-1 database included in the European Soil Database had serious limitations when applying models in a Pan-European context. SPADE-2 was developed to derive appropriate characterisation of soil profile data for STUs in the SGDBE (Hollis et al., 2006). SPADE 2 aims to provide sufficient soil property data to support higher tier modelling of pesticide fate at the European level.

Acquisition of soil property data

Derivation of the soil property data was achieved through the European Soil Bureau Network (Montanarella *et al*., 2005).

The first phase of acquisition resulted in data sets from Belgium and Luxembourg, Denmark, England and Wales, Finland, Germany, Italy, Netherlands, Portugal and Scotland (Hollis et al., 2006).

In a second phase of data acquisition providers from Bulgaria, Croatia, Czech Republic, Estonia, Greece, France, Hungary, Republic of Ireland, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Spain and Switzerland were contacted about participation. There was a negative response from Latvia and no reply from Croatia, Czech Republic and Poland. During subsequent negotiation of contracts, it was established that the specified data could not be supplied for Greece, Lithuania and Slovenia within the project time-scale. Bulgaria, Estonia, France, Hungary, Ireland, Romania, Slovakia and Switzerland supplied complete data sets by December 2008. Spain provided an interim dataset to be completed in summer 2009. The datasets from France and

Ireland were developed from existing SPADE 1 data and literature using expert judgement. Annex 1 lists the data providers.

The current database (SPADE2v11) is a beta version of collated datasets from the first and second phases of soil profile data acquisition. A revised version will be available once datasets have been competed from Spain in late 2009.

Data derivation protocol

The long-term objective of the SPADE-2 project is to provide, for each country in the European Union, a land use-specific data set of soil primary properties relevant to each soil typological unit (STU) of each soil map unit (SMU) included in the 1:1,000,000 Soil Geographical Database for Europe, v. 3.2.8

The primary soil properties required for each STU are as follows:

Horizon nomenclature

Upper depth (cm),

Lower depth (cm).

Particle-size fractions: (as a % of the less than 2mm fraction), clay, silt, total sand and content of at least 3 sand fractions (fine, medium, coarse).

pH in water (1:2.5) or other methods detailed by the data provider

Organic Carbon content (%).

Preferably, based on the Walkley & Black (1934) analytical procedure (see also Tinsley 1950). If not, the exact method of analysis to be specified by the data provider.

Dry Bulk Density (g.cm^{-3}).

Exact method of determination to be specified by the data provider.

Method of derivation of Soil Properties

The data provider was supplied with two Microsoft Excel spreadsheets:

Spreadsheet 1. Comprises a list of each STU in each country, the SMU in which it occurs and the existing associated attributes for the STU (e.g. soil type, dominant land use, secondary land use, dominant parent material, secondary parent material, etc.).

Spreadsheet 2. Comprises a list of each STU, the specified dominant land use and secondary land use of each STU, the horizon sequence for each land use-specific STU and, for each of these, a column for each of the soil primary properties that are required for the database. For the particle-size fractions, pH and organic carbon content, columns for the mean value and standard deviation are included. Standard deviations are NOT required for horizon depths or bulk density.

Procedure.

The data provider was requested to complete Spreadsheet 2 with all the soil primary property values using the methods outlined in Hollis et al, 2006.

Overview of datasets provided

Missing data exists where values have not been measured or derived (particularly bulk density for Spain, France, Ireland and Slovakia) by the data provider or where data does not exist such as for particle size data for organic (O or H) or rock (R) horizons. Other data gaps are due unavailability of data or expert judgement for primary soil properties for specific STUs.

The database from France was derived from expert judgement using SPADE1 profiles to attribute data to representative STUs. There are large data gaps due to the paucity of data in SPADE 1 profiles for France.

The database from Spain is still under construction. However, an initial database was provided for the beta database (Spade2v11) that includes the characterisation of the majority of STUs within 22 of the largest SMUs with a dominant agricultural land use.

Harmonisation of data supplied

Table 1 shows the characteristics of the data supplied by each national provider. It indicates a need for harmonisation of the datasets for some soil properties. For the second phase data providers harmonisation of the particle-size data for the intermediate sand fractions is necessary. Organic carbon data should be consistent (see below) however pH is measured in three different solutions.

Country	Clay mm	Silt mm	Total sand mm	Sand 1	Sand 2	Sand 3	Sand 4	OC method[1]	pH	BD[2]	Stones
Belgium & Luxembourg	0.002	0.05	2	0.2	0.5	2		WB	H_2O	meas	y
Bulgaria	0.002	0.05	2	0.2		2		WB	H_2O, KCl	calc	n
Denmark	0.002	0.05	2	0.2		2		WB	H_2O	meas	n
England, Wales & N. Ireland	0.002	0.06		0.2		2		WB/DC	H_2O	meas	n
Estonia	0.002	0.05	2	0.25	0.5	2		Tyrin/ DC	H_2O	meas	y
Finland	0.002	0.06	2	0.2	0.6	2		WB/DC	H_2O	meas	y
France	0.002	0.05	2	0.2		2		OM	H_2O	meas	y
Germany	0.002	0.06	2	0.2	0.6	2		WB/DC	H_2O	meas	y
Hungary	0.002	0.02 0.05	2	0.25				WB	H_2O	meas	n
Ireland	0.002	0.05	2	0.2		2		WB/DC	H_2O	n	y
Italy	0.002	0.05	2	0.25	0.5	2		WB	H_2O	meas	y
Netherlands	0.002	0.05	2	0.105	0.21	2		WB	KCl	meas	y
Portugal	0.002	0.05	2	0.2		2		WB	H_2O	meas	y
Romania	0.002	0.05	2	0.2				WB	H_2O	meas	y
Scotland	0.002	0.05	2			2		CHN	H_2O	meas	y
Slovakia	0.002	0.05	2					Turin	KCl	n	y
Spain	0.002	0.05	2	0.2	0.5	2		WB	H_2O	n	y
Switzerland	0.002	0.05	2	0.1	0.2	0.5	2	WB	$CaCl_2$	meas	y

Table 1 Summary of raw data from data providers. Countries in italics indicate new data providers for the second phase of data acquisition [1]WB Walkley and Black method (1934); DC Dry combustion (peat soils only); Tyrin/Turin wet oxidation method similar to WB; CHN CHN analyser. [2] meas BD measured; calc BD derived from local pedotransfer functions(PTFs); n no data available to be determined by appropriate PTFs

Particle-size distribution

For the interim database particle size fractions of clay (<0.002 mm), silt (<0.05 mm) and total sand (<2 mm) are included for all data providers.

Intermediate sand fractions (0.1; 0.2; 0.5; 2 mm) are determined from curve fitting methods (monotonic cubic spline) detailed in Hollis et al. 2006, where sufficient data exists to produce interpolated particle size distributions.

The interpolation procedure was not applied to the data for Slovenia as only total sand rather than individual sand fractions was provided. Switzerland provided the distribution of total sand to the intermediate sand fractions by expert judgement and hence further interpolation methods were not considered necessary.

Organic carbon

Most data providers measured organic carbon by the Walkley-Black method. Other wet oxidation methods (e.g Turin, Tyrin) used by Estonia and Slovakia are comparable to the WB method and dry combustion (Batjes, 2002; Hegymegi et al., 2007 Speigel et al., 2007).

The data used to populate STUs for France contained organic matter content which was converted to organic carbon % using the relationship in [1].

$$\text{OC\%} = \text{OM\%}/1.724 \qquad [1]$$

pH

pH was measured in water (1:2.5 dilution ratio) for the majority of data providers. Switzerland used 0.01M $CaCl_2$ solution (1:2.5 dilution) and Slovakia and Bulgaria KCl (0.1M KCl). Additional columns have been created in the database to indicate that these values are not comparable to pH measured in water. Several conversion factors are suggested below to enable pan-European comparisons and these should be selected by the user as appropriate.

