R-05-15

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ISSN 1402-3091
SKB Rapport R-05-15

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Keywords: Soils, Regolith, Hydrology, Parent material, Pedology, Peat soil, Hitosols, Gleysol, Podzol, Umbrisol and regosol.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

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Abstract

Investigations to give prerequisite information for long-term storage of nuclear waste are made by the Swedish Nuclear Fuel and Waste Management Ltd (SKB AB). Ecosystem functions are crucial in this management. The range of the scope is wide including bedrock, regolith, hydrosphere and biosphere. The interface between deep geological formations and surface systems is then considered very important. This would be the top of the regolith, where soils are developed. Special attention has been paid these layers with fairly comprehensive investigations. The Department of Forest Soils, Swedish University of Agricultural Sciences, carried out Field investigations for the Oskarshamn candidate area in 2003.

The investigations in the upper regolith enclosed soil hydrology, soil parent material, pedology with soil sampling for physical and chemical analysis and on top of the soil also vegetation determinations. Methods followed the instructions for the Swedish Forest Soil Inventory. This would then provide possibilities to compare the conditions in the Oskarshamn investigation area with those of Sweden as a whole and also to relevant regions. However, there are basic differences with respect to spatial coverage. In the Swedish soil inventory, the distribution of plots provides spatial estimations for large areas but this would not be possible in the rather small Oskarshamn area. In this area, the investigation instead focused on thorough determination in relevant selected soil types. Determinations and sampling furnishes possibilities for statistical comparisons.

Geographical location of the Oskarshamn area is on the west Baltic Sea coast (N 57°25'; E 16°33') in the Kalmar county in the landscape Småland. Altitudes in the area (Figure 2-1) are up to the highest places on 53 m but mainly the area is found below 20 m. The climate is characterized by an annual precipitation of c 600 mm, fairly high evapotranspiration (> 400 mm) and an annual average temperature on c +6.5°C.

Based on a first surveillance, ten soil types were selected and surveyed in two replicates. The plots had a size of 15 m × 15 m, where site conditions were determined and eight soil profiles investigated and sampled.

Results reveal conditions similar land-cover and partly also geophysiographical conditions to large parts of Sweden, however, but with more frequently existing thin soils and rather often occurring small peat lands. Peat soils and Histosol dominated investigated sites. Other frequently occurring soils are Gleysol, Podzol, Umbrisol and Regosol. The small-scale broken topography provided considerable variations in hydrological conditions varying from the upslope bare bedrock and thin soils where fresh and dry conditions prevailed often on till soils to low-lying moist and wet sorted sediment soils and on many locations peat. Upslope and in the slopes mor and mull constituted the humus forms. The upslope areas included frequently occurring bedrock outcrops but in-between these and on the upper parts of the slopes to lower land, the soil depth anyhow could reach certain depths. Sampling and description was located to sites with slightly thicker soils, to provide soil properties for as deep horizons as possible in the vicinity to the upslope bedrock outcrops.

Vegetation conditions were fairly closely linked to soil moisture conditions with lichens on the dry bare bedrocks, mesic mosses on drained soils and wet mosses, mostly Sphagnum, in the low-lying moist and wet locations. The field layer was dominated by grasses and blueberry type. Partly, were also found low herbs and on some locations poor shrubs. On the wetlands low sedges occurred.

Soil chemical conditions were to a large extent reflected in the pH value, which furnished patterns rather similar to the region and mainly also to Sweden as a whole. In the O-horizon pH was on average 4.3 and in the mineral soil layers close to 5.2 all through the soil profile.

Carbon contents in the O- and C-horizon were somewhat higher as compared to all Sweden, with values on 39% and 1.2%, respectively. In the upper mineral soil horizons the contents were considerably higher with values on c 10%. Partly, this could be explained by a low frequency of Podzol soils and thereby rather few bleached horizons. Nitrogen content are often related to carbon and therefore the values in the Oskarshamn area showed higher values compared to total Sweden but in the C-horizon, the 0.12% was similar to Sweden region IV.

Sammanfattning

Undersökningar genomförs för att klargöra förutsättningar och fastställa förhållanden inför långtidslagring av utbränt kärnbränsle. Svensk Kärnbränslehantering (SKB AB) undersöker ekosystemförhållanden i de två områdena Forsmark och Oskarshamn. Dessa platsundersökningar har stor omfattning, alltifrån det djupa berget upp till de lösa avlagringarna ovan berg samt vatten- och biosfärssystemen. Känsliga delar i hela systemet är övergången från geosfär till biosfär, där de övre marklagren och jordmånsskiktet är avgörande för de ytliga ekosystemen. Fältundersökningar av Oskarshamnsområdets jordar genomfördes 2003 av Institutionen för skoglig marklära, SLU.

De särskilda jordmånsundersökningar, som har genomförts omfattade vegetationsförhållanden, markhydrologi, jordartsgeologi, pedologi och inbegrep också markprovtagning för laboratorieanalyser av fysikaliska och kemiska förhållanden. Inkluderat i dessa var främst skrymdensitet, pH, total C och N.

Undersökningarna följde gängse metoder för Riksinventeringen av Skogs markinventering /Lundin et al. 2002/. Detta medför att de egenskaper som bestämts för Oskarshamnsområdet kan jämföras med förhållanden i hela Sverige eller delar därav. En avvikelse från markinventeringen, som är spatiellt täckande för lite större områden, är att sådan täckning inte eftersträvades för Oskarshamnsområdet. Istället var avsikten att söka nå statistisk spridning för egenskaper inom utvalda enhetliga marktyper. För att kunna applicera dessa över hela området så användes GIS i en areell skattning av marktyper över området. Denna kartläggning baserades på vegetations-, jordarts- och hydrologiska digitala kartor. Från detta material kan den spatiella utbredningen av marktyper bestämmas och jämföras med markinventeringens uppgifter. Detta ingår inte i föreliggande rapport, som främst är en lägesbeskrivning av genomförda insatser.

De undersökta marktyperna fastställdes till tio varianter och varje sådan inventerades i två upprepningar. Varje lokal utgjordes av en 15 m × 15 m yta, där ståndortegenskaper fastställdes och åtta markprofiler undersöktes avseende fältbestämning av jordmån, jordart, textur, humusform och för torv nedbrytningsgrad. Markprover för laboratorieanalyser togs från humuslagret, de övre 0.2 m av mineraljorden och från modermaterialet på 0.6 m djup.

Det geografiska läget för Oskarshamnsområdet (N 57°25'; E 16°33') är vid Östersjökusten i östra Småland. Området ligger strax ovan havsytenivån med högsta höjder upp till ca 53 m men med större delen av området under 20 m höjd. Detta medför att jordarna är relativt unga och att jordmånsutvecklingen pågått endast relativt kort tid. Klimatet karaktäriseras av ca 600 mm årsnederbörd, en årsmedeltemperatur av ca +6,5 °C och ofta relativt torra och varma vegetationsperioder.

Undersökningarna visar i stort på relativt stora likheter mellan Oskarshamnsområdet och stora delar av Sverige såsom varande ett skogklätt område på tämligen vanliga jordarter. Noteras särskilt bör dock den småskaligt kuperade terrängen med frekvent förekommande berggrund med hällmark där tunna jordlager endast förekommer insprängt mellan hällarna och med något ökade utbredning av lite djupare jordlager i de övre delarna av sluttningarna. Förhållandena medförde en jordmånskarta som för sluttningarnas övre delar kom att innehålla en blandning av tunna jordtäcken och hällmark. Jordmånsinventeringen syftade dock på beskrivning av regolitens egenskaper och provtagning lokaliserades till platser med något djupare markavlagringar, som kanske inte helt representerade merdelen av de kartlagda områdena i denna klass men likväl förekommer och ger representativa markförhållanden.

Markfuktigheten kan ofta hänföras till frisk mark men fuktig och blöt torvmark förekommer också. De relativt unga jordarna utgörs till stor del av sorterade sediment såsom lera och sand men flerstädes också torv. Moräner förekommer endast ställvis. Bearbetning och omlagring genom havsvattnets försorg medför att de mer moränliknande jordarterna finns i de högre belägna delarna där också renspolade hällar förekommer frekvent. I lägre liggande lägen har jordmaterialet bearbetats mer och där förekommer också de vattensorterade sedimenten. I den småskaligt varierade topografin har bidragit till dominerande humusformer främst av typerna torv, mull och mår.

Under strandförskjutningen (landhöjningen) har havsvikar blivit avsnörda från havet varvid grunda sjöar uppstått som senare omförts till våtmarker med torvbildande miljöer. Inslaget av fuktiga och blöta jordmåner såsom histosol och gleysol förekommer frekvent. I övrigt finner man ofta podsol, umbrisol och regosol.

Vegetationsutvecklingen följer i stort fuktighetsförhållanden med lavar på de kala bergytorna, friskmossor på dränerade jordar och sumpmossor, främst vitmossa, i de lägre belägna och fuktiga till blöta områdena. Fältskiktet domineras av grästyper och blåbärris. Ställvis finner man också lågörter och på andra områden fattigris. Våtmarkerna domineras av lågstarr vegetation.

Markkemin speglas delvis av pH värdet, som uppvisar likheter med förhållanden för regionen och även övriga Sverige med pH i O-horisonten på 4,3 och i mineraljorden ca 5,2 från de övre lagren ner i C-horisonten. Kolinnehållet visar något högre värden än Sverige i övrigt vad avser O- och C-horisonterna med 39 % respektive 1,2 % medan de övre mineraljordshorisonterna har klart högre halter med ca 10 % än vad som vanligen präglar skogsmineraljordar i Sverige. Kväveinnehållet påverkas delvis av kolinnehållet och därmed är halterna något högre än för Sverige i övrigt, särskilt i de övre mineraljordshorisonterna medan värdena i C-horisonten är likartade övriga Sverige.

Contents

1 Introduction

The Swedish Nuclear Fuel and Waste Management Ltd (SKB AB) carries out comprehensive investigations related to management for long-term storage of nuclear waste. These investigations concern ecosystem properties and functions in tentative areas of bedrock storage. In this work, the soil and site type survey is one important part. One of the candidate areas is the Oskarshamn area where soil and site conditions were investigated in 2003. Another candidate area is Forsmark in east central Sweden, where similar investigations were made in 2002 /Lundin et al. 2004a/. Information of regolith properties is necessary to provide possibilities to model possible transport of nuclide leaching as well as determine impacts of the preparatory work for the storage compartment building.

The Department of Forest Soils, Swedish University of Agricultural Sciences in Uppsala carried out the survey using mainly similar methods as for "The Swedish Forest Soil Inventory" /RIS 2003/. This combination provides possibilities to compare the conditions in the Oskarshamn area with national and regional conditions. The variables included in the investigation are mainly the same as in the forest soil inventory.

The upper part of the soil is one of the more crucial components for ecosystem functions. Clarification of the conditions in the uppermost metre of the soil was the main focus in this investigation. The general approach in the work has been to classify the land into the typical soil types of the area based on spatial information on vegetation, Quaternary deposits and a topographical index of soil wetness. This work was carried out in a GIS environment. Variables determined will include vegetation, hydrology, soil parent material and textural composition, soil profile type and physical and chemical properties of relevant soil layers.

The project results were preliminary reported in a short document presenting the determinations that were carried out /Lundin et al. 2004b/. Mainly, the report includes an overview of the investigated sites with common descriptions.

A more comprehensive report based on a GIS of a soil map of the Oskarshamn area is here the focus for detailed presentation of site conditions. The results from the field investigation form the basis for the soil classes selected as suitable to characterise the Oskarshamn area. The further development was to extrapolate this information and give the geographical distribution of the defined soil classes in the total candidate area.

Soil here refers to the upper part of the regolith, which is characterised by horizons with certain physical and chemical properties. The soil is developed as a result of the interaction of many different factors, such as typically influences of ***soil parent material, climate, hydrology*** and ***organisms***, being integrated over ***time***. The aim of soil classification is to define soils of similar characteristics, i.e. soil types. By mapping soil types it is possible to assign properties collected in well-described soil profiles to other locations with the same soil type. Since soils are the result of many different processes, they are a sensitive component of the ecosystem and may serve as indicators for changes induced by disturbances. In the Oskarshamn area, it is of interest to be able to trace any short- or long-term changes induced by the actions taken in relation to the possible long-term bedrock storage of nuclear waste material. Short-term changes may involve changes induced by e.g. a changing groundwater surface level, whereas the long-term changes that might occur are partly unknown but could be related to biological effects of radioactive elements.

2 Investigation area

The Oskarshamn area is located on the west Baltic Sea coastline in the south-east part of Sweden. The area is c 20 km^2 and located approximately N 57°25’ and E 16°33’, west of the Oskarshamn nuclear fuel plant (Figure 2-1). The altitudes of the area range from coastal sea level up to c 53 m a s l but with most of the area below 20 m. The main land cover is forest on different soil types, together with partly open land on wet soils and bedrock outcrops. The landscape type has a lowland broken topography of small hills of till and bedrock with small, mainly wet soil valleys in-between. There, the land types are forest, pasture and arable.

The climate of the region is characterised by a snow covered winter period during three months in 60% of the years, ranging approximately from first of December to March, c 75 days. Greatest snow depth is on average 35 cm. The vegetation period extends over 195 days, mainly April to October. Hydrology is characterised by fairly dry summers, autumn rains with increasing runoff as well as with snowmelt periods during winter. Annual precipitation amounts to c 600 mm, having the highest monthly values in July–September with c 60 mm/month and the lowest in February–March with c 25 mm. Evapotranspiration reaches over 400 mm resulting in a runoff of less than 200 mm. The mean annual temperature is c +6.5°C /Raab and Vedin 1995/.

The soils of the Oskarshamn area are fairly young. The soil material is of till origin, which has been influenced by the sea during the transgressions of the Baltic Sea. By these, redistribution of soil material occurred and left course water washed tills in higher locations, also with thin soils and bare bedrock. Elsewhere, in depressions the redistributed fine material has been deposited as sorted sediment soils. During the overall transgression, sea bays have been cut off and now forms wet soils and peatlands.

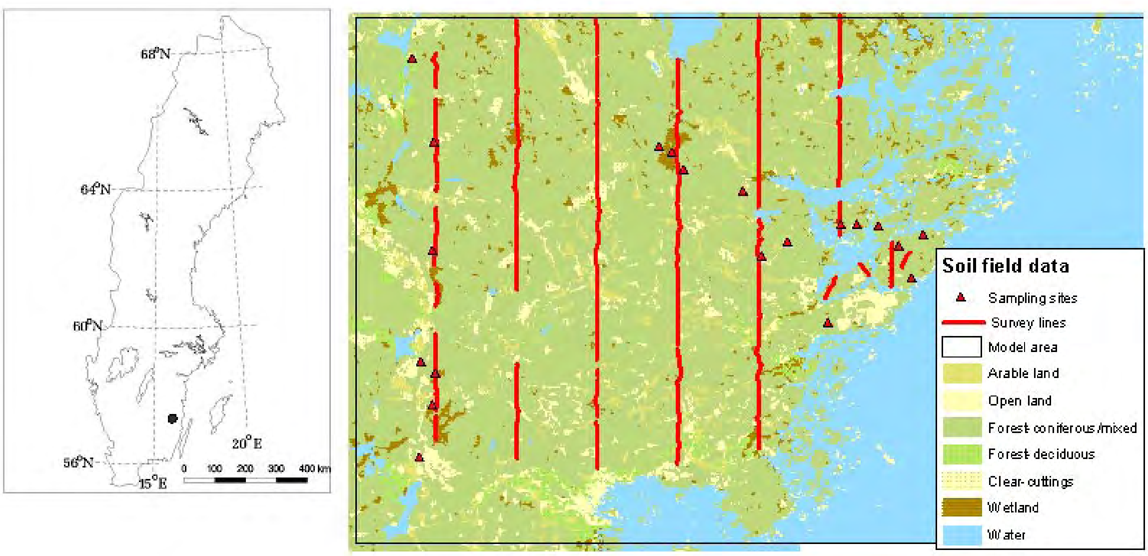


Figure 2-1. *Geographical location of the Oskarshamn investigation area and presentation of land use types, inventory transects and sites.*

3 Methods

3.1 Investigation design

The investigations on site and soil conditions are linked, by mainly using similar methods, to the Swedish Forest Soil Inventory (RIS-MI). Conditions and properties of the Oskarshamn area were classified from the plots investigated with the intention to compare with other parts of Sweden. In the total Oskarshamn regional area, the sub-area SKB Oskarshamn Laxemar has been a core area for investigations and GIS map soil class determinations primarily were related to this area. Investigation plots were however, also located outside this area.

The primary interest in the soil inventory is to identify characteristic land types and for each of these determine statistically based values on a number of properties, especially chemical elements. These values would in a tentatively later repeated investigation provide possibilities to detect changes over time. Another interest is the possibility to compare the Oskarshamn area conditions with the national and regional conditions, surveyed in the "Swedish Forest Soil Inventory", to show distributions of properties for the Oskarshamn area in comparison with all of Sweden and also a few other relevant regions, such as the Kalmar county and the Oskarshamn community.

In the initial inventory stage, studies were made to get an overview of the area. Two methods were used;

1) available maps were studied,
2) a site land surface survey along 11 transects over the area was made (Figure 2-1). However, this was not sufficient to achieve a total coverage of the survey area. Related comprehensive work would have been to time-consuming.

From these preparatory stages ten site types were selected and representative plots thoroughly investigated. The plots were selected based on five criteria:

- The plots should be representative for typical sites in the area, primarily with respect to hydrology and vegetation.
- The sites should have representative soil material and humus forms.
- The plots should be fairly homogeneous with respect to topography, soil moisture class, vegetation, humus form and soil patent material composition.
- Elevation differences inside the plot should not exceed one metre.
- There should inside the Oskarshamn area exist a similar site, not belonging to the same biotope, to be used as replicate.

Each of the ten site types had two replicates, which makes up 20 investigated plots. On each plot, being 15×15 m, a 5×5 m grid was established and used to select the exact soil profile locations. These were selected based on a systematic approach, where the first location was intended for a deep profile (to 0.7 m), second used as a reserve and third for a profile for upper horizons (0–0.5 m) and then a reserve for this and after this the same consecutive four locations repeated. Reasons for not using pre-set locations could be trees, boulders or deviating water levels. A deep profile could be changed to an upper layer pit if there would be problems to go deeper and then the reserve or next location was chosen as next deep pit.

The investigations were carried out according to Activity Plan SKB AP PS 400-03-26 (SKB internal control document). The data have been incorporated in the SICADA database.

3.2 Site survey methods

At each of the plots one site description was made including type of field- and bottom layer vegetation, hydrology, subsurface water flow, drainage activities, frequency of stones and boulders and the thickness of the humus layer. These characteristics were then valid for all the eight soil profile locations inside the plot. Presented codes refer to the SICADA database.

3.2.1 Aspect

Indicates the plot facing direction.

1 north	12 northeast
2 east	14 northwest
3 south	32 southeast
4 west	34 southwest

3.2.2 Site hydrology – soil moisture class

This variable reflects the average distance from the groundwater table to the ground surface during the vegetation period. Estimations are made from geophysiographical conditions.

1 dry
2 fresh
3 fresh/moist
4 moist
5 wet

3.2.3 Probability of subsurface water flow

This variable mainly refers to the slope and length of slope uphill from the plot studied. Estimations are made from topography and slope length.

1 Missing/rare
2 Shorter periods
3 Longer periods

3.2.4 Drainage

Estimations reflect effect of ditches on the plot where 20 m considers being the largest distance of influence.

0 not drained
1 drained

3.2.5 Stones and boulders

Statement shows the possibility to perform the stoniness inventory. The special determination means pushing a 10 mm steel rod into the soil until a stone or boulder is hit within max. depth of 30 cm. This was made in 36 points over the 15×15 m plot. At the same locations also the thickness of the humus layer was measured. The average stoniness depth is used in a function to estimate the volumetric content of stones and boulders in the soil. The function used relates to the Viro method /Viro 1958/ but was modified according to Melkerud and Lundin /Lundin et al. 2004a/.

$Z = 71.7 - 2.39X$, where Z is volumetric content, % and X the penetration depth, cm

Database content
0 measurements not possible to make
1 measurement made, and if made depth in cm.

3.2.6 Vegetation

Vegetation types and dominating species within the list of species used in the "Forest Soil Inventory" and percentage of coverage were determined.

Vegetation types included in the bottom layer:

1 lichen type
2 lichen-moss type
3 lichen rich type
4 *sphagnum* (White moss) type
5 wet moss type
6 mesic moss type

Field layer:

01 tall herbs without shrubs
02 tall herbs with shrubs/bilberry
03 tall herb type with shrubs/vitis idea
04 low herbs without shrubs
05 low herbs with shrubs/bilberry
06 low herbs with shrubs/vitis idea
07 without field layer
08 broad leaved grass
09 narrow leaved grass
10 tall sedge
11 low sedge
12 horse tail type
13 bilberry type
14 vitis idea/whortleberry, marsh rosemary type
15 crowberry/heather type
16 poor shrubs type

The species identified relates to the number of types (c 270 species or groups of species) in the "Soil and Vegetation Survey Manual" /Lundin et al. 2002/.

3.3 Methods for soil inventory on profile level

Presented codes and values refer to the SICADA database (Section 3.1).

3.3.1 Soil profile

Thickness of the genetic horizons was determined. This refers to common designations of the horizons /Lundin et al. 2002/. Values are given as depth from the soil surface. When depth values are followed by a plus-sign (+), this means a horizon deeper than the value given.

Humus layer, deepest border
A-horizon, deepest border
AB-horizon, deepest border
E-horizon, deepest border
B-horizon, deepest border

3.3.2 Soil parent material in the profile

Soil material composition is determined at 20 cm depth in the mineral soil and as peat if the organic surface layer is thicker than 30 cm.

1 Well sorted sediments
2 Poorly sorted sediments
3 Till
4 Bedrock
5 Peat

3.3.3 Soil material texture

Textural conditions were determined in the field using common methods by working the material /Lundin et al. 2002/. Determinations were made on a sample from a depth of 20 cm in the mineral soil.

0 Boulders in the profile
1 Stone/Boulder/Bedrock
2 Gravel/Gravely till
3 Coarse sand/Sandy till
4 Sand/Sandy silty till
5 Fine sand/Silty sandy till
6 Coarse silt/Coarse silty till
7 Fine silt/Fine silty till
8 Clay/Clayish till/Gyttja
9 Peat

3.3.4 Humus form

The humus form was determined in situ according to the Swedish forest soil inventory /Lundin et al. 2002/.

1 Mor1
2 Mor2

3 Moder
4 Mullike moder
5 Mull
6 Peaty mor
7 Peat

3.3.5 Soil type

Classification on soil types refers to the international World References Base system (WRB) /WRB 1998/. The system used is a simplified version including the appropriate types for Sweden and with field determinations, which actually is not totally correct while a thorough classification needs chemical analysis. However, the simplified determination would reflect an almost correct classification.

1 Histosol
2 Leptosol
3 Gleysol
4 Podzol
5 Umbrisol
6 Cambisol
7 Arenosol
8 Regosol
9 Unclassified (could be caused by too much water, etc)

3.3.6 Additional features in the soil profile

There are a number of specific features that are of decisive interest in the soil profile and some of these have been determined. These are related to anthropogenic influences and chemical properties.

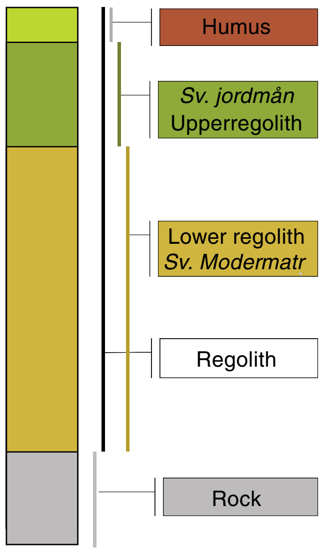
0 None
1 Culture influence (especially ploughing)
2 Disturbances (soil scarification, wind thrown trees, etc)
3 Spodic B horizon (determining the Podzol soil type)
4 Calcium carbonate (frequently found in Forsmark area /Lundin et al. 2004a/)
14 Combination of 1 and 4
34 Combination of 3 and 4

3.3.7 Soil sampling

Soil was sampled from the profiles and the system was adopted both to international conditions and the traditional Swedish system to give the possibility to compare with the ongoing Swedish "Forest Soil Inventory". The horizon from which soil was sampled was recorded and the soil parent material and texture determined on the deepest sample, belonging to the C-horizon. This determination used the classes given above for soil parent material and texture in the soil parent material. Sampling of the soils was made according to the soil type with the basic sampling related to:

Humus layer was sampled separately and mineral soils mainly in three layers (Figure 3-1).
Mineral soil layers: 0–10 (H10 sample in mull and mull like moder), 10–20 and 55–65 cm.
In Podzols: additional 0–5 cm in the B-horizon.
In Histosols: 0–30 and 40–60 cm.

Rock, Regolith and Soil Sampling



Sampling depths, cm

Main types	Podzols	Peat
0–30	0–30	0–30
0–10	0–5	
10–20	5–20	40–60
55–65	55–65	

Figure 3-1. *The regolith over the bedrock with soil sampling depths in three categories of soils.*

Despite the careful preparations and consecutive analysis, the importance of sampling depths may not be neglected. The fixed sampling depths mixed in some cases genetic horizons giving a less distinct result.

3.3.8 Sampling for bulk density

Volumetric mineral soil samples were taken to determine dry bulk density. Two profiles on each plot were sampled, if possible, in the depths: 0–10, 10–20, 20–30, 30–40, 40–50 and 50–60 cm. The steel cylinder size used in mineral soils had the height 5 cm and radius 3.6 cm. In peat soils the larger humus sampler were used with radius 5 cm and sampled depth of c 10 cm.

3.3.9 Mineral soil material underlying peatlands

The composition of the parent material underlying peat deposits were determined according to:

1 Clay
2 Silt
3 Sand
4 Gravel
5 Stone
6 Non-sorted material
7 Boulder or bedrock

3.3.10 Peat humification degree

The degree of peat humification, according to the von Post scale /von Post and Granlund 1926/ was determined in two depths in the peat, i.e. 10 cm and 50 cm.

Decomposition degree:

1 Undecomposed or very weakly, von Post H1–2
2 Weakly, von Post H3–4
3 Moderately well, von Post H5–6
4 Strongly, von Post H7–8
5 Almost completely, von Post H9–10

3.4 GIS map soil classification

The core investigations being basis for the map classification were carried out for the SKB Oskarshamn area Laxemar and soil class distribution from this area was used for comparisons with other parts of Sweden. Deviations between the sub-area and the total Oskarshamn regional area were minor.

3.4.1 Soil formation and classification

The soil refers to the upper part of the regolith, which in total rests on the underlying solid bedrock. The soil is characterised by soil chemical and physical properties different from the material of the regolith underneath. The soil is the result of many interacting processes that are commonly summarized in the soil forming properties, being climate, parent material, topography, biota and time. Although these properties interact in a complex way, the soil type in a location is often influenced more strongly by one or a few of these properties. Based on the fundamental theory of soil formation, the Oskarshamn area was classified into different soil types from secondary geographical information describing different properties as basis of soil formation. In this case these properties were the soil parent material as described by maps of quaternary deposits, the biota through maps of the vegetation composition of the ground, field and tree layer, and the topography, related to hydrology, through a digital elevation model (DEM). The soil types assigned were derived from criteria set for each input data source starting with the quaternary deposit, followed by the wetness and the vegetation data. For example the quaternary deposit data was used to outline areas with peatland soils, and the vegetation data was used for classification into subcategories such as open wetland and forested wetland soils. The climate was considered similar across the area in the classification.

3.4.2 Input data

A detailed map of quaternary deposits was available for the Laxemar area (Figure 3-2) /Rudmark 2004/, while the map for the rest of the Oskarshamn area was of poorer quality /Svedmark 1904/. Both datasets were vector data and the classes for them can be found in Appendix I. In order to improve the quality of the data on the quaternary deposits for whole Oskarshamn area, an improved map was produced based on the digitalized version of the old map of quaternary deposits /Svedmark 1904/, remote sensing data of bedrock areas /Rudmark 2004/, and topographic information (Figure 3-3). The bedrock areas were entirely based on the remote sensing data irrespective of the old digitalized map. In addition, a classification of downslope areas was made based on the topographical wetness index (see below, Figure 3-5), since the quaternary deposit in the area was strongly related to position in the landscape. The downslope areas generally consist of different sediment deposits. The vegetation data was also used as a guideline to locate these deposits.

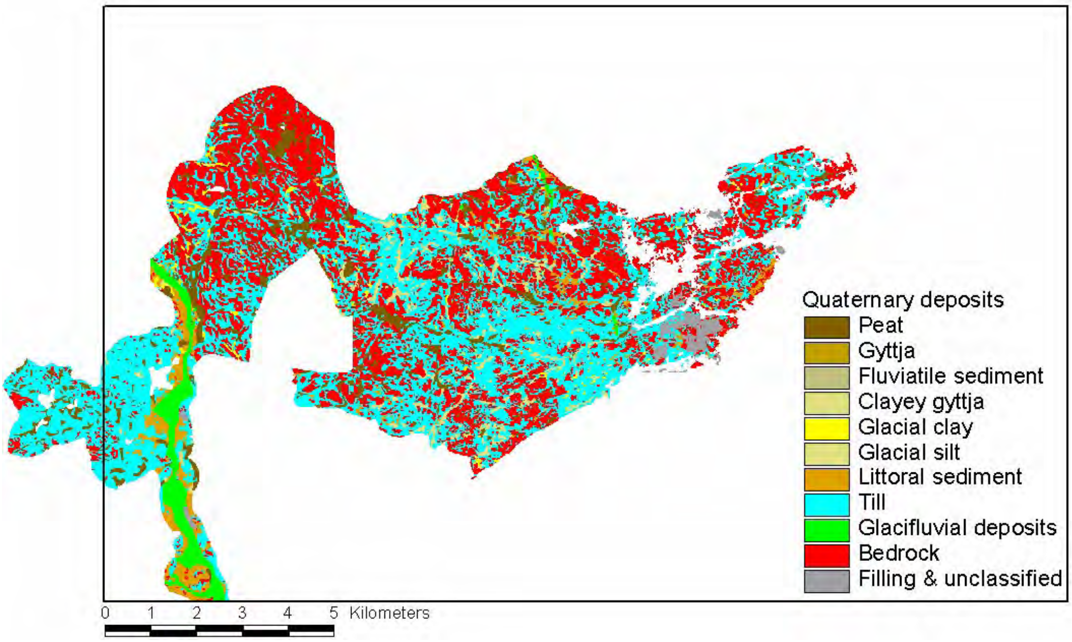


Figure 3-2. *The map of quaternary deposits map for the Laxemar area /Rudmark 2004/.*

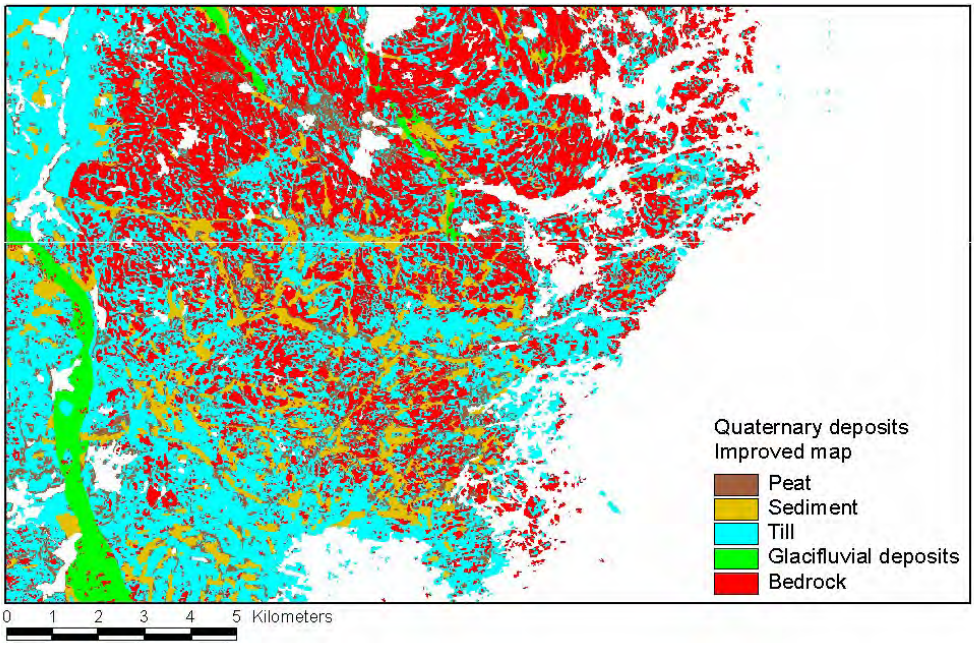


Figure 3-3. *Improved map of Quaternary deposits for Oskarshamn area derived from the old map /Svedmark 1904/, remote sensing data of bedrock areas and topographical wetness index.*

The available vegetation data was produced from classification of satellite images by remote sensing techniques /Boresjö et al. 2002/, and included information on the ground-, field- and tree layer (Figure 3-4a–c). The data was in vector format with an approximate scale of 1:50,000. The classes for each layer can be found in Appendix II.

