URBAN SMS Soil Management Strategy

Recording and documentation of archive functions of soils in the Stuttgart city area

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June, 2010

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REPORT

Title:

Development of new soil management strategies Part 1 in the EU project URBAN SMS (Project No. 6.56)

WP 4: Recording and documentation of archive functions of soils in the Stuttgart city area

Date:	07 June 2010
Client:	City of Stuttgart, Environmental Protection Office
Order dated:	3 February 2009
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File number:	08337 / URBAN SMS
Copy No.:	Final version, revised

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1 INTRODUCTION

One of the main aims in the "Soil management strategies for urban areas" (URBAN SMS) project is to increase awareness about soil as an ecological resource and to make access to soil information easier via the development of a "Soil Manager". This includes the task of clearly communicating the versatile efficiency, quality and functionality of soil to decision carriers, professional planners and the public. An important aspect of soil quality is also taking into account the function of soil as an archive for natural and cultural history.

The improvement of existing concepts such as the Stuttgart soil protection concept (BOKS) through the inclusion of new functions, such as the acquisition and documentation of archive functions of soils in the Stuttgart city area, is an important task in the working package 4.

This working package looks at how the function of soil as an archive for natural and cultural history can be evaluated. The city of Stuttgart is used here as an example. This report is a contribution to Measure 4.2.1 in the working package 4.

2 SOILS AS ARCHIVES OF NATURAL AND CULTURAL HISTORY

According to § 2 Sec. 2 BBodSchG (German soil protection law), the function of soil as an archive for natural and cultural history must be protected as the soil stores information about specific conditions of soil formation in the past or information about human culture and agriculture. Protection for soil archive functionality is also regulated by the monument preservation law in addition to the Federal soil protection law. This means that soil monuments, e.g. archeological sites or historical forms of usage, can be protected as per the law § 2 DSchG issued by the state of Baden-Württemberg. In addition, geotopes can also be protected as natural monuments according to § 23 and § 28 NatSchG (nature protection act). A differentiation is made here between soil sub-functions between archives for natural history and archives for cultural history:

- "As archives for natural history, soils provide information about formation conditions over the history of soil development. Fossilised soils are of particular significance as climatic witnesses of former terrestrial eras. Drumlins, erratic blocks and moors are also visible remnants of primeval natural history.

- The archives of cultural history encompass human "footprints" that have been retained in the soil. Relicts in archeological sites can provide information about the construction forms of buildings or living circumstances of humans, and can even provide evidence of conflicts in battlefield archeological sites.

> Historical forms of agricultural uses can also frequently be determined from soil changes" (ELSA 2007).

As soils cannot be restored as archives for natural and cultural history if they are destroyed e.g. by building or sealing, and the information about the natural formation process or human history would be lost, protection of these soil functions is particularly important.

One exception is represented by artifacts in archeological sites as these are excavated before building occurs and secured by means of scientific documentation. To some extent, finds will not be damaged by close to the surface sealing measures if lower-lying soil layers with findings are not affected by such interventions, as the subsoil is thereby not disturbed.

In order to comply with this high protection need for archive soils, the soils that are listed in the soil quality map for the city of Stuttgart are classified in the highest quality stage (QS = 5). There is no differentiation here - as in the natural soil functions - between different values of the archive as all archives are seen as worthy of protection (cf. STATE CAPITAL STUTTGART 2006). The aim of the evaluation is therefore to check whether an archive is present. The assignment to the highest protection category is also because, in addition to the non-restorability, it is not possible to assign a historical hierarchy in the evaluation of the protection worthiness. Currently there are no evaluation criteria available with which it would be possible to classify whether e.g. a Celtic grave is more or less worthy of protection than a more recent Roman grave or a fossil site.

When the soil quality map was drawn up by KÜBLER 2001, the digital soil map was evaluated on a scale of 1:20,000 (cf. city soil mapping as per HOLLAND 1995), in order to identify rare or special soil forms. Pedogenic archives of natural and cultural history were determined on the basis of this data. Further data sources for evaluation of the archive function were not available at that time and were therefore not a part of the soil quality map and the soil protection concept of the city of Stuttgart (BOKS) (cf. KÜBLER 2001).

