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Soil and plant sampling and cultivation experiments at Byle gård and Forsmark 2020–2022

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Keywords: Agricultural crops, Chemical characterization, Concentration ratio, CR, Cultivation experiment, K_d, Natural vegetation, Regolith, Soil samples, Sorption coefficient

Contents

1 Introduction

Sorption coefficients (K_d) are used by SKB in transport models to assess the mobility of radionuclides in regolith systems. K_d values are defined as the ratio of the solute concentration in the soil solid phase and that of the pore water. They are known to vary greatly between different elements and soil types. The K_d values are therefore considered to be element, soil type and site-specific (IAEA 2010).

Concentration ratios (CR) are used to assess uptake of radionuclides in crops and other biota. The CR for a soil-plant system is defined as the plant to soil concentration ratio. CR is also known to vary greatly between different crop types, soil types and elements. Like K_d, it is considered to be crop, element and site-specific (IAEA 2010).

To model transport and uptake of radionuclides in the biosphere, K_d and CR values for all relevant elements in a number of different soil types and crops are required.

1.1 Regolith and crops in the radionuclide transport model

The radionuclide transport model used by SKB in the SR-PSU safety assessment (SKB 2015) defines compartments that are significant and homogenous units with respect to physical, chemical, and/or biological properties influencing radionuclide transport and accumulation. The regolith layers are therefore split into separate geological layers present in the modelled site at Forsmark today and in the future (Figure 1-1). Since K_d values differ between regolith types, they need to be derived for all regolith types at the modelled site.

The regolith layers identified in the Forsmark landscape are till (RegoLow), glacial clay (regoGL), post-glacial clay (regoPG), and peat. The peat layer can be divided into a lower layer located under the groundwater table (regoPeat) with dead vegetal materials and reducing conditions (catotelm), and an upper layer (regoUp) featuring living plants where oxidizing conditions can prevail (acrotelm). In addition to these layers, sand layers can occur as part of the post-glacial sediment (see Figure 1-1).

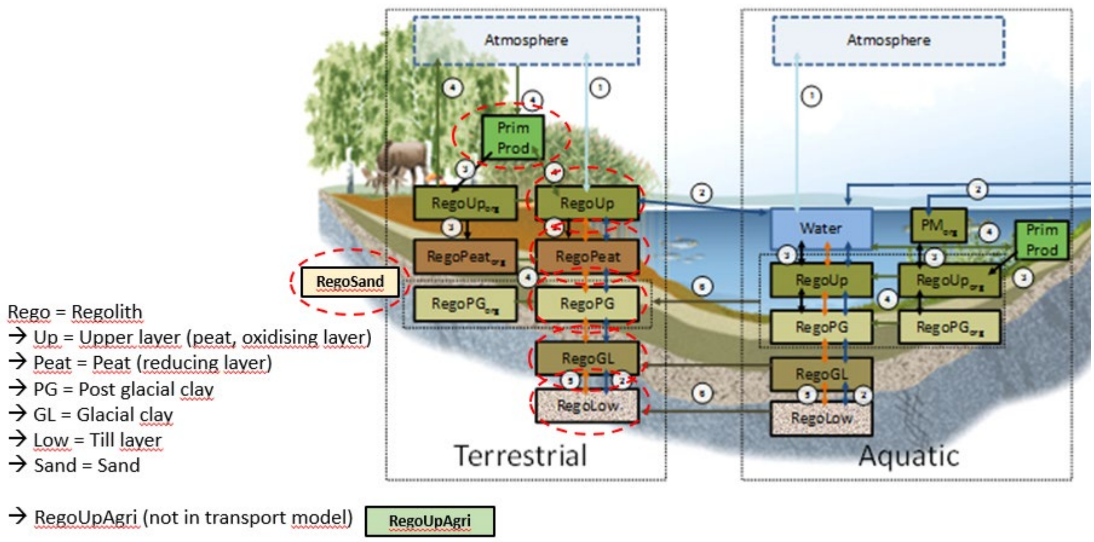

Figure 1-1. The regolith compartments used in the radionuclide transport model for the FPSAR assessment for the extension of SFR (SKB 2015). The dashed red ovals indicate which compartments that were included in this project.

In addition to these natural regolith layers, agricultural soils will form due to human activity. These soils have altered properties compared to the undisturbed regolith layers. Three agricultural practices which result in altered regolith layers are identified and included in the model (SKB 2014, section 7.2). The first is the drained mire, where cereal, potatoes and pasture are cultivated on drained organic soils (peat and postglacial clay). The second practice is cultivation of cereals on higher laying mineral soils as glacial clay and/or till soils. The third agricultural practice is a garden plot (also called cultivation plot) on mineral soil (glacial clay and/or till) where vegetables and potatoes are grown for household consumption. K_d values representing cultivated organic soils and cultivated mineral soils, both clay and till, are therefore needed.

The crop groups identified as relevant for cultivation in Forsmark now and in the future are cereals, tubers, root crops and vegetables. Pasture is also identified as fodder for cows. These types of crops were chosen since these represent the most commonly cultivated food staples, as well as representing a wide variety of crop types.

1.2 Existing data for K_d and CR values in the terrestrial ecosystem

K_d and CR samples have been analysed within the SKB site-investigation program at the Forsmark and Laxemar sites (as summarised in Tröjbom et al. 2013, section 3.1). These samples have been used for assignment of K_d and CR values for identified soil and crop types in the previously conducted safety assessments for the spent nuclear fuel repository (Nordén et al. 2010), the extension of SFR (Tröjbom et al. 2013), and for the safety evaluation of the SFL repository (Grolander and Jaeschke 2019).

Site-specific K_d data exist with a statistical support of 5 – 10 samples per parameter. K_d values for the deeper regolith layers of glacial clay and post-glacial clay are based on samples from surface soil. Since these data might not be fully representative of the deeper layers, it is therefore of particular importance to add new samples of these regolith types from deeper layers. A summary of available site-specific data from SKBs sampling sites Forsmark and Laxemar can be found in Chapter 9.

For crops, site-specific data are missing for vegetables, tubers, root crops and for pasture. Site-specific data for cereals is available with stem samples and seed samples of wheat and barley.

1.3 Purpose of the study

The overall purpose of the project is to collect site-specific data for concentrations of different elements in soils and crops that can be used to estimate K_d and CR values needed to model transport and uptake of radionuclides in the terrestrial ecosystem. These samples will fill data gaps in SKBs site-specific datasets, increase the number of samples for critical parameters, and thereby possibly decrease parameter uncertainty. The K_d and CR for aquatic ecosystems are not included in this study.

The purpose of this report is to describe the procedures for sampling of regolith layers, agricultural soils, crops, and natural vegetation, as well as documenting the samples that were taken.

1.4 This report

In this report, an overview of the sampling sites is given in Chapter 3. Here, the development of the sites is described as well as the current land use. In Chapter 4, the sampling procedures for soils and vegetation are described. The cultivation experiment at Byle site is described in Chapter 5, including sampling and treatment of crops, as well as technical installations and maintenance. In Chapter 6 the regoliths which were sampled during the period 2020 – 2022 are listed with information of sample ID, regolith classification, sampling depth and sampling time. In Chapter 7 all vegetation and crop samples are listed. Chapter 8 describes the discrepancies identified in this study. In the final Chapter 9, a discussion is given including a summary and categorization of all regolith and vegetation samples. The final selection of samples for analysis and results from these analyses are presented in coming SKB reports.

2 Overview of field activities

Sampling of regolith and vegetation was performed at the Byle, Rasbo, and Forsmark sites during the period 2020 – 2022. Cultivation experiments were performed at the Byle site during the summers of 2020, 2021 and 2022.

In summary, 69 different soils were sampled where most originated from the Byle site. In this report the term soil is used for both cultivated and non-cultivated topsoils as well as the deeper regolith layers of till, glacial clay, gyttja clay, and sand found in the deeper trenches at the site. Of the 69 sampled soils, 18 were used in the cultivation experiment. In the cultivation experiment, sixteen different crops were grown and sampled. At the Forsmark site, natural vegetation was sampled from the bottom layer, field layer, shrub layer and tree layer. The performed sampling activities are summarised in Figure 2-1.

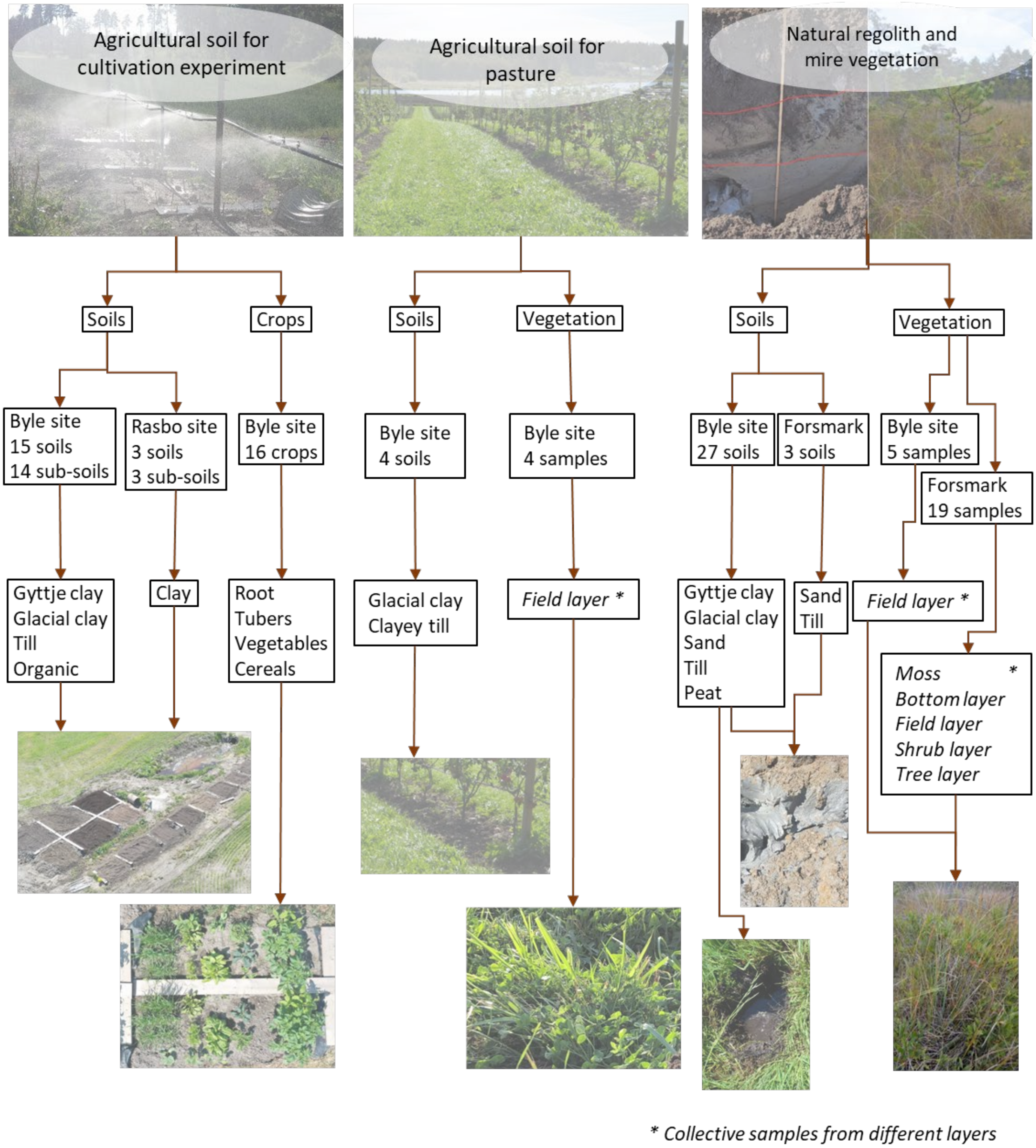

Figure 2-1. Overview of the field activities described in this report.

3 Overview of the sites

3.1 The Byle Site

The Byle Site is located in Uppland in Sweden, about 70 km south of Forsmark (Figure 3-1).

***Figure 3-1.** Map of the sampling sites included in this report.*

3.1.1 Landscape development

The lowest part of the Byle site is located about 12 meters above sea level. It emerged from the sea about 3000 years ago as a result of land uplift. The hills surrounding the former lake bottom reach up to 40 meters above the sea level, meaning that the ground level at the Byle Site has been above sea level for about 3000 – 6000 years. Figure 3-2 illustrates the landscape both when the Byle site (marked in red) was a bay of the Baltic Sea, and when the sea bay was isolated 2500 years ago and lake Slänningen was formed (Figure 3-3) The lake became successively shallower, and ingrowth of peat resulted in formation of a wetland around the lake (Figure 3-3).

At the Byle site, landscape development and soil forming processes have resulted in a more mature landscape in comparison to the SKB modelling site in Forsmark. The Forsmark site is expected to undergo similar landscape development and soil forming processes as the Byle site and therefore the Byle site is a suitable analogue of a future, more mature, Forsmark landscape.