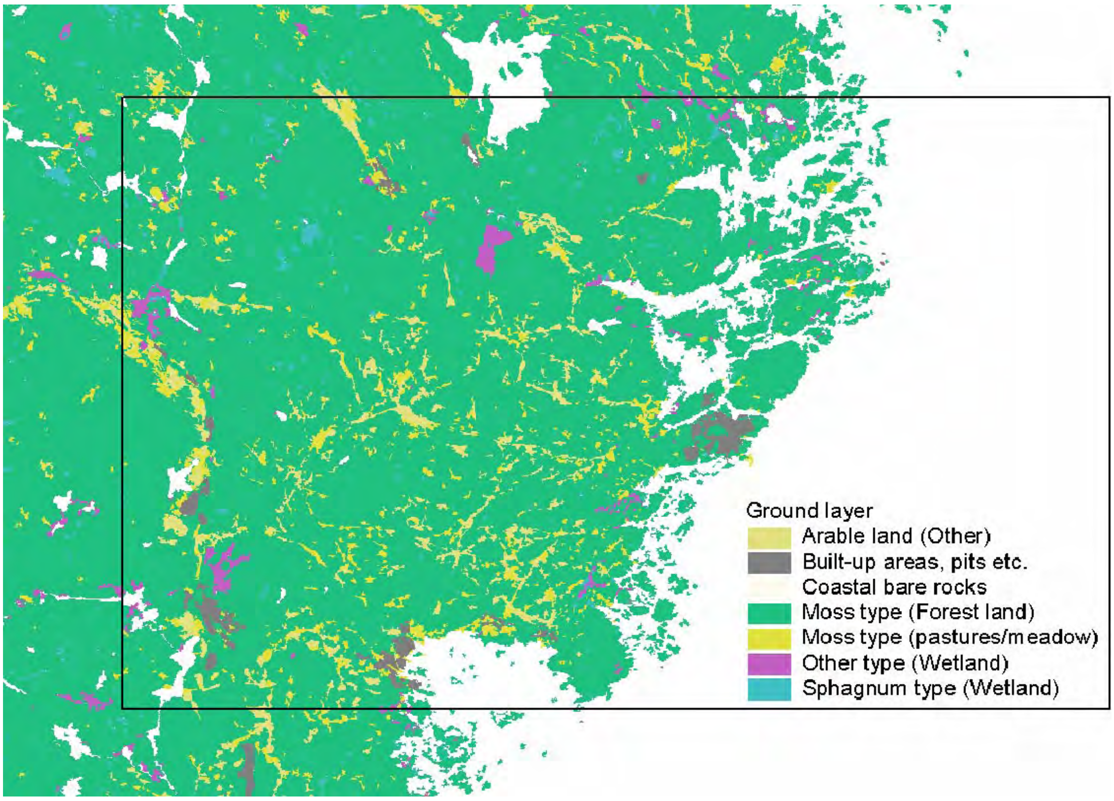


Figure 3-4a. *The ground layer vegetation map of the Oskarshamn area /Boresjö Bronge and Wester 2003/.*

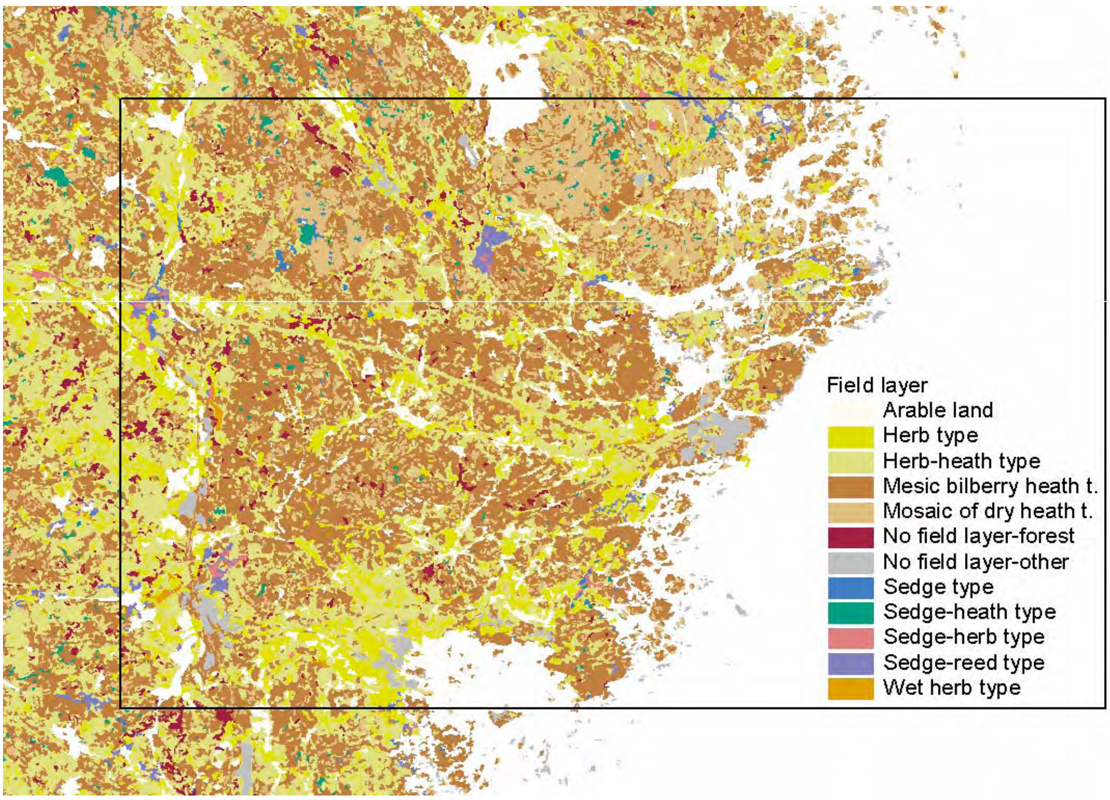


Figure 3-4b. *The field layer vegetation map of the Oskarshamn area /Boresjö Bronge and Wester 2003/.*

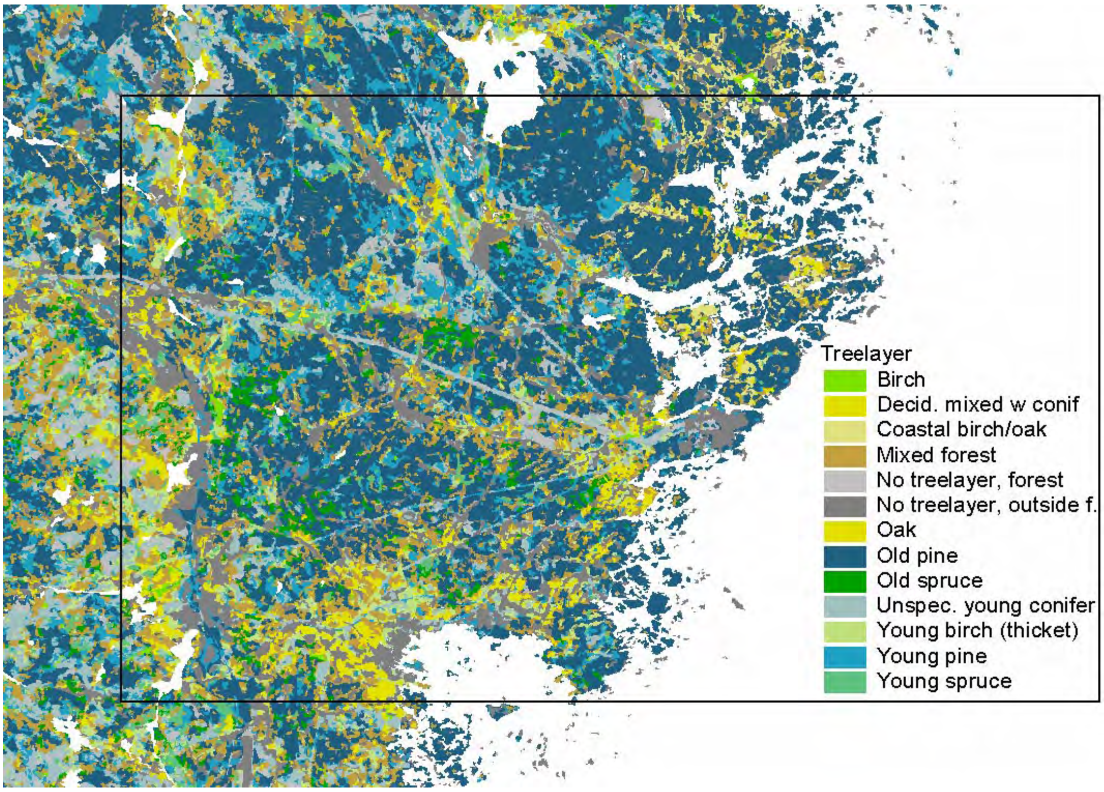


Figure 3-4c. *The vegetation map of the Oskarshamn area: tree layer /Boresjö Bronge and Wester 2003/.*

3.4.3 Topographical wetness index

The influence of topography on the soil formation is mainly through the hydrological conditions given by the topography. Upland areas are generally drier than lower areas in the landscape and this variation in moisture conditions can be described from topographic information. This information may be used to differentiate between soil types although other conditions are similar.

The wetness conditions in a certain location relates to its specific catchment area, i.e. the upslope area draining through that location, and the slope. This relation is used to calculate a topographical wetness index (TWI) from a DEM in the TOPMODEL hydrological model /Beven and Kirkby 1979, Seibert et al. 1997/. The index describes the spatial distribution of the groundwater table, which reflects the soil moisture in the upper part of the soil. The index is valid as long as the groundwater surface varies according to the topography and the soil transmissivity is constant. When the accumulated flow reaches a certain threshold the flow becomes saturated and a stream is formed, which discharges the surface water. The index (TWI) for a grid cell is a non-linear function of the upslope area (α) and slope (β):

$$TWI = \ln (\alpha/\tan \beta)$$

A large index indicates wet soil conditions as opposed to low index, which indicates dry conditions. Before it was used further, the calculated TWI values for the Oskarshamn area (Figure 3-5) were smoothened by calculating a local mean value in a three by three cell neighbourhood (30 by 30 m).

Topographical information was available in the form of a high-resolution digital elevation model (DEM) with 10 m raster cell size /Wiklund 2002/. The elevation data was used to calculate a topographical index of soil moisture, which could be used to outline downslope areas with moist conditions.

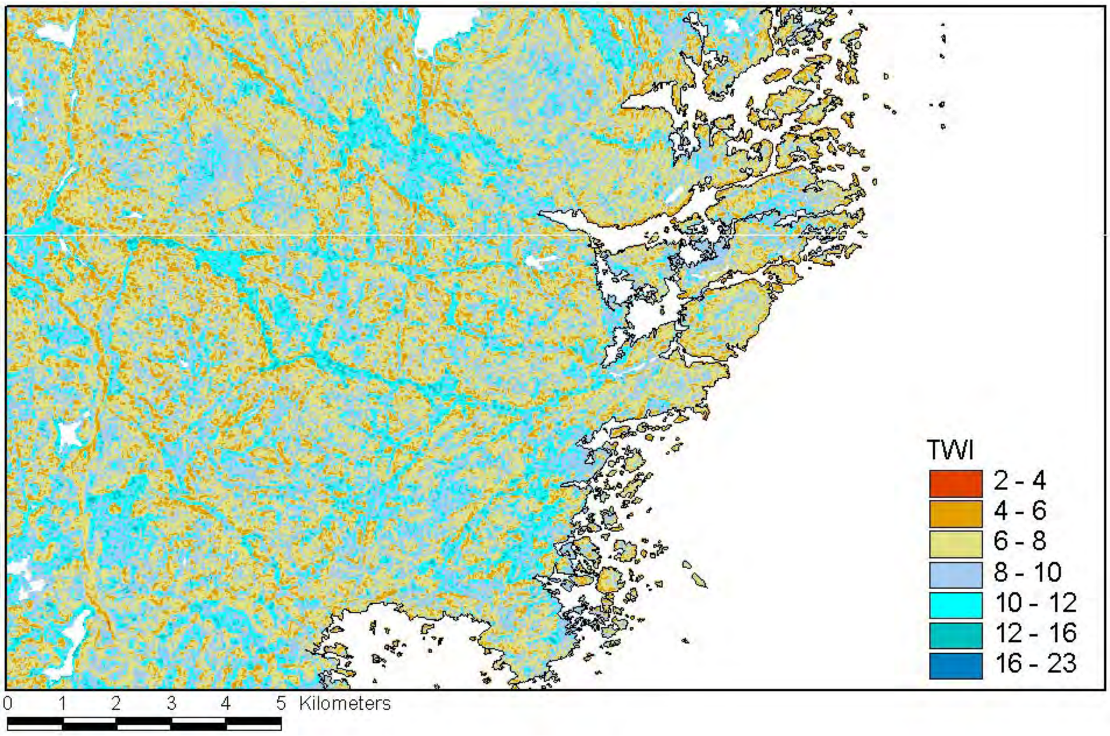


Figure 3-5. *Map of the calculated topographical wetness index as modelled by TOPMODEL for the Oskarshamn area.*

3.4.4 Processing of geographical data

The processing of the geographical data was made in Arc/Info and ArcView software. All vector input data sets were converted into 10 m raster maps, with a common extent and origin, in order to facilitate overlay analysis. The raster was defined based on the DEM raster layer of the area. The distance to the sea was derived by spatial neighbourhood analysis (Expand operation in Arc/Info GRID) and used as input data. The raster maps of each input data source formed a spatial database of the Oskarshamn area, which could be used to classify the area into soil classes. Through Boolean logic operations in Arc/Info GRID the area was classified into soil types based on defined criteria for each input data layer. For some soil types other methods were applied, based on e.g. distance to sea of size of connected soil areas. The soil map was generated by a batch Arc/Info AML-script that included all defined criteria.

3.4.5 GIS soil map classes

Ten classes were defined to characterize the soil conditions in the Oskarshamn area. The names are in accordance with the Soil Classification /WRB 1998/, although GIS soil map classes in the Oskarshamn area often embrace two WRB classes, in order to describe the special conditions in the area. The classes were defined during the field survey of soil and site conditions at plots and along transects in the area.

The map classification was based on one or several of the input layers (Figure 3-6), such as the quaternary deposits, the vegetation (tree, field and ground layer), the topographical wetness index, and distance to the sea. Since the data on the quaternary deposits were different for the Laxemar area and the whole Oskarshamn area the criteria were set somewhat different. The criteria for the soil classification that is summarized below refers to the classification of the Laxemar area, although a similar approach was used for the Oskarshamn area. For a detailed description of each step in the classification see Appendix III for the batch script that was used in Arc/Info to generate both soil maps. The names and definitions of the classes and their codes are given in Appendix I and II. Description of methods to identify the GIS soil map classes in the Oskarshamn area:

LP: Leptosol (bedrock)

This class covers bedrock or very thin soils typically found in upslope locations. Leptosol soil type, which dominates this class, has a soil depth of less than 25 cm overlaying the bedrock or parent material dominated by stones and boulders. The main part of this class consists of bedrock outcrops, with a tree layer that is missing or consists of sparse pines, and a field layer of dry heath type.

Map classification

This class was assigned to bedrock areas according to the map of quaternary deposits. Further, the field layer had to be of dry heath type. Note that the bedrock class of the quaternary deposits may have a soil cover of approximately 30 cm.

PZ/RG: Podzol/Regosol (thin forested soil)

This class consists of rather thin coniferous forest soils found in upslope locations with fresh soil moisture class. Soil thicknesses could vary from zero to circa one metre in different locations and there exist also bedrock outcrops. The Podzol and Regosol soil types, which dominate this class, are formed on course textured parent material and are characterized by a leaching horizon although often poorly developed in the area due to the young soil age. The forest is dominated by pine and some spruce with a field layer of heath type.

Map classification

This class was assigned to areas with course mineral soil and bedrock according to the quaternary deposit. Because of the small scale variation between soil covered bedrock and bare bedrock spots the class includes a considerable variety of soil thicknesses. The criteria for the forest type included conifer tree layer, a field layer not of dry heath type. The ground layer excluded all arable and other open land.

RG: Regosol (esker soil)

This class is found on the esker in the western part of the area. The soil is mainly of poorly developed Regosol type, rich in stones and boulders. The soil moisture class is mainly fresh or partly dry. The tree layer is dominated by pine and the ground layer excluded all arable and other open land.

Map classification

This class was assigned to areas located on glacifluvial deposits according to the map of quaternary deposits and the ground layer excluded all arable and other open land.

UM/RG: Umbrisol-Regosol (drained forest soil)

This class consists of deciduous forest soils found in upslope locations with fresh soil moisture class. The prevalent soil types include the fertile Umbrisol and poorly developed Regosols soil types. Deciduous trees dominate the tree layer together although some mixed forests occur. The field layer is of heath and herb type.

Map classification

This class was assigned to areas with mineral soil and bedrock according to the quaternary deposit and a tree layer, which consisted of deciduous trees. The ground layer excluded all arable and other open land.

UM/GL: Umbrisol-Gleysol (open, partly forested moist soils)

This class include open pastures and partly forested moist soils in downslope locations. The soil type is mainly the fertile Umbrisol but also include the periodically saturated Gleysol.

Map classification

This class was assigned all area with ground layer of pastures and meadows type. Also, areas with a high TWI value (> 10) on mineral parent material according to the quaternary deposit. Areas with a dry heath field layer were excluded.

HI-f: Histosol (forested peatland)

This class consists of forest-covered peatland soils. The Histosol, which comprises organic soils of at least 40 cm depth, are mainly forested with pine although other deciduous trees also occur. Peatland soils forested with monocultures of spruce are also found in the area.

Map classification

This class was assigned all area with peat according to the quaternary deposits and which also had a forest present according to the tree layer. The ground layer excluded all arable and other open land.

HI-w: Histosol (open wetland)

This class covers open peatland soils and includes open mires as well. The dominant soil class is Histosol, which comprises organic soils of at least 40 cm depth.

Map classification

This class was assigned to areas with ground layer of type “Peatland” or of type “Not peatland (Wetland)” in case field layer was sedge-reed. Furthermore the areas that were peat according to the map of quaternary deposits were included.

HI-s: Histosol (small peatland)

This class covers small peatland areas, which are formed in small depressions in the bedrock areas. The limited drainage is the key factor in the formation of these peatland soils.

Map classification

The method for assigning areas to this class was different from the other classes. Among the areas with peatland according to the quaternary map objects that were smaller than 5,000 m^2 and a TWI value smaller than 9.5 were selected. This located small peatland areas with a small catchment area.

RG/HI: Regosol/Histosol (shoreline area)

This class is found along the sea shoreline and is influenced by the closeness to water. The Regosol soils are formed on sandy beach sediment material and the Histosol soils where reed and other shoreline vegetation has formed an organic soil layer.

Map classification

This class was assigned to shoreline areas along the coast and formed a 10 m wide (one pixel) zone. Shoreline areas located on coastline bedrocks were excluded from this class.

RG/GL-a: Regosol/Gleysol, arable land

This class covers arable land on fine texture sediments and some organic parent material. The class is dominated by Regosol and Gleysol soils, with fresh or fresh-moist conditions.

Map classification

This class was assigned to areas with ground layer of arable land type.

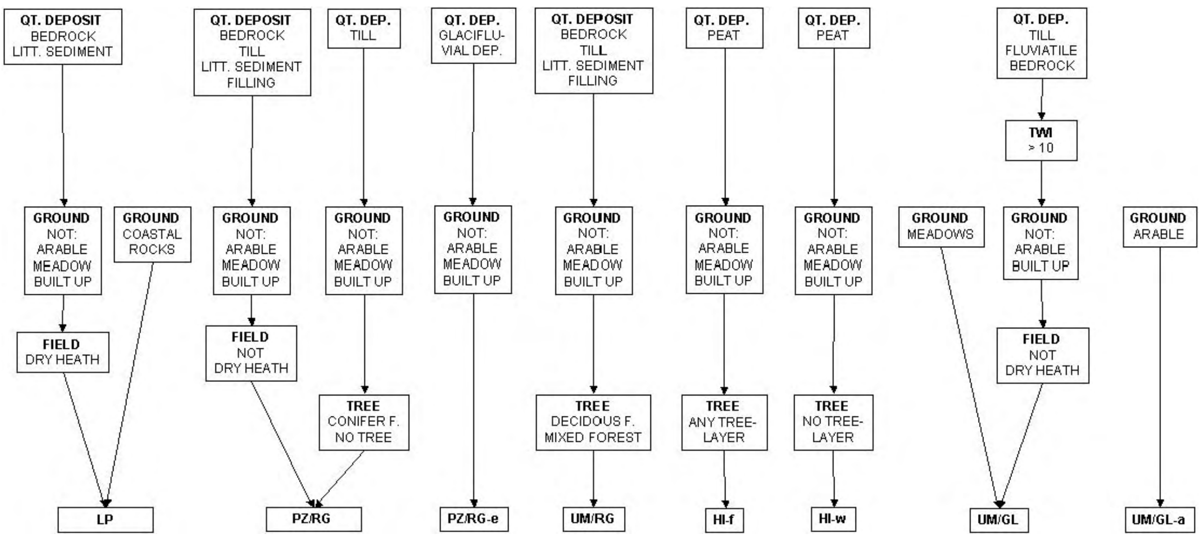


Figure 3-6. *Classification scheme of the soil types based on quaternary deposits, vegetation, and topographical index.*

4 Results

4.1 Short summary on results

The overall impression of the Oskarshamn area displays a broken topography with variations from wet downslope soils with peatland Histosols and moist mineral Gleysols to drier upslope soils where Leptosols and bare bedrock are frequently occurring. These Leptosols were not sampled while sampling of deep soil horizons requested a substantially thick soil cover, i.e. Leptosols do not by definition furnish possibilities for deep soil sampling. Small dimensions of lowland and upslope hills characterized the area both related to altitudes and spatial scale. Where mainly bare bedrock existed the soil type was Leptosol, however frequently bedrock outcrops did not furnish any soil type, but rock. Close to the bedrock outcrops at in locations inbetween site types could include a large variation of soil depth from existing bare rocks to small areas of soil depths up to one metre. Such areas were rather frequently occurring in the Oskarshamn area. In locations in-between wet and dry, especially fresh soils, Umbrisols, Podzols and Regosols occurred. A forested land cover dominates this area with relatively small areas of mires, pastures and arable land. Settlement requirements have during 19th and beginning of 20th century taken all possible land into consideration for farming and cattle holding. This influenced the land use, being intensive with many small antrophogenically drained sites. These have later partly been forested and provide drained forest peatlands occurring frequently.

Soil parent material furnished both till and sorted sediments. Tills were rather coarse grained with sandy and sandy-silty texture and on these areas mainly forests occurred. In the low-lying areas with pastures and arable land, the soil materials mainly were silt, clay and gyttja. In the organic soils, peat constituted the material. In relation to Swedish conditions, the area might have slightly coarser soil parent material.

Typical soil types for Sweden would be Podzol but partly also wet soils such as Gleysol and Histosol. In the Oskarshamn area Podzol was on lower frequency as compared to Sweden as a whole and this would also be valid also for Histosol and Gleysol. Instead Umbrisol spatial cover was larger in the Oskarshamn area with over 20% that could be compared with less than 10% of Cambisol/Umbrisol in Sweden. Regosol showed more than double values for Oskarshamn compared to total Sweden.

4.2 Properties and spatial coverage

Variables identifying properties of the soil were determined on a representative plot scale with ten site types in two replicates. The plots were chosen in a stratified selection to cover the major occurring land types of the Oskarshamn area and to achieve good statistically based information from these types. The spatial coverage of land types was provided from the GIS mapping of the area. There, a combination of the plot determinations and the spatial coverage was used in the comparisons of spatial distributions of land and soil properties in the Oskarshamn area with relevant areas of Sweden to reflect similarities and deviations of the Oskarshamn area land types in relation to Swedish land area conditions.

Within the Oskarshamn regional area there are two sub-areas, one being a central investigation area, the SKB Oskarshamn area Laxemar, and the other the remaining parts of the Oskarshamn regional area. The main emphasis was put on the Laxemar area and therefore comparisons with other parts of Sweden are related to this area. Deviations between the total regional area Oskarshamn including the Laxemar area and the Laxemar sub-area separately were only minor. The GIS map soil classes PZ/RG, HI-f and UM/GL-a had smaller coverage in the total Oskarshamn area as compared to the Laxemar area separately, while the classes LP, HI-w and UM/GL had larger coverage (Table 4-1).

Table 4-1. Spatial coverage of the GIS map soil classes in the two Oskarshamn areas Laxemar and total regional area.

GIS map soil class	Site code	SKB Oskarshamn Laxemar	Total Oskarshamn regional
LP		7.8	10.9
PZ/RG	ASM001428, ASM001429	46.7	44.1
PZ/RG-e	ASM001424, ASM001425	1.9	1.8
UM/RG	ASM001426, ASM001427	17.0	16.9
UM/GL	ASM001430, ASM001431	12.0	15.2
	ASM001440, ASM001441		
HI-f	ASM001434, ASM001435	4.6	1.7
HI-w	ASM001442, ASM001443	1.0	2.1
HI-sp	ASM001432, ASM001433	0.9	0
RG/HI	ASM001436, ASM001437	1.0	1.4
UM/GL-a	ASM001438, ASM001439	5.2	4.2
No class		2.1	1.6

4.3 Properties of the Oskarshamn area land types

The Oskarshamn area is presented by the ten land and soil type classes selected for the inventory to represent the major part of the area. However, these rather few plots (20) did not give possibilities to reach a representative spatial coverage. This will be better presented in the GIS map. Based on this, the distributions of the soil types will be compared with prevailing conditions for total Sweden, the relevant region of Sweden (No IV) and with the Kalmar County. Forest land and peatland seems rather well represented as compared with the region and also Sweden as a country.

4.3.1 Site types and investigated plots

Ten site types with two replicates were investigated. These types were selected on basis of the most frequent site types in the area determined from map studies and the field transect observations. The ten types were designated R “HÄLL”, H “HÄLL”, E “ÅS”, L “LÖV”, P “ÄNG”, G “GRAN”, SS “SUMP”, T “VÅT”, VH, S “STRAND” and A “ÅKER” (Table 4-2). In this section a brief description is made of the plots. The two replicates had sampling identities (ID; both related to soil type class and the SKB Id-codes) and these plots were transformed into the GIS map classification soil types (Table 4-2). With land type, site type and soil type should be understood the reference mainly to land cover. Soil type refers to the actual WRB soils classified while the GIS soil map class is the combined soil class determined for the Oskarshamn area.

4.3.2 GIS soil map classes

The number of classes related to field and map classification was the same. But, the characterisation of the map sites was somewhat altered, related to the ten field investigation plot selection. Mainly the structure was consistent but one site type classification was divided into two classes and two were merged into one. The field class on thin soils ("Häll") was divided into two, one being bare bedrock or with very thin soils and the other close to the first but having slightly thicker soil cover (Table 4-2). No soil sampling was carried out on the bare bedrock type.

The other change between field investigations and map classification concern the two site types with forested peatlands ("GRAN" and "SUMP"). From a soil type perspective, these two classes were similar and each had fairly low coverage. Therefore the types could be merged into one map soil type class (HI-f).

Table 4-2. Sample plots, prevailing soil type and SKB Id-codes.

Sample plot	Site code	Soil type /WRB 1998/ Field determinations	GIS map soil class	
R (HÄLL)	–	Leptosol	LP –	bedrock
H (HÄLL)	ASM001428, ASM001429	Podzol/Regosol	PZ/RG –	upslope thin soils
E (ÅS)	ASM001424, ASM001425	Podzol/Regosol	PZ/RG-e	esker
L (LÖV)	ASM001426, ASM001427	Umbrisol/Regosol	UM/RG	drained soils
P (ÄNG)	ASM001430, ASM001431	Umbrisol/Gleysol	UM/GL	moist soils
G (GRAN)	ASM001440, ASM001441	Histosol	HI-f	forested peatland
SS (SUMP)	ASM001434, ASM001435	Histosol	HI-f	forested peatland
T (VÅT	ASM001442, ASM001443	Histosol	HI-w	open wetland
VH (VH)	ASM001432, ASM001433	Histosol	HI-sp	small peatlands
S (STRAND)	ASM001436, ASM001437	Histosol, Regosol	RG/HI	shore
A (ÅKER)	ASM001438, ASM001439	Umbrisol/Gleysol	UM/GL-a	arable

The class names are in accordance with the soil classification WRB /WRB 1998/, although the classes in many cases have been slightly modified or extended to cover the characteristics of the Oskarshamn area. The names and characteristics of the classes are given below:

LP "Häll" – Upslope thin soils and bare bedrock

This site type was found mainly on high locations being bare bedrock or very thin soils, estimated mainly to 0–0.3 m, close to bedrock outcrops. The class was identified from maps and the transect survey and no soil sampling was made. However, the class PZ/RG with slightly deeper soils would partly represent also this soil type, of course, apart from the bedrock outcrops. Land cover furnish sparsely distributed pine trees on mainly dry or fresh soil moisture type with a ground vegetation of lichens and fresh mosses in the bottom layer and with field layer missing or heather and lingonberry "vitis idea". On locations with thin soils there was a fairly coarse sandy and sandy silty till with on top a humus layer of mor type dominating. The developed soil types are in most cases Leptosols but possibly also Regosols but Podzols exist. These types refer to slightly deeper soil covers. This map class was extracted from the field investigation class "Häll" – upslope thin soils (see next).