Based on this background, it is therefore necessary to check and optimise the availability of GIS data and their content and technical properties that can be evaluated. In particular, geotopes and cultural history archives (soil monuments) not taken into account in the previous evaluations of archive functions must be evaluated here and included in the soil quality map.

A significant basis for the expansion and updating of archive functions in the city of Stuttgart is the guideline published in the interim by Baden-Württemberg: "Soils as archives of natural and cultural history" (cf. LUBW 2008). This country-wide evaluation method will be used to check the current BOKS methods for evaluation of soil archive and to methodically expand and upgrade such data.

The Stuttgart soil quality map must be redrafted within the framework of the archive function upgrade. In the updated version, the pedogenic archives already present will be supplemented by cultural historical archives and geotopes. This requirement is based, among other things, on the statutory obligation for proper evaluation which includes taking into account cultural historical archives and geotopes. Any impact on soil in its natural function as an archive of natural and cultural history must therefore be avoided as far as possible in accordance with the legislation dated 17.03.1998 regarding soil protection (§ 1 Sentence 2 BBodSchG). In this manner, the BBodSchG supplements the national laws on protection and maintenance of soil monuments (cf. HÖNES 2006).

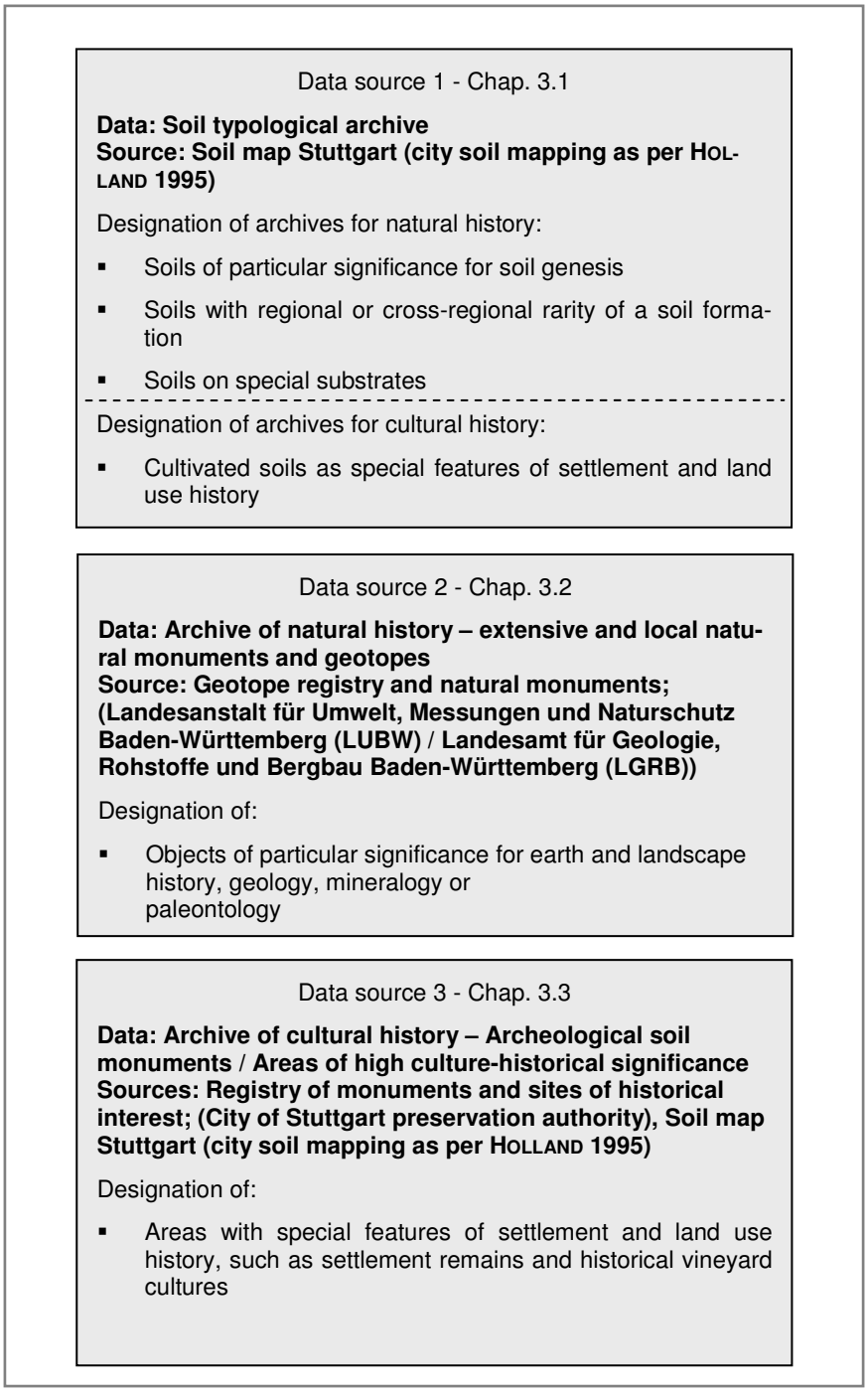
3 DERIVATION OF ARCHIVE FUNCTIONS

The archive function of the soil is divided into five groups (cf. Table 1, LUBW 2008) according to its value-relevant properties in compliance with the "Soils as archives of natural and cultural history" guideline drawn up by Baden-Württemberg.

Table 1: Differentiation of soil functions as archives of natural and cultural history in Baden-Württemberg (as per LUBW 2008)

VALUE-RELEVANT PROPERTY	DESCRIPTION	EXAMPLES IN BADEN-WÜRTTEMBERG	EXAMPLES IN STUTTGART	DATA BASIS (FIG. 1)
Natural history				
Particular significance for soil genesis	Palaeosoils and relict Holocene soil formations	E.g. Terrae rossae (as relicts of tertiary soils) or chernozem	Chernozem-lessivè and brown alluvial soil ("Vega")	Soil map Stuttgart
Regional or cross-regional rarity of a soil form	Soils that are seen as rare in a specific greater soil region	E.g. strongly acidic or waterlogged soils in karst landscapes	Rendzina on travertine	
Particular significance for earth and landscape history, geology, mineralogy or paleontology	Special landscape-shaping morphological elements and landscape history	E.g. dunes or terminal moraines from the Black Forest glaciers	Gorges and valley slopes with special strata sequences	Geotope land registry and Soil map Stuttgart, if necessary