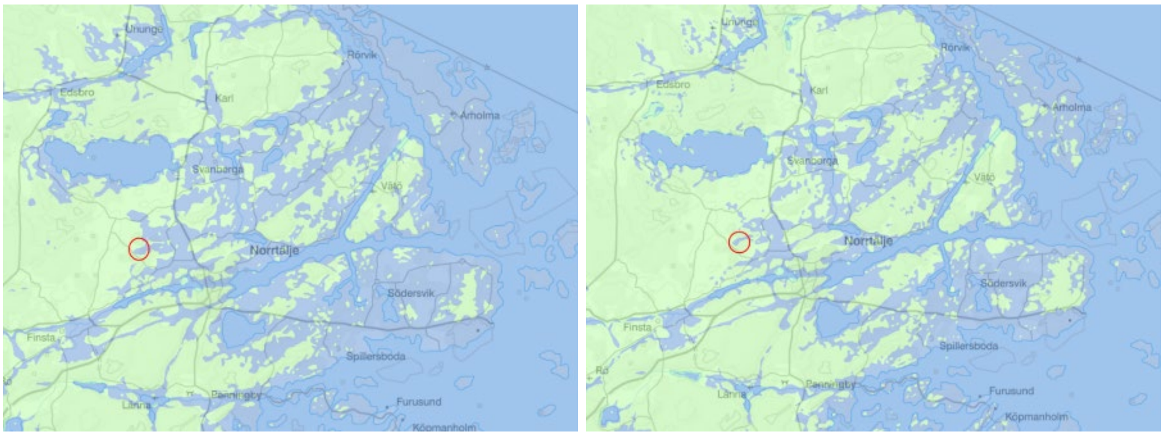

***Figure 3-2.** left: Byle site approximately 3000 years ago when the area was still a sea bay, right: the Byle site 2500 years ago when the Lake Slänningen got isolated from the sea (SGU, shoreline map https://apps.sgu.se/kartvisare/kartvisare-strandforskjutningsmodell.html)*

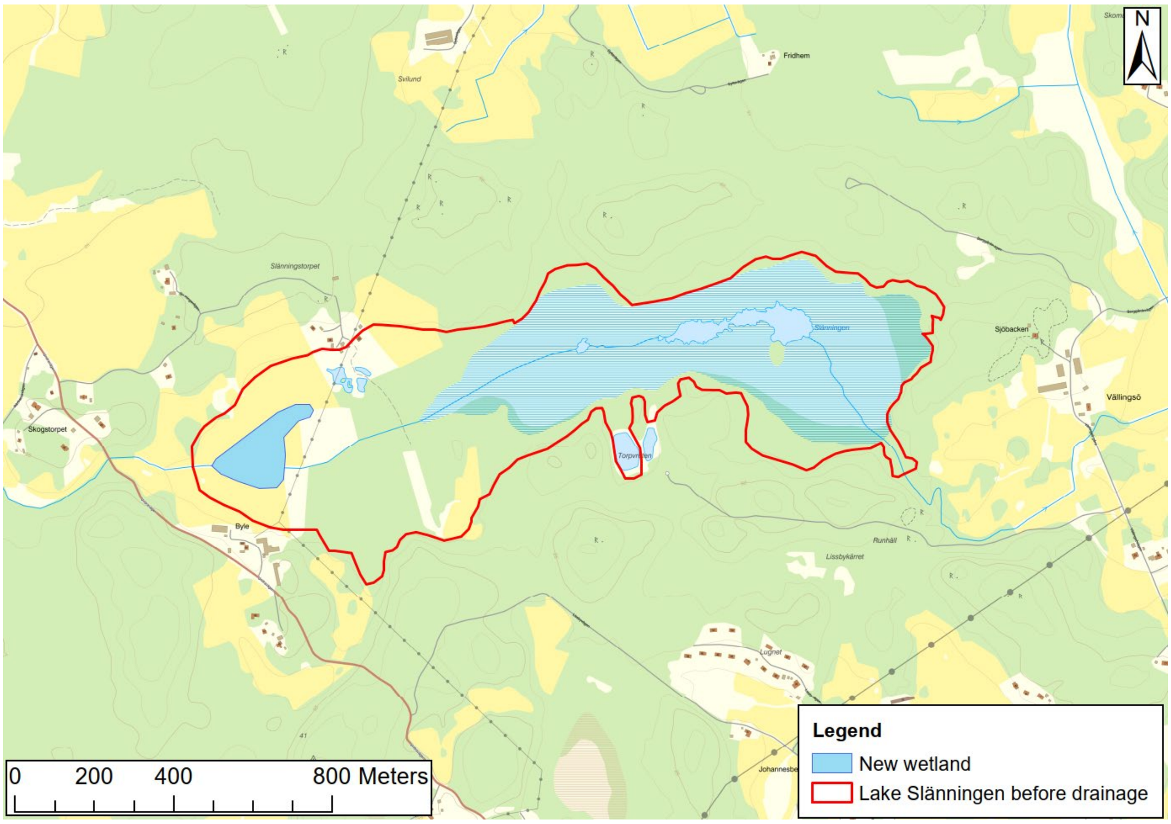

***Figure 3-3.** The size of the lake Slänningen before draining by diches was conducted is marked with a red line, the blue-shaded area with stripes marks the extent of the wetland after drainage of the lake and the current lake Slänningen is the smaller light blue area. The slightly darker light blue area to the left is the newly constructed wetland © Lantmäteriet.*

3.1.2 Quaternary geology

The quaternary geology of the area is dominated by clayey till with bedrock at the surface in higher laying areas and glacial clay, post-glacial clay, and peat in low laying areas (Figure 3-4). The Byle site is located in a low lying area with regolith layers of peat, gyttja clay, glacial clay and clayey till.

The regolith depth profile at the Byle site is typical for areas located below the highest coastline with till overlaying the bedrock followed by glacial clay deposited during the retreat of the icecap. Overlaying the glacial clay is post-glacial clay consisting of gyttja clay that has been accumulated during the period when the area was a shallow sea bay and lake. Under or within this post-glacial clay, sand layers can be present. The top regolith layer is peat that has accumulated in the area during the lake and mire stages. Due to land use practices such as ditching, the peat has been removed from parts of the site. This regolith profile is also found in wetland areas of Forsmark today and is expected to occur in the future Forsmark landscape (Brydsten and Strömgren, 2013; Figure 3-5).

Calcite-bearing till deposits, with the same origin as the calcite-bearing deposits found in Forsmark, are present at the Byle site, which makes the two sites similar in terms of geochemical conditions. The post-glacial deposits in lake Slänningen are comprised of thick layers of "kalkgyttja" that was precipitated during the lake state in the form of calcium carbonate ($CaCO_3$), with Ca^{2+} originating from the leaching of the surrounding calcite-rich till.

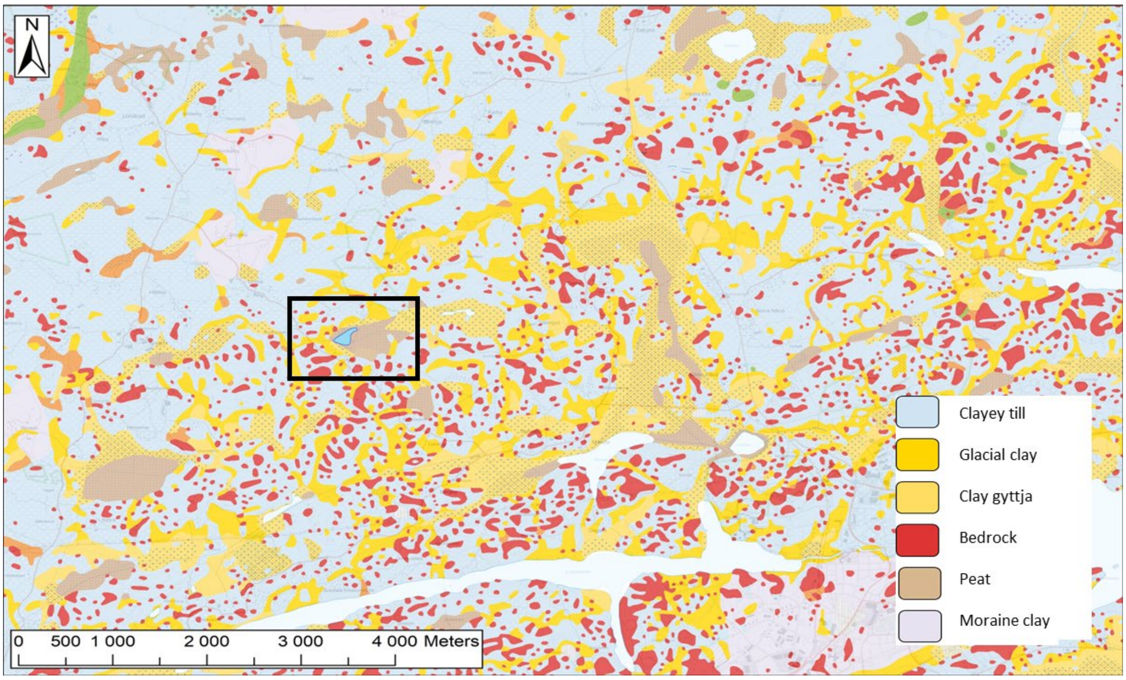

***Figure 3-4.** SGU soil map showing a till dominant area with bedrock at higher elevation areas and peat and gyttja clay in more low-lying areas. The Byle site is marked with a square, the constructed wetland marked in blue is surrounded by peat, clay gyttja and glacial clay © Sveriges geologiska undersökning (Swedish geological survey).*

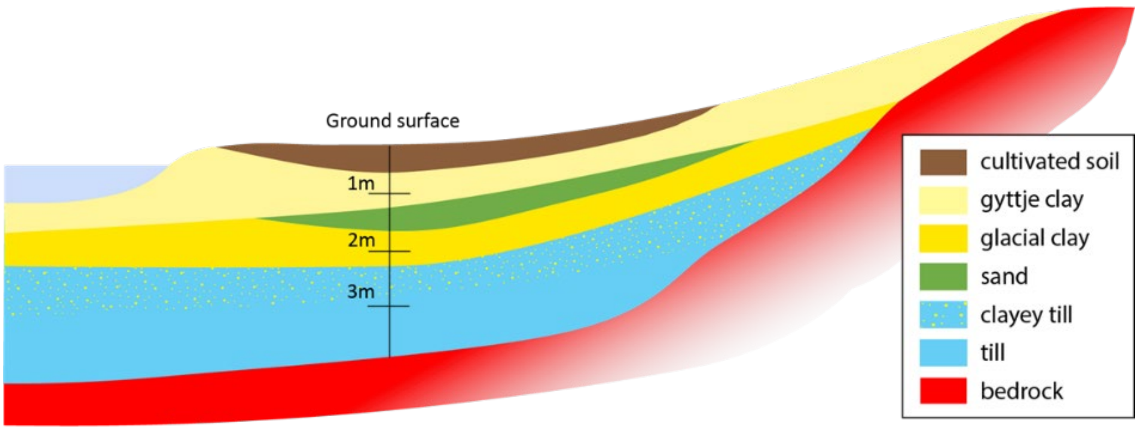

***Figure 3-5.** A conceptual picture of the regolith profile at Byle site with clayey till overlying the bedrock followed by glacial clay, post-glacial clay, and sand. The topsoils are cultivated post-glacial clays or glacial clays. Peat has been present in the area but removed in recent years.*

3.1.3 Land use

The Byle site has a long history of agricultural practice. The farm Byle Gård was established in the beginning of 1700, but remnants show that there has been ongoing agriculture in the area since the bronze age (~ 3000 years ago). The wetland in the area has been drained in several steps over the past centuries to gain arable land, mainly north of Byle Gård. The latest drainage activity was performed in 1936 when the outlet of Slänningen was significantly lowered (Figure 3-6). This drainage resulted in lowering of the water level of Lake Slänningen and start of rapid ingrowth of vegetation in the lake. In Figure 3-3, the area of the current lake and the former lake area before draining are visualized.

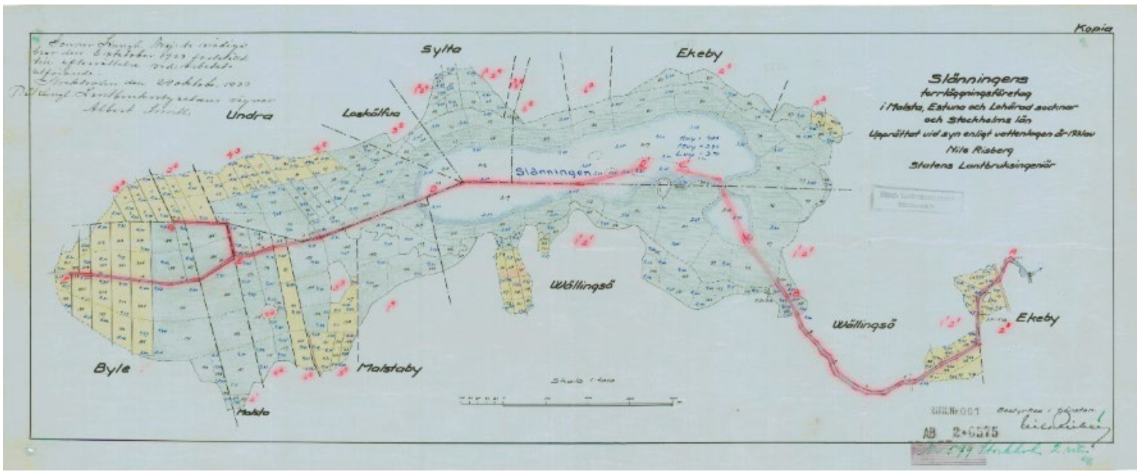

Figure 3-6. The extent of Lake Slänningen 1933 prior to the final drainage that was completed in 1936 (map from Stockholms stadsarkiv).

