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Soil Vulnerability to Diffuse Pollution in Central and Eastern Europe (SOVEUR Project)

(Version 1.0)

N.H. Batjes

Food and Agriculture Organization of the United Nations

International Soil Reference and Information Centre

Enquiries:
c/o Director,AGL
FAO
Viale delle Terme di Caracalla
00100 Rome, Italy
Fax: +39 06 570 56275
E-mail:land-and-water@fao.org

and

c/o Director, ISRIC
P.O. Box 353
6700 AJ Wageningen
The Netherlands
Telefax: +31-(0)317-471700
E-mail: soil@isric.nl

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

ABSTRACT

This study was carried out in the framework of the project GCP/RER/007/NET on Mapping of Soil and Terrain Vulnerability in Central and Eastern Europe (SOVEUR). It presents a procedure for assessing the relative vulnerability of soils to diffuse pollution, using the 'vulnerability to heavy metal mobilization, inducible by acid deposition' as an example. The resulting maps should be seen as first approximations, as no field-validation was possible within the framework of the SOVEUR project. Additional maps of soil vulnerability can easily be generated, using the available 'parametric overviews of derived soil properties', in combination with specialist knowledge of contaminant behaviour. In a GIS, the vulnerability maps can be overlaid onto a map of current or anticipated (accumulated) loadings to show where so-called Chemical Time Bombs are prone to occur. Exploratory analyses of soil vulnerability at the (sub)continental level, as adopted for the 1:2,500,000 scale SOVEUR project, can provide the basis for identifying areas considered at risk from diffuse pollution once auxiliary databases on heavy metal loadings and acid deposition become freely accessible. More detailed scales are required to determine Chemical Time Bombs associated with point-source pollution, such as mine spoilings and waste dumps.

ACKNOWLEDGEMENTS

Project GCP/RER/007/NET on Mapping of Soil and Terrain Vulnerability in Central and Eastern Europe, SOVEUR, was signed between the Food and Agriculture Organization of the United Nations (FAO) and the Government of the Netherlands, within the framework of the FAO/Netherlands Government Programme. In view of the specific nature of the services to be rendered, the Project activities were implemented under a Contractual Service Agreement with the International Soil Reference and Information Centre (ISRIC). It was carried out in close collaboration with specialists from soil survey institutes in Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, the Russia Federation (West of the Urals), Slovak Republic and the Ukraine, who collated the various national data sets using uniform guidelines.

1 INTRODUCTION

The Project GCP/RER/007/NETon Mapping of Soil and Terrain Vulnerability in Central and Eastern Europe, with the acronym SOVEUR, calls for the development of a geo-referenced information system for 13 countries in Central and Eastern Europe. The project elaborated procedures for a geo-referenced assessment of the status of human-induced land degradation, with particular attention to issues of soil pollution, and an assessment of the vulnerability of soils to delayed-pollution (Batjes, 2000a). The resulting databases were produced at an observational scale of 1:2.5 million. The SOVEUR project was carried out in close collaboration with soil survey institutes in Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, the Russian Federation (West of the Urals), Slovak Republic and the Ukraine.

The current report presents a procedure for assessing the relative vulnerability of soils to diffuse pollution. It elaborates upon the methodological framework presented by Batjes (1997). In accordance with the recommendations of the SOVEUR implementation workshop this study focusses on a procedure for rating the 'vulnerability of soils to heavy metal pollution, inducible by acid deposition', with special reference cadmium as an example (see Batjes and Bridges, 1997).

2 METHODOLOGICAL FRAMEWORK

2.1 Soil vulnerability to pollution

Soil vulnerability is the 'capability for the soil system to be harmed in one or more of its ecological functions' (Batjes and Bridges, 1991; Batjes and Bridges, 1993). These functions include: (a) biomass production, (b) filtering, buffering, storage and transformation functions, and (c) biological habitat and gene reserve. Regional differences in static and dynamic soil properties will control a soil's capacity to control movement of pollutants, and hence its vulnerability. Important processes (triggers) that can influence a soil's capacity to hold and release various contaminants and pollutants include: acid precipitation, eutrophication, salinisation, water erosion, as well as changes in climate, hydrological conditions and land use (see Hesterberg *et al.*, 1992).

Soils are chemically and biologically complex media comprising (un)weathered and newly formed mineral fragments, organic matter in various stages of decomposition, micro-organisms, and solutes and gases in its pores. Depending on its inherent 'capacity controlling properties', such as content of clay, organic matter and calcium carbonate and its cation exchange capacity, each soil will react in different ways to pollution and environmental changes. The type of pollutant and research purpose will determine which soil attributes or single value maps are of importance in each special case (Table 1).

Table 1. Conceptual framework for assessment of soil propensity to contaminant accumulation.

Soil Component	Soil properties					Relative propensity to contaminant accumulation			
	pH	OC (%)	$CaCO_3$ (%)	texture	etc...	Pb	Cd	Hg	etc.
ZZ001/1/1 - Orthic Luvisol	7.5	3.3	2.2	SCL		H	H	H	-
ZZ001/1/2 - Orthic Gleysol	6.5	3.0	0.2	CL		M	L	M	-
.... -	-	-	-	-		-	-	-	-

Note: Each SOTER unit comprises several Soil Components (see Van Engelen and Wen, 1995). Each of these components is characterized by its dominant soil unit (FAO, 1988), for which a range of derived soil characteristics have been generated (Batjes, 2000b). Classes of relative propensity for element-accumulation range from 'lowest' (L) to 'highest' (H); ratings shown are hypothetical (see App. 1 and 2).

2.2 Vulnerable soils and areas at risk

The assessment of soil vulnerability forms the first stage in identifying areas considered at risk from ‘delayed and then sudden’ occurrences of pollution, the so-called Chemical Time Bombs (CTB). This concept stresses (Stigliani, 1988):

(1) the (changing) capacity of the soil reservoir to hold or release contaminants, and
(2) a trigger system.

In the CTB-sense, the most vulnerable soils are those with high but finite capacities for storage of potentially harmful and mobilizable chemicals. The chemicals of concern with respect to CTB-occurrences are the long-lived species most resistant to chemical decomposition, especially heavy metals and persistent organic chemicals.

The severity, nature and timing of impacts resulting from CTBs will vary with (Batjes and Bridges, 1993):

(1) the degree of *loading* of the soil with a particular chemical;
(2) the capacity or *propensity* of the soil to retain this chemical;
(3) the type (and intensity) of the environmental and socio-economic *triggers*;

(4) the *sensitivity* of individual soils to the respective triggers; and,
(5) the *targets* affected by the released pollutants.

The combined interpretation of items (2), (3) and (4) will permit mapping of the relative vulnerability of a soil to a pre-defined pollution scenario (Fig. 1).

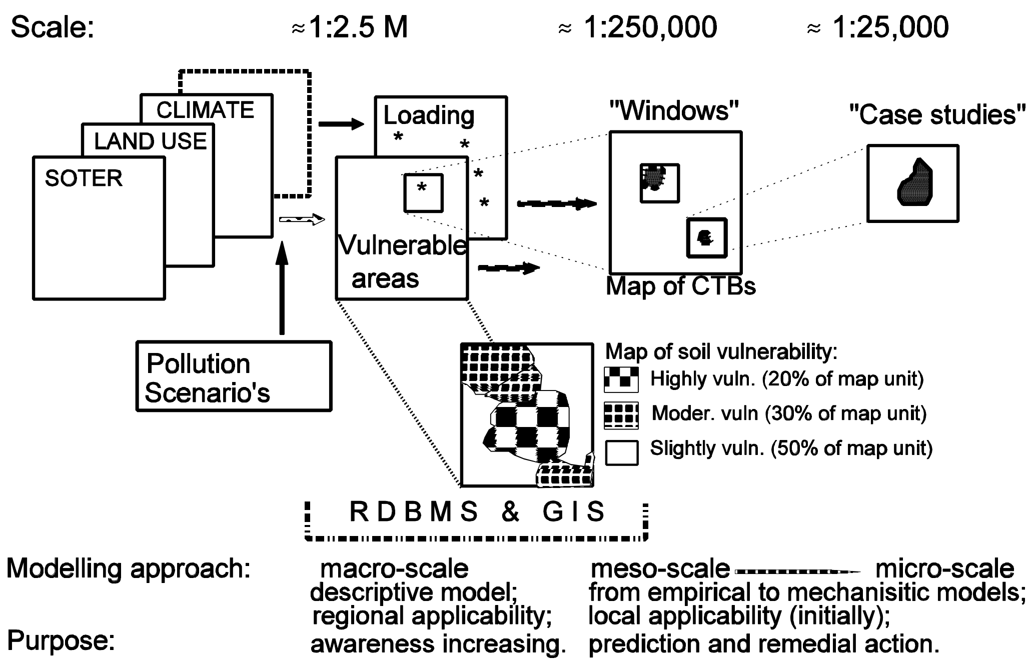

Fig. 1. Schematic GIS procedure for mapping vulnerable soils and areas prone to 'Chemical Time Bombs' (Batjes, 1999a)

In a Geographic Information System (GIS), the data layer for 'soil vulnerability with respect to a specified problem' can be overlaid onto a map of current or anticipated (accumulated) loadings to show where CTBs are prone to occur. Depending on the sources and types of pollution, different scales of mapping and modelling approaches will be needed (Hoosbeek and Bryant, 1992; Loague and Corwin, 1996). Exploratory analyses at the (sub)continental level, based on expert judgement, can provide the basis for identifying areas considered at risk from diffuse pollution. More detailed studies and models are required to determine CTBs associated with point-source pollution, such as mine spoilings and waste dumps (Fig. 1; Section 2.7).

In the context of this paper, the overall procedure for mapping the 'vulnerability of soils to heavy metal mobilization, inducible by acid deposition' will be described. The general assumption when rating the relative vulnerability is that '*pollutant loads and trigger intensities* *are distributed evenly over the region*'. Data on current or future loads will have to be considered when determining areas considered at risk from pollutant remobilisation in a toxic form (Fig. 1).

2.3 Identification of Capacity Controlling Properties

Each soil may be viewed as a chromatographic column, or system of geochemical barriers, with respect to contaminant behaviour (Glazovskaya, 1991). Important in this respect are (Blum, 1990):

(1) the general mechanical filtering capacity of the soils;
(2) the physico-chemical buffering potential;
(3) the resistance of the soil to acidification and alkalinization;
(4) the resistance to mobilization or pesticide buffer potential for the considered contaminant.

The most important Capacity Controlling Properties (CCP) affecting heavy metal binding are soil depth, texture, content and type of organic matter, soil pH-redox conditions, the content of oxides of Fe, Al and Mn (Hesterberg *et al*., 1992). The type of metal is also important in this respect (Blume and Brummer, 1991; Kabata-Pendias and Pendias, 1992). Adsorption of Persistent Organic Pollutants (POP) to soils is determined largely by the type of the pollutant and the organic matter content, texture, and pH of the soil to which they are added (Blume and Brümmer, 1987; Stolpe *et al*., 1998).

2.4 Relative binding capacity of soils for heavy metals

2.4.1 *Depth-weighted ratings by soil unit*

Criteria for rating the CCP are derived from a paper by Blume and Brummer (1991). The rating scheme takes into account that the relative binding strength of a soil with respect to heavy metals will vary with the organic matter, clay content, and clay mineralogy (including the amount of sesquioxides), drainage conditions and content of sulphides. The scheme can be used to rate the binding strength and retention against uptake by plants and groundwater pollution, for 11 metal ions: Cd, Mn, Ni, Co, Zn, Cu, Cr(III), Pb, Hg, Fe(III), and Al. In this report the procedure is illustrated using Cd, Zn and Pb as examples. The relative *binding* effects of soil pH, organic matter content, texture (clay content), Fe-oxide content, soil drainage, and sulphides are considered in sequence.

Table 2 contains data on the binding strength of metal ions in soils, considering interactions with humic substances, sesquioxides, and clay minerals. It further shows the effects of pH and redox conditions under controlled laboratory experimental conditions (Blume and Brummer, 1991). Using these broad relationships, the degree of metal immobilization can be determined for each soil unit that occurs in the SOVEUR area. Median values for the capacity controlling properties, by soil unit, were computed using the profiles held in the SOTER database (Batjes, 2000b). Appendix 1 lists the values for these CCPs.

Table 2. Relative binding strength of metals at normal concentrations in well-aerated soils of weak acidity, and pH and redox range of strong metal binding.