	Special original substrate of soil formation	E.g. soils on volcanites or bean ore clays	Soils on tufa deposits	
	Geotopes and fossil sites	E.g. special structures or rock walls	"Rote Wand" structure, travertine quarry	
Natural and cultural history				
High information value for soil science, soil protection and landscape history	Locations of soil monitoring programmes	E.g. permanent soil monitoring	None exist at present	-
	Moors as evidence of climate and vegetation history, and witnesses of natural and cultural history as pollen archives	E.g. highmoors and fens	None exist at present	-
Cultural history				
Special features of settlement and land use history	Witnesses of historical agricultural techniques (cultivated soils)	E.g. ridge and furrow remains, historical vineyard cultures, plaggen soils	Para-rendzina rigosols as cultivated soils	Soil map Stuttgart
	Buried witnesses of cultural development and archeological sites (soil monuments)	E.g. settlement remains, limes, burial mounds	Burial grounds of linear pottery people, burial mounds, quadrilateral enclosures	registry of monuments and sites of historical interest

The archives of natural and cultural history presented as worthy of protection in the Baden-Württemberg guideline can be assigned to three different data sources for the Stuttgart city area. Based on these data sources and the regional characteristics, the evaluations relevant to Stuttgart for determining the archive function are described below (cf. Fig. 1). The value-relevant properties listed in Table 1 are assigned in bullet point format to the data sources.



.Figure 1: Data for determination of archive functions for soils in Stuttgart

3.1 Soil typological archives for natural and cultural history

Archive soils worthy of protection were already designated in 2001 for the city area of Stuttgart on the basis of city soil mapping as per HOLLAND 1996 (cf. KÜBLER 2001). During the analysis, the approaches available at the time for recording soils with particular archive functions were taken into account. The basis for the evaluation was, amongst other things, the country-wide evaluation of the "Red list for natural soils" (BOSCH 1994) presented in the soil protection handbook.

The evaluation is not implemented according to soil types, but on the basis of the mapped soil forms as per HOLLAND 1996. The local geological and landscape situation can be better integrated in the evaluation in this manner as per KÜBLER 2001. The investigation only takes into account soil forms where soil development took place on natural substrates.