Conversion of pH in KCl to pH in water [2].

$$\text{pH (0.1M KCl)} = 0.7\ \text{pH}_w \qquad [2]$$

where pH_w is pH measured in water (1:2.5 soil:H_2O)

(Focus, 2000)

The pH comparisons between measurements in water and $CaCl_2$ solutions are non-linear at extremes of pH thus additional functions should be used to estimate pH in very acidic or alkaline soils. For most soils in pH range 4.5 to 8.5 a linear function [3] is appropriate, however a third order polynomial better describes the relationship at very low and very high pH outside these pH ranges, where non-linearity in the relationship occurs [4].

$$\text{pH}_{ca} = 0.937\ \text{pH}_w - 0.373 \qquad [3]$$

(Ahern *et al*., 1995)

$$\text{pH}_{ca} = -5.03\ \text{pH}_w + 0.891\ \text{pH}_w^2 - 0.043\ \text{pH}_w^3 + 12.484 \qquad [4]$$

(Ahern *et al*., 1995)

pH_{ca} pH measured in 0.01M $CaCl_2$
pH_w pH measured in water (1:2.5 soil:H_2O)

Bulk density

All data providers gave measured bulk density values, except France, Ireland, Spain and Slovakia, which did not provide either measured or derived estimates. In this case bulk density has been derived from a pedotransfer function (PTF) developed for UK soils. Bulgaria used local pedotransfer functions (regression models) to derive BD estimates from OC and clay content (Table 2).

Topsoil horizons (A)			
clay% (< 0.01 mm)		R^2	SEE
10-30	BD= 1.75-0.22×hum	86	0.10
30-45	BD= 1.49-0.10×hum	76	0.06
45-75	BD= 1.58-0.06×hum-0.005 cl_1	73	0.07
Subsoil horizons (B)			
clay% (< 0.01 mm)			
30-45	BD= 1.42-0.12×hum	72	0.03
45-60	BD= 1.70-0.009×cl_1	39	0.06
60-75	BD= 2.05-0.016×cl_1	39	0.09

Table 2 Regression PTF for Bulgaria BD calculations. Hum humus content %; cl_1 clay content (<0.001mm) %. BD in g/cm^3.

Where bulk density measurements were not available in some national datasets it was derived using a pedotransfer function developed for UK soils. This method is not appropriate for all areas covered by the data providers as it is based on relationships between particle size fractions and organic carbon developed specifically for UK soils. Therefore estimates for some STUs that are not representative of UK STUs could be unreliable. As a result of these limitations a priority for the selection of bulk density values is recommended as follows:

1. DB (measured by data provider)
2. DB_CALC (calculated by data provider using local algorithms)
3. DB_UK_PTF (bulk density derived using a pedotranfster function for UK soils)

Details of the bulk density calculations used for DB_UK_PTF are shown in table 3. To avoid unrealistic predictions the following criteria are applied before selection of the appropriate PTF in table 3.

For soils with unusual particle size distributions:

IF sand % is $\geq$93 %, SET clay % = 2 AND *silt % = 5*

IF silt % is < 2% SET *silt % = 2*

IF clay % is < 1% SET *clay % = 1*

IF sand % is < 5% SET *sand % = 5*

For transitional soil horizons, the primary soil horizon is selected e.g.

IF horizon code is “AB” or “AC”, SET horizon code = “A”

Proctor compaction tests on topsoil and subsoil samples representing a range of textural classes (Hollis & Woods, 1989) suggest that bulk densities are unlikely to exceed values of 1.95 for any textures. Therefore to avoid unrealistic bulk density predictions an upper maximum limit is set to 1.95.

Soil/lithology/land use scenario	Explanation	Bulk density algorithm
Organic topsoils		
H	Organic horizons	BD = -0.00745×OC%+0.593
H1	Organic horizons	BD = -0.00589× OC%+0.554
H2	Organic horizons	BD = -0.00797×OC%+0.553
Topsoils and podzolic horizons		
A_Arable	A Horizon and arable land use	BD=1.46- 0.0254× ln (clay%)+0.0279× ln (total sand %)-0.261× ln (OC%)
A_Ley	A horizon and ley grassland land use	BD=0.807+0.0989× ln (clay%)+0.106× ln (total sand %)-0.215×ln(OC%)
A_PGrass	A Horizon and permanent grassland land use	BD=0.999+0.0451× ln (clay%)+0.0784× ln (total sand%)-0.244× ln (OC%)
A_other	A Horizon and all other land uses	BD=0.87+0.071×ln(clay%)+0.093×ln(total sand %)-0.254×ln(OC%)
B_Podz	Bs or Bh Horizon	BD=0.998-0.0702×ln(silt%)+0.0798×ln(total sand %)-0.131×ln(OC%)
Subsoils in non-stagnogleyic groups		
Non-Stagno Alluv./Colluv.	Subsoil horizons in soils on MAT1 110,120,150	BD=1.56-0.00124×silt%-0.00372*clay%-0.0668*OC%
Non -Stagno Eg	Gleyic Eluvial horizon (Eg) in soils *except* in Stagno- subgroups	BD=1.5-0.00067×silt%+0.00262×clay%-0.139×OC%
Non Stagno. E	Eluvial horizon (E) in soils *except* in Stagno- subgroups	BD=1.54-0.000583×silt%-0.00008×clay%-0.162×OC%
Non Stagno. Bw1	Bw1 horizon in soils *except* in Stagno- subgroups)	BD=1.55-0.00147×silt%-0.00018×clay%-0.209×OC%
Non Stagno. Bg1	Bg1 horizon in soils *except* in Stagno- subgroups	BD=1.47-0.00727×silt%+0.00716×clay%-0.082×OC%
Non Stagno Bt	Bt horizon in soils *except* in Stagno- subgroups	BD=1.66-0.00069×silt%-0.00827×clay%2+0.0123×OC%
Non Stagno. Btg	Btg horizon in soils *except* in Stagno- subgroups	BD=1.67+0.000751×silt%-0.0105×clay%+0.0316×OC%
Non Stagno. Bw2	Bw2 horizon in soils *except* in Stagno- subgroups	BD=1.54-0.00546×silt%+0.00338×clay%-0.16×OC%
Non Stagno. Bg2	Bg2 horizon in soils *except* in Stagno- subgroups	BD=1.69+0.0021×silt%-0.00231×clay%-0.505×OC%
Non Stagno. BC	BC horizon in soils *except* in Stagno- subgroups	BD=1.49-0.00029×silt%+0.00437×clay%-0.314×OC%
Non Stagno. C	C horizon in soils *except* in Stagno- subgroups	BD=1.5-0.00059×silt%+0.00085×clay%-0.254×OC%
Subsoils in stagnogleyic groups		
Stagno. Glacial till	Subsoil horizons on MAT 131	BD=-0.015+0.119×ln(silt%)+0.102×ln(clay%)+0.186×ln(total sand%)-0.141×ln(OC%)
Stagno. Pre-Quat. clay/Mstone	Subsoil horizons on MAT 310-319; 330-340	BD=1.96-0.0158×ln(silt%)-0.154×ln(clay%)+0.0102×ln(total sand%)-0.113×ln(OC%)

Table 3 PTFs for bulk density for UK soils. BD in g/cm^3. (after Hallett et al., 1998). MAT1 refers to the primary parent material detailed in STU attribute table (STU.dbf) in the SGDBE.

Access to and use of the SPADE-2 database

Format of the SPADE2v11.dbf file

The SPADE2v11.dbf file comprises data in columns under the following category headings:

> SMU; STU; COUNTRY; USE; SOIL; PCAREA, HORIZON; DEPTH_UP; DEPTH_LO; CLAY; SILT; SAND_TOT; SAND_01; SAND_02; SAND_05; SAND_20; STONES; PH_KCL; PH_KCLSD; PH_H2O; PH_H2OSD; PH_CA; PH_CASD; OC; OC_SD; DB; DB_CALC; DB_UK_PTF; TEXT1; TEXT2; WR; WM1; WM2; WM3, SOIL_NEW, USE_NEW

Each of these categories is defined in Annex 3 along with the meaning of the codes that are used to classify attributes in COUNTRY; USE; SOIL; TEXT1; TEXT2; WR; WM1; WM2 and WM3 columns.

Missing data codes are used to distinguish unavailable data from insufficient data or data derived from expert judgement.

