01.01 Soil Associations (Edition 2005)

Overview

Definition of Soil

Soil is the layer of earth formed on the surface by weathering and the influence of all other environmental factors. The mineral and organic substances of soil are pervaded with air, water and life forms. Natural soil originates through the combined interaction of parent material (basis rock), climate, water, relief, topography, flora, and fauna. The conditions at each location produce different soil types with characteristic profiles and specific physical and chemical properties.

Along with air, water, and sunlight, soil is the basis of life for plants and animals, including humans. Soil is used as a production base for agriculture and forest plantations. Soil is affected by human interventions, by being moved and removed, altered, and destroyed, such as by construction. Soil is an important natural resource with many functions:

– natural habitat for animals and plants,
– part of the ecosystem and its material cycles,
– production basis for foodstuffs, feeds, and plants useful as raw materials,
– filter and storage depot for groundwater,
– location and supporter of constructed facilities,
– an influential element of nature and the landscape and
– an archive of natural and cultural history.

Soil Formation

Soil formation is a natural process beginning on the surface of the earth and continuing into the depths. Table 1 names factors and processes which lead to differentiations of soil structures and properties, and to the formation of various soil horizons (layers). Soil types are formed by combinations of soil horizons.

Tab. 1: Overview of Soil-forming Factors and Soil Development Processes (after Lieberoth 1982)		
Soil-forming factors		**Soil development processes**
parent material	solid rock	physical weathering
	loose rock	chemical weathering
climate	temperature	humus formation
	water	mineralizing
	wind	carbonate leaching (washouts)
surface formation	surface forms	clay muddying
	slope incline	podzolization
	exposure	gleying
vegetation	soil vegetation	nutrient transport
	shrub vegetation	erosion
	tree vegetation	accumulation
soil fauna		bio- and techno TURBATION
micro fauna		
human interventions	material loss (e.g. crop harvest)	
	melioration	
	material input (e.g. fertilizer, pollutants)	

Tab. 1: Overview of Soil-forming Factors and Soil Development Processes (after Lieberoth 1982)

Soil is formed from source rock; it is a mixture of 3 components and 3 phases of solid, fluid, and gaseous constituents:

solids: minerals, including rock fragments of various sizes, oxides, salts, colloids, and organic materials

fluids: soil solution with dissolved nutrients and other elements

gaseous: soil air (oxygen, nitrogen, carbon dioxide).

Systematization of Soils

Soils are systematized in divisions, major soil groups, soil types, soil units, and soil forms. (Translator's note: Soil systems in various countries and languages are complicated and are not uniform. This translation is oriented to the FAO/UNESCO system, as much as is possible. The terms in parenthesis following the FAO/UNESCO are common terms. The common terms are given so that readers who are not soil specialists may have some access.)

The following divisions are differentiated according to groundwater level:

– terrestrial soils
– semiterrestrial soils (semi-hydromorphic soils)
– hydromorphic soils (groundwater soils)
– sub-enhydrous soils (submerged soils)
– bogs/swamps.

Table 2 exemplifies the principle of systematization with the division of terrestrial soils, major soil group of cambisols and andosols (brown soils). A detailed description of soil systemization in German is found in the Bodenkundliche Kartieranleitung (1982 ,1994 and 2005).

Tab: 2: Soil Classification according to Bodenkundliche Kartieranleitung 1982
(Soil Science Mapping Guidelines)

Division	Major Soil Gro	Soil Type	Soil Unit	Soil Form
terrestrial	cambisols	(typical)	normal type	
soils	(brown soils)	cambisol	cambisol	...on glacial sand
			transitional type	
			spodo-dystric cambisol	...on drift sand
			dystric cambisol	...on glacial sand
		luvisol		...on boulder marl
		podzoluvisol		...on boulder marl

Tab: 2: Soil Classification according to Bodenkundliche Kartieranleitung 1982 (Soil Science Mapping Guidelines)

Soil Types - Horizons

Soil types are seen as stages of soil development often encountered under certain environmental conditions. They unify soils with the same or similar profile structures (horizon layers), due to similar processes of material transformations and translocations.

The most frequent soil types in Berlin are mineral soils with less than 30 mass percent of organic substances. These soils are sometimes overlaid with organic horizons of varying thickness; H, L, or O horizons with more than 30 mass percent of organic substances, especially in forests.

Soil types of mineral soils are categorized into the following horizons:

mineral topsoil horizon A horizon

mineral subsoil horizon B horizon

mineral undersoil horizon C horizon

The **mineral topsoil A horizon** is characterized by the accumulation of organic substances and/or a loss of mineral substance; washouts of clay, humic materials, iron oxides and aluminum oxides. Material-specific accumulation and translocation processes enable further divisions of the A horizon. This differentiation in horizon terminology is given with a lower case letter; e.g., Ah, h stands for humus; Al, l stands for clay lessivation (washout).

The **mineral subsoil B horizon** is characterized by the accumulation of materials washed out of the topsoil horizon, as well as weathering and transformational processes, e.g., brunification, formation of clay, etc. This produces colors and material compositions different than the parent rock. Further differentiation of the B horizon parallels the A horizon, e.g. Bv, v stands for brunification; Bt, t stands for clay illuviation ("wash in").

The **mineral undersoil C horizon** is formed by the relatively unaltered parent rock underneath the soil.

Soils characterized by several material translocational or transformational processes have several A and/or B horizons in their soil profile.

The horizon sequence gives the horizon profile. The horizon profile is then used to differentiate soils into soil types.

Another factor in the formation of soil types is the groundwater level. The temporary or permanent action of groundwater on soils affects how terrestrial soils form gley characteristics, e.g. rust and bleached spots. The depth of gley characteristics is applied in the naming of soil types, such as cambisols (brown soils):

< 40 cm	- eutric gleysol (brown gley soil)
40 - 80 cm	- eutro-gleyic cambisol (gleyic brown soil)
80 - 130 cm	- stagno-gleyed cambisol (gleyed brown soil)

Anthropogenic Alterations of the Soil

Anthropogenic alterations of the soil have increased with progressing use of technologies and the use of ever larger areas.

Today there are hardly any untouched soils with unaltered horizon structures. Soils are categorized as near-natural where horizon sequences remain largely unchanged in spite of human uses such as forest plantations. Soils are categorized as anthrosols (anthric, anthropogenic soils, soils influenced by humans) when the horizon sequence has been destroyed. It has proven extremely difficult to categorize soils into these two groups. The upper 20-30 cm of soils used for agriculture are usually mixed by plowing. Soils used for military training or for cemeteries can sometimes retain near-natural soils alternating in small areas with anthric soils. The degree of anthropogenic influence and/or the degree of destruction is difficult to estimate without soil studies. Another factor for the effect of use is whether area use was total or partial.

A developmental point of view sees soils as relatively "young" or "old". Soils relatively unaffected by use have a developmental period of up to several thousand years. The primary development of soils in the Berlin area occured in the Holocene period, which began about 10,000 years ago. A favorable climate, and the quick spread of vegetation connected with it, caused a stronger formation of soils. Various soil-forming processes took place during the long developmental period, and these processes are reflected in the formation of typical horizons. The horizon sequences of these soil types are much more greatly differentiated than those of "younger" soils.

Soil does not reproduce and is not reproducible. The use of soil is often linked with alterations of the original ecological conditions and this can lead to serious endangerment to the functional abilities of soil or even to its existence.

The **quantity** of this natural resource is endangered by the progressive sealing of surfaces. Industrial, commercial, traffic, and residential uses of soil have greatly increased in recent years. Unsealed soils once used agriculturally are found at the edge of the city; these soils have largely near-natural structures. Building construction causes soils to be transported, mixed, and sealed over extensive areas.

The **quality** of soils is altered by pollutants. Soils are impaired by pollutant inputs from unregulated waste disposal, accidents, spills and leakages, improperly conducted storage depots, as well as emissions from industry, commerce, and traffic.

Pollutant inputs can directly and indirectly endanger all organisms, including humans. The primary danger is uptake of pollutants through the food chain, but attention must also be given to the direct oral uptake of soils, especially by small children.

Soil can only store a certain amount of pollutants. If soil storage capacity is exceeded, pollutants can pass through soils and enter groundwater.

These problems are more intense in metropolitan areas like Berlin: "area use", the quantitative problem of sealing, and the qualitative problem of material loads on soils from old contaminated sites and other pollutant inputs.

The protection of the remaining near-natural soils is urgently necessary because soil does not reproduce; it cannot be manufactured, bred or grown. Strongly impaired soils can hardly ever be restored to their original quality.

Soil Protection

The discussion and considerations on soil protection at the federal and state government levels in West Germany first really got underway at the beginning of the 80's. Soil protection was first anchored in law in the Federal Soil Protection Law of 1999. This law was supplemented by a Berlin law in 2004.