3.2 The Rasbo Site

The Rasbo site is located east of Uppsala, 45 km northwest of the Byle site and 50 km southwest of Forsmark. The quaternary geology is dominated by glacial clay and post-glacial gyttja clay. A high clay content (40 %) is expected in the area according to the Digital soil map of Sweden produced by the Swedish University of Agricultural Sciences, SLU (Piikki and Söderström 2019). The area is located 15 – 30 meters above sea level and was uplifted from the sea 5000 years ago according to open data presented by the Swedish geological survey (https://apps.sgu.se/kartvisare/kartvisare-strandforskjutningsmodell.html). Topsoil was collected at three locations near Henriksberg in Rasbo and transported to the Byle Site for the cultivation experiment.

3.3 The Forsmark Site

The Forsmark area is well-documented and described in several SKB reports, for example SDM-Site (SKB 2008), and SDM-PSU (SKB 2013) and references therein. Therefore, only a short site description of the Forsmark site is given in this report.

The surface distribution of the quaternary deposits is typical for areas located below the highest postglacial coastline. Till is the dominant type of deposit and occupies some 65% of the surface in terrestrial areas and 30% of the seabed outside Forsmark. Glaciofluvial sediments occur at the Börstilåsen esker located southeast of the Forsmark site. Clay occurs primarily in depressions on the sea bottom and below present lakes. Postglacial clay, including clay gyttja is predominantly found in the deeper parts of the seabed. The seabed north of the SFR pier is dominated by till, whereas areas south of the pier are dominated by glacial clay (SKB 2014).

4 Sampling of regolith and vegetation

Regolith samples were taken at three sites; Byle gård, Rasbo, and Forsmark. Vegetation and crop samples were taken at the Byle site and Forsmark site. The sampling locations were documented by photos and field notes, and coordinates were registered for each sampling point. All sampling locations at the Byle site are shown in Figure 4-1.

Protective gloves were used at all times during sampling, for both soils and vegetation. Soil sampling was done using a stainless-steel spade, or by hand. A minimum sample size for soils of 2 kg was collected in diffusion tight sampling bags provided by the laboratory, and efforts were made to minimize the amount of air in the bags. The soil samples that were sent straight to the laboratory were stored in dark and refrigerated at ca +5 °C and. The archive soil samples were stored frozen at -18 °C awaiting analysis.

The sampling and sample treatment of vegetation and crop samples were more complex and varied depending on the sample type.

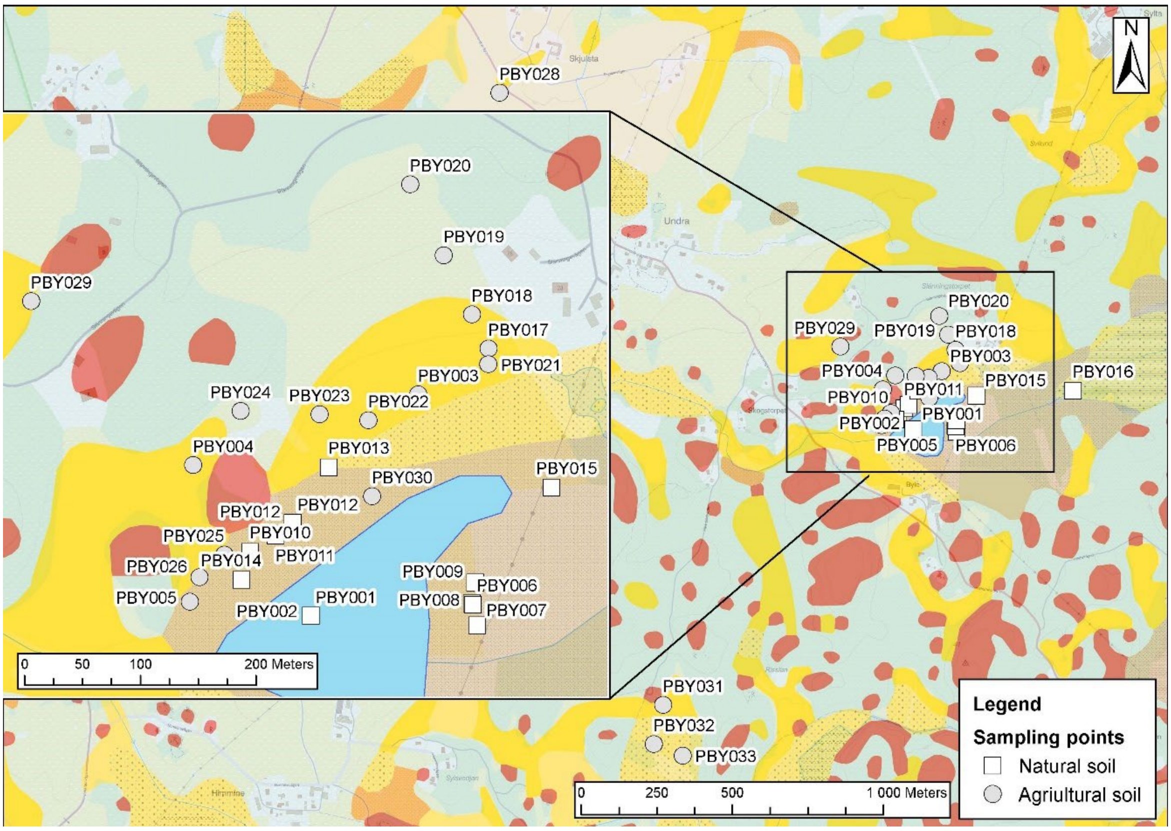

Figure 4-1. Locations of all sampling points at Byle gård © Sveriges geologiska undersökning (Swedish geological survey).

4.1 Sampling of undisturbed regolith layers and vegetation at the Byle site

The sampling performed at the Byle Site was intended to retrieve deep mineral regolith samples representing undisturbed conditions in a potential discharge area. Additionally, organic soils on agricultural land previously used for grazing cattle, were sampled for peat above and under the water table. Cultivated soils were sampled both for in situ analyses of agricultural soils, and for the construction of cultivation plots for the cultivation experiment.

Vegetation samples were taken from both peat and agricultural soils.

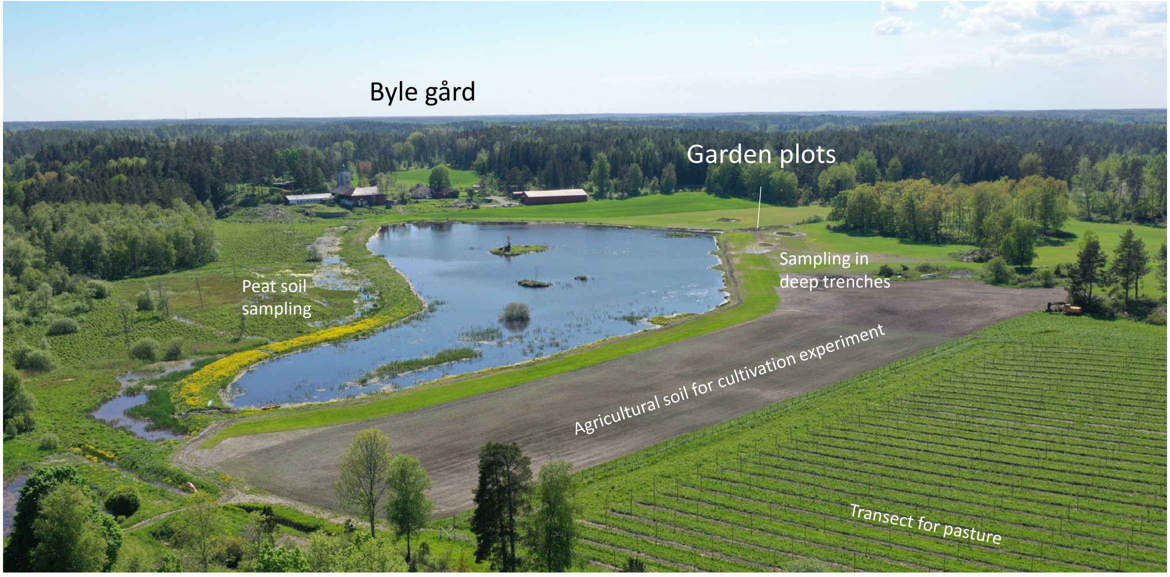

Figure 4-2. Overview of the Byle Site during spring facing towards the southwest with the Byle Gård in the background.

4.1.1 Deep mineral regolith

At the Byle site, undisturbed mineral regolith was sampled in deep shafts up to 3 m below the ground surface (Figure 4-2). The aim was to obtain samples of all identified regolith layers: till, glacial clay, post-glacial clay and postglacial sand (see Chapter 1.1). The sampling strategy was to dig deep shafts at different locations at the sampling site and sample all regolith layers that exist in these deep shafts. Expert quaternary geologists classified the regolith types in the depth profile directly at the field. Five shafts were dug at the same field with the goal of sampling the same regolith layer several times. The locations of the five shafts are shown in Figure 4-1 (PBY010-PBY014). At these locations, the uppermost peat layer has developed into agricultural soil due to ditching; therefore, natural peat layers were not found at these locations.

An excavator was used during sampling and the samples were taken either directly from the bucket of the excavator, or from regolith that was placed on the ground as depicted in Figure 4-3. The samples were taken from inside the regolith mass, avoiding soil that was in direct contact with the atmosphere. This was done to minimise the exposure of regolith to air and to reduce the risk of oxidation of regolith samples coming directly from reducing conditions. Some samples were taken from below the ground water level meaning they were water saturated at the time of sampling. During sampling, the aim was to retain the moisture content of the samples and to include both the soil and the pore water in the sample.

Figure 4-3. One of the shafts (left). The middle panel shows the different layers and the picture to the right shows sampling of the glacial clay.

4.1.2 Peat and mire vegetation

Peat samples were collected on the opposite side of the new wetland as shown in Figure 4-4 and Figure 4-5. Five of the sample points (PBY006, PBY007, PBY008, PBY009, PBY015) represent peatland that has been used for grazing and haymaking for several decades. One sample point (PBY016) represents undisturbed mostly waterlogged peatland that was used for grazing until ca. 50 years ago. All sampling points are shown in Figure 4-1.

Peat samples were taken using a handheld spade. The samples were taken from both the upper layer that was considered to be part of the oxidising, active layer of the peat and the lower part of the peat where reducing conditions were expected. At some sampling points, additional samples of gyttja were taken since a layer of gyttja was detected. Figure 4-5 shows a peat sample with a gyttja layer at the bottom.

Peat samples were collected in the autumn of 2020. These samples were analysed, although no archive samples were saved. Instead, the same points were revisited in the autumn of 2022 and new samples were collected from PBY007, PBY008, PBY009, PBY015 and PBY016 using the same sampling method. The location of all points except PBY016, were marked with survey markers in autumn 2020, so the exact locations could be revisited in 2022.

Natural vegetation was sampled at all sampling points. The peat locations PBY006-009 are dominated by grass and Carex species and PBY015 is dominated by reeds (Phragmites australis). The undisturbed peat location (PBY016) is dominated by Equisetum (horsetail) species.

4.1.3 Gyttja samples

Gyttja samples were collected by an excavator during the construction of the artificial pond. The upper yellowish calcareous algae gyttja was taken a few decimetres below the organic top-soil at around one meter depth (PBY002), whereas the underlaying greyish clay gyttja was sampled at 1,5 to 2 meters depth (PBY001).

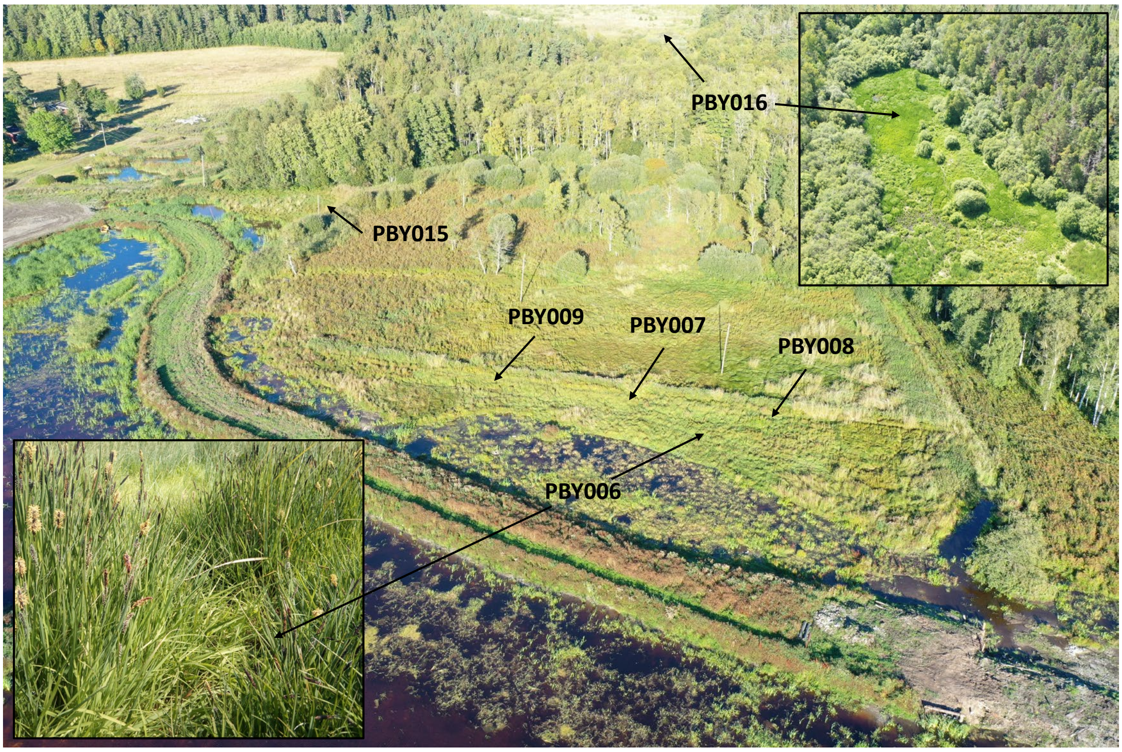

Figure 4-4. Sampling points for peat soils and vegetation at the Byle site.