Data code	Explanation
'-9999'	Indicates all missing data (to facilitate import into GIS and other software packages. This commonly occurs in the columns relating to clay, silt and sand contents for organic soil layers (coded 'H' or 'O' in the horizon column) and for all soil layer property data columns in rock layers (coded 'R' in the horizon column).
-7	Indicates rock horizon
-8	Indicates mean value is based on expert judgement using a limited amount of measured data
-9	Indicates mean value is based on expert judgement only
-1	Indicates there is insufficient data to derive a standard deviation

It should be noted that the SPADE-2 database is made up of three separate types of data: Firstly, the soil property data for each soil HORIZON of each STU–USE (land use) combination. This is defined in columns headed HORIZON; DEPTH_UP; DEPTH_LO; CLAY; SILT; SAND_TOT; SAND_01; SAND_02; SAND_05; SAND_20; STONES; PH_KCL; PH_KCLSD; PH_H2O; PH_H2OSD; PH_CA; PH_CASD; OC; OC_SD; DB; DB_CALC; DB_UK_PTF. Only *one* line of data is included for each HORIZON.

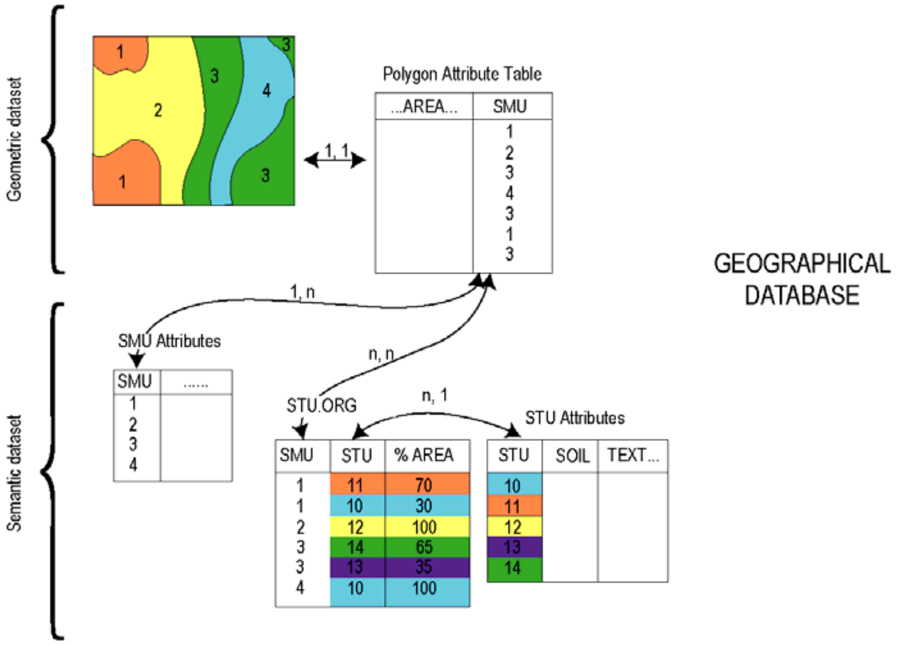
Secondly, there are data relating to each STU. This is defined in columns headed USE; SOIL; TEXT1; TEXT2; WR; WM1; WM2; WM3. These data are derived from the STU.dbf file of the SGDBE database and, for each STU-land use combination, is repeated for each soil HORIZON line. In some cases the data provider indicated different soil types or land uses that typify the SMU more accurately based on new data or expert judgement; this appears in SOIL_NEW and USE_NEW. The respective horizon data is therefore associated with the *new* soil type (SOIL_NEW) and land use (USE_NEW) entries rather than SOIL or USE as described in the spreadsheet and the STU.dbf file. Finally, there are data relating to each SMU (soil map unit). This is defined in columns headed SMU, STU, PCAREA. These data are derived from the STUORG.dbf file of the SGDBE and, for each SMU-STU combination and is repeated for each soil HORIZON line.

Linking the soil property data to the soil geographical data

The SPADE-2 database can be most effectively used in conjunction with the Soil Geographical Database of Europe (SGDBE), providing the soil property data for the Soil Typological Units (STU).

Linking the STU attribute information to the soil polygons in SGDBE

The relationship between STU and Soil Mapping Units (SMU) is qualified by the stuorg.dbf file. Thus setting up a relational join in ArcView® or ArcGIS® or other GIS software allows the user to link the soil property data to the polygons displayed via the SGDBE. Spatial analysis is then possible. This must be undertaken with care because although stuorg.dbf identifies the proportion (%) of each STU in the SMU (Figure 1), the spatial occurrence of the STUs is not specified. Figure 1 shows conceptually how the SGDBE can be linked with the SMU and STU attributes.



Polygon Attribute Table

...AREA...	SMU
	1
	2
	3
	4
	3
	1
	3

SMU Attributes

SMU	......
1	
2	
3	
4	

STU.ORG

SMU	STU	% AREA
1	11	70
1	10	30
2	12	100
3	14	65
3	13	35
4	10	100

STU Attributes

STU	SOIL	TEXT...
10		
11		
12		
13		
14		

Figure 1 Data structure for linking STU attributes to the spatial soil polygon data (after Lambert et al., 2003)

The following procedure details how to link the STU attributes to the spatial soil polygons via a relational join using ArcGIS®

1. Use the add “+” button to add the following to the layers (Figure 2):
    a. soil.shp (soil polygons from SGDBE)
    b. stuorg.dbf (link table between SMU and STU)
    c. stu.dbf (STU attributes from the SGDBE)

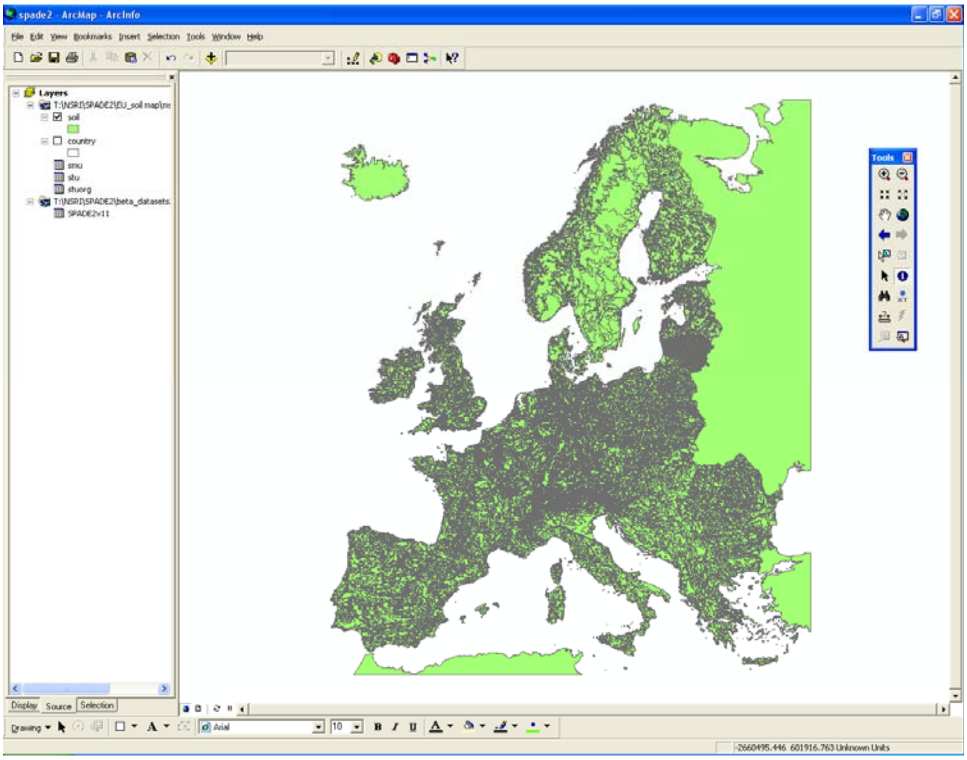
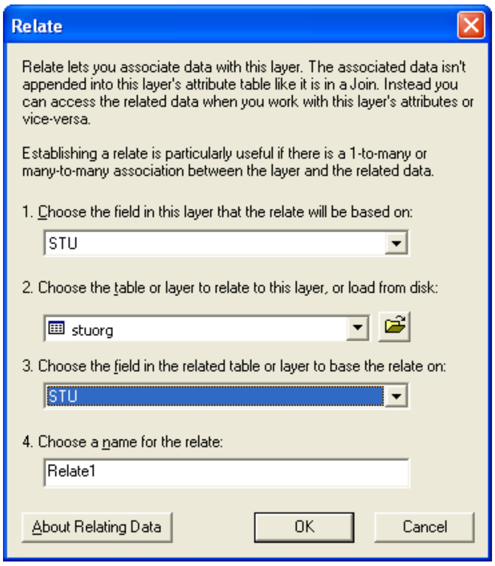


Figure 2 Adding shapefiles and tables

2. Select the ‘stu’ file and right click to display options specific to the table. Select “Joins and Relates” from the list of options and then “Relate…”

3. Select the following in the dialogue box (Figure 3):
    a. Relate field in the stu table is ‘STU’
    b. Relate table is ‘stuorg’
    c. Relate field from the relate table ‘stuorg’ is ‘STU’

Press ‘OK’. This will append the attributes in the stuorg table to the STU table.