The goal of the Berlin Soil Protection Law is "to protect the soil as the basis of life for humans, animals, and plants; to avert damaging alterations and to take precautions against the origin of new ones". Long-term effects to soil are to be avoided, and the natural functions of soil are to be protected.

A prerequisite for effective soil protection is knowledge about the condition of soils, as well as impairments in their quantity and quality. Information has been processed for years in Berlin about soil use, degree of sealing, and material load. This information is the basis for the evaluation of anthropogenic load on soils A Cadastre of impacts on soil were conducted, and a Map of Degree of Sealing, and a Map of Use were prepared.

The planning of soil protection measures and the consideration of soil protection concerns at individual planning levels require determinations of soil value, suitability, and sensitivity. Complete data about distribution of soils and their ecological characteristics must be available. The Map of Soils offers a basis for the derivation of ecological parameters that serve the evaluation of properties and functions of soils.

Statistical Base

A complete Soil Association Map for West Berlin was prepared by Grenzius in 1984, and the map was published in the Environmental Atlas (SenStadtUm 1985). Soils in a landscape segment interact with neighboring soils, air, water, and vegetation. Grenzius did not identify individual soil types, but rather combined soil types that interact with each other in a given landscape segment (geomorphic units) into soil associations. These soil associations were studied and evaluated for their location characteristics.

The Concept Map of Soil Associations was prepared for West Berlin based on the Map of Soil Associations and commentaries by Grenzius (Grenzius 1987), which define and describe soil associations, was updated for the first time in 1990. The assignment of soil associations, the determination of new soil associations and concept soil associations for East Berlin were enabled by a transposition concept (Aey 1991) based on analogical conclusions, and with the aid of information from geologic and topographic maps, forest site surveys, detailed maps, aerial photography evaluations, and information about area uses and degrees of sealing. Newer soil maps and an updated map of area uses in West Berlin necessitated a reworking and updating of the map of soil associations in West Berlin. For the first time a map of soil for the entire city was created middle of the (SenStadt 1998). Changes of landuse, updated data of surface sealing and depth to groundwater demand an update in 2003, the result is published now. Table 3 gives the map data bases and the preliminary information used in the different stages of work.

Tab. 3: Grundlagen der Konzeptkarte der Bodengesellschaften von Berlin
Vorinformationen:
· Bodengesellschaften Berlin (West) - Karte 1: 50 000 (1985)
· Grenzius 1987: Die Böden Berlins (West), Diss.
· Fahrenhorst, Haubrok, Sydow 1990: Übernahme der Bodengesellschaftskarte Berlin in das Umweltinformationssystem Berlin und Zuordnung von Bodeninformationen
· Aey 1991: Konzept zur Erstellung einer Bodenkarte von Berlin
· Gerstenberg, J.H.; Smettan, U. 2003: Erstellung von Karten zur Bewertung der Bodenfunktionen, im Auftrag der Senatsverwaltung für Stadtentwicklung, Berlin; unveröffentlicht.
Flächendeckende Zusatzinformationen:
· Geomorphologische Karten 1 : 100 000 und 1 : 200 000
· Geologische Karten 1 : 25 000
· Geologischer Übersichtskarte (GÜK) von Berlin und Umgebung (M 1 : 100.000)
· Topographische Karten 1 : 25 000 verschiedenen Alters
· Topographische Karten 1 : 10 000 (Militärtopographische Karten) (1988)
· Topographische Karten 1 : 5 000, 1 : 4 000
· Luftbilder 1 : 4 000 und 1 : 6 000 (1990)
· Datei der aktuellen Nutzungen und Versiegelungsgrade (Stand:2001)
· Karte des Flurabstandes des Grundwassers 1 : 50 000 (Stand: Mai 2002)
· Karte des Zustandes der Gewässerufer 1 : 50 000 (1994)
Detailinformationen:
· Forstliche Standortserkundung 1 : 10 000 (Ost-Berlin) (1992)
· Standortkundliches Gutachten für die Berliner Forsten (Westteil) - FSK Berlin-West (1991)
· Geologische Karten 1 : 10 000
· Mittelmaßstäbige Landwirtschaftliche Standortkartierung (MMK) 1 : 100 000 und 1 : 25 000 (1976)
· Karte der Rieselfelder 1 : 30 500 (1993)
· Karten der Gebäudeschäden 1945, 1 : 10 000 und 1 : 25 000
· Detailkartierungen aus naturschutzrechtlichen Unterschutzstellungsverfahren
· Bodenkundliche Untersuchungen des Instituts für Bodenkunde der TU Berlin
· Altlastenkataster (Stand: Dezember 1993 Ost-Berlin, September 1994 West-Berlin)

Tab. 3: Basis of the Concept Map of Soil Associations of Berlin

Methodology

Basic Situation

Aey (1991) wrote a guide for the preparation of a Concept Map of Soil Associations in the entire city. This guide was based on: 1) the method described by Grenzius (1987) for the preparation of a Soil Association Map for West Berlin; 2) the Map of Soil Associations by Grenzius which was transferred into the spacial reference system of Information System (ISU) by Fahrenhorst, Haubrok, and Sydow (1990). No Soil Association Map of this or a similar kind existed for East Berlin. The bases for the development of the soil association map of West Berlin were the excavations and drilling stock samples conducted in all of West Berlin. These were conducted in forest plantations and agricultural areas under consideration of geomorphological-hydrological conditions, and, in populated areas, under consideration of uses. All parent rock and most uses, with the exception of industrial areas, were surveyed several times, and mapping was begun. The evaluation of this mapping enabled analogical conclusions for soil conditions at unmapped areas.

The comprehensive soil science studes used for the Map of Soil Associations in West Berlin have verified the Map for many areas, such as forest and agricultural areas (farmland). The map is to be regarded as partially verified for areas with lesser degrees of soil science studies. Such detailed soil mapping for East Berlin only exists for forests. All derivations and determinations of soil associations for East Berlin - except for forest plantations - had to be made on the basis of analogical conclusions and existing material, such as geological and topographical maps, soil maps, and area uses, etc.. The accuracy, informational content, and age of this material varied greatly.

More precise classification schemes for soil associations, as well as the definition of new soil associations not yet described by Grenzius were enabled by maps and soil studies conducted in West Berlin after the publication of the West Berlin Soil Association Map, as well as existing soil maps for East Berlin, particularly for forest plantation areas.

The existing map for East Berlin is to be regarded as confirmed only for forest plantations. It is a concept map for all other areas. This is the reason why the entire map itself is to be regarded only as a concept map with some confirmed areas.

The map scale of 1:50,000 does not allow the spatial distribution of individual soil types to be portrayed. Unifying units had to be selected. Soils of spacial and material coherence were combined as soil associations.

Naming

The **naming** of the soil associations was based on the interactions of characteristic soils. The first and last soil of the association were given in the German system, and, usually, one of the soils that characterizes material translocations (Grenzius 1987). This interacting system, or the link between soils in areas still extensively near-natural is characterized in the map legend by "-".

Near-natural soils are found only in loosely settled areas.

The structures of soils in settled areas have sometimes been greatly altered by human influences. Anthrosols appear randomly next to each other and are connected in the legend by "+".

The legend is structured according to the degree of anthropogenic influence on and alterations of the soil. Near-natural soils are at the beginning; first the terrestrial soils, and then the semi-terrestrial soils. Soil associations of anthropogenic aggradations and erosion are listed at the end. (Translator's note: "aggradation" describes soils and materials which have been placed somewhere by natural processes (glaciers, water flows) or human actions. Anthropogenic aggradations include deep landfills (waste and debris depots, etc.), and shallow landfill of upper layers (playgrounds, building construction sites, street construction, etc.))

Drawn Borders

The **borders were drawn** between soil associations at ridges and sinks (relief). Neighboring units could then show the same beginning and ending points. The area delineation of soil associations also had to conform to the Berlin Digital Spatial Reference System based on block and block segment areas of homogeneous use. If this procedure would have led to great losses of information, particularly in non-built-up and loosely built-up areas such as forests, agricultural areas, and settled areas with low degrees of sealing, then these areas were further divided according to the borders of the soil associations. The decisive factors in these cases were the borders of geomorphological and geological units, contour lines, soil types (detail map), and aggradation borders. The factors for the delineation of anthric soil associations were area uses and the borders of aggradation (accumulation) or erosion.

Near-natural and Anthric Soil Associations

Determining factors for soil development are parent substrate, prevailing soil type, relief (slope, sink, channel, gradient etc.), water and climate conditions, as well as the degree of human influence. Anthropogenic influences are characterized by aggradation of natural soil material and non-natural soil materials (war debris, construction debris, slag and cinders), and erosion of natural soil. Important measures for anthropogenic alterations in soil are present and previous use, and the degree of sealing. The map only shows unsealed soils, independent of the degree of sealing. The degree of sealing is used only as an aid for the evaluation of the degree of anthropogenic alterations of unsealed soils in this area.

