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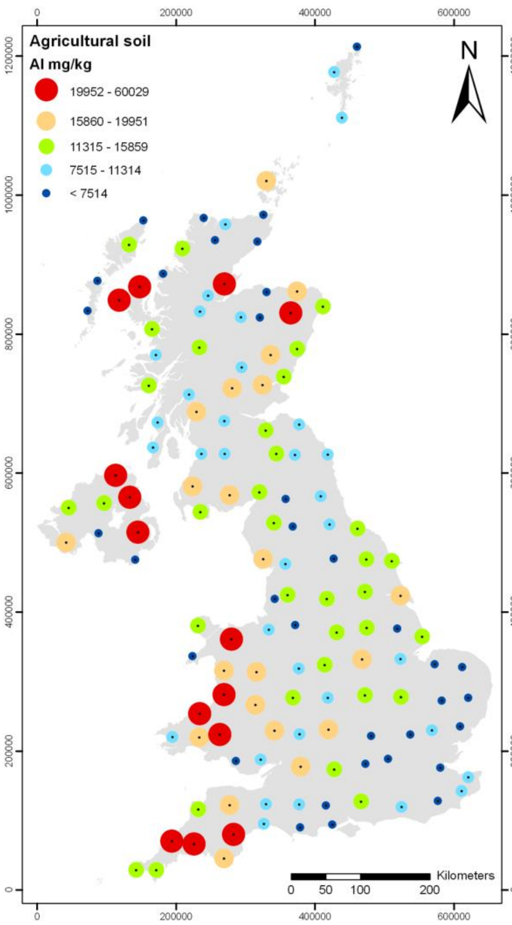
GEMAS - low density geochemical data for arable and grazing land soils of the UK

Geochemical Baselines and Medical Geology Team

Internal Report IR/10/064R



BRITISH GEOLOGICAL SURVEY

GEOCHEMICAL BASELINES AND MEDICAL GEOLOGY TEAM

INTERNAL REPORT IR/10/064R

GEMAS - low density geochemical data for arable and grazing land soils of the UK

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Keywords

Soil geochemistry, agriculutrual soils, aqua regia, EuroGeoSurvey, Europe.

Front cover

Aluminium in arable soils, soil sample pit and soil sampling

Bibliographical reference

SCHEIB A J. 2010. GEMAS - low density geochemical data for arable and grazing land soils of the UK. *British Geological Survey Internal Report*, IR/10/064R. 71pp.

Keyworth, Nottingham British Geological Survey 2010

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Foreword

This report is the published product of a study carried out by the British Geological Survey (BGS) as part of an European-wide project of the EuroGeoSurvey's (EGS) Geochemistry Expert Group (GEG).

Acknowledgements

In addition to BGS staff acknowledged in IR/08/081 that contributed to the collection of soil samples, the author would like to thank colleagues at the State Geological Institute of Dionyz Stur, Slovakia, for sample preparation.

Of the many individuals involved in EGS's Geochemistry Expert Group I would particularly like to thank Clemens Reimann from the Geological Survey of Norway (NGU) for the preparation, quality control and distribution of the aqua regia data.

Contents

FIGURES

TABLES

Summary

This report presents low density geochemical data for arable and grazing land soil from the UK. These soil samples were collected by BGS in 2008 as part of the for EuroGeoSurvey's (EGS) GEochemical MApping of agricultural and grazing land Soil of Europe (GEMAS) project.

The first phase of the project involved the collection of soil samples across each participating country at a sample density of 1 per 2500 km^2. The BGS contribution for the UK is documented in a separate report IR/08/081 (Scheib, 2008). Following collection all samples were prepared and analysed by ICP (AES and MS) following aqua regia extraction. Quality control of the geochemical data was carried out, before each member state received their data individually.

This report provides a primary record and presentation of the soil geochemical data for 49 elements (Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nb, Ni, P, Pb, Rb, S, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Y, Zn and Zr) for the 290 soil samples collected in the UK. Additional to the results of element concentrations this report also presents data on pH, total organic carbon (TOC) and cation exchange capacity (CEC) determined for arable (Ap) and grazing land (Gr) soil samples.

The data are displayed as a series of graduated coloured dot maps alongside basic summary statistics to provide an initial overview of the data.

1 Introduction – The GEMAS project

The GEMAS project was carried out by the Geochemistry Expert Group of EGS in cooperation with Eurometaux and managed for EGS by the Geological Survey of Norway (NGU). Each member Geological Survey of EGS (except the Dutch Survey, TNO) agreed in late 2007/early 2008 to collect the samples needed for the GEMAS project in its country, according to a jointly agreed field procedure.

Eurometaux agreed to fund part of the analytical work in exchange for access to the data as soon as these become available (Reimann, 2009). Eurometaux also applied some restrictions to the usage of data. Hence, this report was published as an Internal BGS report with its earliest public release at the end of 2013. It should be emphasized that none of the data and especially the 90th percentiles should be made available to anyone outside of BGS prior to 2013 without the approval of Eurometaux. One of the restrictions applied, is on the use of Au, Pd, Pt and Re, which have been excluded from this report.

Sampling took place during the summer and autumn of 2008. All samples were shipped to a central sample preparation facility at the State Geological Institute of Dionyz Stur, Slovakia. The State Geological Institute of Dionyz Stur, Slovakia won a Europe-wide tender for sample preparation of the GEMAS samples. Subsequently, all sample analyses were carried out by ACME laboratories in Vancouver, Canada.

The GEMAS project aims to provide harmonized soil geochemical data for agricultural land across Europe.

Thirty four European countries participated, covering an area of 5.6 million km^2 at a sample density of 1 site per 2500 km^2, collecting one sample from arable land (0-20 cm) and land under permanent grass cover (0-10 cm) each. By late 2008 project participants collected a total of 2211 soil samples from arable land (named “Ap”) and 2118 from permanent grazing land (“Gr”) from a large part of Europe (Figure 1). Both sample types were collected in close vicinity were possible (< 500 m), with the aim to investigate the geochemical difference and effect of farming practices on the soil environment.

Resultant data will provide support to policy makers and those tasked with implementing policy as well as underpinning international collaborative research in topics such as agricultural productivity and trace element status and forensic food geochemistry. A sample archive to support future analyses will also result (Reimann, 2008).

Data from the GEMAS project will support REACH (Registration, Evaluation and Authorisation of Chemicals), the new European Chemicals Regulation, adopted in December 2006 and which came into force on the 1st June 2007. REACH, as well as the pending EU Soil Protection Directive, require additional knowledge about "soil quality" at the European scale.

The following sections present geochemical data for 49 elements, pH, TOC and CEC for both Ap and Gr samples collected across the UK only.

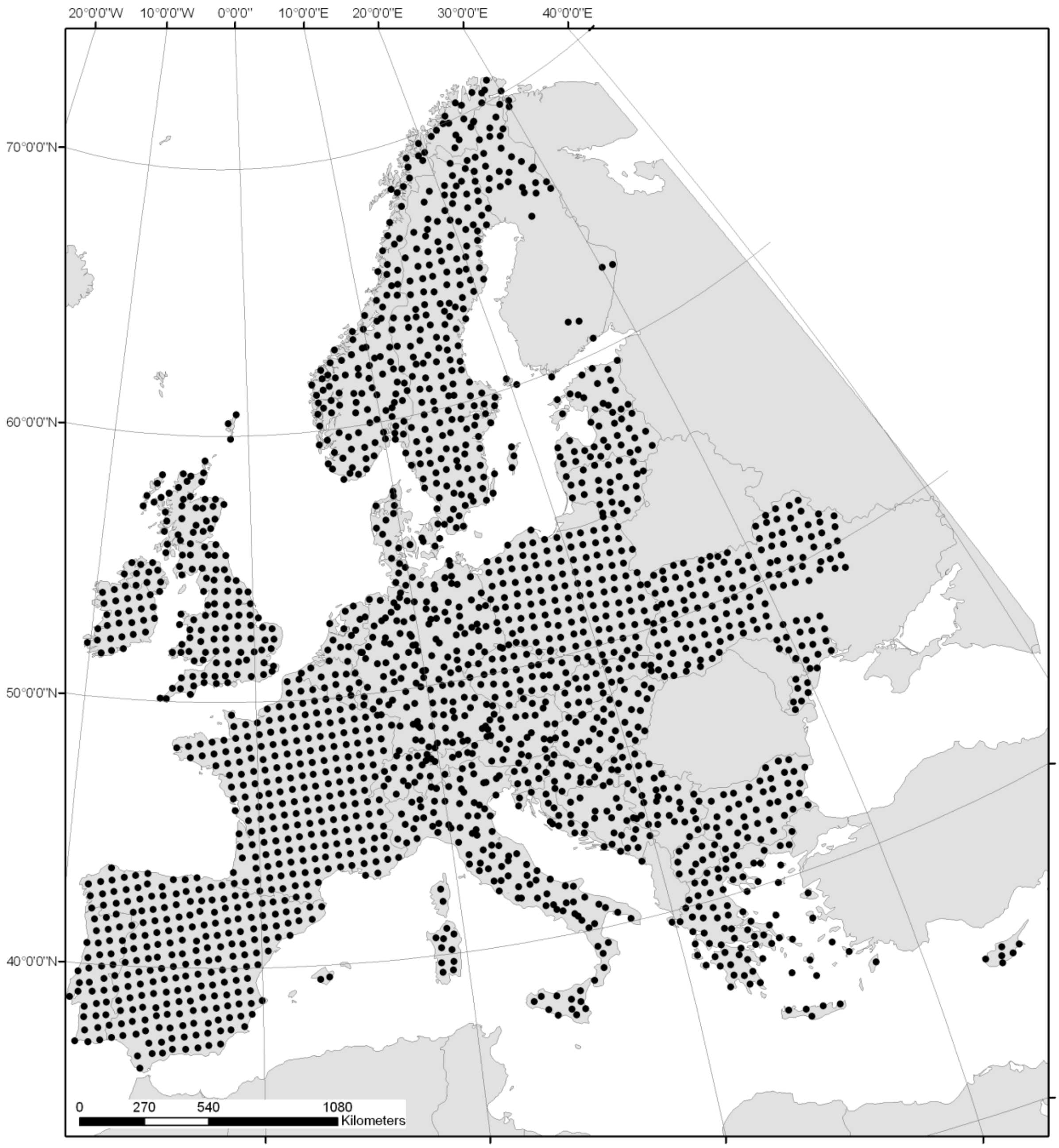


Figure 1. Sample site locations of grazing land soil (Gr samples; n=2118), EGS-GEMAS project.

2 Methods

2.1 SOIL SAMPLING

As mentioned in the introduction, samples were collected following jointly agreed protocols which are documented in more detail by Reimann (2008). This section gives only a brief outline of the GEMAS sampling methods as a detailed report on BGS's GEMAS sampling campaign has already been published by Scheib (2008).

The whole of the UK was divided into 138 equal 50 x 50 km grid cells from which the two different sample types were collected:

- **Ap** sample: the ploughing layer on arable lands at 0 - 20 cm
- **Gr** sample: the topmost part of soil on grazing land (permanent grassland) at 0 - 10 cm

Each sample site was located as close as possible to the centre of the grid cell as well as to each other. The individual soil sample was taken with a stainless steel spade and made up of a composite of 5 sub-samples from the corners and centre of a 10 x 10 m square. Samples were packed in a labelled Rilsan® bag weighing approximately 2 - 2.5 kg each.

Photographs were also routinely taken at each sampling site. Figure 2 below show some examples of sites and soil profiles.

Figure 2. Examples of photographs of sample sites and soil profiles that were taken routinely at sample sites

Figure 3 shows the distribution of site locations of Ap and Gr samples across the UK. In total BGS collected 138 samples of each sample type plus an additionally seven duplicate samples at Ap and seven at Gr sites.

In each sampling grid cell, samplers set out to collect Ap and Gr samples as close as possible to each other to maximise the probability of same parent material. In only a few cases in Scotland both sample types were located much further apart mainly due to the lack of arable land (Scheib, 2008).

Based on the coordinates recorded for each sample site, the average distance between an Ap and Gr site within one sampling cell is 1165 m. The median distance however is only 183 m. This is due to some 20 sites with distances greater than 1500 m. The maximum distance between an Ap and Gr samples measured 18.9 km (Sample ID 119). The shortest distance measured is 10 m. Overall, for approximately 75 % of the sampling cells the distance between an Ap and Gr samples is less than 500 m.

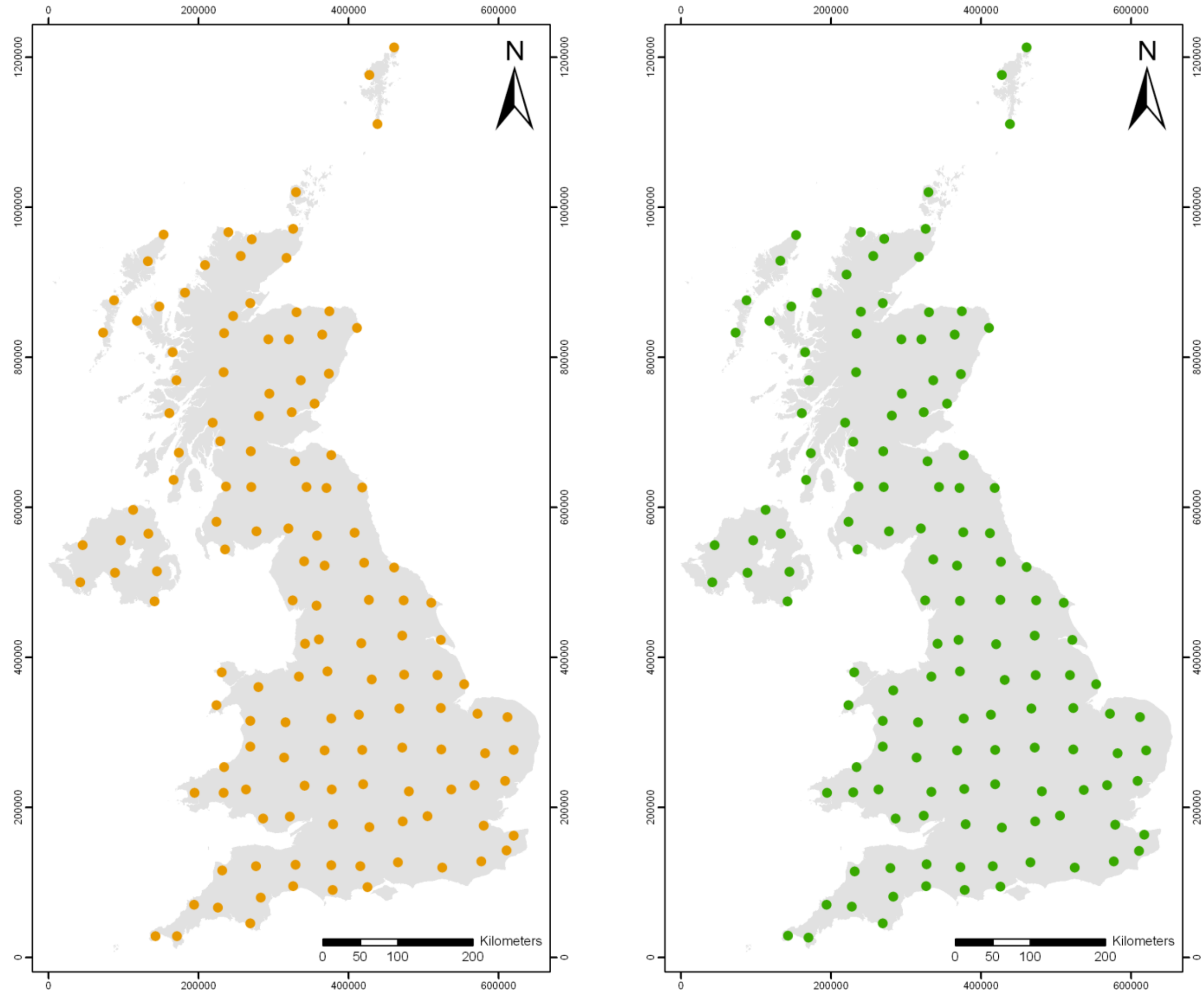


Figure 3. Site locations of Ap (left) and Gr (right) samples across the UK.

2.2 SAMPLE PREPARATION AND ANALYSIS

Following sampling, all soil samples were sent to the laboratory of the State Geological Institute of Dionyz Stur, Slovakia for sample preparation. There samples were air dried, sieved to < 2 mm using a nylon screen, homogenised and split into sub-samples. A total of 10 splits were prepared from each soil sample, 4 splits of 200 ml in volume each for storage, 2 splits of 100 ml in volume and 4 splits of 50 ml each for distribution to the laboratories carrying out the analytical work. The laboratory of the State Geological Institute of Dionyz Stur, Slovakia, which has the necessary equipment and a long experience in the preparation and certification of international reference materials, also prepared the two project bulk standards, Ap and Gr. Large amounts of the project standards are required to monitor the quality of analytical results, These standard samples should not be recognisable by the receiving laboratory once spread among project samples (Reimann, 2009).

After all GEMAS soil samples were received (no samples arrived from Albania, Belarus and Romania), NGU prepared a list of random numbers for each sample set, allowing for the insertion of one field duplicate, one analytical replicate of the field duplicate and the project standard per batch of 20 samples.

On completion of sample preparation, all samples were shipped to ACME laboratories in Vancouver, Canada, which won the international tender for the analysis of the GEMAS samples using aqua regia extraction. At ACME the mineral soil samples underwent a modified aqua regia digestion prior to analysis. A weight of 15 g of the sieved mineral soil samples (<2 mm) were digested in 90 ml aqua regia (nitro-hydrochloric acid) and leached for one hour in a hot (95 °C) water bath. After cooling, the solution was made up to a final volume of 300 ml with 5% HCl.

The sample weight to solution volume ratio was 1 g per 20 ml. The solutions were analysed using a Spectro Ciros Vision inductively coupled plasma atomic emission spectrometer (ICP-AES) and a Perkin Elmer Elan 6000/9000 inductively coupled plasma emission mass spectrometer (ICP-MS). In addition to the project standards and duplicate samples that were unknown to ACME , the laboratory inserted its own project standard and analytical replicates, and analytical results for these samples were reported separately. Finally, approximately 5000 samples were analysed by ACME labs for 53 chemical elements within a time span of 20 days from receiving the samples to final delivery of analytical results (Reimann, 2009).

The parameter TOC was determined using infra-red (IR), CEC by using the silver-thiorurea method and pH of the soil suspension method with 1M $CaCl_2$.

2.3 QUALITY CONTROL

The soil geochemical data for samples collected in the UK already underwent quality control (QC) measures that were carried out on the whole dataset. Detailed results and conclusions are documented in the report by Reimann (2009) and can be downloaded at http://www.ngu.no/no/hm/Publikasjoner/Rapporter/2009/2009-049/ (free of charge).

Results of quality control of the analytical results following an aqua regia extraction presented in the above report indicate excellent overall quality. No serious time trends (drifts) and no breaks (shifts) in element concentration between batches were observed. Quality control using the hidden project QC-samples returns comparable results to QC carried out with the laboratories' own control samples (Reimann, 2009).

For a number of elements the majority of the analytical results are very close to the detection limits (e.g., Ge, Pt, Pd, Re, Ta, Te) and it is here that some quality problems are observed. In all instances where poor precision was observed this was due to very low concentrations (Reimann, 2009).

The main quality related issues detected were occasional, sometimes severe, outliers for single elements for the standard or one replicate analysis. However, these outliers always occurred for single elements and single samples and not as a systematic problem. Elements that showed such outliers include B, Ca, Cu, S and Sn. They must probably be seen as "system inherent" and unavoidable when using aqua regia extraction on a single sample (Reimann, 2009).

Results of the unbalanced ANOVA indicate that most elements can be reliably mapped. Exceptions are Pt, Pd, Re, Ta, Ge, and Te, where maps (for both Ap and Gr) must be viewed with great care, due their analytical results. In the case of Ge, Ta and Te, which feature in this report, a large proportion are below the practical detection limit and ANOVA results show an analytical variance between 45 and 65 % in Ap samples and 33 to 42 % in Gr samples.

However, due to the fact that all samples were randomised prior to analysis, multi-sample anomalies will still be reliable even for these elements. ANOVA also demonstrated that the main problems with technical variability occur at the analytical level. This indicates that the GEMAS sampling as such was fit-for-purpose (Reimann, 2009).

3 GEMAS Data for the UK

3.1 SUMMARY OF SOIL GEOCHEMICAL DATA

The following sections present geochemical data of a total of 49 elements (excluding Au, Pt, Pd and Re, which are restricted) for Ap and Gr samples collected in the UK. Two maps are shown for each element, displaying the data as graduated coloured dots that correspond to 25^{th}, 50^{th}, 75^{th}

and 90th percentiles classes. Additionally to the maps, cumulative probability plots are added to show the data distribution where the concentration (x-axis) displays the lognormal.

Table 1. Summary of descriptive statistics of element concentrations in Ap soils (mg/kg)

	Agricultural soil (Ap)						
Element	**min**	**25th**	**median**	**75th**	**max**	**mean**	**pDL[1]**
Ag	0.006	0.039	0.055	0.089	1.801	0.092	0.007
Al	749	7514	11314	15859	60029	12541	4
As	0.4	5.3	7.4	11.3	56.9	9.3	0.005
B	< pDL	1.8	2.8	4.4	24.8	3.8	0.76
Ba	11.4	37.4	59.9	88.7	818	77.8	1.3
Be	< pDL	0.31	0.50	0.80	2.25	0.58	0.03
Bi	0.01	0.12	0.17	0.25	2.38	0.21	0.01
Ca	465	2063	2819	4406	266148	10497	178
Cd	0.06	0.19	0.25	0.36	3.17	0.34	0.0086
Ce	5.4	18.0	26.0	35.8	144	28.4	1.2
Co	0.5	5.4	8.7	13.0	35.2	9.6	0.085
Cr	2.9	17.2	25.2	34.4	98.6	27.7	0.019
Cs	0.07	0.75	1.15	1.62	11.52	1.43	0.011
Cu	1.43	12.45	17.19	25.12	158	21.45	0.27
Fe	1238	14744	20698	28099	70502	22641	163
Ga	0.3	2.8	4.1	5.3	10.4	4.1	0.065
Ge	< pDL	0.02	0.04	0.06	0.19	0.04	0.019
Hf	< pDL	0.01	0.05	0.09	0.25	0.06	0.01
Hg	0.008	0.044	0.058	0.086	0.590	0.078	0.002
In	< pDL	0.013	0.021	0.029	0.096	0.023	0.004
K	142	659	969	1434	4692	1150	21
La	2.6	8.8	12.6	17.5	68.9	14.1	0.026
Li	1.3	7.9	13.6	21.3	95.4	17.0	0.28
Mg	370	1639	2646	4675	17494	3438	64
Mn	43	299	508	868	5393	688	2
Mo	0.06	0.45	0.66	0.95	9.89	0.88	0.018
Na	11	43	60	86	1507	104	1.1
Nb	0.10	0.29	0.40	0.65	2.66	0.57	0.028
Ni	1.6	11.3	18.1	26.3	126	20.6	0.26
P	256	701	922	1267	3002	1057	4.3
Pb	2.07	20.24	27.25	38.40	1309	45.72	0.88
Rb	0.9	8.8	11.2	17.4	31.9	13.3	0.23
S	< pDL	284	386	537	3030	489	3.3
Sb	0.02	0.27	0.35	0.48	8.03	0.50	0.0002
Sc	0.3	1.4	2.1	2.9	7.9	2.3	0.05
Se	0.1	0.4	0.6	0.8	3.8	0.7	0.1
Sn	0.1	0.8	1.1	1.7	15.3	1.9	0.0056
Sr	4.7	10.2	14.4	23.5	1015	40.4	0.65
Ta	< pDL	< pDL	< pDL	< pDL	0.012	<pDL	0.004
Te	< pDL	< pDL	< pDL	0.0335	0.189	0.025	0.021
Th	0.1	0.9	1.8	2.7	6.7	2.0	0.0008
Ti	8	30	66	167	937	147	6.7
Tl	0.02	0.08	0.11	0.16	0.76	0.13	0.00009
U	0.2	0.6	0.8	1.1	18.2	1.0	0.015
V	2	25	32	44	123	35	0.07
W	0.0	0.05	0.08	0.16	1.41	0.13	0.0045
Y	1.35	3.70	5.31	7.18	41.23	6.50	0.053
Zn	5.8	39.1	60.4	83.1	303	68.9	1
Zr	< pDL	0.6	1.5	2.8	9.0	2.1	0.07

[1] values from Table 3 in Reimann, 2009.

Tables 1 and 2 display <pDL (practical detection limit) where calculated concentrations are below the pDL. The latter limits were calculated for analytical data of the GEMAS replicates

using a modified version of Thompson and Howarth (1978). Based on this approach, values between Ap and Gr of the same element can vary. In geoscience, these practical detection limit (DL) has greater relevance than a "theoretical" DL due to the complex matrix of the samples. The methods and all values, including the theoretical detection limits (DL) supplied by ACME, are outlined in the QC report by Reimann (2009).

Table 2. Summary of descriptive statistics of element concentrations in Gr soils (mg/kg)

	Grazing land soil (Gr)						
Element	**min**	**25th**	**median**	**75th**	**max**	**mean**	**practical DL[1]**
Ag	0.002	0.038	0.058	0.090	0.352	0.075	0.003
Al	966	7917	11233	14494	62136	12396	10
As	0.3	4.7	7.2	11.6	109	9.7	0.014
B	< pDL	1.7	2.6	4.1	22.6	3.8	0.3
Ba	9.1	35.9	56.2	84.4	451	72.7	0.8
Be	< pDL	0.30	0.50	0.72	2.47	0.57	0.05
Bi	0.02	0.12	0.18	0.26	1.32	0.22	0.008
Ca	464	1648	2565	4011	199374	8888	200
Cd	0.06	0.19	0.26	0.38	4.14	0.34	0.0002
Ce	3.9	16.8	26.6	35.0	99.6	27.6	0.3
Co	0.7	4.6	8.2	10.9	32.7	8.6	0.1
Cr	3.2	15.9	24.2	31.3	96.2	26.2	0.25
Cs	0.05	0.73	1.18	1.61	10.3	1.44	0.02
Cu	1.42	11.21	17.66	24.65	133	20.05	0.1
Fe	1598	13600	21867	27881	73676	22017	330
Ga	0.3	2.8	3.9	4.8	12.6	4.1	0.005
Ge	< pDL	0.02	0.03	0.05	0.14	0.04	0.05
Hf	< pDL	0.01	0.04	0.10	0.31	0.06	0.008
Hg	0.005	0.046	0.062	0.080	3.123	0.096	0.003
In	< pDL	0.013	0.023	0.031	0.082	0.023	0.005
K	149	578	866	1365	4633	1121	41
La	2.2	8.2	12.6	17.2	69.9	13.9	0.03
Li	0.2	7.5	13.7	19.6	81.3	16.6	0.2
Mg	253	1485	2507	4204	18485	3276	3.4
Mn	31	263	439	842	2483	576	1
Mo	0.07	0.45	0.69	0.92	7.25	0.85	0.004
Na	14	48	65	96	1847	120	2
Nb	0.11	0.32	0.50	0.74	2.25	0.62	0.01
Ni	1.8	9.4	16.5	24.6	135	19.1	0.4
P	315	711	938	1296	3467	1067	4
Pb	2.50	21.04	29.41	44.34	159	37.97	0.3
Rb	0.9	8.1	12.5	17.6	34.8	13.0	0.2
S	177	378	510	646	2983	610	5
Sb	0.02	0.24	0.38	0.56	4.25	0.50	0.02
Sc	0.2	1.1	1.9	2.8	10.5	2.3	0.02
Se	0.1	0.5	0.6	0.8	5.7	0.7	0.08
Sn	0.1	0.9	1.1	1.7	158	2.8	0.03
Sr	3.6	9.4	13.4	22.3	1146	40.4	0.6
Ta	< pDL	<pDL	0.001	0.002	0.015	<pDL	0.001
Te	< pDL	<pDL	<pDL	0.039	0.181	0.026	0.02
Th	<pDL	0.7	1.5	2.6	5.5	1.8	0.03
Ti	9	27	55	129	1205	140	6.5
Tl	0.02	0.09	0.12	0.17	0.93	0.14	0.01
U	<pDL	0.63	0.82	1.03	2.46	0.90	0.03
V	2.6	23.5	32.3	43.2	132	36.1	0.1
W	0.01	0.05	0.09	0.15	18.46	0.26	0.01
Y	0.84	3.27	5.12	7.25	67.24	6.76	0.1
Zn	5.6	36.8	64.6	87.2	220	65.8	3
Zr	<pDL	0.47	1.56	3.23	13.2	2.28	0.1

[1] values from Table 3 in Reimann, 2009.

Table below lists results of a simple comparison between Ap and Gr data collected within the same sampling cell. It lists for each element the Pearson correlation coefficient p and the mean (average) bias between Ap and Gr data.

Table 3. Pearson correlation coefficients and median bias between Ap and Gr data

Element	p	bias	Element	p	bias	Element	p	bias
Ag	0.54	-0.003	**Hf**	0.77	0.001	**Sb**	0.47	-0.018
Al	0.82	66.2	**Hg**	0.13	-0.002	**Sc**	0.80	0.14
As	0.85	0.14	**In**	0.38	-0.001	**Se**	0.49	-0.001
B	0.76	0.068	**K**	0.76	31.3	**Sn**	0.27	-0.030
Ba	0.57	1.10	**La**	0.46	0.28	**Sr**	0.84	0.043
Be	0.58	0.016	**Li**	0.84	0.005	**Ta**	0.25	0.000
Bi	0.51	-0.018	**Mg**	0.86	139	**Te**	0.58	-0.001
Ca	0.77	225	**Mn**	0.50	38.7	**Th**	0.80	0.091
Cd	0.86	-0.005	**Mo**	0.56	-0.014	**Ti**	0.86	3.83
Ce	0.44	0.39	**Na**	0.85	-5.21	**Tl**	0.75	-0.005
Co	0.74	0.44	**Nb**	0.67	-0.081	**U**	0.14	0.032
Cr	0.73	0.077	**Ni**	0.90	1.12	**V**	0.77	-0.21
Cs	0.78	0.001	**P**	0.69	4.91	**W**	0.49	-0.007
Cu	0.65	0.64	**Pb**	0.42	-0.51	**Y**	0.55	0.19
Fe	0.80	527	**Rb**	0.78	-0.020	**Zn**	0.58	0.047
Ga	0.76	0.021	**S**	0.64	-87.4	**Zr**	0.70	0.017
Ge	0.14	0.006						

Sections 3.2 to 3.51 are each devoted to one element/parameter displaying graduated symbol maps and cumulative probability plots for data of both agricultural and grazing land soils. Map symbols displaying geochemical data are classified based on the 25th, 50th, 75th and 90th percentile classes.

3.2 SOIL PH, TOC AND CEC

Table below lists basic statistics for TOC, CEC and pH determined in both Ap and Gr soil samples. Values for the latter three parameters (Table 4) are very similar, except TOC, which is higher in Gr samples. Almost all samples collected were mineral soils, with only two Ap samples and six Gr samples being organo-mineral soils measuring TOC > 15 wt%. Values for pH show that most soils are acidic. Only 10 % of Ap soils have a pH above 7.5 and for Gr samples this pH was less at 6.2 %.

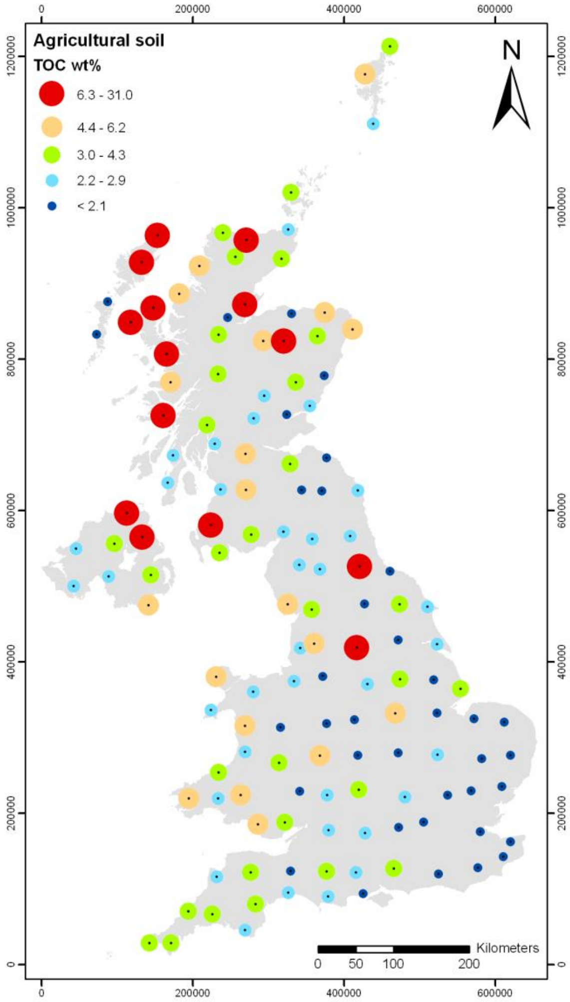
Table 4: Summary statistics of TOC, CEC and pH determined in Ap and Gr soil samples (n=138)

	Ap			Gr		
	TOC wt%	**CEC** meq	**pH** $CaCl_2$	**TOC** wt%	**CEC** meq	**pH** $CaCl_2$
min	0.6	6.7	4.05	1.6	8.5	3.45
max	31	40.8	7.52	48	41.3	7.24
25th	2.1	13.4	5.22	3.2	13.6	4.83
median	2.9	17.7	5.72	4.3	17.3	5.15
75th	4.3	20.8	6.40	5.5	23.5	5.80
90th	6.2	27.3	7.02	7.5	29.5	6.6

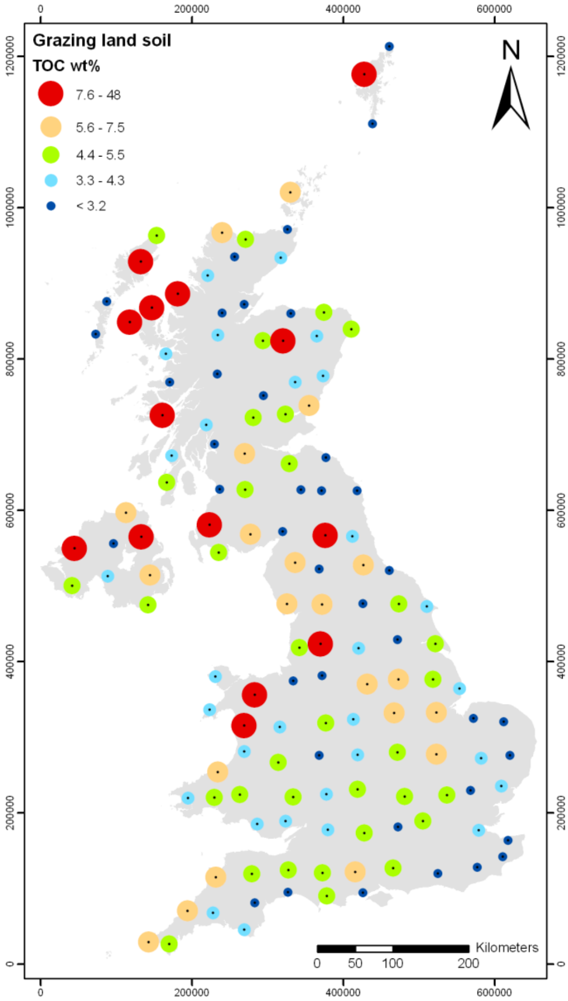
The following three sub-sections display the spatial distribution of the above data. Note, that symbols for pH values are flipped so that the 10th percentile class symbol is largest and in red instead of the 90th percentile. This allows to display the low pH values more clearly.