Figure 4-5. Sampling of peat in 2020.

4.1.4 Agricultural soils and pasture

Sampling of agricultural soils for the cultivation experiment is described in Chapter 5. Here, sampling of four agricultural soils and corresponding vegetation samples representing pasture (grass and clover, non-fertilised) is described.

Four agricultural soil samples (PBY017, PBY018, PBY019 and PBY020) were collected in a transect from a low lying area with gyttja clay to an area at higher elevation with glacial clay and till (Figure 4-6). The samples were collected at 5 – 10 cm below surface using a small handheld spade. As previously mentioned, these soils were not included in the cultivation experiment. Instead, these samples were collected to represent an agricultural field with pasture.

Figure 4-6. Gradient representing pasture on clay gyttja, glacial clay and till (foremost) soil. Sampling points from the foreground towards the background are PBY020, PBY019, PBY018 and PBY017.

4.2 Regolith and vegetation sampling in Forsmark

4.2.1 Deep mineral regolith in Forsmark

In Forsmark, regolith sampling was conducted from a shaft (Figure 4-7). The shaft was created due to road construction at Söderviken conducted by Skanska in 2020 – 2021 and gave SKB an access to deeper regolith layers. The soil layers were removed from the shaft and bedrock was exposed. SKB conducted an investigation using the shaft to improve knowledge of the site. The investigations in the shaft focused on bedrock characterisation, measuring soil depth profile and characterisation of soil types. In addition to these investigations, soil sampling was performed on 24th of March 2021. The sampling points are shown in Figure 4-8. Three replicates of about 500 grams were taken from two different types of till (230321:1-3 and 230321:4-6) and from one sand (230321:7-9)

The till samples were taken from about two meters depth in two different till units. The deeper layer had rounder boulders and a matrix consisting of silt, whereas the upper layer consisted of smaller and more rugged boulders and the matrix consisted of sand. The noted difference in the matrix could be a result of different water content between the samples.

The sand was sampled from a crevice filled with sorted sand. Till sediments were overlaying the sand, and, thus, the sand was most likely not postglacial sediment.

One of the sub-samples of each sample (230321:1, 4 and 7) were sent to ALS Scandinavia for grain size analysis, although the analysis was not conducted correctly, and the results could not be reported. Unfortunately, the samples were not saved, and the analysis could not be redone. Archive samples with id 1120, 1121, 1122 are stored in SKBs archive, and these samples could be used to redo the analysis if needed in the future. The archive samples are listed in SKBs table over archive samples[1].

[1] SKBdoc: 1904639 ver 0.17. (Internal document, in Swedish.)

Figure 4-7. Photo of the sampled shaft in Forsmark.

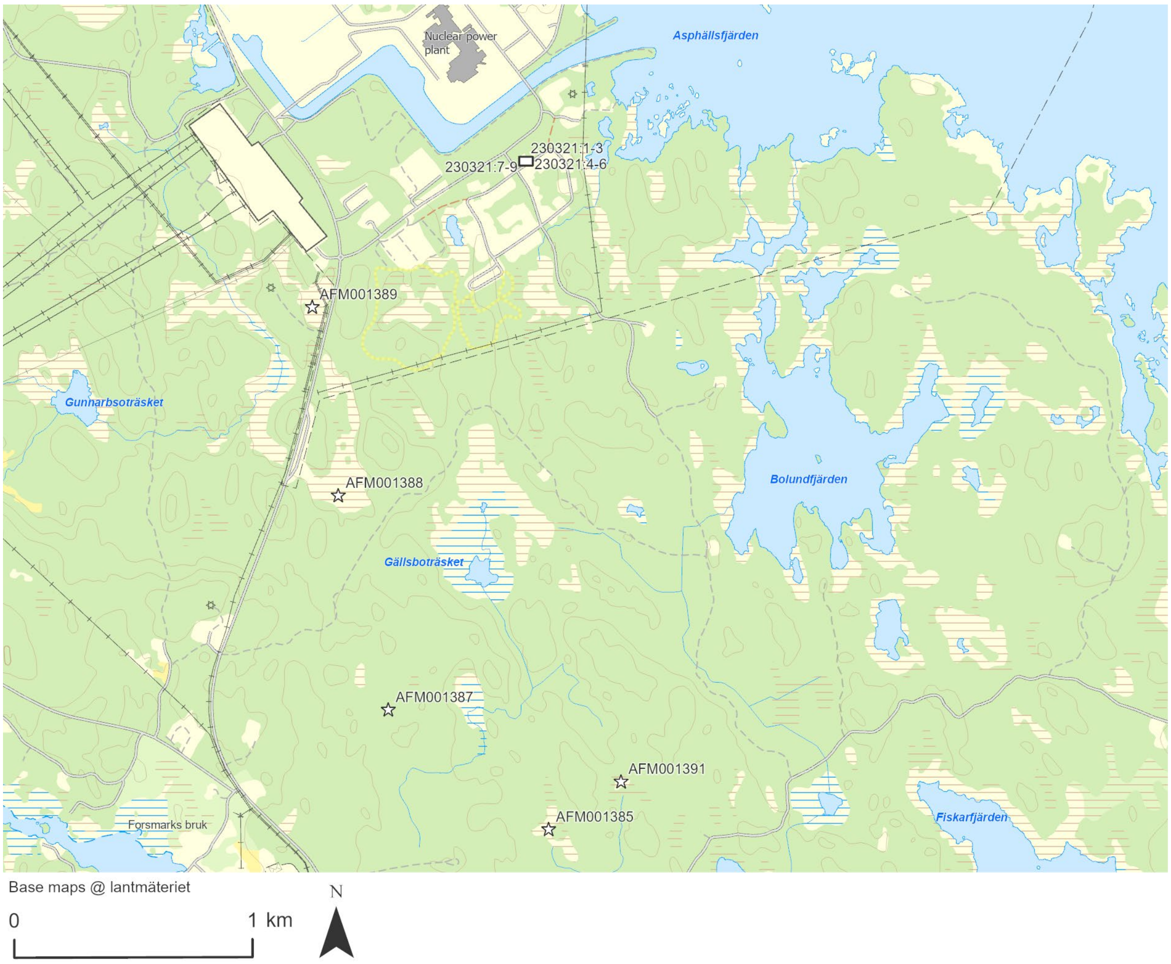

Figure 4-8. The regolith and vegetation sampling points in Forsmark.

4.2.2 Sampling of the mire vegetation in Forsmark

Five of the sampling points (AFM001385, 001387 – 001389 and 001391) used for $\underline{K}_d$ measurements in a previous study (Sheppard et al. 2011) were re-visited to collect samples of natural vegetation (Figure 4-8). Sampling was conducted at the end of vegetation season (sampling date 2020-09-11). The field layer, shrub layer and tree layer were sampled at each point, where possible.

For the field layer, a sample including all dominating species was collected in proportion to the amount of each species at the site, to get a sample that was representative of the sampling point. This resulted in samples consisting of several species. Samples of the field layer were taken in a circle with a radius of 5.6 m, which gave a 100 m^2 sample area around the centre point. A sub-sample of each sampled species was collected for species identification. For the shrub and tree layer, samples of leaves or needles of dominating trees and shrubs were taken, and if several species were present at the location, a sub-sample of each species was taken.

Samples were placed in sampling bags received from the laboratory and kept cool during transport. The samples were dried and stored at room temperature before sending to the laboratory (ALS Scandinavia).

Sampling locations for mire vegetation are displayed in Figure 4-8, and the pictures from each of the sampling points are seen in Figure 4-9, Figure 4-10, Figure 4-11, Figure 4-12 and Figure 4-13.

Figure 4-9. Photos of sampling point AFM001385. At this location moss, Carex, Myrica gale, and pine were sampled.

Figure 4-10. Photos of sampling point AFM001387. At this location moss, narrow-leaved grass in tussocks, and birch were sampled.

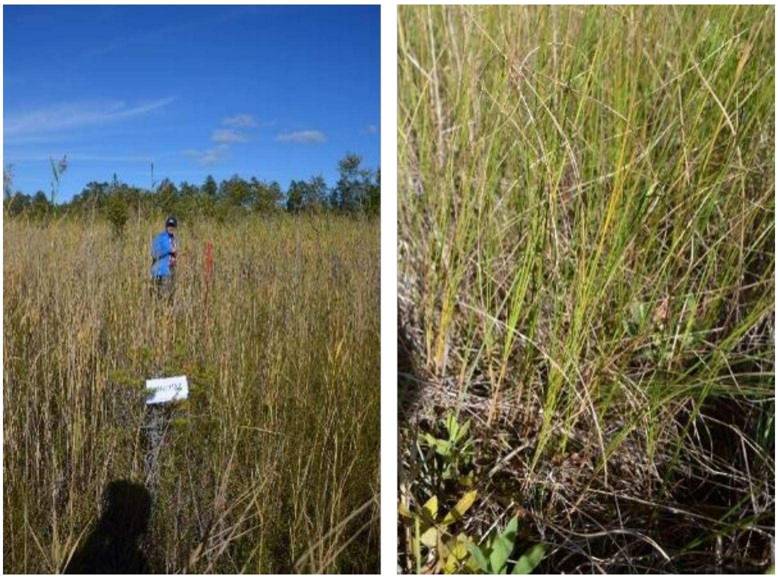

Figure 4-11. Photos of sampling point AFM001388. At this location moss, Carex, reed, Myrica gale, and pine were sampled.

Figure 4-12. Photos of sampling point AFM001389. At this location moss, broad-leaved grass, Carex, reed, Myrica gale, and alder were sampled.

Figure 4-13. Photos of sampling point AFM001391. At this location moss, Carex, Myrica gale, and pine were sampled.

5 Cultivation experiment at the Byle site

During years 2020, 2021 and 2022 cultivation experiments were performed at the Byle site with the purpose of deriving soil and plant element concentrations for K_d and CR estimates for agricultural soils.

5.1 Construction of the cultivation plots

The plots used for the cultivation experiments during 2020 and 2021 were constructed from soil collected from selected fields at the Byle and Rasbo sites.

For the cultivation experiment in 2020, topsoil from three fields at the Byle site were collected. From each field, three replicates were collected from different locations within the same field, resulting in a total of nine cultivation plots. The fields represented different soil types according to the soil map provided by SGU and consisted of clay gyttja (PBY003, PBY0021, PBY0022), glacial clay (PBY004, PBY0023, PBY0024) and clayey till (PBY005, PBY025, PBY026). This gave three samples of each soil type (Figure 4-1). The soils were used to construct nine cultivation plots as illustrated in Figure 5-1.

In 2021, nine additional cultivation plots were added to the experiment. These soils were selected to broaden the range of soil types by adding soils with higher clay content and higher organic matter content. Topsoil was collected from six agricultural fields within Lohärad in the vicinity of the Byle site (Figure 4-1), where three of these fields were representative of clayey soils (PBY028, PBY029 and PBY031) and three were representative of organic soils (PBY030, PBY032, PBY033). In addition, three locations at the Rasbo site were selected because of the high clay content in this area (PRA001-PRA003). In total 18 soils were included in the cultivation experiment during 2021 and 2022. The constructed plots are illustrated in Figure 5-2, Figure 5-3 and Figure 5-4.

For each cultivation plot, sampling of the uppermost layer, about 20 cm from the ground surface, was done from the original fields by a tractor loader and transported to the site for the cultivation experiment. Each soil formed a cultivation plot of approximately 2×2 m size and 0,5 m soil depth (Figure 5-4). The plots were separated from each other, and the local soil below, with a permeable plastic sheet facilitating downwards percolation of water and hindering roots of the crops from reaching the underlying soil.

The soils of the cultivation plots were homogenous at the start of the growing season due to several steps of soil treatment, such as collection of topsoil at the field, transport on a truck and mechanical mixing at the site.