Metal	Binding strength			Strong binding	
	Organic matter	Clay	Sesquioxides	> pH	Eh (pH 7, mV)
Cd	4†	2	3	6.0‡	0 to -200
Zn	2	3	3	5.5	0 to -200
Pb	5	4	5	4	0 to -200

† Rating for binding strength: 1 very weak; 2: weak; 3 medium; 4 strong; 5 very strong

‡ Relevant below threshold pH; at higher pH there is strong immobilization by Fe, Al, and Mn oxides, and other compounds by specific adsorption. Source: Blume and Brummer (1991)

The basic rating of the metal-binding capacity, in Table 3, is for ‘sandy soils (< 10% clay) with a low humus content (< 2%)’. It shows that at a neutral pH and higher, all metal ions are strongly bound. Table 3 further shows that Cd is bound with medium strength at a pH_{CaCl2} of about 5, while in the case of Pb this is so at a pH of 3.5.

The rating scheme in Table 3 uses pH_{CaCl2} values, which not considered in the SOTER database. Therefore, pH_{CaCl2} was correlated with pH_{H2O} values held in the WISE database (Batjes, 1995):

$$pH_{CaCl2} = -0.59262 + 1.01157 \times pH_{H2O} \qquad (r^2 = 0.93;\ n = 221)$$

Table 3. Influence of soil acidity on metal binding for sandy soils low in organic matter (< 2%).

Metal	pH (0.01 *M* $CaCl_2$)									
	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
Cd	0	0.5	1.0	1.5	2.0	2.5	3.5	4.0	4.5	5.0
Zn	0	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0
Pb	1.0	2.0	3.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0

Binding strength: 1 very weak; 2: weak; 3 medium; 4 strong; 5 very strong. Source: Blume and Brummer (1991)

The effects of higher contents of organic matter and clay content on the overall binding capacity of a soil for a particular metal ion can be derived from Table 4. This rating scheme reflects the varying importance of organic matter and clay content on metal binding, as shown in Table 2. Rating schemes are also available for the presence of Fe oxides, overall drainage conditions, and the content of sulphide as reflected by the FAO legend code.

Normal amounts of sesquioxides are already taken into account in the estimation of the clay content since, as a rule, the content of sesquioxides is closely correlated with the amount of clay-size minerals. The rating for ‘high’ amounts of iron-oxides, by soil unit, is based on expert-judgement. In the case of ferric Podzols the rating for binding strength was increased by '1'.

In soils with a water surplus (or oxygen deficiency) and strongly reducing conditions, as occurring for example in thionic soil units, the elements Cd, Ni, Zn, Cu, Pb, and Fe are strongly bound and immobilized as sulphides (rating for binding strength = +5).

In (mottled) soils with alternating wetting and drying cycles, as reflected for instance by gleyic and stagnic properties, Fe and Mn ions are highly mobile. Where these conditions occur, a metal ‘mobilization’ factor is applied. This factor is tentatively set at '-1.5' in case of Gleysols, and at '-2.0' for soil units showing gleyic or stagnic properties.

Table 4. Additions to the ratings of Table 3 for metal binding associated with differences in organic matter content and texture.

Organic matter (%)	Relative binding strength according to Table 2				
	2	3	3.5	4	5
0-2	0	0	0	0	0
2-8	0	0.5	0.5	0.5	1
8-15	0.5	0.5	1	1	1.5
> 15	0.5	1	1	1.5	2
Soil texture					
S, LS, SL[a]	0	0	0	0	0
SiL[a], SCL, L	0	0	0.5	0.5	0.5
SL[b], SiL[b], SC, CL	0.5	0.5	0.5	0.5	1
SiC, SiCL	0.5	0.5	1	1	1.5
C	0.5	1	1	1.5	2

Textural classes: S= sand; LS= loamy sand; SL= sandy loam; SiL= silty loam; Si= silt; L= loam; SCL= sandy clay loam; CL= clay loam; SiCL= silty clay loam; SC= sandy clay; SiC= silty clay; C= clay. Sand(y): [a] < 10% S; [b] > 10% S. Source: Blume and Brummer (1991)

The final rating for the binding capacity for the metal under consideration, for each soil unit in a given SOTER unit, is obtained from:

$$fin_i = b\_ph + b\_orgc + b\_text + b\_feox + b\_sulf + m\_drain$$

where:

i is the depth range under consideration: *top*soil (0 - 0.3 m) and *sub*soil (0.3 - 1 m).

b_X is the relative binding capacity due to capacity controlling property X.

m_drain is a metal-mobilization factor associated with strongly alternating wetting/ drying conditions.

The depth-weighted rating for the binding capacity (mbc_i), for the soil unit (i) and metal under consideration, is obtained as follows:

$$mbc_i = (2 \times fin_{top,i} + 1 \times fin_{sub,i}) / 3$$

The ratings for mbc_i are converted into five relative binding strength classes using Table 5. Inherently, this rating system will be approximative at the considered level of abstraction and validation is difficult without actual field assays.

Table 5. Conversion to relative binding strength classes for heavy metals by soil unit.

Code	Ratings	Relative binding capacity
VL	$mbc_i \leq 1$	Very low
L	$1 < mbc_i \leq 2$	Low
M	$2 < mbc_i \leq 3$	Moderate
H	$3 < mbc_i \leq 4$	High
VH	$4 < mbc_i$	Very high

Class ‘VL’ corresponds with the lowest binding capacity for the heavy metal under consideration. This means that ‘leakage’ of this pollutant to the groundwater or metal uptake by plants is possible, in areas where high loads occur. Such areas would correspond with the polluted areas to be shown on the degradation status map (see Van Lynden, 1997). Such areas can only be determined from laboratory analysis or modelling (Bartnicki and Olendrzynski, 1996; Prieler *et al.*, 1996). Class ‘VH’ would correspond with soils considered most at risk from chemical time bombs, *if* high loads of the (metal) pollutant and intensities of the trigger system *would* occur simultaneously (Fig. 1).

2.4.2 *Area-weighted ratings by SOTER unit*

Each map or SOTER unit considered on the soil and terrain database for the SOVEUR area consists of an assemblage of different soil units of which the relative extents are known (see Van Engelen and Wen, 1995). Many approaches can be used to arrive at a ‘final’ rating, for each SOTER unit, from the ratings for the relative vulnerability of its component soil units. For example, the final rating may be based on the relative extent of soil units in each SOTER unit that have a ‘VH’ rating for the metal-binding capacity. Alternatively, some end-users may be more interested in identifying the stable lands or so-called ‘cold spots’ only, in which case attention should be paid to the relative extent of soil units with a class ‘VL’ rating in each SOTER unit. Alternatively, a map may be produced that presents an area-weighted value (indicator) by SOTER unit, that takes into account the full SOTER unit composition. The latter approach will be elaborated below, as the first two would encompass straight forward interpretations of the relevant databases (see Appendix 1 and 2).

The area-weighted rating for the relative binding capacity (B) for a given heavy metal is calculated by SOTER unit with the following rule:

$$B_{SU} = 1.0 \times A_{VH} + 1/2 \times A_V + 1/4 \times A_M$$

where:

B_{SU} the area-weighted rating for the relative metal-binding capacity for the SOTER unit (*SU)* under consideration,

A_i the relative area of soil units with a class 'VH','H', or 'M' rating for metal-binding capacity.

The selection of class limits for rating the areal extent of B_{SU} will always be subjective. A fairly wide range of options was tested, including the class-limits used for the GLASOD study (Oldeman *et al*., 1991), but these were not satisfactory for our purpose. Ultimately, the "conservative" rating scheme in Table 6 was adopted; this scheme should be seen as a first approximation as there exists no possibility for field-validation. Examples of listings are presented in Appendix 2, while Figure 2 shows the area-weighted, relative Cd binding capacity of soils in Central and Eastern Europe .

Table 6. Area-weighted rating for the relative metal binding capacity by SOTER unit.

Class	Range for B_{SU}	Relative metal binding capacity	
V5	$96 < B_{SU} \leq 100$	Highest	(e.g., 100% VH)
V4	$72 < B_{SU} \leq 96$	..	
V3	$48 < B_{SU} \leq 72$	..	(e.g., 100% H)
V2	$24 < B_{SU} \leq 48$	..	(e.g., 100% M)
V1	$0 < B_{SU} \leq 24$	..	
V0	$0 = B_{SU}$	Lowest	(e.g., 100% VL or L)

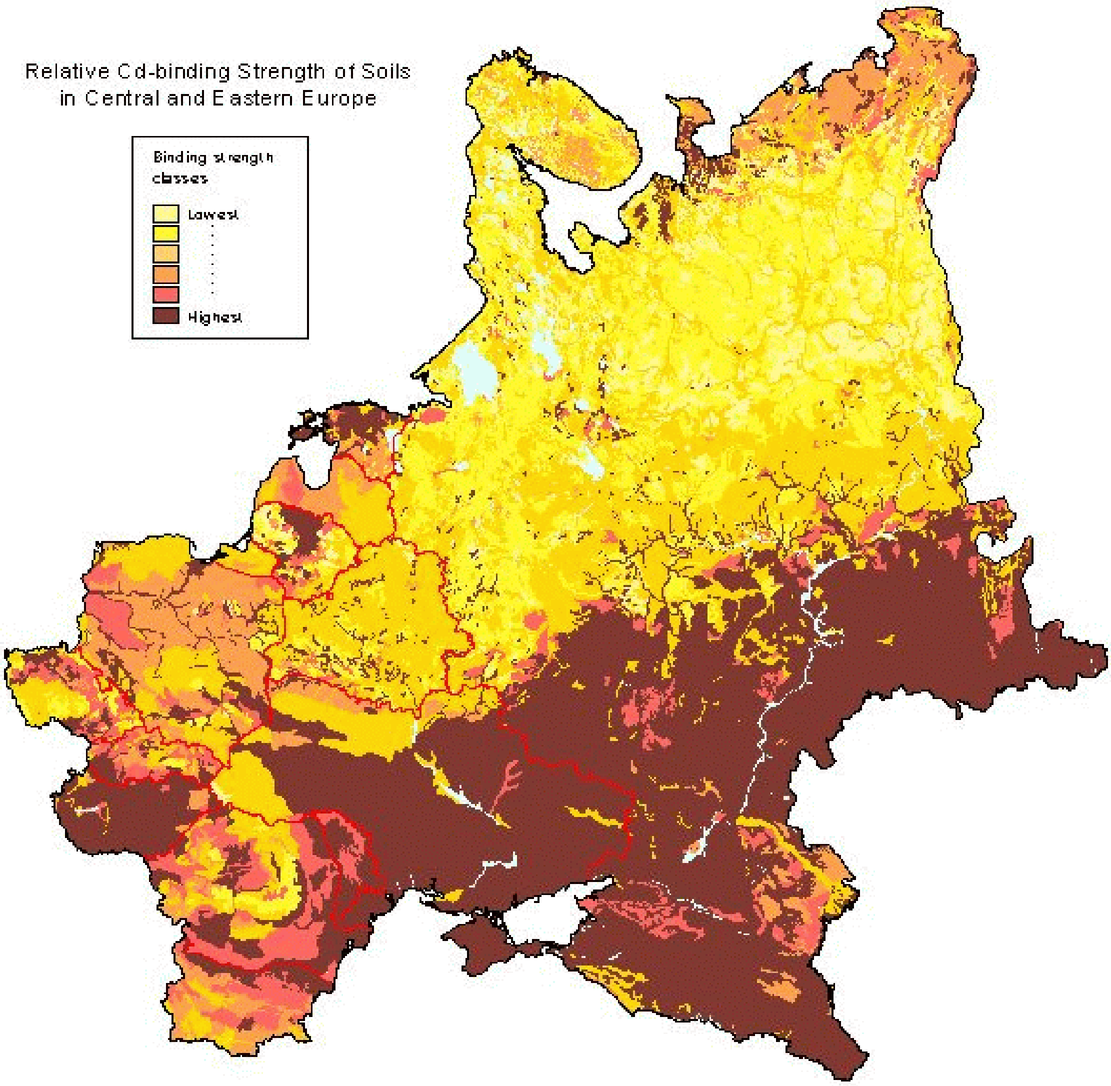

Fig. 2. Area-weighted relative Cd binding capacity of Central and Eastern European soils.

2.5 Relative sensitivity of soils to acid deposition

2.5.1 *Depth-weighted ratings by soil unit*

Each soil unit can be assigned a rating for its relative 'sensitivity to acid deposition' using the median base saturation and CEC (Table 7). If the case of Histosols, the rating obtained with Table 7 is down-graded by 3 classes to account for the lower inherent acid-buffering capacity of organic *vis à vis* mineral soils.

Table 7. Allocation of soil units to five relative 'sensitivity to acid deposition' classes according to median base saturation and cation exchange capacity.

CEC ($cmol_c\ kg^{-1}$)	Base saturation (%)				
	0-20	20-40	40-60	60-80	80-100
<10	VH	VH	H	M	L
10 -25	VH	H	M	L	VL
> 25	H	M	L	VL	VL

Note: Sensitivity classes: VH (5) = Very high; H (4) = High; M (3) = Moderate; L (2) = Low; VL (1)= Very low. Rating system after Cindery *et al.* (1998).