The mapping units for the pedogenic archive soils identified in the city area of Stuttgart by KÜBLER in 2001 have been statistically analysed and evaluated according to the selection criteria shown in Table 2.

Table 2: Selection criteria for the mapping units in the soil map Stuttgart with special archive functions (source: KÜBLER 2001, unchanged)

Mapping unit	Original substrate	Naturalness	Rarity	Charact. use	Charact. soil	Soil diversity	Duration of soil formation
Rendzina / brown rendzina	Shell limestone / Travertine	+	+++	+	+	++	+
Humus lessivé / Chernozem lessivé	Loess	++	++	+++	++	++	+++
Carbonate-containing allochtone vega	Alluvial sediments	++	+++	++	+	+++	+
Vega / Gley vega	Alluvial sediments	++	+	++	++	+++	++
Para-rendzina-rigosol	Loess over shell limestone	-	++	+++	++	++	+

The soils with special archive functions selected by KÜBLER 2001 are evaluated again here based on the criteria (cf. Table 1) in the guideline published in the interim by Baden-Württemberg ("Soils as archives of natural and cultural history" - LUBW 2008) and adapted in the case of the alluvial gleys present in the Keuperbergland floodplains.

The resulting assignments and evaluation principles are shown here:

Rendzina / brown rendzina

The mapping unit "Rendzina and brown rendzina of the shell limestone and travertine slopes (SIG No. 1)" must be considered as an archive soil particularly due to the rare original substrate of the travertine (cf. KÜBLER 2001). Travertine was deposited over the past 500,000 years out of the mineral water rich in carbonic acid mainly during the warmer periods of the Pleistocene. According to LUBW 2008, this soil form is therefore to be classified as worthy of protection due to the criterion "Special original substrate of soil formation".

Figure 2: Travertine in the Haas quarry, Bad Cannstatt. (Source: Environmental protection office)

Humus lessivé / Chernozem lessivé

The mapping unit "Humus lessivé and Chernozem lessivé from loess on the border of the Schmidener Feld and on the Filder plain (SIG No. 21)" is present in the city area of Stuttgart with a surface area of approx. 370 hectares. These soils are worth of protection as per LUBW 2008 as relicts of a soil genesis that is no longer ongoing. The relevant criterion is the "particular significance for soil genesis".

Vega (brown alluvial soil) / Gley vega

The mapping units "Vega (carbonate-containing brown alluvial soil) of the Neckaraue (SIG No. 41)" and "Vega (brown alluvial soils) and Gley-Vega (alluvial gley-brown alluvial soil) of the Körsch- und Ramsbachaue (SIG No. 42)" are, according to KÜBLER 2001, worthy of protection with regards to soil diversity and naturalness as they are particularly formative for the catena of a near-natural soil landscape and rare in comparison to terrestrial soils. When the soil map in Stuttgart was checked, this was the reason why the mapping units "Gley-Vega (alluvial gley alluvial soil) and Gley (alluvial soil) of the floodplains in

Keuperbergland (SIG No.43) were included in the archives of natural history supplemental to KÜBLER 2001.

According to LUBW 2008, vega soils and gley-vega soils are witnesses of fluvial processes and evidence of natural history. They can be worthy of protection as archive soils due to their "special landscape shaping morphological elements and landscape history" in the form of soils on "younger (Holocene) river terraces in the Neckartal". Nationally, vega soils and gley-vega soils are not seen as rare. Based on the detailed data availability following the city soil mapping by HOLLAND 1995, and the evaluation by KÜBLER 2001, it has been shown for the city area of Stuttgart that vega soils and gley-vega soils must be seen as soils with regional rarity because of the high level of terrestrial soils and e.g. soils characterised by intensive agricultural use in the "Filder" region.

Para-rendzina-rigosols

The mapping unit "Para-rendzina rigosols of the loess-covered steep shell limestone slopes of the Neckartal, mainly terraced (SIG No. 45)" is anthropologically affected and provides information about historical vineyard utilisation as a cultivated soil. According to LUBW 2008, this soil form developed from partially historic, mostly terraced vineyards, is worthy of protection as a "special feature of settlement and land use history" and therefore an archive for Stuttgart cultural history.

Fig. 3: Vineyard.
(Source: Environmental protection office)

Overview of archive soils in Stuttgart

Table 3 and figure 4 provide an overview of the pedogenic archives of natural and cultural history currently known in the city area of Stuttgart. They are classified as worthy of protection as soil typological archives for natural and cultural history in the latest version of the soil quality mapped updated in 2009.