Near-natural soil associations are characterized by typical soil types, geomorphological structures, substrate/soil types, and the influence of water. Alterations caused by humans are low.

The soil structure and soil associations of **anthric soil associations** are not influenced by the topographical relief but rather by type of use, as well as the occurrence and type of aggradations. Some transitional forms still retain the characteristics of parent substrate, geomorphology, groundwater levels, and some natural soils. This is the case at military training areas, former surface mining sites, cemeteries, and levelled sewage farms.

Table 4 gives results of human effects on soils. It orders the urban area into various soil association categories (anthric soil associations) under consideration of historic and current uses, damage to buildings in the Second World War, the type of construction, and the degree of sealing.

Landscape segments and land uses	Effects on soils
bog	usually dried; soiled above; sometimes acid; sometimes with accumulated heavy metals
forest	topsoil disturbed by planting; accumulated heavy metals in topsoil and organic layer; soil strongly acid
farmland (agricultural field)	top 3 dm plowed; varying degrees of organic and mineral fertilizers; clearly increased pH value compared to forest plantations, according to crops; sometimes accumulated heavy metals
landscape park/park	landscape park situation similar to forest; parts of soil strongly acid; other parts with somewhat increased pH values from caretaking measures; structures sometimes altered by decorative landscaping measures, sometimes replaced by anthropogenically aggraded gravel and stone
	parks - alternate natural soils with soils from landfill/aggradations with high nutrient and pollutant contents; sometimes fertilized and watered
allotment gardens	soils partially transported by house construction, or replaced by anthropogenic landfill/aggradations of gravel and stone; garden areas altered by use of organic substances and excavations (hortisols); heavy fertilization; pH value in neutral range; no original soils at gardens on aggradation or excavated areas; soils on debris (over waste fill) heavy use of organic and mineral fertilizers; watered; sometimes stressed by pollutants
cemetery	soils extensively altered by deep excavation and introduction of organic substances (necrosols); that and fertilization and watering resulting in pH values in weak-acid to neutral range
outdoor water recreation	soil erosion after destruction of reeds and vegetation and by water recreation; sometimes sand landfill; mostly raw soil stage; eutrophied by nutrient-rich water
airport	soils retained after construction exist only in small areas; usually greatly altered by grading, compacting; sometimes soil on debis aggradation/landfill
sewage farms	soils altered during construction by grading, compacting, and irrigation of waste waters; accumulated nutrients, salts, and heavy metals; pH values in moderately weak to acid range; high degree of watering
park, mainly on aggradations; open areas in the inner city; hills of debris	no original soils exist; soil development on debris fill or transported natural stone; sometimes watered, polluted; pH values in neutral range; barely interactive ruderal soils
military practice areas, gravel pits	hardly any original soils; raw soils from excavations and transfer; poor in nutrients
track facilities	no original soils; high levels of herbicides
traffic areas, street edges, paths, squares	aggredations/fills, sealing of soils; reduction of water uptake and gas exchange; penetration of salts, lead, and cadium (traffic), oil (accidents), gas, heat (defective pipelines), etc.
residential areas	
- loose construction (with yards)	some natural soils, according to construction density; humus accumulation and eutrophication; planned watering
- closed construction in the inner city	hardy any or no original soils, depending on construction type; some soils of construction and war debris; sometimes fertilized, watered, stressed by pollutants; pH values in neutral to (extreme) basic range; pollutant inputs
industrial locations and technical supply facilities	hardly any natural soils; production-specific pollutant inputs; aggradations (construction and war debris, ashes, cinders); compaction of soils

Tab. 4: Landscape Segments, Land Uses and Effects on Soils (after Blume et al. 1978 and Grenzius 1987)

Soil Associations / Collective Soil Associations / Concept Soil Associations

The near-natural and anthric soil associations defined for West Berlin by Grenzius were transposed onto East Berlin with the aid of existing data bases, and analogical conclusions for comparable areas, such as geomorphology, use, water conditions, etc.. Problems occurred in areas where existing data bases did not enable clear classifications of soil associations based on analogical conclusions, or where combinations of uses and geomorphology appeared that were not considered or did not exist in West Berlin. Examples of these areas are plots once used for sewage farms, sinks in flat upland areas, and mapped podzolic soils of end morraines. Besides the soil associations applied in the Soil Association Map of West Berlin, the availability of appropriate mapping will be used to develop new soil associations. If there is insufficient information, then concept soil associations as well as collective soil associations will be developed. The soil associations used in the map have three different levels of differentiation and characterization:

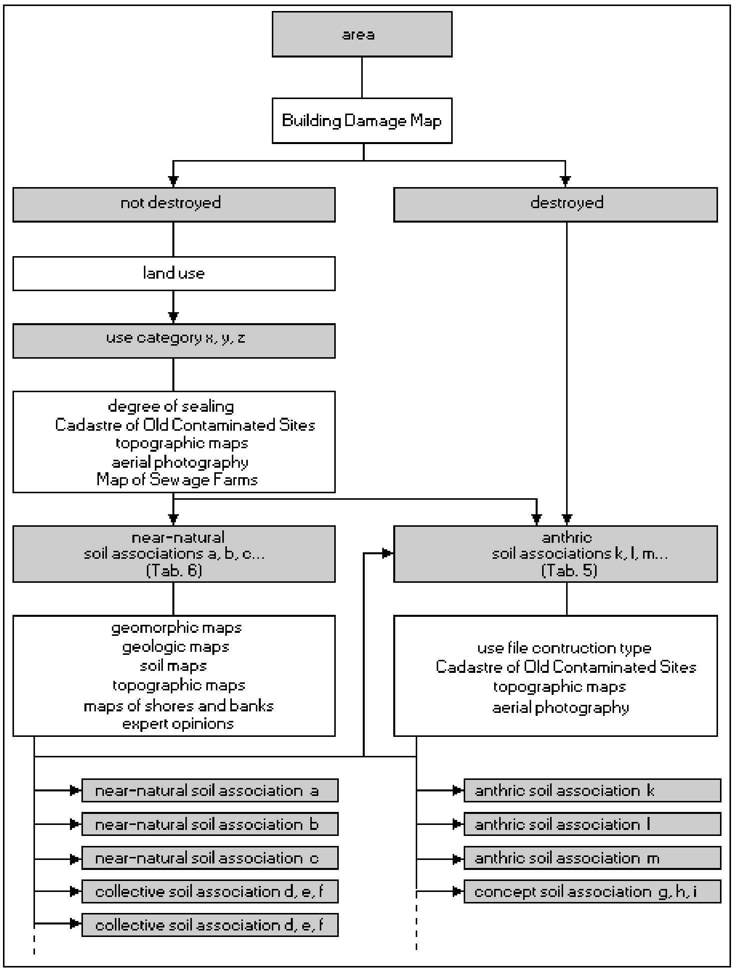
1. **Soil Associations (SA)** - Soil associations in dependence on geomorphology and use. These can be verified by field studies in the form of detail maps, key profiles, and soil profile studies.
2. **Collective Soil Associations (CSA)** - These soil associations are collected because insufficient data material for East Berlin does not allow a differentiated categorization of individual soil associations.
3. **Concept Soil Associations** - are soil associations which do not exist or which have not yet been verified in West Berlin. They are a combination of use and geomorphology, such as levelled sewage farms. They have not yet been verified by soil studies.
4. 

Fig. 1: Classification of Soil Associations, Schematic Depiction of Procedure

Categorization of Soil Associations

The categorization of soil associations occurs in several processing steps:

1. The actual use of a given area was found in the land use file. Each type of use category has a special model pattern for categorization of soil associations (cf. Fig. 1).
2. Areas were defined as having mainly naturally developed soils or highly anthric soils (cf. Fig. 1). Land use and degree of sealing were used as criteria for the extent of anthropogenic alterations of soils. Other factors of determination were existing data material such as geological maps, cadastre of old contaminated sites, topographical maps of various ages, building damage maps, etc. (cf. Tab. 5).
3. Areas with hardly altered soils had no aggradations or erosion, and a degree of sealing of < 30%, or a degree of sealing of < 25% at new, large area construction areas. Soil associations here were categorized into near-natural soils according to the classification pattern in Table 6.
4. Areas with a degree of sealing of ≥ 30%, or ≥ 25% at large-area new constructions, were classified as highly anthric soil associations, depending on the type of use and the type of construction (cf. Tab. 5).