The depth-weighted rating for the sensitivity to acid deposition ($acid_i$), for the soil unit (i) under consideration, is obtained as follows:

$$fin_{acid,i} = (2\times fin_{top,i} + \times fin_{sub,i}) / 3$$

where:

$fin_{top,i}$ is the (numerical) sensitivity rating for the topsoil for soil unit i.

$fin_{sub,i}$ is the sensitivity rating for the subsoil for soil unit i.

2.5.2 *Area-weighted ratings by SOTER unit*

The area-weighted rating for the relative sensitivity to acid deposition for a given heavy metal, by SOTER unit, is calculated using the following rule:

$$S_{SU} = 1.0\times A_{VH} + 1/2\times A_V + 1/4\times A_M$$

where:

S_{SU} is the area-weighted rating for the relative sensitivity to acid deposition for the SOTER unit *(SU)* under consideration,

A_i is the relative area of soil units with a class 'VH','H', or 'M' rating in the SOTER unit.

The values for S_{SU} are converted into classes using Table 8. Class limits for the areal extent are identical to those adopted for the metal binding capacity in Table 6. Results of the analysis for Central and Eastern Europe are shown in Figure 3 (see also App. 3).

Table 8. Area-weighted rating for the relative sensitivy to acid deposition by SOTER unit.

Class	Range for S_{SU}	Relative sensitivity to acid deposition
V5	$96 < S_{SU} \leq 100$	Highest
V4	$72 < S_{SU} \leq 96$	..
V3	$48 < S_{SU} \leq 72$	..
V2	$24 < S_{SU} \leq 48$	..
V1	$0 < S_{SU} \leq 24$	..
V0	$0 = S_{SU}$	Lowest

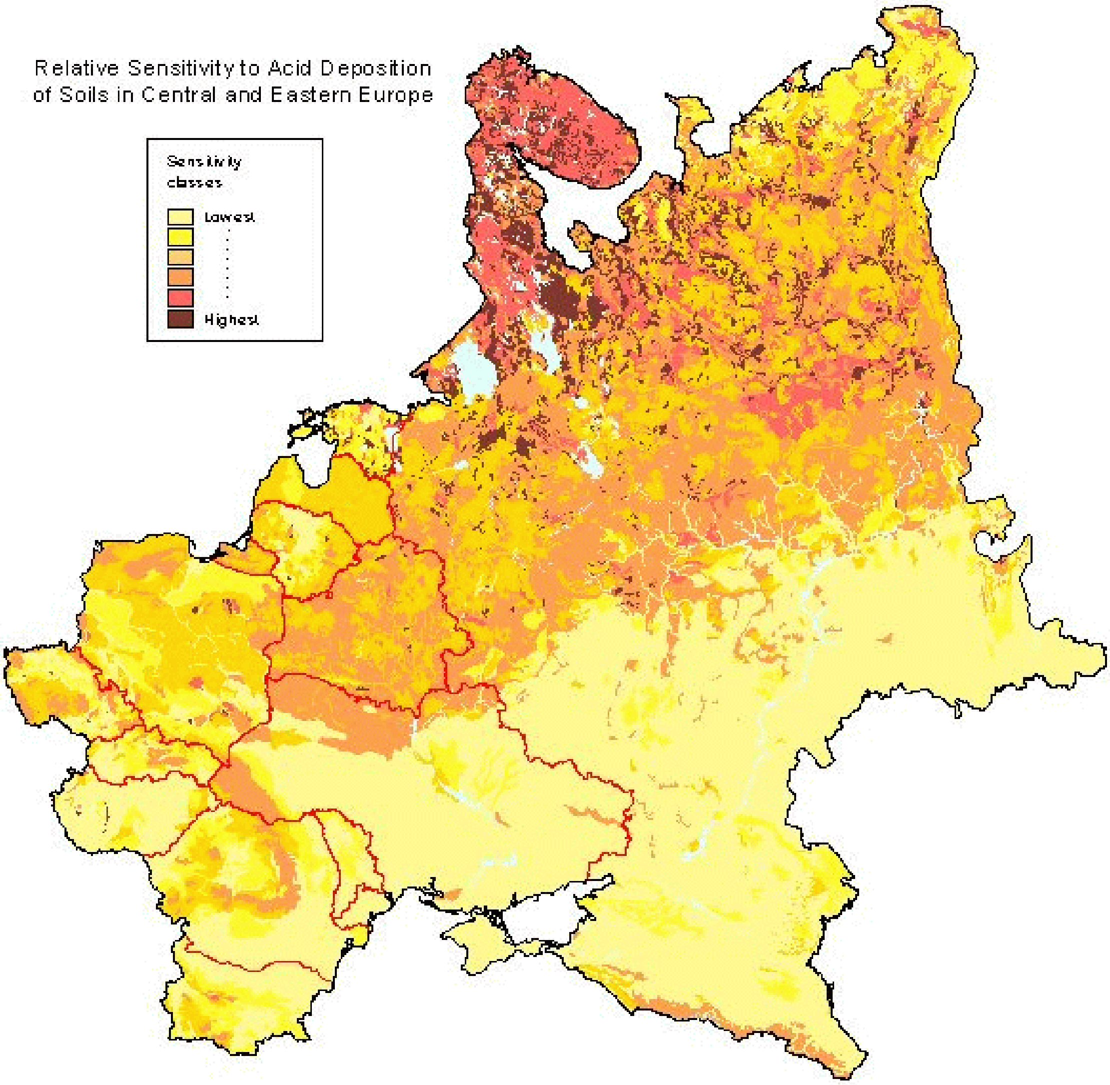

Fig. 3. Area-weighted relative sensitivity to acid deposition of Central and Eastern European soils.

2.6 Relative vulnerability of soils to heavy metal mobilization, inducible by acid deposition

2.6.1 *Depth-weighted ratings by soil unit*

The relative vulnerability of each soil unit to heavy metal mobilization, inducible by acid deposition, is determined from the depth-weighted ratings for ‘sensitivity to acid deposition’ (Table 8) and ‘binding capacity with respect to heavy metals‘ (Table 6) of its individual soil units. The least limiting value for either the ‘sensitivity to acid deposition’ or the relative ‘HM-binding capacity‘ will determine the final rating of a soil unit (Table 9).

Table 9. Rating of relative vulnerability to heavy metal mobilization, inducible by acid deposition, by soil unit

Depth-weighted binding capacity for heavy metals	Depth-weighted sensitivity to acid deposition				
	VL	L	M	H	VH
VL	VL	VL	VL	VL	VL
L	VL	L	L	L	L
M	VL	L	M	M	M
H	VL	L	M	H	H
VH	VL	L	M	H	VH

Note: VH (5) = Very high; H (4) = High; M (3) = Moderate; L (2) = Low; VL (1) = Very low relative vulnerability. See Table 6 for the rating system for ‘relative HM-binding capacity’ and Table 8 for the ‘relative sensitivity to acid deposition’.

2.6.2 *Area-weighted ratings by SOTER unit*

The area-weighted rating for the relative vulnerability of a soil to heavy metal mobilization, inducible by acid deposition, is obtained using the following rule:

$$V_{SU} = 1.0\times A_{VH} + 1/2\times A_H + 1/4\times A_M$$

where:

V_{SU} is the area-weighted rating for the relative vulnerability for the SOTER unit (*SU*) under consideration,

A_i is the relative area of soil units with a class ‘VH’,’H’, or ‘M’ rating with respect to relative vulnerability of a soil to heavy metal mobilization, inducible by acid deposition in the SOTER unit.

V_{SU} values are converted into classes using Table 10. Figure 4 presents the resulting map for Central and Eastern Europe (see also App. 4).

Similar to what is the case for Figure 2 and 3, Figure 4 should be seen as a first approximation as there was no possibility for 'ground-truthing' the findings in the framework of the desk-driven SOVEUR project.

Table 10. Area-weighted rating for the relative vulnerability to heavy metal mobilization, inducible by acid deposition, by SOTER unit.

Class	Range for V_{SU}	Relative sensitivity metal mobilization inducible by acid deposition
V5	$96 < V_{SU} \leq 100$	Highest
V4	$72 < V_{SU} \leq 96$	..
V3	$48 < V_{SU} \leq 72$	..
V2	$24 < V_{SU} \leq 48$	..
V1	$0 < V_{SU} \leq 24$	
V0	$0 = V_{SU}$	Lowest

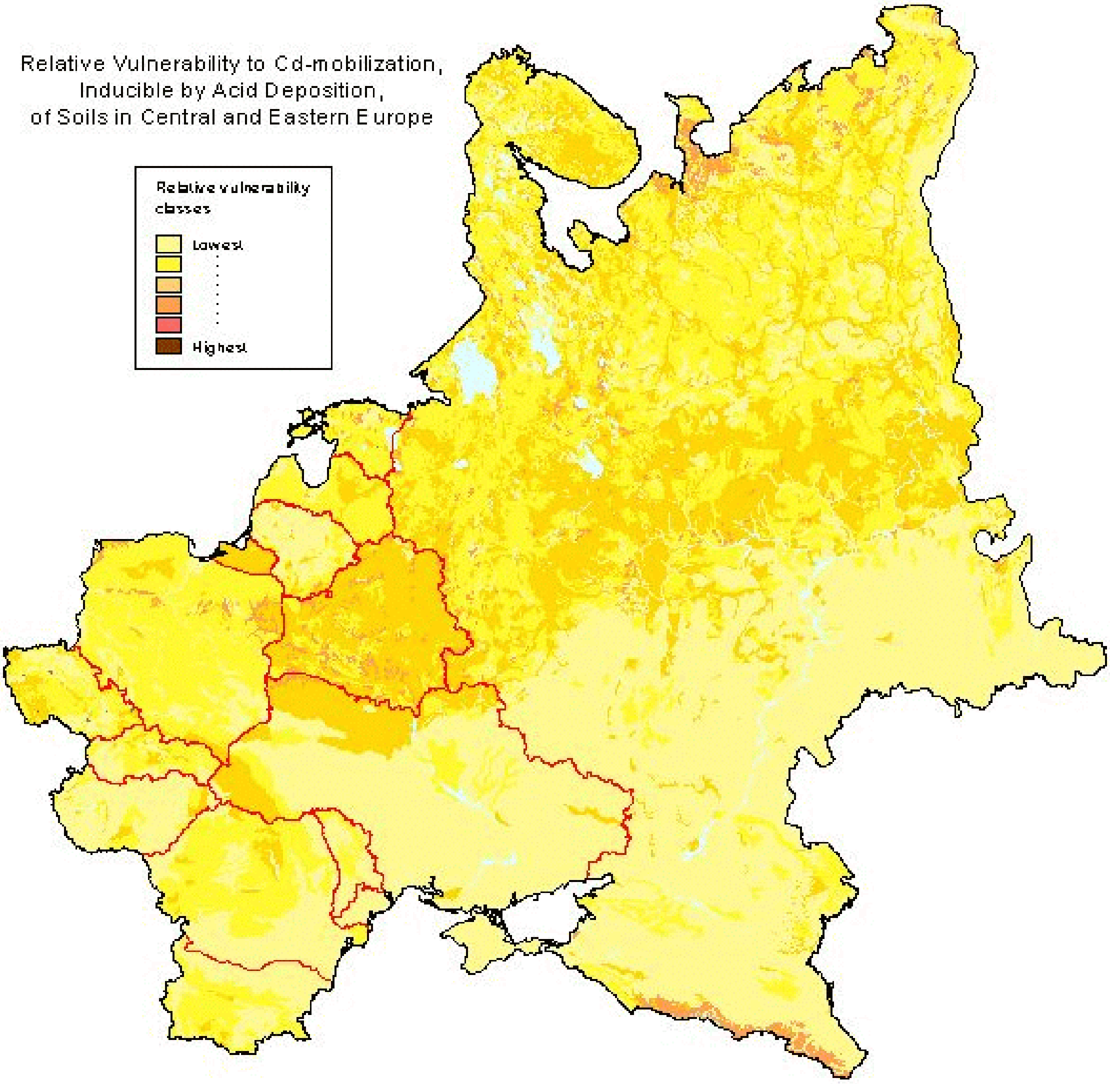

Fig. 4. Area-weighted relative vulnerability of soils to cadmium mobilization, inducible by acid deposition.

2.7 Areas considered at risk from heavy metal mobilization

In theory the information on the relative vulnerability to heavy metal mobilization, inducible by acid deposition, can now be analysed in conjunction with auxiliary layers of climate, land use, acid deposition and Cd loads to identify broad areas considered at risk from Cd remobilisation (see Fig. 1). In practice, however, the required data layers on acid deposition and Cd loadings in Europe, while 'available' at institutes such as RIVM (see Van Woerden *et al*., 1995), proved to be accessible solely to a restricted group of researchers (Van Woerden, *pers. comm.*, 1999). As a result, a map of areas considered at risk from cadmium re-mobilisation could not be prepared within the time span of the SOVEUR project. These aspects illustrate that issues of data accessibility, copyright and legal responsibility are becoming of increasing concern, and that there is a pressing need to clarify the current situation in many of these areas (see Naff, 1999; Webster, 1997).