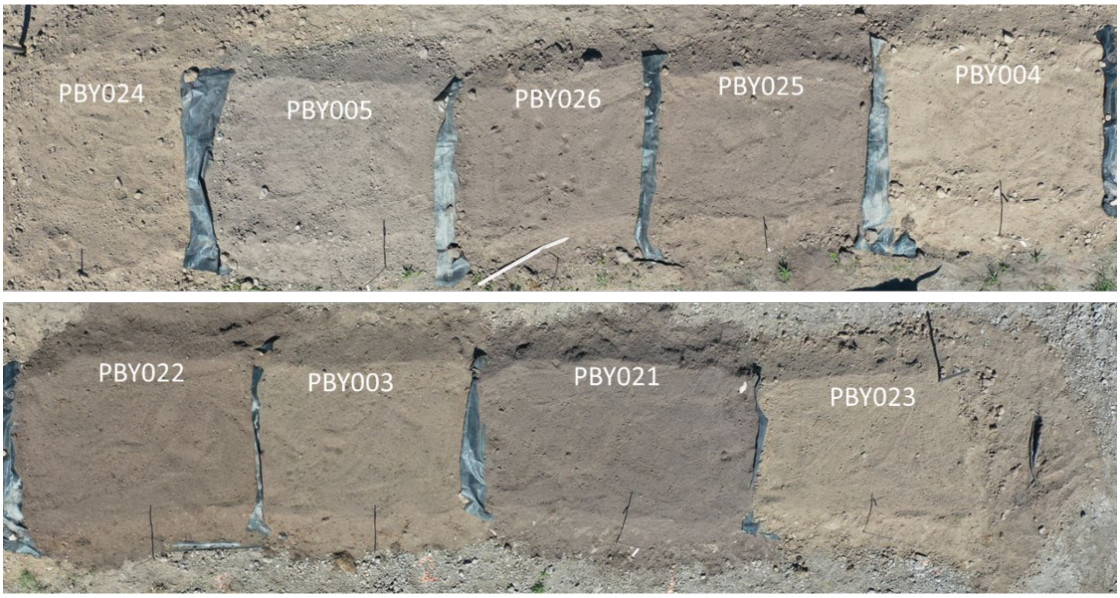

***Figure 5-1.** Cultivation plots for soils used in the cultivation experiment in 2020. According to the soil map they represent gyttja clay (PBY022, 003, 021), glacial clay (PBY005, 026, 025) and clayey till (PBY024, 004, 023).*

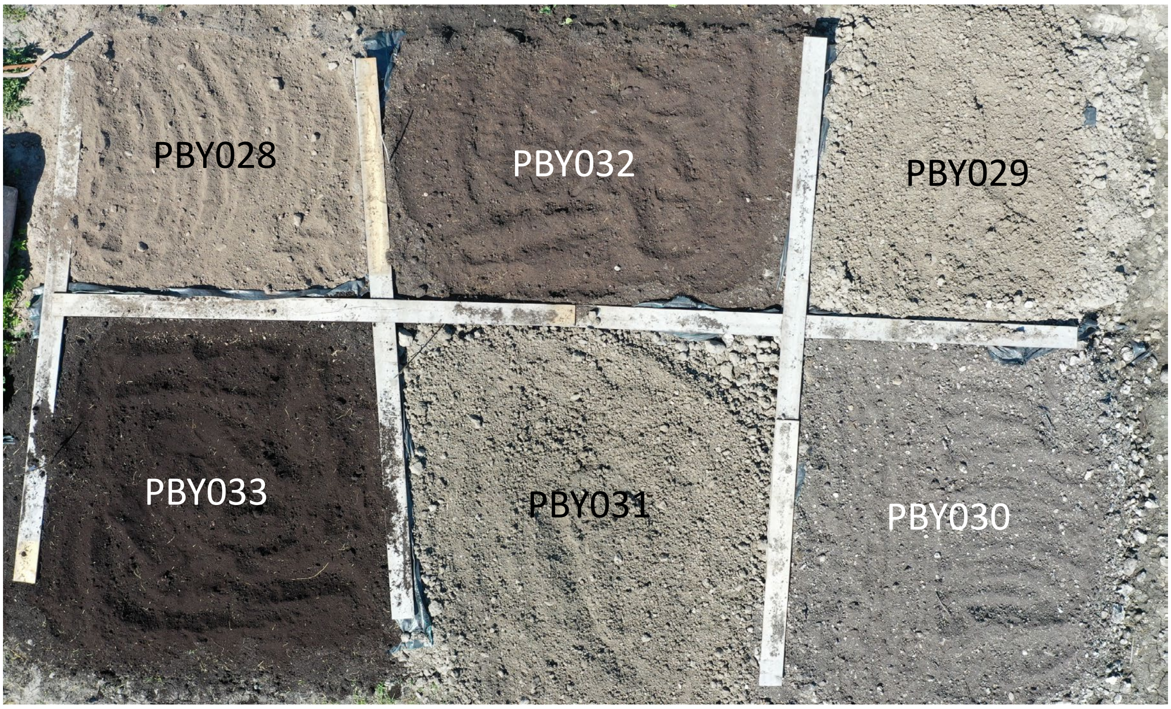

Figure 5-2. Cultivation plots constructed in 2021 with soil from Lohärad in the vicinity of the Byle site. According to the soil map PBY028 represents moraine clay, PBY029 and PBY033 silty clay, and PBY030, PBY032 and PBY033 represent organic soils.

Figure 5-3. The 18 agricultural soils prepared for the cultivation experiment in 2021. The row of nine cultivation plots from 2020 is seen in the upper right, the six cultivation plots from Lohärad (in the vicinity to Byle site) are seen in the upper left. The three cultivation plots with clay soil from Rasbo are marked in the front.

Figure 5-4. Preparation of agricultural soils for the cultivation experiment.

5.2 Soil sampling of the cultivation plots at the Byle site

5.2.1 Soil sampling 2020

Half of each plot was fertilised in 2020, and soil samples were collected at the centre point of the unfertilised part of all nine plots, at about 10 cm depth. Only the unfertilised part of the plot was sampled. Three of the plots were sampled in June 2020 (PBY003, PBY004 and PBY005) and six of the plots were sampled in September 2020.

5.2.2 Soil sampling in in 2021

A total of 18 plots were included in the cultivation experiment in 2021. There were two main purposes of the sampling of soils: General characterization and chemical analysis of the soils, as well as assessment of spatial and temporal variation in soils over the growing season. Sampling was done at the start of the growing season and at harvest to give an indication on how the soil in the whole plot potentially changes throughout the growing season.

While in 2020 the samples from the plots were taken only from the centre point, in 2021 a different strategy was used. Integrated samples were created by taking soil from five excavated holes (one in the centre of the plot, and four in a circle approximately 100 cm from the centre (Figure 5-5) and mixing the samples. Sampling depth was approximately 10 cm.

At each plot, three subsamples from each integrated sample were taken at the start of the growing season and two sub-samples were taken at the time of harvest.

Figure 5-5. Sampling of collective samples.

Soil sampling for analysis of soil physical properties, such as field capacity, wilting point, porosity, and dry bulk density, was conducted using steel cylinders (Figure 5-6). The cylinder was pressed into the soil at approximately 10 cm depth without compacting the soil, and an effort was made not to disturb the soil within the cylinders during sampling. The cylinders with the undisturbed soil were taken up from the soil by carefully digging around the cylinder. Any excess soil was brushed from the cylinder. During this step, care was taken to make sure that the soil did not break up creating cracks in the soil. A filter paper was placed over the soil and lids were put on the cylinders. The samples were transported directly to the SLU soil physics laboratory.

Figure 5-6. Sampling of soil physical properties using steel cylinders. The cylinder was pressed down into the soil without disturbing the soil within the cylinder and then taken out carefully by digging around the cylinder.

5.2.3 Sampling of root soil in 2021

To study the effect of different crops, sampling of root soil was done close to the roots of kale, split pea and Swiss chard spinach. In this study, root soil is the soil found closest to the roots of the crop. These crops were chosen for this experiment as these crops have roots that are sufficiently large with an easily defined root soil zone. This kind of sampling could potentially give information on how that specific crop affects the soil during the growing season.

The root soil was sampled by excavating a small area around the roots and by hand removing large chunks of soil (Figure 5-7). The soil closest to the roots was then shaken into a bag.

Figure 5-7. Pictures showing the sampling of root soils. The roots and the soil close to the roots were collected using two small spades. The root soil zone was cleaned from the excess soil by hand, and the soil closest to the roots was sampled into a paper bag by shaking the roots.

5.2.4 Soil sampling in 2022

Soil samples were taken at the start of the growing season after the cultivation plots were prepared and weed was removed (2022-04-05) and at harvest (2022-08-30) using the same sampling method as in 2021 (described in 5.2.2). Two sub-samples were collected from each cultivated plot in April 2022, and one sub-sample in August 2022.

5.3 Sampling of soil under ploughing depths

In the spring of 2022, the locations from where the cultivated soils were taken were revisited. At each location, a hole of approximately 70 cm was dug with a spade or with a small excavator. Samples were taken under the ploughing depth to characterise the underlying soil at each of the locations (Figure 5-8). Two sub-samples of soil were collected in sampling bags at each location. One sub-sample was used for soil physical parameters and grain size analyses, while the other sub-sample was stored frozen for future chemical analysis. In addition to these, additional samples were collected using cylinders in the same way as described in section 5.2.2 (Figure 5-9). The cylinder samples were used for soil density and porosity analysis. The ploughing depth was noted, and photos were taken of each soil pit.

Figure 5-8. Soil profile at site PBY004. The brown cultivated soil with higher organic matter content is overlaying a sandier soil layer under the ploughing depth.

Figure 5-9. Cylinder for measuring soil density and porosity was placed at the bottom of the pit below ploughing depth. Pictures from site PBY029.

5.4 Installation of DGT devices

In the autumn of 2020, DGT (diffusive gradient in thin film) devices were installed in three cultivation plots. The DGT were deployed up-side-down in soils heavily irrigated with deionized water (Figure 5-10). The DGT devices were covered by soil sampling bags to prevent drying of the soil. Styrofoam plates of 30x40 cm were placed on top of the plastic bags on the DGT devices to ensure a steady temperature throughout the experiment. Smaller blocks of cement were placed on top of the expanded polystyrene to give some pressure on the DGT to maximize the contact between the soil and DGT device. The deployment area was coved by plastic to further inhibit drying of the soil. The soil was irrigated thoroughly around the deployment area to make sure that saturated conditions were kept. When the DGT devices were collected after the deployment, they were carefully rinsed with deionized water, put in diffusion tight bags, and sent to the lab. The DGT devices were kept cold prior to analysis.

The DGT devices were bought from DGT Research. Three replicates of two different DGT types (Chelex and Feox) were deployed for each time step. Three deployment times were tested: 1, 3 and 7 days. This was done on three different agricultural soils (PBY003-2, PBY004-6 and PBY005-9). Thus, in total 54 DGT devices were deployed. Additionally, three blanks for the Chelex DGT and two blanks for the Feox DGT were analysed at the laboratory (ALS Scandinavia).

Figure 5-10. Installation of the DGT devices.

5.5 Selection of crops for the cultivation experiment

The selection of crops for the cultivation experiment considered several parameters. The goal was to include a wide variation of crop types in terms of biochemical properties, and simultaneously select crops that are likely to be part of the staple food and grow well under the prevailing conditions in the area. The major crop categories specified by IAEA (IAEA 2010) were used as basis for the selection of suitable crops representing different plant families (Table 5-1). The aim was to grow crops with a variety of different edible parts such as leaves roots, fruits, and seeds. An additional criterium was that the selected crops should grow well under Swedish conditions.

In 2020 and 2021, all crops listed were cultivated. Cereals (wheat, barley, rye and oats) did not grow well and could not be sampled. Therefore, cultivation in year 2022 focused on growing only cereals (wheat, barley, rye and oats).

Table 5-1. Selected crops and corresponding IAEA category and plant family.

Crop	IAEA crop category	Family
Swiss chard Spinach (sv Mangold)	Leaf vegetables	Amaranthaceae
Lettuce (sv sallad)	Leaf vegetables	Asteraceae
Kale (sv grönkål)	Leaf vegetables	Brassicaceae
Parsley (sv persilja)	Leaf vegetables	Apiaceae
Zucchini (sv zucchini)	Non-Leafy vegetables	Curcubitaceae
Tomato (sv tomat)	Non-Leafy vegetables	Solanaceae
Haricot vert (sv brytböna)	Legumes	Fabaceae
Split Pea (sv brytärt)	Legumes	Fabaceae
Wheat (sv vete)	Cereals	Poaceae
Barley (sv korn)	Cereals	Poaceae
Rye (sv råg)	Cereals	Poaceae
Oats (sv havre)	Cereals	Poaceae
Carrot (sv Morot)	Root crops	Apiaceae
Beetroot (sv rödbeta)	Root crops	Amaranthaceae
Radish (sv räddisa)	Root crops	Brassicaceae
Potatoes (sv potatis)	Tubers	Solanaceae
Artichoke (Jordärtskocka)	Tubers	Asteraceae

5.6 Sampling of crops in the cultivation plots at the Byle site in 2020 and 2021

Samples of crops were collected at the time of normal harvest. In both 2020 and 2021 representative edible parts of the crops were sampled. Additionally, in 2021, some of the crops were sampled, including various plant parts, to study the uptake of different elements in various plant organs. The crop parts that were sampled for each crop are described in Chapter 6.

5.6.1 Harvest and sample treatment of edible parts of crops

In both years, the sampling procedure was the same: the crops were harvested and all plants were rinsed thoroughly with tap water to remove the soil (Figure 5-11 upper left picture). After rinsing with tap water, the sample was rinsed with deionised water to remove potential ions from the tap water. The samples were then dried at 70 °C for 24 hours (Figure 5-11 lower left and right picture). Protective gloves were used during all steps of the sampling and sample treatment. The dried samples from 2020 were stored at room temperature in sample bags before sending the samples to the laboratory, while the dried samples from 2021 were stored frozen before analysis.

In 2021, an additional sub-sample was prepared for many of the samples as an archive sample. This sample was larger (approximately 50 g wet weight) and was frozen directly after rinsing. The wet weights of the samples were recorded before freezing, see Appendix B. Available archive samples are listed in Appendix A.1. Archive samples are missing for artichoke, haricot verts (green beans), tomato and zucchini. All samples were weighed before and after drying, see Appendix B. The total weight of most of the crops at harvest was measured to estimate the productivity, see Appendix B.