Tab. 5: Classification Guidelines for Soil Associations, in Dependence on Use Category and Degree of Sealing

Use category	Possible soil association (SA)
independant of use (except industry), strongly destroyed (> 50 % of building substance destroyed)	SA 52
residential area	according to construction type: degree of sealing (ds) >= 30 %, SA 50, 51; ds >= 25 % in newly constructed large settlement areas, concept SA 50a, 50aR; near-natural SA at settlement/single house/village construction and ds < 30 %
mixed area	according to character, construction type and ds, SA 57, 50, 51, 50a, 50aR, or near-natural SA
core area	according to character, construction type and ds, SA 57, 50, 51, 50a, 50aR or near-natural SA
industrial/commercial area	SA 57
public facilities and special uses	according to character and construction type, SA 57, 50, 51, 50a, 50aR; ds < 30 % near-natural SA or SA 42/43
supply and disposal facilities (utilities areas)	according to character and construction type, SA 57, 50, 51, 50a, 50aR; ds < 30 % near-natural SA
weekend cottage area	near-natural SA or SA 50
traffic areas (except streets)	SA 49, concept SA 50a
construction sites	no SA, or concept SA 50a, 50aR
forest	near-natural SA, except by aggradations
surface waters	no SA
meadows and pastures	near-natural SA, or sewage farm SAs
agricultural land (farmland)	near-natural SA, or sewage farm SAs
parks, green spaces	near-natural SA, SA 50, 50a, 50aR or disposal site SA
city square, promenade	SA 50, 50a, 50aR, 51, 52
cemetery	SA 38 to 41
allotment gardens	near-natural SA; with aggradations, concept SA 49a, SA 50, or disposal site SA
vacant areas, ruderal areas	near-natural SA; with aggradations, according to aggradation type SA 57, 50, 50a, 53, 55, and 49
campground	near-natural SA, except with aggradations
sport areas, outdoor swimming pools (including water sports, tennis, riding, etc.)	near-natural SA, or SA 50a when ds >= 30 %
tree nursery, horticulture	near-natural SA, or SA 50, 50a
surface mining, gravel pit	SA 47, 48
levelled sewage farms, sewage farms	SA 60, 62, 63, concept SA 50aR, 12a, 13a
waste disposal site	SA 53, 55

ds = degree of sealing, SA = soil association

Tab. 5: Classification Guidelines for Soil Associations, in Dependence on Use Category and Degree of Sealing

The classification rules given in the figures and tables are to be seen as general rules. The precise classification of soil associations is frequently not possible due to lack of information about current land use or the degree of sealing. This means numerous special decisions have to be made for individual cases. The classification of soil associations in residential areas considered the construction type; the historical land use was also significant. Residential settlements on locations previously used by industry were evaluated as industrial areas, e.g., the Thälmannpark residential unit. The evaluation of waste disposal sites, military locations, sewage farms, and other landfills and aggradations was made based on information such as maps, the Cadastre of Old Contaminated Sites, aerial photography, and expert opinions, etc..

The determination of near-natural soil associations was made according to the procedure depicted in Table 6, if great anthropogenic soil alterations could be ruled out.

Tab. 6: Classification of Soil Associations of Natural Lithogenesis (after Aey 1991)

Geomor-phology	Soil type/ substrate	Morphological division	CSA	Differentiating characteristics to other SAs	SA 1:1	Additional information	*Concept* *SA* /**SA**
flat upland	▪ (boulder) marl			▪ sand (on BM) < 0.8 m	1	▪ intact sewage farm	*12a*
						▪ influenced by sewage farm water, low-lying location	12
				▪ clayey sink fill	11		
		▪ fluvioglacial meltwater channel		▪ turf	27		
	▪ fine sand on (boulder) marl	▪ dune		▪ fine sand < 2.0 m	8		
	▪ (glacial) sand			▪ sand (on BM+G47) 0.8 - 2.0 m	2,3*		
				▪ sand > 2.0 m	6	▪ intact sewage farm	*13a*
						▪ influenced by sewage farm water, low-lying location	13
		▪ fluvioglacial meltwater channel		▪ without turf	7		
				▪ fossil gley, dried lower bog	29		
				▪ lower bog	30		
		▪ flat upland slope, end morraine slope			5		
		▪ fluvioglacial meltwater channel with alluvial dynamic			28		
end morraine (oser/kames)	▪ (glacial) sand with (boulder) marl			▪ lime slope bog, slope gley	17		
	▪ (glacial) sand/gravel			▪ dystric cambisol (rusty brown soil)	4		
				▪ podzol	72		
sink	▪ (glacial) sand on (boulder) marl			▪ sand < 2.0 m		Geolog. Karte 1 : 25 000	*2a*
				▪ sand < 2.0 m + turf		Geolog. Karte 1 : 25 000	*2b*
	▪ (glacial) sand			▪ sand > 2.0 m		Geolog. Karte 1 : 25 000	*6b*
Pleistocene watercourse (Urstromtal)/ outwash plain	▪ sand				15		
				▪ turf		Geolog. Karte 1 : 25 000	*15d*
				▪ lime	14		
		▪ lowland		▪ turf (some dry)	26		
				▪ lime accumulation	23		
		▪ dead ice sink			25		
		▪ meltwater channel with dune		▪ turf	22		
		▪ meltwater channel without dune		▪ turf + bog		Geolog. Karte 1 : 25 000	*22a*
		▪ shallow channel		▪ lime	21		
	▪ sand on (boulder) marl			▪ sand < 2,0 m		Geolog. Karte 1 : 25 000	*2a*
				▪ sand < 2,0 m + turf		Geolog. Karte 1 : 25 000	*2b*
dunes	▪ fine sand	▪ no bog (GOK > 40 m)	9, 10	▪ podzol	9		
				▪ no podzol	10		
		▪ with bog			19		
		▪ low dune on valley sand or driftsand cover, remote from groundwater (GOK < 40 m)			18		
		▪ dune on valley sand, slope, near to groundwater			20		
river lee	▪ sand			▪ calcaric regosol (para-rendzina) of lime mud	31		
	▪ sand		33, 34				
	▪ sand + turf		24, 32, 35, 36				

* In East Berlin SA 3 corresponds to the term "clayey sand cover with pockets of clay" in the geognostische Karten 1 : 25 000 Blatt Bernau und Königs-Wusterhausen.

BM = Boulder Marl, GOK = high edge of area, CSA = Collective Soil Association

Tab. 6: Classification of Soil Associations of Natural Lithogenesis (after Aey 1991)

Typical landscape segments with characteristic soil types, key profiles and the most important ecological properties exist for almost all soil associations.

The **portrayal in the map** gathered soil associations, concept soil associations, and collective soil associations into groups of uniform color. Geomorphic uniformity was decisive for the formation of near-natural soil association groups. Land use was decisive for the formation of anthric soil association groups..

Update of the Map in 2003

By reason of changes in the geometry of the basic map (splitting or merging of areas) and update of landuse and surface sealing the map had to be revised after a decade in 2003.

For all new areas the soil association of the existing map was adopted if a clear geometric mapping was possible, no major change of landuse took place and the degree of surface sealing were not far from the domain of the old soil association. In the case of a landuse change from a built-up to an open space landuse the old soil association was also maintained.

The map at hand has a scale of 1 : 50,000 and is an overview map used by public planning agencies in determining goals and measures. Detailed statements about individual lots are not possible, for those kinds of statements require project-orientated detail maps.

Map Description

Soils vary greatly in their **ecological properties**, depending on parent substrate, grain size, composition, humus contents, relief profiles and depth to groundwater.

Important parameters that characterize the ecological properties of soils are: usable field-moisture capacity, aertion, cation exchange capacity, pH values, effective rooting depth, and summer moisture level.

Usable field-moisture capacity is a measure for the amount of water in soil available to plants. This is slowly moving seepage water and retained water in the coarse and medium pores of soil. Soil water in the fine pores (dead water) is subject to high water tension and cannot be taken up by plants. The amount of water stored in the soil is determined by pore volume, pore size distribution, grain size composition, and humus levels.

Aeration of the soil includes gas exchange by diffusion between the atmosphere and soil. Aeration is critical for the growth of plant roots and the existence and activity of soil organisms. The intensity of gas exchange depends on pore volume, particularly the amount of coarse pores, as well as their continuity. Other factors are grain size composition, structure, and the water content of the soil.

Cation exchange capacity is the amount of exchangeable cations bound to clay minerals and humus materials in the soil; e.g. Ca^{2+}, Mg^{2+}, K^+, Na^+, NH_4^+, H^+. Cation exchange capacity gives indications of the soil's ability to bind and store nutrients. This binding capacity, or nutrient storage capacity, depends on the type and amount of clay minerals, humus amounts, and pH values. Current actual nutrient levels in the soil can be lower than potential nutrient levels. The potential (maximum) cation exchange capacity for soil is given as a pH value of 8.2, and the effective cation exchange capacity for the current actual pH value of the soil is determined. Effective cation exchange capacity, air and water conditions, biological activity, and redox properties, etc. are important factors for an evaluation of nutrient levels actually available in the soil.

The **pH value** allows direct and indirect determinations of various processes and properties of soils, including a) weathering processes; b) soil formation processes, such as podzolization and clay translocation; c) species range and activity of soil organisms; d) humic material formation; e) structural stability; and f) the silting (mud filling) process.

The **summer moisture figure** is an expression for the water supply useable for the effective root area in critical dry periods during the main vegetation growth period. The figure takes into consideration usable field-moisture capacity, climate, relief, and groundwater.