3 CONCLUSIONS

! Working at the scale of 1:2.5 million is an excellent exercise for integrating data and expertise from a large number of countries.

! Results of the soil vulnerability mapping exercise will mainly be applicable to large areas as a whole. These maps can help to increase awareness of possible (adverse) effects of human intervention on the quality of soil resources.

! Other maps of soil vulnerability can easily be generated using the ‘parametric overviews of derived soil properties’ (Batjes, 2000b) and specialist knowledge of contaminant behaviour (e.g., Boumans *et al*., 1987; Fränzle, 1987; Stolpe *et al*., 1998), but serious knowledge gaps do remain (De Haan and Visser-Regeneveld, 1996; Japenga *et al*., 1997).

! Uncertainties associated with data and model errors are prone to be significant at the considered scale. The various types of uncertainties are difficult to evaluate, and they will vary amongst the various national data sets and models used (Batjes, 1999b).

! Identification of areas considered most at risk from re-mobilization of selected types of contaminants in the SOVEUR area, as schematized in Figure 1, will first become feasible upon the unfettered access to existing, auxiliary databases of chemical loads.

! Issues of data accessibility, copyright and legal responsibility are likely to become of increasing importance in the near future, notably in the context of EU-driven projects (see Jones and Buckley, 1997). There is a pressing need to clarify the current situation in many of these areas (Naff, 1999; Webster, 1997).

! For the future, more detailed systems need to be developed to allow for more detailed studies at the regional or national level, that may include the identification of main sources of point pollution, as well as the model-based identification of possible sites for Chemical Time Bombs, and possible remedial action.

! Linkage with a soil monitoring system would permit analysis of changes in the driving-forces of soil processes in relation to toxicant (im)mobilization, thereby providing a better scientific basis for model development, evaluation, and risk assessment (see GTOS, 1995; Van Duijvenbooden, 1998; Varallyay, 1993).

APPENDICES

App. 1. Capacity Controlling Properties, by FAO soil unit and for two depth zones, used in the vulnerability assessment

FAO_90	PH_T	PH_S	ORG_T	ORG_S	CEC_T	CEC_S	BSAT_T	BSAT_S	SAND_T	SAND_S	SILT_T	SILT_S	CLAY_T	CLAY_S	TEXT_T	TEXT_S	DRAIN
AC	5.3	5.1	10.2	3.8	6.7	8.7	38.0	23.5	50.5	40.5	28.8	25.1	20.9	34.6	L	CL	M
ACh	5.3	5.1	10.2	3.8	6.7	8.7	38.0	23.5	50.5	40.5	28.8	25.1	20.9	34.6	L	CL	M
AN	5.5	5.9	91.3	44.1	38.9	30.8	16.0	8.0	27.6	36.0	46.6	39.2	25.9	25.1	L	L	W
ANu	5.5	5.9	91.3	44.1	38.9	30.8	16.0	8.0	27.6	36.0	46.6	39.2	25.9	25.1	L	L	W
AR	6.8	6.7	3.4	1.4	3.4	2.2	75.5	78.0	88.6	90.5	7.5	6.1	4.2	3.6	S	S	S
ARb	5.8	5.7	5.9	1.1	4.5	2.3	48.0	78.0	88.4	91.9	7.8	5.5	3.9	2.9	S	S	S
ARc	8.1	8.3	3.0	1.7	2.7	3.1	75.5	78.0	88.3	89.6	7.6	6.2	4.6	4.5	LS	S	S
ARh	6.2	6.0	3.3	1.5	3.3	2.2	75.5	78.0	88.9	89.8	6.9	6.8	4.2	3.5	S	S	S
AT	6.3	6.9	14.7	4.3	15.9	14.7	87.0	96.0	38.9	37.6	39.2	36.2	22.0	26.2	L	L	W
ATu	6.3	6.9	14.7	4.3	15.9	14.7	87.0	96.0	38.9	37.6	39.2	36.2	22.0	26.2	L	L	W
CH	7.2	7.5	22.3	11.3	30.4	28.3	100.0	99.0	17.2	16.9	50.6	51.3	32.2	32.0	SiC	SiC	M
CHg	7.2	7.6	22.3	8.5	35.0	31.3	100.0	99.0	31.0	26.5	38.0	36.8	31.0	37.0	CL	CL	I
CHh	7.1	7.3	23.7	12.6	27.4	26.1	100.0	100.0	18.8	17.0	51.7	54.0	29.5	29.0	SiC	SiC	M
CHk	7.6	7.9	20.3	10.1	31.9	30.0	100.0	99.5	13.6	13.5	52.2	52.9	34.3	33.8	SiC	SiC	M
CHl	6.9	7.6	29.5	12.1	39.5	24.5	95.5	97.0	16.7	19.7	48.9	45.7	34.6	34.6	SiC	SiC	M
CHw	7.2	7.5	22.3	11.3	30.4	28.3	100.0	99.0	17.2	16.9	50.6	51.3	32.2	32.0	SiC	SiC	W
CL	8.1	8.2	6.7	3.3	14.8	14.8	100.0	100.0	42.6	40.6	34.3	33.4	23.1	26.0	L	L	W

FAO_90	PH_T	PH_S	ORG_T	ORG_S	CEC_T	CEC_S	BSAT_T	BSAT_S	SAND_T	SAND_S	SILT_T	SILT_S	CLAY_T	CLAY_S	TEXT_T	TEXT_S	DRAIN
CLh	8.0	8.3	8.0	3.3	15.0	15.1	100.0	100.0	40.1	42.0	36.0	33.7	23.9	24.4	L	L	W
CLl	8.1	8.1	4.6	2.9	13.6	11.9	100.0	100.0	48.8	37.3	30.1	32.9	21.0	29.9	L	CL	W
CM	6.1	6.5	15.0	4.0	15.1	11.4	71.0	93.0	39.2	41.2	37.9	35.3	23.1	23.7	L	L	M
CMc	7.9	8.2	10.0	3.6	18.2	15.5	100.0	100.0	29.2	29.9	44.8	42.7	26.1	27.4	L	CL	W
CMd	5.1	5.2	23.5	5.5	14.7	9.0	26.5	19.0	42.9	49.2	37.3	32.7	19.9	18.3	L	L	W
CMe	6.8	7.2	11.3	3.0	15.3	13.0	86.0	90.0	43.6	43.0	35.1	33.9	21.3	23.1	L	L	W
CMg	6.3	6.7	18.0	4.9	16.3	12.3	85.5	86.5	40.5	39.1	35.4	33.5	24.2	27.4	L	CL	I
CMi	5.0	5.1	18.3	7.6	12.2	10.3	32.0	39.0	35.3	39.0	43.2	39.2	21.6	21.9	L	L	M
CMu	5.1	5.0	19.4	7.1	23.6	22.2	19.0	19.0	43.6	47.3	28.9	26.4	27.7	26.6	CL	SCL	W
CMx	7.2	7.1	14.2	4.4	15.0	15.1	91.0	87.0	32.3	33.8	33.5	32.8	34.1	33.5	CL	CL	W
FL	7.6	7.8	11.4	4.5	17.1	15.3	98.5	99.0	30.5	32.0	43.6	42.2	26.0	25.8	L	L	I
FLc	7.8	8.0	7.8	3.6	13.3	13.8	100.0	100.0	28.4	27.8	45.8	45.2	25.8	27.0	L	CL	M
FLd	4.9	5.6	14.0	4.1	13.4	9.1	26.5	31.8	55.5	61.0	28.2	25.2	16.5	14.0	SL	SL	I
FLe	6.9	7.5	12.1	5.4	19.2	18.5	83.0	91.0	31.2	32.8	43.1	41.9	25.7	25.3	L	L	I
FLm	7.6	7.8	11.4	4.5	17.1	27.7	98.5	99.0	30.5	23.8	43.6	50.2	26.0	25.8	L	SiL	P
FLt	7.6	7.8	11.4	4.5	17.1	15.3	98.5	99.0	30.5	32.0	43.6	42.2	26.0	25.8	L	L	P
FLu	5.8	5.7	11.4	8.7	17.1	22.4	26.5	99.0	30.5	53.7	43.6	26.2	26.0	18.5	L	SL	P
GL	6.1	6.5	22.7	4.0	20.4	13.3	79.0	94.0	39.5	38.4	37.6	35.3	23.0	26.4	L	L	P
GLd	5.1	5.0	28.1	4.3	17.2	10.1	39.0	44.0	44.9	44.6	36.8	33.9	18.5	21.7	L	L	P
GLe	6.1	6.5	19.2	3.1	19.0	14.0	75.0	86.5	37.2	35.4	35.7	32.7	27.3	31.9	CL	CL	P

FAO_90	PH_T	PH_S	ORG_T	ORG_S	CEC_T	CEC_S	BSAT_T	BSAT_S	SAND_T	SAND_S	SILT_T	SILT_S	CLAY_T	CLAY_S	TEXT_T	TEXT_S	DRAIN
GLi	6.1	6.7	24.6	8.1	40.3	17.6	96.5	100.0	33.6	30.7	46.6	47.6	19.7	21.8	L	L	P
GLk	7.0	7.9	12.8	3.7	14.6	12.1	79.0	94.0	33.6	29.9	36.3	38.4	30.1	31.7	CL	CL	P
GLm	7.2	7.4	22.0	7.0	21.7	18.3	99.0	99.0	31.5	27.0	42.2	42.2	26.5	30.7	L	CL	P
GLu	5.9	6.4	28.0	3.0	27.9	8.0	38.0	66.0	56.7	63.7	32.2	24.6	11.1	11.6	SL	SL	P
GR	6.6	6.7	15.7	3.6	19.8	15.5	92.0	78.8	23.1	22.2	55.7	50.8	21.2	27.0	SiL	CL	M
GRg	6.6	6.7	15.7	3.6	19.8	15.5	92.0	78.8	23.1	22.2	55.7	50.8	21.2	27.0	SiL	CL	P
GRh	6.6	6.9	15.7	2.9	21.2	17.5	93.5	81.2	23.7	21.8	54.4	49.9	21.9	28.3	SiL	CL	M
HS	5.7	5.5	477.0	469.9	91.5	98.3	62.5	68.0	22.7	38.8	33.3	37.5	44.0	23.8	ORG	ORG	V
HSf	4.1	4.0	443.5	431.2	91.0	97.5	21.0	30.5	22.7	38.8	33.3	37.5	44.0	23.8	ORG	ORG	V
HSl	5.7	5.5	477.0	469.9	91.5	98.3	62.5	68.0	22.7	38.8	33.3	37.5	44.0	23.8	ORG	ORG	W
HSs	5.9	5.9	477.0	503.6	90.5	91.0	68.0	83.5	22.7	40.6	33.3	39.6	44.0	20.0	ORG	ORG	V
HSt	5.7	5.5	477.0	469.9	91.5	98.3	62.5	68.0	22.7	38.8	33.3	37.5	44.0	23.8	ORG	ORG	P
KS	7.4	7.8	14.2	6.6	26.5	25.7	100.0	100.0	25.2	26.3	44.1	42.9	30.7	31.0	CL	CL	W
KSh	7.3	7.9	14.5	4.8	23.8	19.9	100.0	100.0	29.6	30.1	41.4	40.1	29.1	29.9	CL	CL	W
KSk	7.9	7.9	14.0	6.6	28.8	28.6	100.0	100.0	22.4	25.8	44.1	43.0	33.6	31.6	CL	CL	W
KSl	7.2	7.7	17.2	7.1	28.7	24.6	100.0	100.0	21.3	17.8	51.7	49.8	27.0	32.3	CL	SiC	M
LP	7.5	7.6	23.1	9.5	23.3	19.9	99.0	99.5	41.4	36.6	37.5	41.2	21.3	22.3	L	L	W
LPd	7.5	7.6	23.1	9.5	23.3	19.9	26.5	31.8	41.4	36.6	37.5	41.2	21.3	22.3	L	L	W
LPe	7.9	7.6	5.4	9.5	18.1	19.9	99.5	88.8	44.8	36.6	34.7	41.2	20.5	22.3	L	L	S
LPi	7.5	7.6	23.1	9.5	23.3	19.9	99.0	99.5	41.4	36.6	37.5	41.2	21.3	22.3	L	L	W