Table 3: Overview of pedogenic archives of natural and cultural history in Stuttgart

Value-relevant property (as per LUBW 2008)	**Description of soil form**	**Signature of soil form (SIG5)**
Special original substrate of soil formation	**Rendzina** and **brown rendzina** of the *shell limestone* and *travertine* slopes	1
Particular significance for soil genesis	**Humus lessivè** and **Chernozem lessivè** from *loess* on the borders of the Schmidener Feld and on the Filder plain	21
Rare soils or soil formation processes as per city soil mapping by HOLLAND 1995	**Vega** (carbonate-containing brown alluvial soils) of the Neckaraue	41
	Vega (brown alluvial soils) and **Gley-Vega** (alluvial gley-brown alluvial soils) of the Körsch- und Ramsbachaue	42
	Gley-Vega (alluvial gley alluvial soils) and **Gley** (alluvial soils) of the floodplains in *Keuperbergland*	43
Cultivated soils as special features of settlement and land use history	**Para-rendzina rigosols** of the *loess-covered* steep *shell limestone* slopes of the Neckartal, mainly terraced	45

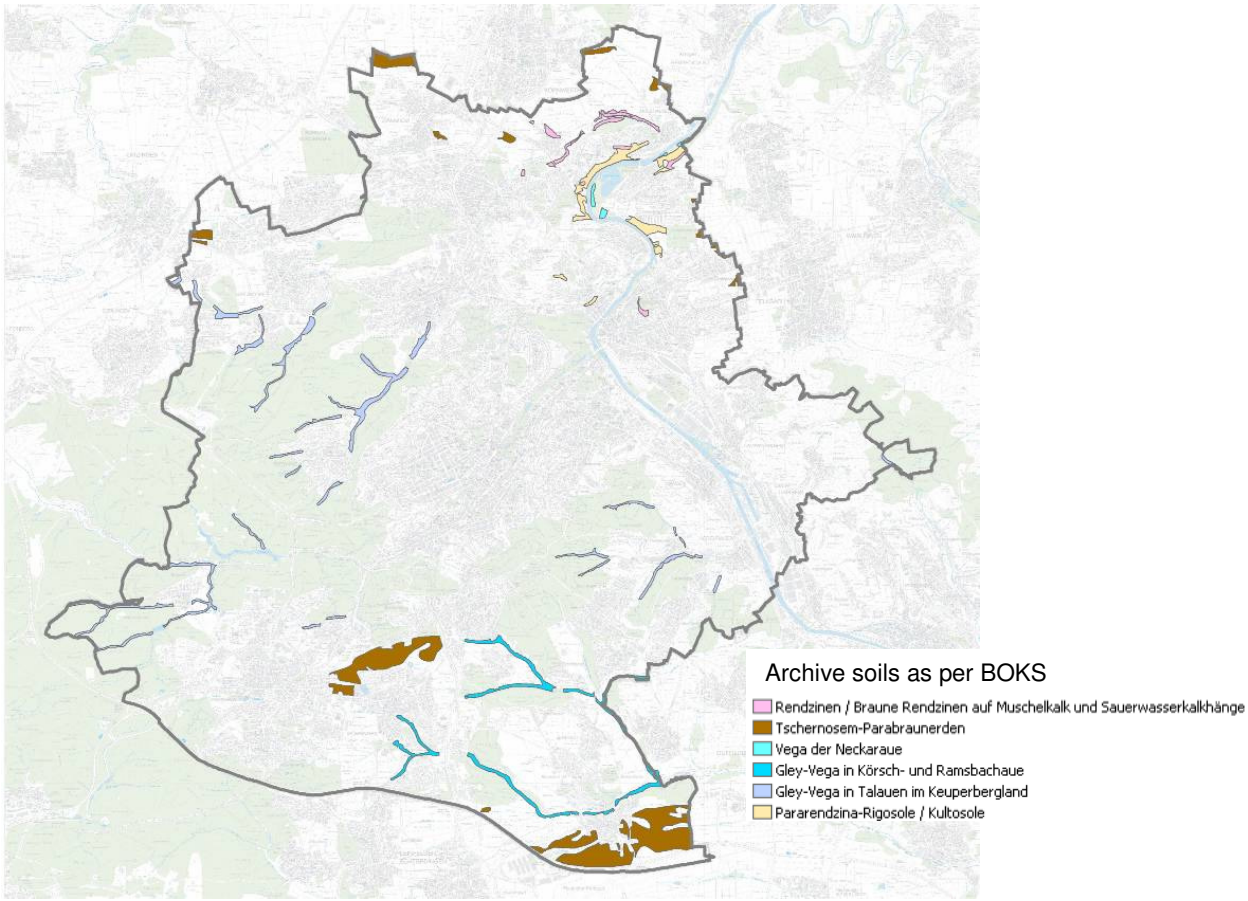


Figure 4: Spatial overview of the pedogenic archives of natural and cultural history of the city of Stuttgart (Source: BOKS)

3.2 Archives of natural history / Extensive and local natural monuments

Natural history archives have a particular significance for earth and landscape history, geology, mineralogy and paleontology (LUBW 2008). Geotopes are generally the "geological formations of inanimate nature that provide information about the development of the earth or life. They include structures of rocks, soils, minerals and fossils, as well as individual natural creations and landscape elements. Geotopes are windows on the history of the earth. They are part of the geological natural heritage. Geotopes characterised by their particular geological significance, rarity, uniqueness or beauty are worthy of protection" (cf. LfU 2002).