3.2.1 TOC

Arable soil

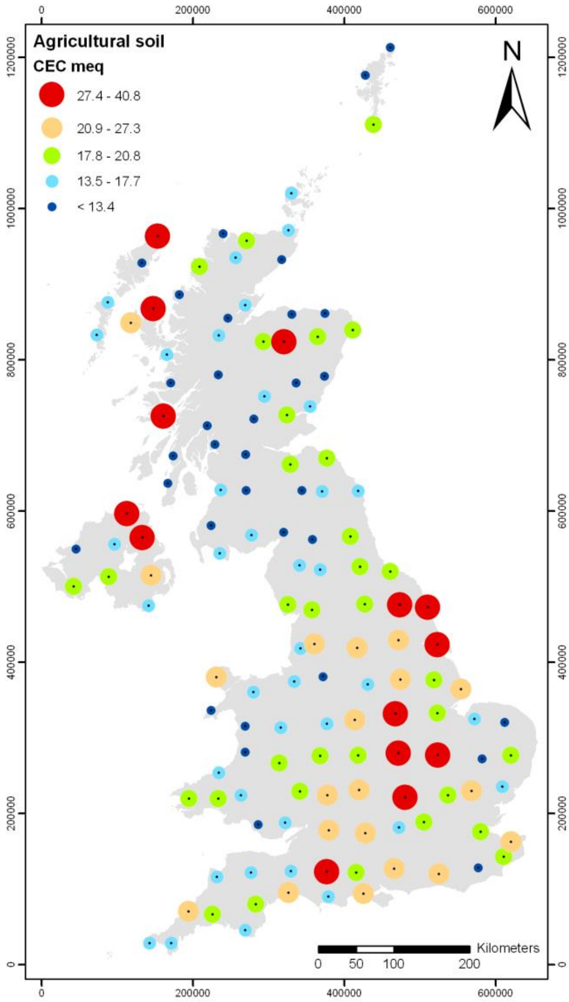


Grazing land soil

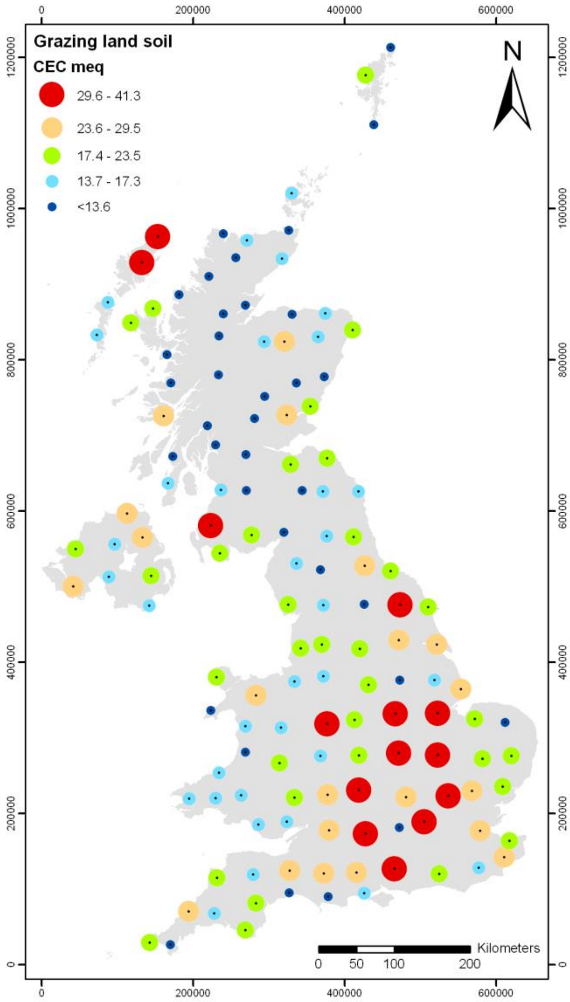


3.2.2 CEC

Arable soil

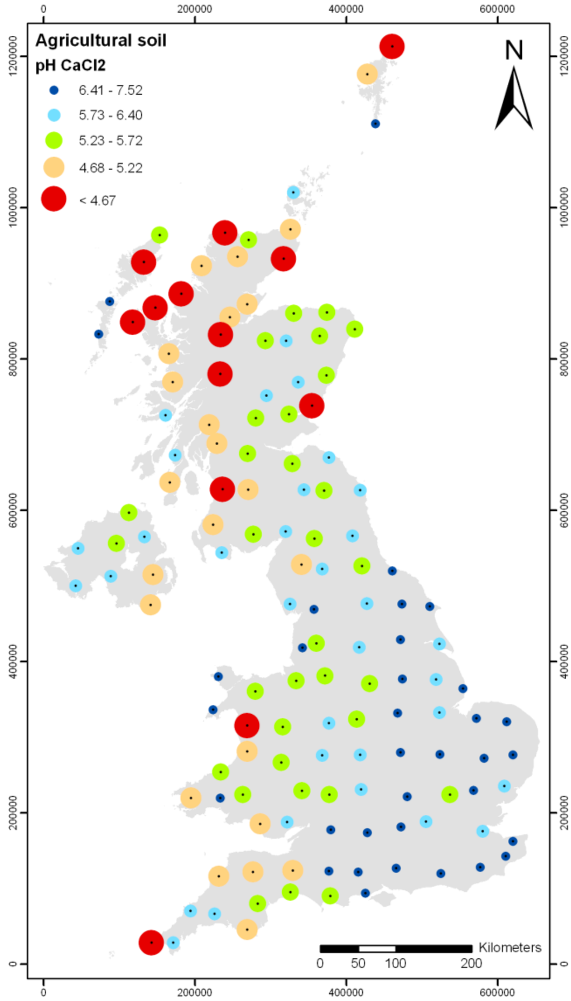


Grazing land soil

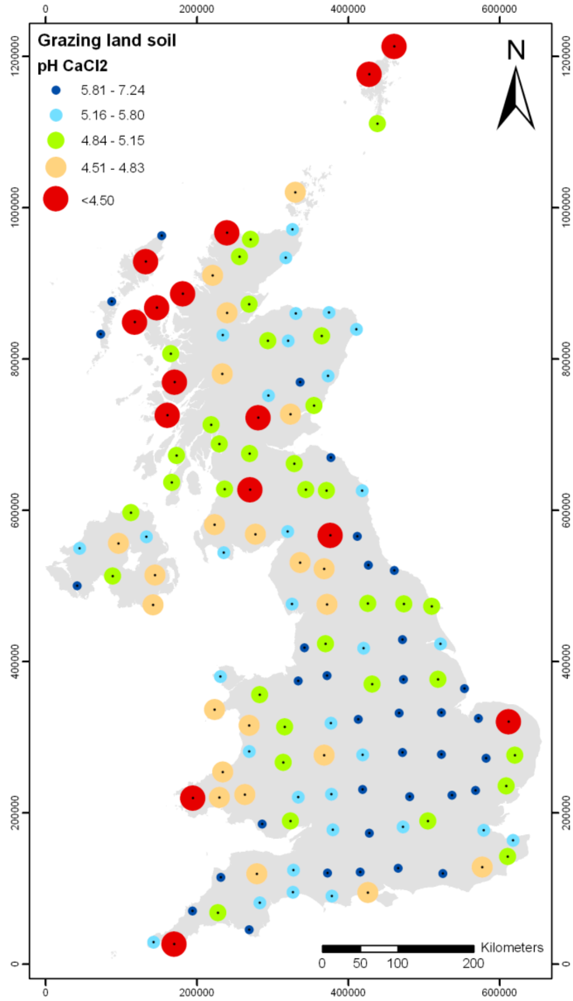


3.2.3 pH

Arable soil

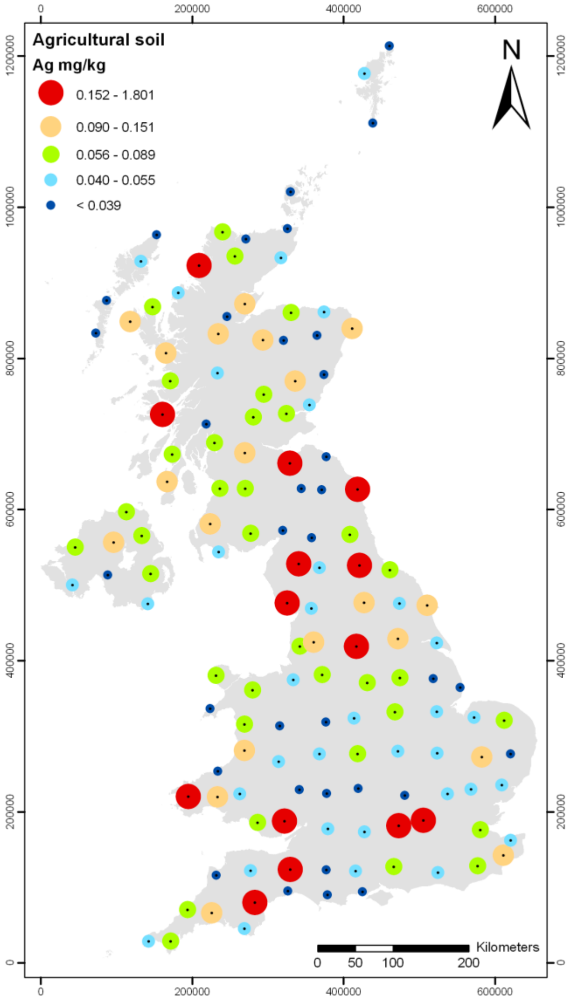


Grazing land soil

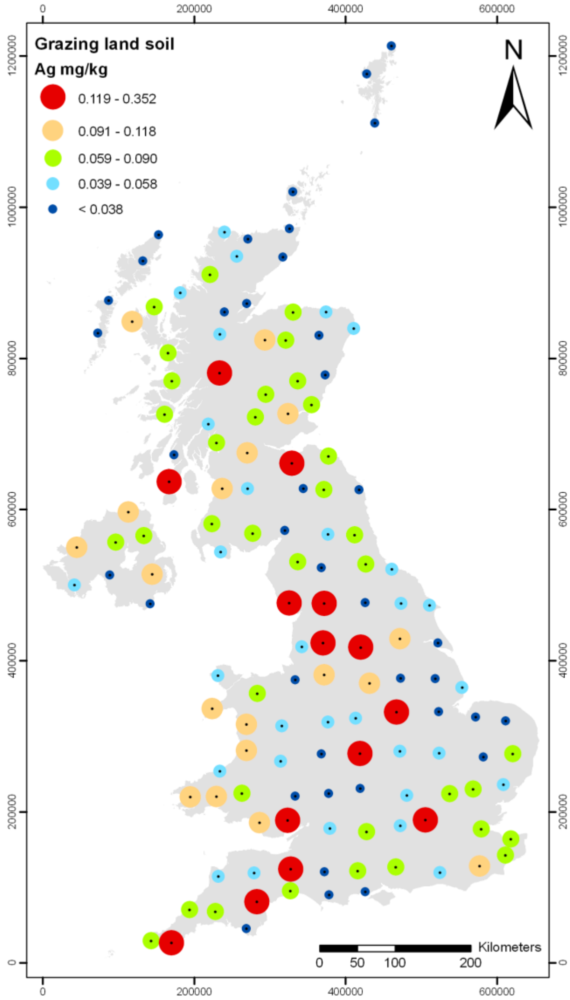


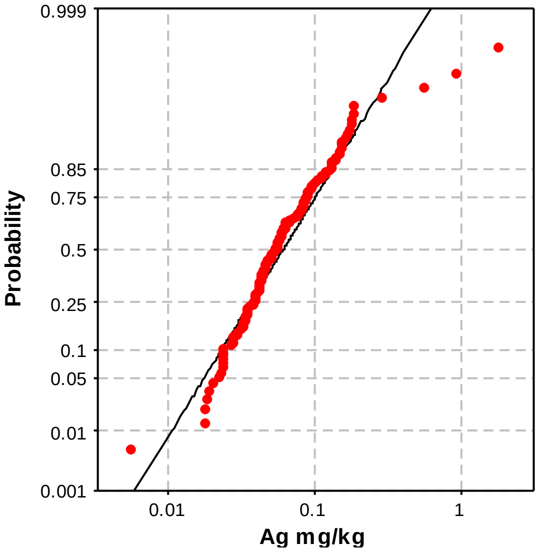
3.3 SILVER (Ag)

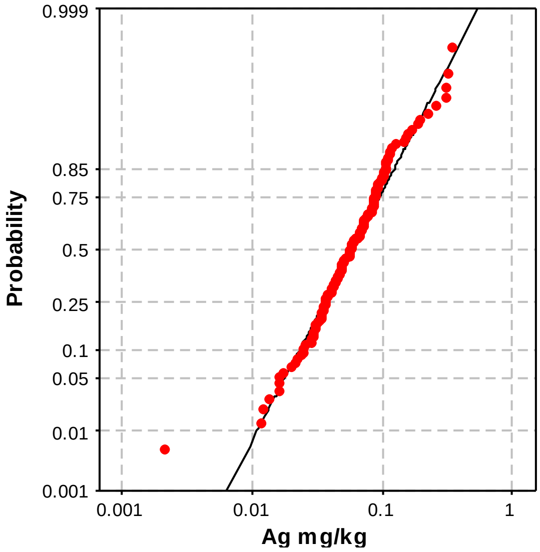
Arable soil



Grazing land soil

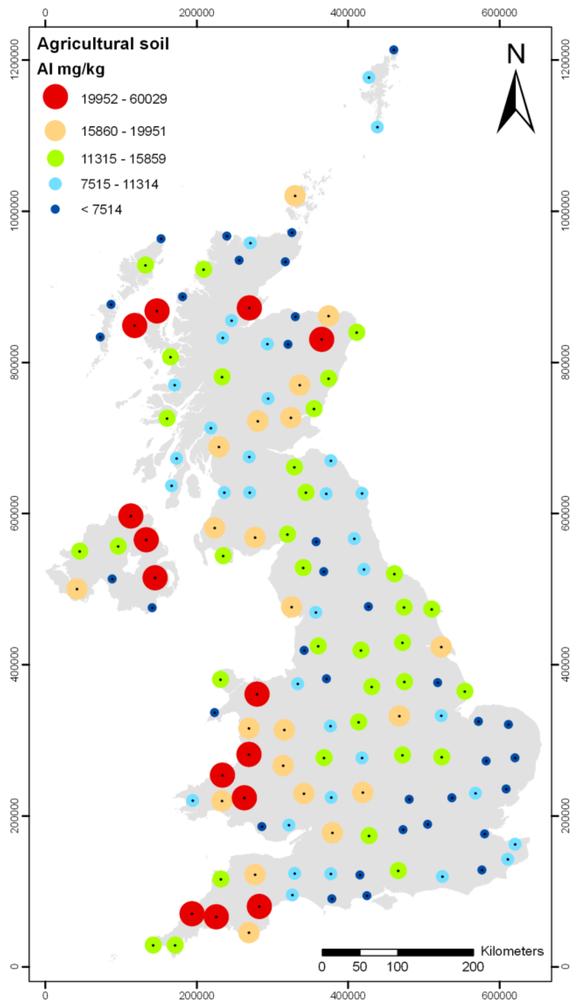




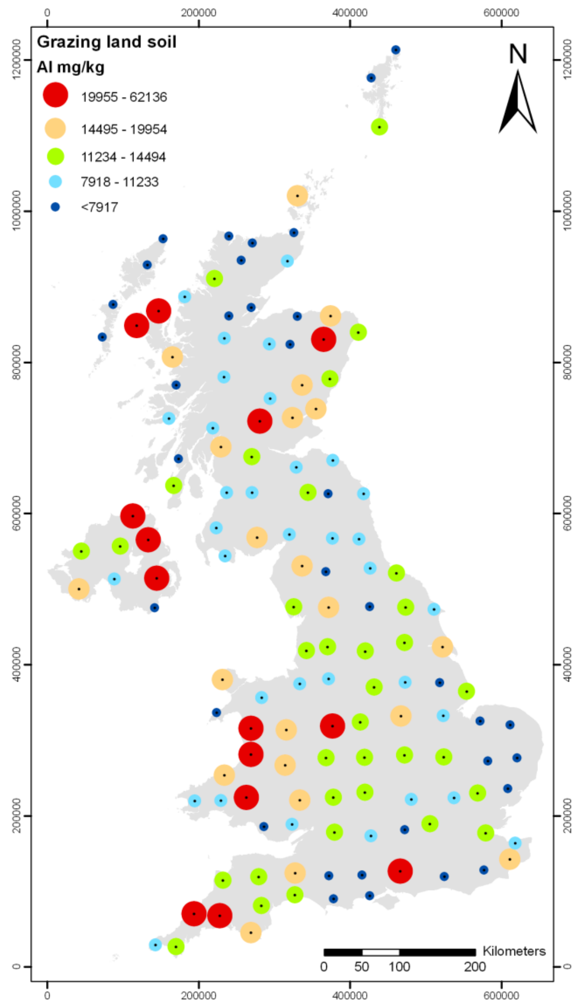


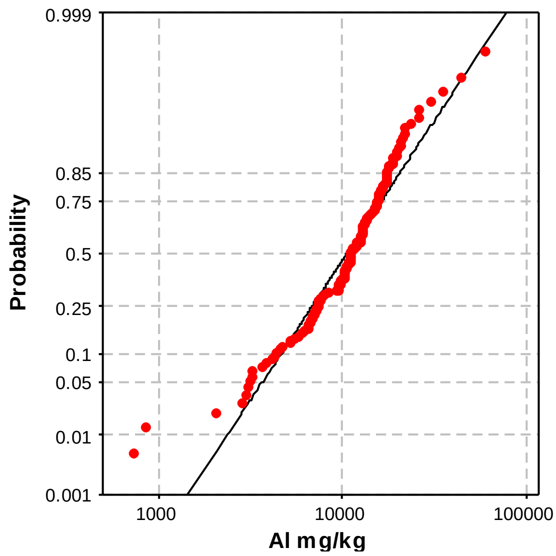
3.4 ALUMINIUM (Al)

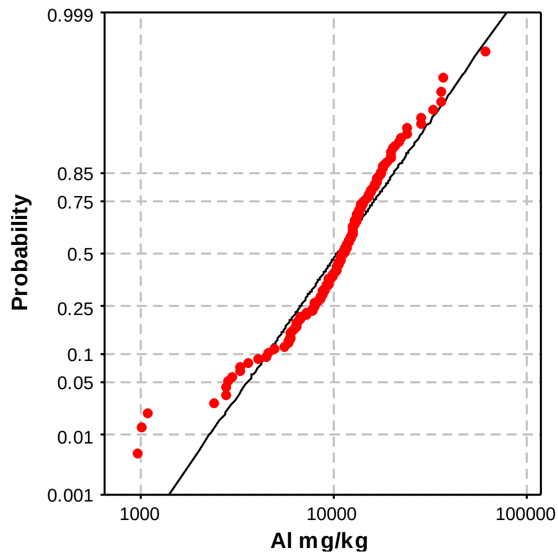
Arable soil



Grazing land soil



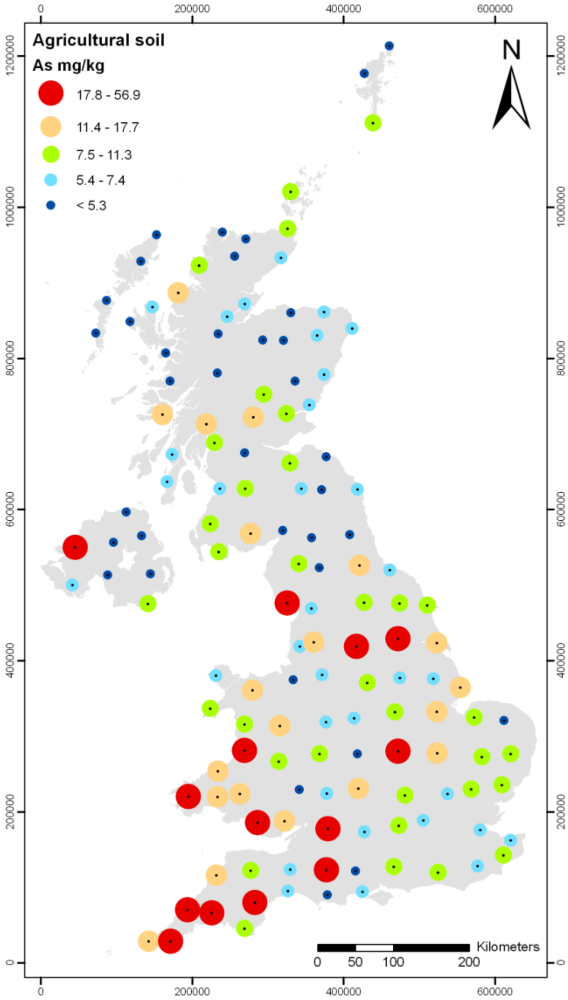


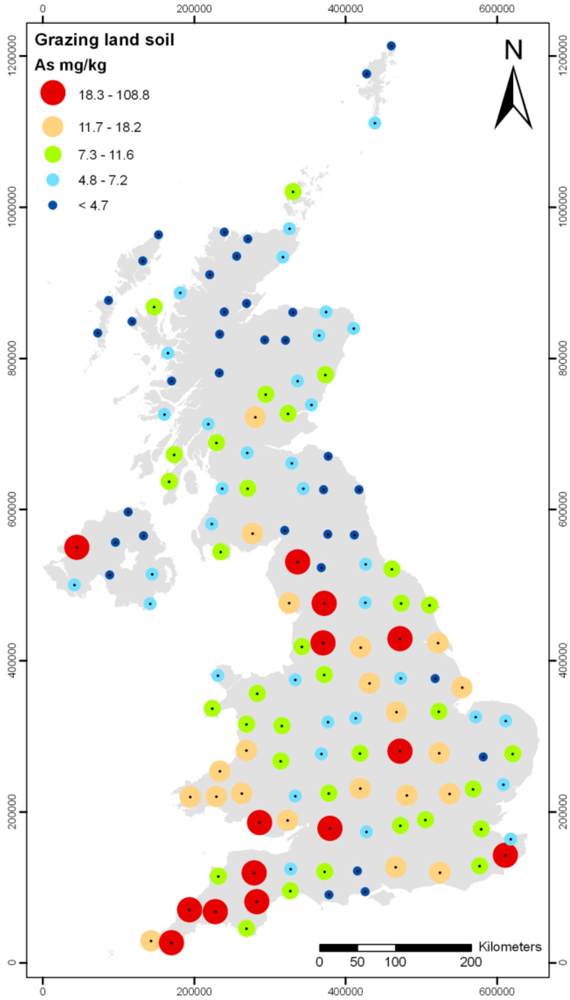


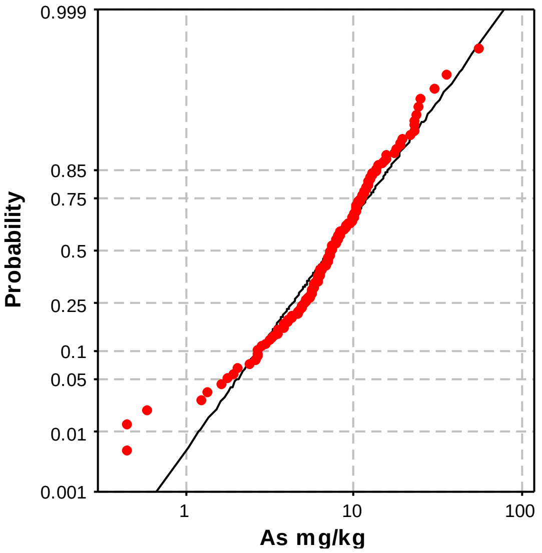
3.5 ARSENIC (As)

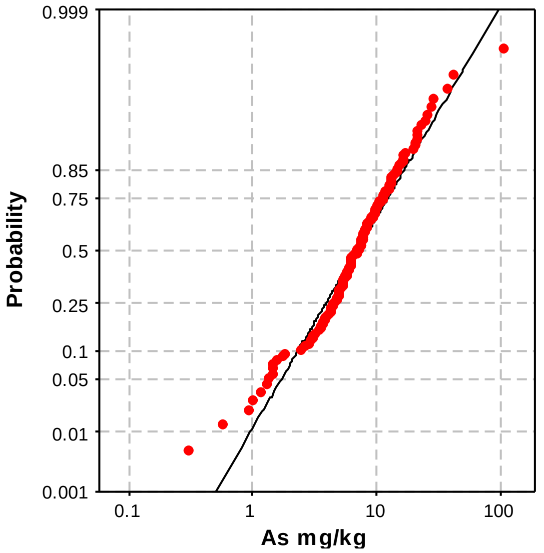
Arable soil

Grazing land soil





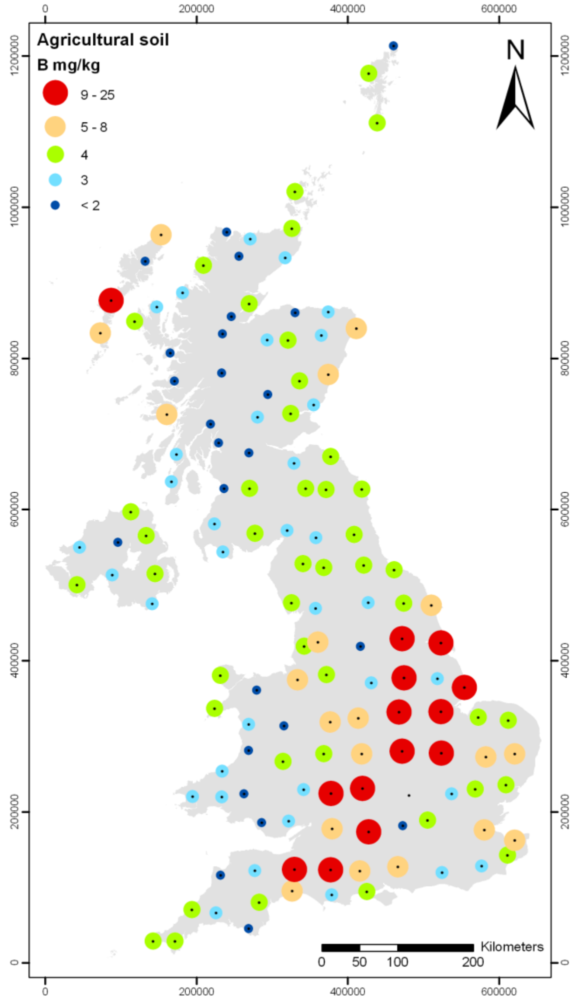


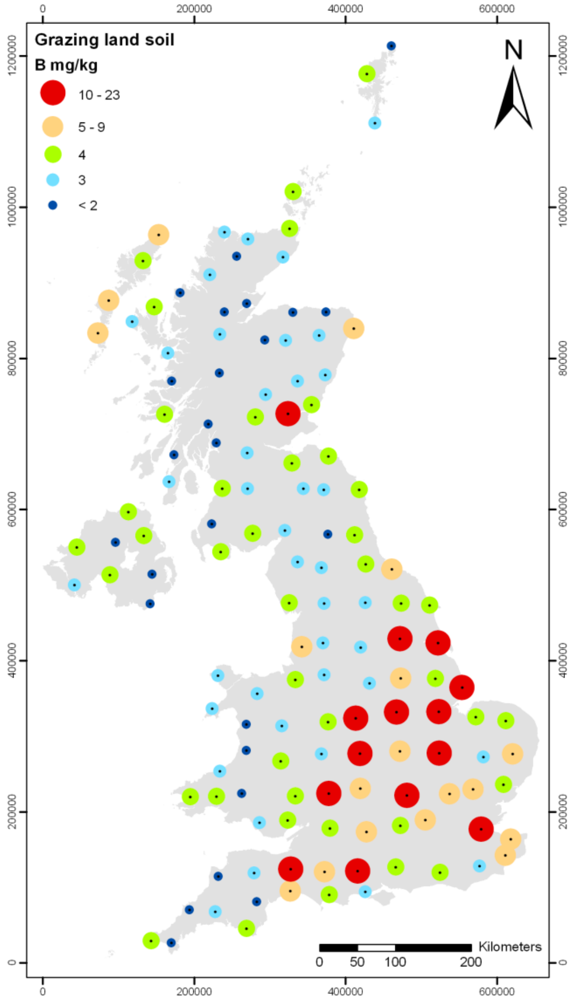


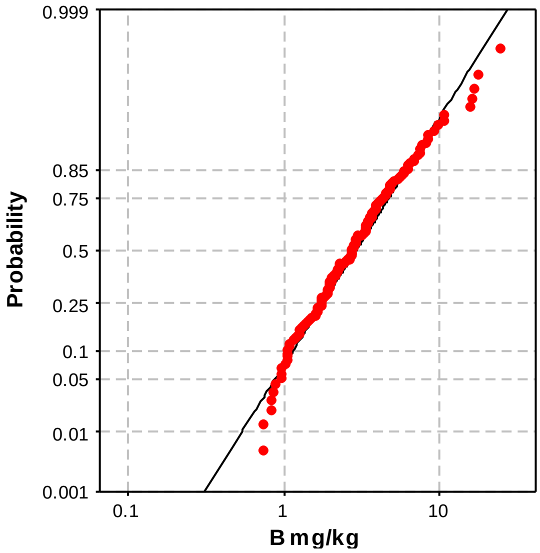
3.6 BORON (B)

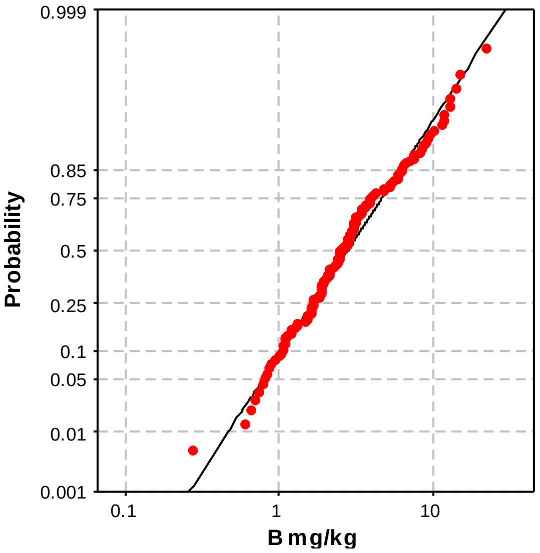
Arable soil

Grazing land soil



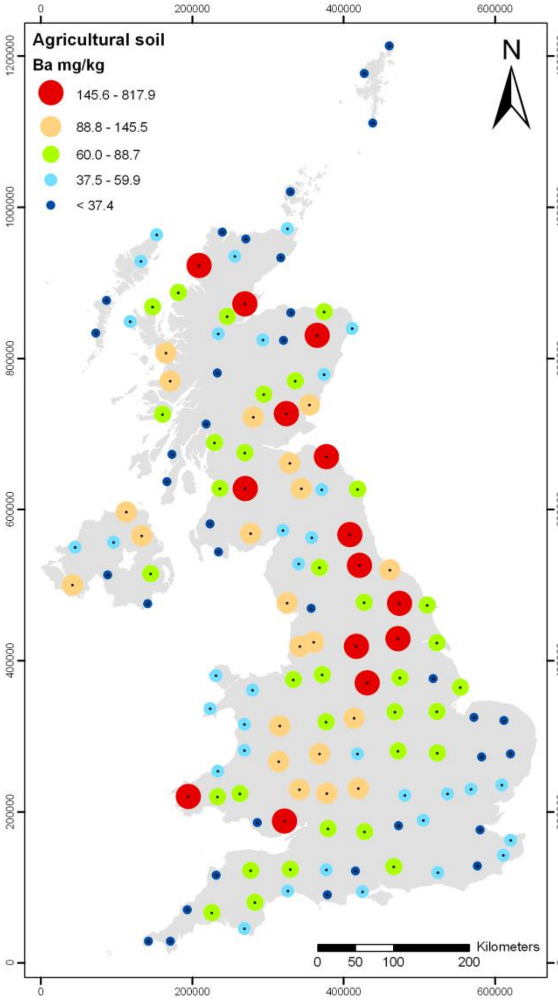




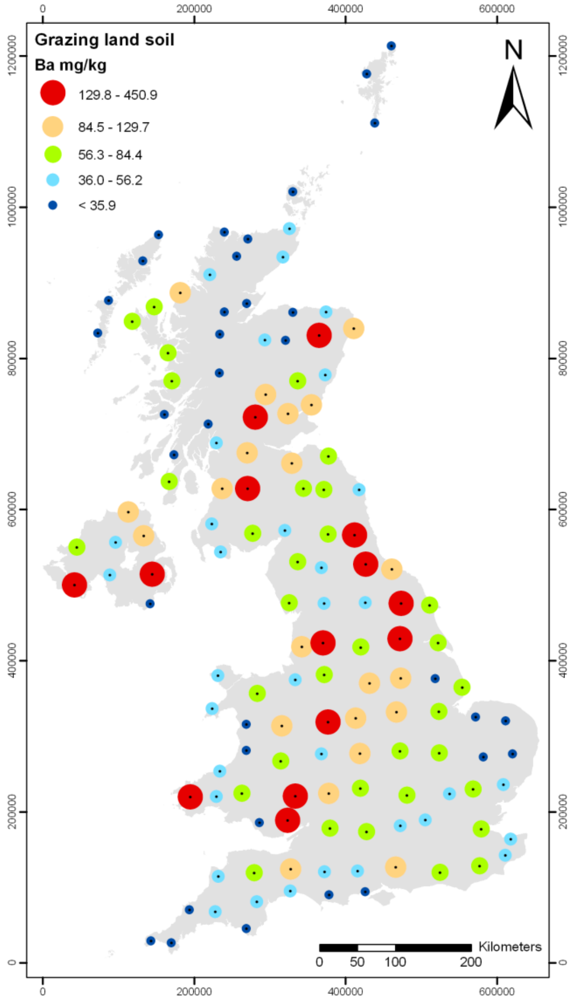


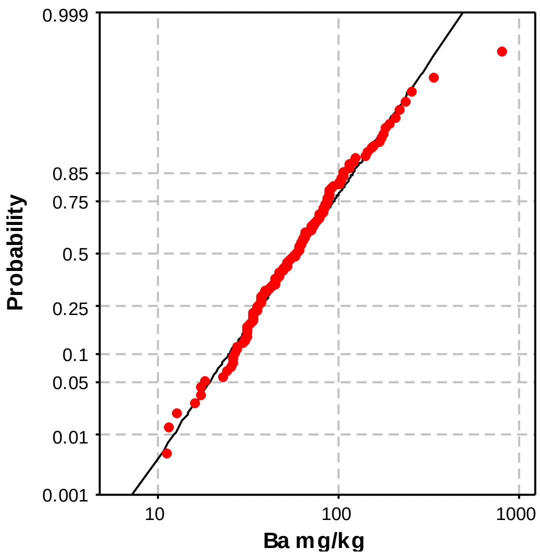
3.7 BARIUM (Ba)

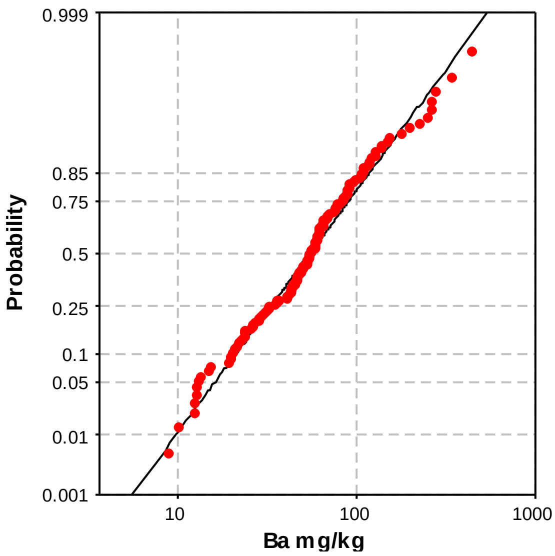
Arable soil



Grazing land soil

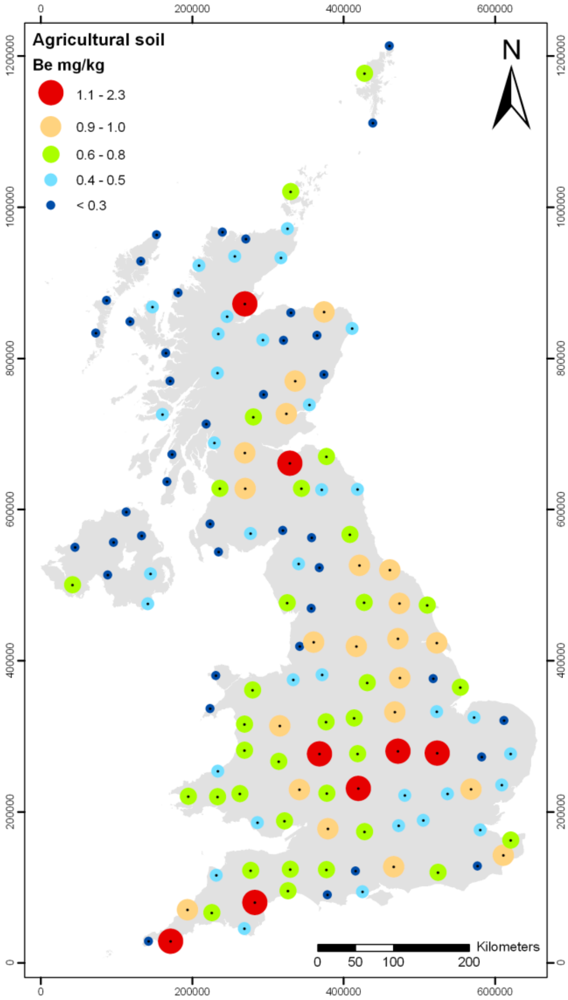




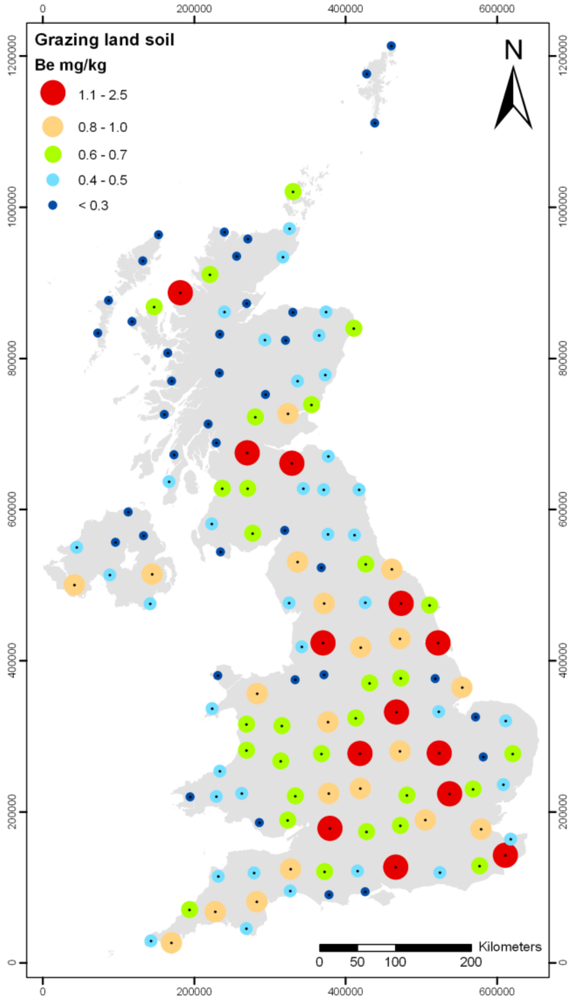


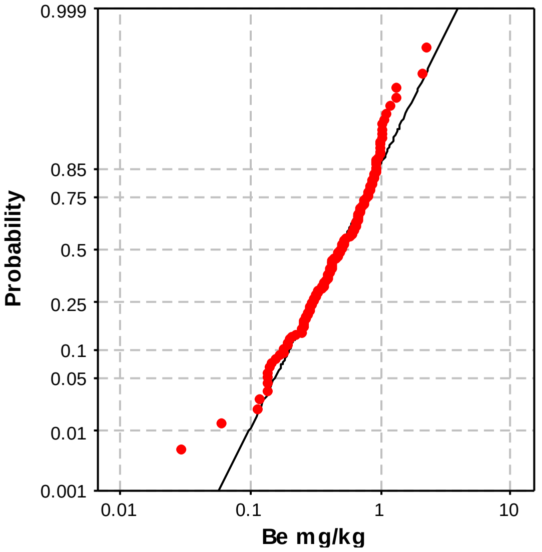
3.8 BERYLLIUM (Be)

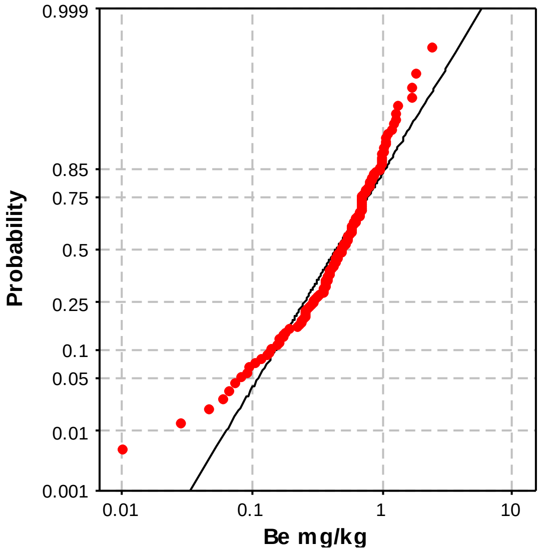
Arable soil



Grazing land soil

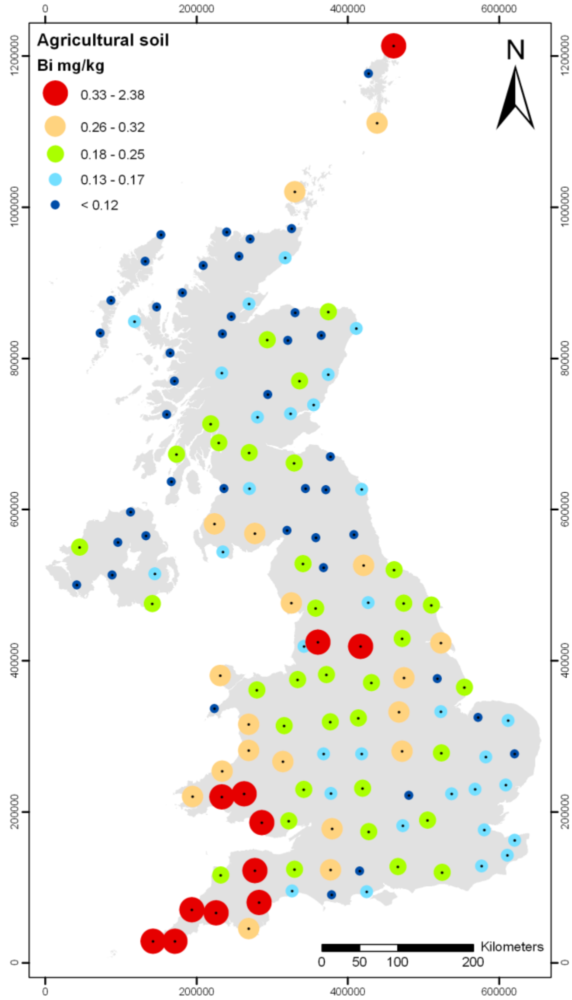




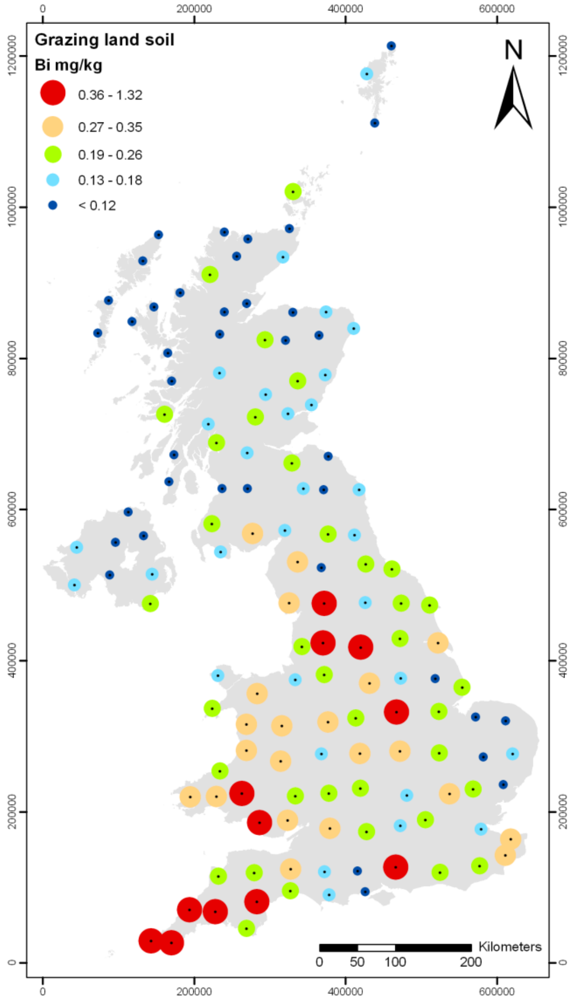


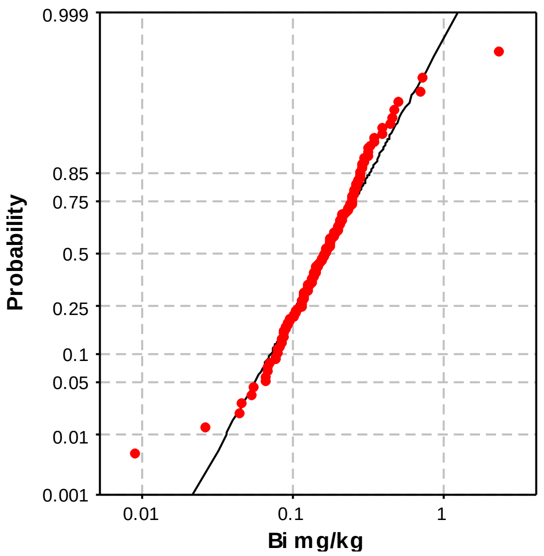
3.9 BISMUTH (Bi)