FAO_90	PH_T	PH_S	ORG_T	ORG_S	CEC_T	CEC_S	BSAT_T	BSAT_S	SAND_T	SAND_S	SILT_T	SILT_S	CLAY_T	CLAY_S	TEXT_T	TEXT_S	DRAIN
LPk	7.6	7.7	22.5	7.7	27.3	29.7	99.0	99.5	34.6	27.1	41.5	43.4	24.1	29.7	L	CL	W
LPm	7.0	7.6	34.5	9.5	26.6	19.9	99.0	99.5	42.3	36.6	39.4	41.2	18.5	22.3	L	L	W
LPq	6.4	6.4	30.7	30.7	23.6	23.6	99.0	99.0	53.0	53.0	26.8	26.8	20.2	20.2	SCL	SCL	S
LPu	4.7	7.6	116.3	20.1	34.6	9.4	26.5	99.5	41.4	66.0	37.5	24.0	21.3	10.0	L	SL	M
LV	6.6	7.0	9.5	3.0	12.5	15.5	88.5	97.0	40.5	35.1	37.7	33.5	21.8	31.5	L	CL	M
LVa	6.1	6.7	8.5	3.0	10.8	20.1	81.0	87.0	40.2	35.1	44.8	37.4	14.9	27.6	L	CL	M
LVg	6.0	6.5	11.9	2.2	13.3	15.9	57.5	96.0	34.7	29.5	44.8	38.6	20.6	31.9	L	CL	I
LVh	6.6	7.1	10.0	3.5	12.8	14.9	94.0	98.0	37.7	34.1	42.3	39.1	20.1	26.9	L	CL	M
LVj	5.3	5.5	12.1	2.7	11.3	13.5	55.0	72.0	35.8	30.1	47.5	40.9	16.7	28.9	L	CL	I
LVk	7.7	8.0	6.2	2.7	11.5	13.9	100.0	100.0	52.5	45.6	27.1	26.1	20.5	28.5	SCL	SCL	W
LVv	7.2	7.1	10.1	4.2	24.4	29.0	97.0	98.0	22.3	15.8	32.4	26.0	45.2	58.1	C	C	M
LVx	6.4	6.9	7.0	3.9	13.4	17.2	81.0	87.0	45.1	37.8	27.9	23.7	27.1	38.5	L	CL	M
PD	5.1	5.2	10.0	2.0	7.2	5.9	42.0	66.0	51.3	52.1	40.6	35.0	8.1	12.9	L	SL	M
PDd	4.9	5.0	17.7	2.0	20.6	10.5	21.0	31.8	42.7	33.1	46.0	44.9	11.5	22.0	L	L	I
PDe	5.2	5.2	9.8	2.0	6.4	4.3	52.5	77.0	53.6	57.8	39.4	31.6	7.0	10.6	SL	SL	W
PDg	4.9	5.3	11.6	1.2	14.8	9.0	42.0	66.0	53.3	46.5	36.1	37.8	10.6	15.9	SL	L	I
PDi	5.1	5.2	10.0	2.0	7.2	5.9	42.0	66.0	51.3	52.1	40.6	35.0	8.1	12.9	L	SL	W
PDj	4.4	5.2	17.0	4.0	16.3	14.0	42.0	66.0	29.2	22.0	59.0	56.8	12.4	21.4	SiL	SiL	I
PH	6.4	7.1	19.7	7.3	21.6	24.4	87.5	97.0	29.1	26.5	42.6	39.0	28.4	34.6	CL	CL	M
PHc	7.8	8.2	14.8	5.9	26.5	14.9	100.0	100.0	30.6	31.0	39.7	39.2	29.7	29.7	CL	CL	W

FAO_90	PH_T	PH_ S	ORG_T	ORG_S	CEC_T	CEC_S	BSAT_T	BSAT_S	SAND_T	SAND_S	SILT_T	SILT_S	CLAY_T	CLAY_S	TEXT_T	TEXT_S	DRAIN
PHg	6.3	7.4	16.7	4.8	18.1	23.1	74.5	92.0	29.9	26.7	46.0	42.2	24.1	31.3	L	CL	I
PHh	6.5	6.9	20.8	9.3	21.7	20.6	92.0	97.0	27.7	28.4	42.5	40.6	29.9	31.0	CL	CL	M
PHj	6.4	7.1	19.7	7.3	21.6	24.4	87.5	97.0	29.1	26.5	42.6	39.0	28.4	34.6	CL	CL	I
PHl	6.2	7.0	19.7	7.9	20.7	26.2	86.5	96.0	30.1	24.8	42.9	37.7	27.0	37.5	CL	CL	M
PL	5.8	6.2	14.3	4.5	14.0	17.9	73.5	92.0	43.9	33.3	37.3	30.8	19.4	36.1	L	CL	I
PLd	4.5	4.6	12.5	3.7	12.1	18.2	19.5	32.5	50.9	30.8	32.5	27.2	16.6	42.0	L	C	P
PLe	5.6	6.0	12.1	4.7	8.0	14.4	54.0	88.0	53.8	42.6	32.1	25.8	15.3	31.8	SL	CL	I
PLm	6.0	7.4	19.6	6.4	17.2	30.4	75.0	94.0	21.8	19.3	50.6	42.9	27.6	38.0	CL	SiC	I
PZ	4.3	5.0	33.7	5.3	16.0	5.2	10.0	7.0	71.4	76.1	22.3	18.0	6.5	6.0	SL	SL	W
PZb	4.7	5.2	31.5	13.0	15.6	5.1	21.0	7.0	60.6	67.5	30.0	24.1	9.5	8.3	SL	SL	W
PZc	4.3	4.7	95.2	12.7	7.7	9.0	10.0	7.0	84.7	89.7	11.7	6.9	3.7	3.7	LS	S	I
PZf	4.3	5.0	33.7	5.3	16.0	5.2	10.0	7.0	71.4	76.1	22.3	18.0	6.5	6.0	SL	SL	W
PZg	4.4	4.9	28.8	5.5	14.4	6.4	22.0	15.0	70.0	74.6	24.0	19.8	5.9	5.7	SL	SL	I
PZh	4.2	5.0	36.6	3.6	20.1	4.7	9.5	7.0	74.6	77.5	19.7	16.9	5.8	5.8	SL	LS	W
PZi	4.3	5.0	33.7	5.3	14.2	5.2	10.0	7.0	59.8	73.2	31.3	21.8	9.2	5.0	SL	SL	W
RG	7.8	8.1	6.2	3.0	11.3	9.8	100.0	100.0	55.5	46.2	31.6	36.6	13.1	17.1	SL	L	W
RGc	7.7	8.1	4.0	3.0	11.3	10.1	100.0	100.0	58.9	49.3	28.0	32.6	13.2	18.0	SL	L	S
RGi	7.8	8.1	6.2	3.0	11.3	9.8	100.0	100.0	55.5	46.2	31.6	36.6	13.1	17.1	SL	L	I
SC	8.0	8.2	5.7	2.6	17.2	15.3	94.1	96.5	33.4	36.5	39.4	33.7	27.3	29.8	CL	CL	I
SCg	7.9	8.2	5.7	3.3	16.6	17.7	92.9	96.5	34.5	31.9	40.3	36.1	25.3	32.2	L	CL	P

FAO_90	PH_T	PH_ S	ORG_T	ORG_S	CEC_T	CEC_S	BSAT_T	BSAT_S	SAND_T	SAND_S	SILT_T	SILT_S	CLAY_T	CLAY_S	TEXT_T	TEXT_S	DRAIN
SCh	8.6	8.1	5.0	1.2	17.2	15.7	100.0	95.3	31.8	42.8	38.1	30.5	30.3	26.6	CL	CL	I
SN	7.5	8.6	9.3	2.9	21.2	27.9	100.0	100.0	26.8	19.9	44.7	42.1	28.6	37.2	CL	CL	I
SNg	7.7	8.6	13.3	2.4	24.8	30.0	94.5	100.0	22.4	18.4	49.6	44.3	28.1	37.4	CL	SiC	P
SNh	8.3	8.5	6.3	2.6	15.2	18.0	100.0	100.0	34.6	25.2	36.9	37.3	28.6	37.7	CL	CL	I
SNm	7.1	9.0	13.4	5.9	24.3	32.5	83.5	95.0	14.8	8.7	55.2	50.0	30.0	35.0	SiC	SiC	I
VR	7.6	7.9	11.6	6.9	37.6	37.3	100.0	100.0	16.3	14.6	34.1	31.8	49.6	53.6	C	C	I
VRe	7.2	7.9	13.7	7.7	37.8	37.7	100.0	100.0	14.7	12.9	35.0	31.9	50.3	55.3	C	C	I
VRk	7.7	8.1	9.0	5.8	37.5	36.0	100.0	100.0	18.7	16.9	32.8	31.8	48.5	51.3	C	C	M
#CR	6.4	6.4	30.7	30.7	23.6	23.6	99.0	99.0	53.0	53.0	26.8	26.8	20.2	20.2	SCL	SCL	S
#RK	6.4	6.4	30.7	30.7	23.6	23.6	99.0	99.0	53.0	53.0	26.8	26.8	20.2	20.2	SCL	SCL	S
#SA	6.8	6.7	3.4	1.4	3.4	2.2	75.5	78.0	88.6	90.5	7.5	6.1	4.2	3.6	S	S	S
#ST	8.0	8.2	5.7	2.6	17.2	15.3	94.1	96.5	33.4	36.5	39.4	33.7	27.3	29.8	CL	CL	I
##	6.3	6.9	14.7	4.3	15.9	14.7	87.0	96.0	38.9	37.6	39.2	36.2	22.0	26.2	L	L	W

Notes:

1) Median values listed above should be seen as the 'currently best available' estimates for the Capacity Controlling Properties for the SOVEUR area (see Batjes, 2000b). Two depth-weighted values are shown for each soil attribute (X), the first for the topsoil (X_T; 0 - 0.3 m) and the second for the subsoil (X_S; 0.3 - 1 m). All numeric derived soil data were rounded to one decimal place.
2) Abbreviations: pH, soil reaction in water; ORG= organic carbon content (g C kg^{-1}); CEC= cation exchange capacity ($cmol_c$ kg^{-1}); BSAT= base saturation expressed as % of CEC; SAND, SILT, CLAY, is the weight % of sand, silt and clay size fractions; TEXT= soil textural class (USDA); DRAIN= the FAO soil drainage class. Issues of comparability of soil data, obtained in the various countries/laboratories, are discussed elsewhere (see Batjes, 2000b).
3) By default, the derived soil data for Arenosols (AR) were used for areas of 'Sand Dunes' (#SA), the values for lithic Leptosols (LPq) were used for areas of 'Rock Outcrops' (#RK) and 'Crumbly Rock' (#CR), and the values for Solonchaks (SC) were used for areas of 'Salt Flats' (#ST). If there are no derived soil data at all for a particular mineral soil unit, the medians computed for all mineral soils combined, but excluding Arenosols, Andosols and Vertisols, have been used as best available proxies (##).
4) File: VULSCOMP.dbf.

App. 2. Ratings for the relative Cd binding capacity by FAO soil unit

A) Depth-weighted ratings for the topsoil (0-0.3 m)

FAO_90	B_PH	B_ORGC	B_TEXT	B_FEOX	B_SULF	M_DRAIN	B_CLASS
AC	2.0	0.0	0.0	0.0	0.0	0.0	L
ACh	2.0	0.0	0.0	0.0	0.0	0.0	L
AN	2.0	1.5	0.0	0.0	0.0	0.0	H
ANu	2.0	1.5	0.0	0.0	0.0	0.0	H
AR	4.0	0.0	0.0	0.0	0.0	0.0	H
ARb	2.5	0.0	0.0	0.0	0.0	0.0	M
ARc	5.0	0.0	0.0	0.0	0.0	0.0	VH
ARh	3.5	0.0	0.0	0.0	0.0	0.0	H
#SA	4.0	0.0	0.0	0.0	0.0	0.0	H
CH	4.5	0.5	0.5	0.0	0.0	0.0	VH
CHg	4.5	0.5	0.5	0.0	0.0	0.0	VH
CHh	4.5	0.5	0.5	0.0	0.0	0.0	VH
CHk	5.0	0.5	0.5	0.0	0.0	0.0	VH
CHl	4.0	0.5	0.5	0.0	0.0	0.0	VH
CHw	4.5	0.5	0.5	0.0	0.0	0.0	VH
CL	5.0	0.0	0.0	0.0	0.0	0.0	VH
CLh	5.0	0.0	0.0	0.0	0.0	0.0	VH
CLl	5.0	0.0	0.0	0.0	0.0	0.0	VH
CM	3.5	0.5	0.0	0.0	0.0	0.0	H
CMc	5.0	0.0	0.0	0.0	0.0	0.0	VH
CMd	2.0	0.5	0.0	0.0	0.0	0.0	M
CMe	4.0	0.0	0.0	0.0	0.0	0.0	H
CMg	3.5	0.5	0.0	0.0	0.0	0.0	H
CMi	1.5	0.5	0.0	0.0	0.0	0.0	L
CMu	2.0	0.5	0.5	0.0	0.0	0.0	M
CMx	4.5	0.5	0.5	0.0	0.0	0.0	VH
FL	5.0	0.0	0.0	0.0	0.0	0.0	VH
FLc	5.0	0.0	0.0	0.0	0.0	0.0	VH