PZ/RG "Häll" – Upslope soils representing thin soils – "ASM001428, ASM001429"

This site type was found close to bedrock outcrops and then with rather thin soil covers, 0.3–1.0 m. Also areas with bare bedrock were included in the mapped areas. Site locations for soil sampling were chosen at the deeper soil thicknesses to furnish the desired also deep layers of the soil. The two main upslope sites furnish fairly common properties with considerable influence from the closeness to the bedrock. Land cover is coniferous forest on mainly fresh soil moisture type with a vegetation of fresh mosses in the bottom layer and with a field layer of blueberry type. On top of the fairly coarse sandy and sandy silty till soils, a humus layer of mor type dominate. The developed soil types are in most cases Regosols but also Podzols exist. These types refer to slightly deeper soil cover where sampling of deeper horizons was possible.

PZ/RG-e "Ås" – Glaciofluvial ridge deposit "ASM001424, ASM001425"

The glaciofluvial deposit forms an esker in the west part of the Oskarshamn regional area, where out-washed fine soil material is lacking. This provides poorly sorted sediments of coarse sand, sand and partly fine sand but low content of boulders and clay. The soils have developed to mainly well-drained Podzols. Vegetation is characterised by a coniferous pine forest with ground vegetation being fresh mosses and blueberry.

UM/RG "Löv" – Forested relatively nutrient rich site types – "ASM001426, ASM001427"

Sites are located on the hillside slopes. Deciduous trees such as oak, birch and mountain maple mainly dominated the tree layer. Ground vegetation was composed of fresh mosses, grass and low herbs on well-drained soils of fresh soil moisture type. Fairly coarse till soils of sandy and sandy-silty texture occurred with one site being fine grained (silty sandy). Soil types developed varied between Regosols and Umbrisols with a dominating mull humus form and probably in a long-range time perspective turning more frequently into better developed Umbrisols.

UM/GL "Äng" – Meadow and pasture "ASM001430, ASM001431"

In downslope locations open land or sparsely forested sites could be found. Open land for grazing as constituting pastures. Mainly well drained soils but partly with small bedrock outcrops and on some locations also moist soils were found. The parent material was dominated by sorted sediments mainly being clay but on one site exposed to wave-washing. This had resulted in slightly less sorted clay with content of silt and fine sand. The land has been used in agriculture and Umbrisol dominates the soil type developed. Broad-leaved grasses were found in the field layer and fresh mosses occurred on one site.

HI-f "Gran" – Forested (f) peat soils in downslope locations – "ASM001440, ASM001441"

These are drained peatlands with spruce on fresh and fresh moist soils. During periods of more wet conditions the soils most likely turns into imperfectly drained sites with high groundwater levels. The combination of ditches and forest evapotranspiration, provides a field vegetation type of blueberry and low herbs. Partly, these spruce forests could provide high yields. The drainage furnishes fresh mosses in the bottom layer. However, there is still more than 0.4 m organic layer resulting in a Histosol soil. In this case the humus form is peat and sampling made of the two pre-set peat layers. The humification degree was dominated by strongly decomposed peat in both layers. Under the peat there are mainly coarse mineral soils such as stones and boulders, perhaps occasionally also the bedrock surface. This field inventory class was merged with the following forest wetland type (HI-f "Sump").

HI-f "Sump" – Wetland forest type – "ASM001434, ASM001435"

Forested sites with rather rich peat soils covered by more rich mosses compared to Sphagnum spp and field layers of broad leaved grasses. The humus form is peat and the soil type Histosol. The mineral soil under the peat varied from clay and sand to peat on bedrock and the humification degree was moderately well decomposed in the upper layer and strongly decomposed in the deeper one. This field inventory class was merged with the previously presented "peat soils in downslope locations" (HI-f "Gran").

HI-w "Våt" – Open wet (w) fen areas "ASM001442, ASM001443"

The sites were characterized by open wetlands of fen type. It is a water rich type with Sphagnum mosses in the bottom layer and broad leaved grass and sedges in the field layer. The parent material is peat and the soil is a Histosol. Humification degree in the upper layers is weak and in the deep layer up to strong. The underlying mineral soils are fine sand and sand on top of the bedrock.

HI-sp "VH" – Small peatlands (sp) in bedrock depression – "ASM001432, ASM001433"

Often this mire type was found at locally high places. The site type represents small peat-lands in-between bedrock outcrops and is characterised as a moist dwarf shrub type with bog bilberry, lingonberry and marsh rosemary over a Sphagnum bottom carpet. In the peat soil, Histosols have developed and the humification degree is weekly or moderately well decomposed peat in the upper layers and strongly in the deeper layers. Underneath the peat mainly bedrock is found but on top of this occasionally also sand. The site type deviates from the open fen areas in relation to nutrient richness, site location and could partly be regarded as similar to the bog mire type.

RG/HI "Strand" – Young soils in the shoreline – "ASM001436, ASM001437"

These are very young soils, earlier being covered by the sea. Actually, two sites types were found differing due to soil parent material with one being peat and the other a well-sorted mineral soil of sandy texture. Moisture condition at the first site was wet while the sand was partly well drained and differed between fresh and fresh-moist. No actual bottom layer vegetation had developed and the field layer was dominated by broad leaved grasses and reed. On the wet site, the was phragmites peat forming the peatland soil with a Histosol type while the sandy soil often was without humus layer and the soil types there varied between Arenosols and Regosols. The site type forms mainly a narrow band between higher land and the sea water.

UM/GL-a "Åker" – Arable land "ASM001438, ASM001439"

Well-drained or partly imperfectly drained soils of fresh and fresh moist type used for crops such as oats, etc. Drainage was often improved by ditching. No bottom vegetation and mainly cereals as field vegetation. The typical location of such land in this region is in small valleys in-between surrounding coarser soil formations and bedrocks. The parent materials were well-sorted clay or gyttja soils furnishing fairly rich conditions with mainly Umbrisols but occasionally, where water influence, Gleysols.

4.4 Soil map of SKB Oskarshamn area Laxemar and total Oskarshamn area

The general distribution of soils in the Oskarshamn area is strongly related to the topography (Figures 4-1 and 4-2). Soil types related to fine textured sediment parent material (UM/GL and UM/GL-a) are typically found in depressions in the landscape, while in the upslope areas there are thin forested soils (PZ/RG and UM/RG) mixed with bedrock (LP). Peat soils covered by forest (HI-f) are scattered over the area, whereas the open peatland soils (HI-w) are more concentrated to a few areas. The peatland soils are generally more frequent towards the west. Areas with very thin soils or bedrock (LP) are more common in the north, although scattered areas are found throughout the area. In the Laxemar area the very thin soils and bedrock areas (LP) are concentrated to the northwest. The Regosol soils on course-textured parent material are concentrated to the esker in the western part of the area.

Quaternary deposits were only inventoried for the Oskarsham area Laxemar. This means a lack of a high quality map of the quaternary deposits for the whole Oskarshamn area. An “improved” map of quaternary deposits for the whole area had to be produced. This approach could be questionable since it lacks the reliability of a proper map that would have been controlled in the field. However, when comparing the produced map for the Laxemar area and the inventoried map for the same area quite good similarities could be recognised. Differences were very small in the comparison between the maps. A major weakness of the produced map was that it lacks the small peatland areas. The main difference in the soil maps over the Laxemar and Oskarshamn area is thus the lack of the class HI-sp in the Oskarshamn area.

4.4.1 Validation of the soil map with transect data

The GIS soil map (Figure 4-1 and 4-2) was created based on secondary sources of information, i.e. maps of vegetation, quaternary deposits and the index of soil moisture conditions, which all provide information with high spatial resolution. The spatial uncertainty with this approach was thus much better than mapping only from field data since it had very limited spatial coverage. However, with the approach used, there is an additional source of uncertainty in how well the secondary information may describe the soil types. In order to investigate this, a validation of the soil map was made.

During the field inventory of the area soil data was collected along transects, which was one surveillance information to identify the typical soil types of the area. This data was used to validate the soil map by comparing the transect data with the soil map data by overlay analyses. One problem with this validation was that the transect data only included information of the soil type to a limited extent, due to restrictions in the fieldwork. In the transect surveillance, the emphasis had to be put on “nature type” determined from land surface overview, rather then the soil identification, that needed soil pit information. These “nature types”, registered along the transects, were used to calculate the distribution of mapped soil types (Table 4-3a and 4-3b). The “nature types” agreed to a large degree with the soil types.

The result of the validation showed good agreement for most soil classes, although the representation of some classes with very small spatial extention was low in the transect data, e.g. the shoreline soils (RG/HI) and the small wetland soils (HI-sp). Further, the forested peatland (HI-f) is mainly classified as coniferous forest “nature type”, which may reflect discrepancies in the classification of the soil map classes and the transect data.

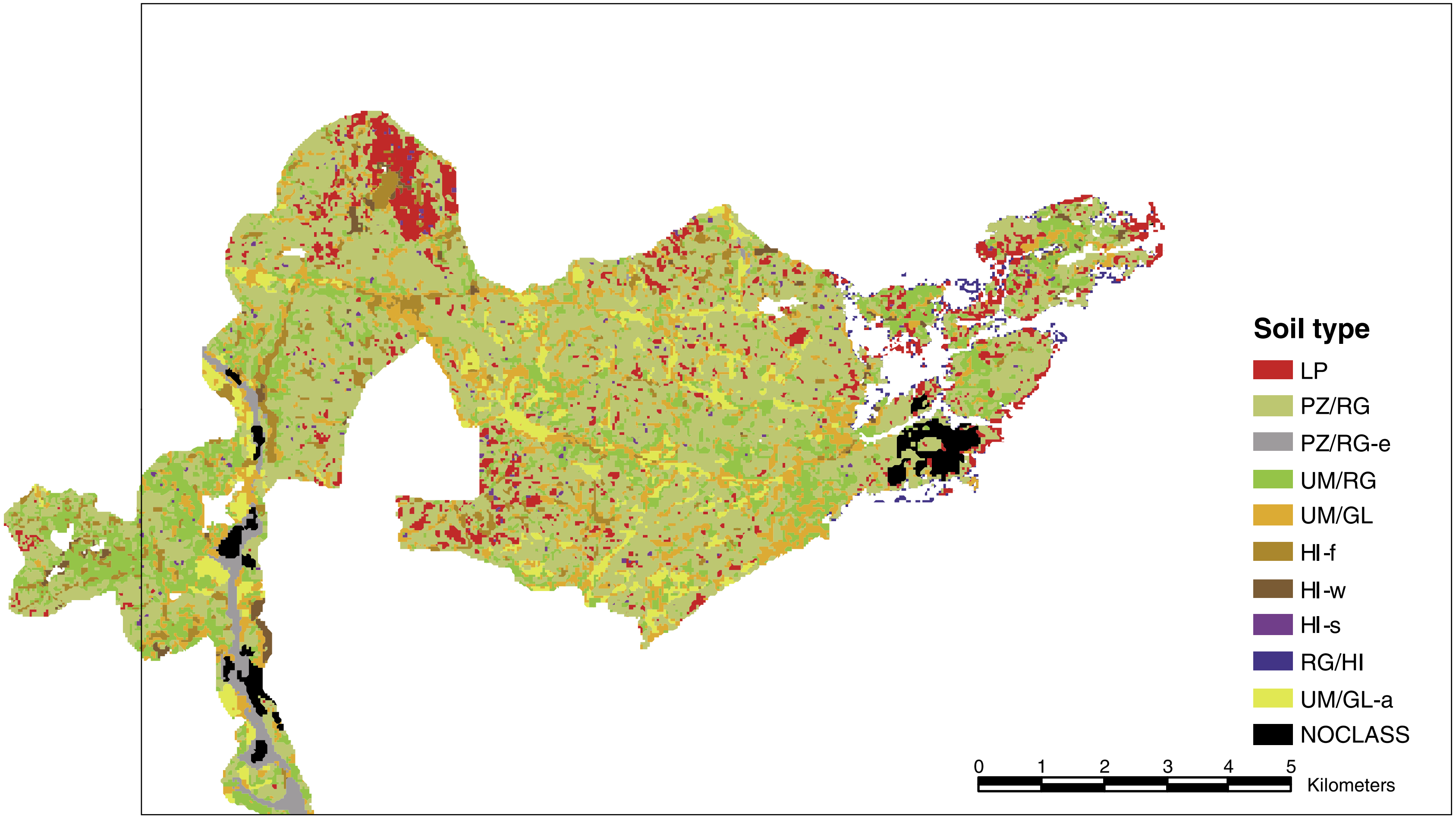


Figure 4-1. The soil map of the SKB Oskarshamn area Laxemar. Explanation to the soil types, see Table 4-2.

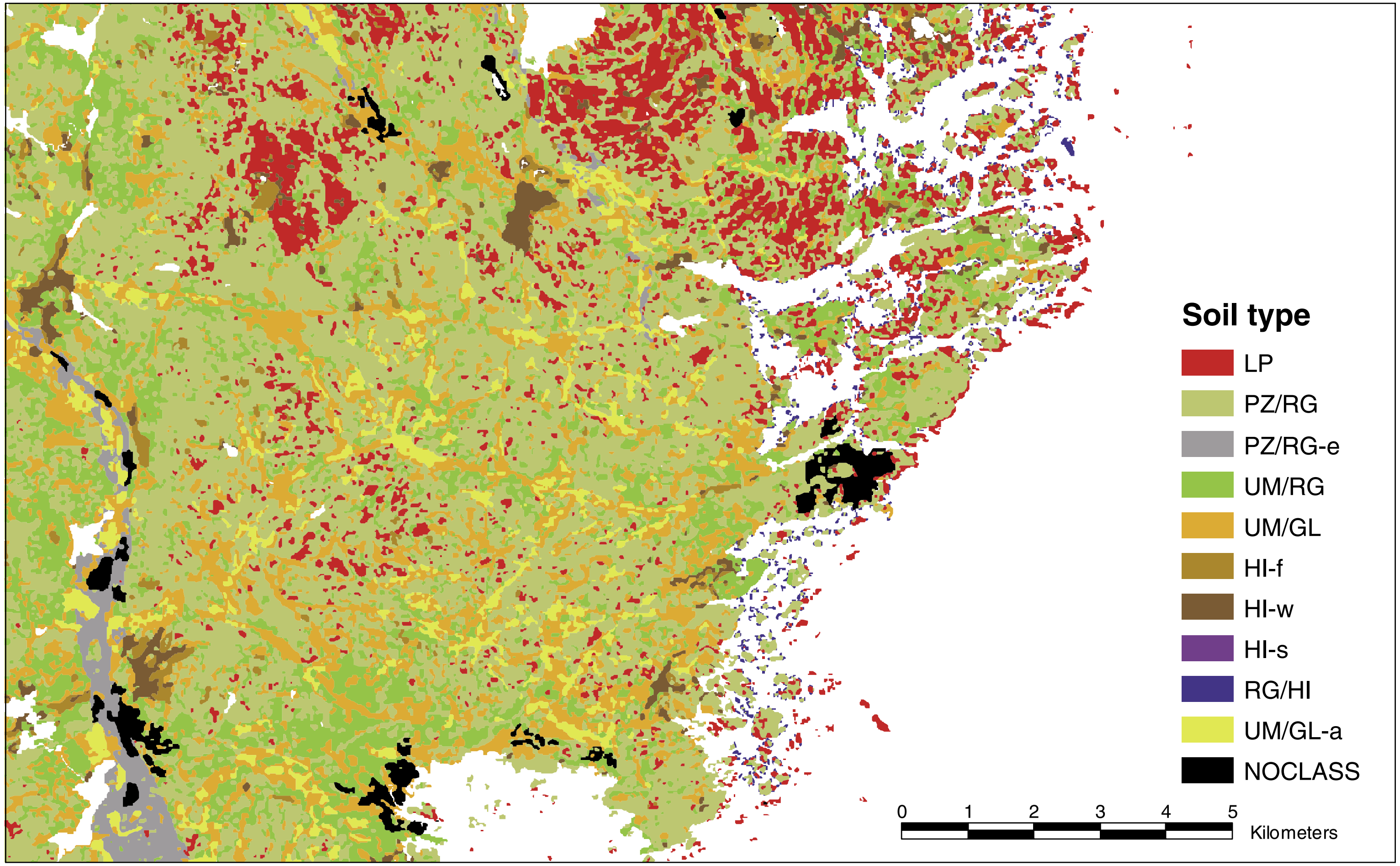


Figure 4-2. *The soil map of the total Oskarshamn area. Explanation to the soil types, see Table 4-2.*

Similarly, forested thin soil (PZ/RG) are to some degree classified as bedrock in the transect data, although the "nature type" **bedrock** allows for a sparse tree cover. The results indicate that the soil map for the whole Oskarshamn area is acceptable in quality compared to that of the Laxemar area, despite the use of the inferior map of quaternary deposits.

Table 4-3a. Validation of the mapped soil types for the SKB Oskarshamn area Laxemar using field transect data of "nature type". The rows contain the distribution of "nature type" percentage for each soil type. Table 4-3a to be compared to the total Oskarshamn area (Table 4-3b). Transformation between soil types and codes, see Table 4-2.

Nature type in transect / Mapped soil type	Barrskog Conif. forest	Lövskog Decid. forest	Blandskog Mixed forest	Våtmark Wetland	Hällmark Bedrock	Sumpskog Forested wetl.	Hygge Clearcutting	Åker Arable	Ängsmark Pastures	Hällkar Small wetl.	Strand Shore
PZ/RG	49.1	1.6	6.6	0.3	29.4	0.4	7.1	2.7	1.7	1	0
UM/RG	35.6	25.3	13.4	1	14.6	1.6	1.4	1.6	5.3	0	0
RG/HI	0	33.3	0	0	66.7	0	0	0	0	0	0
HI-f	38.2	17.6	0	21.8	7.9	1.2	1.8	3	2.4	6.1	0
HI-sp	41.4	10.3	27.6	0	13.8	0	3.4	0	0	3.4	0
HI-w	4.1	0	0	82.4	1.4	4.1	0	0	0	1.4	6.8
UM/GL-a	10.9	1.6	8.2	0	0	0	2.7	34.4	42.1	0	0
PZ/RG-e	100	0	0	0	0	0	0	0	0	0	0
UM/GL	33.1	11.9	12.2	0.6	5.5	1.1	1.1	7.5	26.8	0	0.3
LP	31.7	0	0.6	3.4	49.4	0	2.5	0	2.8	9.6	0

Table 4-3b. Distribution of "nature types" on soil type classes for the total Oskarshamn area. Validation of the mapped soil types for the SKB Oskarshamn area Laxemar using field transect data of "nature type". The rows contain the distribution of "nature type" percentage for each soil type. To be compared to Table 4-3a. Transformation between soil types and codes, see Table 4-2.

Nature type in transect / Mapped soil type	Barrskog Conif.forest	Lövskog Decid.forest	Blandskog Mixed forest	Våtmark Wetland	Hällmark Bedrock	Sumpskog Forested wetl.	Hygge Clearcutting	Åker Arable	Ängsmark Pastures	Hällkar Small wetl.	Strand Shore
PZ/RG	42.6	2.1	8	0.7	30.8	1.3	9	1.3	1.6	2.6	0
UM/RG	34.1	18.2	20	1	12.4	2.7	6.2	0.6	4.2	0.5	0
RG/HI	0	50	0	0	50	0	0	0	0	0	0
HI-f	40	4.8	5.2	19.5	17.1	3.3	1	0	5.7	3.3	0
HI-w	4.6	1	2.1	73.8	1.5	4.1	0	0	8.7	1	3.1
UM/GL-a	9.4	6	5.7	0	2.3	0	1.9	30.9	43.8	0	0
PZ/RG-e	0	0	0	0	100	0	0	0	0	0	0
UM/GL	32.9	16.2	13.2	0.7	8.6	0.8	2.8	3.9	20.5	0.3	0
LP	27.5	2.6	0.3	1.1	54.2	1.4	0.8	0	1.4	10.5	0

4.5 Properties of the SKB Oskarshamn area Laxemar land types

Ten land and site classes represented the main part of the Oskarshamn area. However, these rather few plots did not give possibilities to reach a representative spatial coverage. Instead, this was better achieved in the GIS map presentation (Figure 4-1 and 4-2). Based on this map, the distributions of the soil types in the SKB Oskarshamn area Laxemar were compared with prevailing conditions for the total Sweden, the middle part of south Sweden, with the Kalmar county and Oskarshamn community (Table 4-4 and Figure 4-3). Forest land dominated the area and the coverage was higher as compared to total Sweden and connected regions apart from the Oskarshamn community where similar forest coverage existed. Peatland, pasture and arable land mainly constituted smaller areas but agreed fairly well with conditions in the Oskarshamn community.

Table 4-4. Spatial distribution (%) of land use classes in the SKB Oskarshamn area Laxemar compared to national and regional distributions.

Class	Region Sweden	Sweden-IV	Kalmar County	Oskarshamn community	Oskarshamn Laxemar
Forest land	62	67	64	87	87
Pasture	1	1	4	2	1
Arable land	7	11	16	3	4
Peatland	16	11	3	3	2
Other land*	14	10	13	5	6

* Other land includes: Populated area and other open land.

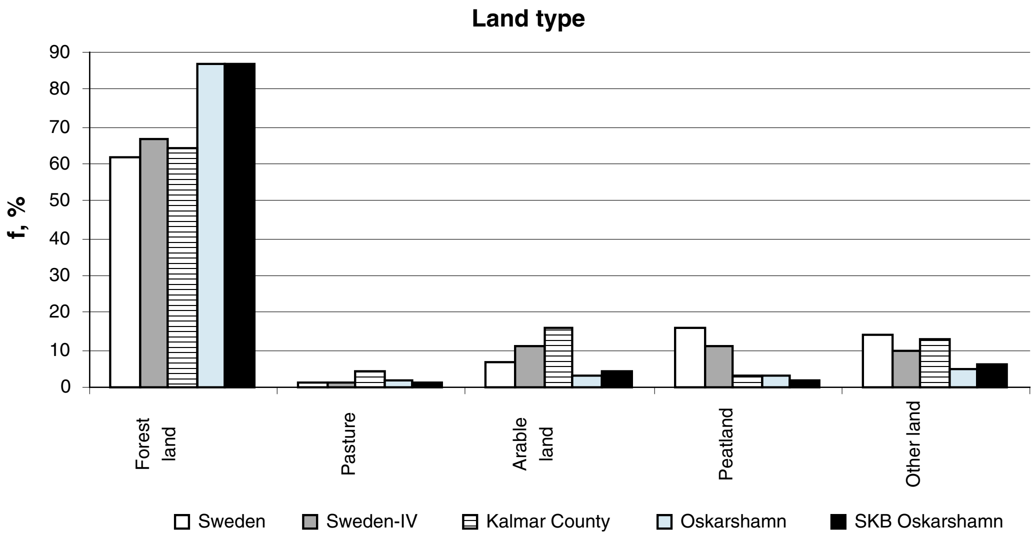


Figure 4-3. Distribution of land types (%) in the SKB Oskarshamn area Laxemar in relation to related regions.

4.6 Characteristics of the site types

Properties related to the site types in the Oskarshamn area varied related to soil types mainly between Histosols, Leptosols, Podzols, Umbrisols and Regosols with Gleysols and Arenosols less commonly existing. Large parts of the area are dry and fresh, however with low-lying moist and wet land. Most common humus forms were mor and mull. Till was the dominate parent material but with bare bedrock and sorted sediments also rather common. Nutrient conditions were fairly poor with dominating broad leafed grasses and bilberry in the field vegetation. The soil chemistry also indicates slightly richer conditions as compared with total Sweden, i.e. pH values are on average higher and CN-quotient lower.

4.6.1 Site hydrology

The soil moisture conditions in the Oskarshamn area were dominated by mainly well-drained soils with a fresh hydrology site type (Figure 4-4 and Table 4-5). However, dry soils, i.e. bedrock or adjacent soils made up almost 10%. In comparison to other regions, the area showed similarities but was more pronounced on the fresh class. The larger regions, such as total Sweden and Sweden region IV included larger areas of moist and wet land, which would be related to the humidity of this part of Sweden, that do not host as large areas of peatlands as other Swedish regions do, also as compared to the total region SE IV.

The distribution of soil hydrology (wetness) on the GIS map classes showed fresh sites dominating in PZ/RG, UM/RG and UM/GL. Dry sites could be allocated to the LP class, however no site investigation was made there. Moist and wet sites only constitute c 7% of the area and were mainly found at Histosol sites (Figure 4-5).

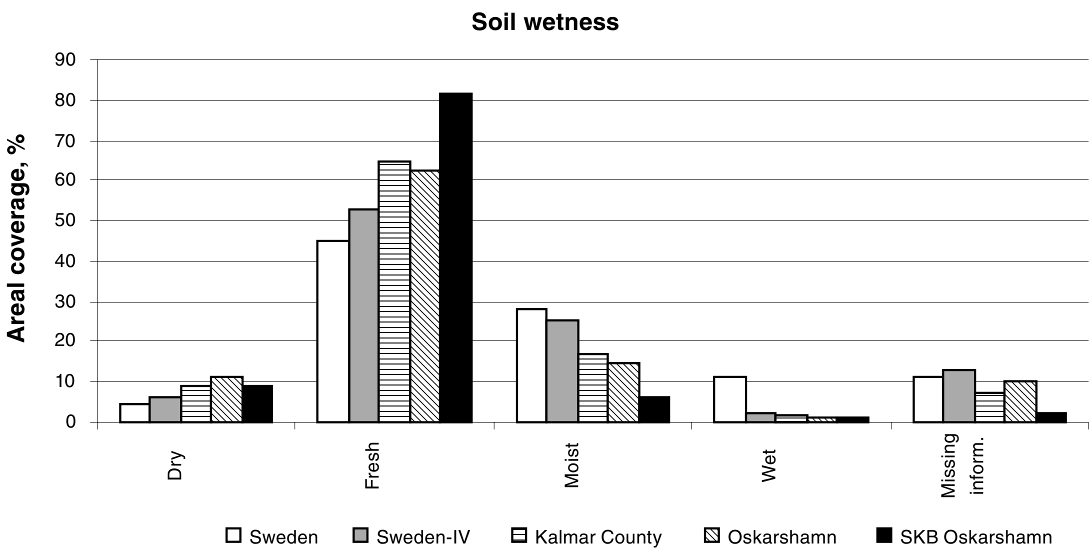
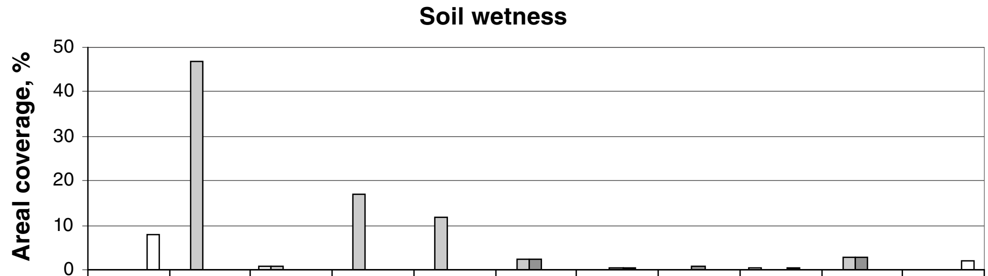


Figure 4-4. Wetness distribution conditions for the SKB Oskarshamn area Laxemar in relation to distributions of soil hydrology (wetness) in relevant Swedish areas.



	LP	PZ/RG	PZ/RG-e	UM/RG	UM/GL	HI-f	HI-w	HI-sp	RG/HI	UM/GL-a	No-classif.
□ Dry			0.9						0.5		
□ Fresh		47.6	0.9	17.0	12.0	2.3				2.6	
■ Moist *						2.3	0.5	0.9		2.6	
■ Wet							0.5		0.5		
□ No-classif.	7.8										2.1

* incl. Fresh-moist

Figure 4-5. *Soil hydrology, wetness class, in the SKB Oskarshamn area (Laxemar) presented as distribution on GIS map soil classes. Transformation between soil types and codes, see Table 4-2.*

Table 4-5. Soil moisture class frequencies (%) in the SKB Oskarshamn area Laxemar and four other parts of Sweden.

Class, %	Region Sweden	Sweden-IV	Kalmar County[1]	Oskarshamn[1]	SKB** Oskarshamn
Dry	4.4	6.2	8.8	11.4	9.2
Fresh	45.0	52.7	64.9	62.5	81.4
Moist*	28.2	25.5	17.1	14.8	6.2
Wet	11.4	2.4	1.8	1.1	1.0
Missing inform.	11.0	13.2	7.5	10.2	2.1

[1] Based on 'Forest data base' only.

* Incl. Fresh-moist.

** Map area – 6,985.2 ha.

4.6.2 Soil parent material

Till, bare bedrock and well-sorted sediments dominated, with the till making up almost 50% of the soil cover in the area. The areas of bare bedrock were not included in field inventory, made up rather large areas, almost 20% embracing also thin soils. This would be much more than total Sweden and only found similarities with Oskarshamn community (Figure 4-6 and Table 4-6). Well-sorted sediments showed higher frequencies as compared to almost all regions in comparison, except SE region IV where 17% was well sorted sediments.

Site classification related to the GIS map soil classes revealed till soils dominating the PZ/RG and UM/RG soil types with together almost 50% of the area. Sorted sediments were found at UM/GL sites making up 12% while both peat soils (6%) and well-sorted sediments (1.5%) were found at the HI sites. Well-sorted sediments also occurred in arable land (Figure 4-7).

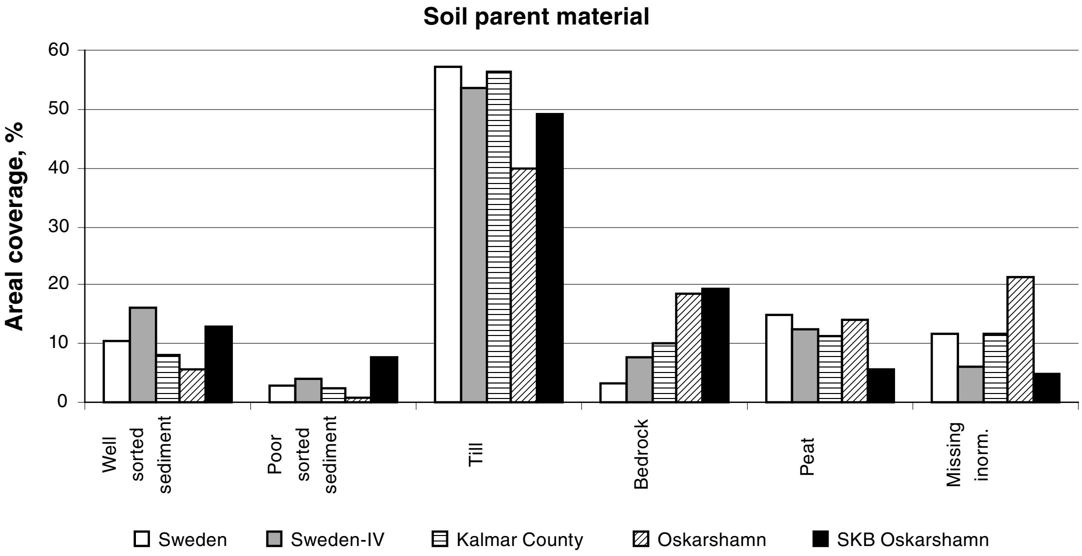
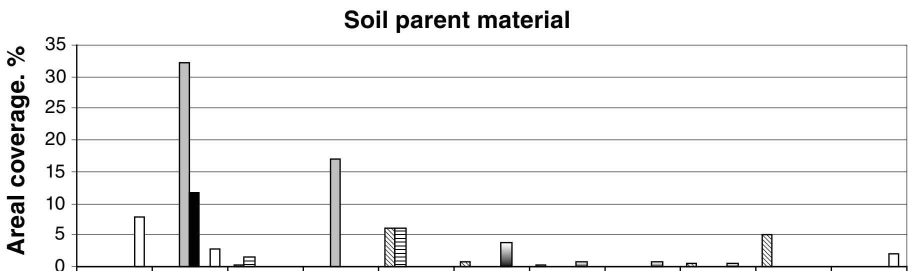


Figure 4-6. *Soil parent material distribution in the SKB Oskarshamn area Laxemar and in comparison to conditions of four relevant Swedish areas.*

Table 4-6. Soil parent material frequencies (%) in the SKB Oskarshamn area Laxemar and four other areas in Sweden.