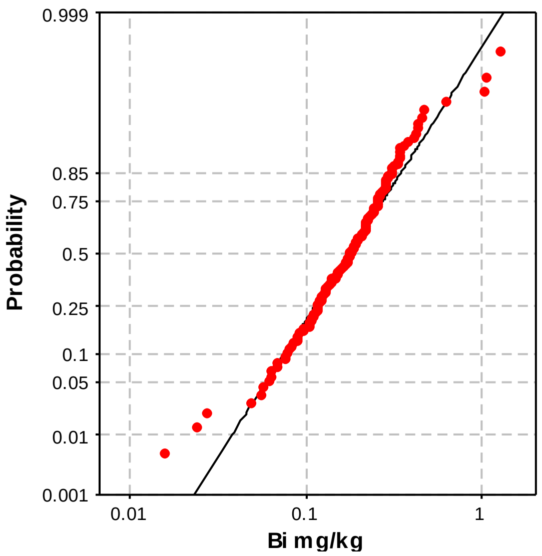
Arable soil



Grazing land soil



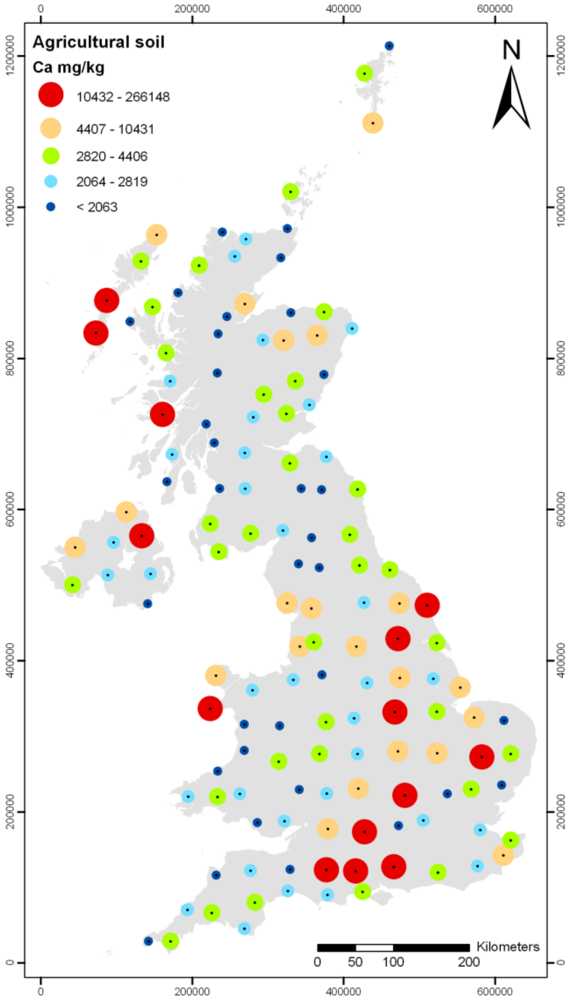


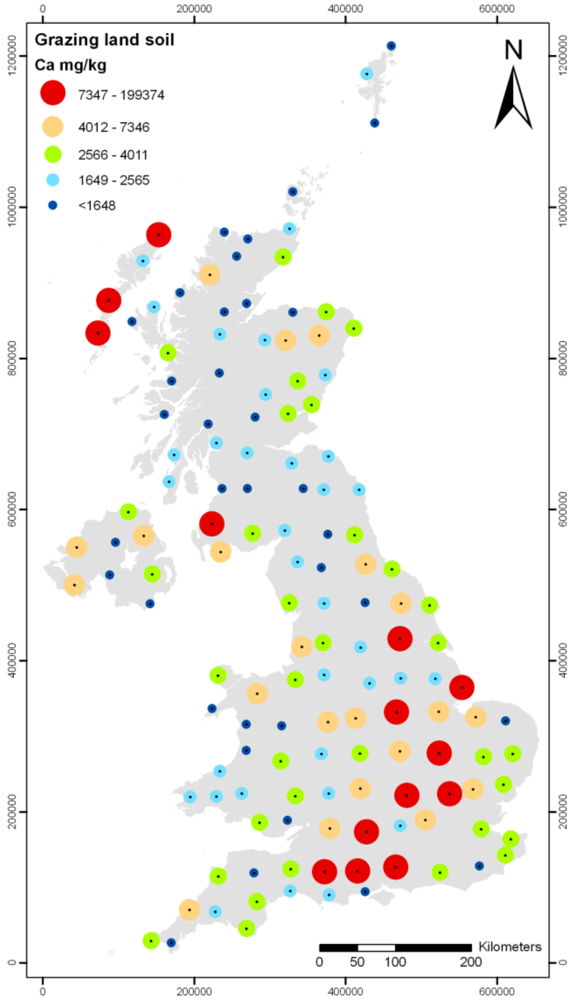


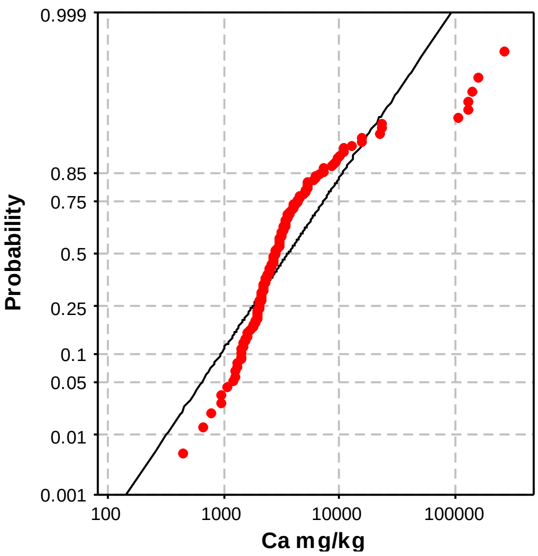
3.10 CALCIUM (Ca)

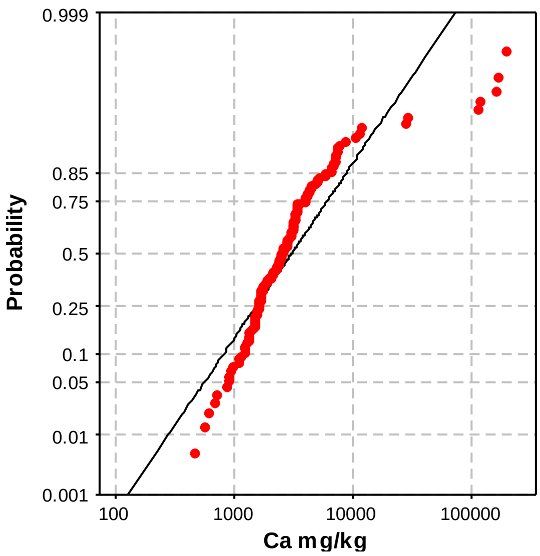
Arable soil

Grazing land soil



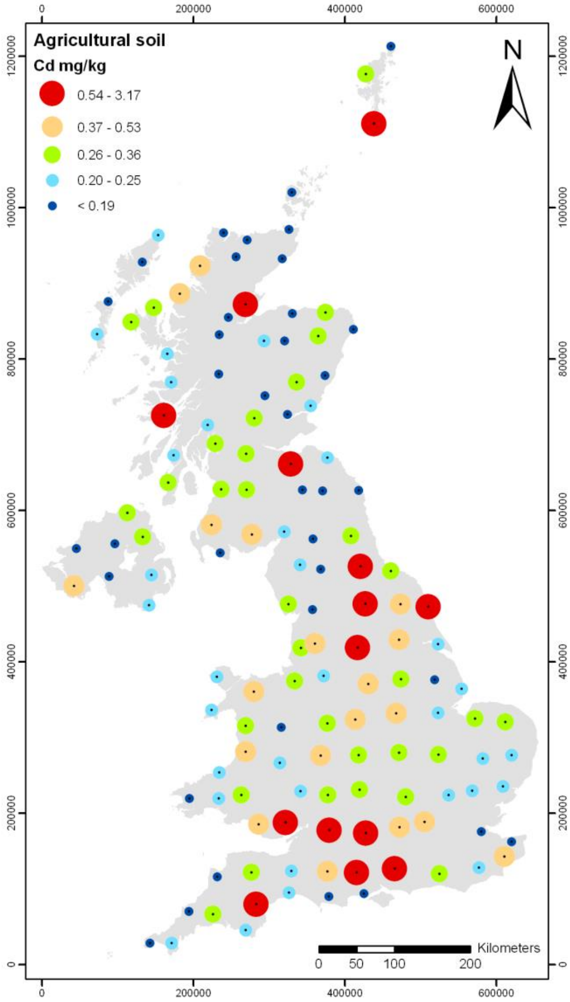


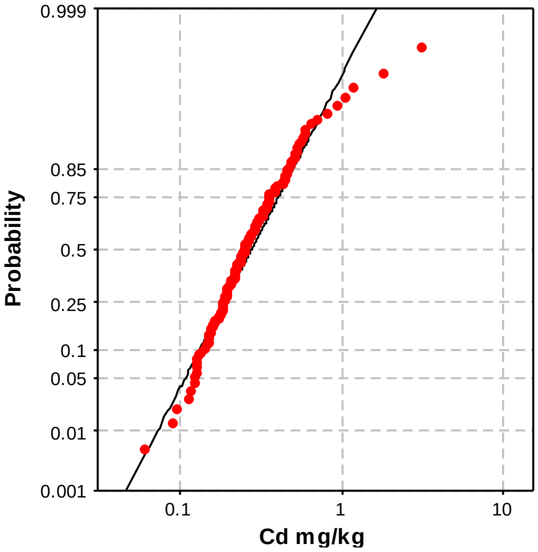




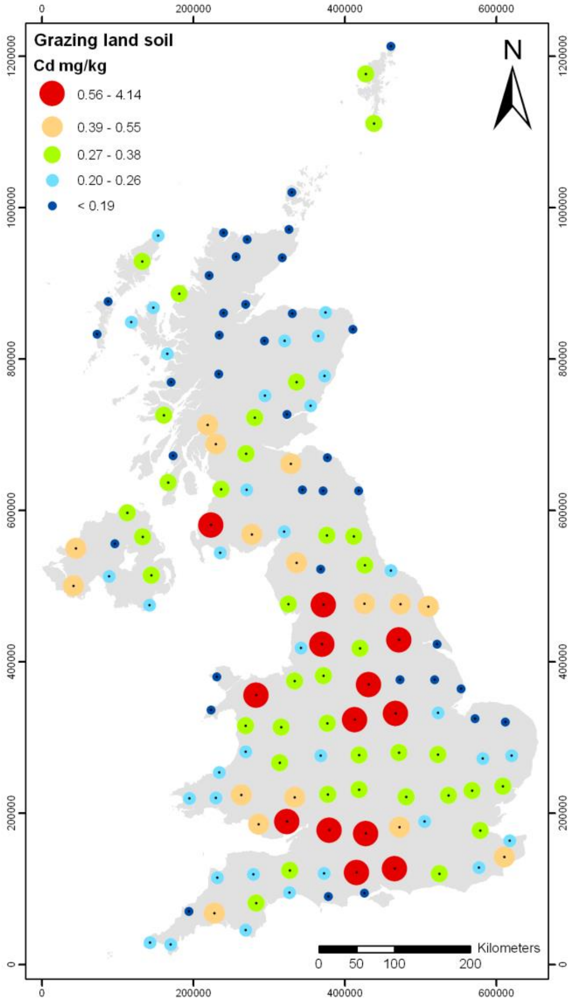
3.11 CADMIUM (Cd)

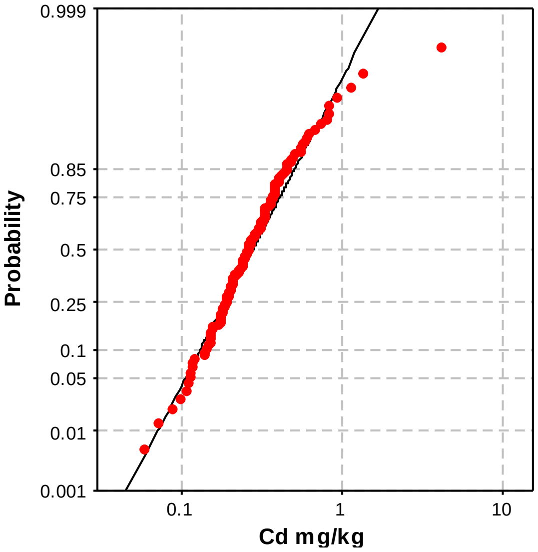
Arable soil





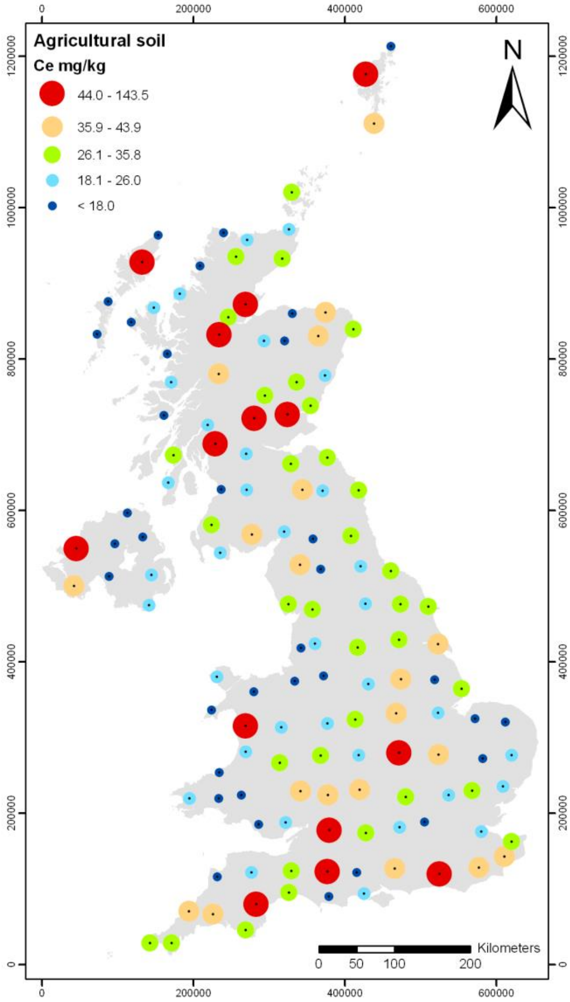
Grazing land soil



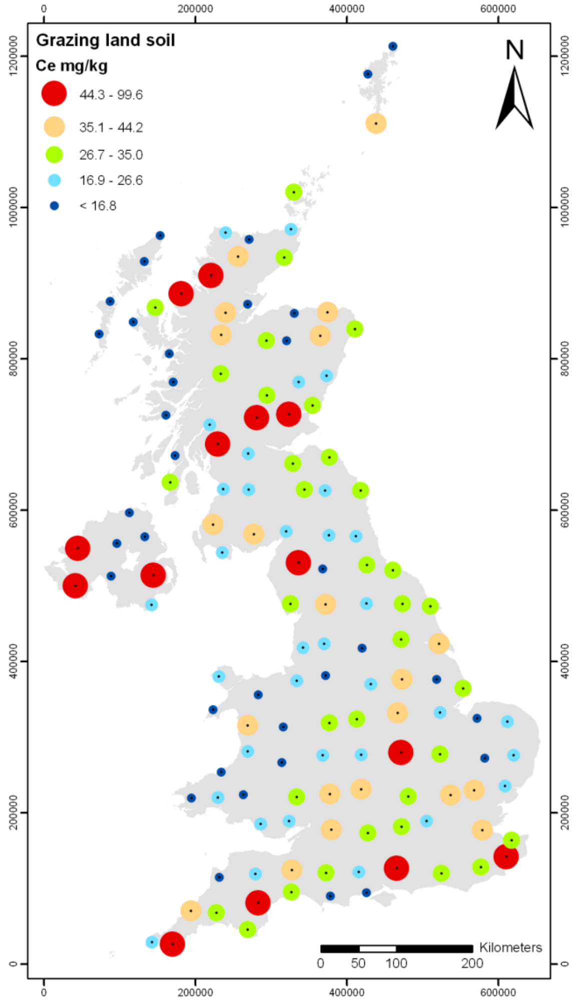


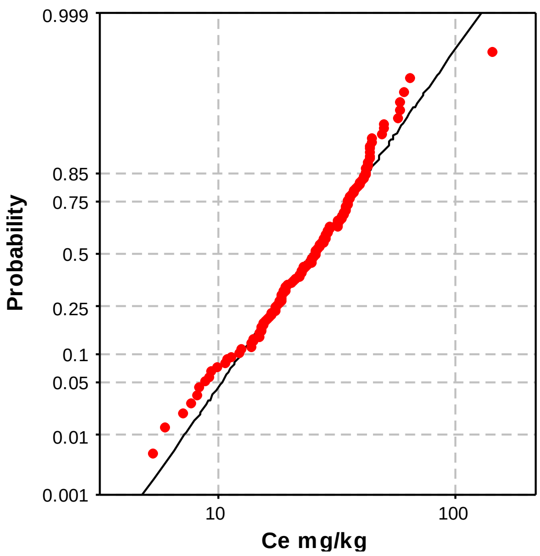
3.12 CERIUM (Ce)

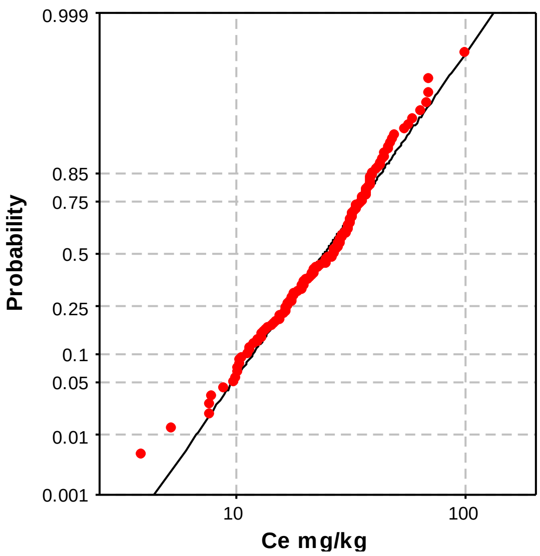
Arable soil



Grazing land soil

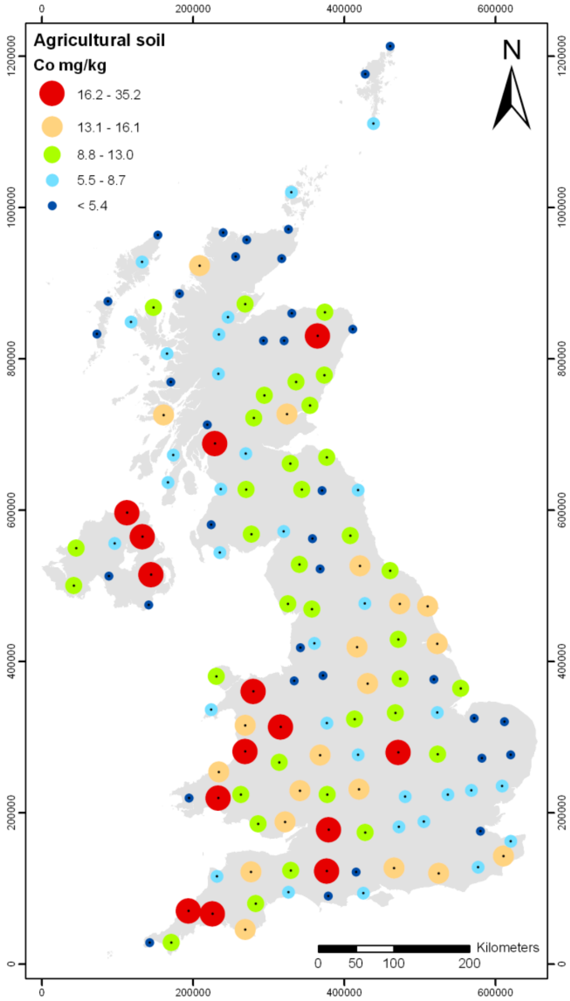


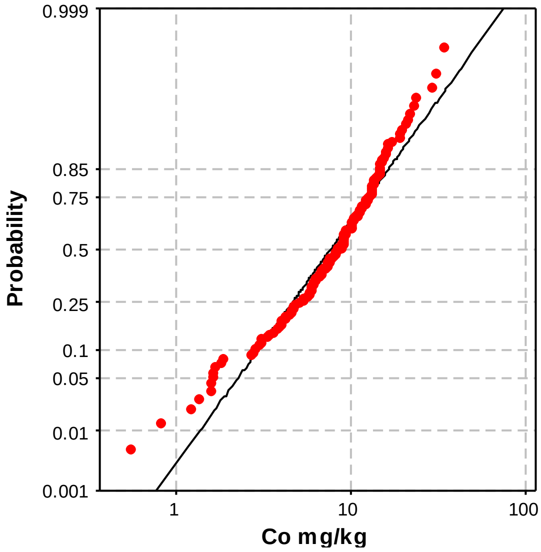




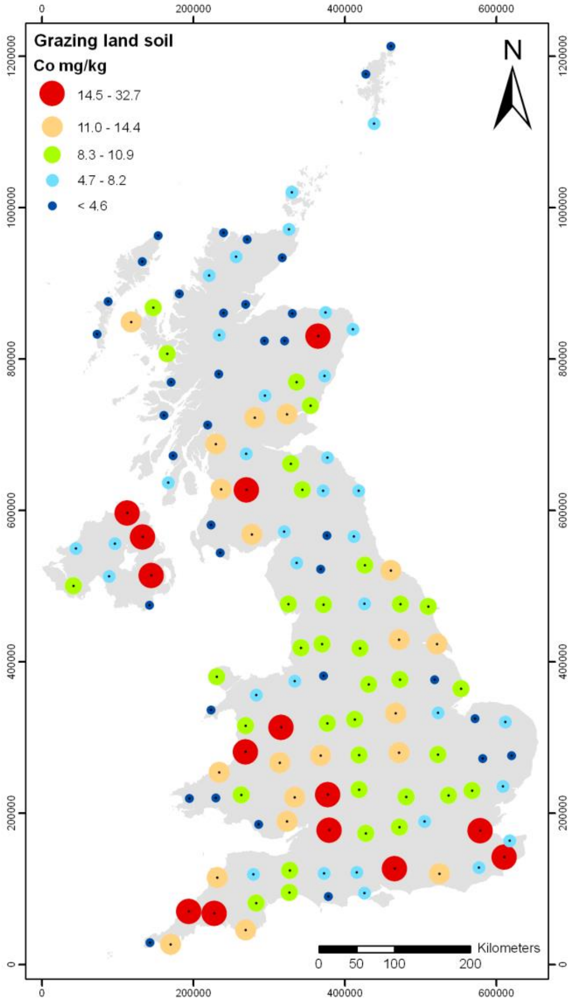
3.13 COBALT (Co)

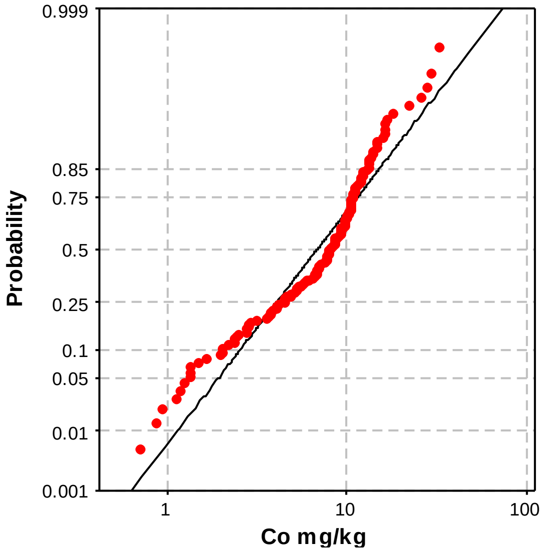
Arable soil





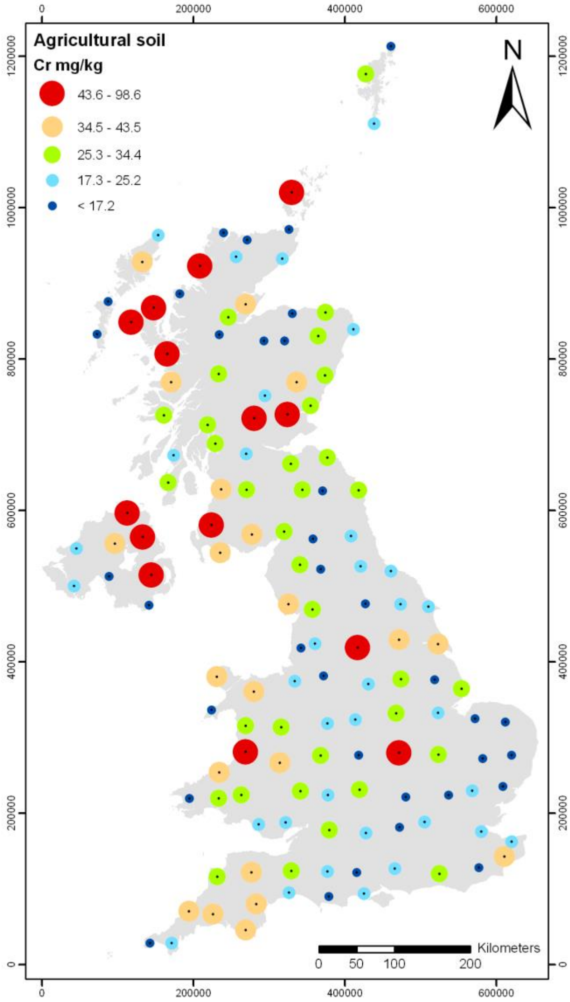
Grazing land soil



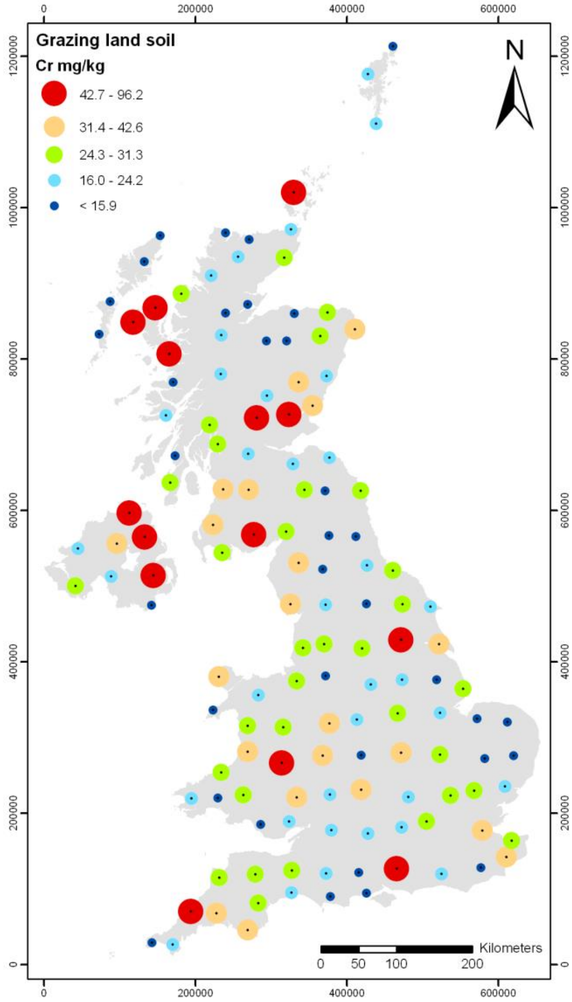


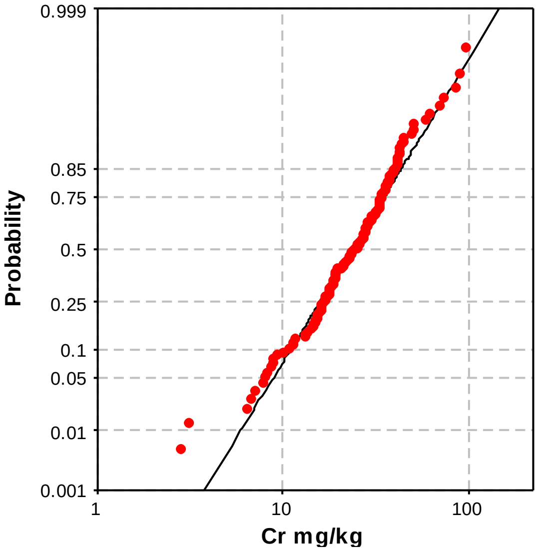
3.14 CHROMIUM (Cr)

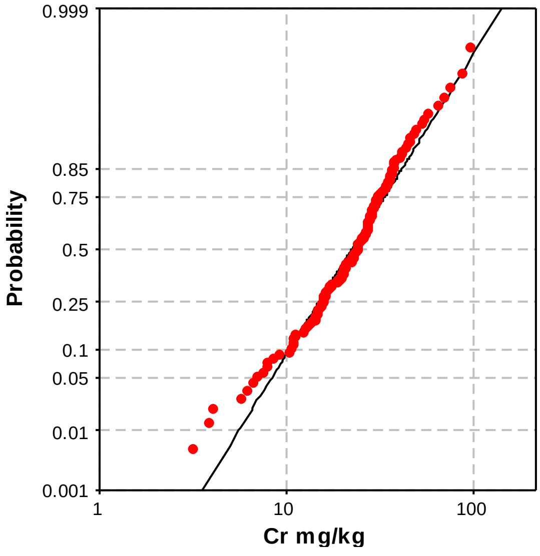
Arable soil



Grazing land soil

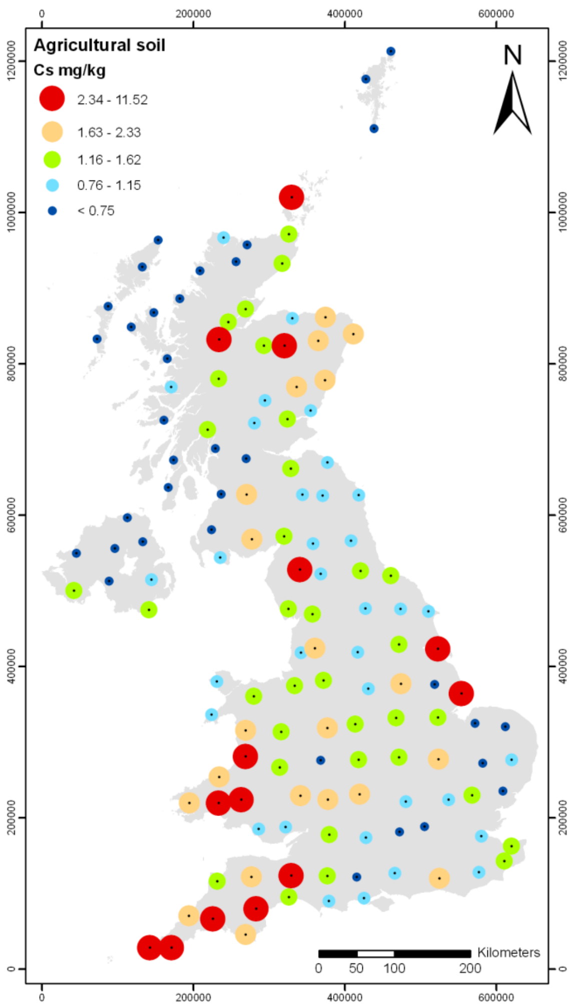




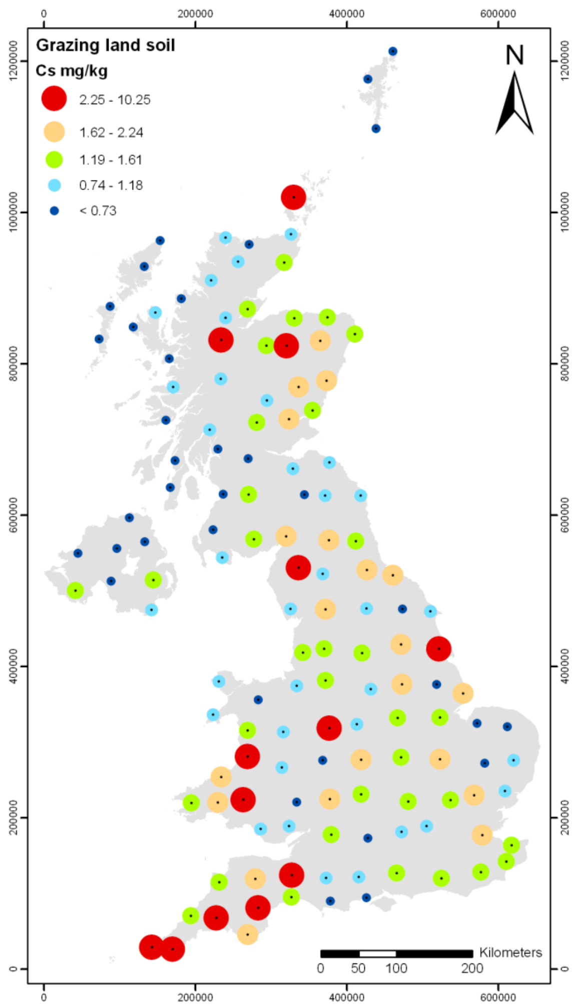


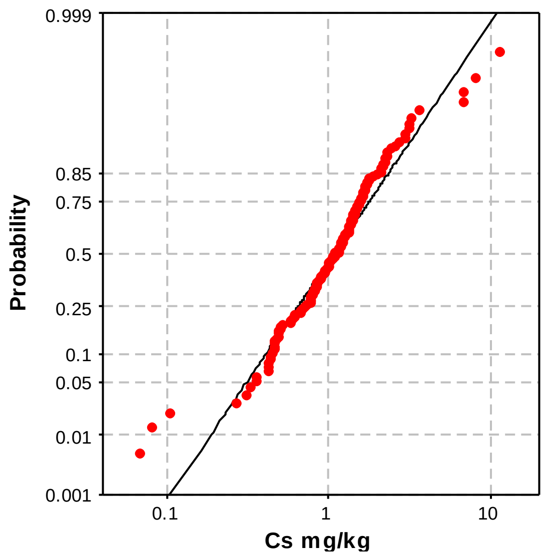
3.15 CAESIUM (Cs)