Figure 5-11. Sample preparation of crops. Upper left picture shows rinsing of crops using tap water, lower left picture shows rinsed crops ready for drying and the right-hand picture crops in the oven ready for drying.

5.6.2 Sample treatment of the roots

The roots of kale, split pea and swiss chard spinach were sampled in 2021. The soil was removed from the roots by hand in the field and the roots were rinsed first with tap water and then with deionized water and scrubbed in the sample preparation laboratory to remove as much of the soil as possible (Figure 5-12). After rinsing and scrubbing, the roots of kale and split pea were dried and stored frozen until analysis. The root samples from swiss chard spinach were rinsed and then frozen, without drying.

Figure 5-12. Sample preparation of the roots. Here is an example of roots of kale directly after sampling (upper left picture), cleaned roots (right picture) and scrubbed roots ready for drying (lower left picture).

5.7 Cultivation of cereals in 2022

5.7.1 Sowing of cereals

In 2022 wheat, rye, oats, and barley were cultivated on all of the 18 plots from 2021. Sowing was done according to a specific protocol to ensure that the results were comparable between the plots but also to mimic the sowing procedure of large-scale local farming practices as closely as possible.

Each plot was divided into four 0.5 m^2 parts, one for each cereal type. The recommended seed density (gram of seed per m^2) used by the local farmers in the area was used to determine the mass of seeds per plot (Scandinavian seed 2022). The seeds were therefore weighed and packed in plastic wrap prior to sowing, creating 18 small packaged of each seed type. The masses (g) used per plot are listed in Table 5-2. To ensure that the seed was evenly spread out on each plot, sowing was conducted in a wooden frame with four 0.5 m^2 squares (0.71 m x 0.71 m). Within each square five rows of seed were sown (15 cm between the rows), see Figure 5-13. The location of each square was marked by placing small wooden sticks in each corner which made it possible to locate the squares after the wooden frame was removed.

After sowing, a net was placed over all 18 plots to protect the plots from scavenging Corvids and other animals.

A mistake was made during sowing of plot PBY003, whereby rye was sown in two of the squares instead of wheat. This resulted in missing wheat samples from this plot.

Table 5-2. Recommended seed quantities per hectare is recalculated to gram used per plot part of 0.5 m^2 (Scandinavian Seeds 2022).

	kg per ha	gram used per plot
Oats	200	10
Wheat	220	11
Rye	130	6.5
Barley	170	8.5

Figure 5-13. Seeds were carefully weighed before sowing (left panel). Sowing was done in five rows, 15 cm apart within the wooden frame of 0.5 m^2 (right panel).

5.7.2 Harvesting and sample treatment of the cereals

Harvesting was done in September 2022 after a few days of dry weather so that the cereals were dry during sampling. The ear (grain bearing tip of the stem) was removed using scissors and all the ears were collected from each cereal type and plot. The remaining part of the above ground plant (the stems and leaves) were also collected using scissors, resulting in one sample of grain and one sample of stems and leaves of each cereal and plot.

The grain samples were stored indoors, at room temperature, before the samples were divided into three different subsamples. Two smaller sub-samples (10 – 50 g) were prepared by hand, one sample for chemical analyses and one archive sample to be stored for later use. The seed were removed from the ear by grinding by hand and using an airpistol to separate the seeds from the rest of the ear. Protective gloves were used during sample preparation. A third sub-sample was created by threshing the remaining part of the axes in a threshing machine at Swedish University of Agricultural Sciences in Uppsala. This larger sample created by threshing can be used to measure the production of seed (mass) and should not be used for chemical analysis due to the risk of contamination using the threshing machine. The weight of each sub-sample was recorded. The sub-samples were stored frozen after sample preparation.

The stems and leaves were dried in a shelter (not heated) for some three months and then weighed. A small sub-sample of stem was collected from all four cereal types from the plots PBY004, PBY029, PBY030 and PRA001, these samples are stored frozen (listed in Appendix A).

5.8 Technical installations and maintenance

5.8.1 Preparation of soil plots

The 18 cultivation plots were prepared by tilling (sv. fräsning), removing weed, and smoothing the plot using a rake and a garden pickaxe in years 2021 and 2022 (Figure 5-14). In 2020, the plots were newly installed, and the soil was already mixed and weed was not present at the start of the growing season, thus, no soil preparation was needed.

Figure 5-14. Tilling of the cultivation plots in 2022. The right picture shows the results after tilling and smoothing process.

5.8.2 Irrigation system and watering

Water from a local artesian spring close to the cultivation plots was used for irrigation of the cultivation experiment (Figure 5-15). Archive samples of the spring water are kept for future reference purposes. In year 2020, the irrigation was performed by sprinklers at intervals based on experience and actual rainfall. In general, watering was performed once or twice a week.

In years 2021 and 2022 irrigation was performed by a more sophisticated irrigation system which sprayed small droplets over the plots in a regular pattern. Each plot was covered by three sprinklers with adjustable nozzles. During the growing season the nozzles were adjusted for the individual plots in order to achieve an even water supply to keep the moisture content around field capacity (pF=2). The water content of the soils was measured using TDR-equipment (Time Domain Reflectometer) (cf. section 5.8.3 and 6.3). In general, irrigation was performed once or twice a week.

Figure 5-15. The artesian natural spring used for irrigation of the cultivation plots (upper). In 2020 irrigation was performed by sprinklers at regular interval (lower left), and 2021 an adjustable sprinkler system with continuous moisture measurements was installed (lower right).

5.8.3 TDR-equipment

In 2021 and 2022 the soil moisture content was measured using two types of TDR equipment (Time Domain Reflectometer). Stationary TDRs, logging the soil water content continuously during the whole growing season, were installed in five of the plots. The five plots that got a TDR device installed were: PBY003, PBY004, PBY029, PBY032 and PRA003. The other TDR type was a handheld TDR equipment that was used to take direct measurements of the soil. The information from the TDR was used to regulate the irrigation.

TDRs were installed at root depth of the plots, approximately 10 cm below the ground surface. The sensors were placed at around 45-degree angle to vertical with the two conductors placed one above 10 cm and one below 10 cm. This measured the water content of a profile of the soil from around 9 cm to 14 cm depth. The TDRs were placed at the center point of the selected plots before the crops were planted/sown.

5.8.4 Fertilisation

In the cultivation experiment in 2020 each cultivation plot was divided into two parts where one side was fertilised, and the other was not. Liquid mineral fertiliser was added at regular occasions by manual watering. The amount of fertiliser used was recorded and a sample of the water containing the mineral fertiliser was collected for reference. In total, slightly less than two litres of concentrated fertiliser were used for all plots spread over ca eight occasions.

In years 2021 and 2022 no fertilisation was used.

5.8.5 Weather station

An automatic weather station was installed at the site for the cultivation plots during the summer 2021 (Figure 5-16). Continuous measurements of temperature, humidity, precipitation, atmospheric pressure, insolation, and wind were recorded for reference purposes.

Figure 5-16. The automatic weather station installed during the summer 2021.

5.8.6 Pest and weed control

In all three years (2020, 2021 and 2022), an electric fence was installed around the cultivation experiment area to protect from animals such as wild boar (Figure 5-17).

In 2021, kale plants were protected by a small net tunnel during the first part of the growing season to protect from insects. The whole cultivation plots were later protected by a coarser net to protect from birds, especially a family of crows that showed extraordinary interest in the experiments.

Weeds were cleared by manual methods at regular intervals to keep the soil bare and free of weeds during the whole growing season.

Figure 5-17. Kale plants were protected from insects by a small net tunnel, and later bird nets protected the whole cultivation plots. An electrical fence surrounded the whole area to protect from larger animals.

6 Results – Regolith samples

The results in this report comprise lists with all samples collected, prepared, and stored for analysis during 2020, 2021, and 2022. The final selection of samples for analysis and results from these analyses are presented in coming SKB reports.

For most samples listed below, additional archive samples are available for analysis. The samples with archive samples missing are the samples collected in the spring of 2020: PBY001_GYT, PBY002_ALG, PBY003_TRV and samples collected in June 2020: PBY003, PBY004, PBY005.

6.1 Overview of regolith samples for characterisation

In total, 52 regolith samples were taken. In Table 6-1 all natural regoliths sampled in 2020 and 2021 are listed together with sampling depth, field classification, sampling time, and sampling location. In Table 6-2 four samples of cultivated soils from the Byle area are listed. These samples represent cultivated soils, but were not included in the cultivation experiment (c.f. 4.1.4). In Table 6-3, soils included in the cultivation experiment are also listed. In 2020 soil samples from nine plots were taken, three of the soil samples were taken in June and six samples were taken in September. In 2021, all 18 plots were sampled at the time of sowing in June and once again at harvest in August. Soil cylinder samples were taken in all 18 cultivation plots to analyse soil physical properties. In 2022, all 18 plots were sampled both at the time of sowing in June and once again at harvest.

Coordinates for each sampling point are found in Appendix C.

Table 6-1. All sampling points and natural soil samples from Forsmark and the Byle site that were sampled in 2020 and 2021.

Sampling point	Sample ID	Soil classification	Sampling depth (m)	Sampling time
Forsmark				
230321	230321:2	Sand	unknown	Spring 2021
	230321:5	Till	Approx. 2	Spring 2021
	230321:8	Till	Approx. 2	Spring 2021
Byle site				
PBY001*	PBY001_GYT	Gyttja clay	c. 1.0	Spring 2020
PBY002*	PBY002_ALG	Algae gyttja	c. 1.5	Spring 2020
PBY006*	PBY006_TRV	Peat	0.2 – 0.2	Spring 2020
PBY007**	PBY007_1	Peat ox	0.05 – 0.1	Autumn 2020 and 2022
	PBY007_2	Peat	0.15 – 0.3	Autumn 2020 and 2022
PBY008**	PBY008_1	Peat	0.05 – 0.1	Autumn 2020 and 2022
	PBY008_2	Peat	0.15 – 0.3	Autumn 2020 and 2022
PBY009**	PBY009_1	Peat	0.05 – 0.1	Autumn 2020 and 2022
	PBY009_2	Peat	0.1 – 0.2	Autumn 2020 and 2022
PBY010	PBY010_1	Gyttja clay	0.5 – 0.8	Autumn 2020
	PBY010_2	Sand	0.8 – 0.9	Autumn 2020

Sampling point	Sample ID	Soil classification	Sampling depth (m)	Sampling time
	PBY010_3	Glacial clay	0.9 – 1.4	Autumn 2020
	PBY010_4	Glacial clay	1.4 – 2.5	Autumn 2020
PBY011	PBY011_1	Till	1.1 – 1.45	Autumn 2020
	PBY011_2	Till	1.45 – 2.5	Autumn 2020
PBY012	PBY012_1	Gyttja clay	0.4 – 1	Autumn 2020
	PBY012_2	Glacial clay	1.1 – 2	Autumn 2020
	PBY012_3	Till	2 – 2.5	Autumn 2020
PBY013	PBY013_1	Gyttja clay	0.8 – 1.4	Autumn 2020
	PBY013_2	Till	1.5 – 3.5	Autumn 2020
PBY014	PBY014_1	Sand	1 – 1.5	Autumn 2020
	PBY014_2	Glacial clay	1.5 – 2.5	Autumn 2020
PBY015**	PBY015_1	Peat ox	0.05 – 0.1	Autumn 2020 and 2022
	PBY015_2	Peat	0.15 – 0.3	Autumn 2020 and 2022
	PBY015_3	Peat	0.3 – 0.4	Autumn 2020 and 2022
PBY016**	PBY016_1	Peat ox	0.05 – 0.1	Autumn 2020 and 2022
	PBY016_2	Peat	0.2 – 0.3	Autumn 2020 and 2022
	PBY016_3	Gyttja clay	0.5 – 0.6	Autumn 2020 and 2022

** no archive sample is available for this sample*
*** No archive samples were taken in autumn 2020, the sites were sampled again in autumn 2022.*

Table 6-2. Cultivated soils sampled at the Byle site, but not included in the cultivation experiments. Sample depth of all the samples is 5 – 10 cm.

Sampling point	Sample ID	Soil classification	Sampling depth (m)	Sampling time
PBY017	PBY017	sandy Gyttja clay	0.05 – 0.1	Autumn 2020
PBY018	PBY018	Glacial clay	0.05 – 0.1	Autumn 2020
PBY019	PBY019	Clayey till	0.05 – 0.1	Autumn 2020
PBY020	PBY020	Clayey till	0.05 – 0.1	Autumn 2020

Table 6-3. List of all samples collected from the cultivated plots included in the cultivation experiment in 2020, 2021 and 2022. Sample depth of all the samples is approximately 10 cm.

Sample ID	Field classification	Sampling 2020		Sampling 2021			Sampling 2022	
		June	Sept.	Soil cylinders June	June	Aug.	April	Aug.
PBY003	Gyttja clay	x*		x	x	x	x	x
PBY004	Till	x*		x	x	x	x	x
PBY005	Glacial clay	x*		x	x	x	x	x
PBY021	Gyttja clay		x	x	x	x	x	x
PBY022	Gyttja clay		x	x	x	x	x	x
PBY023	Till		x	x	x	x	x	x
PBY024	Till		x	x	x	x	x	x
PBY025	Glacial clay		x	x	x	x	x	x
PBY026	Glacial clay		x	x	x	x	x	x
PBY028	Clayey till			x	x	x	x	x
PBY029	Clay			x	x	x	x	x
PBY030	Organic soil			x	x	x	x	x
PBY031	Clay			x	x	x	x	x
PBY032	Organic soil			x	x	x	x	x
PBY033	Organic soil			x	x	x	x	x
PRA001	Glacial clay			x	x	x	x	x
PRA002	Glacial clay			x	x	x	x	x
PRA003	Glacial clay			x	x	x	x	x

** no archive sample is available for this sample*

6.2 Root soil samples

The soil in close proximity to the root was sampled for Swiss chard spinach, kale and split pea (Table 6-4). For Swiss chard spinach it was possible to sample the soil close to the root in all the plots. However, for kale and split pea, between six and ten plots were sampled. For three of the plots it was possible to sample the soil close to the root for all three crops.