Relate

Relate lets you associate data with this layer. The associated data isn't appended into this layer's attribute table like it is in a Join. Instead you can access the related data when you work with this layer's attributes or vice-versa.

Establishing a relate is particularly useful if there is a 1-to-many or many-to-many association between the layer and the related data.

1. Choose the field in this layer that the relate will be based on:
STU

2. Choose the table or layer to relate to this layer, or load from disk:
stuorg

3. Choose the field in the related table or layer to base the relate on:
STU

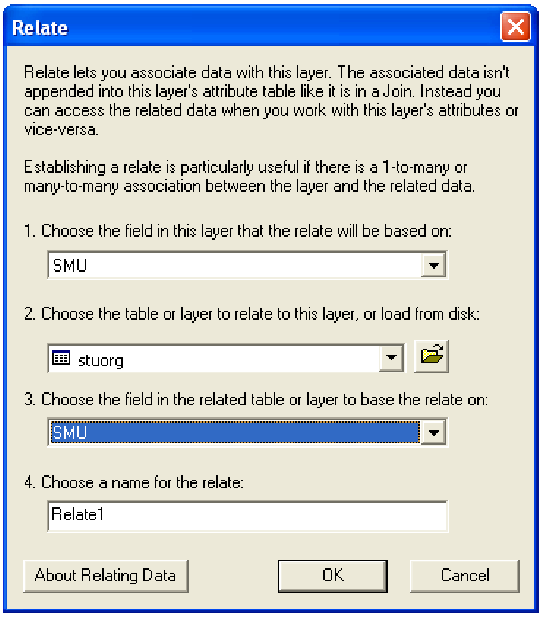
4. Choose a name for the relate:
Relate1

Figure 3 Relating STU with stuorg link table

4. Select “soil” and right click, select “Joins and Relates” from the list of options and then “Relate…”

5. Select the following in the dialogue box (Figure 4):
    a. Relate field in 'soil' is 'SMU'
    b. Relate layer is 'stuorg'
    c. Relate field from the relate layer 'soil' is 'SMU'

Press 'OK'. This will link the associated STUs in the stuorg link table with the SMUs in the soil shapefile ensuring each STU can be interrogated in the soil shapefile.



Relate lets you associate data with this layer. The associated data isn't appended into this layer's attribute table like it is in a Join. Instead you can access the related data when you work with this layer's attributes or vice-versa.

Establishing a relate is particularly useful if there is a 1-to-many or many-to-many association between the layer and the related data.

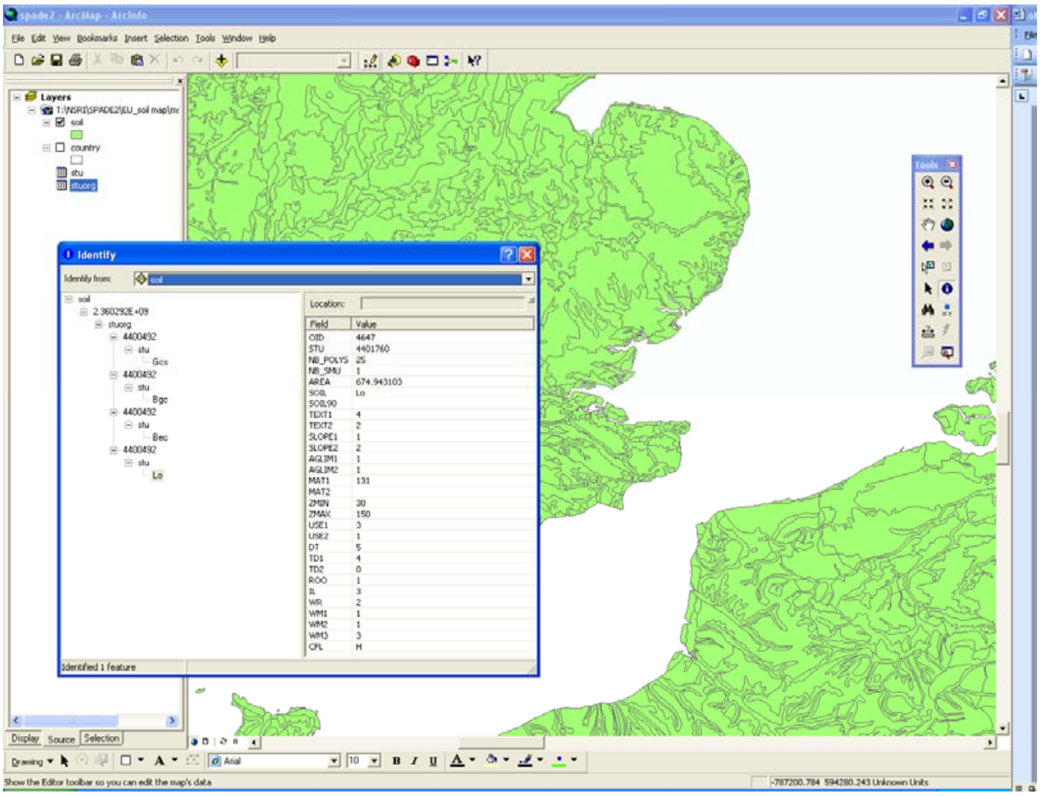
1. Choose the field in this layer that the relate will be based on: SMU
2. Choose the table or layer to relate to this layer, or load from disk: stuorg
3. Choose the field in the related table or layer to base the relate on: SMU
4. Choose a name for the relate: Relate1

Figure 4 Relating stuorg to the soil polygon shapefile

Note: A join will not work in this instance as there is a one-to-many relationship between the single reference to SMU in 'soil' and the numerous STUs associated with each SMU in 'stu'.

6. To interrogate the attributes of the STUs within the mapped SMUs use the "i" identify button to query a soil polygon (SMU). Expand all layers to reveal the related attributes for the STU (Figure 5). As the relationships are one-to-many ARCGIS cannot append the data to the soil.shp attribute table.
7. Changing the primary display fields for the layers shows the related layer information more systematically. To change primary display properties right click a layer and select 'properties', select 'fields' and choose primary display field. e.g change 'soil' primary display field to 'SMU' and 'stuorg' display field to STU'. When you expand the layers in the identify feature this will relate the layers using the SMU and STU identifiers.

A comprehensive list of the attribute coding for the STU table is detailed in a document in the SGDBE (attricod.doc).