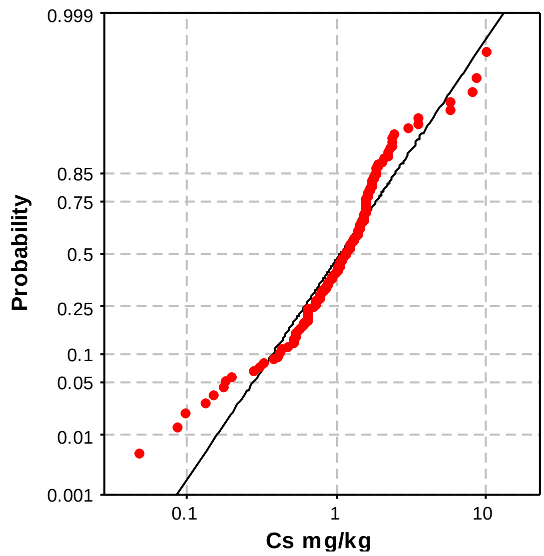
Arable soil



Grazing land soil

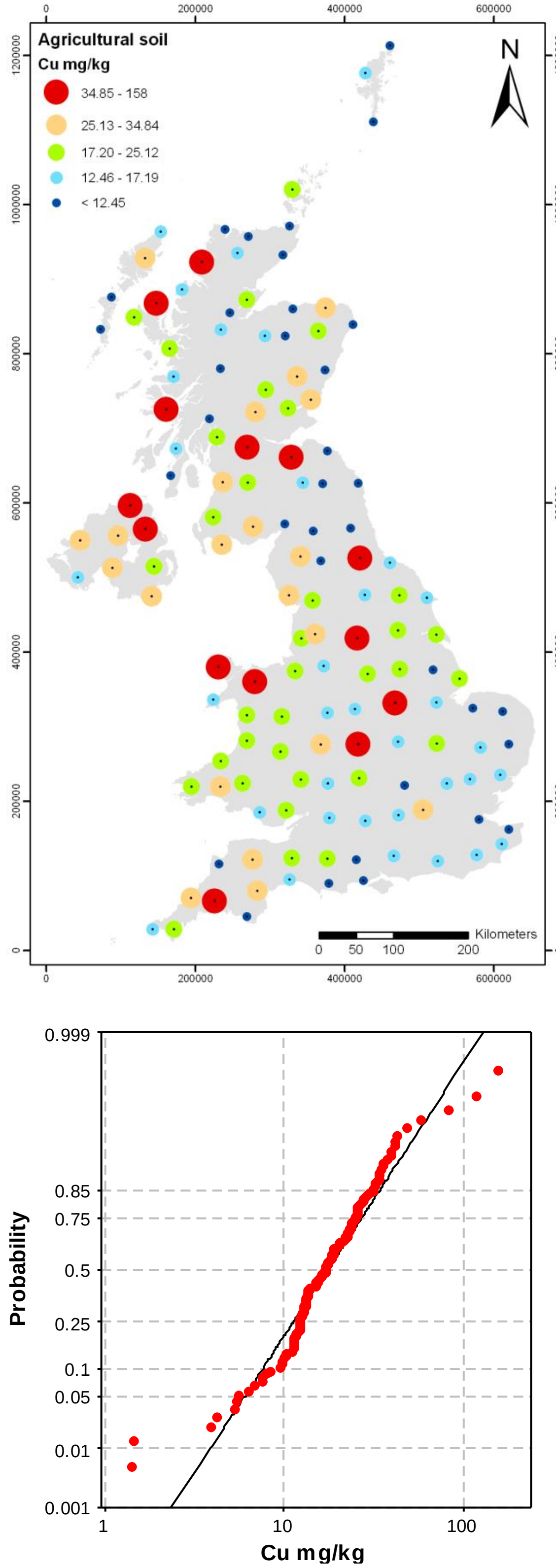




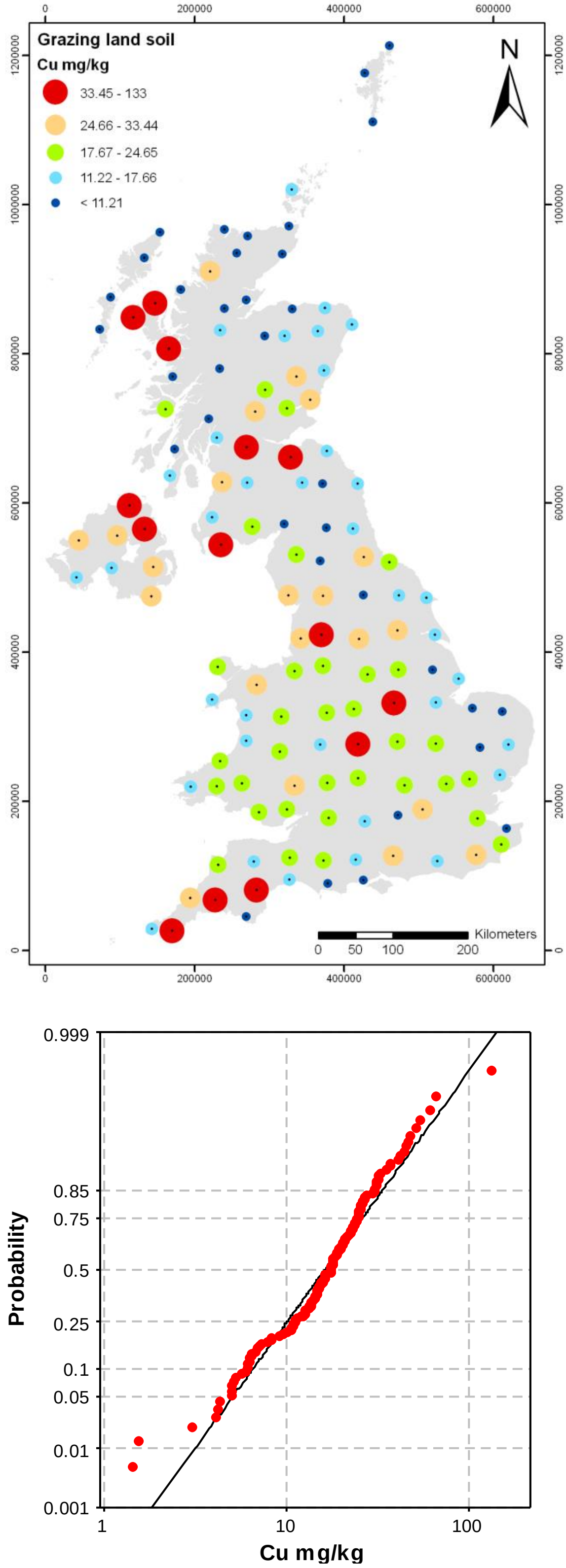


3.16 COPPER (Cu)

Arable soil

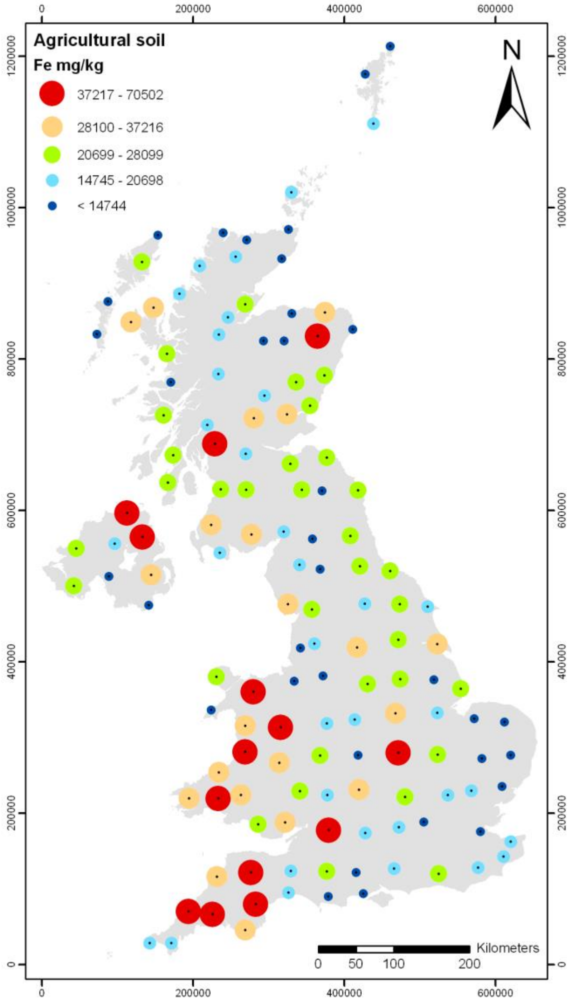


Grazing land soil

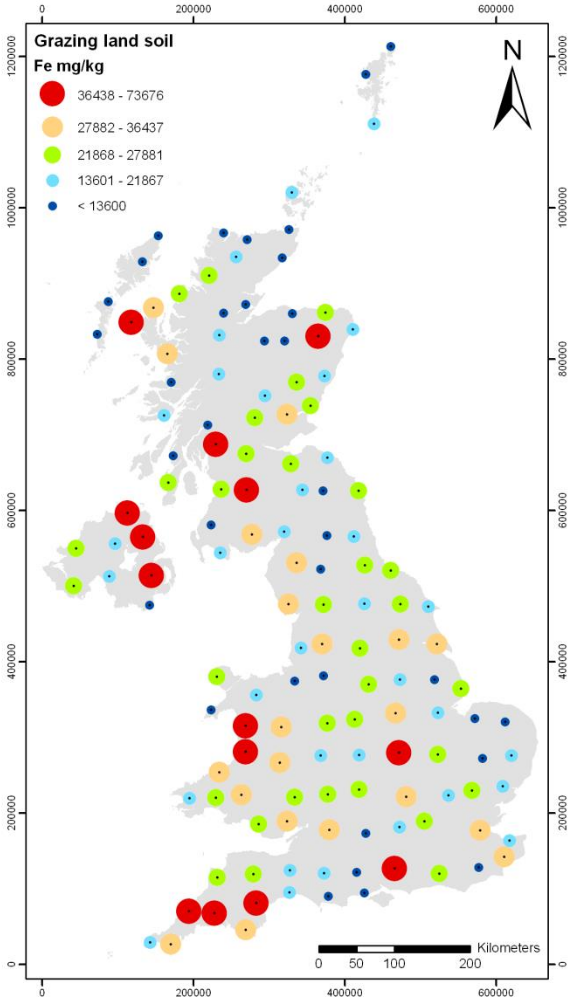


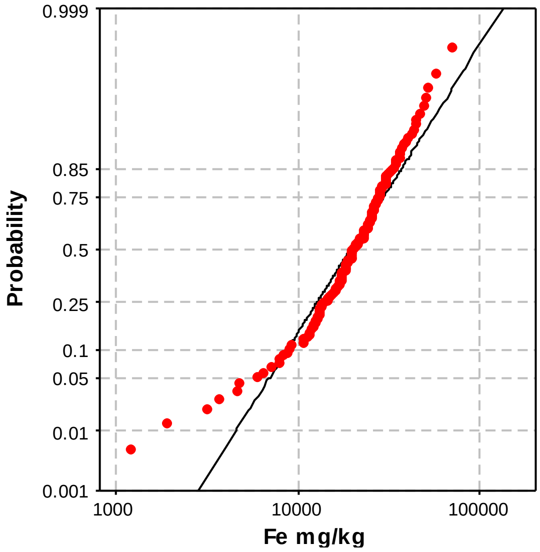
3.17 IRON (Fe)

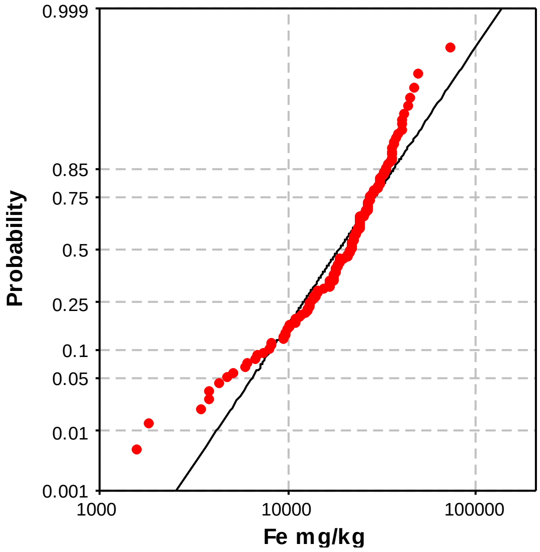
Arable soil



Grazing land soil

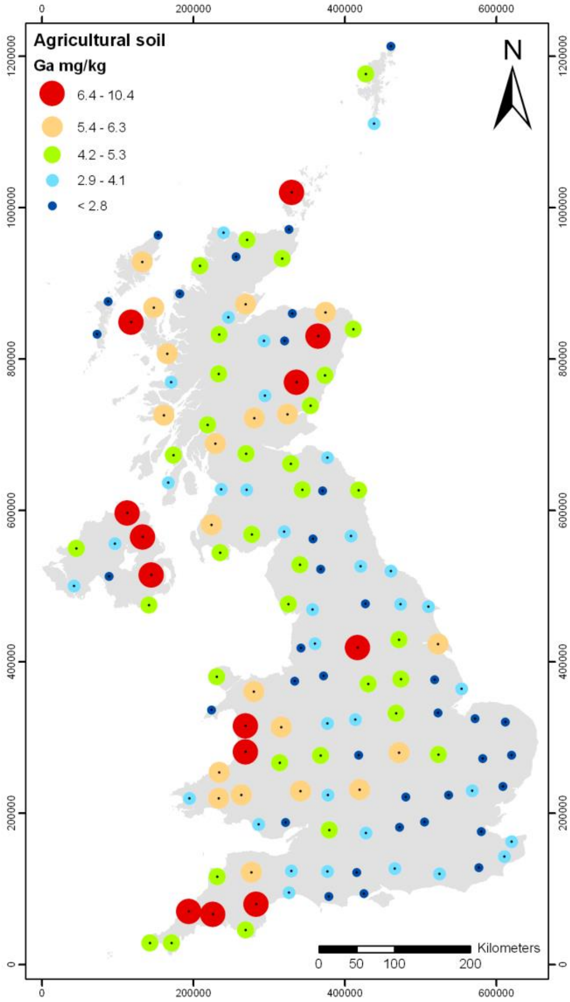


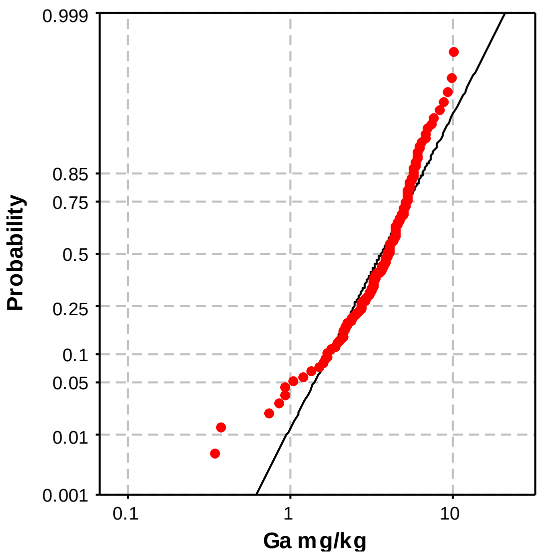




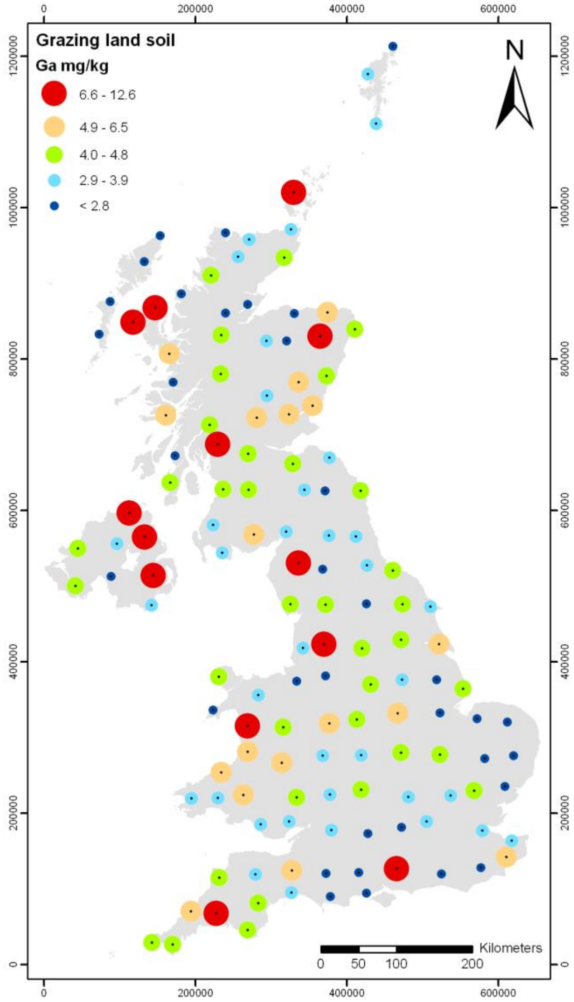
3.18 GALLIUM (Ga)

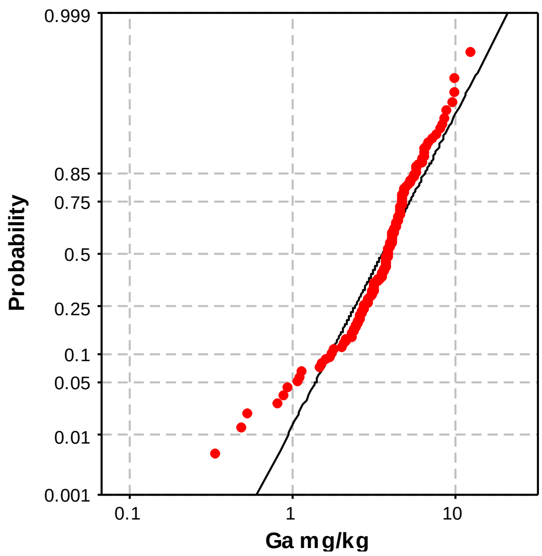
Arable soil





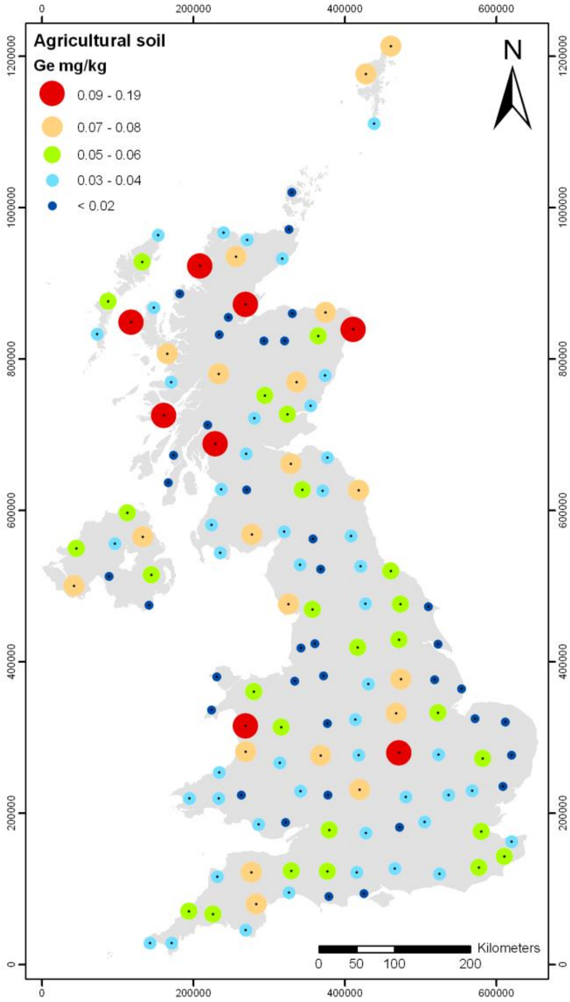
Grazing land soil



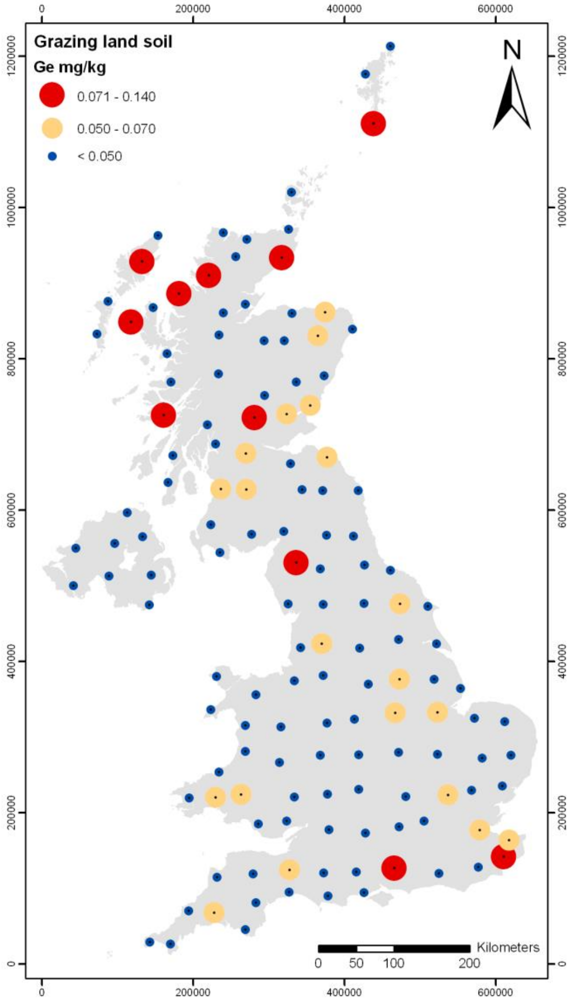


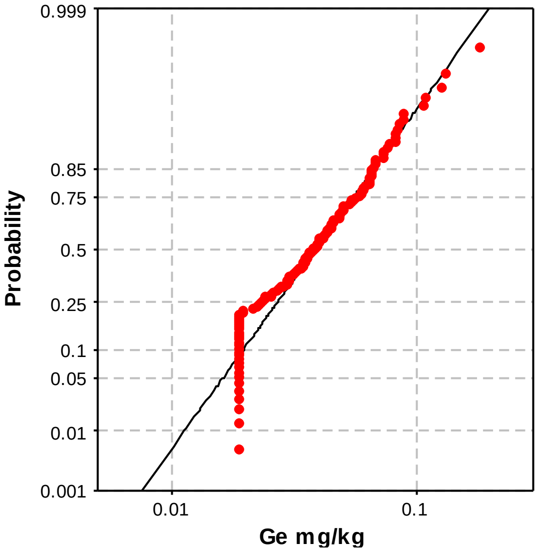
3.19 GERMANIUM (Ge)

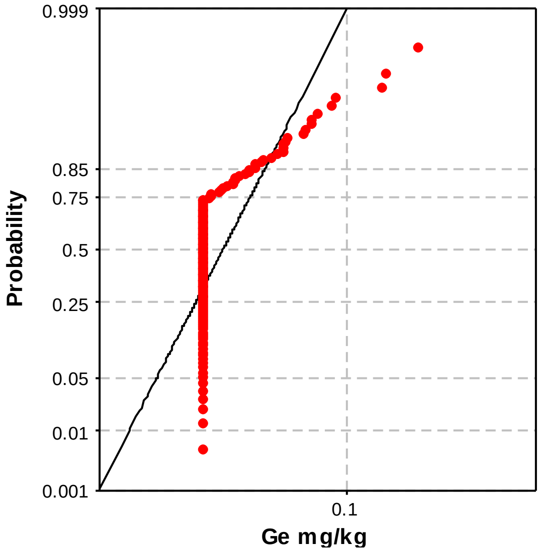
Arable soil



Grazing land soil

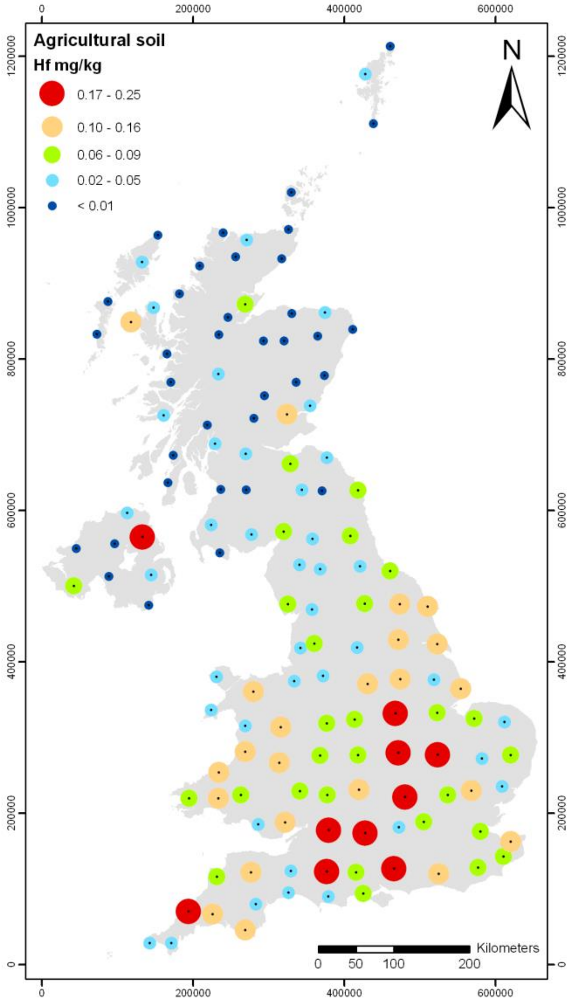




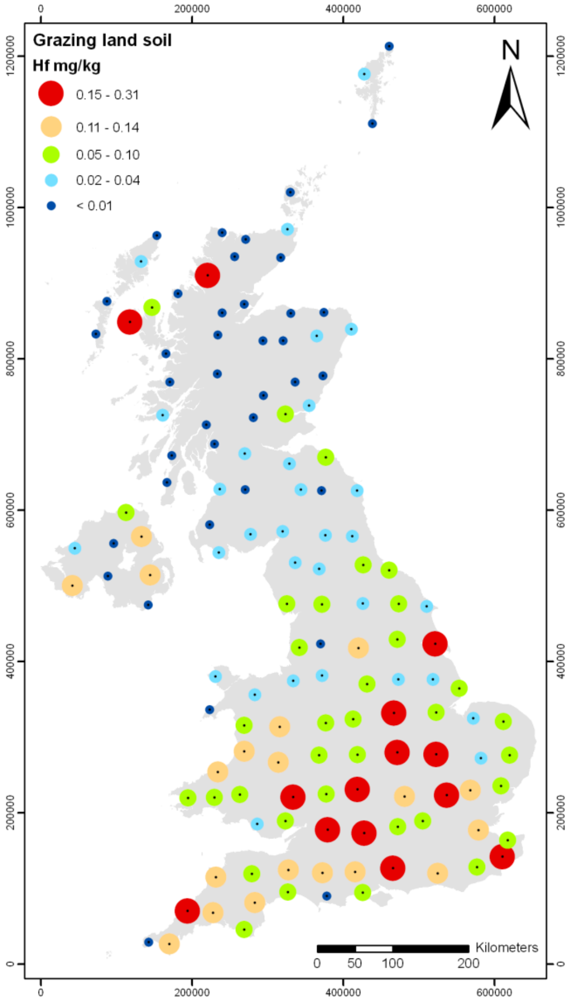


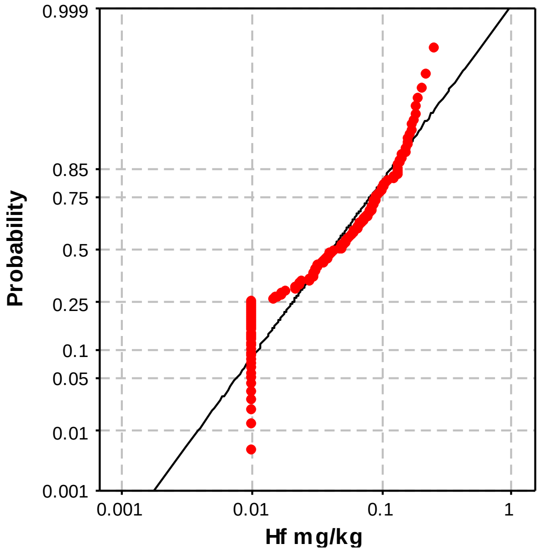
3.20 HAFNIUM (Hf)

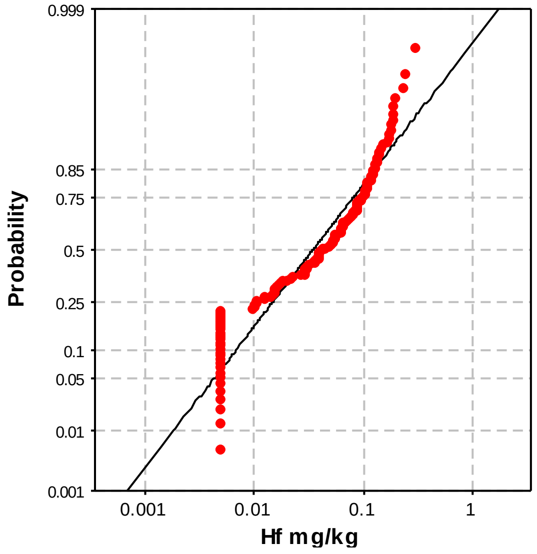
Arable soil



Grazing land soil

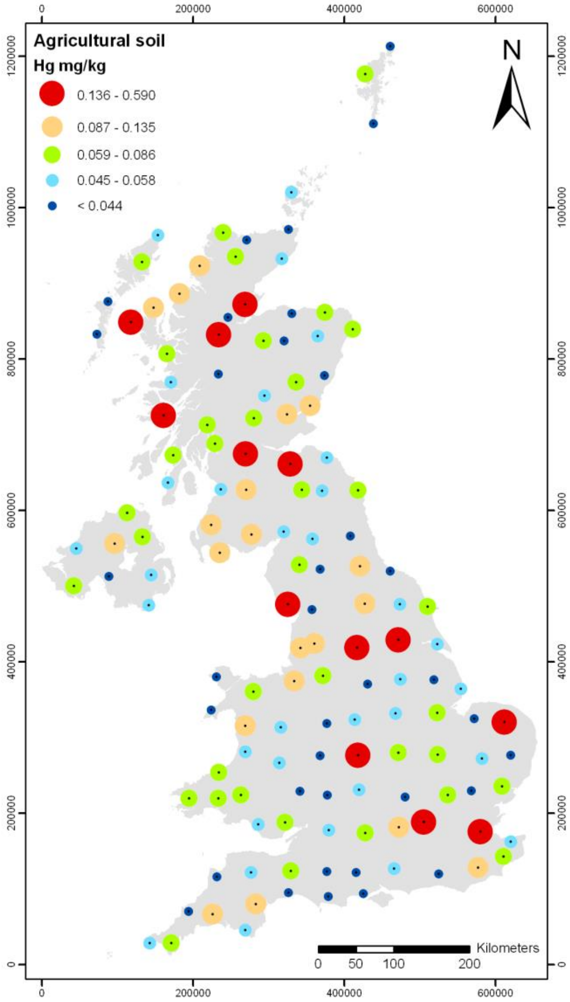




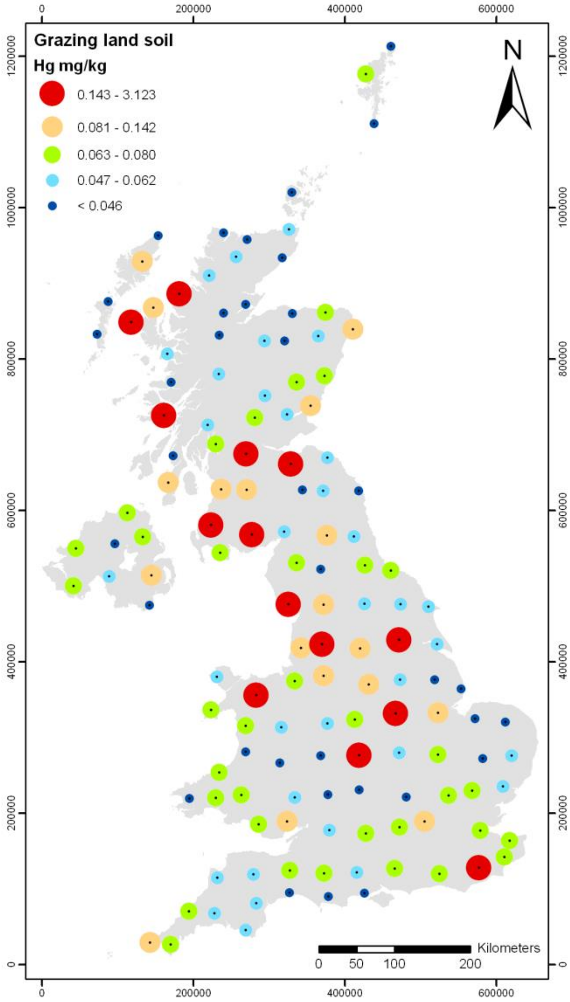


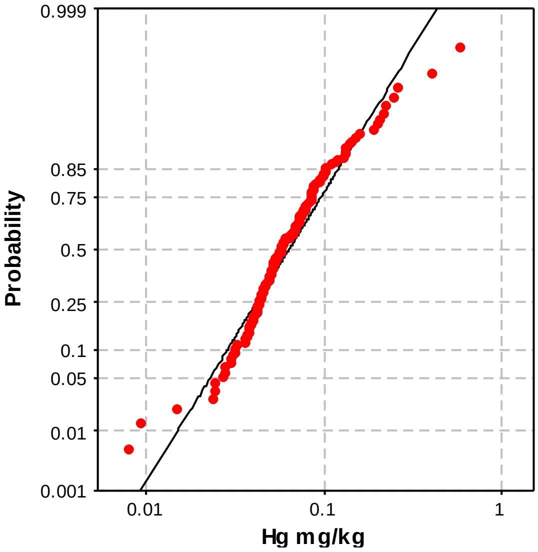
3.21 MERCURY (Hg)

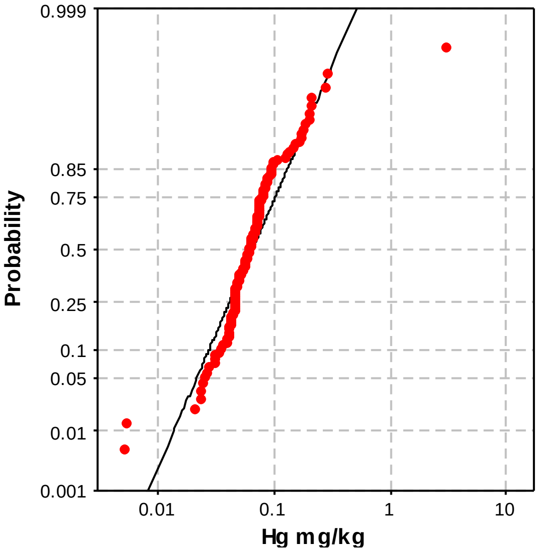
Arable soil



Grazing land soil

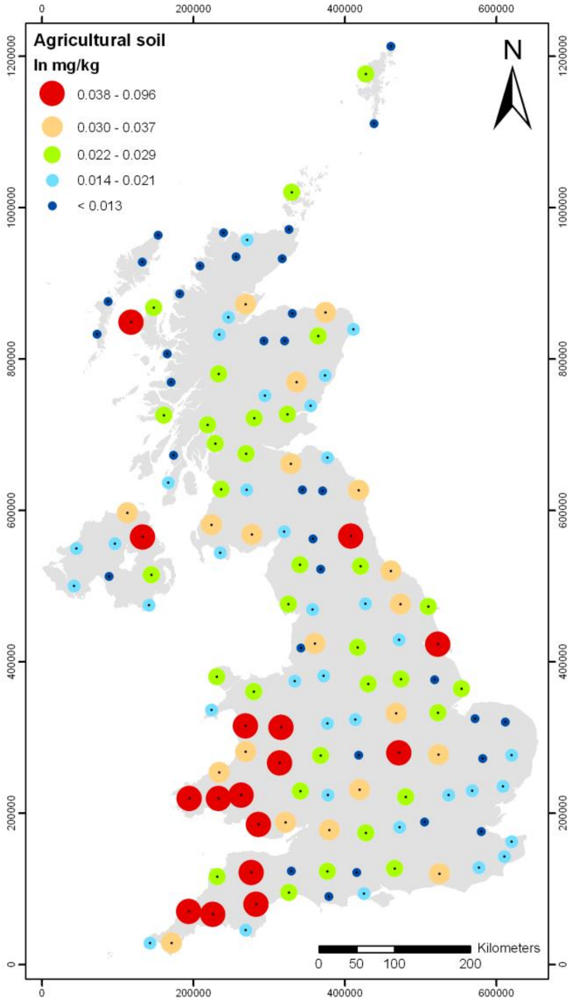




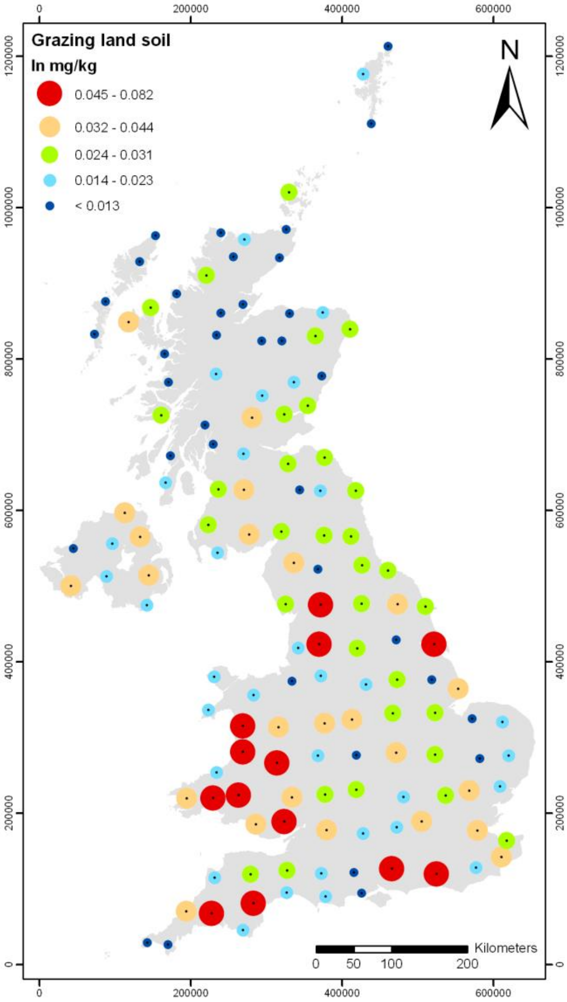


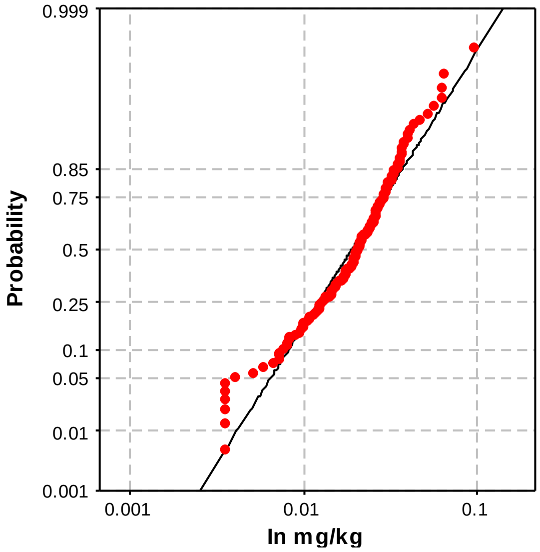
3.22 INDIUM (In)

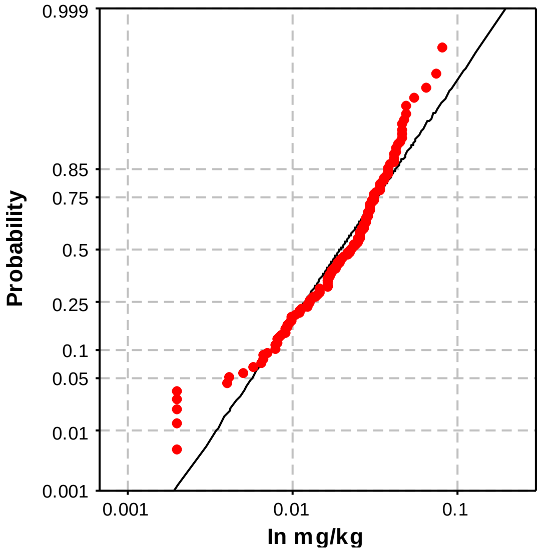
Arable soil



Grazing land soil

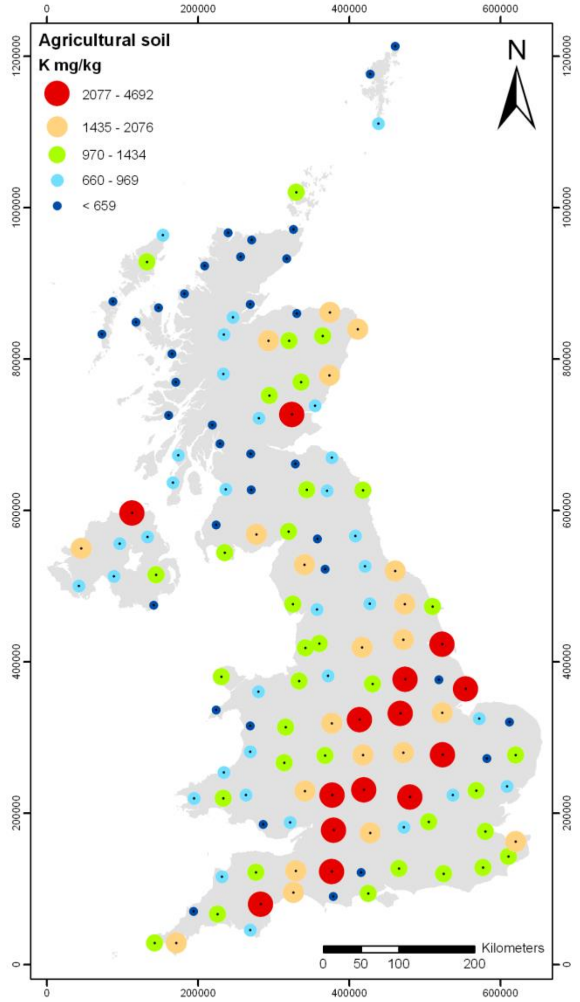




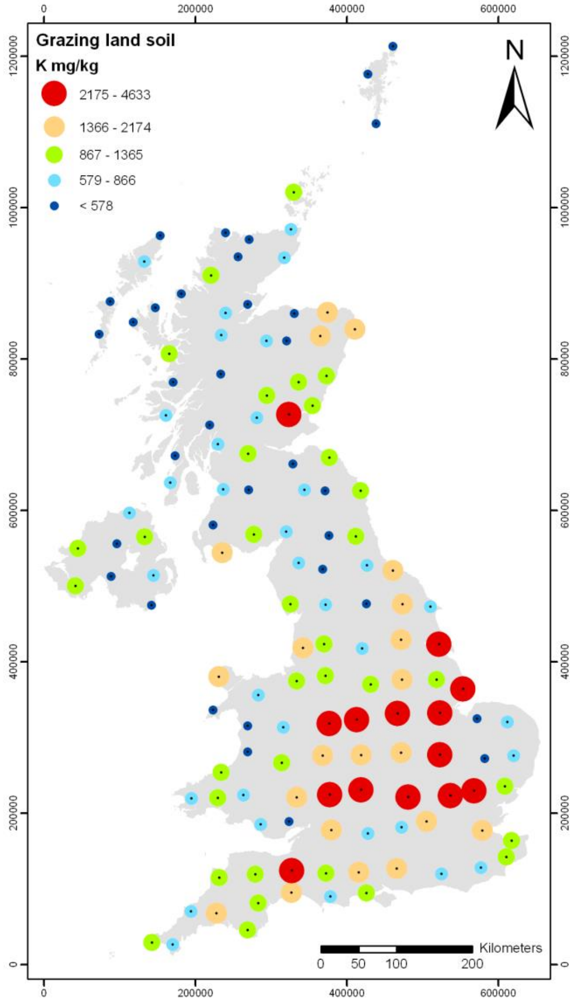


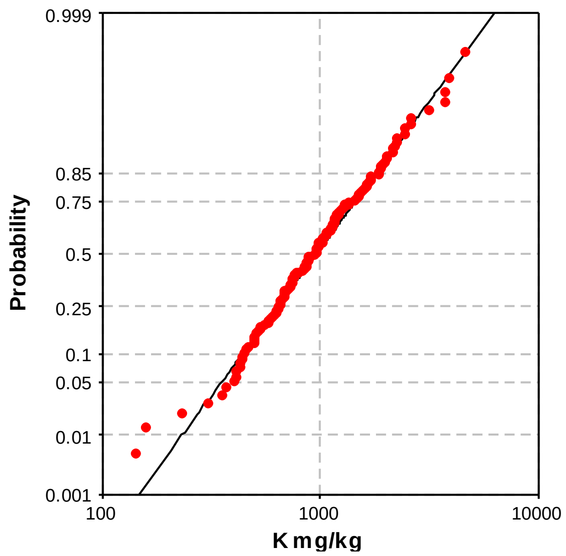
3.23 POTASSIUM (K)