Effective rooting depth is the depth in the soil where plants can draw water. Anthrosols can restrict rooting by impenetrable layers, e.g. concrete, lack of air, or the formation of methane in waste disposal site soils.

Soil Types

The **near-natural soils** in Berlin with a long developmental history and relatively uninfluenced by use are: luvisols (para-brown soils), podzoluvisols (leached soils), cambisols (brown soils), dystric cambisols (rusty-brown soils), spodo-dystric cambisols (podzol brown soils), podzols, gleysols, and histosols (bog soils). Histosols (bog soils) appear almost only in the less densely settled and unsettled outer edges of the city.

Luvisols (para-brown) and podzoluvisols (leached soils) are the most widely distributed soils in the sandy overlayered Barnim and Teltow boulder marl flat uplands. They are dealkalized to a depth of 1 - 2 m. Podzoluvisols (leached soils) occur mainly in forest areas. The greater humus and clay contents in the topsoil give luvisols (para-brown soils) a distinctively greater nutrient supply than podzoluvisols (leached soils). Luvisols have a medium to high storage capacity for water and nutrients and are well aerated. The pH values of topsoils in forest plantation areas are usually low at 3 - 4; with soil acidification by humic acids and "acid rain". The pH values of agricultural soils are higher because of fertilizers and liming. The nutrient supply of forest plantation soils in the shallow root zone down to 0.3 m depth is low to moderate. The nutrient supply in the deep root zone down to 1.5 m depth is medium to high because of the increase in pH (Grenzius 1987). Podzoluvisols (leached soils) have a greater nutrient supply in the subsoil - Bt horizon - than topsoils with little clay. Water storage capacity and aeration are sufficient. Luvisols (para-brown soils) are good locations for agriculture, particularly in Rudow, Mariendorf, Lichtenrade (Teltow flat upland area), Kladow (Nauen plate), Hohenschönhausen, Hellersdorf, Weißensee, and Pankow (Barnim flat upland area).

Cambisols (brown soils) develop on the sandy areas of the Barnim and Teltow boulder marl flat upland areas, on the lower slope of flat upland areas, morraine hills, and end morraines. Cambisols develop particularly well as colluvial (transported) formations in the sometimes silty medium and fine sands of the Berlin pleistocene watercourse, the Panke valley, and in the sinks of dune landscapes. Stagno-gleyed and residual stagno-gleyed cambisols, and eutro-gleyic cambisols occur mainly in the pleistocene watercourse, depending on earlier and current groundwater levels.

Cambisols are deeply rootable and well aerated. They have a low, sometimes medium water storage capacity at lower slopes of end morraines through water inputs and deposits of clay. They are dry locations for shallow-rooted plants and fresh locations for deep-rooted plants. The stagno-gleyed and eutro-gleyic cambisols of the pleistocene watercourse were moist locations before the groundwater level sank. Cambisols usually have a moderate nutrient storage capacity, but the actual nutrient supply of cambisols with low pH values used for forests and grain production is very low to moderate. The nutrient supply is higher with greater humus contents and pH values, such as found in vegetable crop and horticultural areas.

Dystric cambisols (rusty brown soils) are found on the glacial sands of the Nauen plate (Gatow-Kladow), and the Barnim and Teltow flat upland areas. Dystric cambisols are also the dominate soils of the end morraines in the Düppel Forest, in Grunewald (Havelberge), in the Köpenick Forest (Müggelberge), the Gosenberge, and the Seddinberg. Dystric cambisols are also formed in valley sands remote from groundwater, such as in the Jungfernheide forest, and dystric cambisols, along with spodo-dystric cambisols (podzol brown soils), are the leading soils in dunes in the Spandau, Tegel, and Köpenick forests.

Both dystric and spodo-dystric cambisols are deeply rootable and well aerated. They posess a low to moderate usable field-moisture capacity and a medium nutrient storage capacity. They are very dry to dry and are very nutrient-poor locations. Their water and nutrient storage capacities are increased by interstratifications of silt in the subsoil, and by horticultural use, or in the vicinity of bogs (gleyed spodo-dystric cambisols or stagno-gleyed dystric cambisols, and dystric gleysols or spodo-dystric cambic gleysols).

The formation of **podzol soils** requires special climatic conditions, such as low temperatures and high precipitation. Podzol soils develop on fine-grained, lime-free sandy substrates. They only appear at a few locations in Berlin forests; mainly at the northeast slopes of dunes in the Tegel forest (cf. Grenzius 1987), the Püttberge in the Köpenick forest (cf. Smettan 1995), and in part of the end morraine formation of the Seddinberg.

Podzol soils are usually deeply rootable and well aerated, but in spite of their medium to high water and nutrient storage capacity, they are nutrient-poor and dry soils.

Gleysols form from sandy or silty substrate at locations with high groundwater levels. Gleysols appear in sinks of valley sand levels in the Spandau forest. They are dependent on relief profiles and are often associated with stagnic gleysols (wet gleys), histo-humic gleysols (turfy moulder gleys) and histosols (bogs). These are the soils of the sinks in the dunes in the Spandau forest and in the Schmöckwitz forest area south of Seddinsee lake; the meltwater channels such as the Kuhlake, Breite Fenn, Rudower Fließ, Tegeler Fließ, Wuhle, Neuenhagener Mühlenfließ, and the Krumme Laake; the dead ice sinks of the Großer Rohrpfuhl and the Teufelsbruch in Spandau, and the dead ice sink Teufelssee in Köpenick.

The ecological properties of gleysols differ greatly depending on the parent substrate, humus amounts, groundwater level, and the nutrient supply in the groundwater. Residual gleysols are also found in Berlin in areas of lesser depth to groundwater where groundwater levels have sunk. The residual gleysols have typical gley characteristics in profile structure, but their ecological properties differ very greatly from gleysols.

Gleysols are usually moist topsoil locations for shallow-rooted plants, and wet subsoil locations for deep-rooted plants. The available air supply is inversely proportional to the water level of the soil. This results in air-poor subsoil and, depending on water levels, a good to poorly aerated topsoil (sometimes alternately dry to wet), and medium rootability. Gleysols have a large to high nutrient storage capacity and a moderate to high nutrient supply, depending on humus amounts. The nutrient supply is high if additional nutrient inputs occur by way of the capillary uptake of eutrophied groundwater.

Residual gleysols are dry to very dry, well aerated into the subsoil, deeply rootable locations with generally medium to high water capacities. The nutrient supply is low to medium, depending on humus amounts and pH values. Nutrient input from groundwater is usually lacking.

Histosols (bog soils) have a high water level, are poorly aerated, and only shallowly rootable. Histosols have a very high water storage capacity and a medium to high nutrient storage capacity. They are undrained, near-natural locations with varying nutrient supplies.

Bogs are subject to drying and mineralization when groundwater levels sink. Properties relevant for plants change. Dried boggy (histosols) and turfy moulder soils (histo-humic soils) that appear in the Pleistocene watercourse, such as in allotment garden areas along the Teltow and Neukölln canals, and in Treptow along the edge of the Teltow flat upland area, are deeply rootable, well aerated, and moist locations, in contrast to intact bogs.

Loose lithosols (raw soils of loose material), regosols, and calcaric regosols (para-rendzinas) are relatively young soil formations, compared to soils that have developed for hundreds or thousands of years. They develop on young aggraded areas of eroded natural rocks, and at areas of anthropogenically aggraded materials.

Natural soil erosion occurs by the action of wind or water on the slopes of dunes, kames (short morraines crosswise to the flowing direction of the ice), and morraine hills. Anthropogenic soil erosion is caused by human use of soil. Soil inputs can occur both through natural translocation processes and through anthropogenic aggradations. Aggradations are differentiated into aggradations of natural material, such as soil excavation and gravel, and aggradations of artificial substrates such as war damage debris, construction debris, slags and cinders, etc..

Loose lithosols, regosols and calcaric regosols (para-rendzinas) of anthropogenically aggraded material undergo the same soil development as natural rock. The various parent material is described by the soil form, e.g. regosol of glacial sand, regosol of war damage debris, etc. (Grenzius 1987).

The soils of the Berlin urban area are characterized by intensive anthropogenic interventions resulting from the "rebuilding measures" of settlement, demolition of buildings, and damage incurred during the Second World War. There are large-area aggradations of war debris, slag and cinders, and building materials, as well as eroded areas due to construction of streets and railway lines, and the surface mining of gravel, sand, and clay. This has led to the wide distribution of loose lithosols, regosols, and calcaric regosols in the Berlin urban area.

Loose lithosols (raw soils of loose material) appear mainly on eroded areas of natural rock in the outer urban area. They develop where dystic cambisols (rusty-brown soils) and cambisols (brown soils) of glacial, valley, and drift sands have been removed by use, such as at military training areas and surface mining sites. Near-natural soils can still be found in small parts of lessly impaired areas.