FAO_90	B_PH	B_ORGC	B_TEXT	B_FEOX	B_SULF	M_DRAIN	B_CLASS
FLd	1.5	0.5	0.5	0.0	0.0	0.0	M
FLe	4.0	0.5	0.0	0.0	0.0	0.0	VH
FLm	5.0	0.0	0.0	0.0	0.0	0.0	VH
FLt	5.0	0.0	0.0	0.0	5.0	0.0	VH
FLu	2.5	0.0	0.0	0.0	0.0	0.0	M
GL	3.5	0.5	0.0	0.0	0.0	0.0	H
GLd	2.0	0.5	0.0	0.0	0.0	0.0	M
GLe	3.5	0.5	0.5	0.0	0.0	0.0	VH
GLi	3.5	0.5	0.0	0.0	0.0	0.0	H
GLk	4.5	0.5	0.5	0.0	0.0	0.0	VH
GLm	4.5	0.5	0.0	0.0	0.0	0.0	VH
GLu	2.5	0.5	0.5	0.0	0.0	0.0	H
GR	4.0	0.5	0.5	0.0	0.0	0.0	VH
GRg	4.0	0.5	0.5	0.0	0.0	0.0	VH
GRh	4.0	0.5	0.5	0.0	0.0	0.0	VH
HS	2.5	1.5	0.0	0.0	0.0	0.0	H
HSf	1.0	1.5	0.0	0.0	0.0	0.0	M
HSl	2.5	1.5	0.0	0.0	0.0	0.0	H
HSs	2.5	1.5	0.0	0.0	0.0	0.0	H
HSt	2.5	1.5	0.0	0.0	5.0	0.0	VH
KS	4.5	0.5	0.5	0.0	0.0	0.0	VH
KSh	4.5	0.5	0.5	0.0	0.0	0.0	VH
KSk	5.0	0.5	0.5	0.0	0.0	0.0	VH
KSl	4.5	0.5	0.5	0.0	0.0	0.0	VH
LP	5.0	0.5	0.0	0.0	0.0	0.0	VH
LPd	5.0	0.5	0.0	0.0	0.0	0.0	VH
LPe	5.0	0.0	0.0	0.0	0.0	0.0	VH
LPi	5.0	0.5	0.0	0.0	0.0	0.0	VH
LPk	5.0	0.5	0.0	0.0	0.0	0.0	VH
LPm	4.5	0.5	0.0	0.0	0.0	0.0	VH

FAO_90	B_PH	B_ORGC	B_TEXT	B_FEOX	B_SULF	M_DRAIN	B_CLASS
LPq	3.5	0.5	0.0	0.0	0.0	0.0	H
LPu	1.5	1.5	0.0	0.0	0.0	0.0	M
#CR	3.5	0.5	0.0	0.0	0.0	0.0	H
#RK	3.5	0.5	0.0	0.0	0.0	0.0	H
LV	4.0	0.0	0.0	0.0	0.0	0.0	H
LVa	3.5	0.0	0.0	0.0	0.0	0.0	H
LVg	3.5	0.5	0.0	0.0	0.0	0.0	H
LVh	4.0	0.0	0.0	0.0	0.0	0.0	H
LVj	2.0	0.5	0.0	0.0	0.0	0.0	M
LVk	5.0	0.0	0.0	0.0	0.0	0.0	VH
LVv	4.5	0.0	0.5	0.0	0.0	0.0	VH
LVx	3.5	0.0	0.0	0.0	0.0	0.0	H
PD	2.0	0.0	0.0	0.0	0.0	0.0	L
PDd	1.5	0.5	0.0	0.0	0.0	0.0	L
PDe	2.0	0.0	0.0	0.0	0.0	0.0	L
PDg	1.5	0.0	0.5	0.0	0.0	0.0	L
PDi	2.0	0.0	0.0	0.0	0.0	0.0	L
PDj	1.0	0.5	0.5	0.0	0.0	0.0	L
PH	3.5	0.5	0.5	0.0	0.0	0.0	VH
PHc	5.0	0.5	0.5	0.0	0.0	0.0	VH
PHg	3.5	0.5	0.0	0.0	0.0	0.0	H
PHh	4.0	0.5	0.5	0.0	0.0	0.0	VH
PHj	3.5	0.5	0.5	0.0	0.0	0.0	VH
PHl	3.5	0.5	0.5	0.0	0.0	0.0	VH
PL	2.5	0.5	0.0	0.0	0.0	0.0	M
PLd	1.0	0.5	0.0	0.0	0.0	0.0	L
PLe	2.5	0.5	0.5	0.0	0.0	0.0	H
PLm	3.5	0.5	0.5	0.0	0.0	0.0	VH
PZ	1.0	0.5	0.0	0.0	0.0	0.0	L
PZb	1.5	0.5	0.0	0.0	0.0	0.0	L

FAO_90	B_PH	B_ORGC	B_TEXT	B_FEOX	B_SULF	M_DRAIN	B_CLASS
PZc	1.0	1.5	0.0	0.0	0.0	0.0	M
PZf	1.0	0.5	0.0	1.0	0.0	0.0	M
PZg	1.0	0.5	0.0	0.0	0.0	0.0	L
PZh	1.0	0.5	0.0	0.0	0.0	0.0	L
PZi	1.0	0.5	0.0	0.0	0.0	0.0	L
RG	5.0	0.0	0.5	0.0	0.0	0.0	VH
RGc	5.0	0.0	0.5	0.0	0.0	0.0	VH
RGi	5.0	0.0	0.5	0.0	0.0	0.0	VH
SC	5.0	0.0	0.5	0.0	0.0	0.0	VH
SCg	5.0	0.0	0.0	0.0	0.0	0.0	VH
SCh	5.0	0.0	0.5	0.0	0.0	0.0	VH
#ST	5.0	0.0	0.5	0.0	0.0	0.0	VH
SN	5.0	0.0	0.5	0.0	0.0	0.0	VH
SNg	5.0	0.5	0.5	0.0	0.0	0.0	VH
SNh	5.0	0.0	0.5	0.0	0.0	0.0	VH
SNm	4.5	0.5	0.5	0.0	0.0	0.0	VH
VR	5.0	0.0	0.5	0.0	0.0	0.0	VH
VRe	4.5	0.5	0.5	0.0	0.0	0.0	VH
VRk	5.0	0.0	0.5	0.0	0.0	0.0	VH
AT	3.5	0.5	0.0	0.0	0.0	0.0	H
ATu	3.5	0.5	0.0	0.0	0.0	0.0	H
##	3.5	0.5	0.0	0.0	0.0	0.0	H

Note:
FAO_90, soil classification according to FAO (1988).
B_PH, binding strength associated with pH conditions (see Table 3)
B_ORGC, binding strength associated with organic matter content (see Table 4)
B_TEXT, binding strength associated with soil textural class (see text, section 2.41)
B_FEOX, binding strength associated with presence of iron oxides (see text, section 2.4.1)

B_SULF, binding strength associated with sulfides (see text, section 2.4.1)

M_DRAIN, mobilizing capacity (or decrease in binding strength) associated with alternating wetting/drying conditions (see text, section 2.4.1).

B_CLASS, relative binding strength for heavy metal for the topsoil.

Data file: Cd_TOP.dbf. Similar filename presented for the metals: Mn, Ni, Co, Zn, Cu, Cr(III), Pb, Hg, Fe(III), and Al.

B) Depth-weighted ratings for the subsoil

FAO_90	B_PH	B_ORGC	B_TEXT	B_FEOX	B_SULF	M_DRAIN	B_CLASS
AC	2.0	0.0	1.5	0.0	0.0	0.0	H
ACh	2.0	0.0	1.5	0.0	0.0	0.0	H
AN	2.5	1.5	0.0	0.0	0.0	0.0	H
ANu	2.5	1.5	0.0	0.0	0.0	0.0	H
AR	4.0	0.0	0.0	0.0	0.0	0.0	H
ARb	2.5	0.0	0.0	0.0	0.0	0.0	M
ARc	5.0	0.0	0.0	0.0	0.0	0.0	VH
ARh	3.5	0.0	0.0	0.0	0.0	0.0	H
#SA	4.0	0.0	0.0	0.0	0.0	0.0	H
CH	5.0	0.0	1.5	0.0	0.0	0.0	VH
CHg	5.0	0.0	1.5	0.0	0.0	0.0	VH
CHh	4.5	1.5	1.5	0.0	0.0	0.0	VH
CHk	5.0	0.0	1.5	0.0	0.0	0.0	VH
CHl	5.0	1.5	1.5	0.0	0.0	0.0	VH
CHw	5.0	0.0	1.5	0.0	0.0	0.0	VH
CL	5.0	0.0	0.0	0.0	0.0	0.0	VH
CLh	5.0	0.0	0.0	0.0	0.0	0.0	VH
CLl	5.0	0.0	1.5	0.0	0.0	0.0	VH
CM	4.0	0.0	0.0	0.0	0.0	0.0	H
CMc	5.0	0.0	0.5	0.0	0.0	0.0	VH
CMd	2.0	0.0	0.0	0.0	0.0	0.0	L
CMe	4.5	0.0	0.0	0.0	0.0	0.0	VH
CMg	4.0	0.0	0.5	0.0	0.0	0.0	VH
CMi	2.0	0.0	0.0	0.0	0.0	0.0	L
CMu	1.5	0.0	0.0	0.0	0.0	0.0	L
CMx	4.5	0.0	1.5	0.0	0.0	0.0	VH
FL	5.0	0.0	0.0	0.0	0.0	0.0	VH
FLc	5.0	0.0	0.5	0.0	0.0	0.0	VH

FAO_90	B_PH	B_ORGC	B_TEXT	B_FEOX	B_SULF	M_DRAIN	B_CLASS
FLd	2.5	0.0	0.5	0.0	0.0	0.0	M
FLe	5.0	0.0	0.0	0.0	0.0	0.0	VH
FLm	5.0	0.0	0.5	0.0	0.0	0.0	VH
FLt	5.0	0.0	0.0	0.0	5.0	0.0	VH
FLu	2.5	0.0	0.5	0.0	0.0	0.0	M
GL	4.0	0.0	0.0	0.0	0.0	0.0	H
GLd	1.5	0.0	0.0	0.0	0.0	0.0	L
GLe	4.0	0.0	1.5	0.0	0.0	0.0	VH
GLi	4.0	0.0	0.0	0.0	0.0	0.0	H
GLk	5.0	0.0	1.5	0.0	0.0	0.0	VH
GLm	4.5	0.0	1.5	0.0	0.0	0.0	VH
GLu	3.5	0.0	0.5	0.0	0.0	0.0	H
GR	4.0	0.0	0.5	0.0	0.0	0.0	VH
GRg	4.0	0.0	0.5	0.0	0.0	0.0	VH
GRh	4.0	0.0	1.5	0.0	0.0	0.0	VH
HS	2.0	2.5	0.0	0.0	0.0	0.0	VH
HSf	0.5	2.5	0.0	0.0	0.0	0.0	M
HSl	2.0	2.5	0.0	0.0	0.0	0.0	VH
HSs	2.5	2.5	0.0	0.0	0.0	0.0	VH
HSt	2.0	2.5	0.0	0.0	5.0	0.0	VH
KS	5.0	0.0	1.5	0.0	0.0	0.0	VH
KSh	5.0	0.0	1.5	0.0	0.0	0.0	VH
KSk	5.0	0.0	1.5	0.0	0.0	0.0	VH
KSl	5.0	0.0	1.5	0.0	0.0	0.0	VH
LP	5.0	0.0	0.0	0.0	0.0	0.0	VH
LPd	5.0	0.0	0.0	0.0	0.0	0.0	VH
LPe	5.0	0.0	0.0	0.0	0.0	0.0	VH
LPi	5.0	0.0	0.0	0.0	0.0	0.0	VH
LPk	5.0	0.0	1.5	0.0	0.0	0.0	VH
LPm	5.0	0.0	0.0	0.0	0.0	0.0	VH