Field	Value
OID	4647
STU	4401760
NB_POLYS	25
NB_SMU	1
AREA	674.943103
SOIL	Lo
SOIL90	
TEXT1	4
TEXT2	2
SLOPE1	1
SLOPE2	2
AGLIM1	1
AGLIM2	1
MAT1	131
MAT2	
ZMIN	30
ZMAX	150
USE1	3
USE2	1
DT	5
TD1	4
TD2	0
ROO	1
IL	3
WR	2
WM1	1
WM2	1
WM3	3
CFL	H

Figure 5 Identifying STU attributes data linked to the spatial soil data

Linking the SPADE2 database to the soil polygons in SGDBE

The following procedure details how to link SPADE2v11 dataset to the spatial soil polygons via a relational join in ArcGIS®

1. Use the add "+" button to add the following to the layers:
    a. soil.shp (soil polygons from SGDBE)
    b. stuorg.dbf (link table between SMU and STU)
    c. Spade2v11.dbf

2. Select the Spade2v11.dbf file and right click to display options specific to the table. Select "Joins and Relates" from the list of options and then "Relate…"

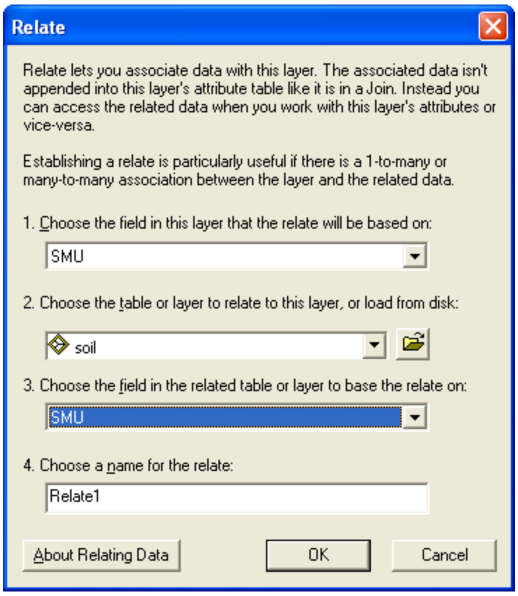
3. Select the following from the dialogue box (Figure 3):
    a. Relate field in the spade2v11 layer is 'STU'
    b. Relate table is 'stuorg'
    c. Relate Field from the relate table 'stuorg' is 'STU'

Press 'OK'. This will link the attributes in the SPADE2v11 database with STU with in the stuorg link table.

Note: A join will not work in this instance as there is a one-to-many relationship between the single STU in stuorg and the numerous soil horizon data associated with each STU in SPADE2v11.dbf.

4. Select "stuorg.dbf" right click and select "Joins and Relates" from the list of options and then "Relate…"
5. Select the following (Figure 6):
    a. Relate field is 'SMU'
    b. Relate layer is 'soil' (SGDBE soil shapefile)
    c. Relate Field from 'soil' is 'SMU'

Press 'OK'. This will link the associated STUs in the stuorg link table with the SMUs in the soil shapefile.



Relate

Relate lets you associate data with this layer. The associated data isn't appended into this layer's attribute table like it is in a Join. Instead you can access the related data when you work with this layer's attributes or vice-versa.

Establishing a relate is particularly useful if there is a 1-to-many or many-to-many association between the layer and the related data.

1. Choose the field in this layer that the relate will be based on: SMU

2. Choose the table or layer to relate to this layer, or load from disk: soil

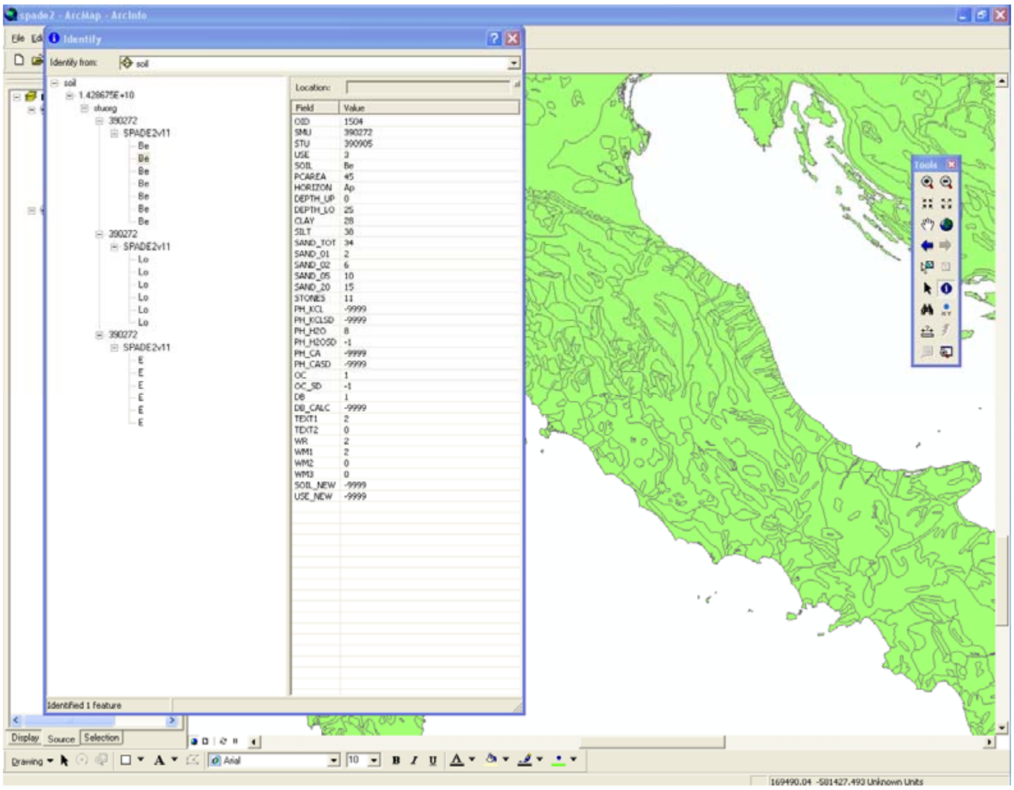
3. Choose the field in the related table or layer to base the relate on: SMU

4. Choose a name for the relate: Relate1

Figure 6 Relating stuorg to the soil polygon shapefile

6. To interrogate the soil profile data (spade2v11) for each STU-landuse within the mapped SMUs use the “i” identify button to query one soil polygon (SMU). Expand all layers to reveal the related attributes and profile data for the STU (Figure 7). As the relationships are one-to-many ARCGIS cannot append the data to the soil.shp attribute table.

7. Changing the primary display fields for the layers shows the related layer information more systematically. To change primary display properties right click a layer and select ‘properties’, select ‘fields’ and choose primary display field. e.g change primary display field of ‘soil’ to ‘SMU’, ‘stuorg’ to ‘STU’ and Spade2v11 to ‘SOIL’. When you expand the layers in the identify feature this will relate the layers using the SMU, STU and soil type identifiers.



spade2 - ArcMap - ArcInfo

Identify

Identify from: soil

- soil
  - 1.428675E+10
    - stuorg
      - 390272
        - SPADE2v11
          - Be
          - Be
          - Be
          - Be
          - Be
          - Be
          - Be
      - 390272
        - SPADE2v11
          - Lo
          - Lo
          - Lo
          - Lo
          - Lo
          - Lo
      - 390272
        - SPADE2v11
          - E
          - E
          - E
          - E
          - E
          - E

Location:

Field	Value
OID	1504
SMU	390272
STU	390905
USE	3
SOIL	Be
PCAREA	45
HORIZON	Ap
DEPTH_UP	0
DEPTH_LO	25
CLAY	28
SILT	38
SAND_TOT	34
SAND_01	2
SAND_02	6
SAND_05	10
SAND_20	15
STONES	11
PH_KCL	-9999
PH_KCLSD	-9999
PH_H2O	8
PH_H2OSD	-1
PH_CA	-9999
PH_CASD	-9999
OC	1
OC_SD	-1
DB	1
DB_CALC	-9999
TEXT1	2
TEXT2	0
WR	2
WM1	2
WM2	0
WM3	0
SOIL_NEW	-9999
USE_NEW	-9999

Identified 1 feature

169490.04 -581427.493 Unknown Units

Figure 7 Identifying SPADE2 data linked to the spatial soil data

Quantifying areas of selected soil types under specified land uses

In order to get an estimation of the area occupied by a mapped soil scenario, it is necessary to work with a joined Soil-SPADE_2.dbf file and to make some assumptions about the fraction of STU areas that are represented by their defined 'dominant' land use (USE1) and 'secondary' land use (USE2). The following procedure is suggested:

i. Open the SPADE_2.dbf file and make a selection using a soil scenario. Ensure that the scenario will only select a single STU line, for example where the Upper depth = 0 and the USE = 3. Export the selected lines as Soil***.dbf, to a scenario folder.