Larger military training areas are located in Heiligensee at Baumberge, in the Grunewald forest, and in the Köpenick forest at Jagen 161. Surface mines in the Berlin urban area are at Kaulsdorfer Seen, the Kiessee Arkenberge in Pankow, the Tegeler Flughafensee, and the Laszinssee in Spandau.

Ecological properties are marked by natural undersoil and groundwater levels, e.g., loose lithosols created by erosion of dystic cambisols are well-aerated, usually dry, and nutrient-poor soils.

Loose lithosols (raw soils of loose material) at aggradation areas of anthropogenically transported rock (war damage debris, construction debris, railway track crushed rock, industrial crushed rock) are found at open areas throughout the entire densely-populated urban area, such as the inner city; at all areas greatly damaged or destroyed during the Second World War (soil association 52); and at industrial, and commercial locations. Loose lithosols also appear at war and construction debris disposal sites like the Eichberge in Köpenick, Arkenberge in Pankow, Teufelsberg in Grunewald, Trümmerberg in Friedrichshain, Volkspark Prenzlauer Berg, and at railway tracks throughout the entire urban area. Loose lithosols are more seldom at aggraded or translocated natural rock, such as landfill bullwarks at military training areas, including firing ranges.

The ecological properties of these loose lithosols are determined by the aggraded material. Loose lithosols of sands and artificial substrates form very dry to dry locations; tar or concrete layers in the undersoil form locations of periodic moisture. Aeration and thus oxygen suppy are good; rootability is restricted by high rock contents; rootability is deep in rock-free, sandy soils. Nutrient supply and storage capacity is low to high, according to parent rock and use.

The formation of **regosols** (cf. Grenzius) is a result of natural erosion (water and wind) and anthropogenic erosion (in Berlin often a high pedestrian load on slopes) of the loose lithosols on kames, morraines, or dune sands. The soil formation process is continuous. Humus accumulation in the Ah horizon results finally in regosols. These regosols appear, for example, on the steeper slopes along the Havel River in Grunewald, in the Düppeler forest, and on the slopes of the Müggelberge. Soil aggradation and erosion by the construction and closing (levelling) of sewage farms in the north of the boroughs Pankow, Weißensee, and Hohenschönhausen also influence the formation of regosols from natural materials. These are soil associations 60, 62, and 63.

Regosols of sandy, lime-free aggradations develop mainly in all urban areas of more dense construction, including smaller green areas and park facilities. They are usually nutrient-poor. Humus accumulation in the topsoil improves the nutrient supply. They often have a low water storage capacity, good aeration, and a deep to medium rootability, depending on the rock.

Calcaric regosols (para-rendzinas) develop from loose lithosols of limey substrate. Calcaric regosols of natural origin develop on eroded areas of marl pits which have been left open, on translocated marl, such as at foundation excavations, and on eroded slopes of bodies of water and channels of boulder marl flat upland areas.

Calcaric regosols develop in the bottom land of the Bäke at the Landgut Eule, and at Albrechts Teerofen from lime mud or disturbed shallow water sediments. This material was excavated for the Teltow canal and redeposited (cf. Grenzius 1987).

Calcaric regosols of anthropogenic aggradation material occur all throughout the entire densely built-up urban area at sites filled with war debris or construction debris; at all areas of heavy war damage with debris aggradations; and at railway facilities. Calcaric regosols are also found along the many landfill banks and bottom lands of the Havel and Spree rivers and their lake-like broadenings.

The higher clay levels of boulder marl calcaric regosols show an increased nutrient storage capacity, and a medium to high usable field-moisture capacity. Calcaric regosols of debris are nutrient-poor and dry. Aeration is good, the rootability of debris calcaric regosols is shallow because of the stone content. Calcaric regosols of lime muds are fresh, nutrient-rich, and good to poorly aerated locations, according to the groundwater level.

Selected Soil Associations

Some characteristic soil associations (SA) will be described here. A more detailed description of soil associations was made by Grenzius (1987). The depicted landscape segments originate from Grenzius' dissertation (1987). The abbreviations used for soil types in Figures 2 - 10 are explained in Table 7.

Near-natural Soil Associations

SA 1 [1010] Luvisol (para-brown soil) - arenic cambisol (wedged sand-pit brown soil)
(ground moraine flat upland area of boulder marl)

The parent material is flat upland boulder clay or marl. Shrinkage created wedges filled with sand; this was then overlaid with drift sand. A mixture of drift sand with boulder marl led to the formation of the glacial cover sand. Luvisols developed on the 1 - 3 m deep wedged sand-pits of arenic cambisols (wedged sand-pit brown soils) where the boulder clay and marl was covered with a thin glacial sand cover.

This soil association is particularly found at the Teltow and Barnim boulder marl flat upland areas.

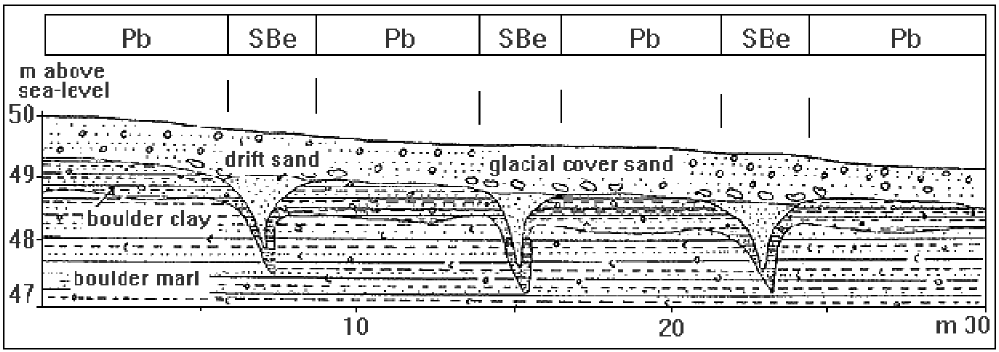


Fig. 2: Luvisol (para-brown soil) - Arenic Cambisol (wedged sand-pit brown soil)
(soil association of the ground moraine flat upland area of boulder marl)

SA 6 [1070)Dystic cambisol (rusty brown soil) - colluvial cambisol (colluvial brown soil)
(outwash plain over) moraine area of detritial sand

This soil association comprises dystric cambisols on the sandy, morphologically relatively flat area of the boulder marl flat upland plain and the ground moraines of the Teltow (Grunewald, Düppler forest) and Barnim flat upland plain. The upper 2 meters of glacial sand do not contain boulder clay or marl.

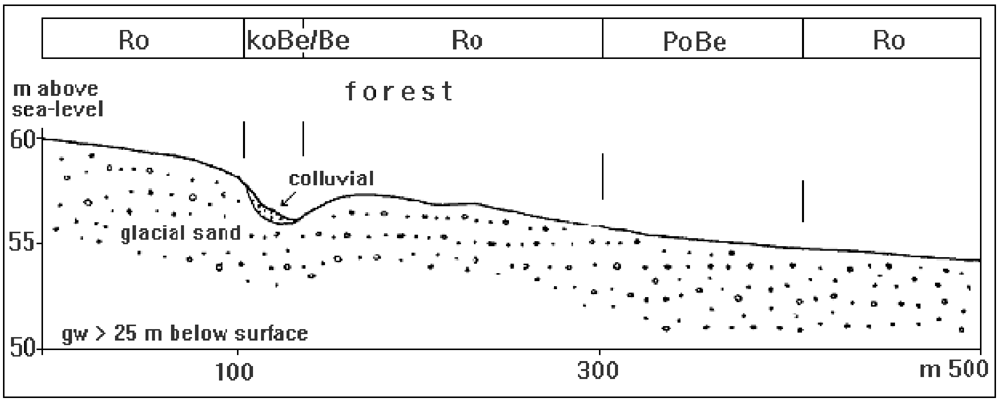


Fig. 3: Dystric Cambisol (rusty brown soil) - Colluvial Cambisol (colluvial brown soil)
(soil association of moraine areas (outwash plain) of glacial load sand)

Dystric cambisols also appear at the kames formations of the Grunewald forest, from Lübars to Arkenberge, and in the end moraine formations in Gatow and Müggelberge. They have a different spatial relationship there (geomorphological unit). This is why this geomorphological unit was included with another soil type in another soil association, SA 4.

Another soil association, SA 2 or 3, is of dystric cambisols on relatively higher moraine hills of glacial sand with some boulder marl or boulder clay remainders within the first two meters of the glacial sand.