FAO_90	B_PH	B_ORGC	B_TEXT	B_FEOX	B_SULF	M_DRAIN	B_CLASS
LPq	3.5	1.5	0.0	0.0	0.0	0.0	VH
LPu	5.0	1.5	0.0	0.0	0.0	0.0	VH
#CR	3.5	1.5	0.0	0.0	0.0	0.0	VH
#RK	3.5	1.5	0.0	0.0	0.0	0.0	VH
LV	4.5	0.0	1.5	0.0	0.0	0.0	VH
LVa	4.0	0.0	0.5	0.0	0.0	0.0	VH
LVg	4.0	0.0	1.5	0.0	0.0	0.0	VH
LVh	4.5	0.0	0.5	0.0	0.0	0.0	VH
LVj	2.0	0.0	1.5	0.0	0.0	0.0	H
LVk	5.0	0.0	1.0	0.0	0.0	0.0	VH
LVv	4.5	0.0	1.5	0.0	0.0	0.0	VH
LVx	4.0	0.0	1.5	0.0	0.0	0.0	VH
PD	2.0	0.0	0.5	0.0	0.0	0.0	M
PDd	1.5	0.0	0.0	0.0	0.0	0.0	L
PDe	2.0	0.0	0.5	0.0	0.0	0.0	M
PDg	2.0	0.0	0.0	0.0	0.0	0.0	L
PDi	2.0	0.0	0.5	0.0	0.0	0.0	M
PDj	2.0	0.0	0.5	0.0	0.0	0.0	M
PH	4.5	0.0	1.5	0.0	0.0	0.0	VH
PHc	5.0	0.0	1.5	0.0	0.0	0.0	VH
PHg	4.5	0.0	1.5	0.0	0.0	0.0	VH
PHh	4.0	0.0	1.5	0.0	0.0	0.0	VH
PHj	4.5	0.0	1.5	0.0	0.0	0.0	VH
PHl	4.5	0.0	1.5	0.0	0.0	0.0	VH
PL	3.5	0.0	1.5	0.0	0.0	0.0	VH
PLd	1.5	0.0	1.5	0.0	0.0	0.0	M
PLe	3.5	0.0	1.5	0.0	0.0	0.0	VH
PLm	4.5	0.0	1.5	0.0	0.0	0.0	VH
PZ	1.5	0.0	0.0	0.0	0.0	0.0	L
PZb	2.0	1.5	0.0	0.0	0.0	0.0	H

FAO_90	B_PH	B_ORGC	B_TEXT	B_FEOX	B_SULF	M_DRAIN	B_CLASS
PZc	1.5	1.5	0.0	0.0	0.0	0.0	M
PZf	1.5	0.0	0.0	1.0	0.0	0.0	M
PZg	1.5	0.0	0.0	0.0	0.0	0.0	L
PZh	1.5	0.0	0.0	0.0	0.0	0.0	L
PZi	1.5	0.0	0.0	0.0	0.0	0.0	L
RG	5.0	0.0	0.0	0.0	0.0	0.0	VH
RGc	5.0	0.0	0.0	0.0	0.0	0.0	VH
RGi	5.0	0.0	0.0	0.0	0.0	0.0	VH
SC	5.0	0.0	1.5	0.0	0.0	0.0	VH
SCg	5.0	0.0	1.5	0.0	0.0	0.0	VH
SCh	5.0	0.0	0.5	0.0	0.0	0.0	VH
#ST	5.0	0.0	1.5	0.0	0.0	0.0	VH
SN	5.0	0.0	1.5	0.0	0.0	0.0	VH
SNg	5.0	0.0	]1.5	0.0	0.0	0.0	VH
SNh	5.0	0.0	1.5	0.0	0.0	0.0	VH
SNm	5.0	0.0	1.5	0.0	0.0	0.0	VH
VR	5.0	0.0	1.5	0.0	0.0	0.0	VH
VRe	5.0	0.0	1.5	0.0	0.0	0.0	VH
VRk	5.0	0.0	1.5	0.0	0.0	0.0	VH
AT	4.0	0.0	0.0	0.0	0.0	0.0	H
ATu	4.0	0.0	0.0	0.0	0.0	0.0	H
##	4.0	0.0	0.0	0.0	0.0	0.0	H

Note:
FAO_90, soil classification according to FAO (1988).
B_PH, binding strength associated with pH conditions (see Table 3)
B_ORGC, binding strength associated with organic matter content (see Table 4)
B_TEXT, binding strength associated with soil textural class (see text, section 2.41)
B_FEOX, binding strength associated with presence of iron oxides (see text, section 2.4.1)
B_SULF, binding strength associated with sulfides (see text, section 2.4.1)
M_DRAIN, mobilizing capacity (or decrease in binding strength) associated with alternating wetting/drying conditions (see text, section 2.4.1).
B_CLASS, relative binding strength for heavy metal for the topsoil.
File: CD_SUB.dbf ; similar files are presented for the metals: Mn, Ni, Co, Zn, Cu, Cr(III), Pb, Hg, Fe(III), and Al.

C) Depth-weighted ratings for Cd binding by FAO soil unit

FAO_90	T_FIN	S_FIN	B_CLASS
AC	2.0	3.5	M
ACh	2.0	3.5	M
AN	3.5	4.0	H
ANu	3.5	4.0	H
AR	4.0	4.0	H
ARb	2.5	2.5	M
ARc	5.0	5.0	VH
ARh	3.5	3.5	H
#SA	4.0	4.0	H
CH	5.0	5.0	VH
CHg	5.0	5.0	VH
CHh	5.0	5.0	VH
CHk	5.0	5.0	VH
CHl	5.0	5.0	VH
CHw	5.0	5.0	VH
CL	5.0	5.0	VH
CLh	5.0	5.0	VH
CLl	5.0	5.0	VH
CM	4.0	4.0	H
CMc	5.0	5.0	VH
CMd	2.5	2.0	M
CMe	4.0	4.5	VH
CMg	4.0	4.5	VH
CMi	2.0	2.0	L
CMu	3.0	1.5	M
CMx	5.0	5.0	VH
FL	5.0	5.0	VH
FLc	5.0	5.0	VH
FLd	2.5	3.0	M

FAO_90	T_FIN	S_FIN	B_CLASS
FLe	4.5	5.0	VH
FLm	5.0	5.0	VH
FLt	5.0	5.0	VH
FLu	2.5	3.0	M
GL	4.0	4.0	H
GLd	2.5	1.5	M
GLe	4.5	5.0	VH
GLi	4.0	4.0	H
GLk	5.0	5.0	VH
GLm	5.0	5.0	VH
GLu	3.5	4.0	H
GR	5.0	4.5	VH
GRg	5.0	4.5	VH
GRh	5.0	5.0	VH
HS	4.0	4.5	VH
HSf	2.5	3.0	M
HSl	4.0	4.5	VH
HSs	4.0	5.0	VH
HSt	5.0	5.0	VH
KS	5.0	5.0	VH
KSh	5.0	5.0	VH
KSk	5.0	5.0	VH
KSl	5.0	5.0	VH
LP	5.0	5.0	VH
LPd	5.0	5.0	VH
LPe	5.0	5.0	VH
LPi	5.0	5.0	VH
LPk	5.0	5.0	VH
LPm	5.0	5.0	VH
LPq	4.0	5.0	VH

FAO_90	T_FIN	S_FIN	B_CLASS
LPu	3.0	5.0	H
#CR	4.0	5.0	VH
#RK	4.0	5.0	VH
LV	4.0	5.0	VH
LVa	3.5	4.5	H
LVg	4.0	5.0	VH
LVh	4.0	5.0	VH
LVj	2.5	3.5	M
LVk	5.0	5.0	VH
LVv	5.0	5.0	VH
LVx	3.5	5.0	H
PD	2.0	2.5	M
PDd	2.0	1.5	L
PDe	2.0	2.5	M
PDg	2.0	2.0	L
PDi	2.0	2.5	M
PDj	2.0	2.5	M
PH	4.5	5.0	VH
PHc	5.0	5.0	VH
PHg	4.0	5.0	VH
PHh	5.0	5.0	VH
PHj	4.5	5.0	VH
PHl	4.5	5.0	VH
PL	3.0	5.0	H
PLd	1.5	3.0	L
PLe	3.5	5.0	H
PLm	4.5	5.0	VH
PZ	1.5	1.5	L
PZb	2.0	3.5	M
PZc	2.5	3.0	M

FAO_90	T_FIN	S_FIN	B_CLASS
PZf	2.5	2.5	M
PZg	1.5	1.5	L
PZh	1.5	1.5	L
PZi	1.5	1.5	L
RG	5.0	5.0	VH
RGc	5.0	5.0	VH
RGi	5.0	5.0	VH
SC	5.0	5.0	VH
SCg	5.0	5.0	VH
SCh	5.0	5.0	VH
#ST	5.0	5.0	VH
SN	5.0	5.0	VH
SNg	5.0	5.0	VH
SNh	5.0	5.0	VH
SNm	5.0	5.0	VH
VR	5.0	5.0	VH
VRe	5.0	5.0	VH
VRk	5.0	5.0	VH
AT	4.0	4.0	H
ATu	4.0	4.0	H
##	4.0	4.0	H

Note:
FAO_90, soil unit classification according to FAO (1988). Codes starting with "#" refer to miscellaneous soil units (see footnote App. 1).
T_FIN, rating for binding strength of top soil (B_CLASS from file: Cd_TOP.dbf)
S_FIN, rating for binding strength of topsoil (B_CLASS from file: CD_SUB.dbf)
B_CLASS, depth-weighted rating for relative binding strength for Cd (see text, section 2.4.1).
File: CD_WEI.dbf; derived from analysis of files Cd_TOP.dbf and CD_SUB.dbf, see A and B above. Similar files are presented for the metals: Mn, Ni, Co, Zn, Cu, Cr(III), Pb, Hg, Fe(III), and Al.

E) Example of ratings for the relative Cd binding capacity by SOTER unit

NEWSUID	TCID	SCID	CLAF	PROP	SENS_C
RO0030	1	1	LVh	55	VH
RO0030	1	2	CMe	45	VH
RO0031	1	1	LVh	60	VH
RO0031	1	2	CMe	25	VH
RO0031	1	3	PDj	15	M
RO0032	1	1	ANu	45	H
RO0032	1	2	PZb	40	M
RO0032	1	3	CMe	15	VH
RO0033	1	1	LVh	70	VH
RO0033	2	1	CMe	15	VH
RO0033	2	2	CMd	15	M
RO0034	1	1	CMd	75	M
RO0034	1	2	PZb	25	M
RO0035	1	1	CMd	70	M
RO0035	2	1	CMe	15	VH
RO0035	3	1	LVh	15	VH
RO0036	1	1	CMd	55	M
RO0036	1	2	CMe	30	VH
RO0036	2	1	PZb	15	M
RO0037	1	1	PZb	55	M
RO0037	2	1	CMd	30	M
RO0037	3	1	LPq	15	VH
RO0038	1	1	PZb	40	M
RO0038	2	1	CMd	30	M
RO0038	3	1	CMe	30	VH
RO0039	1	1	PZb	65	M
RO0039	1	2	ANu	20	H
RO0039	1	3	PZh	15	L

NEWSUID	TCID	SCID	CLAF	PRO P	SENS_C
RO0040	1	1	PZb	50	M
RO0040	1	2	CMd	30	M
RO0040	2	1	PZh	20	L
RO0041	1	1	#W	100	?
RO0042	1	1	CHl	15	VH
RO0042	1	2	VRe	15	VH
RO0042	2	1	CHh	30	VH
RO0042	2	2	CHk	25	VH
RO0042	3	1	FLe	15	VH

Note:
NEWSUID, number of SOTER unit.
TCID, number of Terrain Component in specified SOTER unit.
SCID, number of Soil Component in specified Terrain Component and SOTER unit.
CLAF, soil classification according to FAO (1988).
PROP, relative area (%) of SCID (i.e., FAO soil unit) in SOTER unit.
SENS_C, rating for the relative Cd binding capacity for the specified combination of NEWSUID, TCID and SCID.
File: Cd_PAT1.dbf. File: Similar files are presented for the metals: Mn, Ni, Co, Zn, Cu, Cr(III), Pb, Hg, Fe(III), and Al.

D) Area-weighted ratings for the Cd binding strength by SOTER unit

NEWSUID	SENS_VL	SENS_L	SENS_M	SENS_H	SENS_V H	NO_DATA	REV_CLAS
RO0030	0	0	0	0	100	0	V5
RO0031	0	0	15	0	85	0	V4
RO0032	0	0	40	45	15	0	V2
RO0033	0	0	15	0	85	0	V4
RO0034	0	0	100	0	0	0	V2
RO0035	0	0	70	0	30	0	V2
RO0036	0	0	70	0	30	0	V2
RO0037	0	0	85	0	15	0	V2
RO0038	0	0	70	0	30	0	V2
RO0039	0	15	65	20	0	0	V2
RO0040	0	20	80	0	0	0	V1
RO0041	0	0	0	0	0	0	#W
RO0042	0	0	0	0	100	0	V5

Note:
NEWSUID, number of SOTER unit
SENS_VL, relative area of soil units with a rating of VL (Very Low) for the relative Cd binding capacity within the specified SOTER unit (Takes into account the full map unit composition, in terms of Terrain Components and Soil Components, of each SOTER unit).
SENS_L, as above but Low for the relative Cd binding capacity.
SENS_M, as above but for Moderate for the relative Cd binding capacity.
SENS_H, as above but for High for the relative Cd binding capacity.
SENS_VH, as above but for Very High for the relative Cd binding capacity.
NO_DATA, relative area for which data availability for CCPs precluded the assessment of the relative Cd binding capacity.
REV_CLAS, area-weighted rating for the Cd 0.0.0.1binding capacity (see Table 6); values range from V0 for the lowest to V5 for the highest rating.
File: Cd_PAT3.dbf. Similar files are presented for the metals: Mn, Ni, Co, Zn, Cu, Cr(III), Pb, Hg, Fe(III), and Al.