Class, %	Region Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
Well sorted sediment	10.6	16.0	8.2	5.5	13.0
Poorly sorted sediment	2.7	3.9	2.5	0.9	7.5
Till	57.1	53.6	56.4	39.9	49.2
Bedrock	3.2	7.7	10.1	18.4	19.5
Peat	14.7	12.6	11.2	13.9	5.8
Missing inform.	11.7	6.2	11.6	21.3	5.0



	LP	PZ/RG	PZ/RG-e	UM/RG	UM/GL	HI-f	HI-w	HI-sp	RG/HI	UM/GL-a	No-classif.
Well sorted sediment			0.4		6.0	0.9	0.1		0.5	5.2	
Poor sorted sediment			1.5		6.0						
Till		32.2		17.0							
Bedrock		11.7									
Peat						3.7	0.8	0.9	0.5		
No-classif.	7.8	2.8					0.1				2.1

Figure 4-7. *Soil parent material in the SKB Oskarshamn area Laxemar presented as distribution on GIS map soil classes. Transformation between soil types and codes, see Table 4-2.*

4.6.3 Soil texture

The soil textural compositions of the selected plots, determined in the field, reveal a fairly coarse textured soil with mainly sand and sandy-silty material but in the UM/ RG, UM/GL and UM/GL-a areas also finer fractions such as silt, clay and gyttja. In peatlands, of course, peat dominated (Figures 4-8 and 4-9).

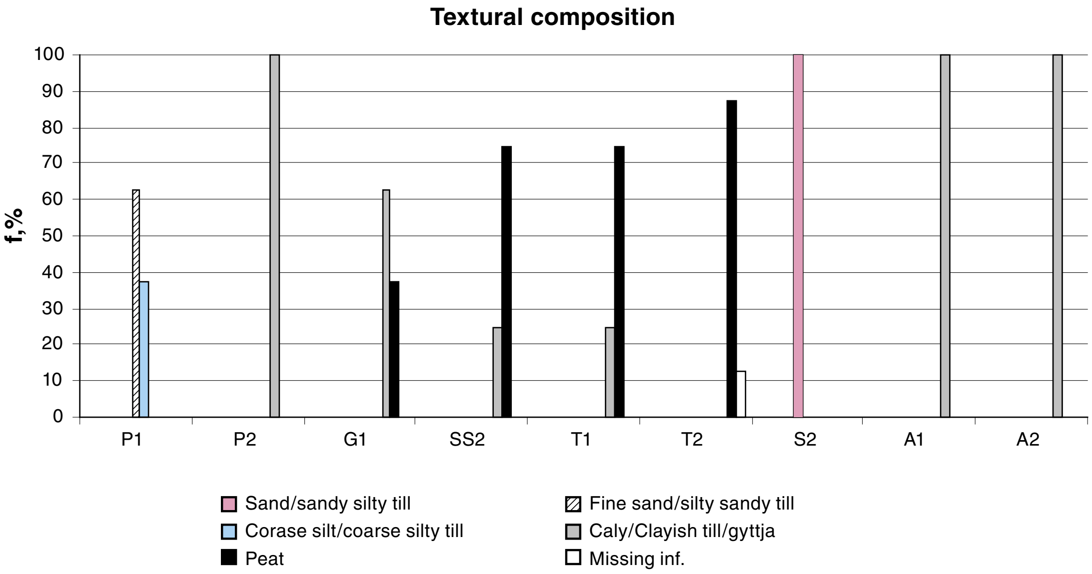
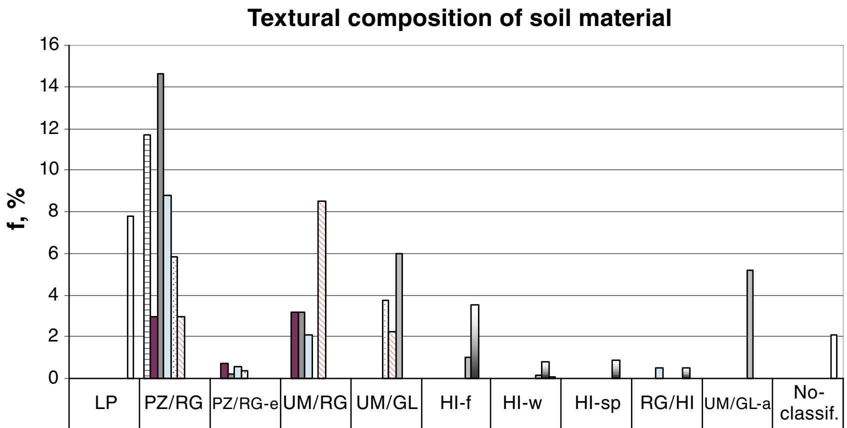


Figure 4-8. *Soil textural composition (%) in the investigation sites of the Oskarshamn area. Transformation between soil types and codes, see Table 4-2.*



	LP	PZ/RG	PZ/RG-e	UM/RG	UM/GL	HI-f	HI-w	HI-sp	RG/HI	UM/GL-a	No-classif.
Stone/boulders		11.7									
Gravel/gravelly till		2.9	0.7	3.2							
Coarse sand/sandy till		14.6	0.2	3.2							
Sand/sandy silty till		8.8	0.6	2.1					0.5		
Fine sand/silty sandy till		5.8	0.4		3.7						
Corase silt/coarse silty till		2.9		8.5	2.2						
Caly/Clayish till/gyttja					6.0	1.0	0.1			5.2	
Peat						3.6	0.8	0.9	0.5		
No-classif.	7.8						0.1				2.1

Figure 4-9. *Soil textural composition (%) in the SKB Oskarshamn area Laxemar soil types. Determination from the field method. Transformation between soil types and codes, see Table 4-2.*

No laboratory textural analysis was carried out on the soil samples from the Oskarshamn area. This means difficulties in the determination of quantitative composition of the fine material (< 2 mm). The field determinations were mainly qualitative but literature values could add information and provide a rough estimate of the total grain size distribution. However, great uncertainties would remain.

4.6.4 Dry bulk density

In the investigation sites, sampling plots, the dry bulk densities were determined. In peat soils the densities were comparably low, ranging from 0.03 g/cm^3 to 0.36 g/cm^3. The lowest values existed at a very wet fen ("Våt 1"), while higher values were found at sites with tree cover ("Gran" and "Sump"). In the peat of the shoreline ("Strand") reed bed values were between 0.1 g/cm^3 and 0.2 g/cm^3. Densities at ordinary Sphagnum moss and sedge peat ("VH") were found in the ordinary range of natural peatland soils, i.e. 0.1 g/cm^3–0.2 g/cm^3 (Table 4-7).

In the mineral soils, the ordinary stratification with depth was observed. In the upper soil layers, the densities were often below 1.0 g/cm^3 but increased up to 1.8 g/cm^3 at 0.5–0.6 m depth. Variations occurred between single layers (Table 4-7).

Table 4-7. Dry bulk densities at depths to 0.6 m at the 20 sampling plots together with presentation of the parent material. Number of determinations, N. Transformation between soil types and codes, see Table 4-2.

Dry bulk density at Oskarshamn, g/cm3								
Plot	Material	Depth, cm						N
		0–10	10–20	20–30	30–40	40–50	50–60	
Gran 1	Peat	0.17	0.24	0.36	0.29	0.30	0.27	2
Gran 2	Peat	0.23	0.36	0.27	0.23	0.15	0.16	2
Häll 1	Till	0.87			1.35	1.18		1
Häll 2	Till	0.48	1.01	1.13	1.09		1.28	1
Löv 1	Till	0.52	1.00	1.07	1.38	1.21	1.04	2
Löv 2	Sand silty till	0.71	1.23	1.28	1.13	1.31	1.38	2
Strand 1	Peat	0.09	0.15	0.15	0.20	0.16	0.16	2
Strand 2	Sand	1.55	1.58	1.50	1.63	1.42	1.32	2
Sump 1	Peat	0.18	0.24	0.30	0.31	0.21	0.35	2
Sump 2	Peat	0.17	0.18	0.20	0.15	0.21	0.20	2
VH 1	Peat	0.07	0.07	0.09	0.14			4
VH 2	Peat	0.14	0.17	0.18	0.19	0.16	0.18	2
Våt 1	Peat	0.05	0.03	0.04	0.05	0.18	0.11	1
Våt 2	Peat	0.04	0.07	0.06	0.06	0.10	0.16	2
Åker 1	Gyttja (clay)	0.70	0.69	0.66	0.56	0.54	0.68	3
Åker 2	Gyttja (clay)	0.45	1.00	1.18	1.82	1.81	1.63	2
Ås 1	Coarse to fine sand	1.16	1.35	1.58	1.48	1.66	1.57	
Ås 2	Coarse to fine sand	0.45	1.00	1.18	1.82	1.93	1.63	2
Äng 1	Fine sand	1.22	1.22	1.43	1.22	1.46	1.74	2
Äng 2	Clay	0.29	0.48	0.35	0.36	0.50	0.57	2

4.6.5 Volumetric content of soil

In laboratory, textural determinations would provide grain size distributions on weight basis. These could be recalculated to volumetric values using the dry bulk densities. This would provide the quantitative composition of the fine (< 2 mm) material. However, this fraction only constitutes a part of the mineral soil distribution (Table 4-8). The other part is composed of coarser material such as gravel, stones and boulders. In the Oskarshamn area a rod penetration method /Viro 1958/ was used and by this estimations on the stone and boulder content could be made. The Viro-method uses an equation for the calculation. This has been modified by Melkerud and Lundin (see Methods).

Table 4-8. Volumetric composition of the soil in the Oskarshamn area.

Site	Stones and boulders, %	Soil material < 20 mm, %	Porosity, %
H1, ASM001428			
10–20 cm	70	12	18
20–30 cm	70	16	15
55–65 cm	70	14	15
H2, ASM001429			
10–20 cm	54	18	28
20–30 cm	54	19	26
55–65 cm	54	23	23
E1, ASM001424			
10–20 cm	58	22	21
20–30 cm	58	24	18
55–65 cm	58	25	17
E2, ASM001425			
10–20 cm	59	16	25
20–30 cm	59	29	12
55–65 cm	59	25	16
L1, ASM001426			
10–20 cm	56	17	27
20–30 cm	56	24	20
55–65 cm	56	17	27
L2, ASM001427			
10–20 cm	45	27	28
20–30 cm	45	24	31
55–65 cm	45	29	26
P1, ASM001430			
10–20 cm	20	40	40
20–30 cm	20	40	40
55–65 cm	20	53	27
P2, ASM001431			
10–20 cm	1	29	69
20–30 cm	1	22	77
55–65 cm	1	23	76
A1, ASM001438			
10–20 cm	8	27	65
20–30 cm	8	22	70
55–65 cm	8	24	68
A2, ASM001439			
10–20 cm	0	48	52
20–30 cm	0	44	56
55–65 cm	0	62	38
S2, ASM001436			
10–20 cm	5	57	38
20–30 cm	5	59	36
55–65 cm	5	48	48

In the Oskarshamn area, subdivision on the coarse and fine fractions were made, resulting in high contents of stones and boulders in the till but fairly low content of soil material < 20 mm and also a low porosity (Table 4-8). In most of the sorted sediment site types, the content of stones and boulders were low and porosity rather high. Also content of fine soil material (< 20 mm) was higher than in till soils. Peat soils of course differed greatly from the mineral soils as having very high porosities, i.e. mainly 80–95% (Table 4-9).

Table 4-9. Porosity (%) at the peat sites in the Oskarshamn area. Transformation between soil types and codes, see Table 4-2.

	G1	G2	SS1	SS2	T1	T2	VH1	VH2	S1
0–30	83	84	88	89	98	95	95	88	92
40–60	87	87	86	91	94	95	90	87	92

Since no laboratory determinations were made to analyse the textural composition, no actual soil grain size distribution may be presented. However, to furnish a view on how the distribution could look, calculations based on the content of soil material < 20 mm and the stone and boulder determination, literature values on typical till textural composition have been used. This revealed the larger fractions of the till fine soil to be sand and silt. Such a distribution was applied on the till soil composition in the Oskarshamn area and a typical picture of soil fraction distributions could be revealed (Table 4-10).

Table 4-10. Volumetric content, % of the soil material in 10–20 cm depth at the two till sites H2 and L2 at the Oskarshamn area. Transformation between soil types and codes, see Table 4-2.

Site	Clay	Silt	Fine sand	Sand	Gravel	Stones and boulders	Organic material	Porosity
H2	0.6	6.1	3.2	4.4	2.9	53.8	1.3	28.3
L2	0.8	7.8	4.4	5.7	3.7	45.1	4.2	28.4

4.6.6 Humus form

The distribution of humus forms in the SKB Oskarshamn area Laxemar covered most of the type range with mor types domination reaching almost 40% of the area. Also, the mull type was found frequently with 34% occurrence in the area. The frequently distributed small peat soils, anyhow did not make up more than c 10% of the area and then there was included also peat-like mor. Related to other regions of Sweden, the mor and peat humus form types had less coverage but instead mull type was more frequent (Table 4-11 and Figure 4-10).

The distribution of humus forms on the GIS map soil type classes shows mor types at PZ/RG areas and mull types in the UM/RG and UM/GL areas. Peat type is common on HI areas (Figure 4-11).

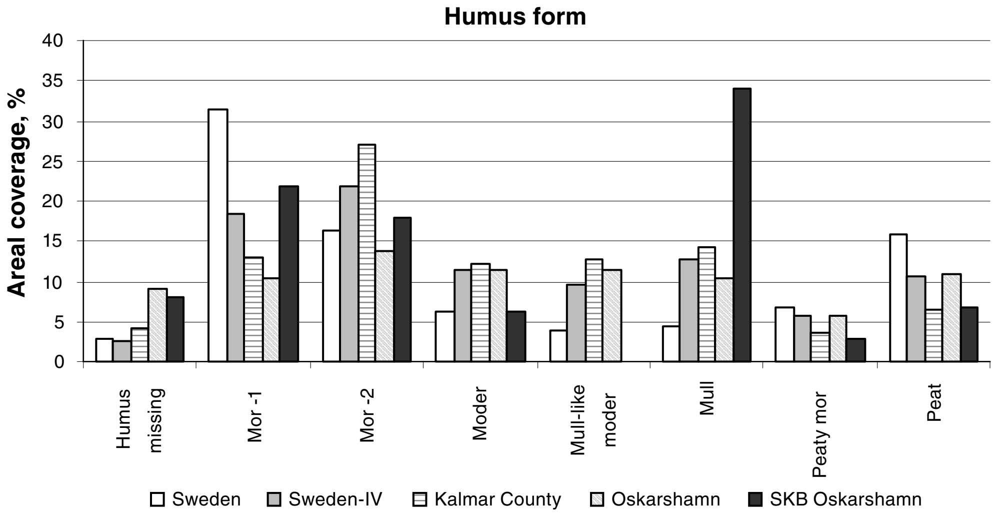
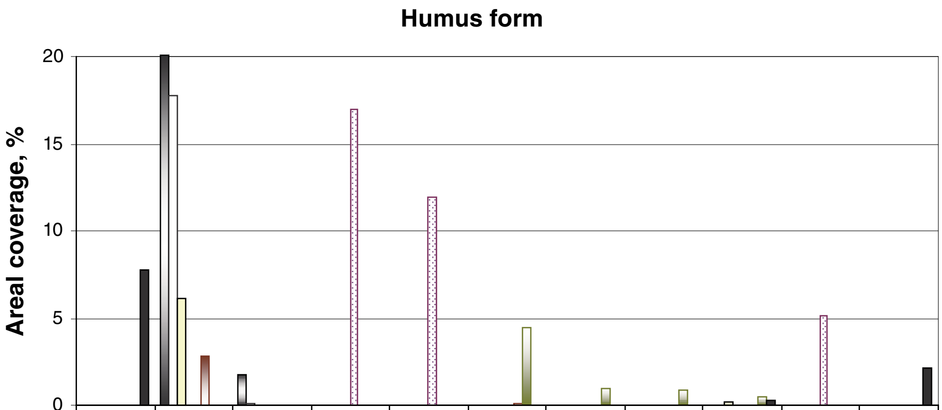


Figure 4-10. *Humus form distribution for the SKB Oskarshamn area Laxemar and in comparison with other Swedish area conditions.*



	LP	PZ/RG	PZ/RG-e	UM/RG	UM/GL	HI-f	HI-w	HI-sp	RG/HI	UM/GL-a	No-classif.
Mor-1		20.1	1.8								
Mor-2		17.7	0.1								
Moder		6.1							0.2		
Mull-like moder											
Mull				17.0	12.0					5.2	
Peaty mor		2.8				0.1					
Peat						4.4	1.0	0.9	0.5		
Humus missing	7.8								0.3		2.1

Figure 4-11. *Humus form in the SKB Oskarshamn area Laxemar presented as distribution on GIS map soil classes. Transformation between soil types and codes, see Table 4-2.*

Table 4-11. Humus form frequencies (%) of the SKB Oskarshamn area Laxemar and four other parts of Sweden.

Class, %	Region Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
Humus missing	2.8	2.6	4.2	9.2	8.1
Mor –1	31.5	18.4	13.1	10.3	21.9
Mor –2	16.4	21.9	27.0	13.7	17.9
Moder	6.2	11.4	12.1	11.4	6.3
Mull-like moder	3.9	9.7	12.7	11.4	
Mull	4.5	12.8	14.3	10.3	34.0
Peaty mor	6.7	5.8	3.6	5.7	2.9
Peat	15.9	10.7	6.6	10.8	6.8
Other	12.1	6.7	6.4	17.2	2.1

4.6.7 Soil type

Almost all common Swedish soil types according to the WRB-system /WRB 1998/ were found in the Oskarshamn area, only Cambisol was missing but on the other hand Umbrisol was quite common. Arenosol only existed in a few places. A comparison of the soil type conditions in the Oskarshamn area Laxemar (Figure 4-1) with conditions for other Swedish regions was made by converting the inventory of Swedish soil classification to the international system WRB. Inventories in Sweden have related to a Swedish soil classification system and the definitions are not totally the same but reasonable conversion resemblance was achieved. The eight soil types most common in Sweden and used in the Swedish Forest Soil Inventory as well as in the Oskarshamn investigation could be described as follows:

- Histosol with a thick organic layer.
- Leptosol with thin soils on bedrock or skeletal soils with very high stone and boulder content.
- Gleysol with reduced conditions in rather shallow soil layers and thereby limited amount of precipitated elements.
- Podzol with the typical bleached horizon and a Spodic B horizon with precipitated iron and aluminium.
- Umbrisols on fairly well drained sites with an organic topsoil layer and high content of organic matter in the top mineral soil with a clear soil structure.
- Cambisol with a humus form being a mull or mull-like moder, high content of organic matter in the mineral soil and very good structure in these layers.
- Arenosol on sand with weak development of soil layers.
- Regosols having immature soil profiles lacking most of the diagnostic horizons.

Ordinary Swedish forest soils include a large proportion of Podzol being overestimated in the Swedish classification system as compared to the international WRB system. In the Oskarshamn area with partly rather young soils, profile development was on some locations weak and Regosol was common (Figure 4-12 and Table 4-12). Other common types were Umbrisol, Leptosol and Histosol.

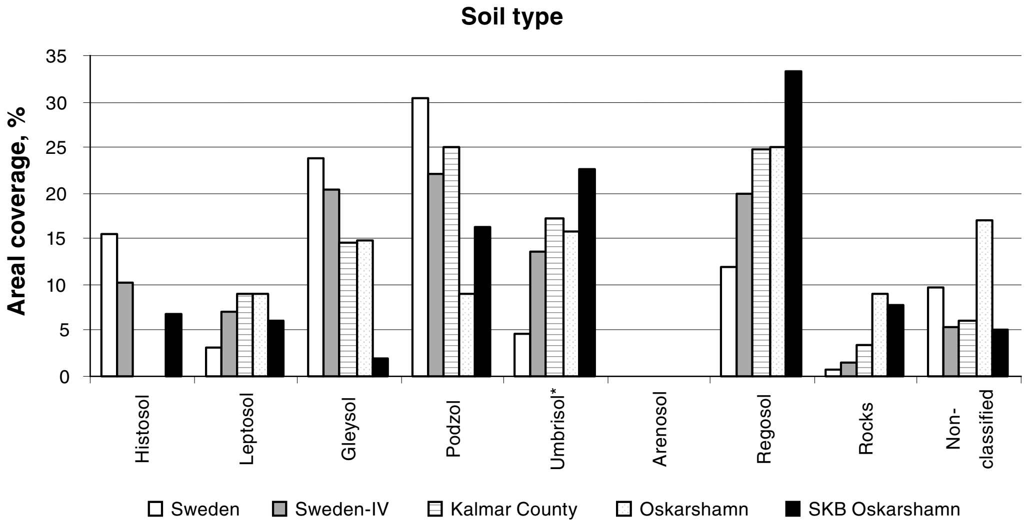


Figure 4-12. Soil type distributions for the Oskarshamn area Laxemar, in comparison to conditions of four relevant Swedish areas. The Umbrisol class includes Cambisol for the four Swedish regions but in Laxemar, Umbrisol was predominant.

Table 4-12. Soil type frequencies (%) in the SKB Oskarshamn area Laxemar and four other parts of Sweden.

Class, %	Region Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
Histosol	15.6	10.2			6.7
Leptosol	3.1	7.0	8.9	9.1	6.1
Gleysol	23.8	20.3	14.5	14.8	2.0
Podzol	30.3	22.0	25.1	9.1	16.4
Cambisol/Umbrisol	4.7	13.5	17.2	15.9	22.6
Arenosol					0.1
Regosol	11.9	20.0	24.7	25.0	33.3
Rocks	0.8	1.5	3.5	9.1	7.8
Non-classified	9.8	5.4	6.1	17.0	5.0

Inside the selected land types, variations occurred and up to four soil type classes were identified in the PZ/RG class. Anyhow, in a number of land types only one soil type class existed, such as for PZ/RG-e, UM/GL and HI-sp (Figure 4-13). In cases with two soil types in one soil type class, often Regosol was present.

Spatial coverage of the soil types was connected to the most common GIS map soil class PZ/RG where four types occurred, making Podzol fairly common with 16.5%. Anyhow, the Regosol type was found most commonly and on almost 34% of the area. Umbrisols was found in the three soil classes UM/RG, UM/GL and UM/GL-a (Figure 4-14).

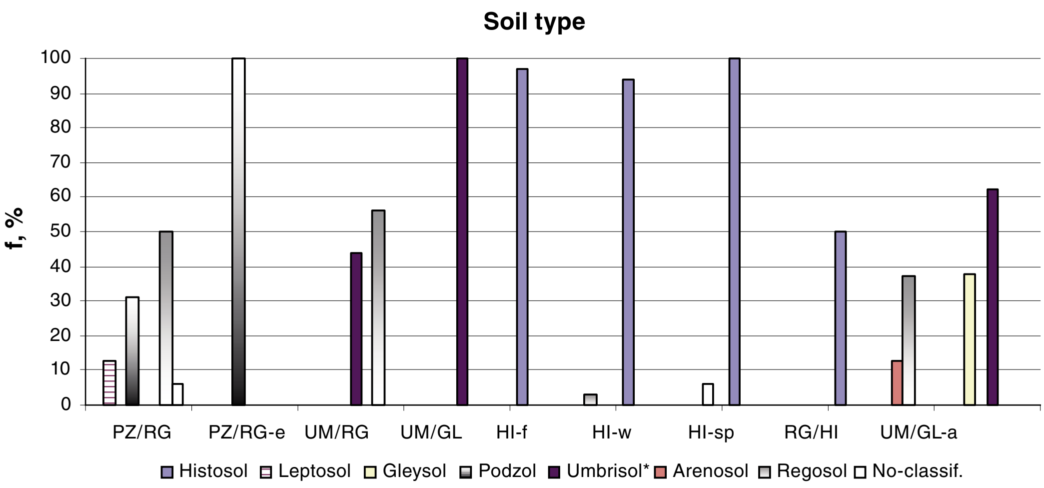
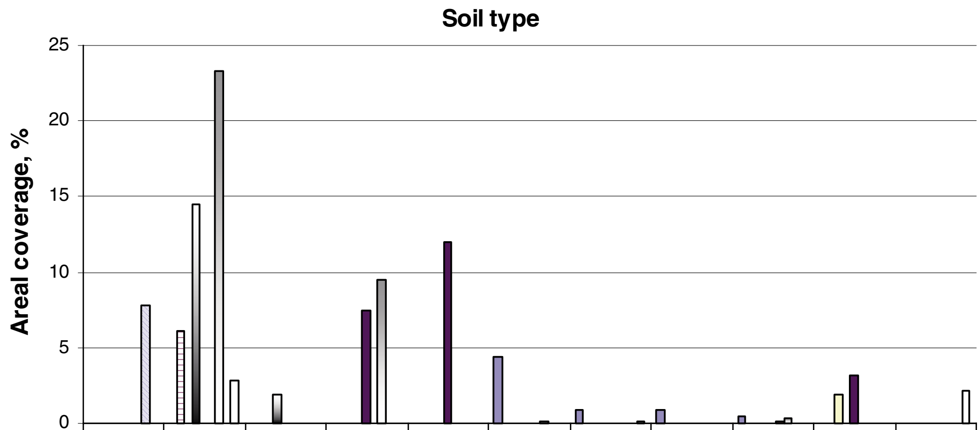


Figure 4-13. *Distribution of soil types (%) within the GIS map soil classes and over the SKB Oskarshamn area Laxemar. Transformation between soil types and codes, see Table 4-2.*



	LP	PZ/RG	PZ/RG-e	UM/RG	UM/GL	HI-f	HI-w	HI-sp	RG/HI	UM/GL-a	No-classif.
Histosol						4.4	0.9	0.9	0.5		
Leptosol		6.1									
Gleysol										2.0	
Podzol		14.5	1.9								
Umbrisol*				7.5	12.0					3.2	
Arenosol									0.1		
Regosol		23.4		9.5		0.1			0.4		
Rocks	7.8										
No-classif.		2.8					0.1				2.1

Figure 4-14. *Soil type spatial coverage (%) as distributed over the GIS map soil classes of the SKB Oskarshamn area Laxemar. Transformation between soil types and codes, see Table 4-2.*

4.6.8 Ground layer vegetation

Bottom layer vegetation

Bottom layer vegetation distributions over the investigated sites, were dominated by mesic mosses, being frequently occurring on drained land types. Lichens would have been found on the dry locations mainly constituting the bedrock areas (not inventoried). In peatlands and on wet soils there were *sphagnum* mosses but also other wet mosses existed (Figure 4-15). Missing information relates to areas mainly without bottom layer vegetation such as e.g. shorelines and arable land (Table 4-13).

Table 4-13. Ground vegetation, bottom layer distribution (%) in the SKB Oskarshamn area Laxemar in comparison to other areas of Sweden.

Class, %	Region Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
Lichen	3.6	0.7	0.8	3.4	
Lichen-mosses	0.4	0.2			
Lichen-rich	3.1	1.1	0.9		
Sphagnum	18.9	13.5	5.3	4.5	20.0
Wet mosses (not Sph)	9.4	6.6	3.9	4.5	5.0
Mesic-mosses	56.8	73.3	81.6	77.3	40.0
Missing inform.					
Mainly no bottom layer	7.7	4.6	7.5	10.2	35.0

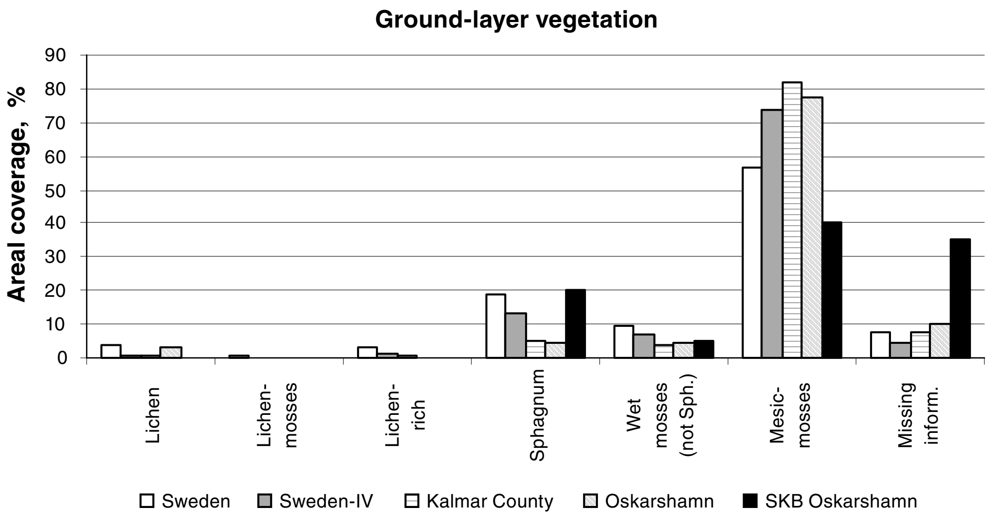


Figure 4-15. Ground vegetation, bottom layer distribution in the SKB Oskarshamn area Laxemar in comparison to other areas of Sweden. Parts of the missing information for Oskarshamn relate to no bottom layer.

Field layer vegetation

The field layer vegetation of the sites investigated was mainly included in the classification groups broad leafed grasses and bilberry types. Also low herbs without shrubs, poor shrub type and low sedge type existed (Figure 4-16 and Table 4-14). In this case the GIS map soil classes were not used for distribution calculations. Dominating ground vegetation species are presented in Appendix IV.

Table 4-14. Field layer vegetation frequencies (%) for the Oskarshamn area investigation sites with comparisons to other areas of Swedish forest land.