SA 9 [1090] Spodo-dystric cambisol (podzol brown soil) - podzol - colluvial dystic cambisol (colluvial rusty brown soil)
(dunes of fine sand)

SA 10 [1100] Spodo-dystric cambisol (podzol brown soil) - dystric cambisol (rusty brown soil) - colluvial dystric cambisol (colluvial rusty brown soil)
(dunes of fine sand)

Soil associations 9 and 10 are dunes several meters thick, remote from groundwater, as well as larger dune areas with terrain heights over 40 m. They differ primarily in the presence of podzols. They appear mainly in the Tegel and Frohnau forests, but in the Köpenick forest as well. No statements can be made about the presence of podzols without soil profile studies. These two soil associations in East Berlin are listed as collective soil associations; these soil associations are listed separately if mapping has been done (Standortskarten des Forstbetriebes Ost-Berlin, Smettan 1995) (Site Maps of East Berlin Forest Management).

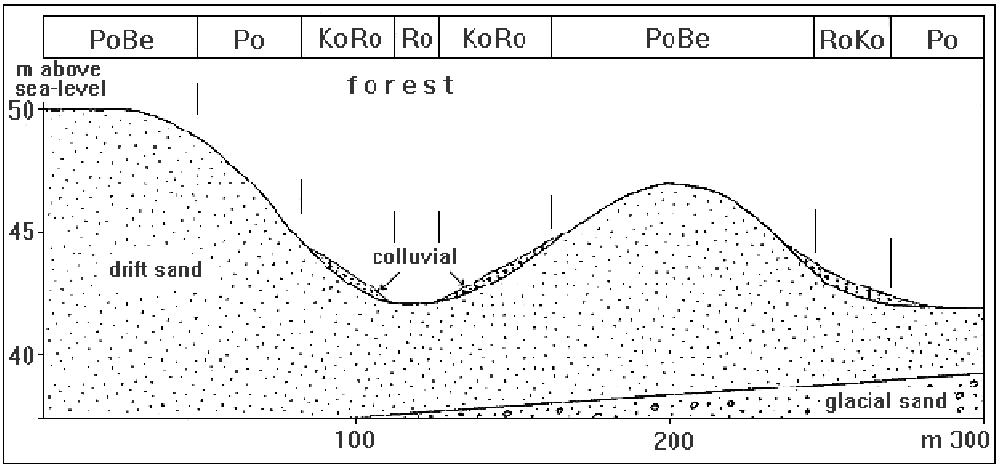


Fig. 4: Spodo-dystric Cambisol (podzol-brown soils) - Podzols - Colluvial Dystic Cambisols (colluvial rusty brown soil)
(soil association of dunes of fine sand)

SA 15 [1160] Dystric cambisol (rusty brown soil) - gleyic cambisol (gleyed brown soil) - eutro-gleyic cambisol
(valley sand areas of medium and fine sand)

This soil association is widely distributed in the Berlin Pleistocene watercourse (Urstromtal). The Berlin Urstromtal is the last meltwater valley of the Frankfurt phase of the Weichsel ice age. The medium and fine sands transported and deposited by meltwater formed the parent substrate for the formation of cambisols and dystric cambisols. Varying groundwater levels caused the formation of gley properties, such as rusty spots, in various depths. These are represented by the soil types stagno-gleyic cambisol and eutro-gleyic cambisol. Groundwater levels sank in this century because of groundwater removals by the Berlin Waterworks. Gley properties are often present only as residual, i.e. groundwater levels today are deeper than the gley characteristics they once produced. This soil association is present particularly in the Spreetal in Köpenick, and in the valley sand areas of forests in Spandau, Tegel and Jungfernheide.

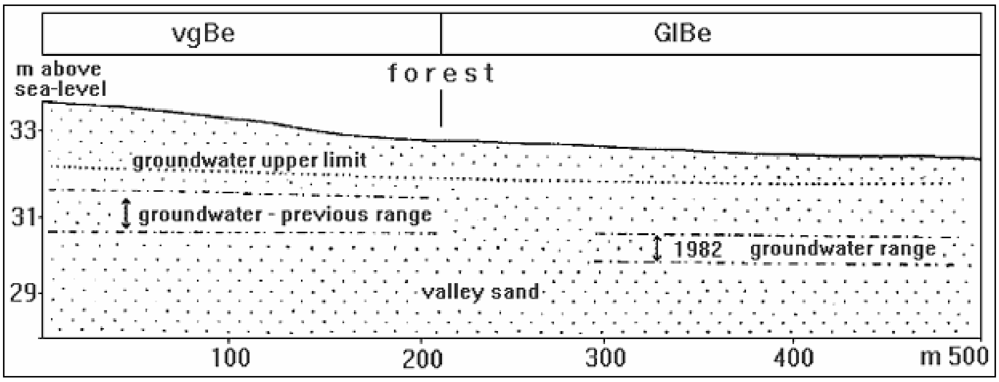


Fig. 5: Stagno-gleyed Cambisol (gleyed brown soil) - Eutro-gleyic Cambisol (gleyic brown soil)
(soil association of valley sand areas of medium and fine sand in the Spandau Forest)

SA 22a [1231] Eutro-gleyic cambisol (gleyic brown soil) - gleysol - eutric histosol (lower bog)
(meltwater channels in valley sand areas without dunes)

The great pressure from the weight of the glaciers melted ice at their bottom layers. The runoff of this meltwater produced subglacial meltwater channels. Great amounts of meltwater produced in the warm periods between ice ages flowed into the valleys and deepened the runoff channels. The channels in the vicinity of groundwater bogged after the last ice age. Many of these channels, particularly in the Berlin inner city, were landfilled and/or built upon, and are not visible today.

Such fluvoglacial meltwater channels within valley sand areas are found in parts of the Wuhle, the Neuenhagener Mühlenfließ, Spekte-Lake, the Egelpfuhlwiesen, and the Breite Fenn. Histo-humic gleysols (turfy moulder gleys) and valley bog torf formed directly in the middle of these channels, depending on groundwater levels. Depending on groundwater levels, eutro-gleyic, eutro-gleyic dystric, stagno-gleyed and stagno-gleyed dystric cambisols were formed towards the channel edges.

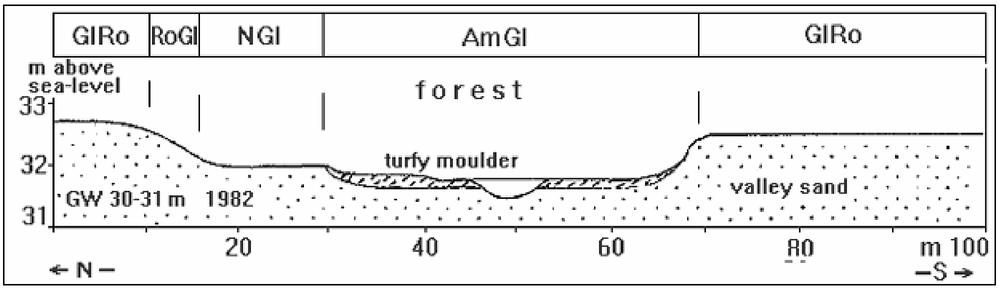


Fig. 6: Eutro-gleyic Cambisol (gleyic brown soil) - Gleysol - Eutric Histosol (lower bog)
(meltwater channels in valley sand areas without dunes)

Anthric Soil Associations (anthropogenically alterered soils)

SA 41 [2420] Necrosol + eutro-gleyic cambic hortisol (gleyic brown horticultural soil) + gleysol (cemeteries on valley sand areas of medium and fine sands)

This soil association is comprised of valley sand soils. The use as cemeteries brings certain anthropogenic influences. Necrosols are defined as soils resulting from excavations for graves. The unused cemetery areas of valley sands still retain residual eutro-gleyic cambisols and gleysols. The longterm input of humus develops humic regosols, horti-gleyic cambisols, and hortisols (horticultural soils).

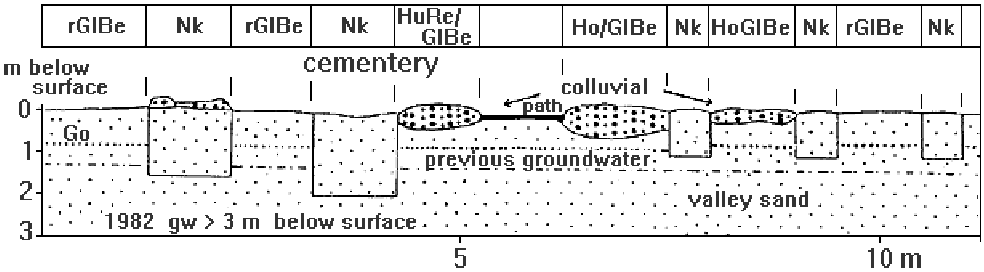


Fig. 7: Necrosols + Eutro-gleyic Cambic Hortisol (gley brown horticultural soil) + Gleysol
(soils of cemeteries on valley sand areas of fine and medium sands)

Other anthropogenic uses have so strongly altered soils that once natural soils are extensively destroyed, or have been overlaid by other materials.

SA 49 [2470] Lithosol + calcic regosol + calcaric regosol (para-rendzina)
(railway tracks on aggraded and eroded surfaces)

This soil association includes soils used for railway facilities and railway stations. The trackbeds are of coarse gravel of various materials; the embankments are of sand, war and construction debris are also used as fill. Lithosols, loose lithosols, calcaric and calcic regosols are mainly formed, depending on the soil substrate.