ii. Add Soil***.dbf to the work area and **link** it to 'soil.dbf'. The resulting map should highlight all the Soil Map Units (SMU) which contain the selected STU. Save the map as a record of where the selected soil scenario occurs. Export the selected soils as Soil***_selection.dbf to the scenario folder.

iii. Using Soil***.dbf, **join** the file to the STU.dbf file to create a Soil***_STU.dbf file. Export the file to the scenario folder.

iv. Outside of the GIS, open Soil***_selection.dbf and save as an MS Excel file. Use Excel to calculate the total area of each **SMU** in the file.

v. Outside of the GIS, open Soil***_STU.dbf and save as an MS Excel file. Add the calculated total area of each SMU to the Soil***_STU.xls file.

vi. Add a column to the Soil***_STU.xls file headed *USE_fraction*. Using MS Excel, create a formula in the first cell in the column, to calculate the USE_fraction as follows: =**IF(AND(USE1 cell = scenario use code, USE2 cell = 0), 0.8, IF(USE1 cell = scenario use code, 0.6, IF(USE2 cell = scenario use code, 0.3,0)))**. Copy this formula to all cells in the column.

vii. Using MS Excel, add a column to the Soil***_STU.xls file headed *STU_areas*. Create a formula in the first cell of the column, to calculate the scenario-specific use area of each STU as follows: = (SMU_area cell) * (PC_AREA cell/100) * (Use_fraction cell).

viii. Using MS Excel, SUM all the values in the *STU_areas* column. This value is the estimated area of the selected soil scenario. The calculation is based on the following broad assumptions:
    1. Where an STU has values for USE1 only (i.e. USE2 is 0), that use covers 0.8 of the total area of the STU;
    2. Where an STU has values for both USE1 and USE2, USE1 occupies 0.6 of the total STU area, and USE2 occupies 0.3 of the total STU area (this means that 0.1 of the area cannot be assigned a specific land use).
    3. Where the scenario USE does not match either the USE1 or USE2 values, the scenario use does not occupy any of the STU area.

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ANNEX 3 Data dictionary

Field names for SPADE-2 Database (Spade2v11.dbf)

Field Name	Description
SMU	Soil Mapping Unit code
STU	Soil Typological Unit code
COUNTRY	Country ID
USE	Land use class associated with profile data
SOIL	Soil name FAO Legend 1974 modified CEC 1985
PCAREA	(STUarea/SMUarea)100
HORIZON	FAO Nomenclature
DEPTH_UP	Upper depth (cm)
DEPTH_LO	Lower depth (cm)
CLAY	Clay <0.002 mm esd, % oven dry weight (at 105°C)
SILT	Silt 0.002-0.05 mm esd, % oven dry weight (at 105°C)
SAND_TOT	Sand 0.05-2 mm esd, % oven dry weight (at 105°C)
SAND_01	Sand 0.05-0.1 mm esd, % oven dry weight (at 105°C)
SAND_02	Sand 0.1-0.2 mm esd, % oven dry weight (at 105°C)
SAND_05	Sand 0.2-0.5 mm esd, % oven dry weight (at 105°C)
SAND_20	Sand 0.5-2 mm esd, % oven dry weight (at 105°C)
STONES	Stone content as volume %
PH_KCL	pH in 0.1 M KCl sollution
PH_KCLSD	Standard Deviation of pH in KCl
PH_H2O	pH in H_2O solution (soil: water ratio 1:2.5)
PH_H2OSD	Standard Deviation of pH in H_2O
PH_CA	pH in 0.01M $CaCl_2$ solution
PH_CASD	Standard Deviation of pH in $CaCl_2$
OC	Organic Carbon content %
OC_SD	Organic Carbon standard deviation
DB	Bulk Density g m^3 measured
DB_CALC	Bulk Density g m^3 calculated
DB_UK_PTF	Bulk density g m^3 derived from UK pedotransfer function
TEXT1	Dominant surface textural class
TEXT2	Secondary surface textural class
WR	Dominant annual average water regime class
WM1	Water management in agricultural land
WM2	Purpose of water management system
WM3	Type of water management syste
SOIL_NEW	New soil type assigned to STU from data provider
USE_NEW	New land use class assigned to STU from data provider

Soil Name

SOIL	Full 1974 (modified CEC 1985) FAO-Unesco legend soil name.
(Present in:	*STU)*
	No information
A	Acrisol
Af	Ferric Acrisol
Ag	Gleyic Acrisol
Ah	Humic Acrisol
Ao	Orthic Acrisol
Ap	Plinthic Acrisol
B	Cambisol
Ba	Calcaric Cambisol
Bc	Chromic Cambisol
Bcc	Calcaro-Chromic Cambisol
Bch	Humo-Chromic Cambisol
Bck	Calci-Chromic Cambisol
Bd	Dystric Cambisol
Bda	Ando-Dystric Cambisol
Bdg	Gleyo-Dystric Cambisol
Bds	Spodo-Dystric Cambisol
Be	Eutric Cambisol
Bea	Ando-Eutric Cambisol
Bec	Calcaro-Eutric Cambisol
Bef	Fluvi-Eutric Cambisol
Beg	Gleyo-Eutric Cambisol
Bev	Verti-Eutric Cambisol
Bg	Gleyic Cambisol
Bgc	Calcaro-Gleyic Cambisol
Bge	Eutri-Gleyic Cambisol
Bgg	Stagno-Gleyic Cambisol
Bgs	Spodo-Gleyic Cambisol
Bh	Humic Cambisol
Bhc	Calcaro-Humic Cambisol
Bk	Calcic Cambisol
Bkf	Fluvi-Calcic Cambisol
Bkh	Humo-Calcic Cambisol
Bkv	Verti-Calcic Cambisol
Bv	Vertic Cambisol
Bvc	Calcaro-Vertic Cambisol
Bvg	Gleyo-Vertic Cambisol
Bvk	Calci-Vertic Cambisol
Bx	Gelic Cambisol
Bxs	Spodo-Gelic Cambisol
C	Chernozem
Ch	Haplic Chernozem
Chp	Pachi-Haplic Chernozem
Chv	Verti-Haplic Chernozem
Ck	Calcic Chernozem
Ckb	Vermi-Calcic Chernozem
Ckc	Calcaro-Calcic Chernozem
Ckcb	Vermi-Calcaro-Calcic Chernozem
Ckp	Pachi-Calcic Chernozem
Cl	Luvic Chernozem
D	Podzoluvisol
Dd	Dystric Podzoluvisol
De	Eutric Podzoluvisol
Dg	Gleyic Podzoluvisol
Dgd	Dystric Gleyic Podzoluvisol
Dge	Eutric Gleyic Podzoluvisol
Dgs	Stagno-Gleyic Podzoluvisol
Ec	Cambic Rendzina
Eh	Histic Rendzina
Eo	Orthic Rendzina
F	Ferralsol
Fo	Orthic Ferralsol
G	Gleysol
Gc	Calcaric Gleysol
Gcf	Fluvi-Calcaric Gleysol
Gcs	Stagno-Calcaric Gleysol
Gd	Dystric Gleysol
Gdf	Fluvi-Dystric Gleysol
Gds	Stagno-Dystric Gleysol
Ge	Eutric Gleysol
Gef	Fluvi-Eutric Gleysol
Ges	Stagno-Eutric Gleysol
Gev	Verti-Eutric Gleysol
Gf	Fluvic Gleysol
Gfm	Molli-Fluvic Gleysol
Gh	Humic Gleysol
Ghf	Fluvi-Humic Gleysol
Ghh	Histo-Humic Gleysol
Ght	Thioni-Humic Gleysol
Gi	Histic Gleysol
Gih	Humo-Histic Gleysol
Gl	Luvic Gleysol
Gls	Stagno-Luvic Gleysol
Gm	Mollic Gleysol
Gmc	Calcaro-Mollic Gleysol
Gmf	Fluvi-Mollic Gleysol
Gmv	Verti-Mollic Gleysol
Gs	Stagnic Gleysol
Gt	Thionic Gleysol
H	Phaeozem
Hc	Calcaric Phaeozem
Hcf	Fluvi-Calcaric Phaeozem
Hcn	Alkalino-Calcaric Phaeozem
Hcs	Saline-Calcaric Phaeozem
Hg	Gleyic Phaeozem
Hgc	Calcaro-Gleyic Phaeozem
Hgf	Fluvi-Gleyic Phaeozem
Hgs	Stagno-Gleyic Phaeozem
Hgv	Verti-Gleyic Phaeozem
Hh	Haplic Phaeozem
Hhv	Verti-Haplic Phaeozem
Hl	Luvic Phaeozem
Hlv	Verti-Luvic Phaeozem
Ho	Orthic Phaeozem
I	Lithosol
Ic	Calcaric Lithosol
Ich	Humo-Calcaric Lithosol
Id	Dystric Lithosol
Ie	Eutric Lithosol
J	Fluvisol
Jc	Calcaric Fluvisol
Jcf	Fluvi-Calcaric Fluvisol
Jcg	Gleyo-Calcaric Fluvisol
Jd	Dystric Fluvisol
Jdf	Fluvi-Dystric Fluvisol
Jdg	Gleyo-Dystric Fluvisol
Je	Eutric Fluvisol
Jef	Fluvi-Eutric Fluvisol
Jeg	Gleyo-Eutric Fluvisol