The soil quality map of the city of Stuttgart does not as yet contain geotopes and other extensive or local natural monuments. This is why the geotopes mapped as protected and worthy of protection in Stuttgart have been researched and newly included as archives of natural history as per LUBW 2008 in the soil quality map.

The geotopes present in the city area of Stuttgart that have been classified as natural monuments are mainly structures and quarries of particular significant for the history of the earth (cf. Table 4). One example is the "Rote Wand" (red wall) structure near the Uhlandshöhe, east of the Stuttgart central railway station (cf. Fig. 5).

Fig. 5: Rote Wand structure, Untere Bunte Mergel (km3u) (Source: LfU 2002)

The classified geotopes and natural monuments also represent, to some extent, special landscape-shaping morphological elements and landscape history, or special original substrates of soil formation (e.g. tufa deposits).

An overview of the geotopes that are protected and worthy of protection in the city area of Stuttgart can be seen in Table 4 and Figure 6. In the updated BOKS planning map of soil quality, geotopes are represented dependent on the data source as point data with a buffer of

10 m (radius) or as area information (natural monuments of the city of Stuttgart). They receive the highest soil quality stage (QS = 5).

Table 4: Overview of geotopes protected and worthy of protection in the city of Stuttgart

Category	Description	Examples
Structures	Structures with tectonic distortions, important strata formations, special sedimental structures, e.g. bordering embankments, etc.	Rote Wand structure, loess wall at the Max-Eyth lake
Quarries	Quarries with tectonic distortions, important strata formations, special rock types, minerals or fossils	Travertine quarry near Untertürkheim
Cliffs	Special sedimental structures	Dautenfelsen near Untertürkheim
Springs	Spring-water levels, spring sources	Mineral water spring source "Mombachquelle", "Hofener Hohlbrunnen" spring
Tufa deposits	Structures or soils on tufa deposits	Tufa deposits from karst spring near Sillenbuch
Significant landforms	Structures or soils in gorges and valley slopes	Schwäblesklinge near Degerloch