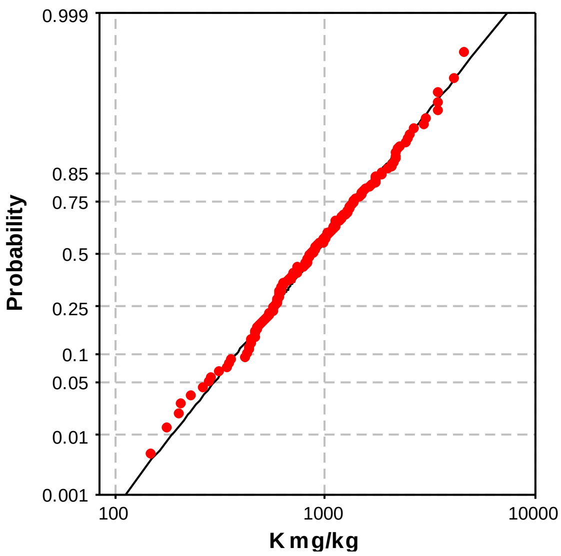
Arable soil



Grazing land soil

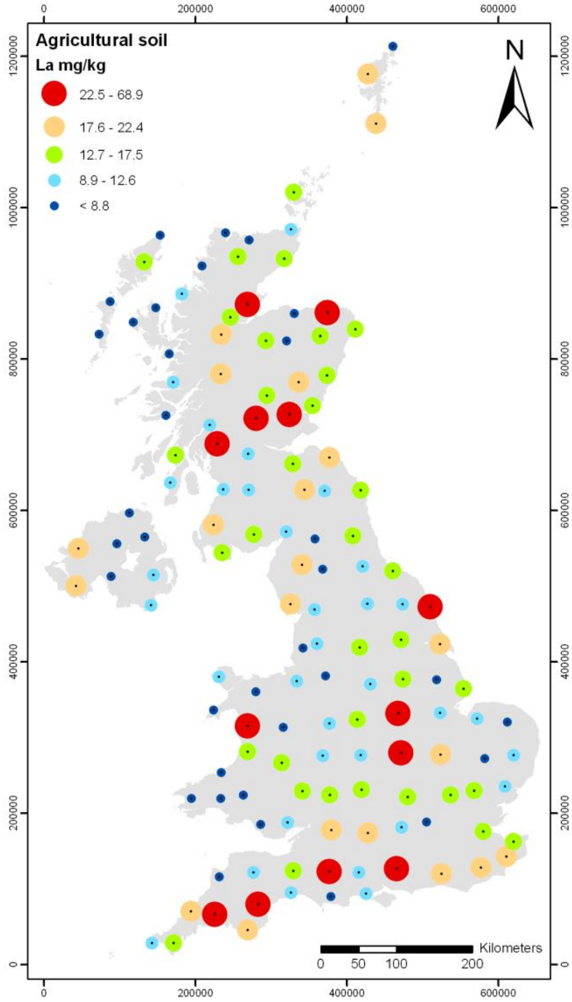


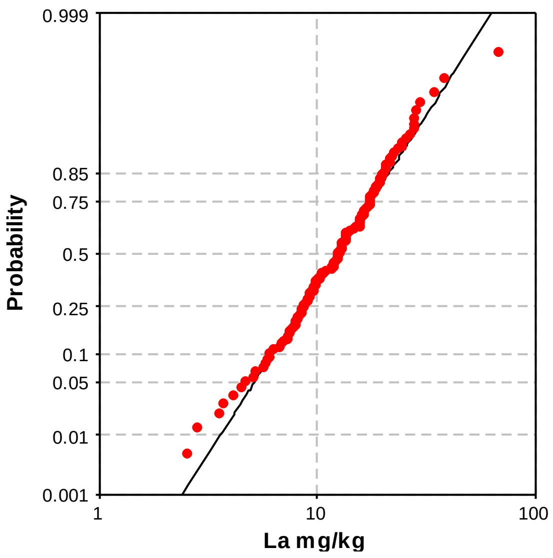




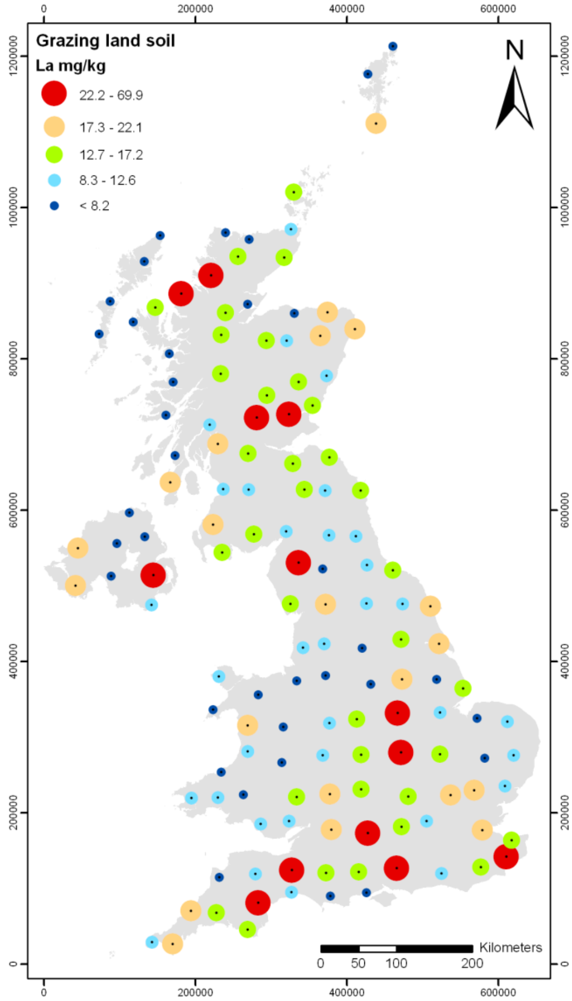
3.24 LANTHANUM (La)

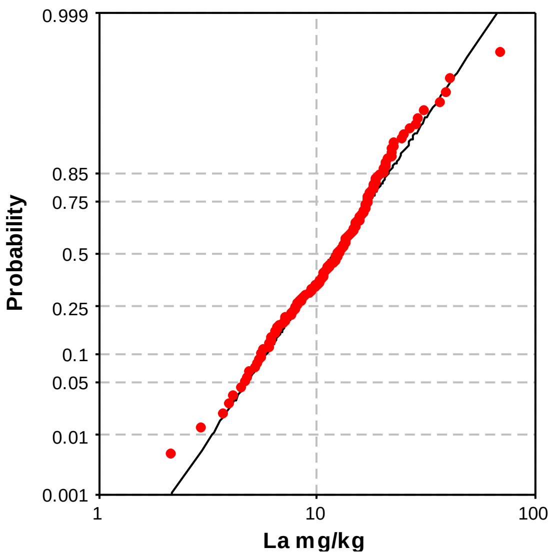
Arable soil





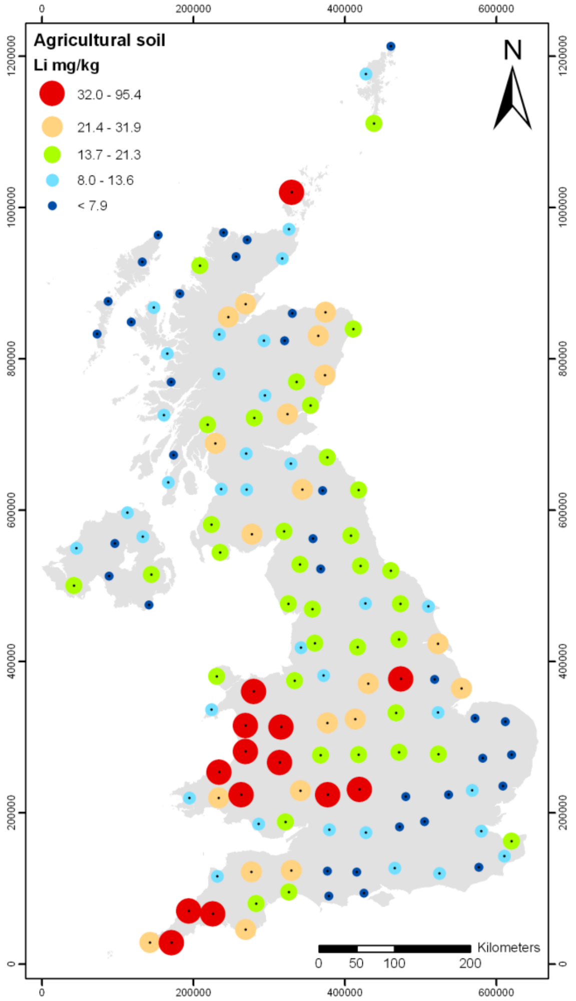
Grazing land soil



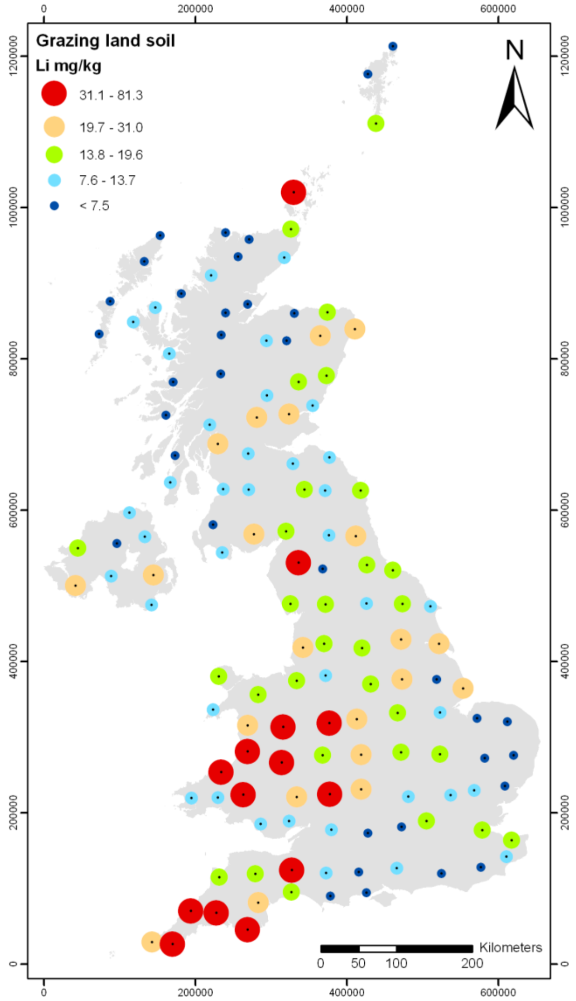


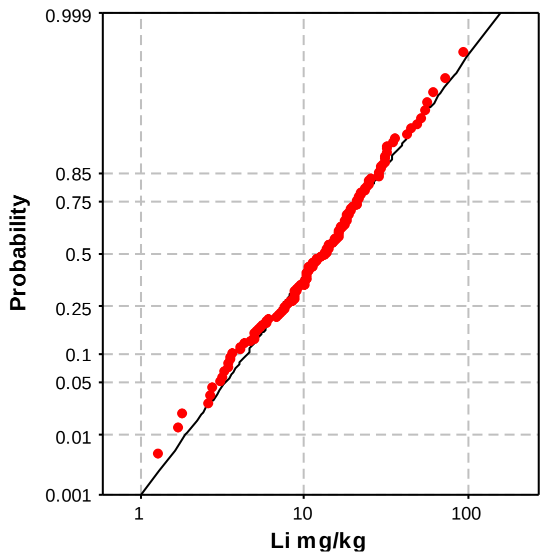
3.25 LITHIUM (Li)

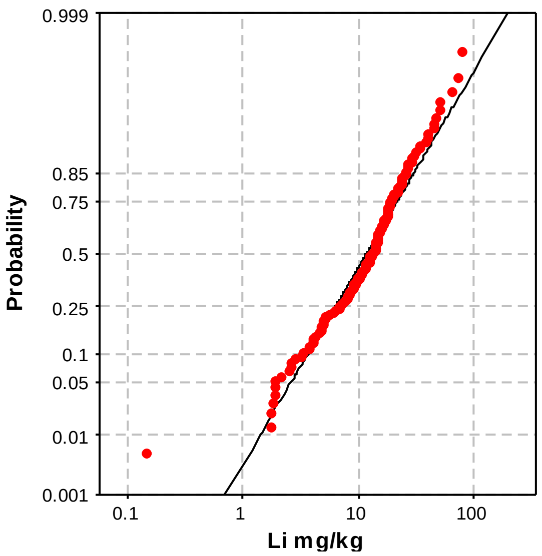
Arable soil



Grazing land soil

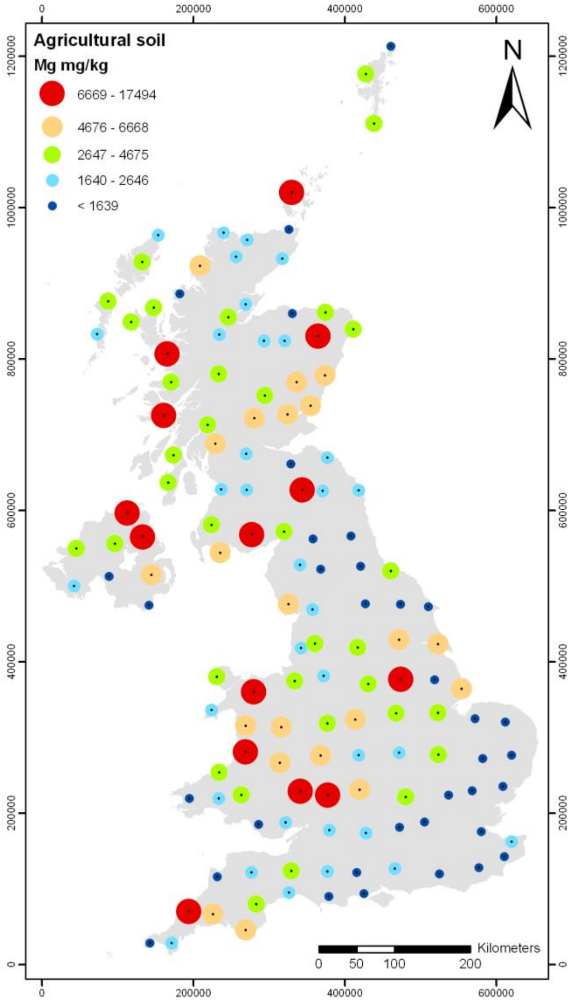




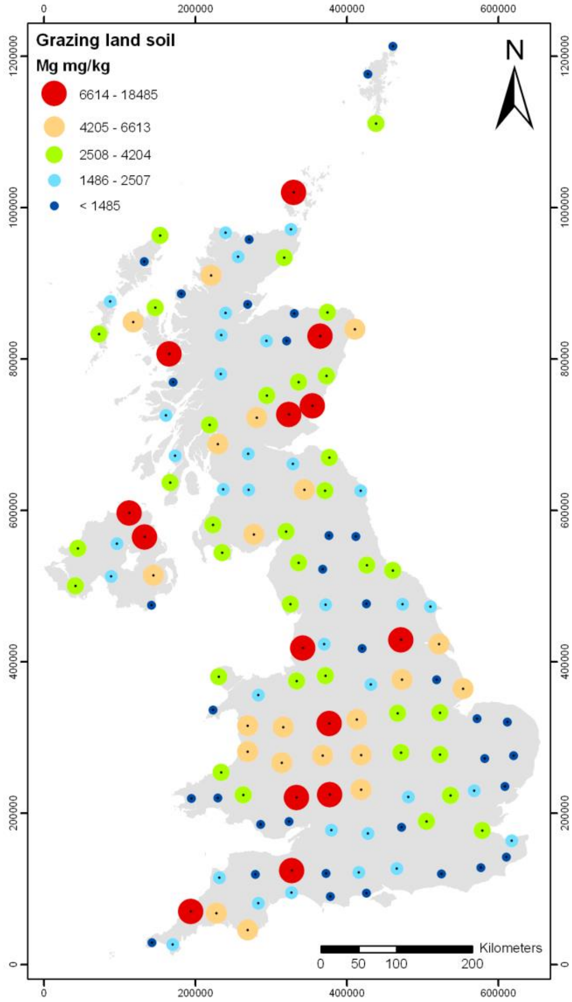


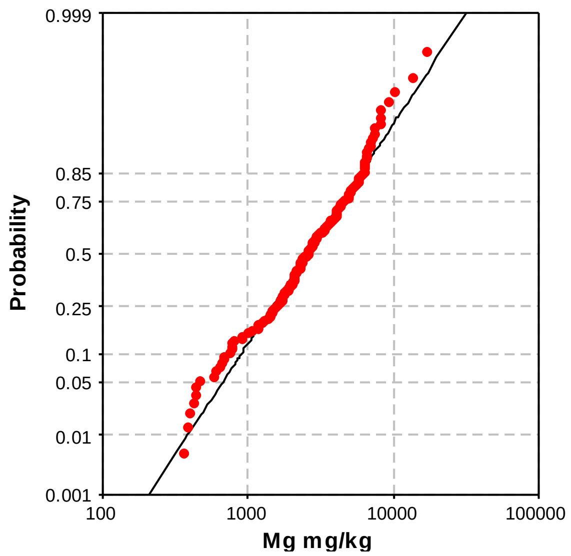
3.26 MAGNESIUM (Mg)

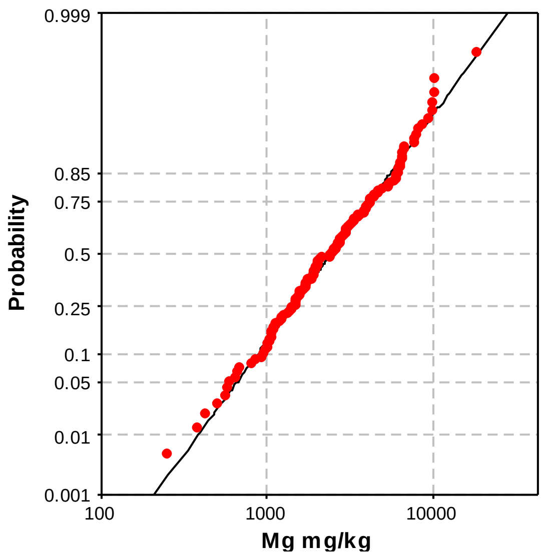
Arable soil



Grazing land soil

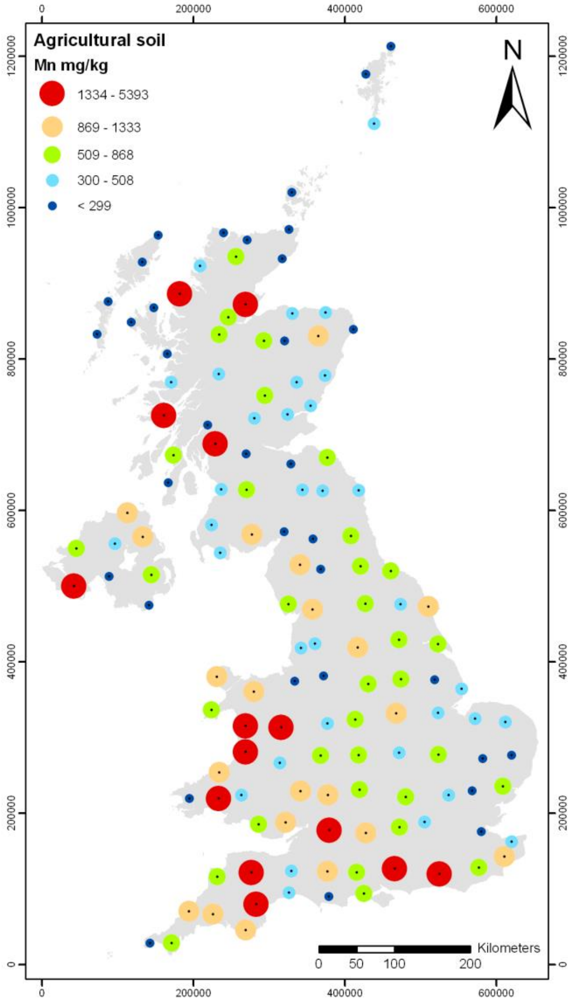




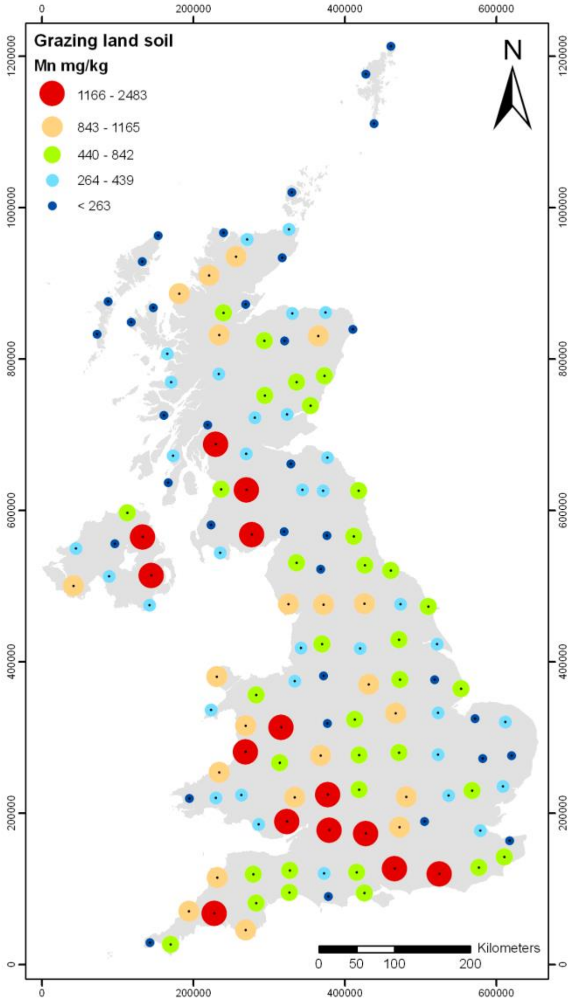


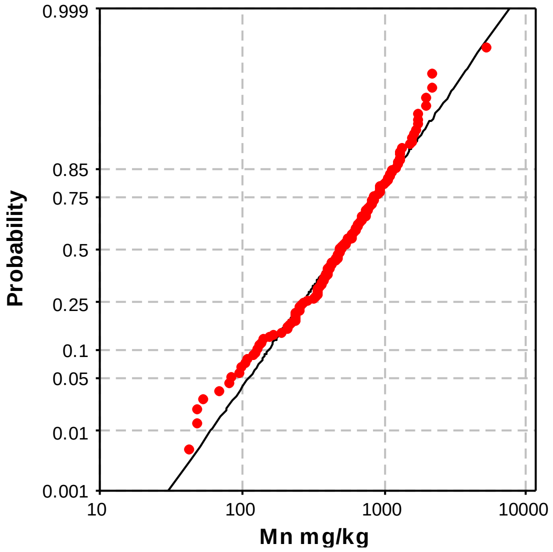
3.27 MANGANESE (Mn)

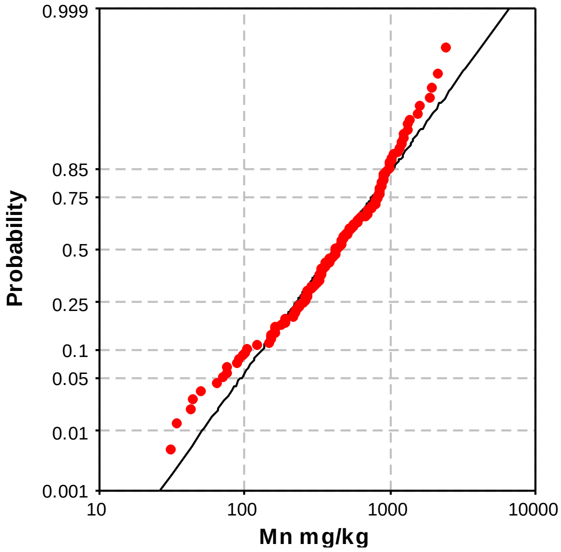
Arable soil



Grazing land soil

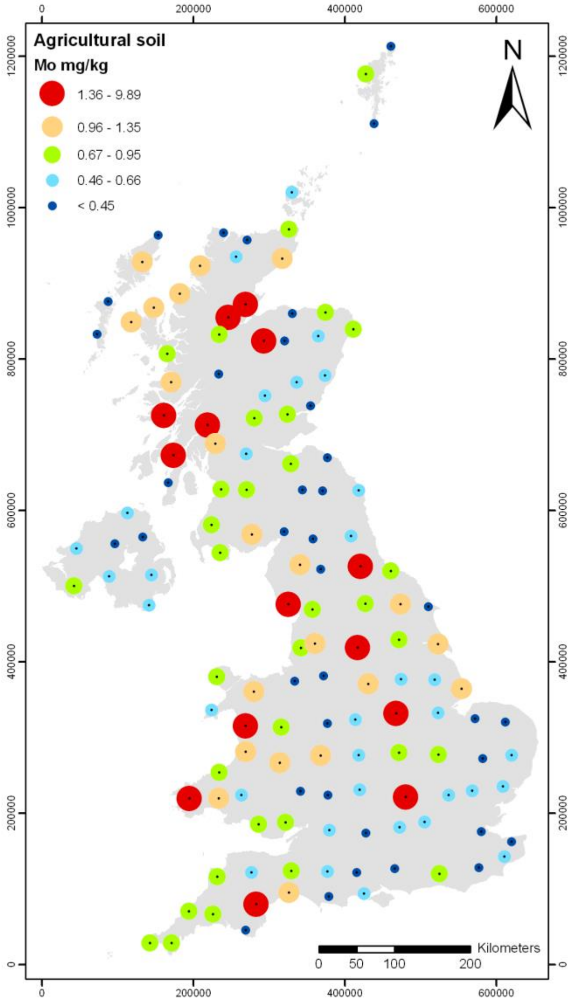




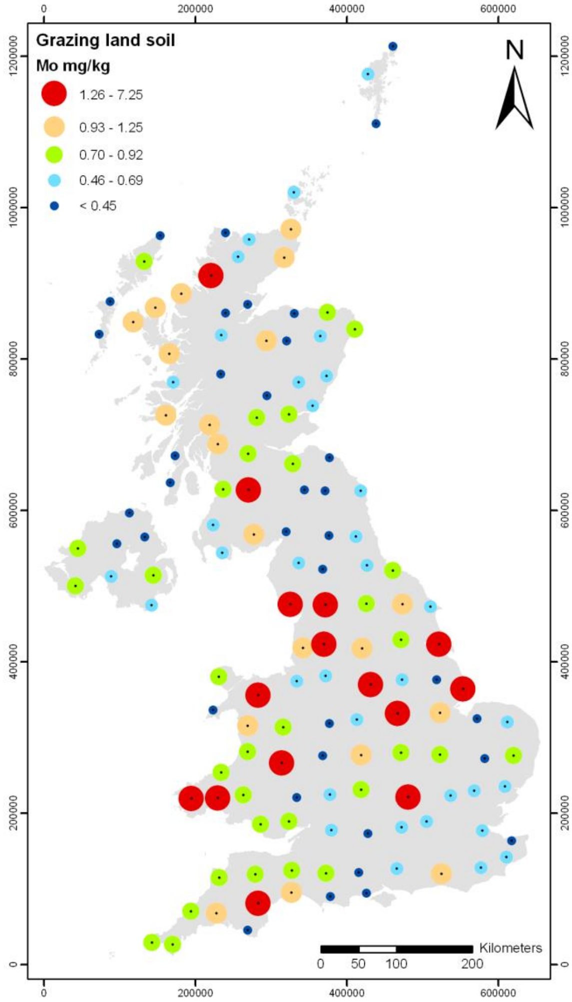


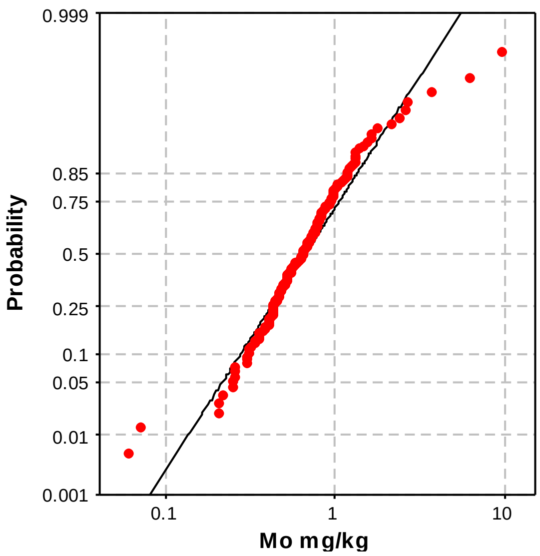
3.28 MOLYBDENUM (Mo)

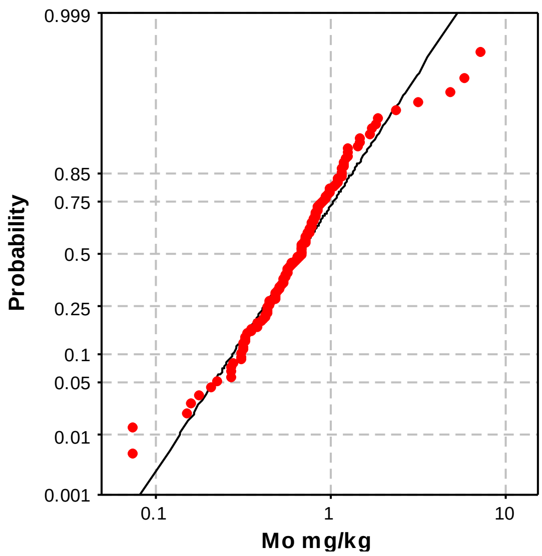
Arable soil



Grazing land soil

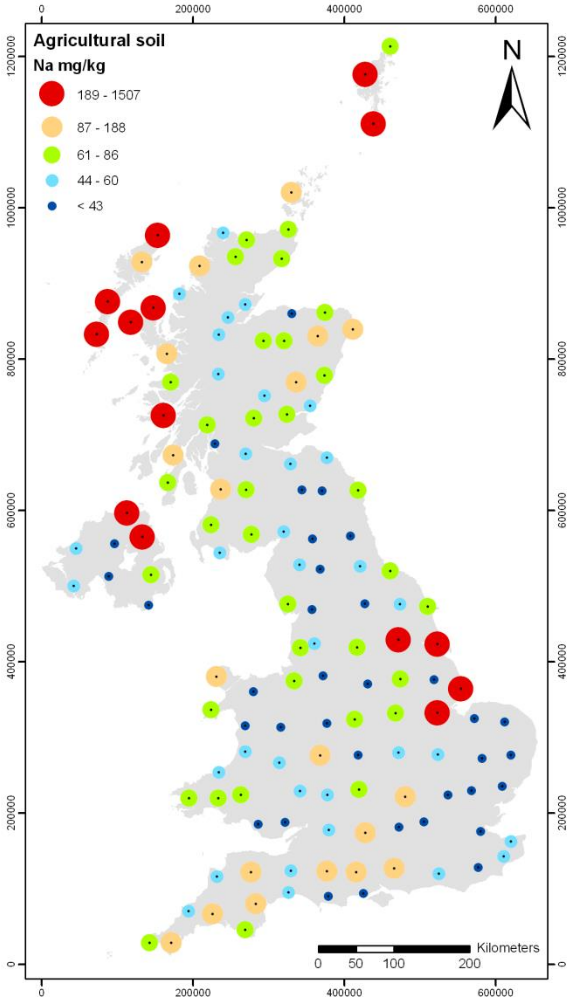




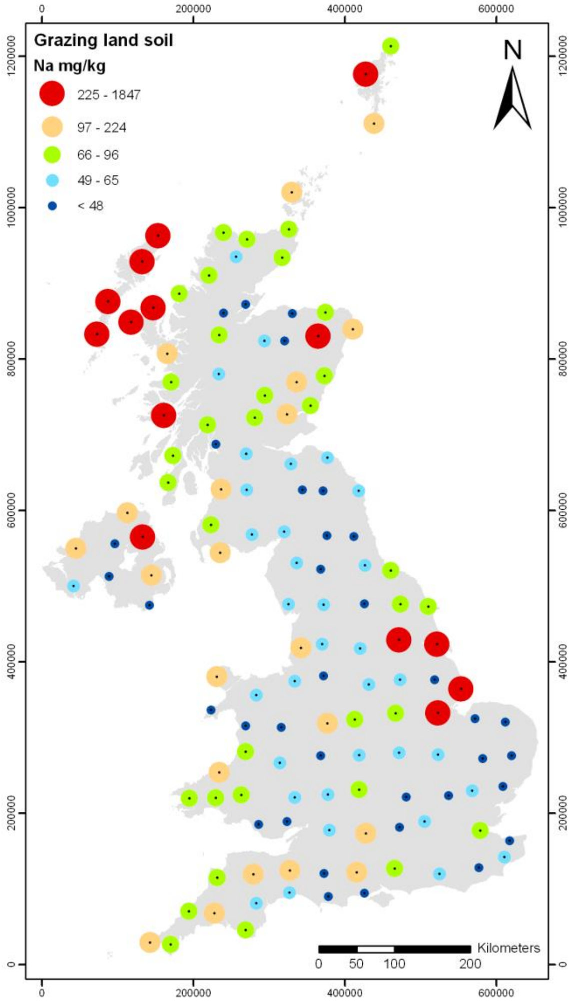


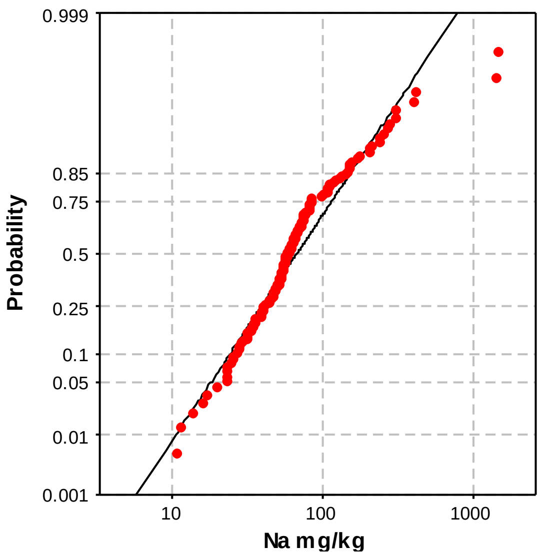
3.29 SODIUM (Na)

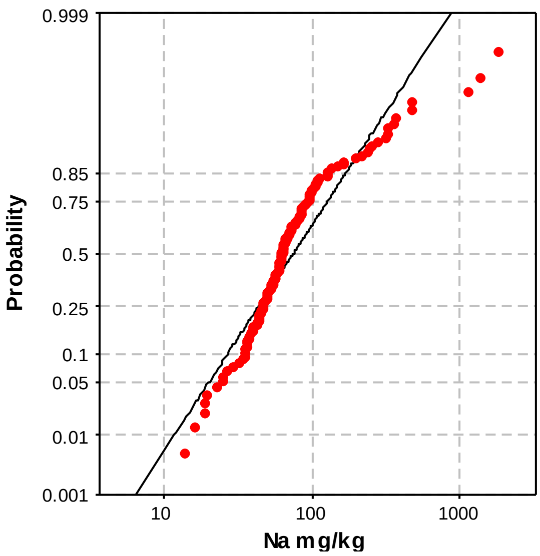
Arable soil



Grazing land soil

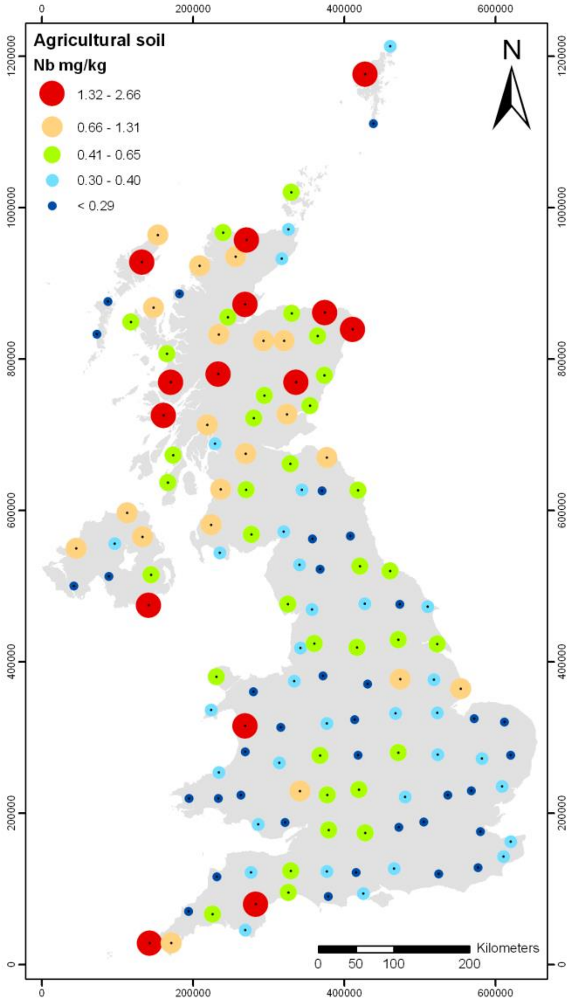




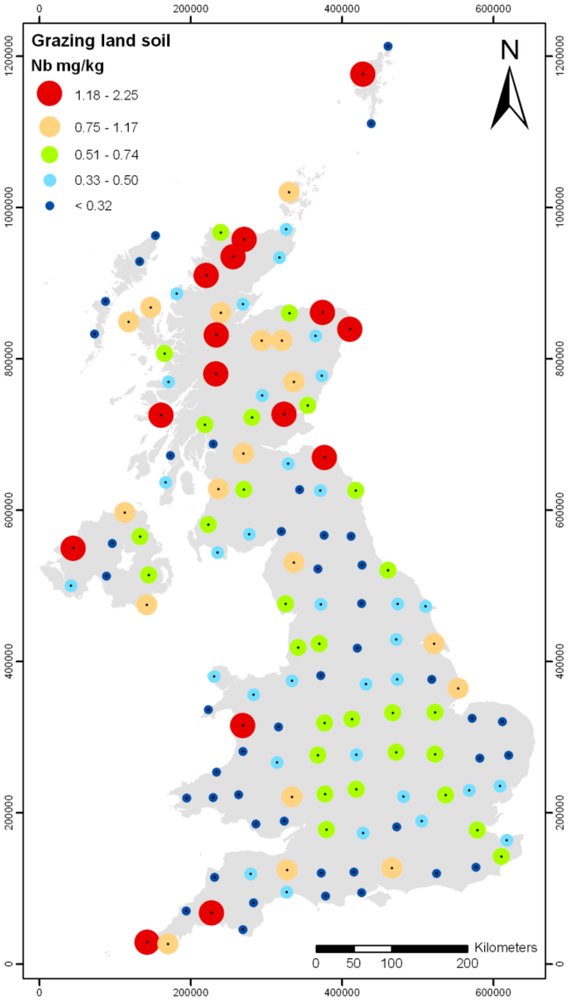


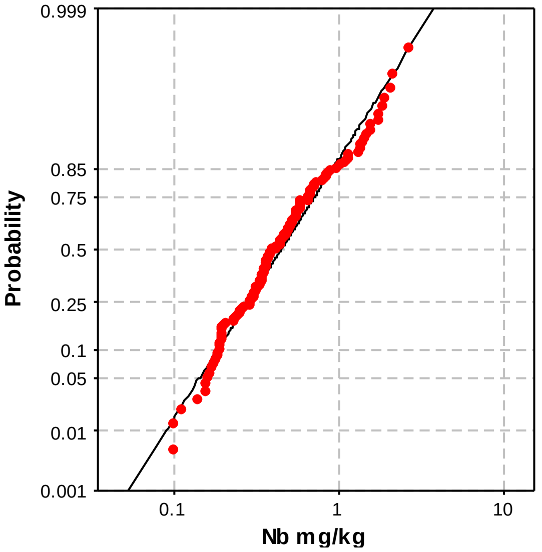
3.30 NIOBIUM (Nb)