Class, %	Region Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
1. Tall herbs without shrubs	5.1	7.9	4.4	5.7	
2. Tall herbs with shrubs/bilberry	1.1	0.2	0.1		
3. Tall herbs with shrubs/lingonberry	0.2	0.0			
4. Low herbs without shrubs	6.0	13.0	17.7	26.1	10.0
5. Low herbs with shrubs/bilberry	3.5	3.9	4.1	4.5	
6. Low herbs with shrubs/lingonberry	0.3	0.1	0.1		
7. Without field layer veg.	8.3	4.6	4.2	1.1	
8. Broad leafed grass	6.9	15.9	19.1	18.2	50.0
9. Narrow leafed grass	11.7	17.1	17.2	10.2	
10. Tall sedge	3.5	2.3	2.0	2.3	
11. Low sedge	8.8	3.9	0.7		5.0
12. Horse tail	1.0	0.3	0.1	1.1	
13. Bilberry	22.7	19.8	17.7	12.5	25.0
14. Lingon-/whortle berry, marsh rosemary	5.0	3.0	2.3		
15. Crowberry/heather	5.9	2.1	2.5	3.4	
16. Poor shrubs	2.1	1.2	0.4	1.1	10.0
17. Missing inform.	7.7	4.6	7.5	13.6	

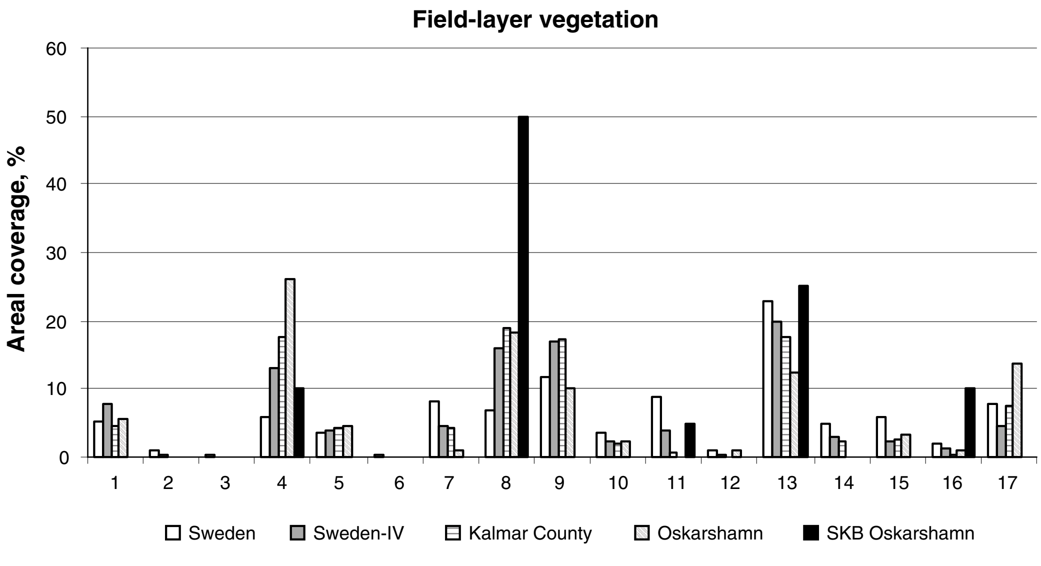


Figure 4-16. Field layer vegetation distribution for the Oskarshamn area investigation sites compared to other parts of Swedish forest land. The vegetation classes are defined in Table 4-14.

4.7 Soil chemistry

Soils in the Oskarshamn area were sampled for chemical analysis on ten land types in two replicates, totally being 20 sites with four to eight soil pits on each site. Chemical analysis included pH, carbon (C) and nitrogen (N). *(Results are found in the Sicada database, field note no 204.)*

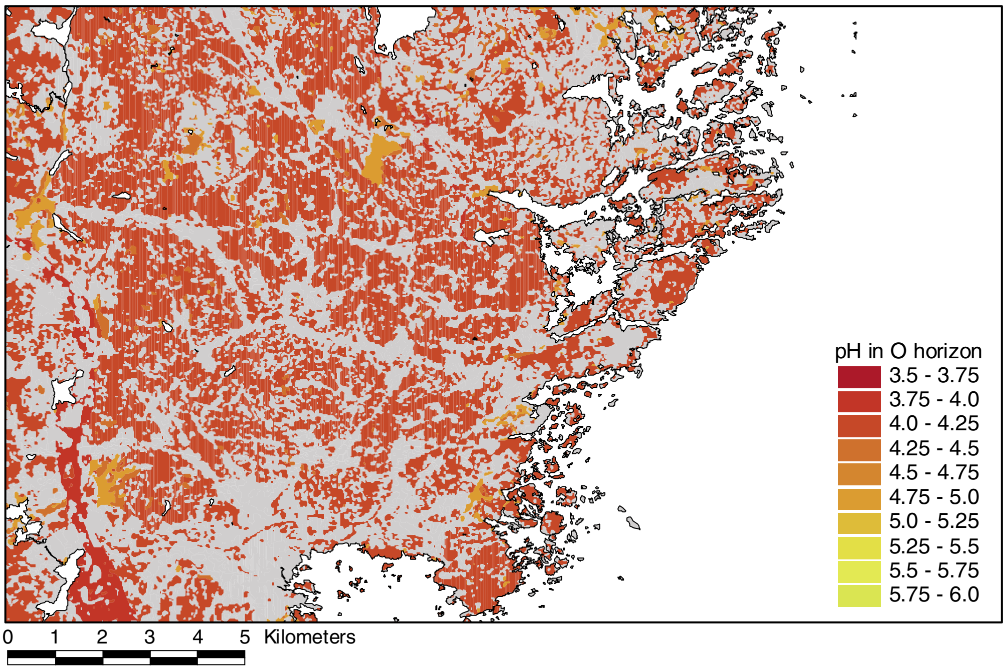
4.7.1 Soil pH

Organic layer pH_{H2O}

In the organic layer of the SKB Oskarshamn area, the pH values were fairly similar to this region of Sweden and also compared to total Sweden. The average value was, however slightly lower as compared to the Kalmar county and the Oskarshamn community (Table 4-15). Most frequently occurring pH values were found in the range 4.0 to 5.0, but with more than 35% of the areas with pH over 5.0 (Figure 4-17 and 4-18 and Appendix Va).

Table 4-15. The pH values of the organic layer in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Min	Max	Std	Cv, %
Sweden	6429	4.2	3.0	7.8	0.7	16.7
Sweden-IV	2662	4.2	3.1	7.3	0.7	16.7
Kalmar County	323	4.4	3.2	6.9	0.8	18.2
Oskarshamn Comm.	30	4.6	3.4	5.9	0.7	15.2
SKB Oskarshamn	107	4.3	3.3	6.4	0.7	16.3



Figur 4-17. *Humus layer pH_{H2O} in the Oskarshamn area. Grey parts include areas without humuslayer.*

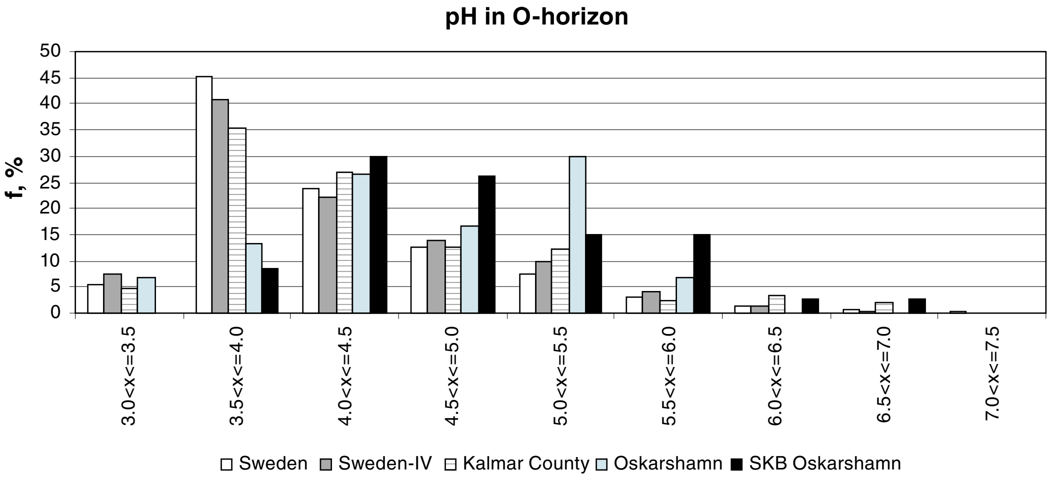


__Figure 4-18.__ Distribution (%) of organic soil pH values on ph classes for Oskarshamn and other parts of Sweden.

Mineral soil pH_{H2O}, 0–10 cm layer

In the upper mineral soil layers, the pH was on average 5.2 and then partly influenced by valley arable soils giving higher pH as compared to ordinary forest land. The pH value was also higher than in the O-horizon and further subsequently increasing with depth at least to 0.2 m while the value was the same (5.2) in the deepest layers (0.6 m) (Tables 4-16 to 4-18 and Figure 4-25). Deviations could be seen in the distribution on pH-classes with higher frequencies in the pH-classes 5.0–6.5 (Figure 4-19 and 4-20 and Appendix Vb).

Table 4-16. Oskarshamn pH values in the upper mineral soil, 0–10 cm. Comparison to other parts of Sweden.

Survey area	Valid N	Average	Min	Max	Std	Cv, %
Sweden	1842	4.9	3.8	8.6	0.5	10.8
Sweden-IV	696	4.9	3.8	8.4	0.5	11.1
Kalmar County	88	4.9	3.9	7.6	0.5	10.2
Oskarshamn Comm.	4	4.6	4.3	5.2	0.4	8.7
SKB Oskarshamn	90	5.2	4.1	6.7	0.5	10.4

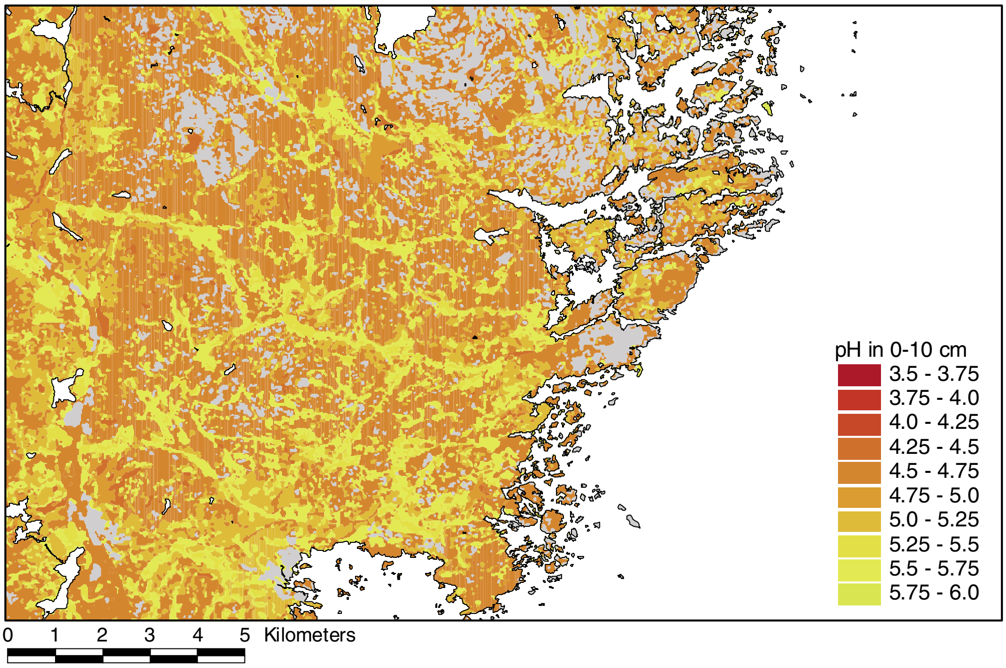


Figure 4-19. *Mineral soil, 0–10 cm, pH_{H2O} values in the Oskarshamn area. The grey areas could be no data or areas with organic soils.*

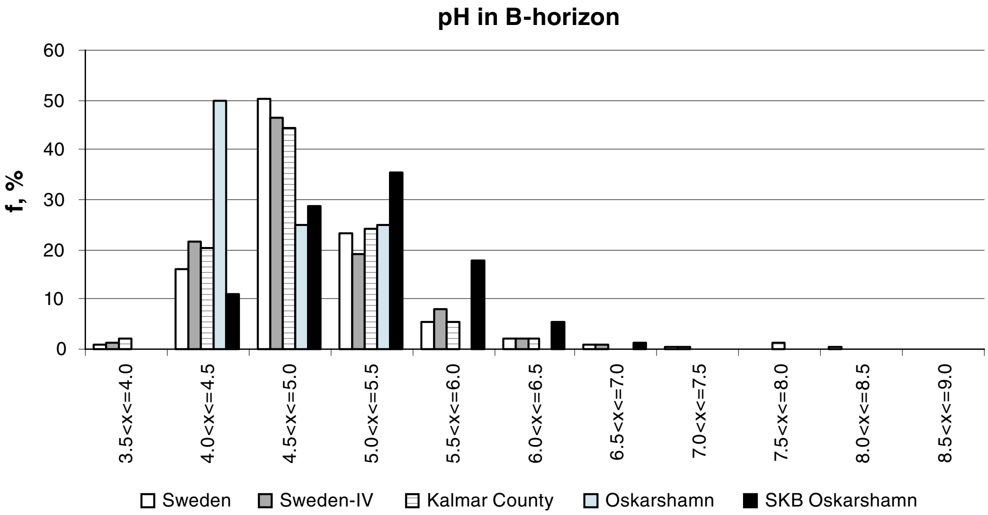


Figure 4-20. *Distribution (%) of upper soil, 0–10 cm, pH values in the SKB Oskarshamn area Laxemar on pH classes compared with other parts of Sweden*

Mineral soil layer 10–20 cm

In the layer 0.1–0.2 m, the highest pH values were found with an average of 5.3, actually only slightly higher as compared to layers above and below (Table 4-17). In comparison to other parts of Sweden also in this layer pH was higher. Distribution on pH-classes showed the same pattern as for the layer above (0.1 m) with higher frequencies in the upper range (Figure 4-21 and 4-22 and Appendix Vc).

Table 4-17. Oskarshamn pH values in the mineral soil, 10–20 cm. Comparison to other parts of Sweden.

Survey area	Valid N	Average	Min	Max	Std	Cv, %
Sweden	1842	4.9	3.8	8.6	0.5	10.8
Sweden-IV	696	4.9	3.8	8.4	0.5	11.1
Kalmar County	88	4.9	3.9	7.6	0.5	10.2
Oskarshamn	4	4.6	4.3	5.2	0.4	8.7
SKB Oskarshamn (M 10–20)	86	5.3	4.2	6.5	0.4	7.9

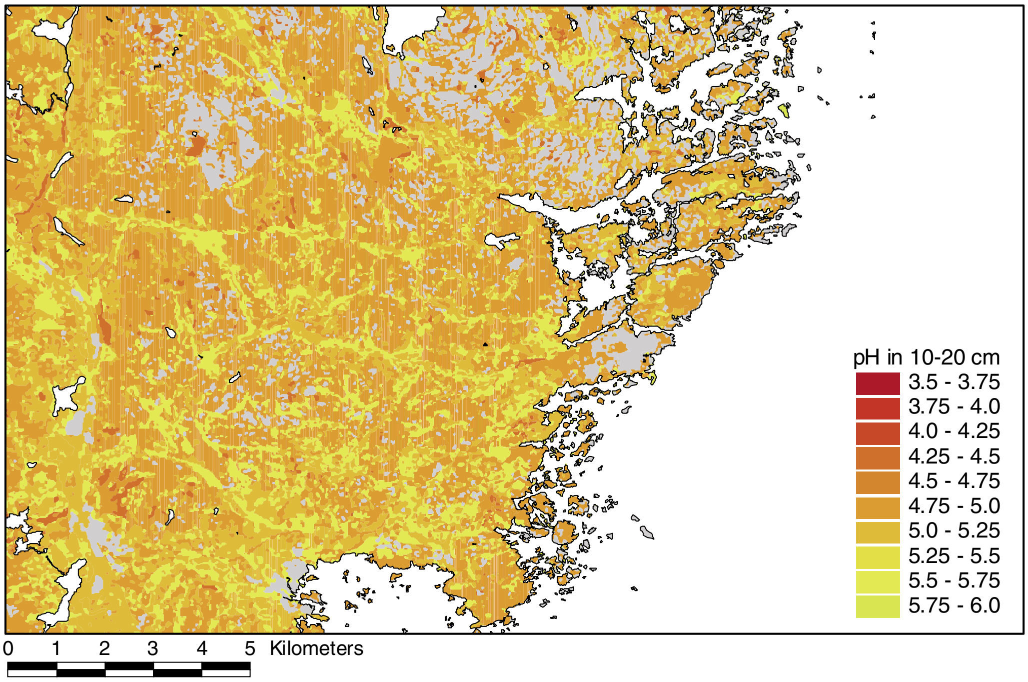


Figure 4-21. *Mineral soil, 10–20 cm, pH_{H2O} in the Oskarshamn area. The grey areas include not sampled areas or could be peatlands.*

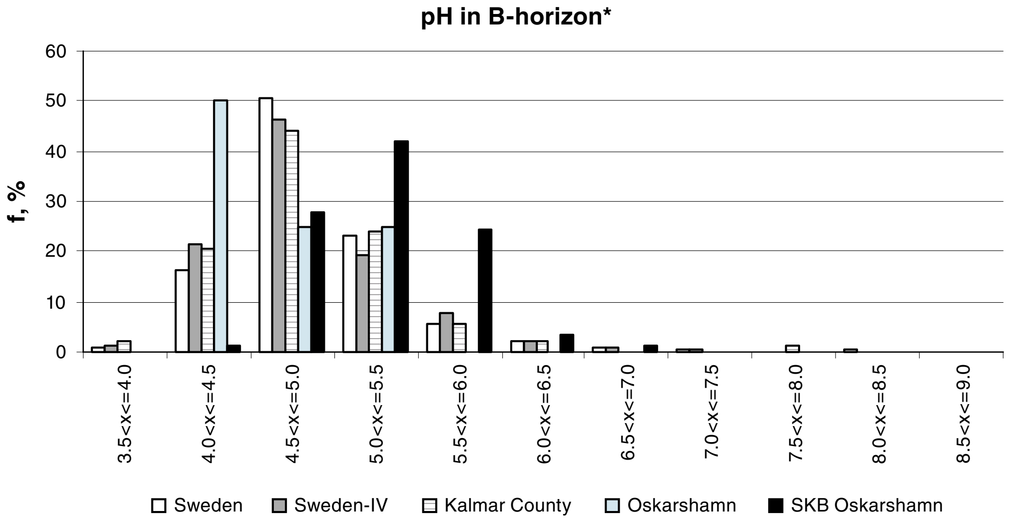


Figure 4-22. *Distribution (%) of mineral soil, 10–20 cm, pH values over pH classes in the SKB Oskarshamn area Laxemar compared with other parts of Sweden.*

Mineral soil C-horizon pH, 55–65 cm depth

The average pH value 5.2 (Table 4-18) did not differ much from layers above but deviated from the overall pattern for Swedish forest soils where pH increased more with depth and also showed high values as compared with the SKB Oskarshamn area. The distribution on pH classes showed higher frequencies in classes below pH 4.5 and comparably high also in the class 5.0–5.5 (Figure 4-23 and 4-24 and Appendix Vd). Site pH values are presented in Appendix VI and VII.

Table 4-18. Oskarshamn pH values in the mineral soil C-horizon, 55–65 cm. Comparison to other parts of Sweden.

Survey area	Valid N	Average	Min	Max	Std	Cv, %
Sweden	1484	5.3	3.5	9.2	0.6	11.3
Sweden-IV	544	5.3	4.5	8.9	0.6	11.3
Kalmar County	69	5.2	4.5	7.9	0.6	11.5
Oskarshamn	3	5.2	4.8	5.5	0.3	5.8
SKB Oskarshamn (M 55–65)	44	5.2	3.6	6.3	0.6	11.0

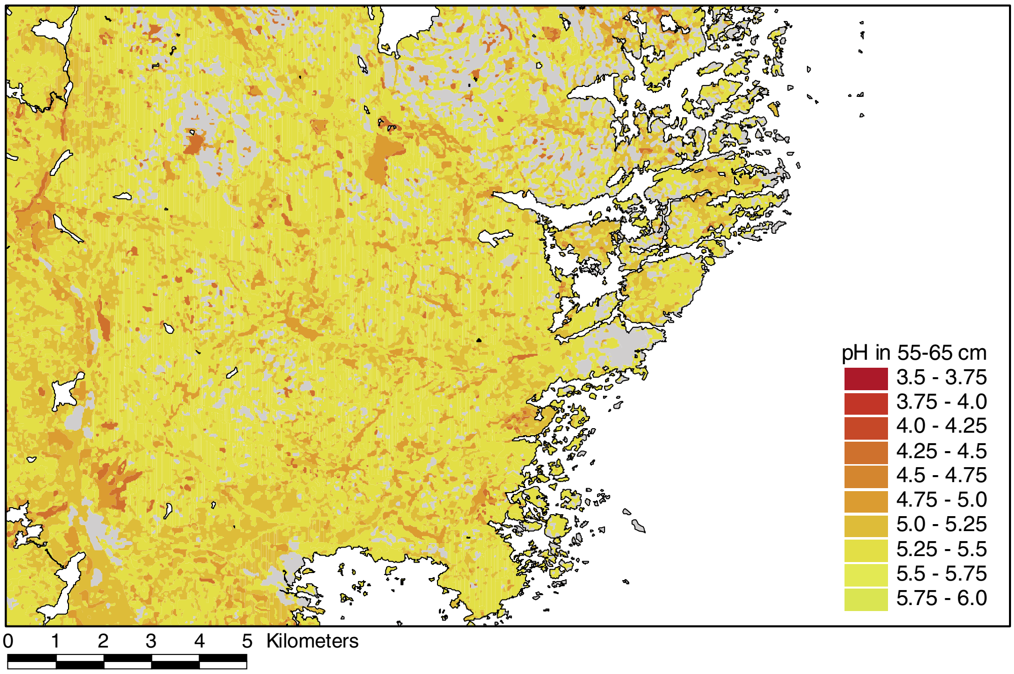


Figure 4-23. *Mineral soil C-horizon, 55–65 cm, pH_{H2O} values in the Oskarshamn area. Grey areas are not sampled areas or peatlands.*

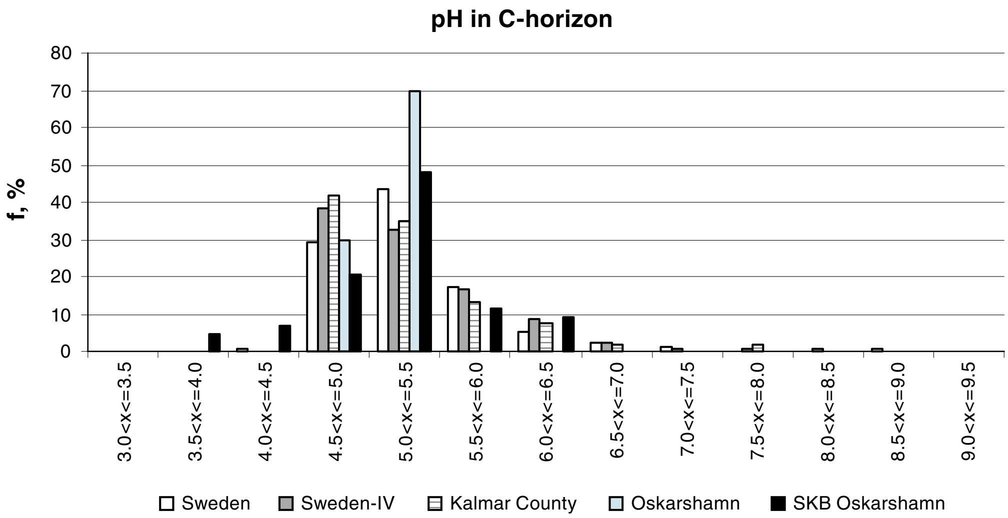
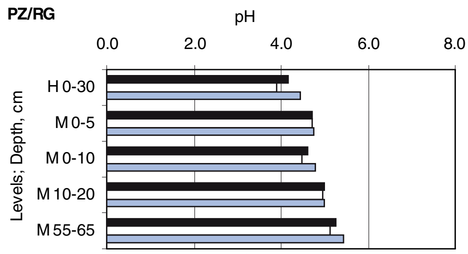
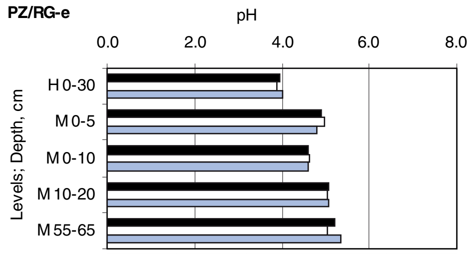


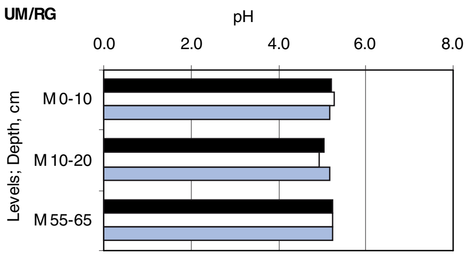
Figure 4-24. *Distribution (%) of mineral soil C-horizon, 55–65 cm, pH values over pH classes in the SKB Oskarshamn area Laxemar compared with other parts of Sweden*



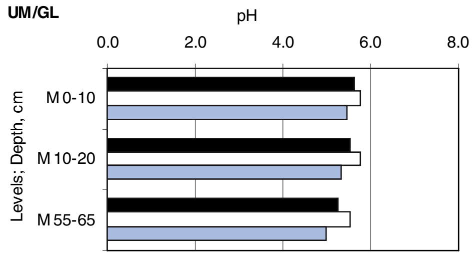
	M 55-65	M 10-20	M 0-10	M 0-5	H 0-30
■ H	5.3	5.0	4.6	4.7	4.2
□ H 1	5.1	5.0	4.5	4.7	3.9
▫ H 2	5.4	5.0	4.8	4.7	4.4



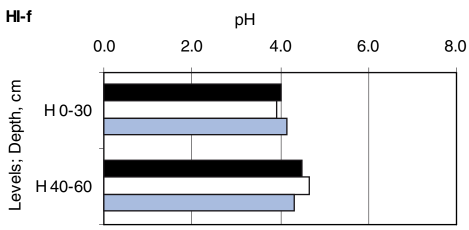
	M 55-65	M 10-20	M 0-10	M 0-5	H 0-30
■ E	5.2	5.1	4.6	4.9	3.9
□ E 1	5.1	5.1	4.6	5.0	3.9
▫ E 2	5.3	5.1	4.6	4.8	4.0



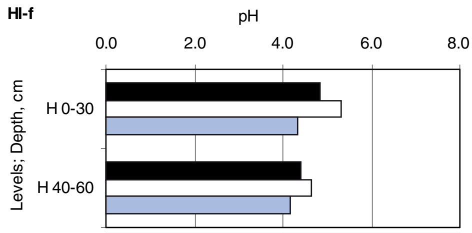
	M 55-65	M 10-20	M 0-10
■ L	5.2	5.0	5.2
□ L1	5.2	4.9	5.3
▫ L2	5.2	5.2	5.2



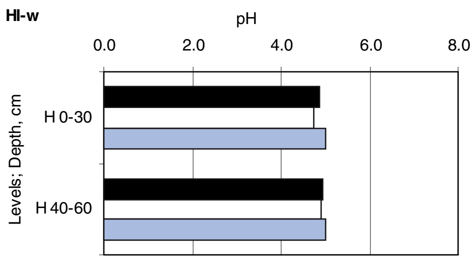
	M 55-65	M 10-20	M 0-10
■ P	5.3	5.5	5.6
□ P 1	5.5	5.8	5.8
▫ P 2	5.0	5.3	5.4



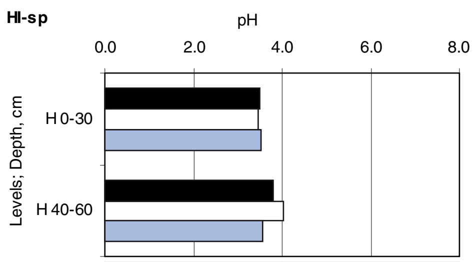
	H 40-60	H 0-30
■ G	4.5	4.0
□ G1	4.7	3.9
▫ G2	4.3	4.1



	H 40-60	H 0-30
■ SS	4.4	4.8
□ SS1	4.6	5.3
▫ SS2	4.2	4.3



	H 40-60	H 0-30
■ T	5.0	4.9
□ T1	4.9	4.7
▫ T2	5.0	5.0



	H 40-60	H 0-30
■ VH	3.8	3.5
□ VH1	4.0	3.5
▫ VH2	3.6	3.5

Figure 4-25. *The pH values in the SKB Oskarshamn area investigation sites distributed on GIS map soil classes and depth. Black bar shows the mean value. Note, the small table below the figure has the depth classes in reverse order.*

4.7.2 Carbon content in the soil

Storage of carbon in the soil depends to a large extent on the site adherent biota, i.e. vegetation and fauna. Organic matter is furnished by litter fall on top of the soil and roots and other organisms in the soil. There is also a part added by deposition. Most organic matter input is in the upper layers of the soil. Therefore, organic carbon, making up roughly 50% of the organic matter, displays stratification towards depth with higher contents in the upper layers and low in the deeper soil. In the Oskarshamn area, the average content is 39% in the organic layer, c 10% in the upper mineral soil layers and only c 1% in the deeper C-horizon. Most soils show this pattern but Histosol with peat, of course, has fairly high content all through the peat deposit. Podzol may furnish a pattern with a fairly low content in the upper bleached horizon and higher values in the B-horizon below but coming down into the C-horizon also these soils have low carbon contents (Figure 4-34).

Carbon in the organic layer

The organic carbon content in the O-horizon was on average 39.2% being lower than the c 50% relevant for pure organic matter (Table 4-19). This probably is related to small contents of mineral material. The distribution on content classes displays higher frequencies in classes over 20% C but fewer with low carbon content as compared to other regions (Figures 4-26, 4-27 and Appendix VIIIa).