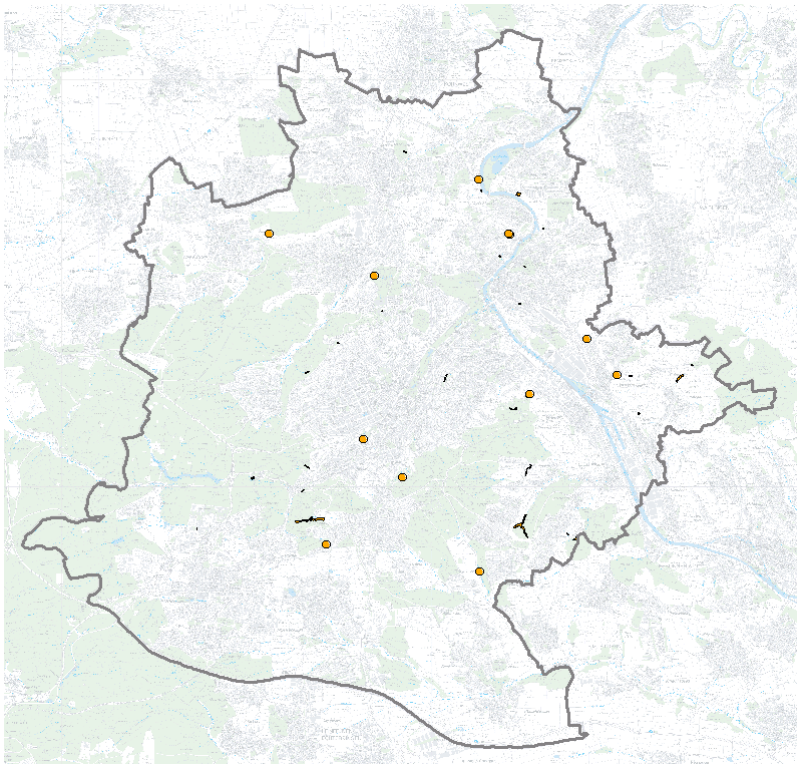


Figure 6: Spatial overview of the location of geotopes in the city of Stuttgart

3.3 Archives of cultural history – Archeological soil monuments / Areas of high culture-historical significance

The soils surrounding archeological sites and historical geographical features are usually "archives of cultural history" in many respects and also special features of settlement and land use history. Archeological features, including usage-based changes in natural soil structure or properties (e.g. increased content of carbon and phosphate), can also be found in the direct vicinity of archeological sites. Important knowledge about the preferred location of settlements and about historic or prehistoric land use forms can be gained from the structure of the soils surrounding such sites (cf. ELSA 2007).

The city area of Stuttgart includes, e.g. “Bandkeramik” (“linear pottery") graves (late Neolithic, 2nd half of the 6th millennium B.C.) around the "Viesenhäuser Hof" near Stuttgart-Mühlhausen (cf. Fig. 7). This burial ground belonged to an extended settlement of the first farmers in the region and provides evidence of the first use of this particularly high-yield loess soil.

Fig. 7: Skeleton with stone axe and 2 ceramic pots. (Source: Landesamt für Denkmalpflege, preservation authorities)

According to LUBW 2008, cultural history archives worthy of protection include archeological sites and soil monuments. This include sites located below and on the current earth surface containing settlement remains, burial grounds, fortifications and roads from all epochs of human history, and witnesses of historic usage forms that have left clear traces (cf. LUBW 2008).

Archeological sites and soil or historic monuments are not included in the previous version of the city of Stuttgart soil quality map. Therefore the updated version of the soil quality map will include, as archives of cultural history, the mapped archeological sites and historic monuments that are registered at the lower office for listed historic monuments of the city Stuttgart. Table 5 provides an overview of the cultural history archives currently located in the city of Stuttgart.

This does not take into account other cultural monuments registered by the preservation authorities which do not have a direct relationship to the soil, e.g. district boundary stones, forest boundary stones, former farmsteads, springs or cemeteries.

Table 5: Overview of soil monuments registered in the city of Stuttgart

Categories	Description
Archeological sites	Roman age sites, settlements and estates
	Graves and burial grounds from the La Tène and Urnfield periods, and Alemannic graves
	Mesolithic and Neolithic settlements and settlement remains (Bandkeramiker / linear pottery people)
Historic and soil monuments	Burial mounds
	Celtic quadrilateral enclosures
	Prehistoric fortifications, castle remains

The updated soil quality map of the city of Stuttgart differentiates, both in the presentation and evaluation, between archeological sites and historic sites/soil monuments.

The reason for this differentiation lies in the different protection requirements for maintenance of these cultural historical records. While historical monuments such as burial mounds or quadrilateral enclosures can be damaged both by building work or by sealing or excavation, artifacts from archeological sites can be removed before building work and preserved by scientific documentation. In the case of close to the surface sealing, it is also possible that artifacts that lie in deeper soil layers are not damaged as long as intervention does not occur down into the subsoil.

In order to meet the different protection requirements, the historical monuments listed in the soil quality map of the city of Stuttgart are assigned the highest quality stage (QS = 5), together with pedogenic archives and geotopes. In contrast, the evaluation of the soil quality is not changed by the presence of archeological sites. Information about sites are included in the soil quality map for information only by showing the listed areas as hatched in the soil quality map.