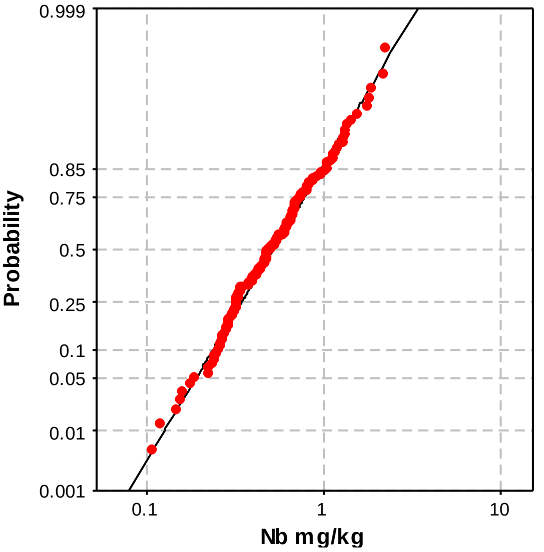
Arable soil



Grazing land soil

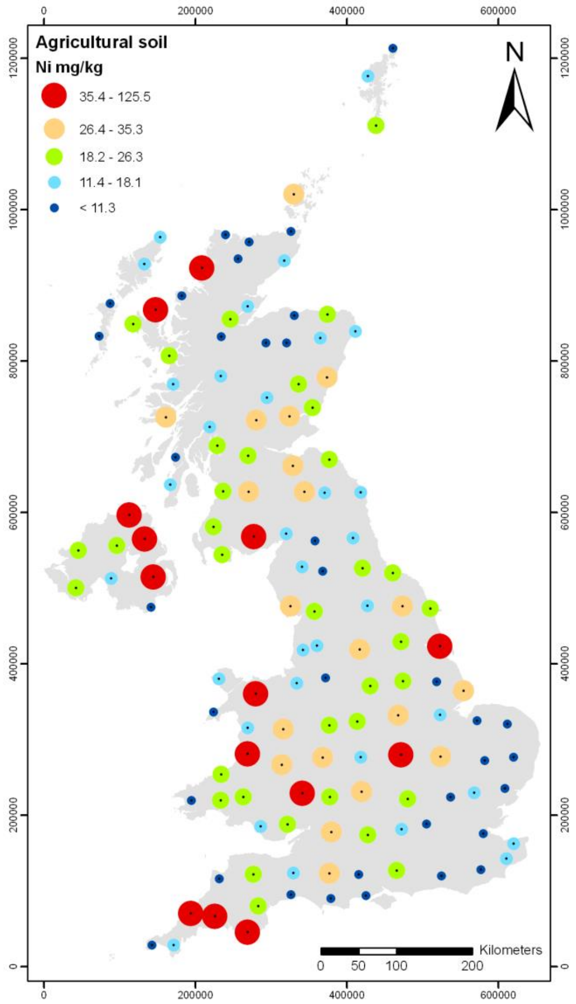




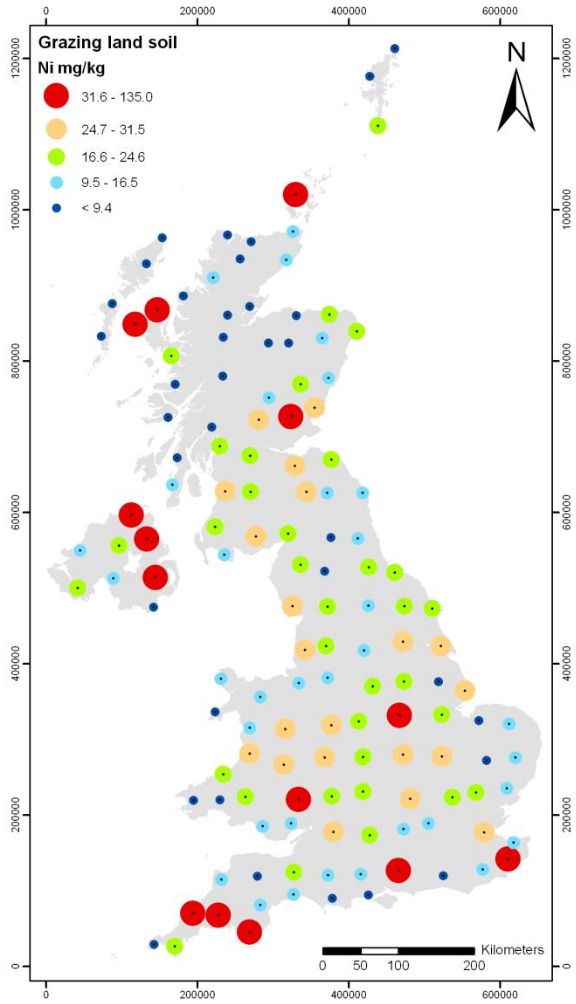


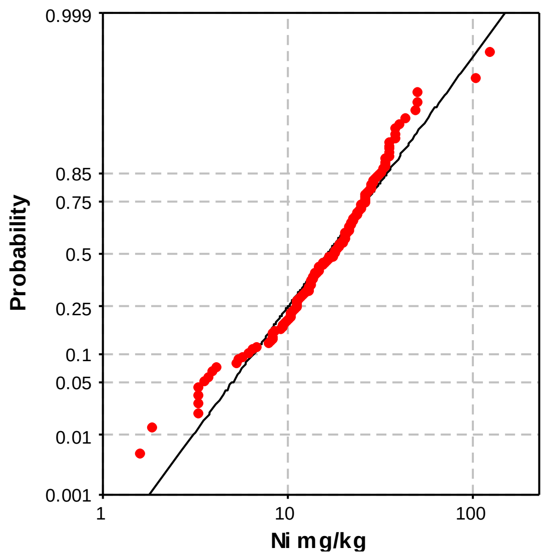
3.31 NICKEL (Ni)

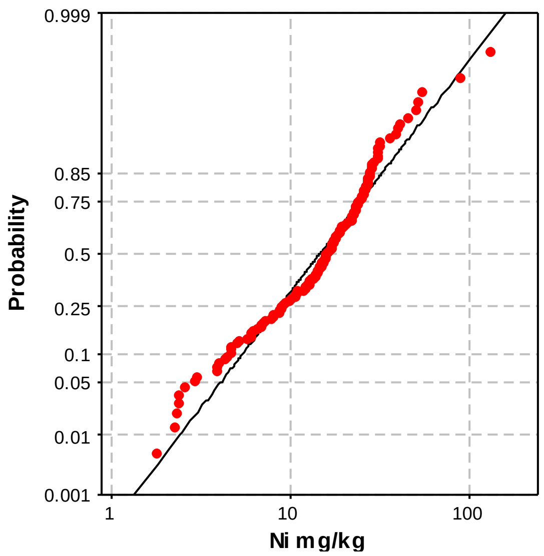
Arable soil



Grazing land soil

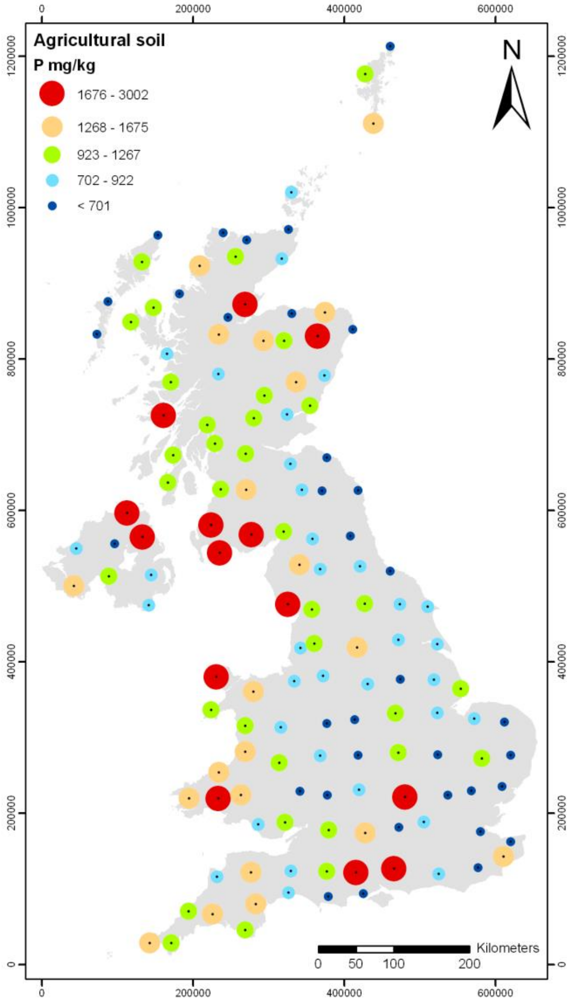




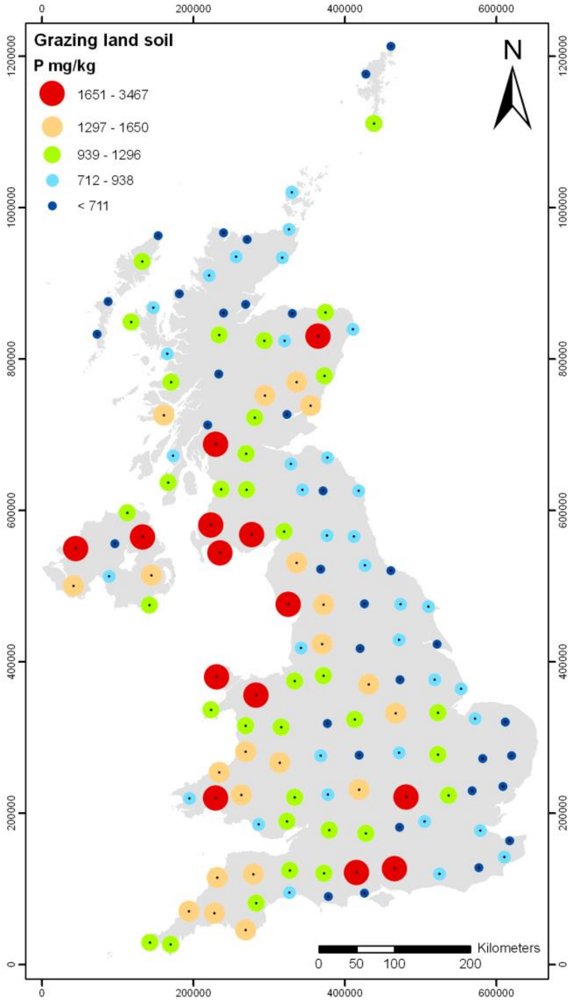


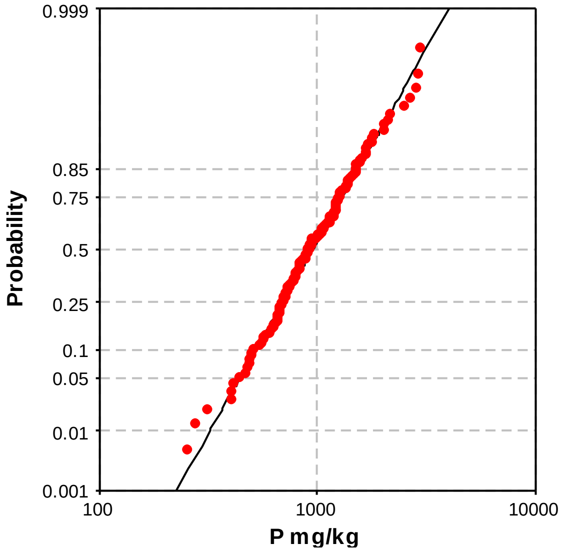
3.32 PHOSPHOROUS (P)

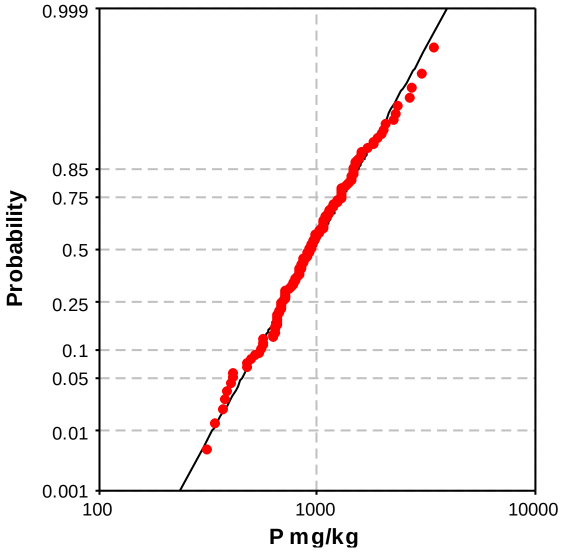
Arable soil



Grazing land soil

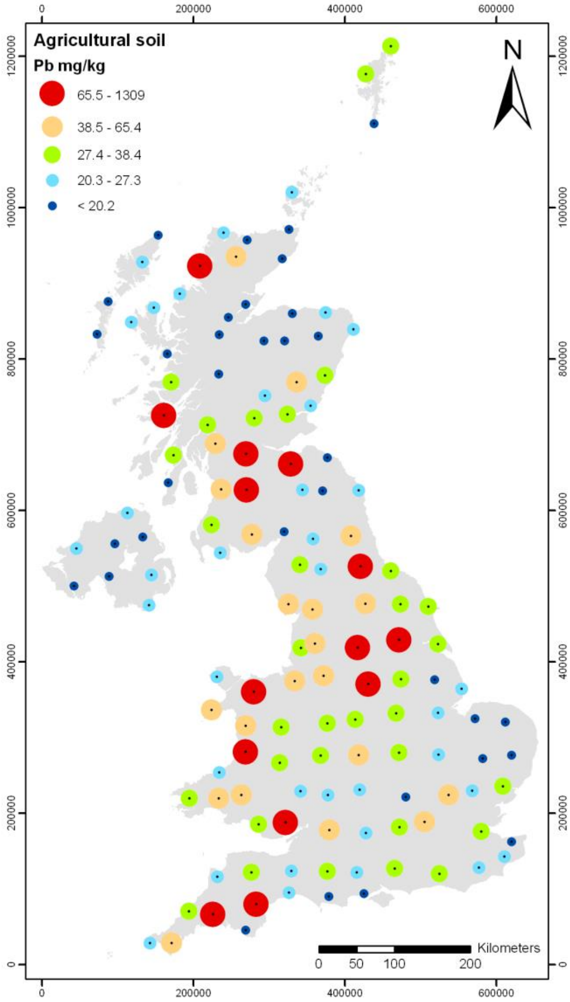




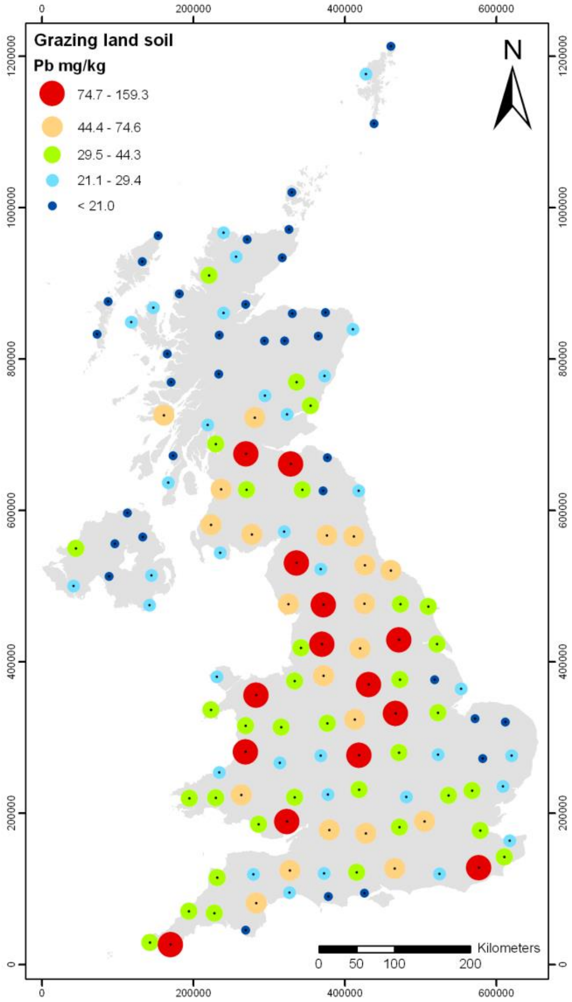


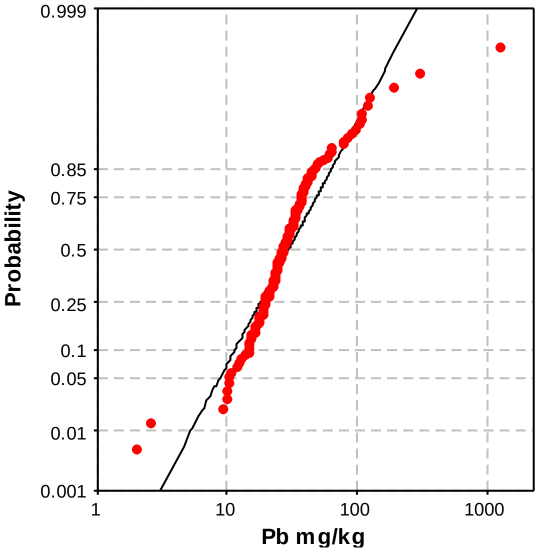
3.33 LEAD (Pb)

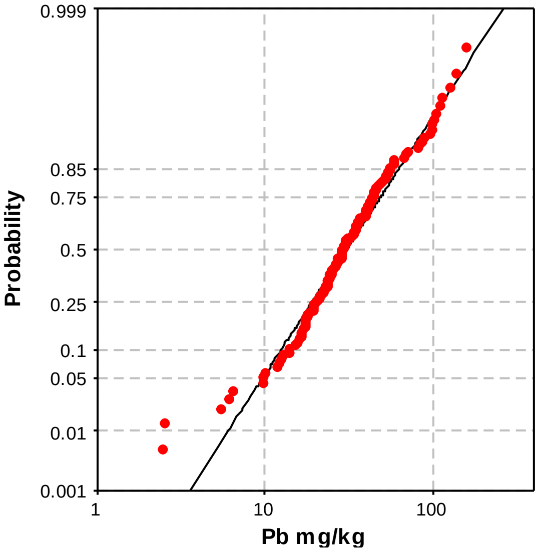
Arable soil



Grazing land soil

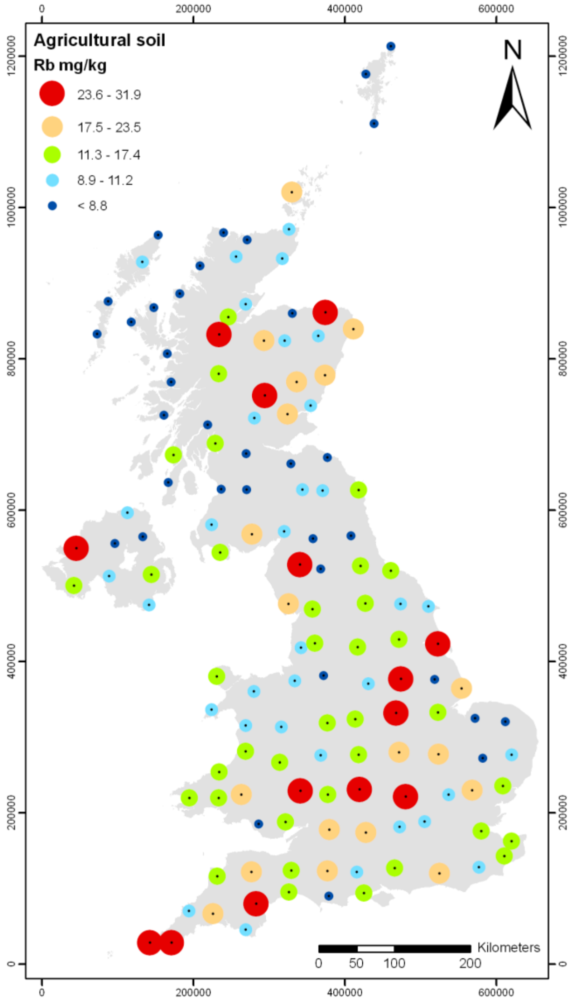




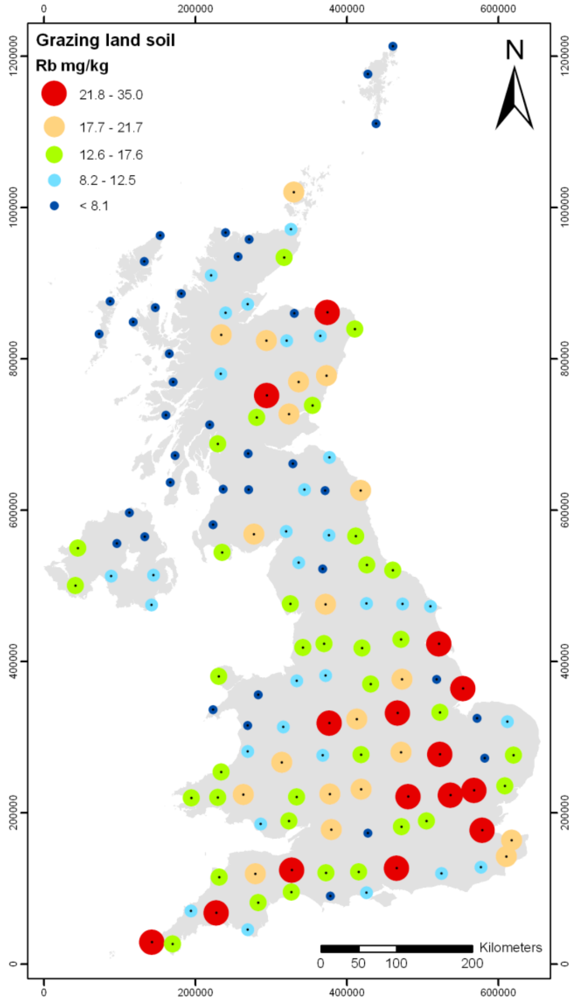


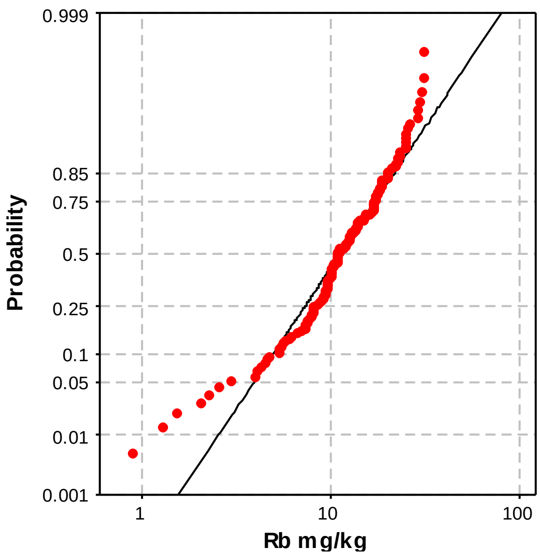
3.34 RUBIDIUM (Rb)

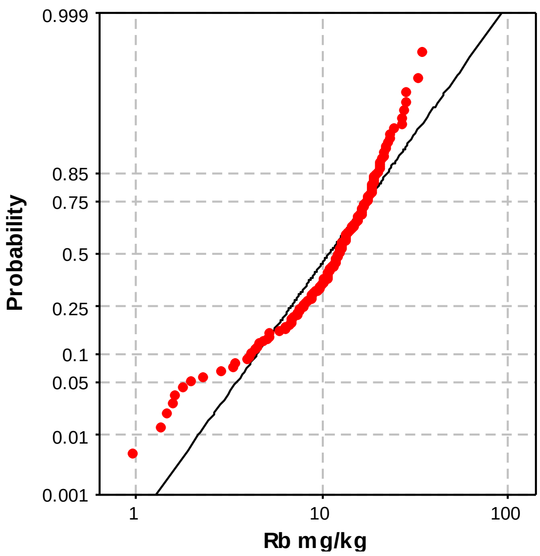
Arable soil



Grazing land soil

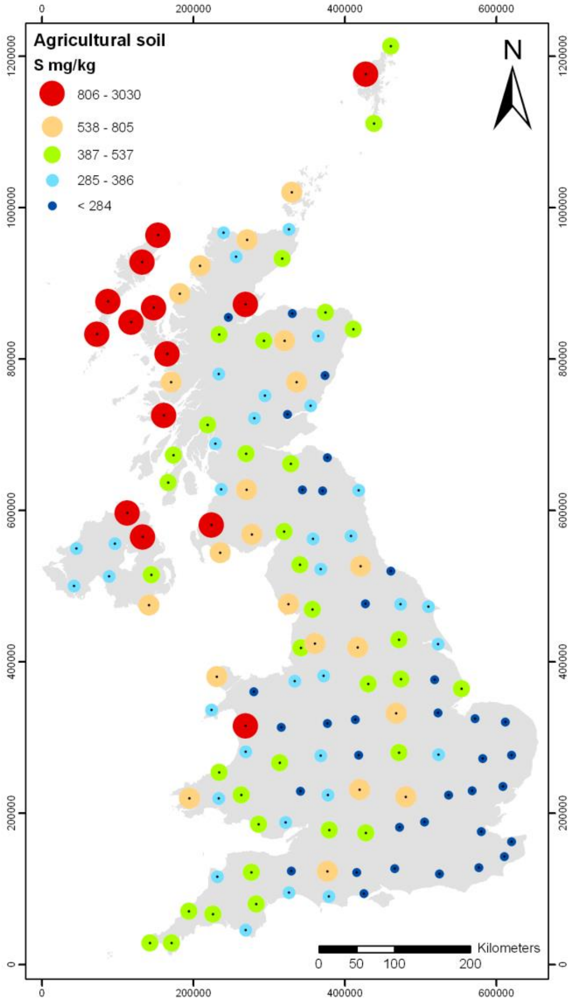




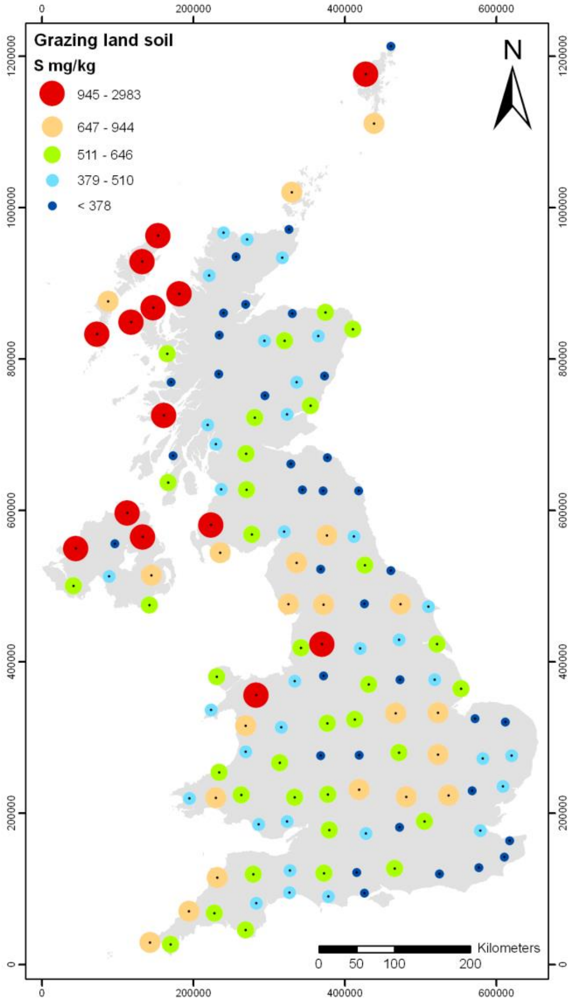


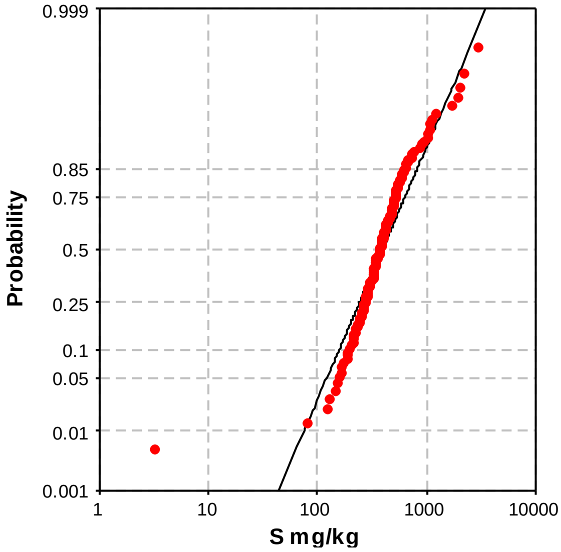
3.35 SULPHUR (S)

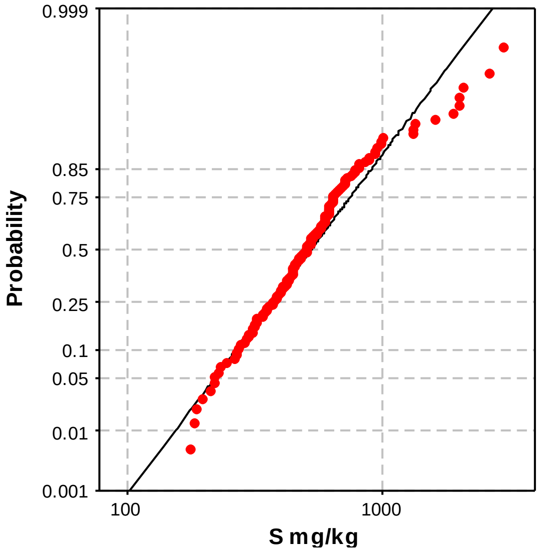
Arable soil



Grazing land soil

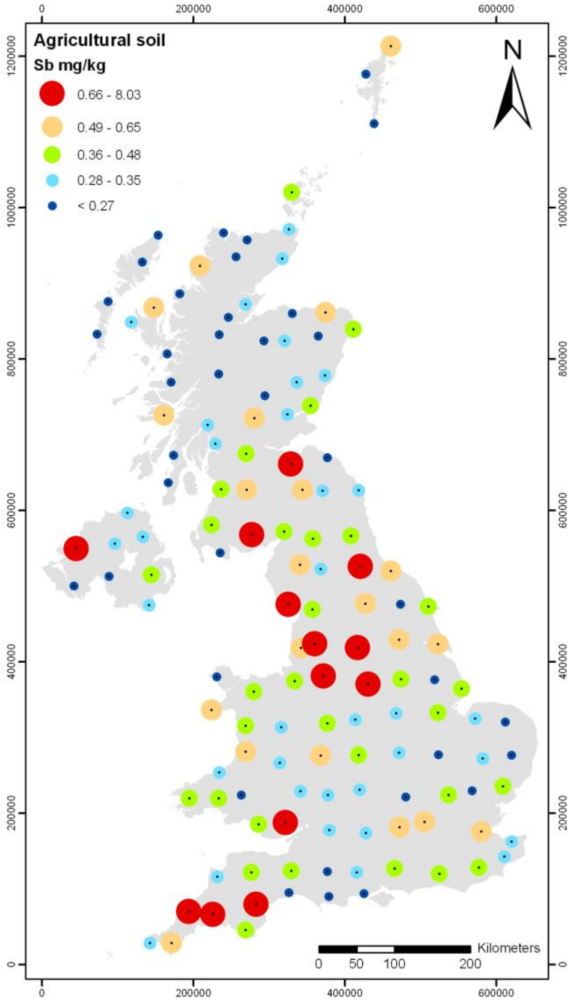






3.36 ANTIMONY (Sb)

Arable soil



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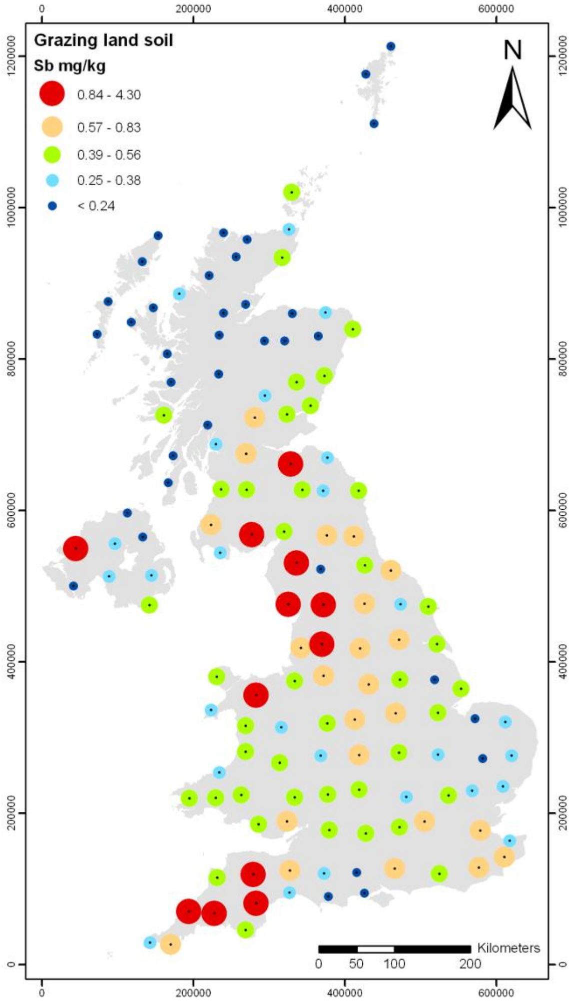
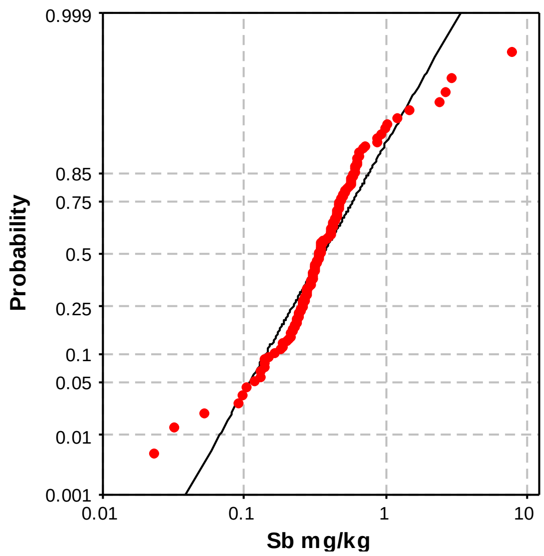
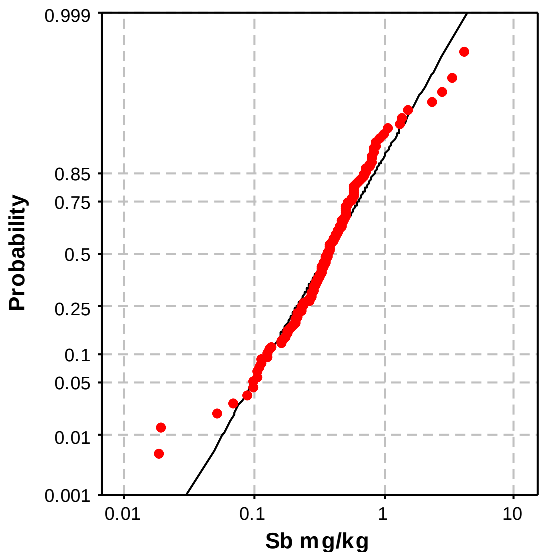
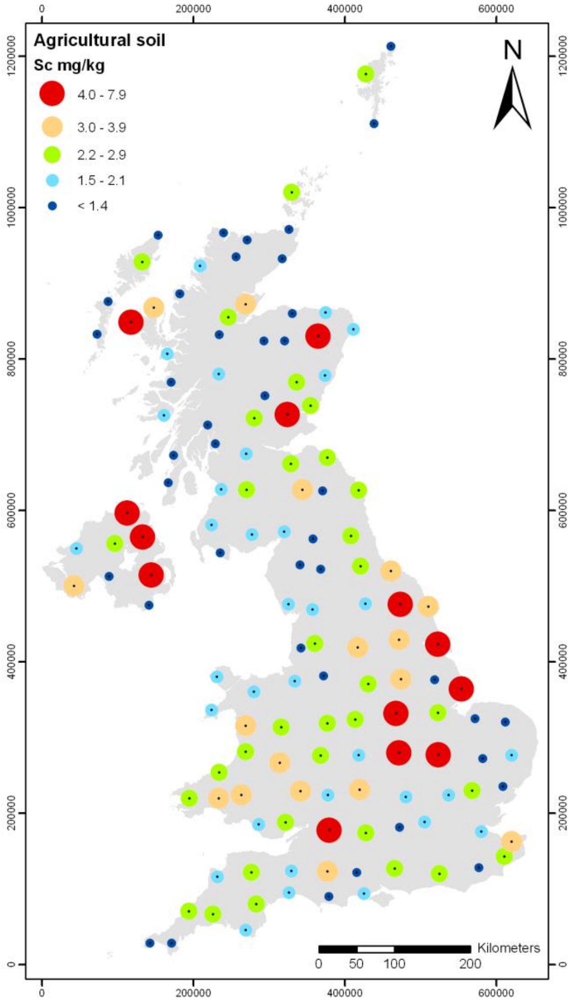