Table 4-19. Carbon content (%) in the organic layer in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Max	Std	Cv, %
Sweden	5449	33.7	56.4	15.0	44.5
Sweden-IV	2345	26.1	56.4	18.4	70.5
Kalmar County	283	25.0	54.1	18.1	72.4
Oskarshamn	27	20.9	49.1	18.5	88.5
SKB Oskarshamn	107	39.2	55.5	12.1	30.9

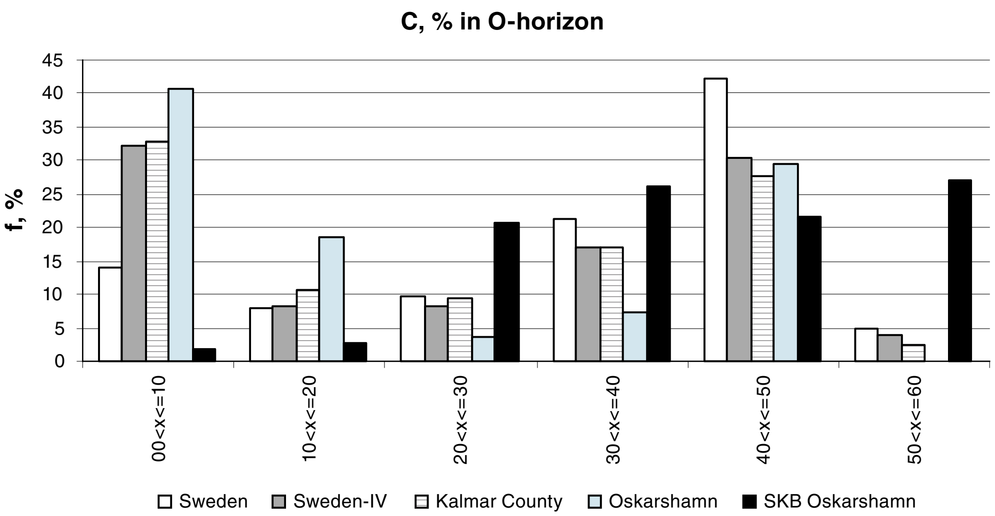


Figure 4-26. *Distribution (%) of carbon content of the organic soil layer over concentration classes in the SKB Oskarshamn area Laxemar compared to other parts of Sweden.*

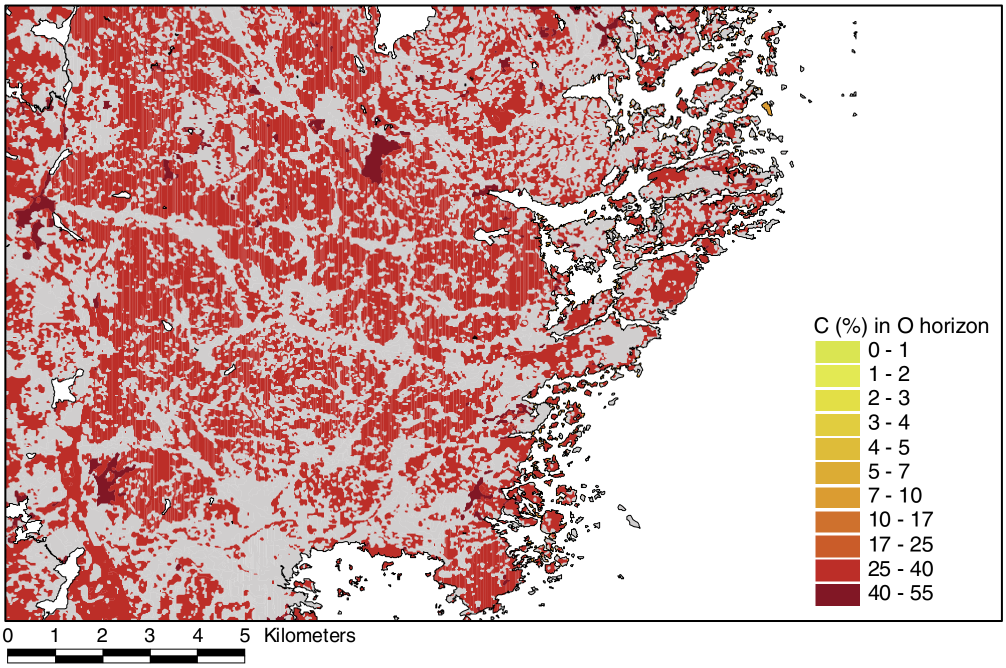


Figure 4-27. *Carbon content of the organic soil layer in the Oskarshamn area. Grey parts are not sampled or could be areas without humus layer.*

Carbon in upper mineral soil, 0–10 cm

In the upper mineral soil layer (0–10 cm), the carbon content was fairly high compared to other parts of Sweden, probably reflecting the low number of Podzol sites in the Oskarshamn area. The mean value of 10.3% was much higher than the 2–5% found in other regions of Sweden (Table 4-20). Distribution on class frequencies showed higher numbers over concentrations of 4% but lower in classes with less carbon content (Figure 4-28 and 4-29 and Appendix VIIIb). The high frequency of carbon contents between 10% and 12% for Oskarshamn community depend on the few monitoring sites in this area.

Table 4-20. Carbon content (%) in the upper mineral soil, 0–10 cm, in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Max	Std	Cv, %
Sweden	1509	2.3	42.8	2.0	87.0
Sweden-IV	588	2.0	16.3	1.9	95.0
Kalmar County	74	2.3	11.7	2.4	104.3
Oskarshamn	3	5.2	10.2	4.3	82.7
SKB Oskarshamn	90	10.3	45.0	11.3	109.5

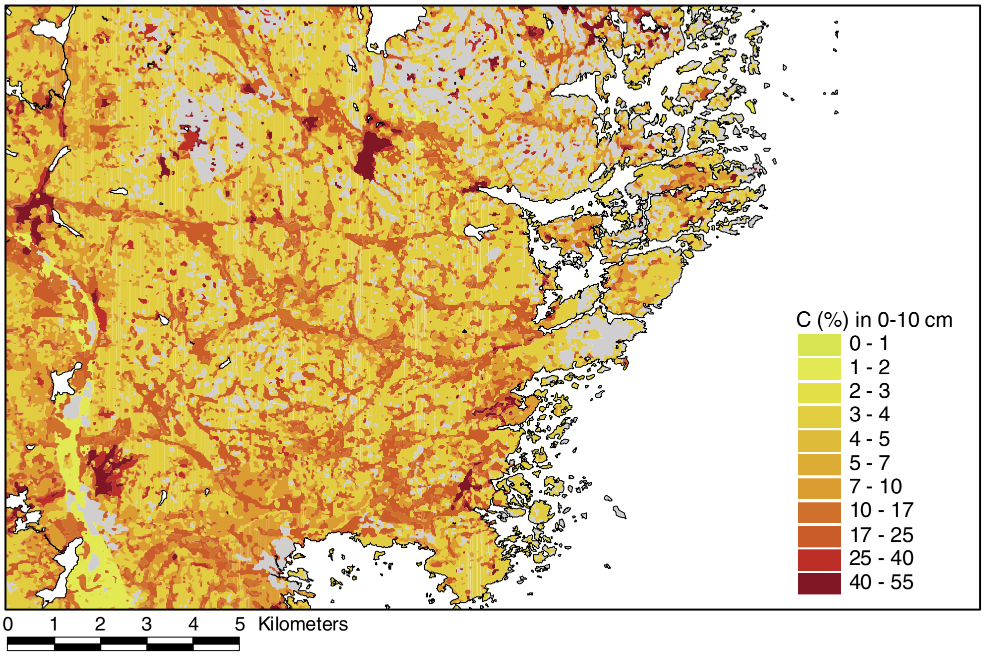


Figure 4-28. *Carbon content of the upper mineral soil layer, 0–10 cm, in the Oskarshamn area. Grey areas are either not sampled or could be peatlands.*

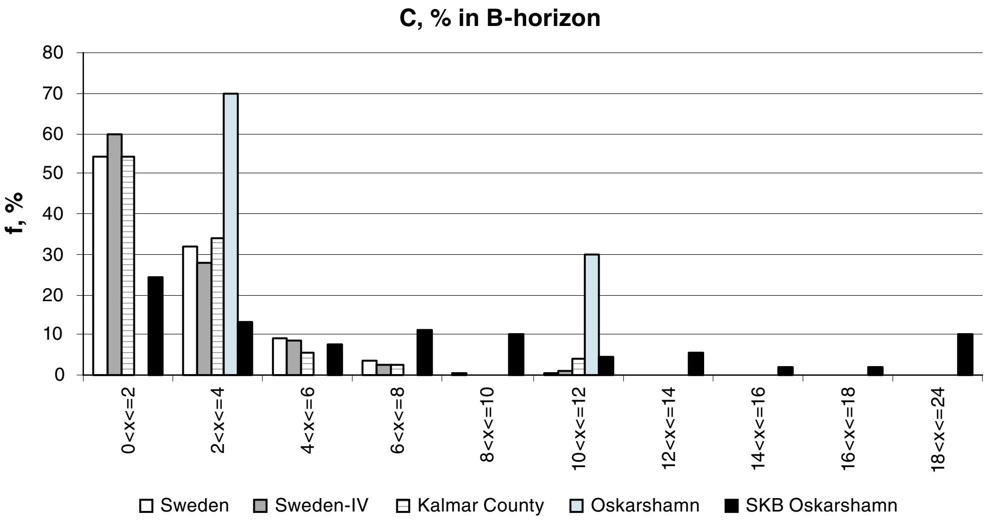


Figure 4-29. *Distribution (%) of carbon content of the upper mineral soil layer, 0–10 cm, over concentration classes in the SKB Oskarshamn area Laxemar compared to other parts of Sweden.*

Carbon in the mineral soil layer 10–20 cm

The content of carbon in the layer 0.1–0.2 m was slightly lower than in the layer above making up 10% in the upper layer and 9.2% in this layer. The value is also higher compared to Sweden regions (Table 4-21). The distributions on concentration values display similar pattern as the layer above with relatively high number of sites over 6% but also quite a number of sites in the lowest range 0–2% (Figure 4-30 and 4-31 and Appendix VIIIc).

Table 4-21. Carbon content (%) in the mineral soil layer 10–20 cm in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Max	Std	Cv, %
Sweden	1509	2.3	42.8	2.0	87.0
Sweden-IV	588	2.0	16.3	1.9	95.0
Kalmar County	74	2.3	11.7	2.4	104.3
Oskarshamn	3	5.2	10.2	4.3	82.7
SKB Oskarshamn	86	9.2	48.4	12.3	134.2

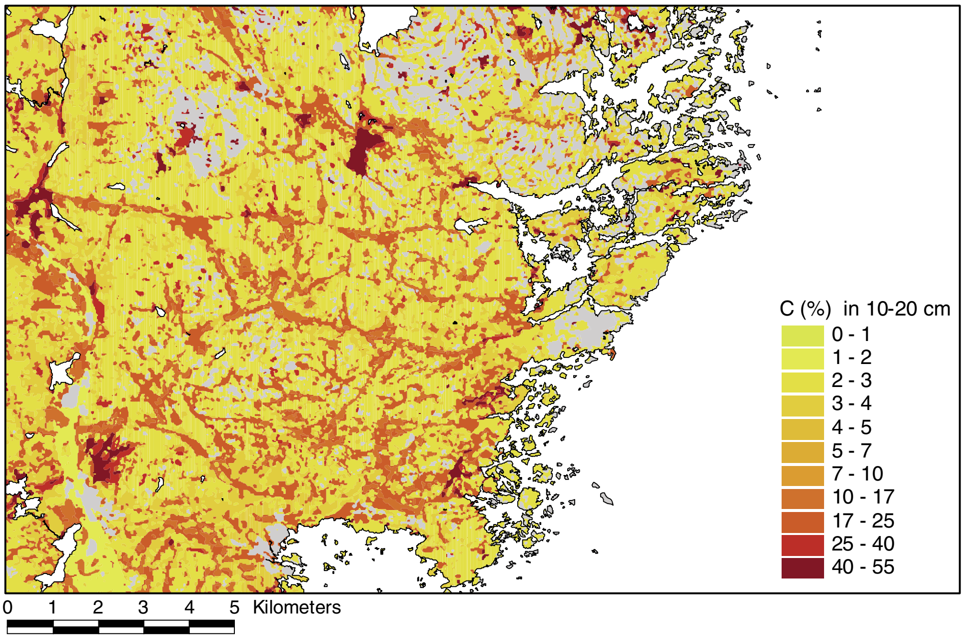


Figure 4-30. Carbon content of the mineral soil layer 10–20 cm, in the Oskarshamn area. Grey areas are those not sampled or being peatlands.

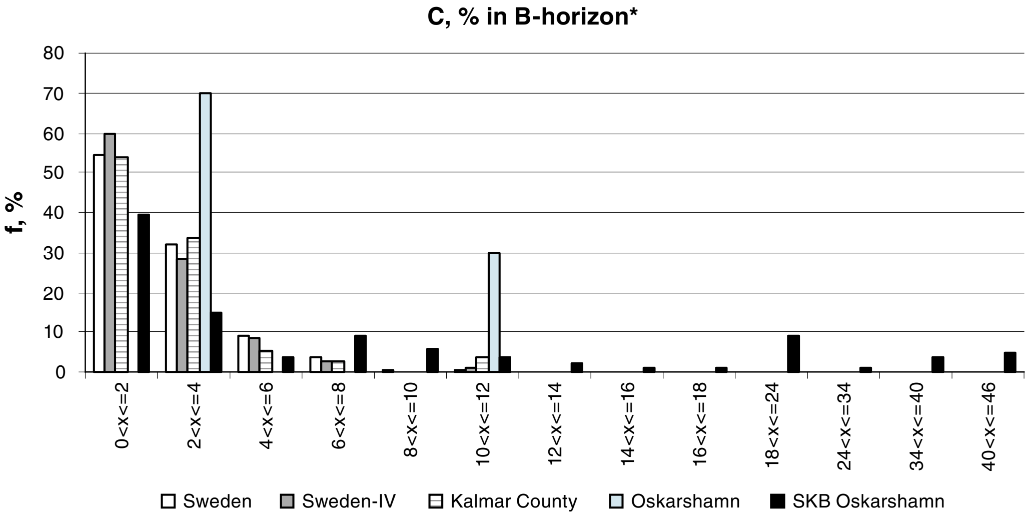


Figure 4-31. *Distribution (%) of carbon content of the mineral soil layer 10–20 cm, over concentration classes in the SKB Oskarshamn area Laxemar compared to other parts of Sweden.*

Carbon in the mineral soil layer C-horizon, 55–65 cm

In the deeper mineral soil, C-horizon, the carbon concentration was low with on average 1.2%, however being relatively high compared to the other parts of Sweden staying on concentration values below 1% (Table 4-22). Distribution on concentration values showed high frequencies in the lowest class 0–2% (Figure 4-32 and 4-33 and Appendix VIIId).

Table 4-22. Carbon content (%) in the mineral soil C-horizon, 55–65 cm, in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Max	Std	Cv, %
Sweden	1213	0.7	46.5	1.7	243
Sweden-IV	450	0.5	7.0	0.8	160
Kalmar County	57	0.9	7.0	1.4	156
Oskarshamn	2	0.9	1.1	0.3	30
SKB Oskarshamn	44	1.2	15.3	2.6	211

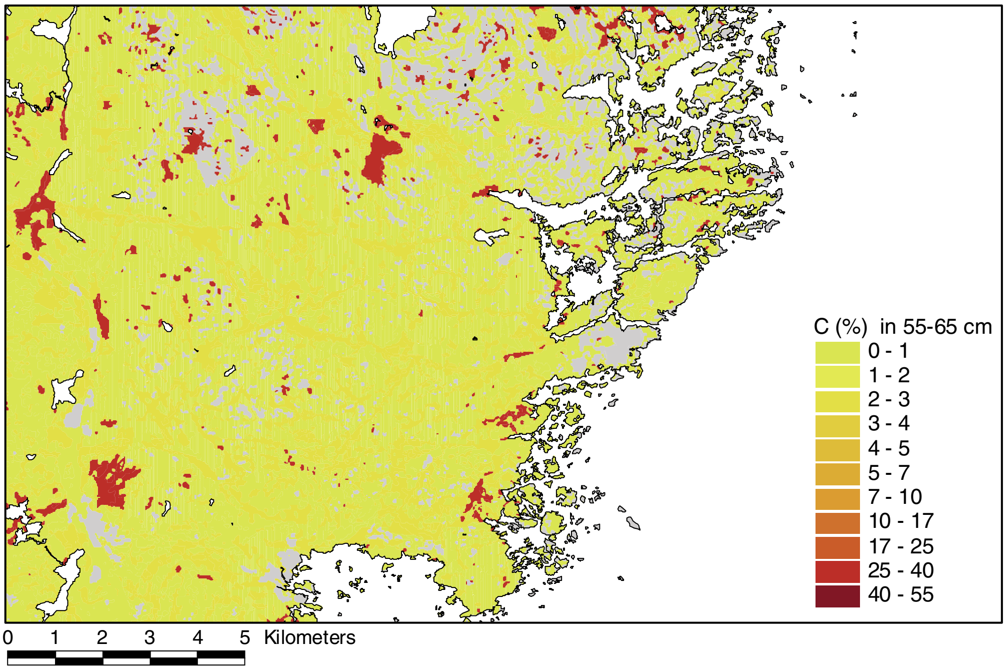


Figure 4-32. *Carbon content (%) in the mineral soil C-horizon, 55–65 cm, in the Oskarshamn area. Grey areas are those without sampling or being peatlands.*

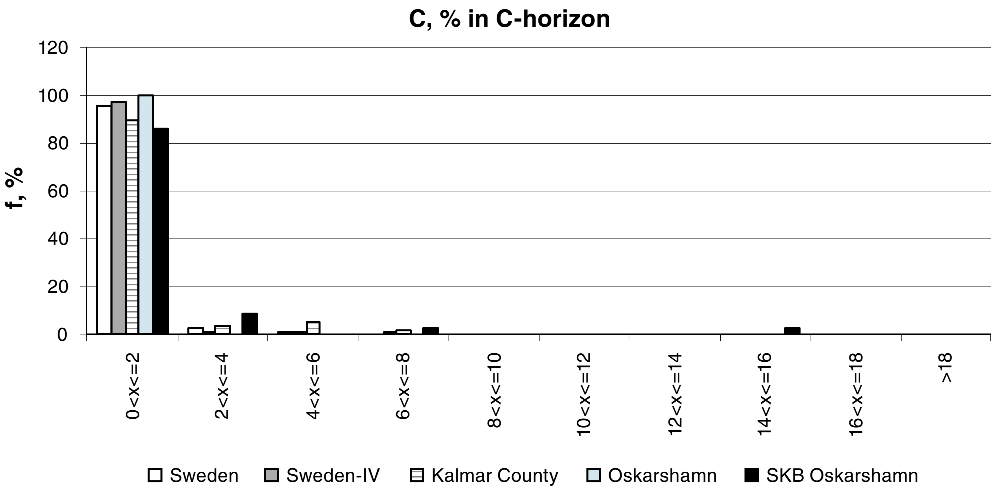
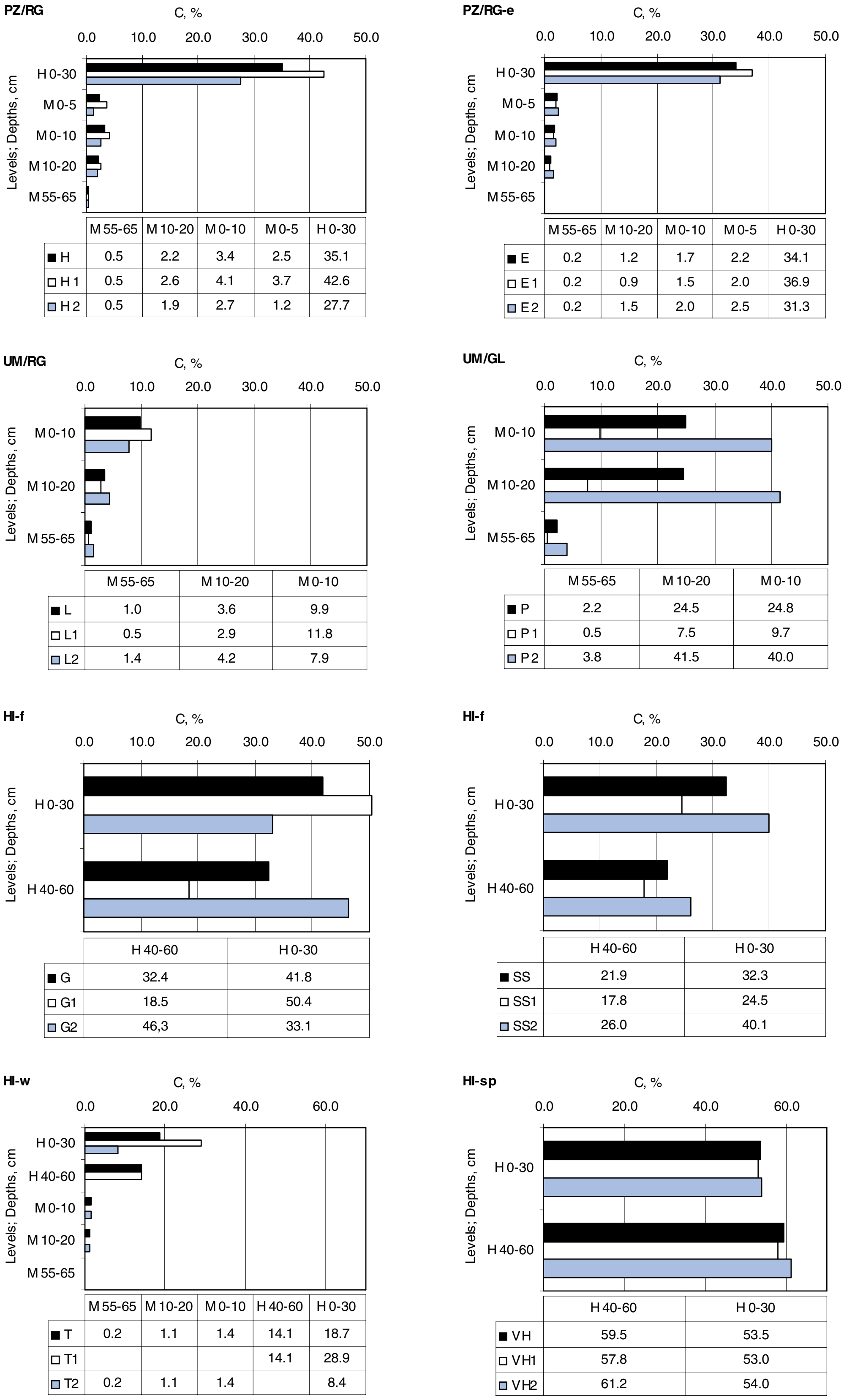


Figure 4-33. *Distribution (%) of carbon content (%) in the mineral soil C-horizon, 55–65 cm, over concentration classes in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.*

When separating the area on different soil types, there could be seen various concentration distribution patterns with soil depth. In Podzol/Regosol type the strong decrease from the organic layer to the mineral soil was obvious. In the Histosol types on the other hand high values was found also in deeper layers. Umbrisol displayed somewhat high concentrations in the mineral soil as compared to the Podzol/Regosol types (Figure 4-34a and b). Site carbon concentrations are presented in Appendix IX.



PZ/RG

	M 55-65	M 10-20	M 0-10	M 0-5	H 0-30
■ H	0.5	2.2	3.4	2.5	35.1
□ H 1	0.5	2.6	4.1	3.7	42.6
□ H 2	0.5	1.9	2.7	1.2	27.7

PZ/RG-e

	M 55-65	M 10-20	M 0-10	M 0-5	H 0-30
■ E	0.2	1.2	1.7	2.2	34.1
□ E 1	0.2	0.9	1.5	2.0	36.9
□ E 2	0.2	1.5	2.0	2.5	31.3

UM/RG

	M 55-65	M 10-20	M 0-10
■ L	1.0	3.6	9.9
□ L1	0.5	2.9	11.8
□ L2	1.4	4.2	7.9

UM/GL

	M 55-65	M 10-20	M 0-10
■ P	2.2	24.5	24.8
□ P 1	0.5	7.5	9.7
□ P 2	3.8	41.5	40.0

Hl-f

	H 40-60	H 0-30
■ G	32.4	41.8
□ G1	18.5	50.4
□ G2	46,3	33.1

Hl-f

	H 40-60	H 0-30
■ SS	21.9	32.3
□ SS1	17.8	24.5
□ SS2	26.0	40.1

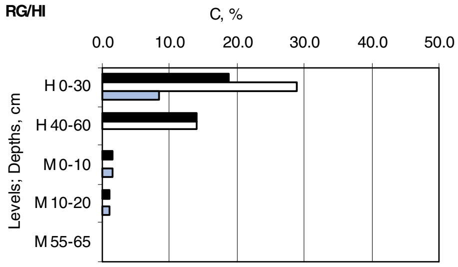
Hl-w

	M 55-65	M 10-20	M 0-10	H 40-60	H 0-30
■ T	0.2	1.1	1.4	14.1	18.7
□ T1				14.1	28.9
□ T2	0.2	1.1	1.4		8.4

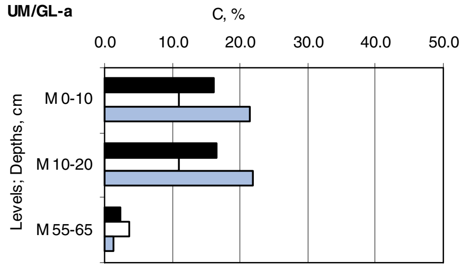
Hl-sp

	H 40-60	H 0-30
■ VH	59.5	53.5
□ VH1	57.8	53.0
□ VH2	61.2	54.0

Figure 4-34. *The carbon content in the SKB Oskarshamn area investigation sites distributed on GIS map soil classes and depth. Black bar shows the mean value.*



	M 55-65	M 10-20	M 0-10	H 40-60	H 0-30
■ S	0.2	1.1	1.4	14.1	18.7
□ S1				14.1	28.9
▫ S 2	0.2	1.1	1.4		8.4



	M 55-65	M 10-20	M 0-10
■ A	2.4	16.5	16.2
□ A 1	3.5	11.0	10.9
▫ A 2	1.2	21.9	21.4

Figure 4-34 (cont). *The carbon content in the SKB Oskarshamn area investigation sites distributed on GIS map soil classes and depth. Black bar shows the mean value.*

4.7.3 Nitrogen content in the soil

Nitrogen concentrations in the Oskarshamn area showed a similar pattern as for carbon meaning decreasing values with depth (Figure 4-43). This was, of course, dependent on the dominating organic nitrogen fraction being stored in the soil. Nitrogen is one element in the organic substances, thereby coinciding fairly well with the organic matter and carbon storage. The overall relation to other parts of Sweden was similarity, however, with low concentrations in the organic layer.

Deviations occurred between the soil types with the common conditions of high nitrogen content in organic soils, i.e. the Histosol. However, also Gleysol and Umbrisol furnished more nitrogen in the mineral soil while Podzol and Regosol were on low levels, c 0.1% with even lower values in the C-horizon with values as low as 0.02% (Figure 4-41).

Nitrogen in the organic layer

The nitrogen concentration in the organic layer was on average 1.7% being lower then the regional values but higher as compared to the total Sweden (Table 4-23). The distribution of the plots on concentration classes showed dominating values on many sites between 1% and 3% but fewer sites on very low values and almost none with higher then 4% (Figure 4-35 and 4-36 and Appendix Xa).

Table 4-23. Nitrogen content (%) in the organic layer in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Max	Std	Cv, %
Sweden	5449	1.1	13.3	0.6	54.5
Sweden-IV	2345	5.1	55.2	11.8	231.4
Kalmar County	283	5.6	51.3	12.7	226.8
Oskarshamn	27	5.8	46.5	13.4	231.0
SKB Oskarshamn	107	1.7	3.0	0.5	32.5

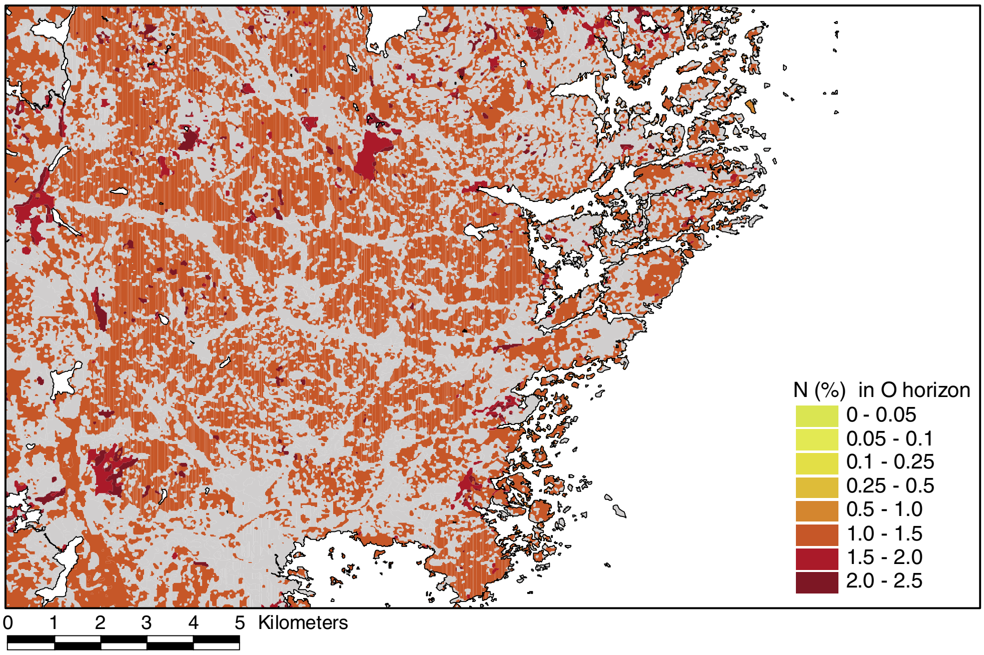


Figure 4-35. *Nitrogen content of the organic soil layer in the Oskarshamn area. Grey parts are not sampled or could be areas without humus layer.*

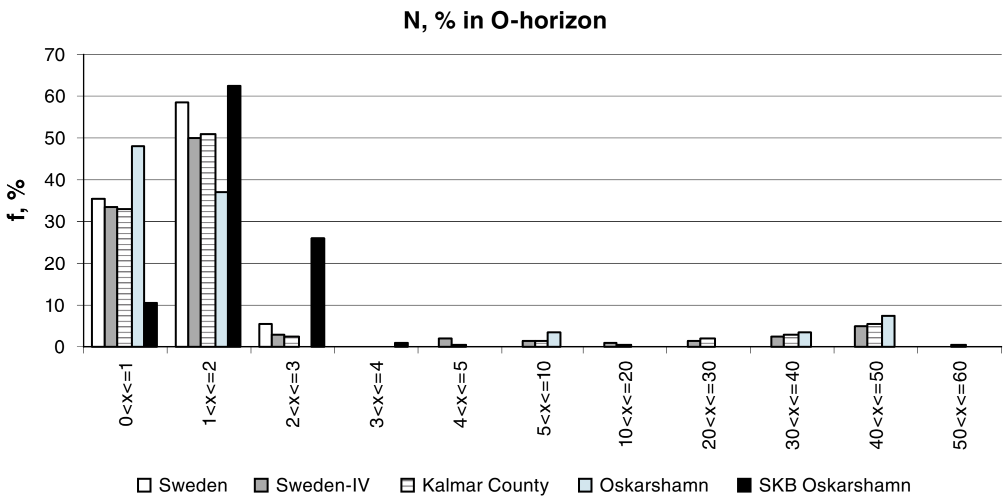


Figure 4-36. *Distribution (%) of nitrogen content of the organic soil layer over concentration classes in the SKB Oskarshamn area Laxemar compared to other parts of Sweden.*

Nitrogen in upper mineral soil, 0–10 cm

Nitrogen concentration in the upper mineral soil layer was on average 0.6% being higher than other parts of Sweden having 0.1–0.5% (Table 4-24). The distribution over the concentration range revealed high frequencies in the class 1–2% and fairly similar frequencies as other parts of Sweden in the lowest class 0–1% but no values over 2% (Figure 4-37 and 4-38 and Appendix Xb).