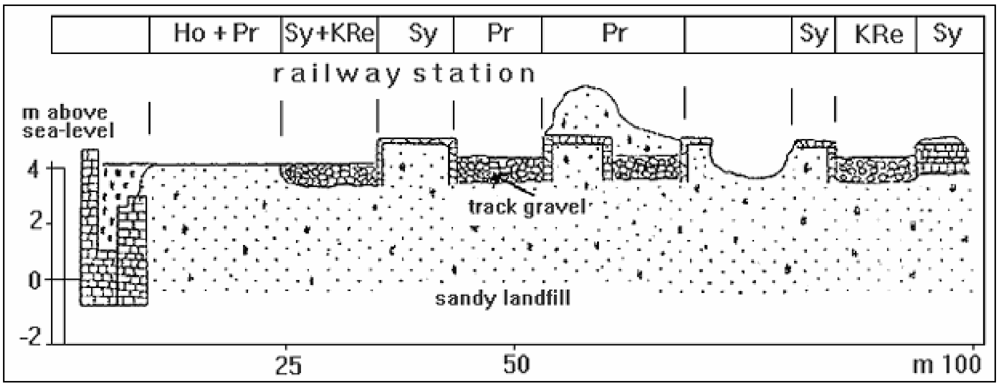


Fig. 8: Lithosol + Calcic Regosol + Calcaric Regosol
(soils of rail facilities on aggraded or eroded surfaces; Potsdamer Güterbahnhof (freight station))

SA 51 [2490] Loose lithosol (raw soil of loose material) + humic regosol + calcaric regosol (para-rendzina)
(dense inner city construction; not destroyed during Second World War ; on aggraded surfaces)

This soil association characterizes soils within areas of uniform construction built before Second World War, undestroyed or only lightly damaged. The degree of sealing is high. Soils in the rear courtyards used currently or previously as yards are characterized by humic topsoils and can develop to humic regosols, hortisols, and humic calcaric regosols. Other back courtyard areas lightly covered by debris form loose lithosols (raw soils of loose material) and regosols.

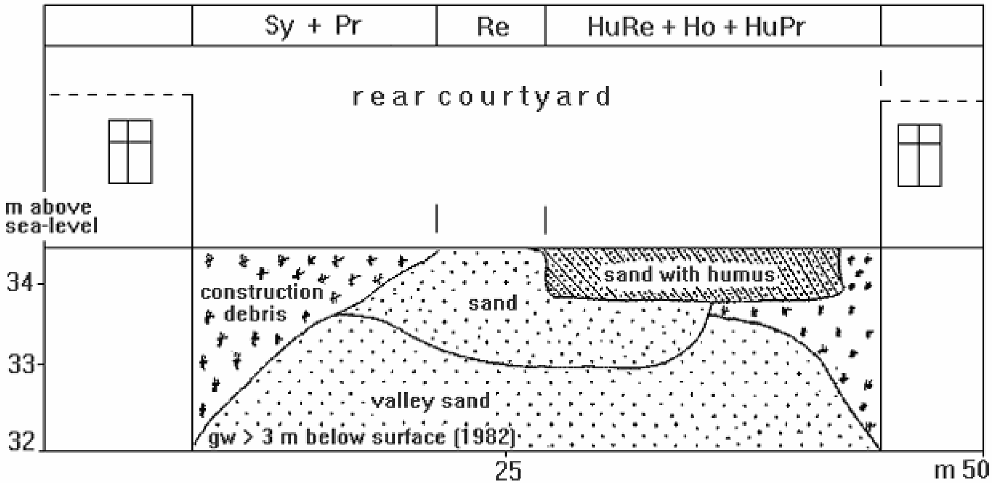


Fig. 9: Loose Lithosol (raw soil of loose material) + Humic Regosol + Calcaric Regosol
(soils of dense inner city construction; not destroyed in the Second World War; on aggraded surfaces)

SA 52 [2500] Loose lithosol (raw soil of loose material) + regosol + calcaric regosol (para-rendzina)
(inner city on aggradation/landfill)

This soil association describes soils of the previously densely constructed inner city, completely destroyed in Second World War. Most war debris remained where it fell. Many surfaces without buildings have a soil layer composed partially or completely of war debris. This thickness of this layer is from a few tenths of a meter up to 2 meters deep (cf. Grenzius 1987). Figure 10 shows how these surfaces develop lithosols and calcaric regosols. Surfaces without war debris develop lithosols and regosols.

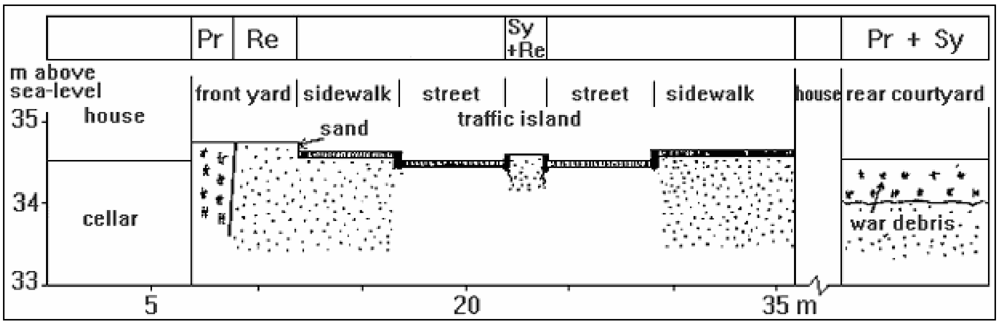


Fig. 10: Loose Lithosol (raw soil of loose material) + Regosol + Calcaric Regosol (para-rendzina) (soils of the inner city on aggradations)

The Concept Map of Soil Associations was prepared from existing data of the most various kinds. The map gives an overview of the near-natural and anthric soil associations to be expected, depending on the parent substrate, geomorphology or landscape segment, groundwater level, and use. The soil association category allows the derivation of main soil types, as well as site characteristics such as aeration, rootability, field-moisture capacity, usable field-moisture capacity, nutrient storage capacity, and potential and effective cation exchange capacity as measure for nutrient storage capacity (cf. Grenzius 1987).

The aid of additional information, such as topographic maps and current groundwater level, and the soil association, enable the determination with a certain probability of soil types and ecological properties in a terrain without a map. Statements about gleysols or residual gleysols, and thus of moist or dry locations, can be made only under consideration of current groundwater levels.

The need for protection of soils can be roughly estimated based on its area distribution (seldom to often), the soil associations in the city, and the degree of alteration of soils from use.

Soils are a basic natural element and co-determinants of species diversity at the site. Seldom, unaltered, and only slightly altered soils are considered in the demarcation of protected areas. Land use category planning attempts to avoid the allowance of greatly soil-impairing or soil-destroying uses on seldom and particularly valuable soils (cf. Stasch et al. 1991).

The Map of Soil Associations is suitable for deriving site characteristics, and for making evaluations regarding soil protection and soil functions. In the map 01.06 of the Environmental Atlas soil-scientific characteristic values, in the map 01.12 a valuation of soil functions and in the map 01.11 criteria for the deduction of these functions are documented.

Tab. 7: List of Soil Type Abbreviations Used in Figures 2 - 10

Po	=	podzol
Be	=	cambisol (brown soil)
Pb	=	luvisol (para-brown soil)
SBe	=	arenic cambisol (wedged sand-pit brown soil)
Ro	=	dystric cambisol (rusty brown soil)
PoBe	=	spodo-dystric cambisol (podzol brown soil)
koBe	=	colluvial cambisol (colluvial brown soil)
KoRo	=	colluvial dystric cambisol (colluvial rusty brown soil)
RoKo	=	dystric cambisol colluvium (rusty brown colluvium)
vgBe	=	stagno-gleyed cambisol (gleyed brown soil)
GlBe	=	eutro-gleyic cambisol (gleyic brown soil)
rGlBe	=	residual eutro-gleyic cambisol (gleyed brown soil)
GlRo	=	eutro-gleyic dystric cambisol (gley rusty brown soil)
RoGl	=	dystric gleysol (rusty brown gley soil)
NGl	=	stagnic gleysol (wet gley)
AmGl	=	histo-humic gleysol (turfy moulder gley)
Nk	=	necrosol
Re	=	regosol
KRe	=	calcic regosol
HuRe	=	humic regosol
Ho	=	hortisol (horticultural soil)
HoGlBe	=	horti-gleyic cambisol (horticultural gley brown soil)
Pr	=	calcaric regosol (para-rendzina)
HuPr	=	humic-calcaric regosol (humic para-rendzina)
Sy	=	loose lithosol (raw soil of loose material) / lithosol
/	=	on
+	=	and

Tab. 7: List of Soil Type Abbreviations Used in Figures 2 - 10

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