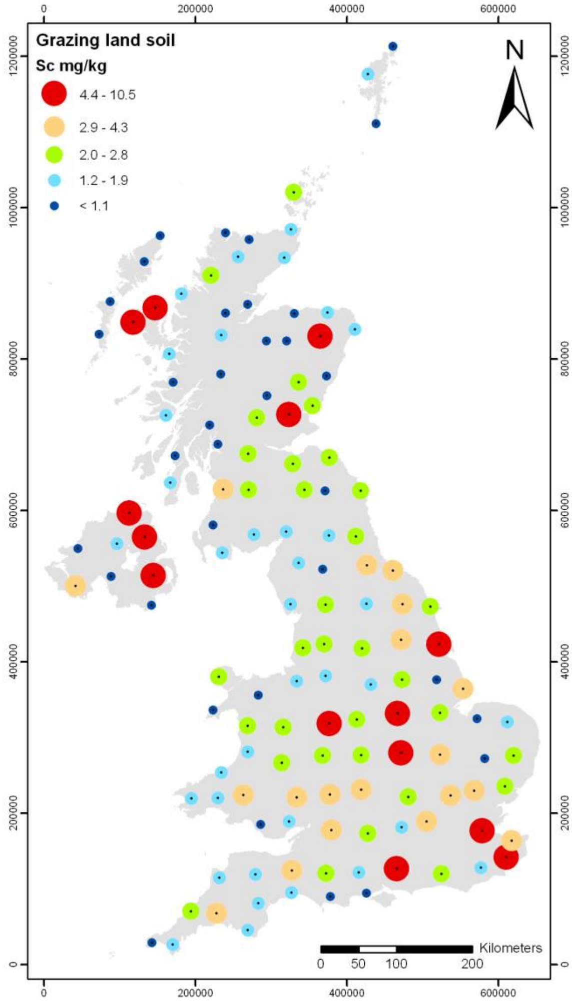


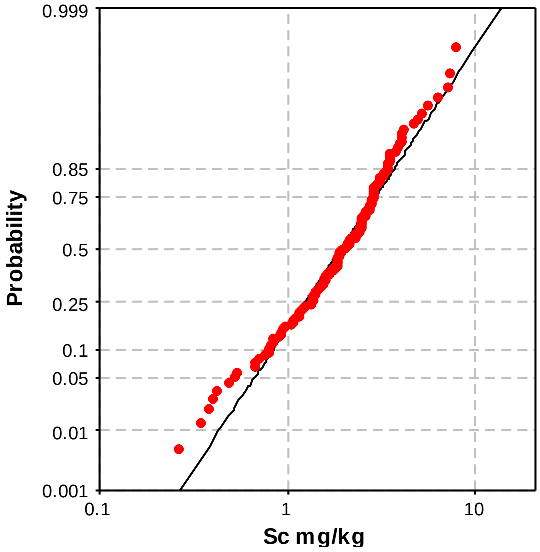
3.37 SCANDIUM (Sc)

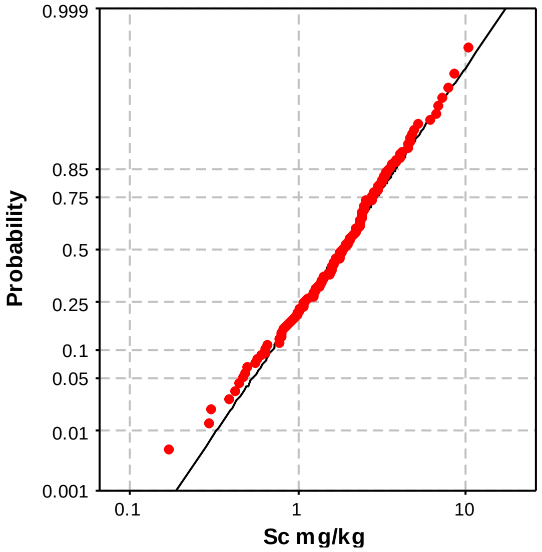
Arable soil



Grazing land soil

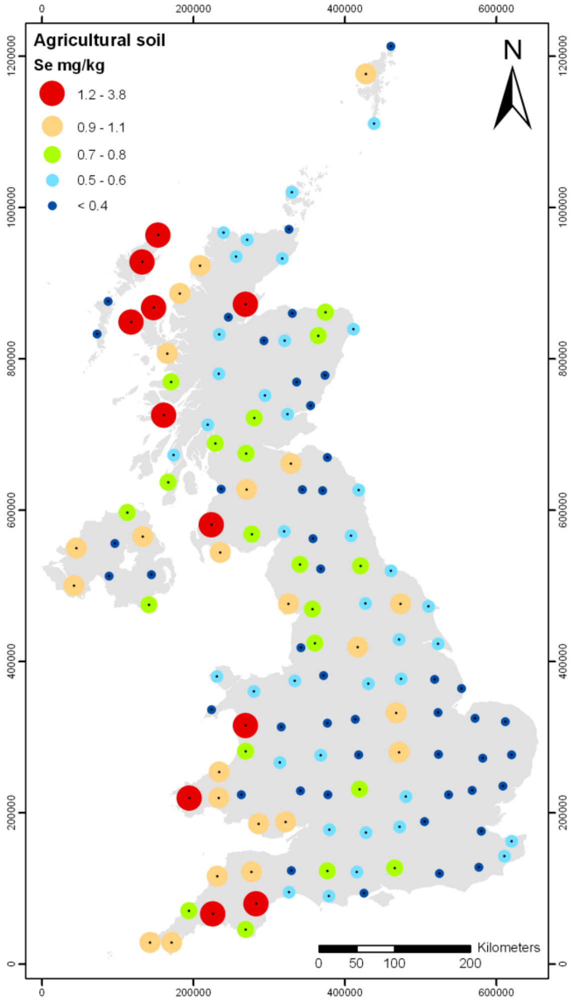




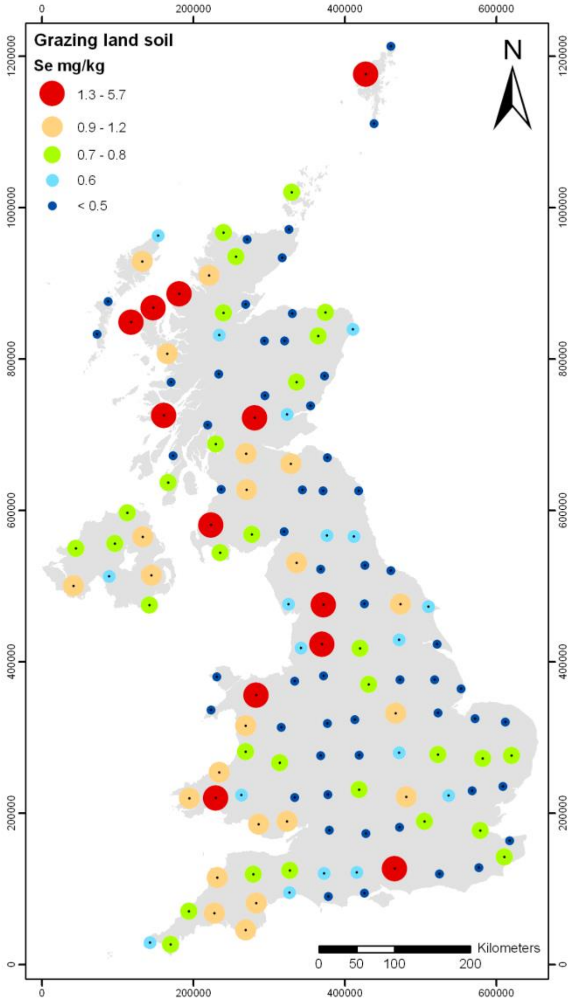


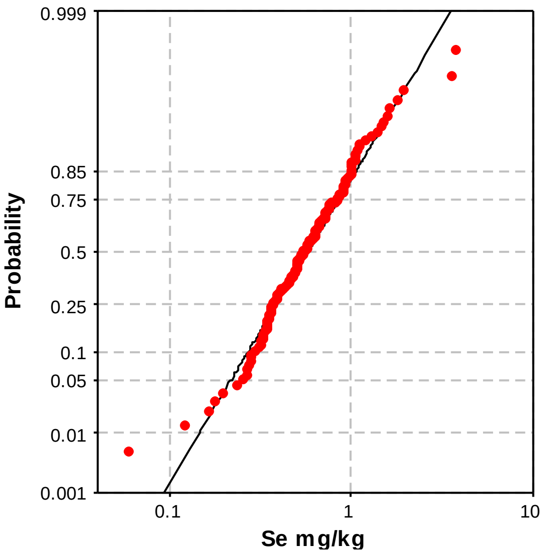
3.38 SELENIUM (Se)

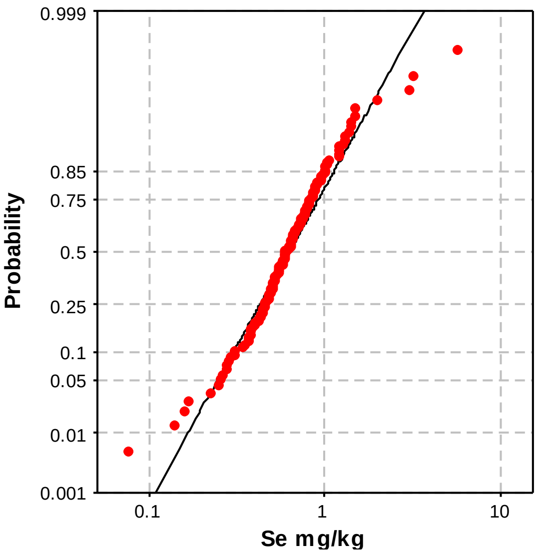
Arable soil



Grazing land soil

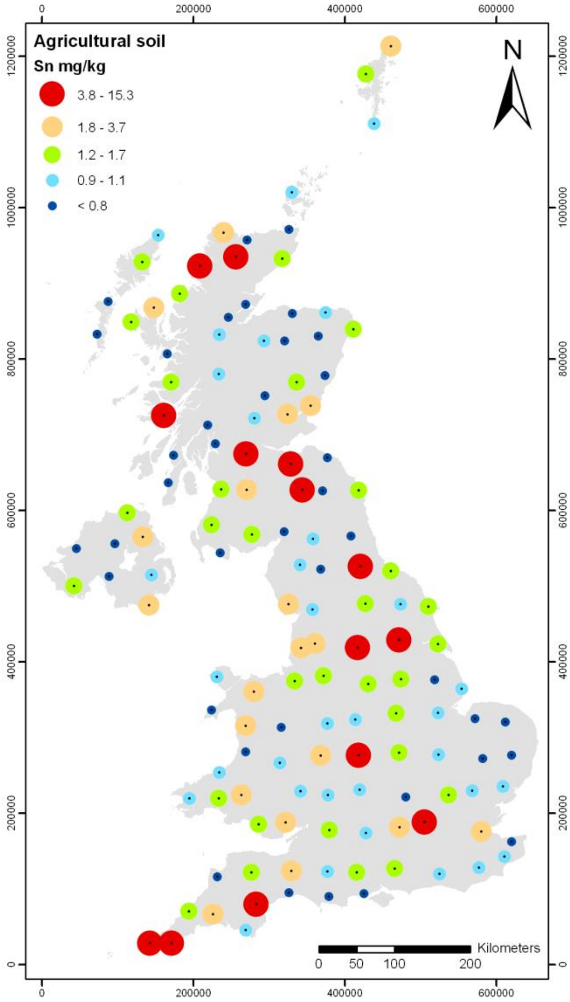


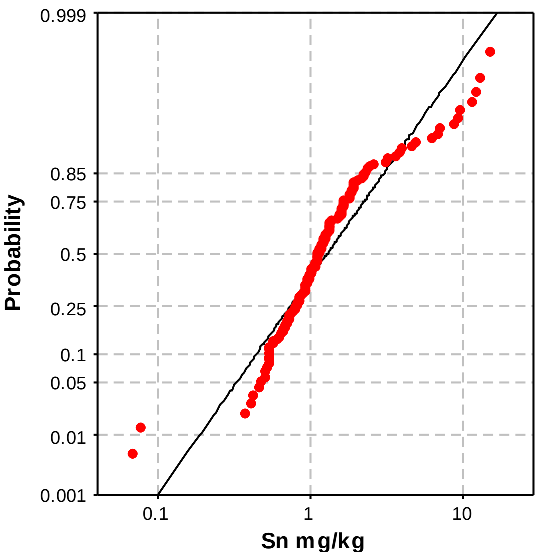




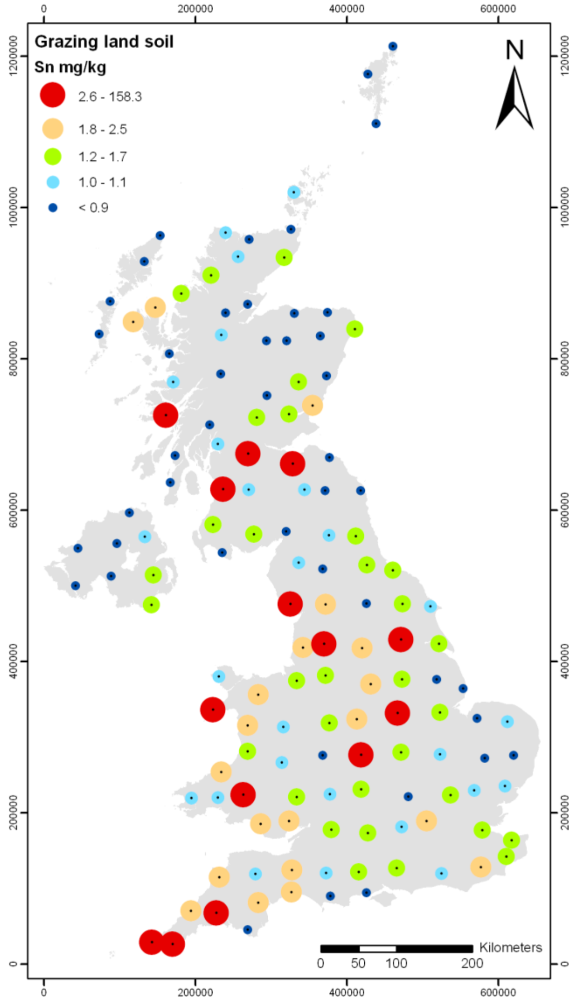
3.39 TIN (Sn)

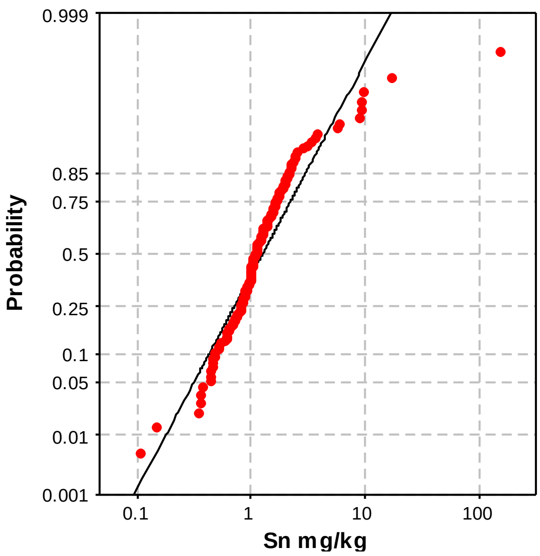
Arable soil





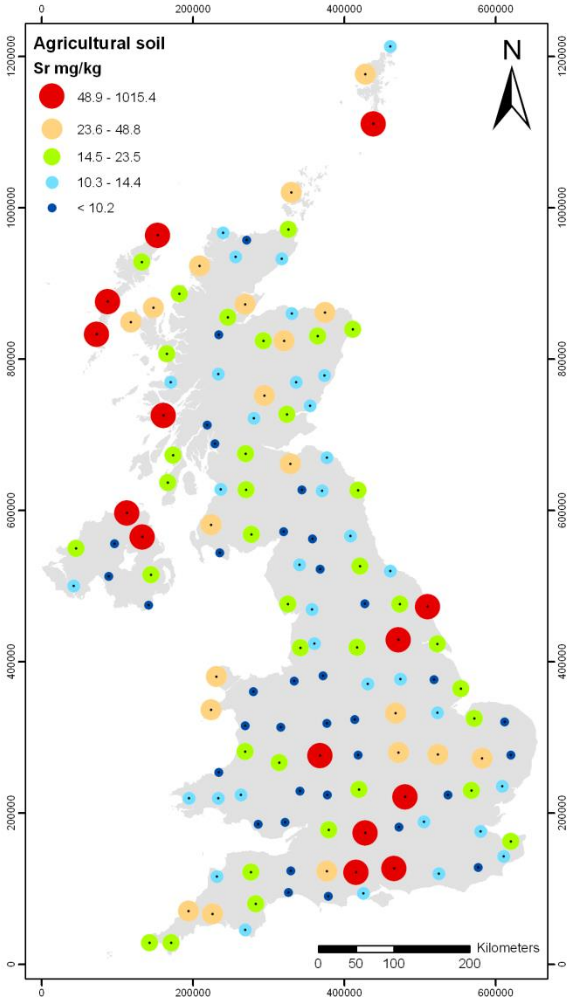
Grazing land soil





3.40 STRONTIUM (Sr)

Arable soil



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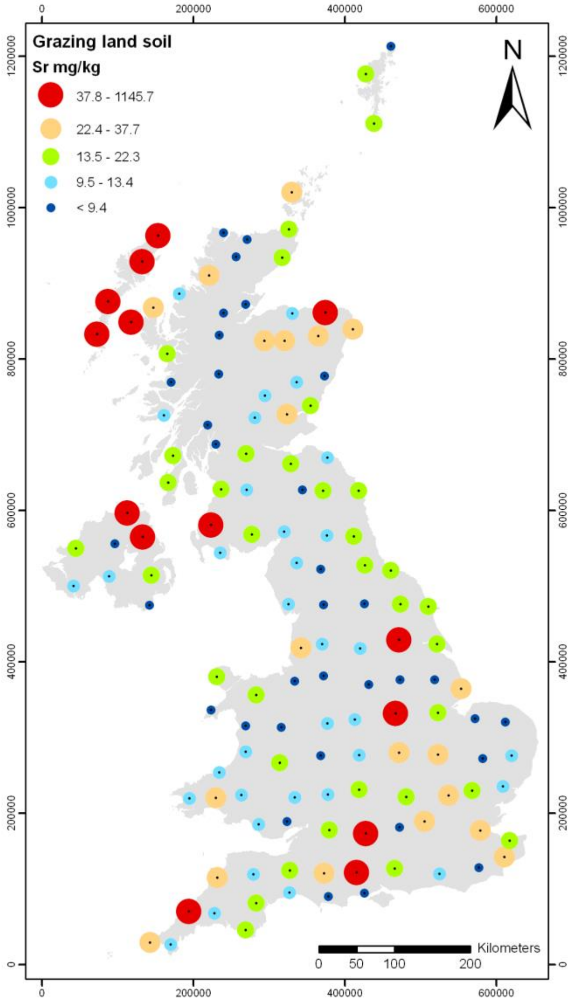
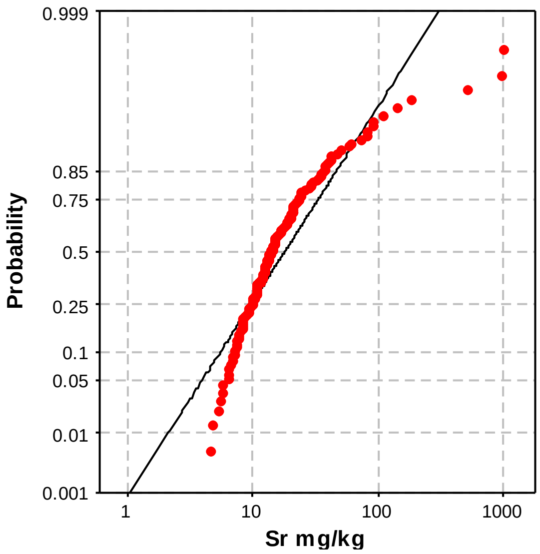
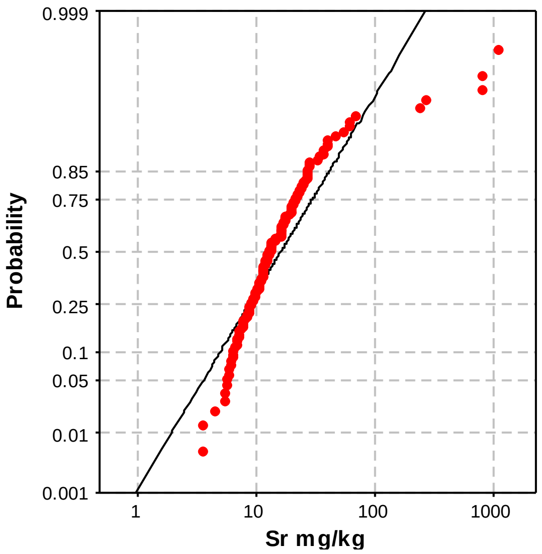
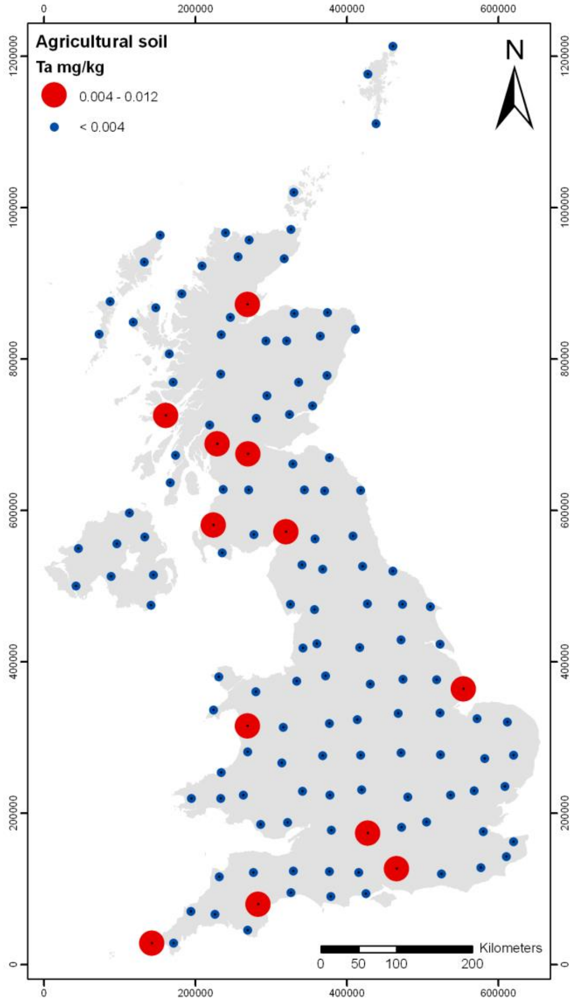






3.41 TANTALUM (Ta)

Arable soil



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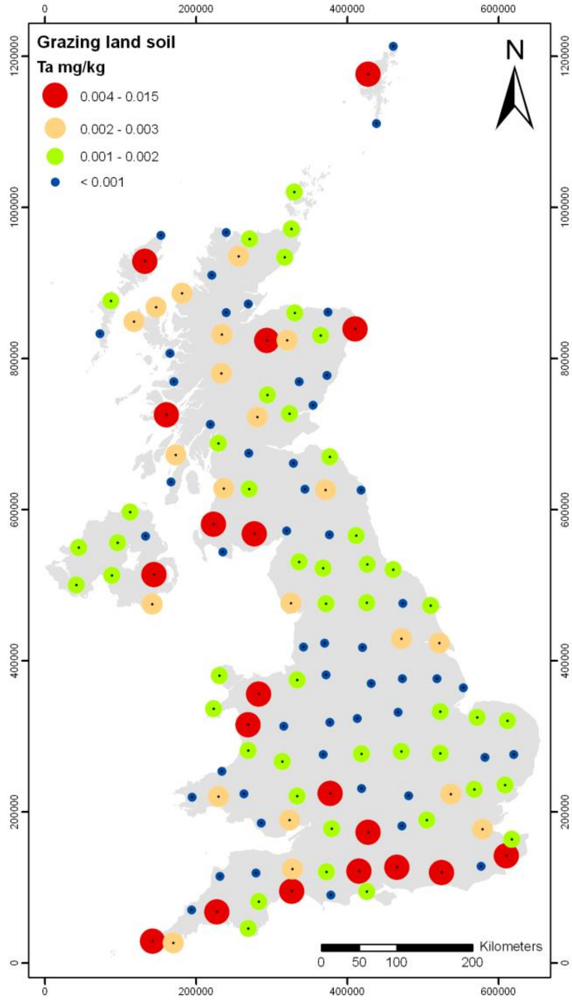
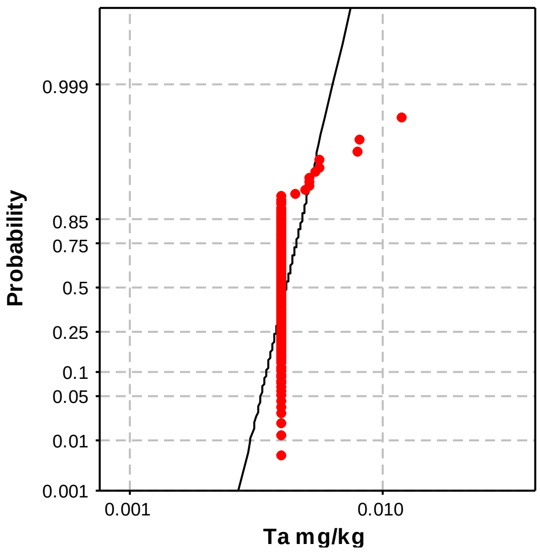
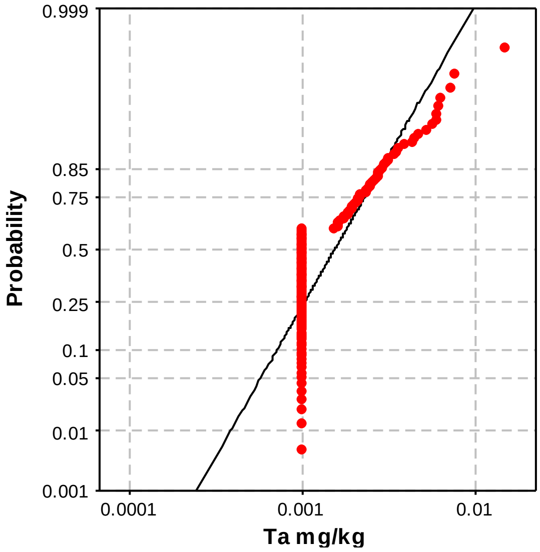
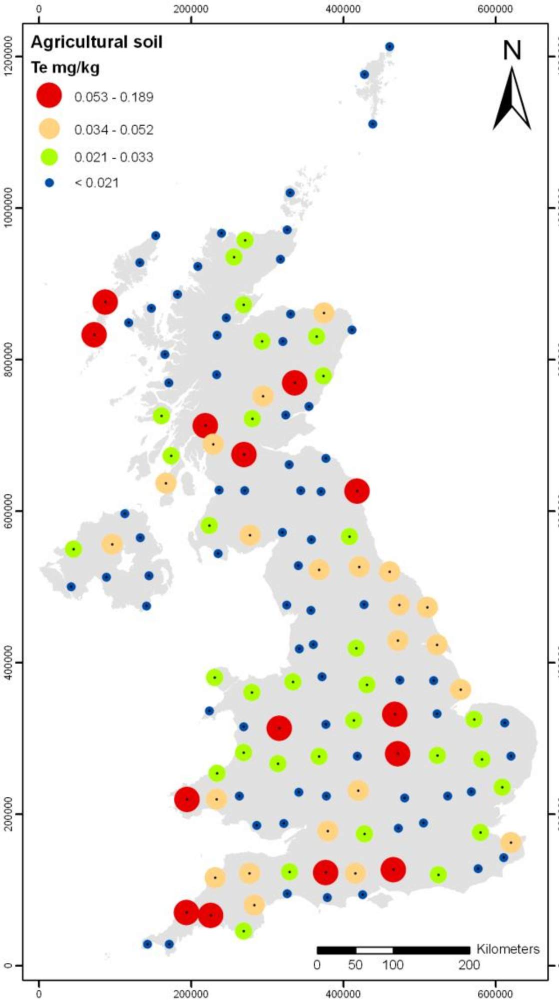




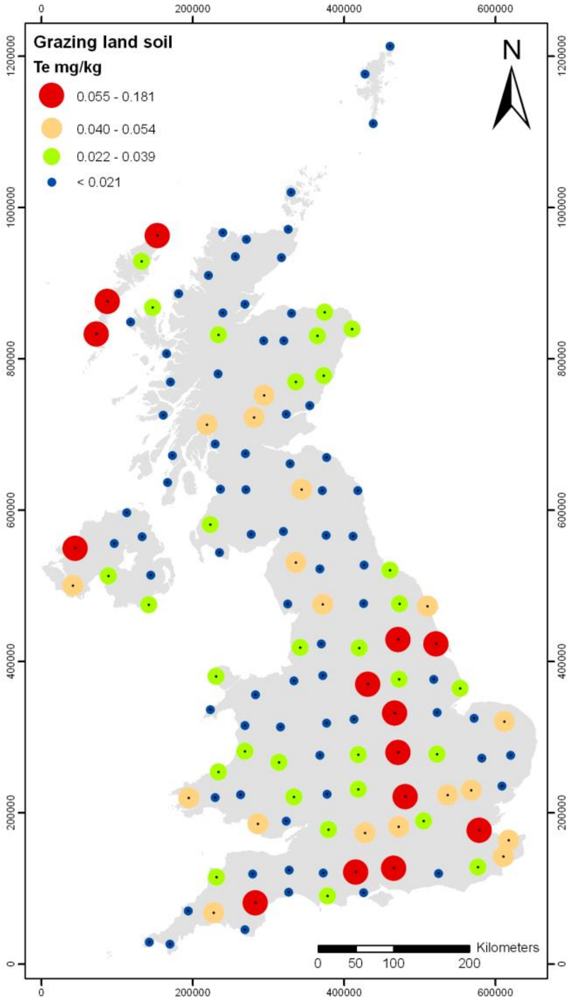


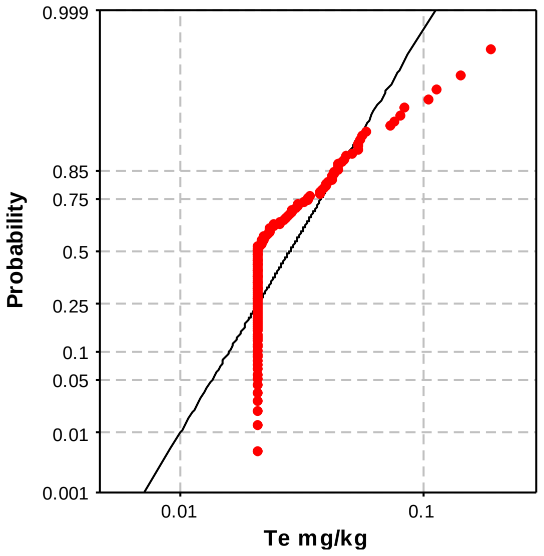
3.42 TELLURIUM (Te)

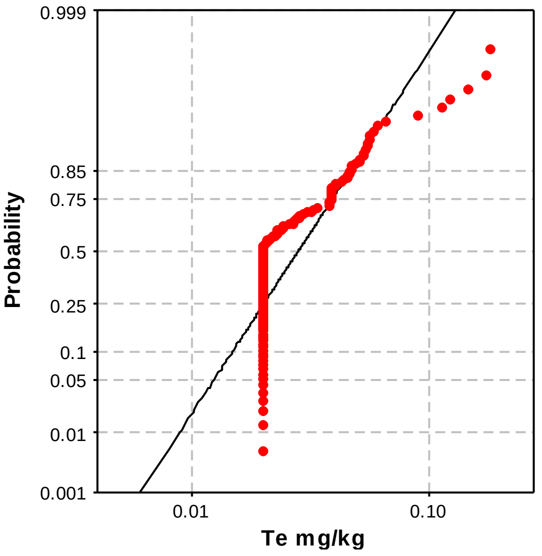
Arable soil



Grazing land soil

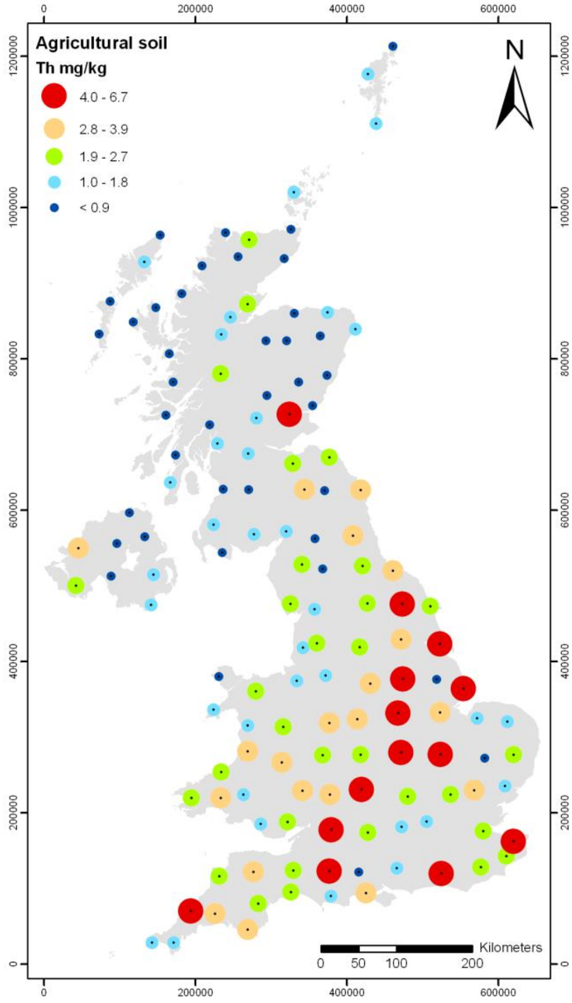


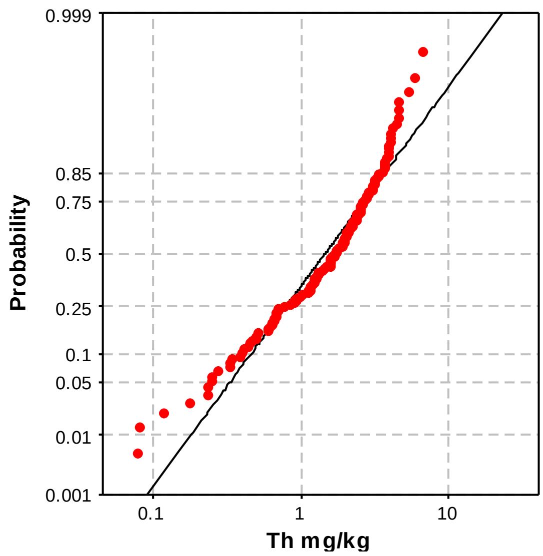




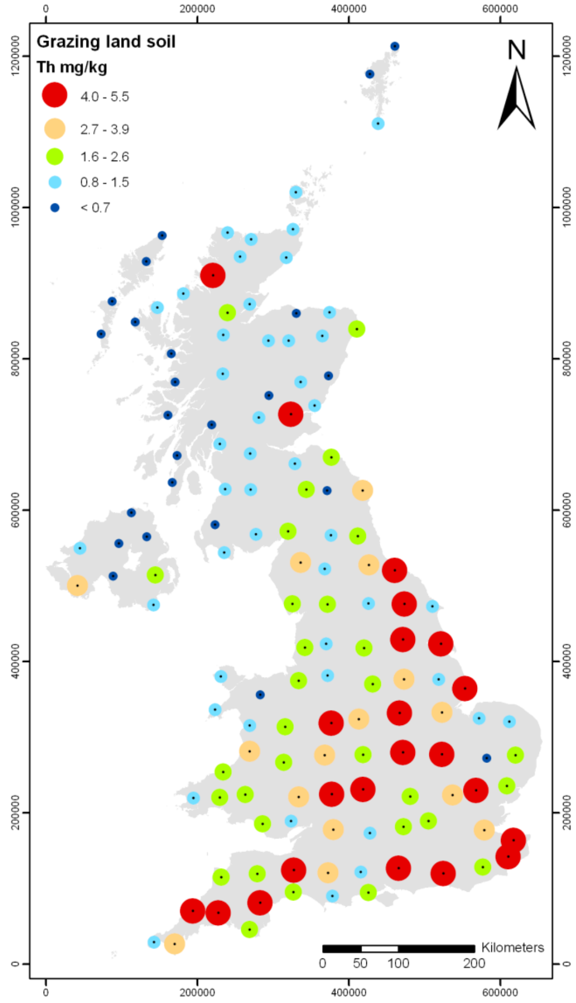
3.43 THORIUM (Th)