Table 4-24. Nitrogen content (%) in the upper mineral soil, 0–10 cm, in the Oskarshamn sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Max	Std	Cv, %
Sweden	1509	0.1	1.5	0.1	100.0
Sweden-IV	589	0.5	18.1	1.5	300.0
Kalmar County	74	0.3	2.8	0.7	233.3
Oskarshamn	3	0.2	0.4	0.2	100.0
SKB Oskarshamn	90	0.6	1.8	0.6	94.9

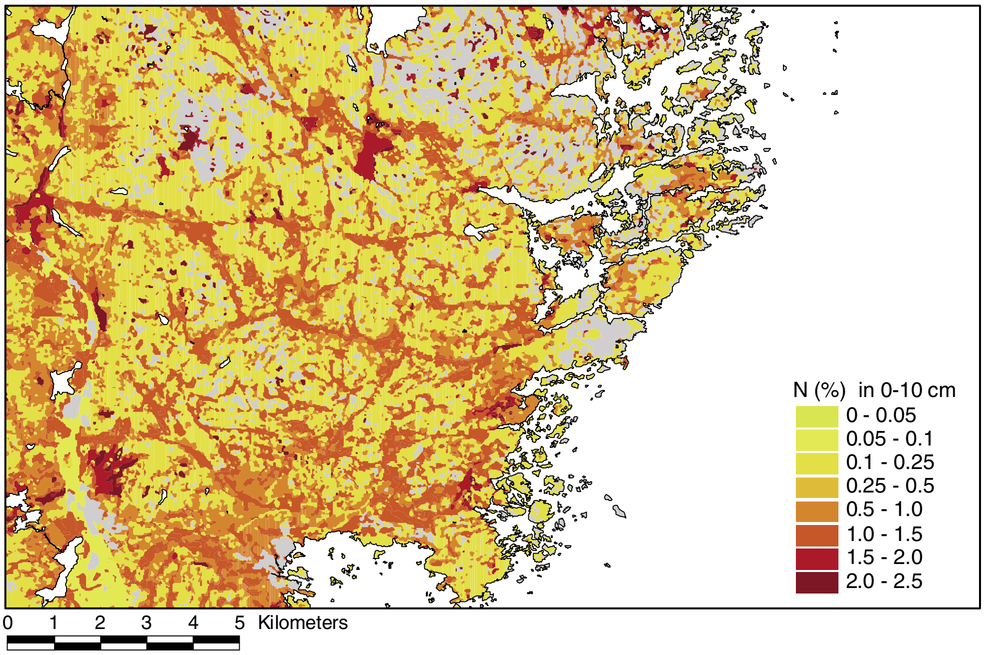


Figure 4-37. Nitrogen content of the upper mineral soil layer, 0–10 cm, in the Oskarshamn area. Grey areas are those without sampling or being peatlands.

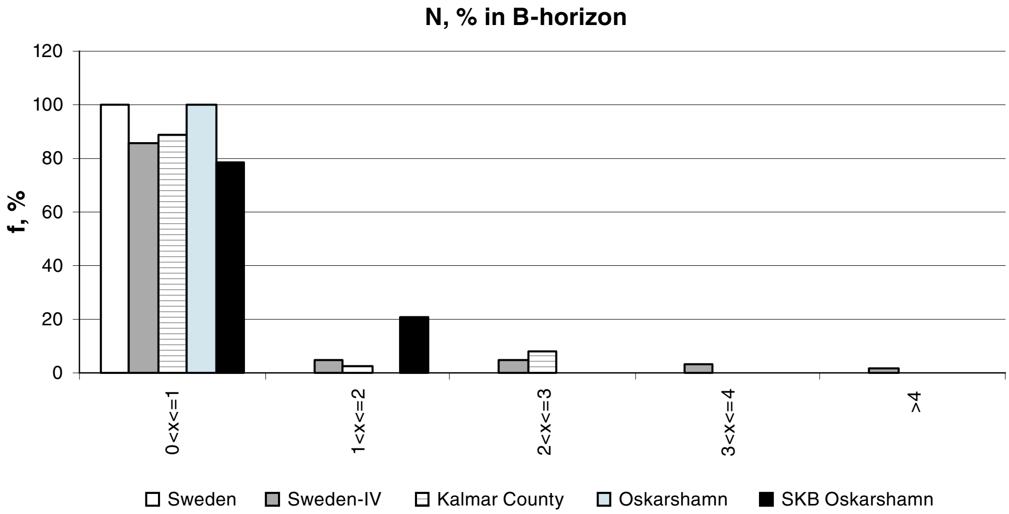


Figure 4-38. Distribution (%) of nitrogen content of the upper mineral soil layer, 0–10 cm, over concentration classes in the SKB Oskarshamn area Laxemar compared to other parts of Sweden.

Nitrogen in the mineral soil layer 10–20 cm

Nitrogen concentration in the 0.1–0.2 m layer was on average 0.5% being somewhat higher than other parts of Sweden but actually on the same level as for Sweden region IV (Table 4-25). The distribution over the range of nitrogen concentrations showed a very similar pattern as the mineral soil layer above with relatively high number of plots in the concentration range 1–2% but also fairly similar frequencies in the lowest range, 0–1% (Figure 4-39 and 4-40 and Appendix Xc).

Table 4-25. Nitrogen content (%) in the mineral soil layer 10–20 cm in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Min	Max	Std	Cv, %
Sweden	1509	0.1	0.0	1.5	0.1	100.0
Sweden-IV	589	0.5	0.0	18.1	1.5	300.0
Kalmar County	74	0.3	0.0	2.8	0.7	233.3
Oskarshamn	3	0.2	0.1	0.4	0.2	100.0
SKB Oskarshamn	86	0.5	0.0	1.7	0.6	108.7

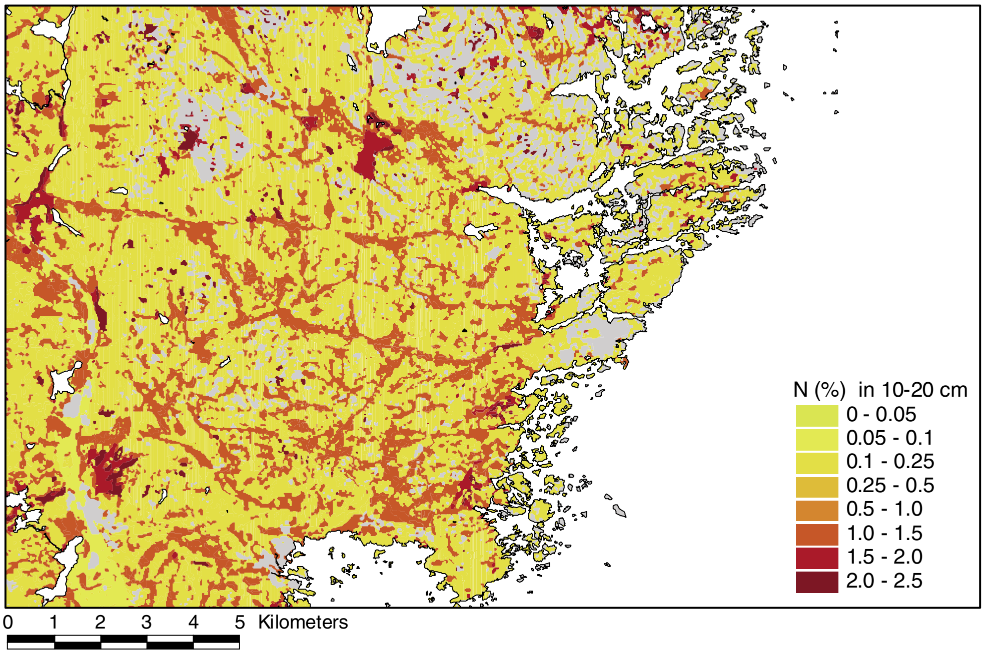


Figure 4-39. *Nitrogen content of the mineral soil layer 10–20 cm, in the Oskarshamn area. Grey areas are either not sampled areas or peatlands.*

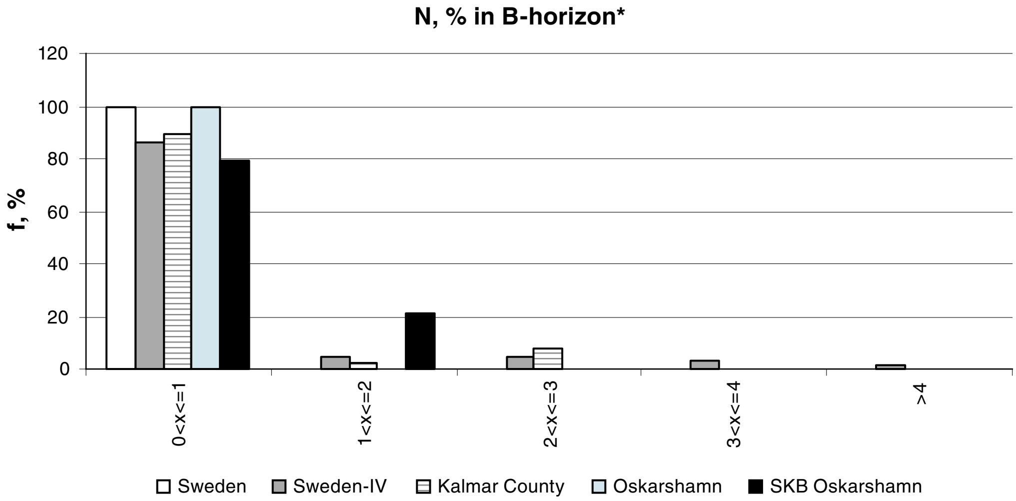


Figure 4-40. *Distribution (%) of nitrogen content of the mineral soil layer 10–20 cm, over concentration classes in the SKB Oskarshamn area Laxemar compared to other parts of Sweden.*

Nitrogen in the mineral soil layer C-horizon, 55–65 cm

The nitrogen concentration in the C-horizon was on average 0.1% being fairly similar to the region Sweden IV and Kalmar county but higher than for total Sweden (Table 4-26). The distribution over the concentration range revealed an almost 100% frequency in the lowest range 0.1%, actually being similar to the rest of Sweden (Figure 4-41 and 4-42 and Appendix Xd).

Table 4-26. Nitrogen content (%) in the mineral soil C-horizon, 55–65 cm, in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.

Survey area	Valid N	Average	Max	Std	Cv, %
Sweden	1213	0.04	2.0	0.11	275.0
Sweden-IV	451	0.12	2.2	0.26	216.7
Kalmar County	57	0.11	1.1	0.22	200.0
Oskarshamn	2	0.04	0.05	0.02	50.0
SKB Oskarshamn	44	0.12	1.8	0.28	225.2

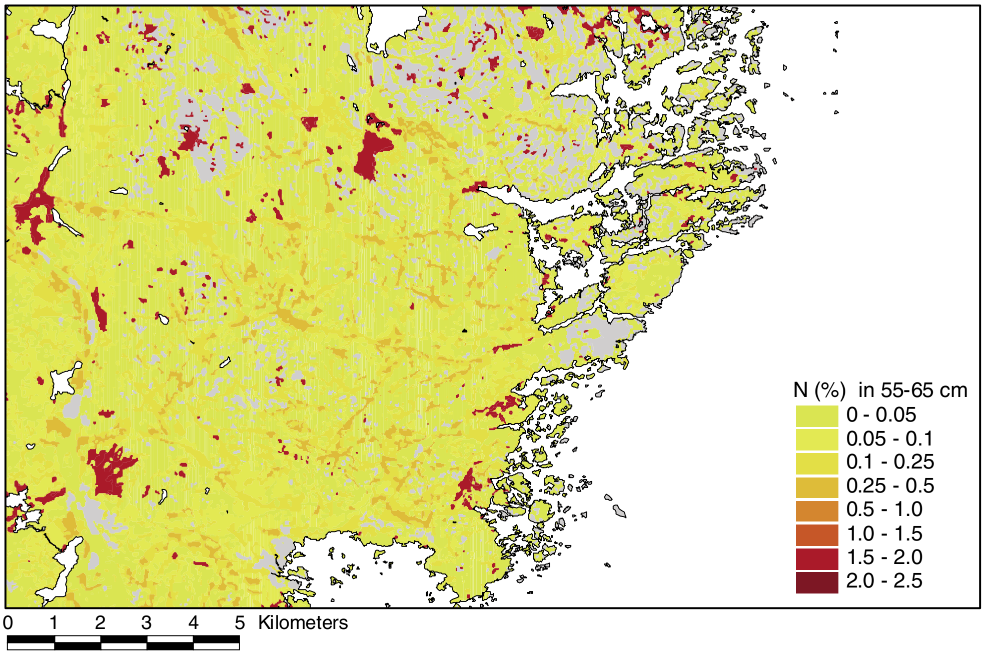


Figure 4-41. *Nitrogen content of the mineral soil layer 55–65 cm, in the Oskarshamn area. Grey areas are either not sampled areas or peatlands.*

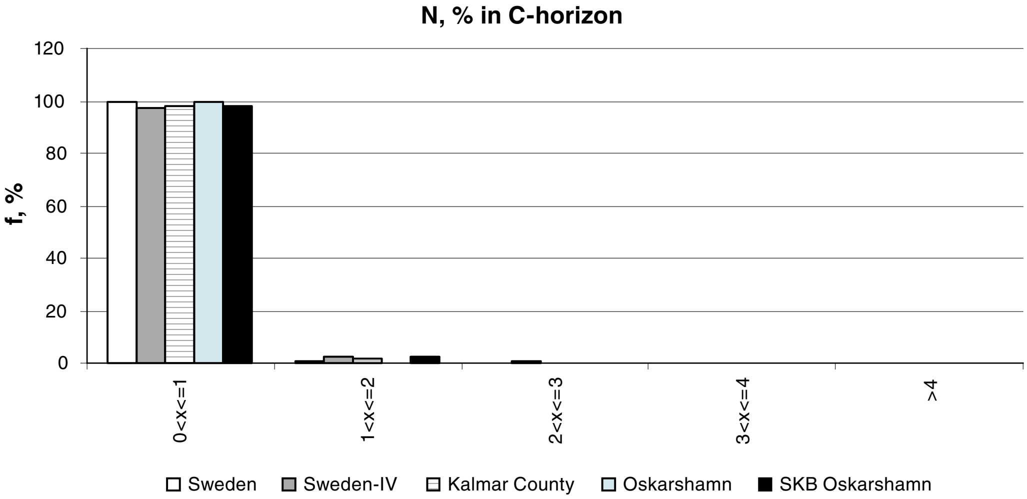
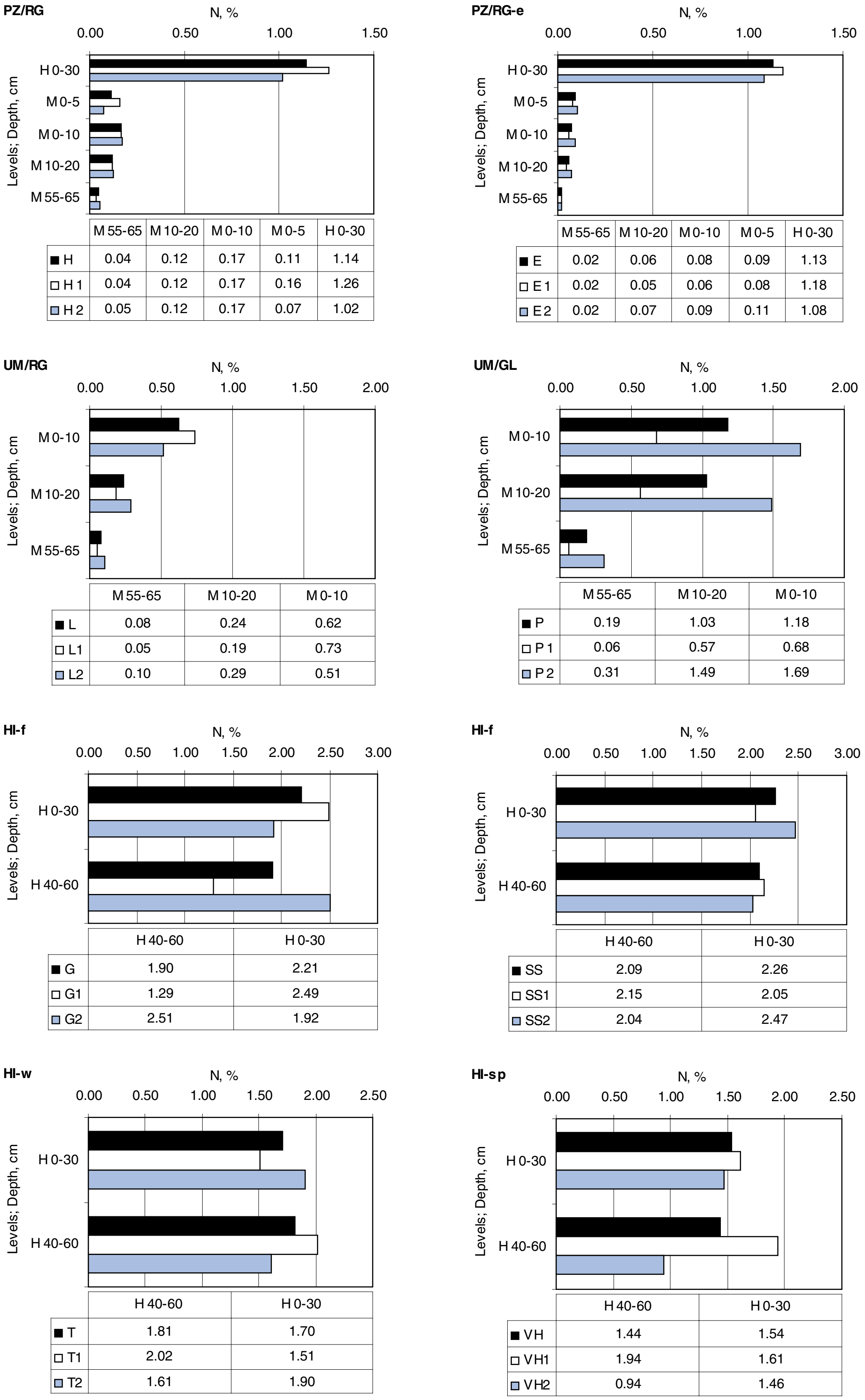


Figure 4-42. *Distribution (%) of nitrogen content (%) in the mineral soil C-horizon, 55–65 cm, over concentration classes in the Oskarshamn investigation sites related to GIS map soil classes and compared to other parts of Sweden.*

In comparing the GIS soil map soil type classes, the organic soils reveal comparably high nitrogen content as was also found in the organic soil layer of the Podzol/Regosol type. But, in deeper layers the content of organic matter coincided well with the higher nitrogen contents leaving the Podzol and Regosol types on low values (Figure 4-43). Site nitrogen concentrations are presented in Appendix XI.



PZ/RG

	M 55-65	M 10-20	M 0-10	M 0-5	H 0-30
■ H	0.04	0.12	0.17	0.11	1.14
□ H 1	0.04	0.12	0.17	0.16	1.26
□ H 2	0.05	0.12	0.17	0.07	1.02

PZ/RG-e

	M 55-65	M 10-20	M 0-10	M 0-5	H 0-30
■ E	0.02	0.06	0.08	0.09	1.13
□ E 1	0.02	0.05	0.06	0.08	1.18
□ E 2	0.02	0.07	0.09	0.11	1.08

UM/RG

	M 55-65	M 10-20	M 0-10
■ L	0.08	0.24	0.62
□ L1	0.05	0.19	0.73
□ L2	0.10	0.29	0.51

UM/GL

	M 55-65	M 10-20	M 0-10
■ P	0.19	1.03	1.18
□ P 1	0.06	0.57	0.68
□ P 2	0.31	1.49	1.69

HI-f

	H 40-60	H 0-30
■ G	1.90	2.21
□ G1	1.29	2.49
□ G2	2.51	1.92

HI-f

	H 40-60	H 0-30
■ SS	2.09	2.26
□ SS1	2.15	2.05
□ SS2	2.04	2.47

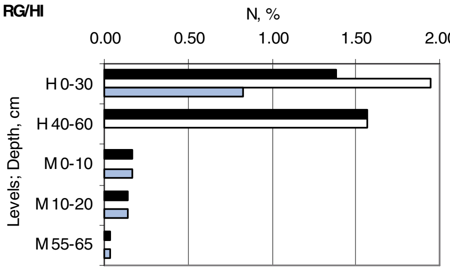
HI-w

	H 40-60	H 0-30
■ T	1.81	1.70
□ T1	2.02	1.51
□ T2	1.61	1.90

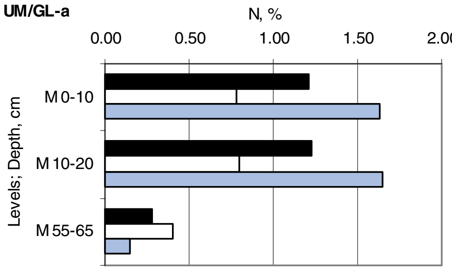
HI-sp

	H 40-60	H 0-30
■ VH	1.44	1.54
□ VH1	1.94	1.61
□ VH2	0.94	1.46

Figure 4-43. *The nitrogen content in the SKB Oskarshamn area investigation sites distributed on GIS map soil classes and depth. Black bar shows the mean value.*



	M 55-65	M 10-20	M 0-10	H 40-60	H 0-30
■ S	0.04	0.14	0.16	1.57	1.39
□ S1				1.57	1.95
▫ S 2	0.04	0.14	0.16		0.83



	M 55-65	M 10-20	M 0-10
■ A	0.28	1.22	1.21
□ A 1	0.41	0.80	0.78
▫ A 2	0.15	1.65	1.63

Figure 4-43 (cont). *The nitrogen content in the SKB Oskarshamn area investigation sites distributed on GIS map soil classes and depth. Black bar shows the mean value.*

4.8 Concluding characteristics of the site types

Properties related to the site types in the Oskarshamn area varied concerning soil types mainly between six classes, with Histosols being most common but showed fairly low coverage. Other frequently occurring soils are Gleysols, Podzols, Umbrisols and Regosols. Soils had developed partly on sorted sediments and peat but also on till with site hydrology variations on investigated plots being fresh to wet while the dry class mainly occurred on local small hills and where bedrock outcrops existed.

Bare bedrock and thin soils often meaning Leptosol, Podzol or Regosol dominated the coverage and highest spatial frequency was for Regosol with 33%. Podzol reached 16% and Leptosol 6%. The interpolation of thin soils over areas close to bedrock could have provided a somewhat low spatial frequency for the Leptosol type.

One other soil type with fairly high spatial frequency was Umbrisol with 23% of the areabut often mixed with Gleysol and Regosol in slopes or low-lying locations.

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Class code definitions for quaternary deposits

The class code definitions for the quaternary deposits. Presented in English and Swedish.

JORD2	QUATERNARY DEPOSIT	JORDART
6	Gyttja	Gyttja
7	Fluviatile sediment	Svämsediment, ler-grus (postglacialt)
14	Unclassified	Jord (oklassad)
16	Clayey gyttja	Lergyttja-gyttjelera
30	Littoral sediment, sand	Svallsediment, sand
33	Littoral sediment, gravel	Svallsediment, grus
34	Littoral sediment, stone-boulders	Svallsediment, sten-block (klapper)
40	Glacial clay	Glacial lera, ospecificerad
48	Glacial silt	Glacial silt
50	Glaciafluvial sediment	Isälvssediment, grovsilt-block
66	Boulders	Blockjord
75	Peat	Torv
90	Unknown	Okänt
91	Water	Vatten
95	Till, sandy	Morän, sandig
100	Till	Morän
200	Filling	Fyllning, oklassad
890	Bedrock	Urberg

Appendix II

Class code definitions for the vegetation data

The class code definitions for the vegetation data (tree, field and ground layer) and for quaternary deposits. Presented in English and Swedish.

TREE	TREE LAYER	TRÄDSKIKT
1	No tree-layer (< 30% crown coverage) within forest land	Trädskikt saknas (< 30% krontäckning) inom skogsmark
2	No tree-layer (< 30% crown coverage) outside forest land	Trädskikt saknas (< 30% krontäckning) utanför skogsmark
11	Old spruce	Gammal gran
12	Young spruce	Ung gran
13	Old pine	Gammal tall
14	Young pine	Ung tall
17	Unspecified young conifer	Ospecificerad ung barrskog
21	Birch	Björk
22	Young birch (thicket on clear-cut)	Ung björk (sly på hygge)
24	Birch or oak/maple mixed with spruce/pine	Björk eller ek/lönn blandat med gran/tall
25	Oak	Ek
27	Coastal birch/oak	Kustnära björk/ek
30	Mixed forest	Blandskog
100	Water	Vatten

FIELD	FIELD LAYER	FÄLTSKIKT
1	No field layer – forest land	Fältskikt saknas – skogsmark
2	No field layer – other land	Fältskikt saknas – övrig mark
4	Arable land (according to T5)	Åker
13	Mesic bilberry heath type	Frisk blåbärsristyp
14	Mosaic of dry heath type and mesic bilbery heath type	
15	Herb-heath type	Ört-ristyp
16	Herb type	Örttyp
20	Sedge-heath type	Starr-ristyp
21	Sedge type	Starrtyp
22	Sedge-herb type	Starr-örttyp
23	Sedge-reed type	Starr-vasstyp
25	Wet herb type	Våt örttyp
100	Water	Vatten

GROUND	GROUND LAYER	BOTTENSKIKT
12	Moss type (Forest land)	Mossmark (Skogsmark)
23	Sphagnum type (Wetland)	Vitmosstyp (Våtmark)
26	Other type (Wetland)	Annan typ (Våtmark)
31	Arable land (Other)	Odlad mark (övrigt)
32	Moss type (pastures and meadow) (Other)	Mossmark (betesmark och äng) (övrigt)
41	Built-up areas, pits etc (Other)	Bebyggelse, täkt etc (övrigt)
42	Coastal bare rocks (Other)	Kustklippor (övrigt)
100	Water (Other)	Vatten (övrigt)

Appendix III

Batch script to create soil map for the SKB Oskarshamn area Laxemar

```
/************************************************************************
/* Batch script to create soil map for the Laxemar area.
/* The input file are raster files for quarternary deposit (jord2), vegetation (tree, field
/* and ground), and TOPMODEL topographic index (twi_med).
/* The batch file will execute in Arc/Info GRID.
/************************************************************************


/***** 1. PZ/RG, Thin forested soils

tmp1 = con(jord2 in {890,95,7,30,33,34,66,200} and tree in {1,2,11,12,13,14,17} and field ne 14 and ground in {12,23,26,42},1)
tmp2 = con(jord2 eq 95 and tree in {11,12,13,14,17} and field eq 14 and ground in {12,23,26,42},1)

th_1 = merge(tmp1,tmp2)


/***** 2. UM/RG, Deciduous forest soils

df_1 = con(jord2 in {890,95,7,30,33,34,66,200} and tree in {21,22,24,25,27,30} and ground in {12,23,26,42},2)


/***** 3. S, Shoreline soils

tmp1 = expand(field,1,list,100)
sh_1 = con(tmp1 eq 100 and field <> 100 and dst_to_sea lt 20 and ground ne 42,3)


/***** 4. HI-f, Wetland forests

wf_1 = con(jord2 eq 75 and tree gt 2 and ground in {12,23,26,42},4)


/***** 5. HI-s, Wetland “hällkar”

/* Other criteria


/***** 6. HI-w, Wetland soils

we_1 = con(jord2 eq 75 and tree in {1,2} and ground in {12,23,26,42},6)


/***** 7. UM/GL-a, Arable soil

ar_1 = con(ground eq 31,7)
```

```
/***** 8. PZ/RG-e, Esker soils

es_1 = con(jord2 eq 50 and ground in {12,23,26,42},8)


/***** 9. UM/GL, Open partly forested moist soils

tmp1 = con(ground eq 32,9)
tmp2 = con(jord2 in {6,16,40} and ground in {12,23,26,42},9)

me_1 = merge(tmp1,tmp2)
me_2 = con(lowland eq 1 and jord2 in {890,95,7} and field ne 14 and ground in
{12,23,26,42},9)


/***** 11. LP, Bare rocks

tmp1 = con(jord2 in {890,66,34} and field eq 14 and ground in {12,23,26,42},10)
tmp2 = con(ground eq 42,10)

br_1 = merge(tmp1,tmp2)


/***** 12. U, Unclassified

un_1 = con(ground eq 41,11)


/***** Merge layers

tmp1 = merge(WH_1,ME_2,SH_1,AR_1,BR_1,DF_1,ES_1,ME_1,TH_1,UN_1,WE_
1,WF_1)

soil_oskar_a3 = con(jord_mall eq 1,tmp1)
```

Appendix IV

Ground vegetation species

Map ID	ID	Ground-layer vegetation	Field-layer vegetation
LP	–	–	–
PZ/RG	H1	Mesic-mosses type: incl. *Hylocomium splendens, Hypnum cupressiforme, Pleurozium schreberi, Sphanum spp*	Bilberry type: incl. *Deschampsia flexuosa, Melampyrum spp, Pteridium aquilinum, Vaccinium myrtillus, Vaccinium vitis-idaea*
	H2	Mesic-mosses type: incl. *Pleurozium schreberi, Polytrichum commune*	Bilberry type: incl. *Deschampsia caespitosa, Festuca ovina, Oxalis acetosella, Pteridium aquilinum, Vaccinium myrtillus*
PZ/RG-e	E1	Mesic-mosses type: incl. Cladonia spp, *Dicranum scoparium, Hylocomium splendens, Pleurozium schreberi*	Bilberry type: incl. Calluna vulgaris, *Vaccinium myrtillus, Vaccinium vitis-idaea*
	E2	Mesic-mosses type: incl. *Dicranum scoparium, Hylocomium splendens, Pleurozium schreberi*	Bilberry type: incl. *Calluna vulgaris, Deschampsia flexuosa, Vaccinium myrtillus, Vaccinium vitis-idaea*
UM/RG	L1	Mesic-mosses type: incl. *Dicranum scoparium, Hylocomium splendens, Hypnum cupressiforme, Pleurozium schreberi, Rhytidiadelphus triquetrus*	Broad leafed grass type: incl. *Anemone nemorosa, Deschampsia flexuosa, Filipendula vulgaris, Melampyrum spp, Melampyrum nemorosum, Melica nutans, Poa nemoralis, Polygonatum odoratum, Rubus saxatilis, Stellaria graminea,Vaccinium myrtillus*
	L2	Mesic-mosses type: incl. *Rhytidiadelphus triquetrus*	Low herbs without shrubs type: incl. *Acer platanoides,Dryopteris filix-mas, Fragaria vesca, Galium odoratum, Hepatica nobilis, Poa nemoralis*
UM/GL	P1	Mesic-mosses type: incl. *Rhytidiadelphus triquetrus*	Broad leafed grass type: incl. *Achillea millefolium spp, Agrostis capillaris, Alchemilla spp, Campanula persicifolia, Deschampsia caespitosa, Filipendula vulgaris, Fragaria vesca, Ranunculus acris, Rubiaceae spp, Primula veris, Stellaria graminea*
	P2	No	Broad leafed grass type: incl. *Achillea millefolium spp, Deschampsia caespitosa, Deschampsia flexuosa, Galium boreale, Hypericum spp, Juncus effeusus, Ranunculus acris, Poa nemoralis, Stellaria graminea*

Map ID	ID	Ground-layer vegetation	Field-layer vegetation
HI-f	G1	Mesic-mosses type: incl. *Hypnum cupressiforme, Pleurozium schreberi, Polytrichum commune, Sphanum spp*	Bilberry type: incl. *Deschampsia flexuosa, Juncus effeusus, Melica nutans, Polypodiaceae, Vaccinium myrtillus*
	G2	No	Low herbs without shrubs type: incl. O*xalis Acetosella*
	SS1	No	Broad leafed grass type: incl. *Filipendula ulmaria, Lysimachia vulgaris, Molinia caerulea, Phragmites australis, Poa nemoralis, Viola palustris*
	SS2	Wet mosses (not *Sphagnum*): incl. *Polytrichum commune*	Broad leafed grass type: incl. *Carex spp, Juncus effeusus, Potentilla palustris*
HI-w	T1	*Sphagnum* type: incl. *Sphanum spp*	Broad leafed grass type: incl. *Phragmites australis*
	T1	*Sphagnum* type: incl. *Sphanum spp*	Low sedge type: incl. *Carex rostrata, Comarum palustre, Equisetum spp, Eriophorum angustifolium, Myrica gale*
HI-sp	VH1	*Sphagnum* type: incl. *Sphanum spp*	Poor shrubs type: incl. *Oxycoccus, Rhododendron tomentosum, Vaccinium myrtillus, Vaccinium vitis-idaea,*
	VH2	*Sphagnum* type: incl. *Dicranum scoparium, Pleurozium schreberi*	Poor shrubs type: incl. *Vaccinium myrtillus, Vaccinium uliginosum, Vaccinium vitis-idaea*
RG/HI	S1	No	Broad leafed grass type: incl. *Eleocharis mamillata, Galium palustre, Lysimachia vulgaris, Mentha spp, Mentha aquatica, Phragmites australis*
	S2	No	Broad leafed grass type: incl. *Arctium minus, Artemisia vulgaris, Calystegia sepium, Chenopodium album, Leymus arenarius*
UM/GL-a	A1	No	Broad leafed grass type: incl. *Avena satina*
	A2	No	Broad leafed grass type: incl. cultural crops

Frequences (%) of pH (H_2O) in O, B and C-horizons

– in the Oskarshamn area and for forest soils in four regions of Sweden.