App. 3. Ratings for the relative sensitivity of soils to acid deposition

A) Depth-weighted ratings for the relative sensitivity of soils to acid deposition

FAO_90	ACID_T	ACID_B	B_CLASS
AC	1	1	VH
ACh	1	1	VH
AN	2	2	H
ANu	2	2	H
AR	3	3	M
ARb	2	3	H
ARc	3	3	M
ARh	3	3	M
CH	5	5	VL
CHg	5	5	VL
CHh	5	5	VL
CHk	5	5	VL
CHl	5	5	VL
CHw	5	5	VL
CL	5	5	VL
CLh	5	5	VL
CLl	5	5	VL
CM	4	5	L
CMc	5	5	VL
CMd	2	1	H
CMe	5	5	VL
CMg	5	5	VL
CMi	2	2	H
CMu	1	1	VH
CMx	5	5	VL
FL	5	5	VL
FLc	5	5	VL

FAO_90	ACID_T	ACID_B	B_CLASS
FLd	2	1	H
FLe	5	5	VL
FLm	5	5	VL
FLt	5	5	VL
FLu	2	5	M
GL	4	5	L
GLd	2	3	H
GLe	4	5	L
GLi	5	5	VL
GLk	4	5	L
GLm	5	5	VL
GLu	3	3	M
GR	5	4	VL
GRg	5	4	VL
GRh	5	5	VL
HS	5	5	H
HSf	3	3	VH
HSl	5	5	H
HSs	5	5	H
HSt	5	5	H
KS	5	5	VL
KSh	5	5	VL
KSk	5	5	VL
KSl	5	5	VL
LP	5	5	VL
LPd	2	2	H
LPe	5	5	VL
LPi	5	5	VL
LPk	5	5	VL
LPm	5	5	VL

FAO_90	ACID_T	ACID_B	B_CLASS
LPq	5	5	VL
LPu	3	4	M
LV	5	5	VL
LVa	5	5	VL
LVg	3	5	L
LVh	5	5	VL
LVj	3	4	M
LVk	5	5	VL
LVv	5	5	VL
LVx	5	5	VL
PD	2	3	H
PDd	2	2	H
PDe	2	3	H
PDg	3	3	M
PDi	2	3	H
PDj	3	4	M
PH	5	5	VL
PHc	5	5	VL
PHg	4	5	L
PHh	5	5	VL
PHj	5	5	VL
PHl	5	5	VL
PL	4	5	L
PLd	1	2	VH
PLe	2	5	M
PLm	4	5	L
PZ	1	1	VH
PZb	2	1	H
PZc	1	1	VH
PZf	1	1	VH

FAO_90	ACID_T	ACID_B	B_CLASS
PZg	2	1	H
PZh	1	1	VH
PZi	1	1	VH
RG	5	4	VL
RGc	5	5	VL
RGi	5	4	VL
SC	5	5	VL
SCg	5	5	VL
SCh	5	5	VL
SN	5	5	VL
SNg	5	5	VL
SNh	5	5	VL
SNm	5	5	VL
VR	5	5	VL
VRe	5	5	VL
VRk	5	5	VL
##	5	5	VL
#SA	3	3	M
#RK	5	5	VL
#ST	5	5	VL
#CR	5	5	VL
AT	5	5	VL
ATu	5	5	VL

Note:
FAO_90, is the soil unit classification according to FAO (1988).
ACID_T, is the rating for the relative sensitivity of the topsoil to acid deposition (see Table 7).

ACID_B, is the rating for the relative sensitivity of the subsoil to acid deposition (see Table 7).
B_CLASS, is the depth-weighted rating for relative sensitivity of the topsoil to acid deposition (see text, section 2.5.1).
File: ACID.dbf. Similar files are presented for the metals: Mn, Ni, Co, Zn, Cu, Cr(III), Pb, Hg, Fe(III), and Al.

B) Example of rating of the relative sensitivity to acid deposition by soil unit and SOTER unit

NEWSUID	TCID	SCID	CLAF	PRO P	SENS_C
RO0030	1	2	CMe	45	VL
RO0031	1	1	LVh	60	VL
RO0031	1	2	CMe	25	VL
RO0031	1	3	PDj	15	M
RO0032	1	1	ANu	45	H
RO0032	1	2	PZb	40	H
RO0032	1	3	CMe	15	VL
RO0033	1	1	LVh	70	VL
RO0033	2	1	CMe	15	VL
RO0033	2	2	CMd	15	H
RO0034	1	1	CMd	75	H
RO0034	1	2	PZb	25	H
RO0035	1	1	CMd	70	H
RO0035	2	1	CMe	15	VL
RO0035	3	1	LVh	15	VL
RO0036	1	1	CMd	55	H
RO0036	1	2	CMe	30	VL
RO0036	2	1	PZb	15	H
RO0037	1	1	PZb	55	H
RO0037	2	1	CMd	30	H
RO0037	3	1	LPq	15	VL
RO0038	1	1	PZb	40	H
RO0038	2	1	CMd	30	H
RO0038	3	1	CMe	30	VL
RO0039	1	1	PZb	65	H
RO0039	1	2	ANu	20	H
RO0039	1	3	PZh	15	VH
RO0040	1	1	PZb	50	H

NEWSUID	TCID	SCID	CLAF	PRO P	SENS_C
RO0040	1	2	CMd	30	H
RO0040	2	1	PZh	20	VH
RO0041	1	1	#W	100	?
RO0042	1	1	CHl	15	VL
RO0042	1	2	VRe	15	VL
RO0042	2	1	CHh	30	VL
RO0042	2	2	CHk	25	VL
RO0042	3	1	FLe	15	VL

Note:
NEWSUID, number of SOTER unit.
TCID, number of Terrain Component in specified SOTER unit.
SCID, number of Soil Component in specified Terrain Component and SOTER unit.
CLAF, soil classification according to FAO (1988).
PROP, relative area (%) of SCID (i.e., FAO soil unit) in SOTER unit.
SENS_C, rating for the relative sensitivity to acid deposition for specified combination of NEWSUID, TCID and SCID (see Table 7).
File: ACI_PAT1.dbf.

C) Example of area-weighted rating for the relative sensitivity to acid deposition, by SOTER unit

NEWSUID	SENS_VL	SENS_L	SENS_M	SENS_H	SENS_VH	NO_DATA	REV_CLAS
RO0030	100	0	0	0	0	0	V0
RO0031	85	0	15	0	0	0	V1
RO0032	15	0	0	85	0	0	V2
RO0033	85	0	0	15	0	0	V1
RO0034	0	0	0	100	0	0	V3
RO0035	30	0	0	70	0	0	V2
RO0036	30	0	0	70	0	0	V2
RO0037	15	0	0	85	0	0	V2
RO0038	30	0	0	70	0	0	V2
RO0039	0	0	0	85	15	0	V3
RO0040	0	0	0	80	20	0	V3
RO0041	0	0	0	0	0	0	#W
RO0042	100	0	0	0	0	0	V0

Note:
NEWSUID, number of SOTER unit.
SENS_VL, relative area of soil with a rating of VL (Very Low) for the relative sensitivity to acid deposition within specified SOTER unit.
SENS_L, as above but for Low relative sensitivity.
SENS_M, as above but for Moderate relative sensitivity.
SENS_H, as above but for High relative sensitivity.
SENS_VH, as above but for Very High relative sensitivity.
NO_DATA, relative area for which data availability for CCPs precluded the assessment of the relative vulnerability.
REV_CLAS, area-weighted rating for the sensitivity to acid deposition (see Table 8).
File: ACI_PAT3.dbf; based on analysis of file ACI_PAT1.dbf.

App. 4. Ratings for the relative vulnerability of soils to Cd mobilization, inducible by acid deposition

A) Example of ratings by individual soil units in a given SOTER unit

NEWSUID	TCID	SCID	CLAF	PROP	ACID_SENS	MET_BIND	VULNER
RO0030	1	1	LVh	55	VL	VH	VL
RO0030	1	2	CMe	45	VL	VH	VL
RO0031	1	1	LVh	60	VL	VH	VL
RO0031	1	2	CMe	25	VL	VH	VL
RO0031	1	3	PDj	15	M	M	M
RO0032	1	1	ANu	45	H	H	H
RO0032	1	2	PZb	40	H	M	M
RO0032	1	3	CMe	15	VL	VH	VL
RO0033	1	1	LVh	70	VL	VH	VL
RO0033	2	1	CMe	15	VL	VH	VL
RO0033	2	2	CMd	15	H	M	M
RO0034	1	1	CMd	75	H	M	M
RO0034	1	2	PZb	25	H	M	M
RO0035	1	1	CMd	70	H	M	M
RO0035	2	1	CMe	15	VL	VH	VL
RO0035	3	1	LVh	15	VL	VH	VL
RO0036	1	1	CMd	55	H	M	M
RO0036	1	2	CMe	30	VL	VH	VL
RO0036	2	1	PZb	15	H	M	M
RO0037	1	1	PZb	55	H	M	M
RO0037	2	1	CMd	30	H	M	M
RO0037	3	1	LPq	15	VL	VH	VL
RO0038	1	1	PZb	40	H	M	M
RO0038	2	1	CMd	30	H	M	M
RO0038	3	1	CMe	30	VL	VH	VL
RO0039	1	1	PZb	65	H	M	M
RO0039	1	2	ANu	20	H	H	H

NEWSUID	TCID	SCID	CLAF	PROP	ACID_SENS	MET_BIND	VULNER
RO0039	1	3	PZh	15	VH	L	L
RO0040	1	1	PZb	50	H	M	M
RO0040	1	2	CMd	30	H	M	M
RO0040	2	1	PZh	20	VH	L	L
RO0041	1	1	#W	100	?	?	#W
RO0042	1	1	CHl	15	VL	VH	VL
RO0042	1	2	VRe	15	VL	VH	VL
RO0042	2	1	CHh	30	VL	VH	VL
RO0042	2	2	CHk	25	VL	VH	VL
RO0042	3	1	FLe	15	VL	VH	VL

Note:
NEWSUID, number of SOTER unit.
TCID, number of Terrain Component in specified SOTER unit.
SCID, number of Soil Component in specified Terrain Component and SOTER unit
CLAF, soil classification according to FAO (1988).
PROP, relative area (%) of SC in SOTER unit.
ACID_SENS, rating for relative sensitivity to acid deposition for specified combination of NEWSUID, TCID and SCID (Corresponds with rating for REV_CLAS in file ACI_PAT1.dbf).
MET_BIND, rating for relative HM-binding capacity for specified combination of NEWSUID, TCID and SCID (Corresponds with rating for REV_CLAS in file CD_PAT1.dbf).
VULNER, rating for the vulnerability of soils to HM-mobilization, inducible by acid deposition (see Table 9).
File: ACI__CD_1.dbf. Similar files, called ACI__xx_1.dbf, are presented for Zn and Pb.

B) Area-weighted soil vulnerability rating with respect to Cd mobilization, inducible by acid deposition

NEWSUID	VUL_VL	VUL_L	VUL_M	VUL_H	VUL_VH	NO_DATA	REV_CLAS
RO0030	100	0	0	0	0	0	V0
RO0031	85	0	15	0	0	0	V1
RO0032	15	0	40	45	0	0	V2
RO0033	85	0	15	0	0	0	V1
RO0034	0	0	100	0	0	0	V2
RO0035	30	0	70	0	0	0	V1
RO0036	30	0	70	0	0	0	V1
RO0037	15	0	85	0	0	0	V1
RO0038	30	0	70	0	0	0	V1
RO0039	0	15	65	20	0	0	V2
RO0040	0	20	80	0	0	0	V1
RO0041	0	0	0	0	0	0	#W
RO0042	100	0	0	0	0	0	V0

Note:
NEWSUID, number of SOTER unit.
VUL_VL, relative area of soil units with a rating of VL (Very Low) for the relative vulnerability to Cd mobilisation, inducible by acid deposition for specified SOTER unit.
VUL_L, as above but for Low relative vulnerability.
VUL_M, as above but for Moderate relative vulnerability.
VUL_H, as above but for High relative vulnerability.
VUL_VH, as above but for Very High relative vulnerability.
NO_DATA, relative area for which data availability for CCPs precluded the assessment of the relative vulnerability.
REV_CLAS, area-weighted rating for the vulnerability to acid deposition (see Table 11).
File: ACI_CD_3.dbf, derived from file ACI_CD_1.dbf. Similar files, called ACI__xx_1.dbf, are presented for Zn and Pb.

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