Jm	Mollic Fluvisol
Jmg	Gleyo-Mollic Fluvisol
Jmv	Verti-Mollic Fluvisol
Jt	Thionic Fluvisol
K	Kastanozem
Kh	Haplic Kastanozem
Khb	Vermi-Haplic Kastanozem
Kk	Calcic Kastanozem
Kkb	Vermi-Calcic Kastanozem
Kkv	Verti-Calcic Kastanozem
Kl	Luvic Kastanozem
Ko	Orthic Kastanozem
L	Luvisol
La	Albic Luvisol
Lap	Plano-Albic Luvisol
Lc	Chromic Luvisol
Lcp	Plano-Chromic Luvisol
Lcr	Rhodo-Chromic Luvisol
Lcv	Verti-Chromic Luvisol
Ld	Dystric Luvisol
Ldg	Gleyo-Dystric Luvisol
Lf	Ferric Luvisol
Lg	Gleyic Luvisol
Lga	Albo-Gleyic Luvisol
Lgp	Plano-Gleyic Luvisol
Lgs	Stagno-Gleyic Luvisol
Lh	Humic Luvisol
Lk	Calcic Luvisol
Lkc	Chromo-Calcic Luvisol
Lkcr	Rhodo-Chromo-Calcic Luvisol
Lkv	Verti-Calcic Luvisol
Lo	Orthic Luvisol
Lop	Plano-Orthic Luvisol
Lp	Plinthic Luvisol
Ls	Spodic Luvisol
Lv	Vertic Luvisol
Lvc	Chromo-Vertic Luvisol
Lvcr	Rhodo-Chromo-Vertic Luvisol
Lvk	Calci-Vertic Luvisol
M	Greyzem
Mo	Orthic Greyzem
O	Histosol
Od	Dystric Histosol
Odp	Placi-Dystric Histosol
Oe	Eutric Histosol
Ox	Gelic Histosol
P	Podzol
Pf	Ferric Podzol
Pg	Gleyic Podzol
Pgh	Histo-Gleyic Podzol
Pgs	Stagno-Gleyic Podzol
Ph	Humic Podzol
Phf	Ferro-Humic Podzol
Pl	Leptic Podzol
Plh	Humo-Leptic Podzol
Po	Orthic Podzol
Pof	Ferro-Orthic Podzol
Poh	Humo-Orthic Podzol
Pol	Lepto-Orthic Podzol
Pp	Placic Podzol
Pph	Humo-Placic Podzol
Q	Arenosol
Qa	Albic Arenosol
Qc	Cambic Arenosol
Qcc	Calcaro-Cambic Arenosol
Qcd	Dystri-Cambic Arenosol
Qcg	Gleyo-Cambic Arenosol
Qcs	Spodo-Cambic Arenosol
Ql	Luvic Arenosol
Qld	Dystri-Luvic Arenosol
Qlg	Gleyo-Luvic Arenosol
R	Regosol
Rc	Calcaric Regosol
Rd	Dystric Regosol
Re	Eutric Regosol
S	Solonetz
Sg	Gleyic Solonetz
Sm	Mollic Solonetz
So	Orthic Solonetz
Sof	Fluvi-Orthic Solonetz
T	Andosol
Th	Humic Andosol
Tm	Mollic Andosol
To	Ochric Andosol
Tv	Vitric Andosol
U	Ranker
Ud	Dystric Ranker
Ul	Luvic Ranker
V	Vertisol
Vc	Chromic Vertisol
Vcc	Calcaro-Chromic Vertisol
Vg	Gleyic Vertisol
Vp	Pellic Vertisol
Vpc	Calcaro-Pellic Vertisol
Vpg	Gleyo-Pellic Vertisol
Vpn	Sodi-Pellic Vertisol
W	Planosol
Wd	Dystric Planosol
Wdv	Verti-Dystric Planosol
We	Eutric Planosol
Wev	Verti-Eutric Planosol
Wm	Mollic Planosol
X	Xerosol
Xk	Calcic Xerosol
Xl	Luvic Xerosol
Xy	Gypsic Xerosol
Z	Solonchak
Zg	Gleyic Solonchak
Zgf	Fluvi-Gleyic Solonchak
Zo	Orthic Solonchak
Zt	Takyric Solonchak
g	Glacier
p	Plaggensol
r	Rock Outcrop
Gtz	Undefined code
Rds	Undefined code
Vgs	Undefined code

Horizon Nomenclature

Horizon nomenclature follows that defined by FAO (1990).

Master horizons

The upper case (Capital) letters H, O, A, B, C and represent master horizons (soil layers). These capital letters are the base symbols to which other characters are added to complete the designation. Most horizons and layers are given a single capital letter but some require two.

Horizon designation	**Description**
H	Layers dominated by organic material, formed from accumulations of undecomposed or partially decomposed organic material at the surface.
O	Layers dominated by organic material, consisting of undecomposed or partially decomposed litter, such as leaves, needles, twigs, moss and lichens, which has accumulated on the surface.
A	Mineral horizons which formed at the surface or below an O horizon in which all or much of the original rock structure has been obliterated.
E	Mineral horixzons in which the main feature is loss of silicate clay, iron, aluminium, or some combination of these, leaving a concentration of sand and silt particles, and in which all or much of the rock structure has been obliterated.
B	Horizons that formed under an A, E, O or H horizon and in which the dominant features are the obliteration of all or much of the original rock structure.
C	Horizons or layers, excluding hard bedrock, that are little or affected by pedological processes and lack properties of H, O, A, E or B horizons
R	Hard bedrock underlying the soil.
AB, EB etc	Transitional horizons with properties of two horizons superimposed or the two properties separate.

Subordinate characteristics within master horizons

Symbol	Description	Properties
b	Buried genetic horizon	Identifiable material formed before burial
c	Concretions or nodules	Significant accumulations
f	Frozen soil	Contain permanent ice or permanently colder than 0 degC
g	Strong gleying	Distinct pattern of mottling occurs; (g) weak gleying
h	Accumulation of organic matter	
j	Jarosite mottles	
k	Accumulation of carbonates	Commonly calcium carbonate
m	Cementation or induration	Continuous (or nearly so) cementation
n	Accumulation of sodium	Exchangeable Na
o	Residual accumulation of sesquioxides	
p	Ploughing or other disturbance	e.g tillage practices
q	Accumulation of silica (secondary)	
r	Strong reduction	Indicating reduction of iron
s	Illuvial accumulation of sesquioxides	Including dispersible organic matter – sesquioxide complexes
t	Accumulation of silicate clay	Formed in situ or moved to it by illuviation
v	Occurrence of Plinthite	Iron-rich humus-poor material
w	Development of colour or structure	
x	Fragipan characteristics	Genetically developed firmness, brittleness or high bulk density
y	Accumulation of gypsum	
z	Accumulation of salts more soluble than gypsum	

The following changes were made to horizon nomenclature supplied by National experts:
Bsh → Bhs, Ah/Cw → A/C, CwBw → BCw, BW → Bw, Bpodz → Bs, Thin Ironpan → Bfe.