Appendix Va. O-horizon pH (H_2O).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
3.0<×<=3.5	5.4	7.3	4.6	6.7	
3.5<×<=4.0	45.4	40.9	35.3	13.3	8.4
4.0<×<=4.5	23.7	22.0	26.9	26.6	29.9
4.5<×<=5.0	12.6	13.9	12.7	16.7	26.2
5.0<×<=5.5	7.5	9.8	12.4	30.0	15.0
5.5<×<=6.0	3.1	4.2	2.5	6.7	15.0
6.0<×<=6.5	1.3	1.4	3.4		2.8
6.5<×<=7.0	0.8	0.3	2.2		2.8
7.0<×<=7.5	0.2	0.1			
7.5<×<=8.0	0.0				

Appendix Vb. Upper soil, 0–10 cm, pH (H_2O).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
3.5<×<=4.0	0.8	1.4	2.3		0.0
4.0<×<=4.5	16.1	21.4	20.4	50.0	11.1
4.5<×<=5.0	50.4	46.4	44.3	25.0	28.9
5.0<×<=5.5	23.2	19.1	23.9	25.0	35.6
5.5<×<=6.0	5.7	7.9	5.7		17.8
6.0<×<=6.5	2.1	2.3	2.3		5.6
6.5<×<=7.0	0.8	0.9	0.0		1.1
7.0<×<=7.5	0.4	0.3	0.0		
7.5<×<=8.0	0.1	0.1	1.1		
8.0<×<=8.5	0.3	0.1			
8.5<×<=9.0	0.1				

Appendix Vc. Mineral soil, 10–20 cm, pH (H_2O).

Classified intervals	Survey area				
	Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
3.5<×<=4.0	0.8	1.4	2.3		
4.0<×<=4.5	16.1	21.4	20.4	50.0	1.2
4.5<×<=5.0	50.4	46.4	44.3	25.0	27.9
5.0<×<=5.5	23.2	19.1	23.9	25.0	41.9
5.5<×<=6.0	5.7	7.9	5.7		24.4
6.0<×<=6.5	2.1	2.3	2.3		3.5
6.5<×<=7.0	0.8	0.9	0.0		1.2
7.0<×<=7.5	0.4	0.3	0.0		
7.5<×<=8.0	0.1	0.1	1.1		
8.0<×<=8.5	0.3	0.1			
8.5<×<=9.0	0.1				

Appendix Vd. Mineral soil C-horizon, 55–65 cm, soil pH (H_2O).

Classified intervals	Survey area				
	Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
3.0<×<=3.5	0.1				
3.5<×<=4.0	0.0				4.5
4.0<×<=4.5	0.7				6.8
4.5<×<=5.0	29.2	38.4	42.0	30.0	20.5
5.0<×<=5.5	43.3	32.7	34.8	70.0	47.7
5.5<×<=6.0	17.3	16.4	13.0		11.4
6.0<×<=6.5	5.4	8.5	7.2		9.1
6.5<×<=7.0	2.2	2.2	1.5		
7.0<×<=7.5	0.9	0.6	0.0		
7.5<×<=8.0	0.3	0.6	1.5		
8.0<×<=8.5	0.2	0.6			
8.5<×<=9.0	0.3	0.2			
9.0<×<=9.5	0.1				

Appendix VI

pH H_2O of the investigation sites

Site	Horizon depth, cm	Used pH treatment	N	Average	Max	Min	Std	Cv, %
1	2	3	4	5	6	7	8	9
H 1	H 0–30	pH H_2O	8	3.9	4.2	3.5	0.2	5.2
	M 0–5	pH H_2O	3	4.7	5.0	4.5	0.2	4.9
	M 0–10	pH H_2O	8	4.5	4.9	4.1	0.3	6.4
	M 10–20	pH H_2O	4	5.0	5.2	4.7	0.2	4.7
	M 55–65	pH H_2O	3	5.1	5.3	5.0	0.2	2.9
H 2	H 0–30	pH H_2O	8	4.4	4.9	4.0	0.3	7.7
	M 0–5	pH H_2O	2	4.7	4.8	4.6	0.1	3.0
	M 0–10	pH H_2O	8	4.8	5.1	4.4	0.2	4.6
	M 10–20	pH H_2O	8	5.0	5.3	4.9	0.1	2.6
	M 55–65	pH H_2O	4	5.4	6.3	4.8	0.6	11.9
E 1	H 0–30	pH H_2O	8	3.9	4.2	3.5	0.2	4.5
	M 0–5	pH H_2O	8	5.0	5.5	4.7	0.2	4.8
	M 0–10	pH H_2O	8	4.6	4.9	4.5	0.1	2.7
	M 10–20	pH H_2O	8	5.1	5.2	4.9	0.1	1.7
	M 55–65	pH H_2O	4	5.1	5.3	4.8	0.2	4.5
E 2	H 0–30	pH H_2O	8	4.0	4.3	3.7	0.2	4.7
	M 0–5	pH H_2O	8	4.8	5.0	4.6	0.1	3.1
	M 0–10	pH H_2O	8	4.6	4.7	4.4	0.1	2.6
	M 10–20	pH H_2O	8	5.1	5.3	4.9	0.1	2.8
	M 55–65	pH H_2O	4	5.3	5.4	5.2	0.1	1.6
L1	M 0–10	pH H_2O	8	5.3	5.5	5.0	0.2	3.4
	M 10–20	pH H_2O	8	4.9	5.4	4.2	0.3	7.0
	M 55–65	pH H_2O	4	5.2	5.4	5.1	0.2	4.0
L2	M 0–10	pH H_2O	8	5.2	5.4	4.8	0.2	4.1
	M 10–20	pH H_2O	8	5.2	5.5	4.9	0.2	3.0
	M 55–65	pH H_2O	4	5.2	5.4	5.1	0.1	2.2
P 1	M 0–10	pH H_2O	8	5.8	6.1	5.3	0.2	3.9
	M 10–20	pH H_2O	8	5.8	6.0	5.6	0.1	2.0
	M 55–65	pH H_2O	4	5.5	6.0	4.9	0.5	9.6
P 2	M 0–10	pH H_2O	8	5.4	5.6	5.4	0.1	1.2
	M 10–20	pH H_2O	8	5.3	5.5	5.0	0.1	2.7
	M 55–65	pH H_2O	4	5.0	5.3	4.7	0.3	5.2

Site	Horizon depth, cm	Used pH treatment	N	Average	Max	Min	Std	Cv, %
1	2	3	4	5	6	7	8	9
G1	H 0–30	pH H_2O	8	3.9	4.0	3.8	0.1	1.5
	H 40–60	pH H_2O	4	4.7	4.9	4.5	0.2	3.3
G2	H 0–30	pH H_2O	8	4.1	4.2	4.1	0.1	1.6
	H 40–60	pH H_2O	4	4.3	4.5	4.2	0.2	3.9
SS1	H 0–30	pH H_2O	8	5.3	5.8	4.6	0.5	8.6
	H 40–60	pH H_2O	4	4.6	5.0	3.7	0.6	13.0
SS2	H 0–30	pH H_2O	8	4.3	4.5	4.2	0.1	3.3
	H 40–60	pH H_2O	4	4.2	4.6	3.8	0.3	8.4
T1	H 0–30	pH H_2O	8	4.7	4.9	4.6	0.1	2.0
	H 40–60	pH H_2O	4	4.9	5.4	4.6	0.3	6.6
T2	H 0–30	pH H_2O	8	5.0	5.3	4.6	0.2	4.3
	H 40–60	pH H_2O	4	5.0	5.2	4.7	0.3	5.7
VH1	H 0–30	pH H_2O	8	3.5	3.7	3.3	0.2	5.1
	H 40–60	pH H_2O	5	4.0	4.3	3.8	0.2	5.5
VH2	H 0–30	pH H_2O	8	3.5	3.8	3.3	0.1	4.2
	H 40–60	pH H_2O	4	3.6	3.8	3.3	0.2	5.3
S1	H 0–30	pH H_2O	8	5.2	5.4	5.0	0.1	1.7
	H 40–60	pH H_2O	4	5.5	5.7	5.4	0.1	2.4
S 2	H 0–30	pH H_2O	3	6.2	6.4	6.1	0.2	2.9
	M 0–10	pH H_2O	8	5.9	6.7	5.4	0.5	7.9
	M 10–20	pH H_2O	8	6.0	6.5	5.7	0.3	5.3
	M 55–65	pH H_2O	4	5.1	6.0	3.9	1.1	22.1
A 1	M 0–10	pH H_2O	10	5.7	6.0	4.9	0.3	5.4
	M 10–20	pH H_2O	10	5.7	5.8	5.3	0.1	2.5
	M 55–65	pH H_2O	5	5.6	6.0	4.8	0.4	7.7
A 2	M 0–10	pH H_2O	8	5.1	5.3	4.8	0.2	3.3
	M 10–20	pH H_2O	8	4.9	5.1	4.6	0.2	4.1

pH $CaCl_2$ of the investigation sites

Site	Horizon depth, cm	Used pH treatment	N	Average	Max	Min	Std	Cv, %
1	2	3	4	5	6	7	8	9
H 1	H 0–30	pH $CaCl_2$	8	3.2	3.4	3.0	0.2	5.2
	M 0–5	pH $CaCl_2$	3	4.1	4.3	4.0	0.2	4.0
	M 0–10	pH $CaCl_2$	8	3.7	4.2	3.4	0.3	7.9
	M 10–20	pH $CaCl_2$	4	4.3	4.4	4.0	0.2	3.6
	M 55–65	pH $CaCl_2$	3	4.5	4.7	4.2	0.3	5.7
H 2	H 0–30	pH $CaCl_2$	8	3.7	4.2	3.3	0.3	8.8
	M 0–5	pH $CaCl_2$	2	4.0	4.1	4.0	0.1	3.0
	M 0–10	pH $CaCl_2$	8	4.0	4.3	3.7	0.2	4.4
	M 10–20	pH $CaCl_2$	8	4.3	4.5	4.1	0.1	2.8
	M 55–65	pH $CaCl_2$	4	4.7	5.5	4.3	0.5	11.2
E 1	H 0–30	pH $CaCl_2$	8	3.2	3.3	3.0	0.1	3.6
	M 0–5	pH $CaCl_2$	8	4.4	5.2	4.0	0.4	8.5
	M 0–10	pH $CaCl_2$	8	3.9	4.3	3.6	0.2	5.7
	M 10–20	pH $CaCl_2$	8	4.6	4.8	4.2	0.2	4.4
	M 55–65	pH $CaCl_2$	4	4.4	5.0	4.1	0.4	8.6
E 2	H 0–30	pH $CaCl_2$	8	3.2	3.4	3.1	0.1	3.7
	M 0–5	pH $CaCl_2$	8	4.1	4.3	4.0	0.1	2.3
	M 0–10	pH $CaCl_2$	8	3.8	3.9	3.7	0.1	2.4
	M 10–20	pH $CaCl_2$	8	4.4	4.6	4.3	0.1	2.0
	M 55–65	pH $CaCl_2$	4	4.7	4.9	4.6	0.1	2.6
L1	M 0–10	pH $CaCl_2$	8	4.4	4.6	4.1	0.2	4.9
	M 10–20	pH $CaCl_2$	8	3.9	4.3	3.3	0.3	7.6
	M 55–65	pH $CaCl_2$	4	4.4	4.7	4.2	0.3	6.1
L2	M 0–10	pH $CaCl_2$	8	4.3	4.6	3.9	0.2	5.7
	M 10–20	pH $CaCl_2$	8	4.2	4.5	4.0	0.2	4.2
	M 55–65	pH $CaCl_2$	4	4.3	4.4	4.2	0.1	1.7
P 1	M 0–10	pH $CaCl_2$	8	5.0	5.2	4.7	0.1	2.9
	M 10–20	pH $CaCl_2$	8	5.0	5.1	4.8	0.1	1.9
	M 55–65	pH $CaCl_2$	4	4.9	5.4	4.4	0.5	9.3
P 2	M 0–10	pH $CaCl_2$	8	4.6	4.8	4.5	0.1	1.7
	M 10–20	pH $CaCl_2$	8	4.6	4.7	4.4	0.1	2.3
	M 55–65	pH $CaCl_2$	4	4.3	4.7	4.0	0.3	7.7

Site	Horizon depth, cm	Used pH treatment	N	Average	Max	Min	Std	Cv, %
1	2	3	4	5	6	7	8	9
G1	H 0–30	pH $CaCl_2$	8	3.1	3.2	3.0	0.1	2.4
	H 40–60	pH $CaCl_2$	4	3.9	4.1	3.8	0.1	3.3
G2	H 0–30	pH $CaCl_2$	8	3.6	3.6	3.5	0.0	1.2
	H 40–60	pH $CaCl_2$	4	3.6	3.8	3.5	0.1	4.0
SS1	H 0–30	pH $CaCl_2$	8	4.7	5.0	4.1	0.3	6.2
	H 40–60	pH $CaCl_2$	4	4.2	4.6	3.6	0.4	10.1
SS2	H 0–30	pH $CaCl_2$	8	3.7	4.1	3.5	0.2	5.0
	H 40–60	pH $CaCl_2$	4	3.9	4.1	3.7	0.2	4.1
T1	H 0–30	pH $CaCl_2$	8	4.2	4.3	4.1	0.1	1.7
	H 40–60	pH $CaCl_2$	4	4.7	5.1	4.3	0.3	6.8
T2	H 0–30	pH $CaCl_2$	8	4.3	4.6	3.8	0.3	6.7
	H 40–60	pH $CaCl_2$	4	4.6	4.9	4.3	0.3	6.7
VH1	H 0–30	pH $CaCl_2$	8	2.9	3.1	2.7	0.1	4.9
	H 40–60	pH $CaCl_2$	5	3.2	3.4	3.0	0.2	5.5
VH2	H 0–30	pH $CaCl_2$	8	2.7	2.8	2.7	0.1	2.3
	H 40–60	pH $CaCl_2$	4	2.7	2.7	2.6	0.0	1.2
S1	H 0–30	pH $CaCl_2$	8	4.8	4.9	4.7	0.1	1.7
	H 40–60	pH $CaCl_2$	4	5.2	5.3	5.1	0.1	1.5
S 2	H 0–30	pH $CaCl_2$	3	5.4	5.7	5.2	0.3	4.7
	M 0–10	pH $CaCl_2$	8	5.3	5.7	5.0	0.4	6.7
	M 10–20	pH $CaCl_2$	8	5.4	5.9	5.0	0.3	6.1
	M 55–65	pH $CaCl_2$	4	4.5	5.3	3.7	0.8	17.8
A 1	M 0–10	pH $CaCl_2$	10	5.0	5.2	4.4	0.2	4.6
	M 10–20	pH $CaCl_2$	10	5.1	5.2	4.8	0.1	2.1
	M 55–65	pH $CaCl_2$	5	4.7	5.1	4.3	0.4	7.4
A 2	M 0–10	pH $CaCl_2$	8	4.4	4.5	4.2	0.1	3.0
	M 10–20	pH $CaCl_2$	8	4.3	4.6	4.1	0.2	4.4

Appendix VIII

Frequencies of carbon concentrations in O-horizon, upper mineral soil and C-horizon

– for the Oskarshamn area and for forest soils in four regions of Sweden.

Appendix VIIIa. O-horizon carbon concentration frequencies (%).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
00<×<=10	13.8	32.2	32.9	40.8	1.9
10<×<=20	7.9	8.3	10.6	18.5	2.8
20<×<=30	9.7	8.4	9.5	3.7	20.6
30<×<=40	21.2	16.9	16.9	7.4	26.2
40<×<=50	42.4	30.4	27.6	29.6	21.5
50<×<=60	5.0	3.9	2.5	0	27.1

Appendix VIIIb. Upper mineral soil layer, 0–10 cm, carbon concentration frequencies (%).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
0<×<=2	54.3	59.5	54.1		24.5
2<×<=4	31.7	28.1	33.8	70.0	13.3
4<×<=6	9.1	8.5	5.4		7.8
6<×<=8	3.6	2.7	2.7		11.1
8<×<=10	0.7	0.2	0.0		10.0
10<×<=12	0.4	0.9	4.0	30.0	4.4
12<×<=14					5.6
14<×<=16					2.2
16<×<=18	0.1	0.2			2.2
18<×<=24	0.1				10.0
24<×<=34					0.0
34<×<=40					3.3
40<×<=46					5.5

Appendix VIIIc. Mineral soil layer 10–20 cm carbon concentration frequencies (%).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
0<×<=2	54.3	59.5	54.1		39.4
2<×<=4	31.7	28.1	33.8	70.0	15.1
4<×<=6	9.1	8.5	5.4		3.5
6<×<=8	3.6	2.7	2.7		9.3
8<×<=10	0.7	0.2	0.0		5.8
10<×<=12	0.4	0.9	4.0	30.0	3.5
12<×<=14					2.3
14<×<=16					1.2
16<×<=18	0.1	0.2			1.2
18<×<=24	0.1				9.3
24<×<=34					1.2
34<×<=40					3.5
40<×<=46					4.8

Appendix VIIId. Mineral soil C-horizon, 55–65 cm, carbon concentration frequencies (%).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
0<×<=2	95.5	97.3	89.4	100.0	86.4
2<×<=4	2.6	1.1	3.5		9.1
4<×<=6	1.1	1.1	5.3		0.0
6<×<=8	0.4	0.4	1.8		2.3
8<×<=10	0.2				0.0
10<×<=12					0.0
12<×<=14					0.0
14<×<=16					2.3
16<×<=18	0.2				
>18	0.0				

Appendix IX

Carbon concentrations, %, of the investigation sites

Site	Horizon depth, cm	N	Average	Max	Min	Std	Cv, %
1	2	3	4	5	6	7	8
H 1	H 0–30	8	42.6	51.7	32.8	8.0	18.8
	M 0–5	3	3.7	5.1	2.1	1.5	40.6
	M 0–10	8	4.1	7.3	2.4	1.6	40.5
	M 10–20	4	2.6	3.9	1.6	1.0	39.8
	M 55–65	3	0.5	1.0	0.1	0.4	80.4
H 2	H 0–30	8	27.7	42.0	19.5	7.2	25.9
	M 0–5	2	1.2	1.8	0.7	0.7	58.8
	M 0–10	8	2.7	6.3	0.6	1.9	71.4
	M 10–20	8	1.9	5.2	0.5	1.5	79.9
	M 55–65	4	0.5	1.1	0.2	0.4	78.4
E 1	H 0–30	8	36.9	42.9	27.7	4.8	12.9
	M 0–5	8	2.0	2.8	1.2	0.5	26.5
	M 0–10	8	1.5	1.8	1.0	0.3	19.5
	M 10–20	8	0.9	1.8	0.3	0.5	57.3
	M 55–65	4	0.2	0.5	0.1	0.2	90.3
E 2	H 0–30	8	31.3	44.3	14.2	8.5	27.0
	M 0–5	8	2.5	3.8	1.7	0.6	25.3
	M 0–10	8	2.0	2.5	0.9	0.6	30.9
	M 10–20	8	1.5	2.3	0.9	0.4	25.5
	M 55–65	4	0.2	0.4	0.1	0.1	56.9
L1	M 0–10	8	11.8	23.4	5.0	5.9	50.2
	M 10–20	8	2.9	11.0	0.8	3.4	116.6
	M 55–65	4	0.5	1.3	0.2	0.5	97.5
L2	M 0–10	8	7.9	13.5	5.1	3.0	38.4
	M 10–20	8	4.2	7.5	2.0	1.9	44.1
	M 55–65	4	1.4	2.3	0.8	0.7	46.7
P 1	M 0–10	8	9.7	12.4	6.5	1.9	19.5
	M 10–20	8	7.5	10.4	3.4	2.2	28.9
	M 55–65	4	0.5	0.7	0.1	0.3	51.4
P 2	M 0–10	8	40.0	45.0	34.8	4.0	9.9
	M 10–20	8	41.5	48.4	33.1	5.3	12.7
	M 55–65	4	3.8	7.5	0.2	3.0	78.6

Site	Horizon depth, cm	N	Average	Max	Min	Std	Cv, %
1	2	3	4	5	6	7	8
G1	H 0–30	8	50.4	52.2	49.0	1.1	2.2
	H 40–60	4	18.5	20.0	16.9	1.3	7.2
G2	H 0–30	8	33.1	36.1	29.9	2.1	6.3
	H 40–60	4	46.3	50.6	42.2	4.0	8.6
SS1	H 0–30	8	24.5	28.5	21.5	2.0	8.2
	H 40–60	4	17.8	18.5	16.5	1.0	5.4
SS2	H 0–30	8	40.1	48.4	26.5	7.6	19.0
	H 40–60	4	26.0	36.4	17.2	8.0	30.9
T1	H 0–30	8	49.4	51.3	47.7	1.3	2.6
	H 40–60	4	31.2	44.5	25.2	8.9	28.7
T2	H 0–30	8	49.6	52.9	47.6	2.0	4.1
	H 40–60	4	27.5	33.5	24.0	5.3	19.2
VH1	H 0–30	8	53.0	54.4	50.5	1.4	2.6
	H 40–60	5	57.8	60.6	55.9	1.8	3.1
VH2	H 0–30	8	54.0	55.5	53.1	0.9	1.6
	H 40–60	4	61.2	62.6	59.5	1.3	2.1
S1	H 0–30	8	28.9	34.9	20.6	4.8	16.5
	H 40–60	4	14.1	15.8	12.7	1.4	10.1
S 2	H 0–30	3	8.4	14.1	3.4	5.4	64.0
	M 0–10	8	1.4	8.5	0.1	3.0	211.6
	M 10–20	8	1.1	6.8	0.1	2.4	204.7
	M 55–65	4	0.2	0.2	0.1	0.0	23.9
A 1	M 0–10	10	10.9	16.8	7.6	3.6	33.3
	M 10–20	10	11.0	16.5	7.3	3.2	28.8
	M 55–65	5	3.5	15.3	0.1	6.6	186.3
A 2	M 0–10	8	21.4	22.0	19.9	0.8	3.8
	M 10–20	8	21.9	22.8	20.9	0.6	2.8
	M 55–65	4	1.2	3.8	0.1	1.7	142.6
G1	H 0–30	8	50.4	52.2	49.0	1.1	2.2
	H 40–60	4	18.5	20.0	16.9	1.3	7.2
G2	H 0–30	8	33.1	36.1	29.9	2.1	6.3
	H 40–60	4	46.3	50.6	42.2	4.0	8.6

Appendix X

Frequencies of nitrogen concentrations in O-horizon, upper mineral soil and C-horizon

– for the Oskarshamn area and for forest soils in four regions of Sweden.

Appendix Xa. O-horizon nitrogen concentration frequencies (%).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
0<×<=1	35.7	33.3	33.1	48.2	10.3
1<×<=2	58.6	50.1	50.8	37.0	62.6
2<×<=3	5.6	3.0	2.5	0.0	26.2
3<×<=4	0.1	0.1	0.0	0.0	0.9
4<×<=5		1.9	0.4	0.0	
5<×<=10		1.5	1.4	3.7	
10<×<=20		1.2	0.4	0.0	
20<×<=30		1.6	1.8	0.0	
30<×<=40		2.4	3.2	3.7	
40<×<=50		4.8	5.7	7.4	
50<×<=60		0.1	0.7		

Appendix Xb. Upper mineral soil layer, 0–10 cm, nitrogen concentration frequencies (%).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
0<×<=1	99.7	85.9	89.1	100.0	78.8
1<×<=2	0.3	4.9	2.7		21.2
2<×<=3		4.6	8.2		
3<×<=4		2.9			
>4		1.7			

Appendix Xc. Mineral soil layer 10–20 cm nitrogen concentration frequencies (%).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
0<×<=1	99.7	85.9	89.1	100.0	79.0
1<×<=2	0.3	4.9	2.7		21.0
2<×<=3		4.6	8.2		
3<×<=4		2.9			
>4		1.7			

Appendix Xd. Mineral soil C-horizon, 55–65 cm, carbon concentration frequencies (%).

Classified intervals	Survey area Sweden	Sweden-IV	Kalmar County	Oskarshamn	SKB Oskarshamn
0<×<=1	99.5	97.6	98.2	100.0	97.7
1<×<=2	0.5	2.0	1.8		2.3
2<×<=3		0.4			
3<×<=4					
>4					

Appendix XI

Nitrogen concentrations, %, of the investigation sites

Site	Horizon depth, cm	N	Average	Max	Min	Std	Cv, %
1	2	3	4	5	6	7	8
H 1	H 0–30	8	1.26	1.87	0.89	0.30	23.7
	M 0–5	3	0.16	0.21	0.10	0.06	36.0
	M 0–10	8	0.17	0.29	0.08	0.07	44.9
	M 10–20	4	0.12	0.17	0.08	0.04	37.2
	M 55–65	3	0.04	0.06	0.02	0.02	57.0
H 2	H 0–30	8	1.02	1.85	0.72	0.37	36.5
	M 0–5	2	0.07	0.09	0.05	0.03	38.7
	M 0–10	8	0.17	0.37	0.05	0.12	73.7
	M 10–20	8	0.12	0.35	0.04	0.10	81.8
	M 55–65	4	0.05	0.08	0.04	0.02	33.1
E 1	H 0–30	8	1.18	1.36	0.98	0.12	10.2
	M 0–5	8	0.08	0.11	0.05	0.02	27.6
	M 0–10	8	0.06	0.09	0.03	0.02	26.1
	M 10–20	8	0.05	0.09	0.02	0.02	49.0
	M 55–65	4	0.02	0.03	0.02	0.00	16.7
E 2	H 0–30	8	1.08	1.45	0.45	0.30	27.9
	M 0–5	8	0.11	0.16	0.08	0.02	22.2
	M 0–10	8	0.09	0.12	0.05	0.03	32.9
	M 10–20	8	0.07	0.10	0.06	0.02	20.8
	M 55–65	4	0.02	0.03	0.02	0.01	23.9
L1	M 0–10	8	0.73	1.31	0.31	0.33	45.0
	M 10–20	8	0.19	0.61	0.05	0.18	97.9
	M 55–65	4	0.05	0.11	0.03	0.04	77.8
L2	M 0–10	8	0.51	0.83	0.30	0.19	36.7
	M 10–20	8	0.29	0.49	0.17	0.11	38.6
	M 55–65	4	0.10	0.16	0.06	0.04	42.6
P 1	M 0–10	8	0.68	0.85	0.39	0.15	21.7
	M 10–20	8	0.57	0.78	0.24	0.16	28.8
	M 55–65	4	0.06	0.09	0.02	0.03	50.2
P 2	M 0–10	8	1.69	1.80	1.49	0.10	6.0
	M 10–20	8	1.49	1.61	1.34	0.09	6.0
	M 55–65	4	0.31	0.53	0.04	0.21	67.3

Site	Horizon depth, cm	N	Average	Max	Min	Std	Cv, %
1	2	3	4	5	6	7	8
G1	H 0–30	8	2.49	2.72	2.29	0.16	6.3
	H 40–60	4	1.29	1.43	1.12	0.13	10.2
G2	H 0–30	8	1.92	2.04	1.73	0.10	5.4
	H 40–60	4	2.51	2.58	2.48	0.04	1.8
SS1	H 0–30	8	2.05	2.34	1.88	0.14	6.6
	H 40–60	4	2.15	2.33	1.89	0.19	8.6
SS2	H 0–30	8	2.47	3.00	1.81	0.37	15.1
	H 40–60	4	2.04	2.26	1.96	0.15	7.3
T1	H 0–30	8	1.51	1.87	1.24	0.23	15.1
	H 40–60	4	2.02	2.08	1.98	0.04	2.1
T2	H 0–30	8	1.90	2.27	1.50	0.25	13.2
	H 40–60	4	1.61	1.93	1.43	0.28	17.5
VH1	H 0–30	8	1.61	2.01	1.31	0.22	13.6
	H 40–60	5	1.94	2.15	1.70	0.18	9.1
VH2	H 0–30	8	1.46	1.62	1.32	0.11	7.8
	H 40–60	4	0.94	1.00	0.83	0.08	8.6
S1	H 0–30	8	1.95	2.09	1.70	0.14	7.4
	H 40–60	4	1.57	1.82	1.37	0.20	12.7
S 2	H 0–30	3	0.83	1.36	0.36	0.50	61.0
	M 0–10	8	0.16	0.84	0.03	0.28	172.4
	M 10–20	8	0.14	0.73	0.03	0.24	171.6
	M 55–65	4	0.04	0.05	0.03	0.01	22.8
A 1	M 0–10	10	0.78	1.14	0.58	0.21	26.7
	M 10–20	10	0.80	1.09	0.58	0.17	21.7
	M 55–65	5	0.41	1.76	0.01	0.76	185.9
A 2	M 0–10	8	1.63	1.71	1.49	0.06	3.9
	M 10–20	8	1.65	1.73	1.56	0.06	3.6
	M 55–65	4	0.15	0.42	0.03	0.18	120.8
G1	H 0–30	8	2.49	2.72	2.29	0.16	6.3
	H 40–60	4	1.29	1.43	1.12	0.13	10.2
G2	H 0–30	8	1.92	2.04	1.73	0.10	5.4
	H 40–60	4	2.51	2.58	2.48	0.04	1.8