Figure 8 shows an overview of the location and distribution of archeological sites and historical sites/soil monuments.

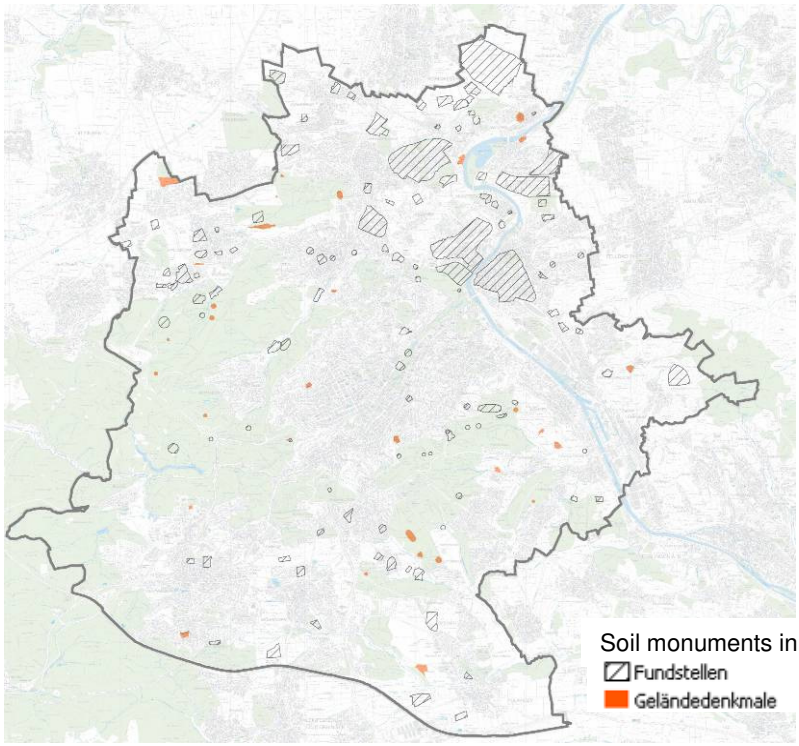


Figure 8: Spatial overview of sites and historical monuments

4 SUMMARY

A soil quality planning map was drawn up for the city area of Stuttgart within the framework of the soil conservation project (protection concept) for the city of Stuttgart (BOKS) containing, in addition to the natural soil functions, the archive functions of the soil. Only pedogenic archives were taken into account according to the data resources in 2001. Further natural and cultural historical archives such as geotopes, natural monuments of particular significance for earth and landscape history, soil and historical monuments, and archeological sites were not included in the original version of the soil quality map. This made it necessary to research data on geotopes and cultural historical archives and update the archive function.

In addition, the "Soils as archives of natural and cultural history" guideline drawn up by Baden-Württemberg was published in the interim (cf. LUBW 2008). This country-wide evaluation method was used to check the current BOKS methods for evaluation of soil archive and to methodically expand and upgrade such data.

Based on this background, the archive function as a component of the soil quality map was updated and supplemented so that improved information can be made available in the latest version. The Stuttgart soil quality map was redrafted within the framework of the archive function upgrade.

The following information was supplemented in the upgraded version:

- Pedogenic archives: Testing and modification of reasons and evaluations based on the procedure of Baden-Württemberg as per LUBW 2008. Updating of mapping units qualified under these criteria as worthy of protection.

- Geotopes: The updated soil quality map takes into account geotopes that are protected and worthy of protection.

- Cultural historical archive: The archeological sites and historic monuments that are registered at the lower office for listed historic monuments are integrated in the soil quality map.

The updated information about archive functions means that the city of Stuttgart soil quality planning map can provide better and more definitive statements about existing archives of natural and cultural history. It therefore offers decision makers and professional planners the possibility of obtaining information at an early stage and implementing alternative plans in order to retain archives worthy of protection.

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URBAN SMS Soil Management Strategy

This paper belongs to the following section of URBAN SMS work plan:
WP4 Soil manager suite / 4.2 selection and optimisation / 4.2.1 soil evaluation method

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This project is implemented through the CENTRAL EUROPE Programme co-financed by the ERDF.

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