Table 6-4. Sampling of soils close to the roots of the crops.

IDCODE	Kale	Split pea	Swiss chard Spinach
PBY003		x	x
PBY004	x		x
PBY005			x
PBY021			x
PBY022			x
PBY023	x		x
PBY024	x		x

IDCODE	Kale	Split pea	Swiss chard Spinach
PBY025	x		x
PBY026	x		x
PBY028			x
PBY029			x
PBY030	x	x	x
PBY031	x		x
PBY032		x	x
PBY033		x	x
PRA001	x		x
PRA002	x	x	x
PRA003	x	x	x

6.3 TDR data

TDR data was successfully collected for all five plots; PBY003, PBY004, PBY029, PBY032, and PRA003. The measured data from these plots can then be extended to other plots with similar texture and organic matter content.

6.4 DGT samples

DGT devices of two different types were deployed in three cultivation plots. Three replicates for each of the three time steps in each soil were deployed, making it a total of 54 DGT devices. In total 19 DGT devices with Chelex and 16 DGT devices with iron oxide (Feox) were successful (Table 6-5). In the remaining DGT devices the gel had dried during storage.

Table 6-5. Number of successful DGT devices for each soil and time step.

Chelex

	PBY003_2	PBY004_6	PBY005_9
1 day	1	3	1
3 days	3	3	3
7 days	0	2	3

Feox

	PBY003_2	PBY004_6	PBY005_9
1 day	0	1	2
3 days	3	3	1
7 days	1	2	3

7 Results – Crops and vegetation samples

A large number of crops and natural vegetation were sampled during the years 2020 – 2022. Samples were taken both in Forsmark and at the Byle site.

7.1 Cultivation experiment at the Byle site

7.1.1 Crops sampled in 2020

In 2020, crops were grown on nine plots where half of the plot was fertilised, and the other half was unfertilised. The outcomes from both the fertilised and unfertilised soils were good, and for most crops both gave similar results (Table 7-1). For the tomatoes, the number of available plants was not sufficient for all plots and parsley did not succeed for some soils due to slow growth. Only the edible parts of the crops were harvested in 2020.

Table 7-1. Crops sampled in 2020 both from the fertilised and the unfertilised part of the plots. Most of the crops could be harvested in all plots. Only the edible part of each crop was harvested.

Crop	Artichoke		Barley		Beetroot		Carrot		Haricot vert		Kale		Parsley		Potato		Split pea		Swiss chard Spinach		Tomato		Zucchini*	
Fertilisation	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.
PBY003	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x		x	x
PBY004	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
PBY005	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x		x	x
PBY021	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
PBY022	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
PBY023	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x
PBY024	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x
PBY025	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x	x	x		x	x
PBY026	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x		x	x

*Zucchini seeds are also dried and saved

7.1.2 Crops and crop parts sampled in 2021

In the cultivation experiment conducted in 2021 only unfertilised plots were used. The same nine plots that were used in 2020 were cultivated, as well as nine new soils. Similar to 2020, edible parts of the crops were sampled for each crop and, in addition, other parts of the plant were sampled in some cases (Table 7-2). All archive samples are listed in Appendix A.

Table 7-2. Sampled crops and crop parts from each of the cultivation plots in 2021. *edible part of the plant

	Artichoke	Beetroot		Carrot		Haricot verts	Kale		Parsley	Potato	Radish		Split pea				Swiss chard Spinach		Tomato	Zucchini
	*Tuber	*Root	Leaves	*Root	Leaves	*Pod+seed	*Leaves	Root	*Leaves	*Tuber	*Root	Leaves	*Seed	*Pod	Leaves	Root	*Leaves	Root	*Fruit	*Fruit
PBY003	x	x	X	x	x	x			x	x			x	x	x	x	x	x	x	x
PBY004	x	x	X	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x
PBY005	x	x	X		x	x				x			x	x	x		x	x	x	x
PBY021	x	x	X	x	x	x			x	x	x	x	x	x	x		x	x	x	x
PBY022	x	x	X	x	x	x			x	x	x	x	x	x	x		x	x	x	x
PBY023	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
PBY024	x	x	X		x	x	x			x		x					x	x	x	x
PBY025	x	x	X	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
PBY026	x	x	X		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
PBY028	x	x	X	x	x		x			x	x	x					x	x	x	x
PBY029	x	x	X	x	x	x			x	x	x	x					x	x	x	x
PBY030	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
PBY031	x	x	x	x	x	x	x		x	x	x	x					x	x	x	x
PBY032		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
PBY033	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x	x
PRA001	x	x	x	x	x	x	x		x	x		x					x	x	x	x
PRA002	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x
PRA003	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x

7.1.3 Cereal samples in 2022

Samples of rye, barley, wheat, and oats were collected from all 18 plots with the exception of wheat from plot PBY003 (Table 7-3). A mistake was made during sowing of PBY003 and no wheat seeds were sown. Each sample was divided into three subsamples as described in section 5.7.2.

Table 7-3. List of cereal samples collected in 2022.

	Wheat			Rye			Oat			Barley		
	Sample	Archive sample	Mass sample	Sample	Archive sample	Mass sample	Sample	Archive sample	Mass sample	Sample	Archive sample	Mass sample
PBY003				x	x	x	x	x	x	x	x	x
PBY004	x	x	x	x	x	x	x	x	x	x	x	x
PBY005	x	x	x	x	x	x	x	x	x	x	x	x
PBY021	x	x	x	x	x	x	x	x	x	x	x	x
PBY022	x	x	x	x	x	x	x	x	x	x	x	x
PBY023	x	x	x	x	x	x	x	x	x	x	x	x
PBY024	x	x	x	x	x	x	x	x	x	x	x	x
PBY025	x	x	x	x	x	x	x	x	x	x	x	x
PBY026	x	x	x	x	x	x	x	x	x	x	x	x
PBY028	x	x	x	x	x	x	x	x	x	x	x	x
PBY029	x	x	x	x	x	x	x	x	x	x	x	x
PBY030	x	x	x	x	x	x	x	x	x	x	x	x
PBY031	x	x	x	x	x	x	x	x	x	x	x	x
PBY032	x	x	x	x	x	x	x	x	x	x	x	x
PBY033	x	x	x	x	x	x	x	x	x	x	x	x
PRA001	x	x	x	x	x	x	x	x	x	x	x	x
PRA002	x	x	x	x	x	x	x	x	x	x	x	x
PRA003	x	x	x	x	x	x	x	x	x	x	x	x

7.2 Natural vegetation in Byle and Forsmark

Natural vegetation was sampled in 2020 both at the Byle site and in the Forsmark area (Table 7-4).

Coordinates of the sampling points are found in Appendix C.

7.3 Samples of natural vegetation and pasture at Byle site

At the Byle site two types of samples were collected. Samples from the field layers consisted of carex, common reed, and horsetail (Table 7-4), representing the dominating natural vegetation on the wetland areas of the site. The other type of samples was grass and clover sampled on mineral soils. These samples represent pasture that can be used as feed for cattle.

Table 7-4 Detailed list of natural vegetation and pasture sampled at the Byle site.

SampleID	Layer	Sample description
PBY007	Field layer	*Carex* (Sedge)
PBY008	Field layer	*Carex* (Sedge)
PBY009	Field layer	*Carex* (Sedge)
PBY015	Field layer	*Phragmites australis* (Common reed)
PBY016	Field layer	*Equisetum* (Horsetail)
PBY017	Field layer	Grass plants and clover/grass
PBY018	Field layer	Clover/grass
PBY019	Field layer	Clover/grass
PBY020	Field layer	Clover/grass

7.4 Samples of natural vegetation at the Forsmark site

At the Forsmark site the dominating species were sampled in proportion to the amounts of each species at the sampling point and collective samples were created. This resulted in samples consisting of several species (Chapter 4.2.2). All vegetation samples are listed in Table 7-5.

Table 7-5. Detailed description of natural vegetation sampled at the Forsmark site.

SampleID	Layer	Sample description
AFM001385	Bottom layer	Moss
	Field layer	*Carex* (Sedge)
	Shrub layer	*Myrica gale* (Bog-myrtle)
	Tree layer	*Pinus sylvestris* (Pine)
AFM001387	Bottom Layer	Moss
	Field layer	High, narrow-leaved tussock grass
	Tree layer	*Betula pubescens* (Birch)
AFM001388	Moss	Moss
	Field layer	*Carex* (Sedge) and reed
	Shrub layer	*Myrica gale* (Bog-myrtle)
	Tree layer	*Pinus sylvestris* (Pine)
AFM001389	Bottom layer	Moss

SampleID	**Layer**	**Sample description**
	Field layer	Broad-leaved grass *Carex* reed (Sedge)
	Shrub layer	*Myrica gale* (Bog-myrtle)
	Tree layer	*Alnus incana* (Alder)
AFM001391	Bottom layer	Moss
	Field layer	*Carex* (Sedge)
	Shrub layer	*Myrica gale* (Bog-myrtle)
	Tree layer	*Pinus sylvestris* (Pine)

8 Discrepancies

In general, no significant discrepancies occurred. Samples of cereals were not obtained during the cultivation experiment of 2021 due to crows that ate the planted seeds, despite countermeasures to prevent the crows from accessing the seeds.

The archive regolith samples from 2020 were stored cold but not frozen for the first months before they were moved and then stored frozen. A notification of this is kept in the database for all relevant samples.

9 Discussion

9.1 Data for parameterisation

The sampling campaign described in this report has resulted in a large number of samples of soils, crops, and vegetation. These samples can be analysed and the results used to calculate the K_d and CR values needed in the radionuclide transport model (see section 1.1). A summary of the number of available samples that can be analysed for each parameter is presented in this section. The final sample selection and results of the analyses will be reported in an upcoming SKB reports.

In Table 9-1 all available samples from previous studies ("existing data") and the samples collected in this study are listed. For the K_d parameter of natural regolith types, between three and six samples have been added to each compartment in the radionuclide model. This resulted in a doubling of available samples for almost all parameters. Three new sand samples were added, noting that no data for sand were available before this study.

For agricultural soils, new samples have been added, resulting in seven samples from cultivated organic soils (kD_regoUp_drain) and 15 samples of cultivated mineral soils (kD_regoUp_garden, kD_regoUp_io). In addition, some of the cultivated soils were sampled multiple times at different time points.

Table 9-1. Number of samples (N) available for each parameter are listed in the table, including both existing K_d data from previous SKB studies and samples added in this study. The total number of samples (Total N) represents the summary of available samples for each parameter.

	Existing data		Added in this study		Total N
	N Forsmark	N Laxemar*	N Bylegård	N Forsmark	
K_d regolith layers					
Till (Kd_regoLow)	7	1	4	2	13
Glacial clay (kD_regoGL)	5		4		9
Gyttja clay (kD_regoPG)	5	2	6		11
Peat (reducing) (kD_regoPeat)	6		6		12
Peat (oxidising) kd_regoUp_ter)	5	1	5		10
Sand (kD_rego_sand)			2	1	3
K_d agricultural soils					
Cultivated peat and gyttja clay (kD_regoUp_drain)	10		7		17
Cultivated clayey till or glacial clay (kD_regoUp_garden, kD_regoUp_io)	10		15**		25

* These samples have not been used in Tröjbom et al. (2013)
** Including samples from the Rasbo site

A large number of crop samples have been collected in 2020, 2021 and 2022. The crops will later be grouped into parameters for different types of foods. One possible grouping could be cereals, root crops, tubers, vegetables, and mire vegetation as in Table 9-2.

Table 9-2. A suggestion for division of crops between different parameters.

Crop group	Crops included
Cereals (cR_ter_ceral)	Barley, Oats, Rye, Wheat
Root crops (cR_agri_root)	Beetroot, Carrot, Radish
Tubers (cR_ter_tuber)	Potato, Artichoke
Vegetables (cR_agri_veg)	Haricot vert, Kale, Split Pea, Swiss chard Spinach, Parsley, Tomato, Zucchini

In Table 9-3, the total number of unique crop/soil combinations are listed per crop type. Hence when the same soil has been sampled both in year 2020 and 2021, or from fertilised and unfertilised soils, these repeated samplings have not been added in the summation. The number of new samples per crop type is largest for vegetables (110).

Table 9-3. The number of samples (N) available for each parameter are listed in the table, including both existing CR data from previous SKB studies and samples added in this study. The total number of samples (Total N) represents the summary of available samples for each parameter. In the table, the number of replicates from two growing seasons and fertilised soils are also listed.