Country

COUNTRY	Country code: identifier of country.
(Present in:	*COUNTRY; SPADE2V11)*
	Background polygon
-8	Ocean polygons
AL	ALBANIA
AL	ALBANIA
AG	ALGERIA
AU	AUSTRIA
BO	BELARUS
BE	BELGIUM
BK	BOSNIA HERZEGOVINA
BU	BULGARIA
HR	CROATIA
EZ	CZECH REPUBLIC
DA	DENMARK
EN	ESTONIA
FO	FAEROE ISLANDS
FI	FINLAND
FR	FRANCE
MK	F.Y.R.O.M. (Former Yugoslav Republic of Macedonia)
GM	GERMANY
GR	GREECE
GK	GUERNSEY
HU	HUNGARY
IC	ICELAND
EI	IRISH REPUBLIC
IM	ISLE OF MAN
IT	ITALY
JE	JERSEY
LG	LATVIA
LH	LITHUANIA
LU	LUXEMBOURG
MT	MALTA
MD	MOLDOVA
MW	MONTENEGRO
MO	MOROCCO
NL	NETHERLANDS
NO	NORWAY
PL	POLAND
PO	PORTUGAL
RO	ROMANIA
RU	RUSSIA
SR	SERBIA
LO	SLOVAKIA
SI	SLOVENIA
SP	SPAIN
SW	SWEDEN
SZ	SWITZERLAND
TS	TUNISIA
TU	TURKEY
UI	UKRAINE
UK	UNITED KINGDOM

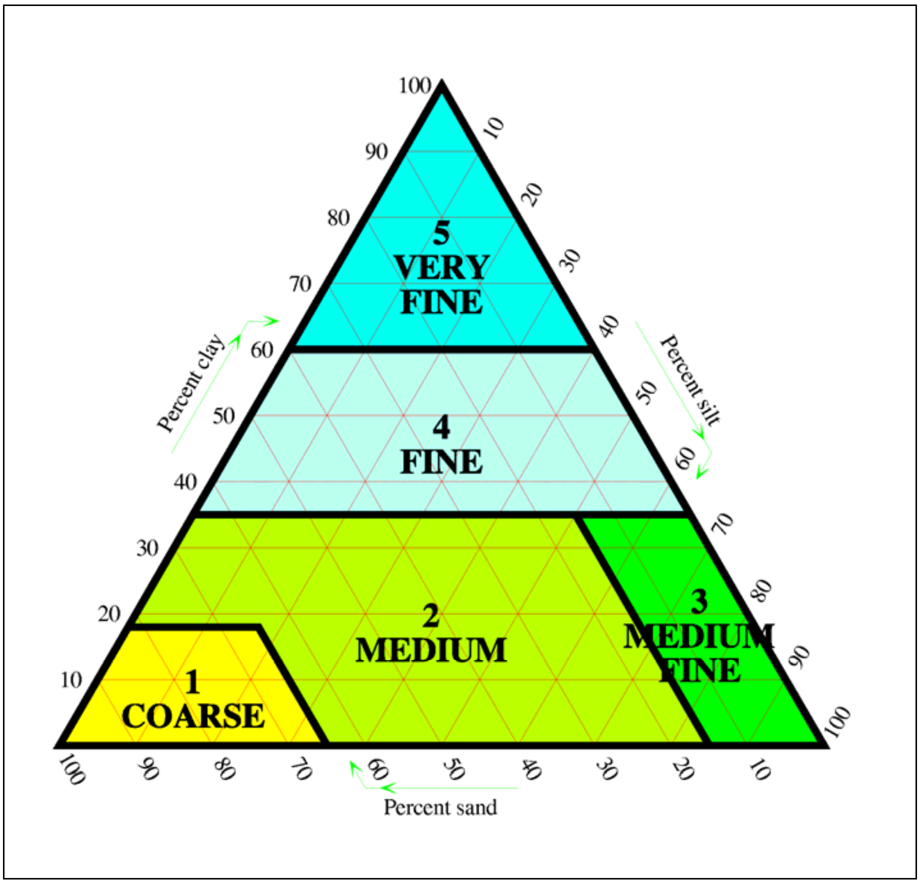
Land Use

USE	Land use associated with profile data
(Present in:	*STU; spade2v11.dbf)*
0	No information
1	Pasture, grassland, grazing land
2	Poplars
3	Arable land, cereals
4	Wasteland, shrub
5	Forest, coppice
6	Horticulture
7	Vineyards
8	Garrigue
9	Bush, macchia
10	Moor
11	Halophile grassland
12	Arboriculture, orchard
13	Industrial crops
14	Rice
15	Cotton
16	Vegetables
17	Olive-trees
18	Recreation
19	Extensive pasture, grazing, rough pasture
20	Dehesa (extensive agricultural-pasture system in forest parks in Spain)
21	Cultivos enarenados (artificial soils for orchards in SE Spain)
22	Wildlife, above timberline

In the STU table dominant and secondary land use is identified by USE1 and USE2, respectively

Texture class: Surface soil

TEXT1 **TEXT2**	Dominant surface textural class. Secondary surface textural class.
(Present in:	*STU;spade2.dbf)*
0	No information
9	No texture (organic soils such as histosols)
1	Coarse (clay < 18 % and sand > 65 %)
2	Medium (18% < clay < 35% and sand > 15%, or clay < 18% and 15% < sand < 65%)
3	Medium fine (clay < 35 % and sand < 15 %)
4	Fine (35 % < clay < 60 %)
5	Very fine (clay > 60 %)



Particle-size classes of FAO

Water Management

WM1	Normal presence of a water management system in agricultural land (on > 50% STU).
(Present in:	*STU; SPADE2v11)*
0	No information
1	Yes, agricultural land normally has a water management system
2	No, agricultural land normally has no water management system

Water Management: Purpose

WM2	Purpose of the water management system.
(Present in:	*STU;SPADE2v11)*
0	No information
1	To alleviate waterlogging (drainage)
2	To alleviate drought stress (irrigation)
3	To alleviate salinity (drainage)
4	To alleviate both waterlogging and drought stress
5	To alleviate both waterlogging and salinity

Water Management: Type

WM3	Evident type of water management system.
(Present in:	*STU; SPADE2V11)*
0	No information

1	Pumping
2	Ditches
3	Pipe underdrainage (network of drain pipes)
4	Mole drainage
5	Deep loosening (subsoiling)
6	'Bed' system (ridge-furrow or steching)
7	Flood irrigation (system of irrigation by controlled flooding as for rice)
8	Overhead sprinkler (system of irrigation by sprinkling)
9	Trickle irrigation

Water Regime

WR	Dominant annual average soil water regime class of the soil profile.
(Present in:	*STU; SPADE2v11)*
0	No information
1	Not wet* within 80 cm for over 3 months, nor wet within 40 cm for over 1 month
2	Wet within 80 cm for 3 to 6 months, but not wet within 40 cm for over 1 month
3	Wet within 80 cm for over 6 months, but not wet within 40 cm for over 11 months
4	Wet within 40 cm depth for over 11 months

* Wet = waterlogged; defined as: a matric suction of < 10 cm, or a matric potential of > -1 kPa.

Abstract

This report describes the development of the Soil Profile Analytical Database for Europe (SPADE-2), Version 2.0. It is an update of the SPADE-2 Version 1.0 report (EUR 22127 EN, 2006) that describes the compilation of soil profile data for nine EU Member States. Both versions of the SPADE 2.0 Database have been funded by the European Crop Protection Association (ECPA) and this latest version (2.0) contains data for a further eight EU Member States & Switzerland. The report describes the background to the development of SPADE-2, the method of its derivation and the harmonisation procedures adopted. Some guidance on use of SPADE-2 in association with the 1:1,000,000 scale Soil Geographical Database of Europe is also provided. The report will be published at the end of 2009 by the Office for the Official Publications of the European Communities, Luxembourg. A third phase of data collection is anticipated to follow, which will aim to provide soil profile data for the whole of the enlarged European Union in the not too distant future.