Crop type	Existing data		Added in this study		Total N
	N Forsmark	N Laxemar	N Byle site	N Forsmark	
Cereals[a]	10	0	80	0	90
Root crops[b]	0	0	44	0	44
Tubers[c]	0	0	36	0	36
Vegetables[d]	0	0	110	0	110
Pasture[e]	0	0	4	0	4
Mire vegetation[f]	15	8	3	19	45

a. Barley, Barley, Oats, Rye, Wheat
b. Beetroot, Carrot, Radish
c. Potato, Artichoke
d. Haricot verts, Kale, Split Pea, Swiss chard spinach, Parsley, Tomato, Zucchini
e. Common reed, Horsetail, Grass plants, clover/grass.
f. Carex, moss, Myrica gale, Pine, High narrow-leaved tussock grass

10 References

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Appendix A – Archive crop samples

Crop samples from 2020 are already analyzed and therefore not stored as archive samples. In 2021, one screening sample was prepared for each crop and crop part. These samples were rinsed and dried before freezer storage and are listed in Table 7-2. In addition, a larger “archive sample” was prepared for many of the crop and crop parts. This sample was rinsed and then stored in freezer without drying. The archive sample was larger, approximately 50 g wet weight and can be used for additional analyses as for example Ra- analysis that requires a larger amount of sample. The existing archive samples are listed in Table A-1. Archive samples are missing for artichoke, haricot verts (green beans), Swiss chard Spinach, tomato and zucchini.

All available archive samples from 2021 are listed in A1.

In 2022 three subsamples were created from each cereal sample. One is a screening sample that can be used for chemical analyses, and one is an archive sample that will be stored frozen and can be used for additional analyses if needed. The third sub-sample is a larger sample created when the remaining part of the ears was threshed in a threshing machine, this sample is used for measuring the production of seed (mass) and should not be used for chemical analysis of metals due to the risk of contamination, see Table 7-3.

In addition, a sub-sample of stem was collected from all four cereal type from the plots PBY004, PBY029, PBy030 and PRA001 as listed in A2

A1. Archive samples of crops samples from 2021. The samples were rinsed and then frozen directly, without drying. The wet weights of these samples are listed in Appendix B, Table B-6. Missing samples are marked with gray color in the table.

	Artichoke*	Beetroot		Carrot		Hari cot verts*	Kale	Parsley	Potato	Radish		Split Pea			Swiss chard Spinach	Tomato*	Zucchini*
	Stem	Root	Leaf	Root	Leaf	Pod+seed	Leaf	Leaf	Stem	Root	Leaf	Pea	Pod	Leaf	Leaf	Fruit	Fruit
PBY003		x	x	x	x			x	x			x	x		x		
PBY004		x	x	x	x		x		x			x	x		x		
PBY005		x	x						x						x		
PBY021		x	x	x	x				x	x	x				x		
PBY022		x	x	x	x			x	x	x	x	x	x		x		
PBY023		x	x	x	x		x	x	x			x	x		x		
PBY024		x	x				x		x						x		
PBY025		x	x	x	x		x		x	x	x	x	x		x		
PBY026		X	x				x		x		x	x	x		x		
PBY028		X	x	x	x		x		x	x					x		
PBY029		X	x	x	x			x	x		x				x		
PBY030		X	x	x	x		x	x	x	x	x	x	x		x		
PBY031		X	x	x	x		x	x	x		x				x		
PBY032		X	x	x	x		x		x		x	x	x		x		
PBY033		X	x	x	x		x	x	x		x	x	x		x		
PRA001		X	x	x	x		x	x	x						x		
PRA002		X	x	x	x		x	x	x			x	x		x		
PRA003		X	x	x	x		x	x	x			x	x		x		

*No archive samples for artichoke, haricot verts (green beans), Swiss chard spinach, tomato and zucchini were saved.

A2. Archive samples of stems of cereals sampled in 2022. The samples are stored frozen directly, without drying.

	Oats stem	Barley stem	Wheat stem	Rye stem
PBY004	x	x	x	x
PBY029	x	x	x	x
PBY030	x	x	x	x
PRA001	x	x	x	x

Appendix B – Weights of crops

The masses of the whole crops are listed in Table B-1 B-2 and B-3 for years 2020, 2021, and 2022 respectively. Whole crop weights are missing for artichoke, haricot verts, and tomato from 2021 and from 2020 whole crop weights are missing for many of the crops (artichoke, haricot verts, kale, parsley, split pea, tomato and zucchini).

B-1. Whole crop mass (kg) of crops from 2020 from fertilised soils.

	Barley	Beetroot	Carrot	Potato	Swiss chard spinach
PBY003		0.63	0.17	3.4	4.55
PBY004		0.7	0.11	3.3	2.95
PBY005	3.55 *				
PBY005		0.72	0.31	2.1	4.45
PBY021		0.84	0.25	1.7	
PBY022		0.64	0.18	2.4	
PBY023		0.8	0.16	3.4	
PBY024		0.62	0.083	1.9	
PBY025		0.44	0.15	4.1	
PBY026		0.57	0.023	1.8	

* Weight from non-fertilised soil

B-2. Whole crop mass (kg) of crops from 2021.

	Beetroot	Carrot	Kale	Parsley	Potato	Radish	Split pea	Swiss chard spinach	Zucchini
PBY003	0.50	1.0	0.25		0.5	0.0	0.5	8.1	6.8
PBY004	0.80	1.3	1.00		1.1	0.0	0.1	4.8	9.1
PBY005	1.20	0.2	0.70		0.9			3.8	11.4
PBY021	0.60	1.0	0.26		1.3	0.4		3.7	6.8
PBY022	0.40	0.8	0.04		0.7	0.3	0.3	4.1	6.8
PBY023	1.10	1.2	0.84		0.9	0.1	0.2	2.5	16.0
PBY024	1.60		0.34		1.0			3.4	2.3
PBY025	0.80	0.6	0.82		1.3	1.1	0.2	4.5	11.4
PBY026	0.60		0.70		1.0	0.0	0.1	4.3	16.0
PBY028	3.60	2.5	1.16		1.0	0.1		9.8	11.4
PBY029	2.10	1.0	0.17	0.03	0.5	0.0		5.9	6.8
PBY030	4.60	2.0		0.23	0.5	0.4	1.4	13.0	13.7
PBY031	0.40	1.5			0.6	0.1		6.5	4.6
PBY032	0.20	1.0	0.15		0.3	0.1	0.4	4.3	6.8
PBY033	1.80	3.5	0.58	0.44	1.0	0.3	0.2	9.9	13.7
PRA001	0.20	0.8	0.73	0.04	1.0	0.0		2.6	4.6
PRA002	0.20	1.3	0.84		0.7	0.0	0.7	5.7	9.1
PRA003	0.10	1.3	0.26	0.07	0.6	0.0	0.6	3.9	4.6

B-3. Total mass of cereal above ground parts and total mass of seeds from 2022 in gram.

	Total mass of above ground parts				Total mass of seeds			
	Barley	Oats	Rye	Wheat	Barley	Oats	Rye	Wheat
PBY003	381	688	682		166	271	198	
PBY004	334	881	589	312	144	396	147	162
PBY005	606	1040	834	702	267	434	204	307
PBY021	225	502	552	641	94	228	159	220
PBY022	405	784	589	548	188	313	159	187
PBY023	448	733	507	705	181	303	131	239
PBY024	479	745	567	541	245	360	166	272
PBY025	423	744	719	576	171	300	182	273
PBY026	590	862	810	641	236	336	186	295
PBY028	514	1055	569	911	194	502	112	308
PBY029	263	984	394	882	95	439	107	308
PBY030	670	900	575	687	292	384	144	238
PBY031	406	536	297	733	165	274	64	255
PBY032	372	616	532	511	146	198	126	173
PBY033	502	1169	625	671	171	500	148	235
PRA001	306	797	249	600	119	334	74	209
PRA002	285	647	234	406	110	258	72	137
PRA003	237	862	305	736	87	322	82	247

Appendix C – Coordinates of the sampling points

Coordinates of all the sampling points.

Sampling point	Lat/northing WGS84	Long/easting WGS84	SWEREF99 18 00 N	SWEREF99 18 00 E	Sampling depth (m bgs)	Soil class	Sampling site	Sample type
230321:1-3	NA	NA	6698523.728	159880.746	unknown	Sand	Forsmark	Natural soil
230321:4-6	NA	NA	6698526.265	159887.915	about two meters	Till	Forsmark	Natural soil
230321:7-9	NA	NA	6698526.165	159888.309	about two meters	Till	Forsmark	Natural soil
PBY001	59.782889	18.594453	6630034	183387	1 – 1	Gyttja clay	Byle site	Natural soil
PBY002	59.782889	18.594453	6630034	183387	1 – 1	Algea Gyttja	Byle site	Natural soil
PBY003	59.784595	18.596133	6630225	183480	0.1 – 0.15	Gyttja clay	Byle site	Agricultural soil
PBY004	59.784062	18.592662	6630164	183286	0.1 – 0.15	Till	Byle site	Agricultural soil
PBY005	59.783003	18.592593	6630046	183283	0.1 – 0.15	Glacial clay	Byle site	Agricultural soil
PBY006	59.782972	18.596933	6630045	183526	0.2 – 0.2	Peat	Byle site	Natural soil
PBY007	59.782801	18.597012	6630026	183531	0.05 – 0.1	Peat ox	Byle site	Natural soil and natural veg.
PBY008	59.782963	18.596948	6630044	183527	0.05 – 0.1	Peat	Byle site	Natural soil and natural veg.
PBY009	59.783135	18.596988	6630063	183529	0.05 – 0.1	Peat	Byle site	Natural soil and natural veg.
PBY010	59.783387	18.593528	6630089	183335	0.5 – 0.8	Gyttja clay	Byle site	Natural soil
PBY011	59.783512	18.593923	6630103	183357	1.1 – 1.45	Till	Byle site	Natural soil
PBY012	59.783609	18.594188	6630114	183372	0.4 – 1	Gyttja clay	Byle site	Natural soil
PBY012	59.783609	18.594188	6630114	183372	1.1 – 2	Glacial clay	Byle site	Natural soil
PBY013	59.784038	18.594753	6630162	183403	0.8 – 1.4	Gyttja clay	Byle site	Natural soil
PBY014	59.783172	18.593392	6630065	183327	1 – 1.5	Sand	Byle site	Natural soil
PBY015	59.783865	18.598173	6630145	183595	0.05 – 0.1	Peat ox	Byle site	Natural soil and natural veg.
PBY016	59.783989	18.603888	6630161	183916	0.05 – 0.1	Peat ox	Byle site	Natural soil and natural veg.
PBY017	59.784941	18.597221	6630264	183541	0.05 – 0.1	sandy Gyttja clay	Byle site	Agricultural soil and fodder/natural veg.
PBY018	59.785208	18.596974	6630294	183527	0.05 – 0.1	Glacial clay	Byle site	Agricultural soil and fodder/natural veg.

Sampling point	Lat/northing WGS84	Long/easting WGS84	SWEREF99 18 00 N	SWEREF99 18 00 E	Sampling depth (m bgs)	Soil class	Sampling site	Sample type
PBY019	59.785669	18.596544	6630345	183502	0.05 – 0.1	Clayey till	Byle site	Agricultural soil and fodder/natural veg.
PBY020	59.786221	18.596039	6630406	183473	0.05 – 0.1	Clayey till	Byle site	Agricultural soil and fodder/natural veg.
PBY021	59.784823	18.597213	6630251	183540	0.1 – 0.15	Gyttja clay	Byle site	Agricultural soil
PBY022	59.784397	18.595365	6630203	183437	0.1 – 0.15	Gyttja clay	Byle site	Agricultural soil
PBY023	59.784448	18.594615	6630208	183395	0.1 – 0.15	Till	Byle site	Agricultural soil
PBY024	59.784477	18.593402	6630210	183327	0.1 – 0.15	Till	Byle site	Agricultural soil
PBY025	59.783365	18.593131	6630086	183313	0.1 – 0.15	Glacial clay	Byle site	Agricultural soil
PBY026	59.783193	18.592745	6630067	183291	0.1 – 0.15	Glacial clay	Byle site	Agricultural soil
PBY028	59.792972	18.57024	6631145	182018	0.1 – 0.15	Clayey till	Byle site	Agricultural soil
PBY029	59.785343	18.590195	6630305	183146	0.1 – 0.15	Clay	Byle site	Agricultural soil
PBY030	59.783808	18.59541	6630137	183440	0.1 – 0.15	Organic soil	Byle site	Agricultural soil
PBY031	59.774747	18.57958	6629120	182560	0.1 – 0.15	Clay	Byle site	Agricultural soil
PBY032	59.773583	18.57901	6628990	182529	0.1 – 0.15	Organic soil	Byle site	Agricultural soil
PBY033	59.773233	18.580697	6628951	182624	0.1 – 0.15	Organic soil	Byle site	Agricultural soil
PRA001*	59.961043	17.895289	6649737	144150	0.1 – 0.15	Glacial clay	Uppsala	Agricultural soil
PRA002*	59.968019	17.912510	6650513	145113	0.1 – 0.15	Glacial clay	Uppsala	Agricultural soil
PRA003*	59.971945	17.914729	6650950	145238	0.1 – 0.15	Glacial clay	Uppsala	Agricultural soil
AFM001385	60.3736752	18.180925	6695720	159982		no soil	Forsmark	Natural vegetation
AFM001387	60.3781976	18.1687521	6696222	159309		no soil	Forsmark	Natural vegetation
AFM001388	60.3862757	18.164995	6697121	159099		no soil	Forsmark	Natural vegetation
AFM001389	60.3933778	18.1630591	6697912	158990		no soil	Forsmark	Natural vegetation
AFM001391	60.3754614	18.186456	6695920	160286		no soil	Forsmark	Natural vegetation

*Not the exact location