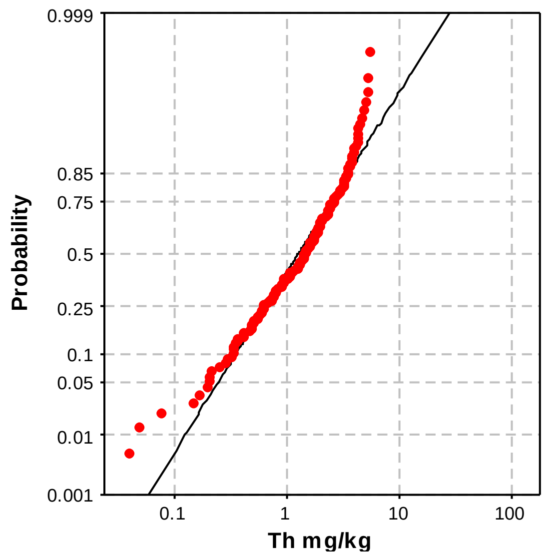
Arable soil





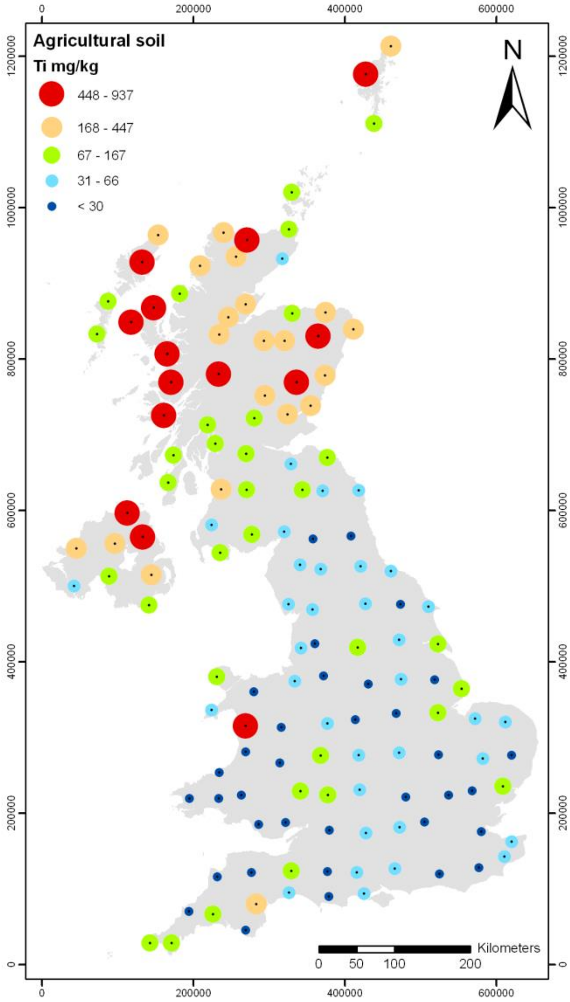
Grazing land soil





3.44 TITANIUM (Ti)

Arable soil



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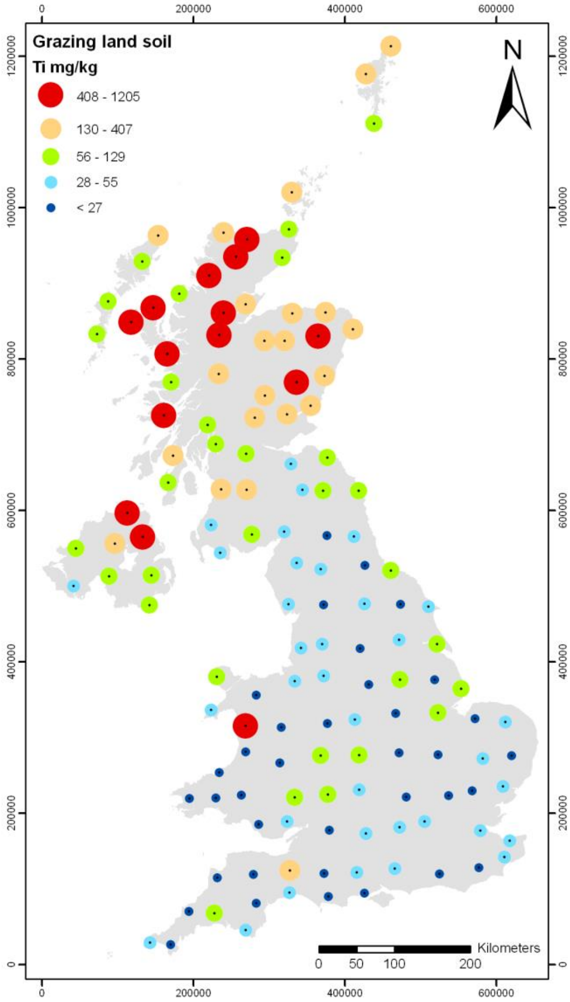
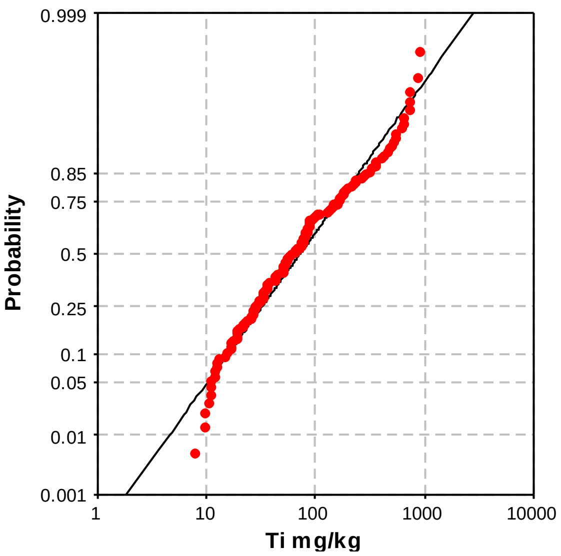
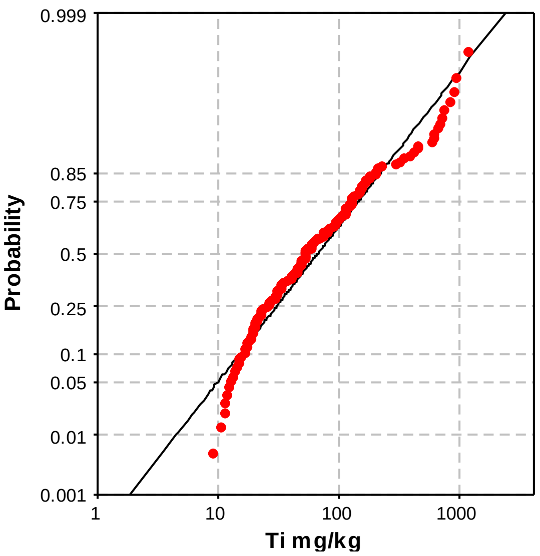
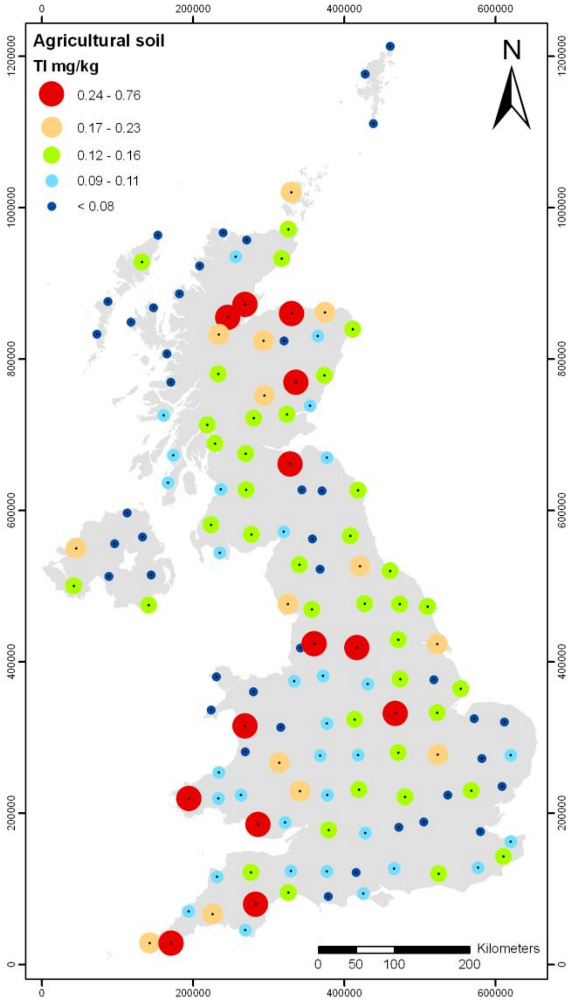






3.45 THALLIUM (Tl)

Arable soil



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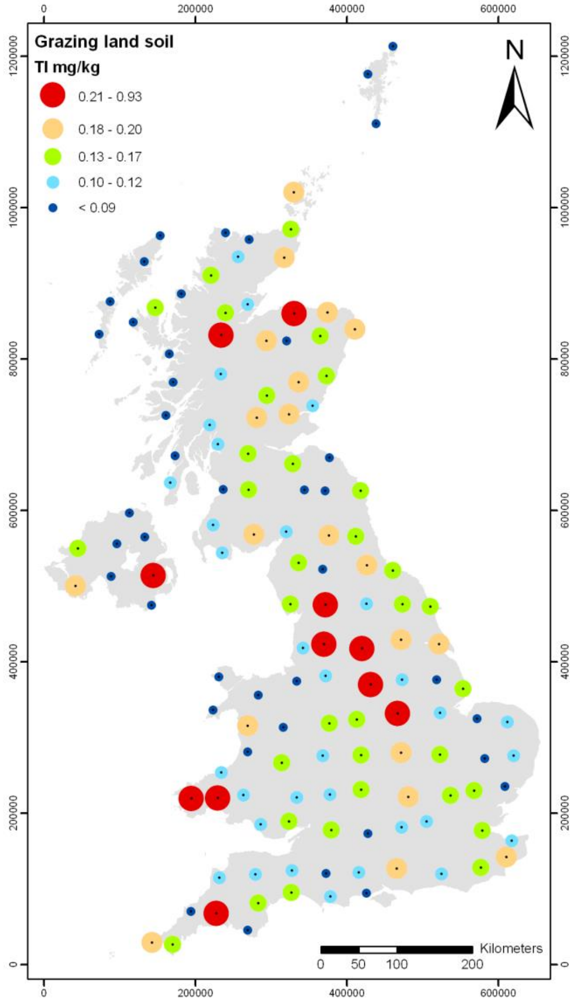
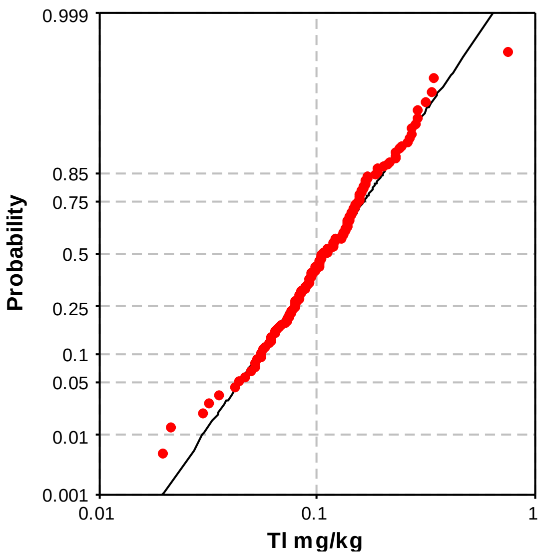
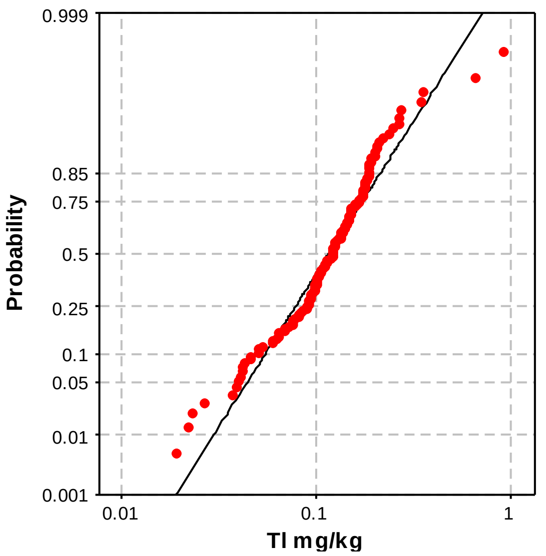
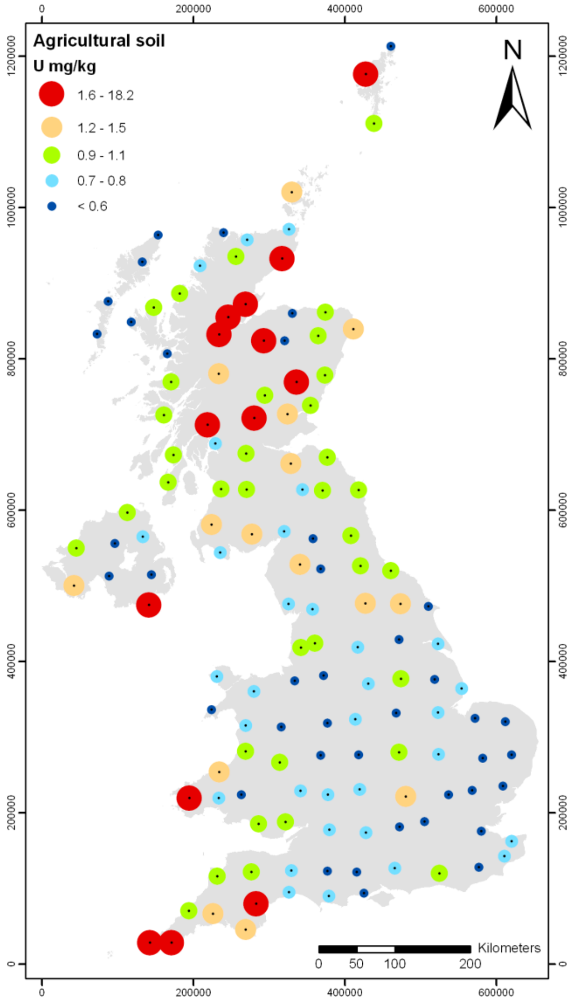






3.46 URANIUM (U)

Arable soil



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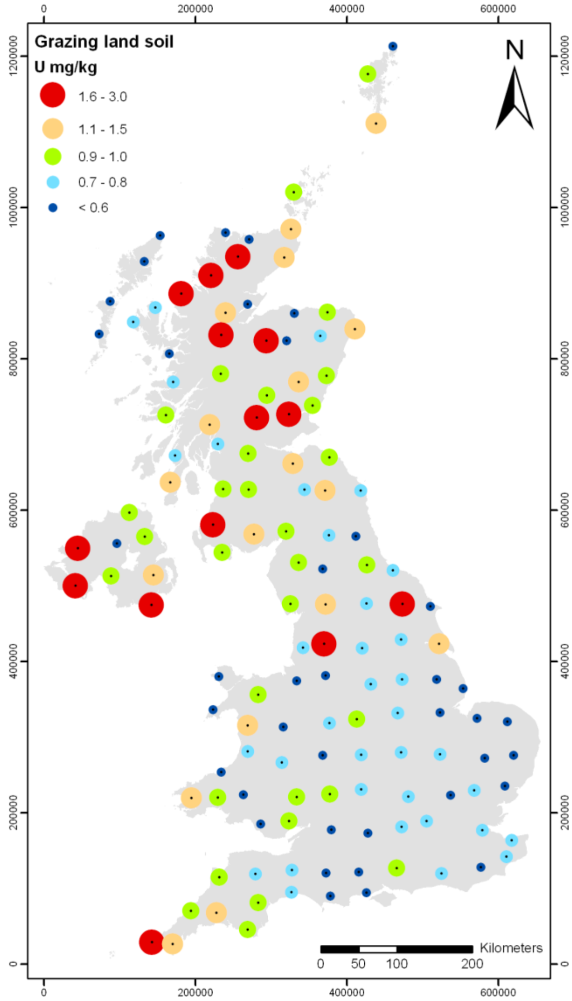
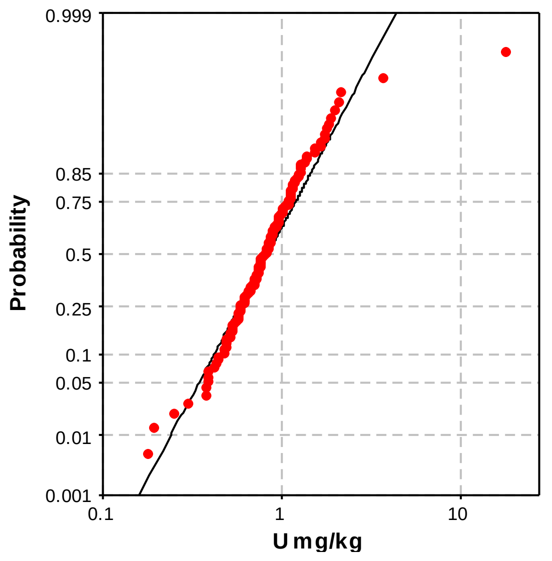
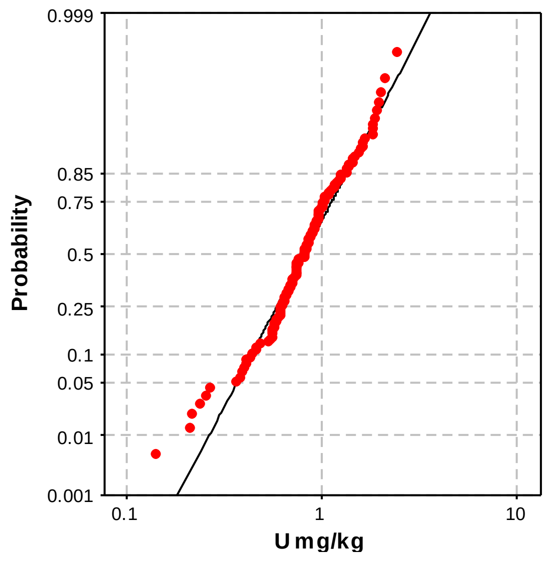
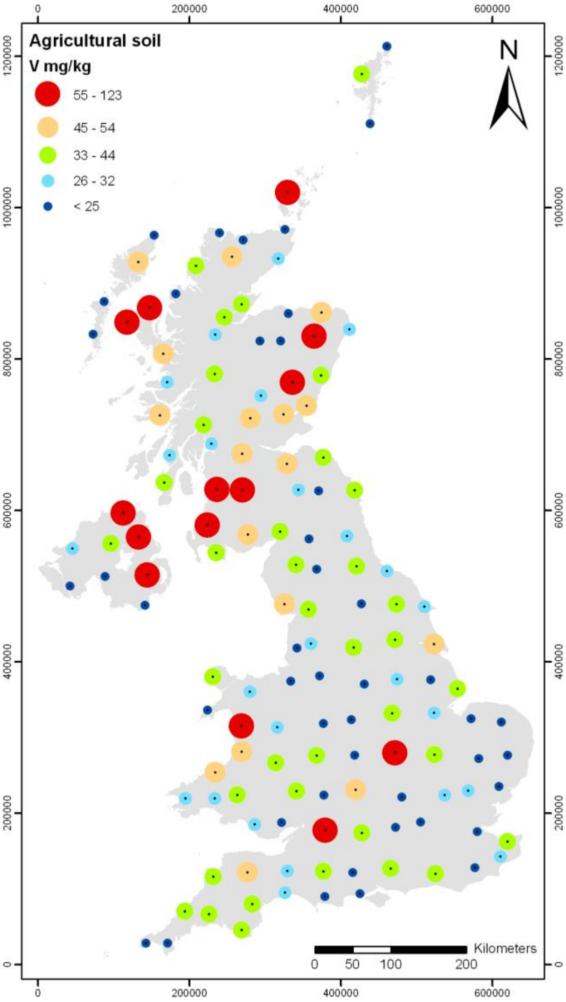






3.47 VANADIUM (V)

Arable soil



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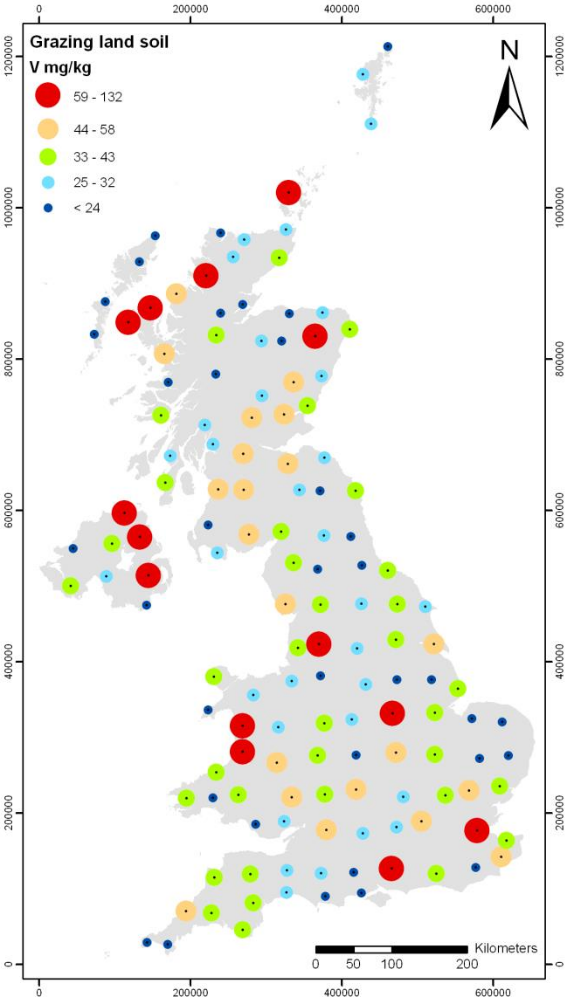
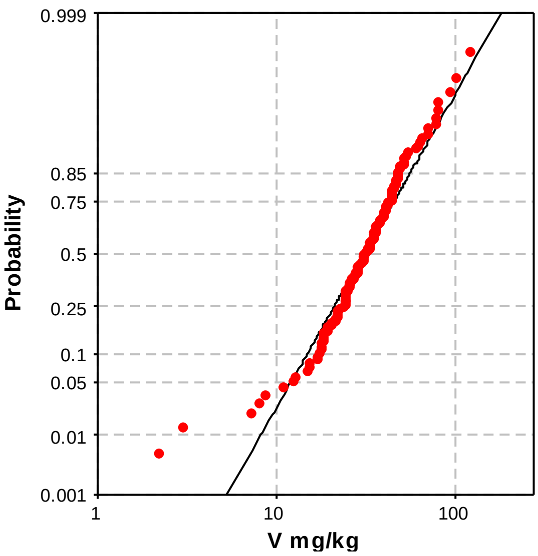
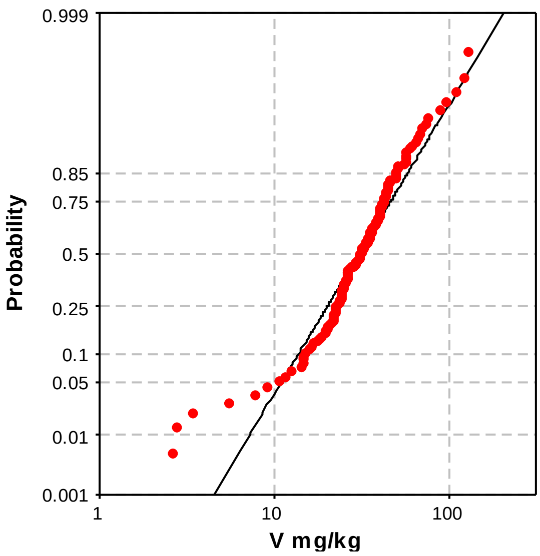
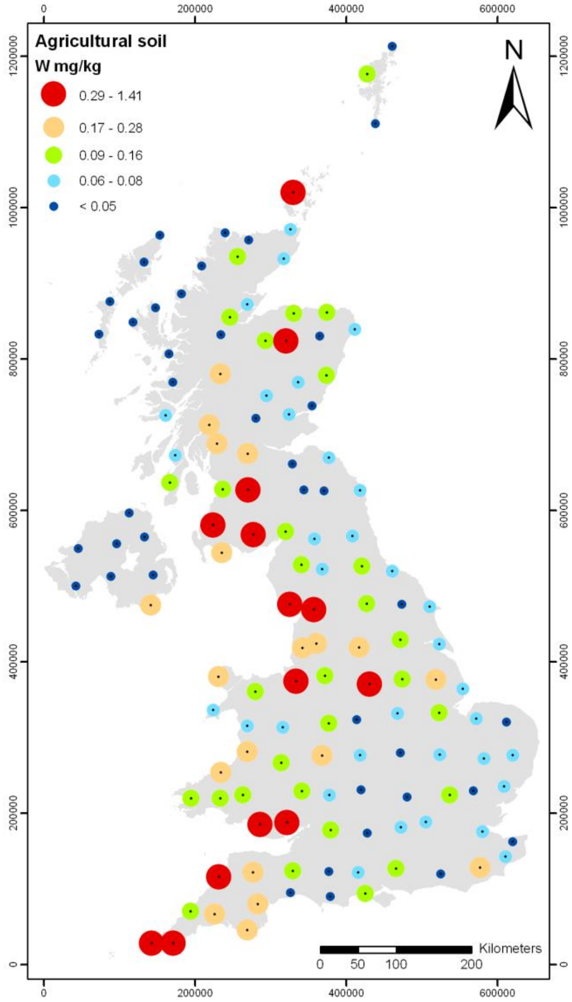






3.48 TUNGSTEN (W)

Arable soil



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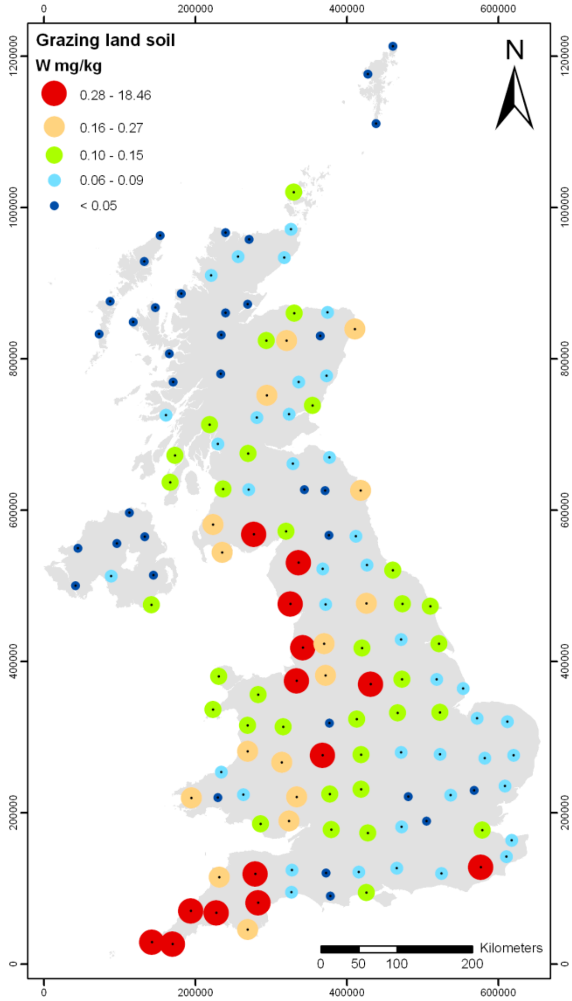
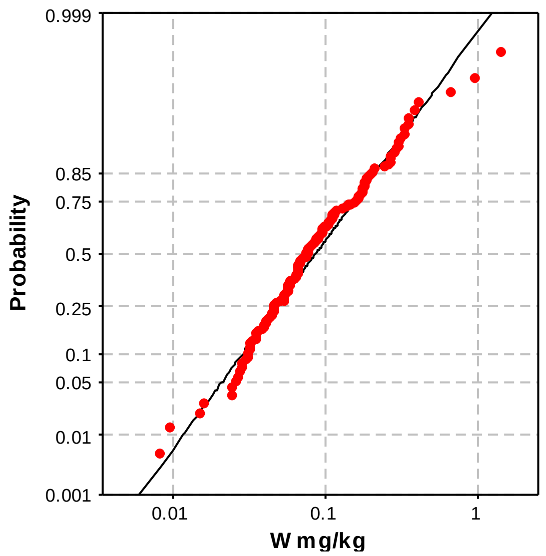
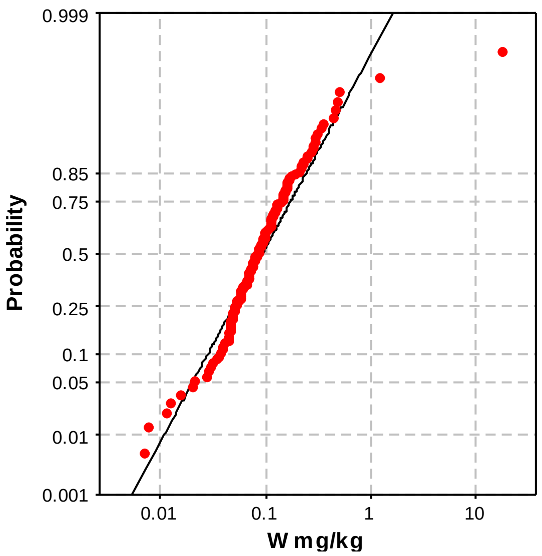
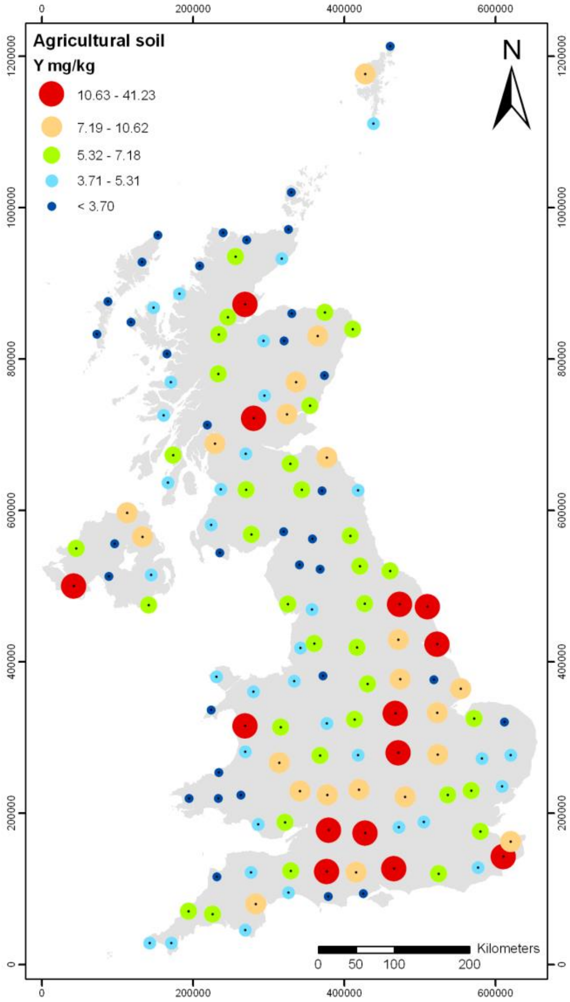






3.49 YTTRIUM (Y)

Arable soil



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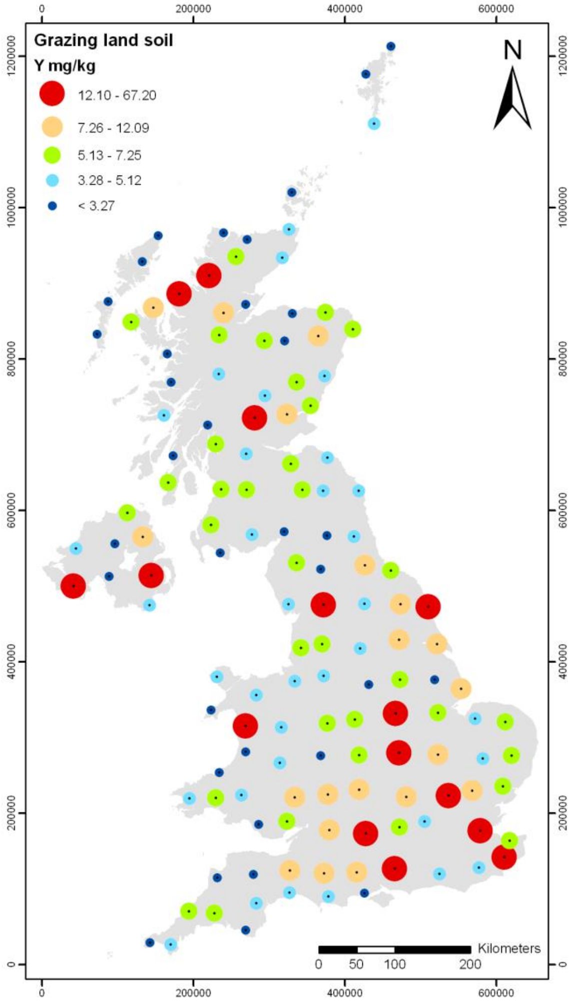
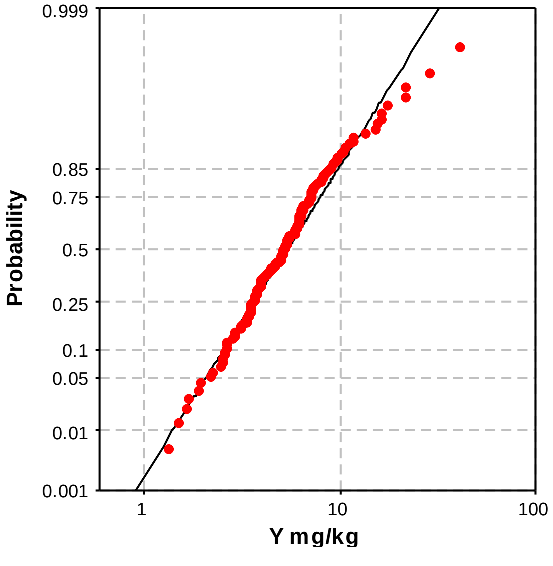
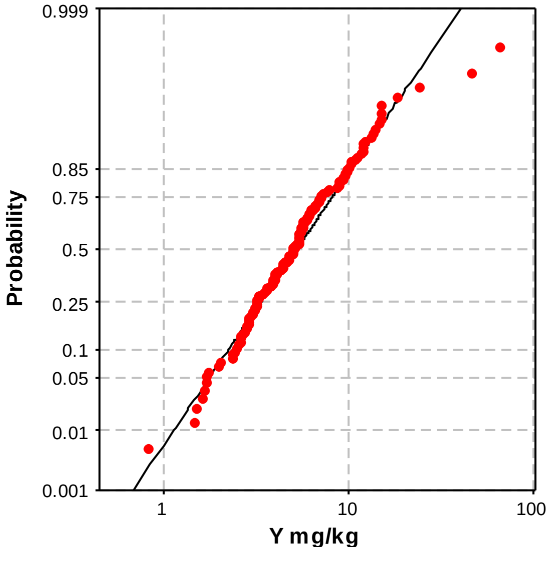
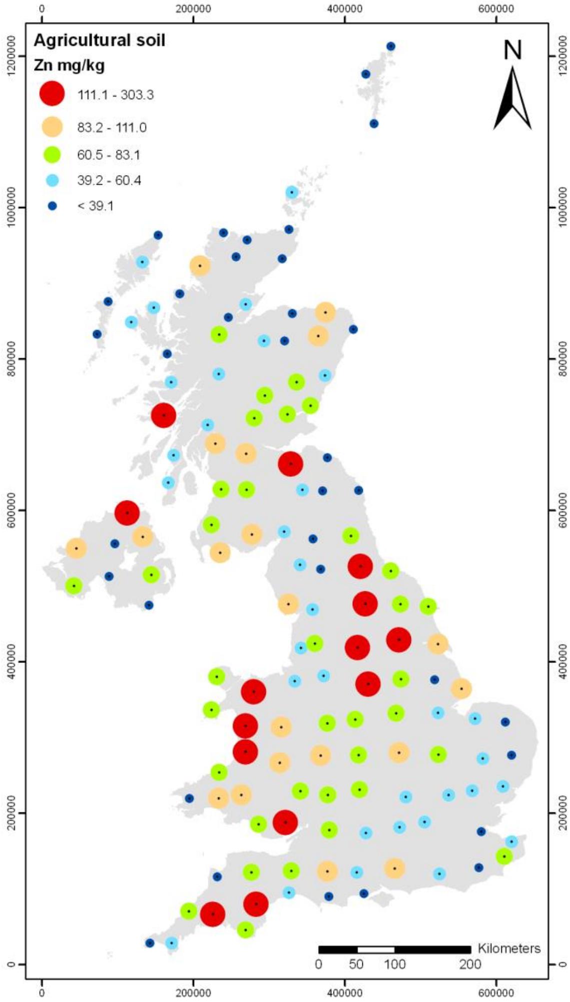




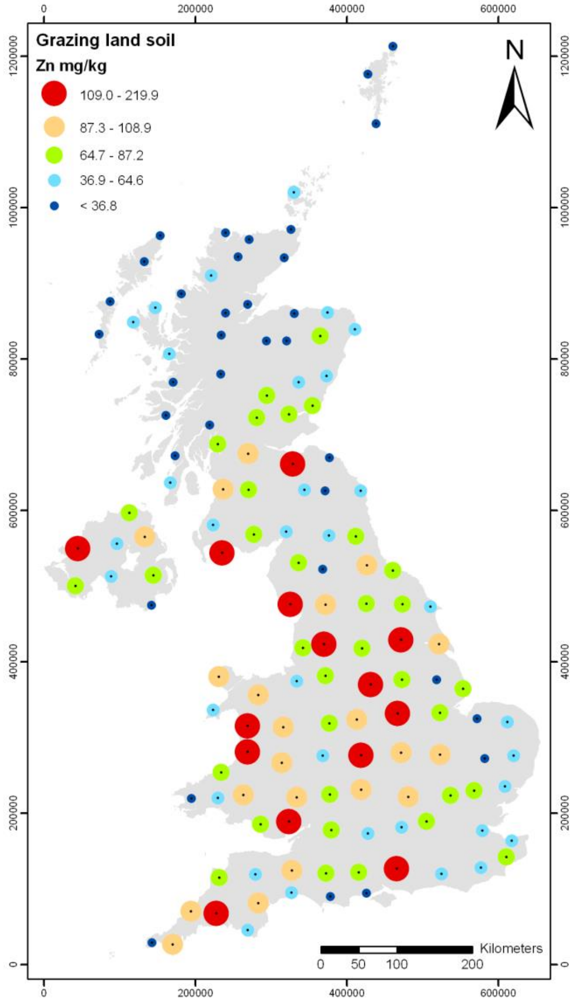


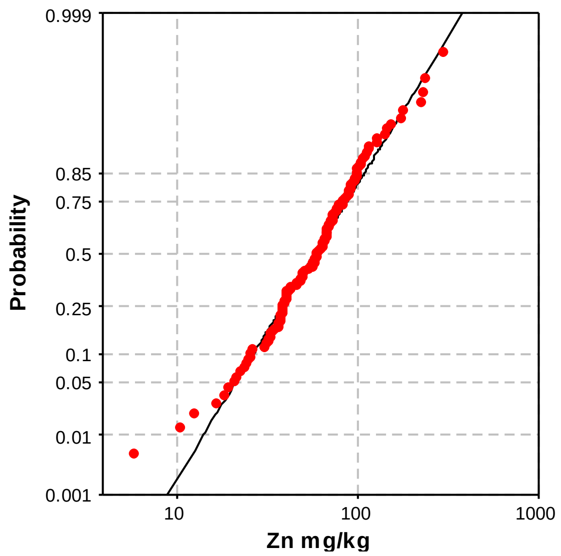
3.50 ZINC (Zn)

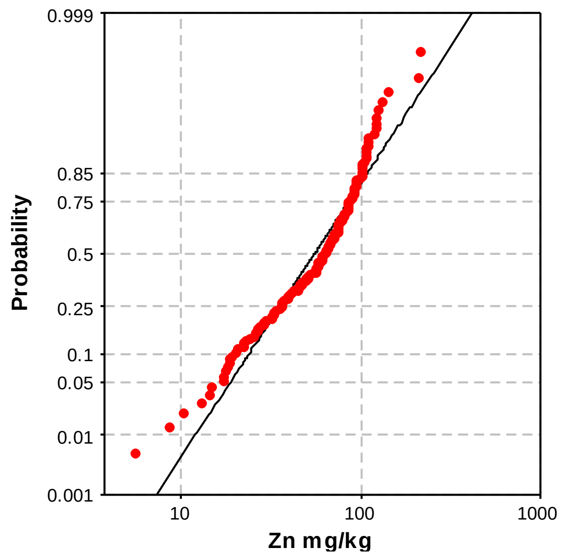
Arable soil



Grazing land soil

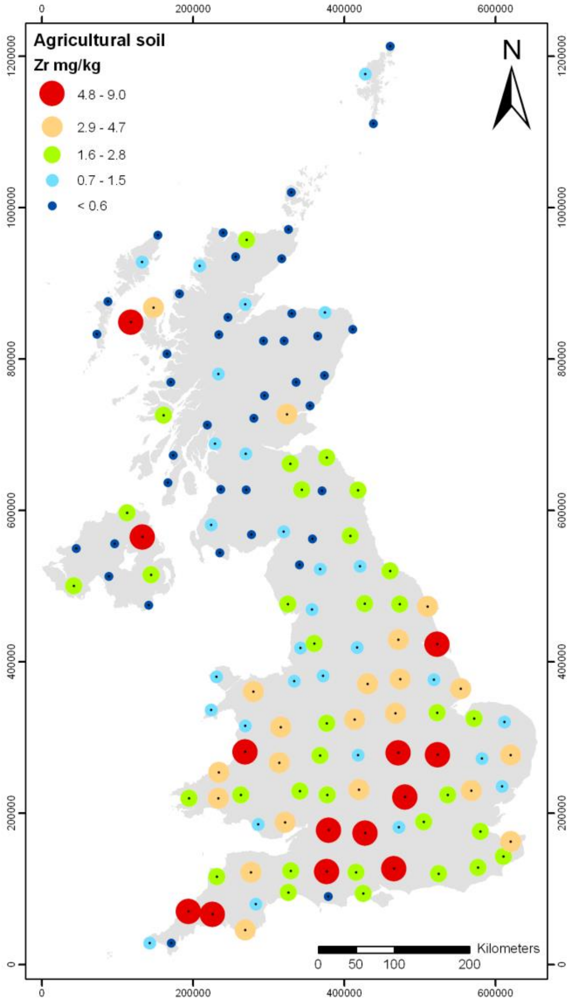






3.51 ZIRCONIUM (Zr)

Arable soil



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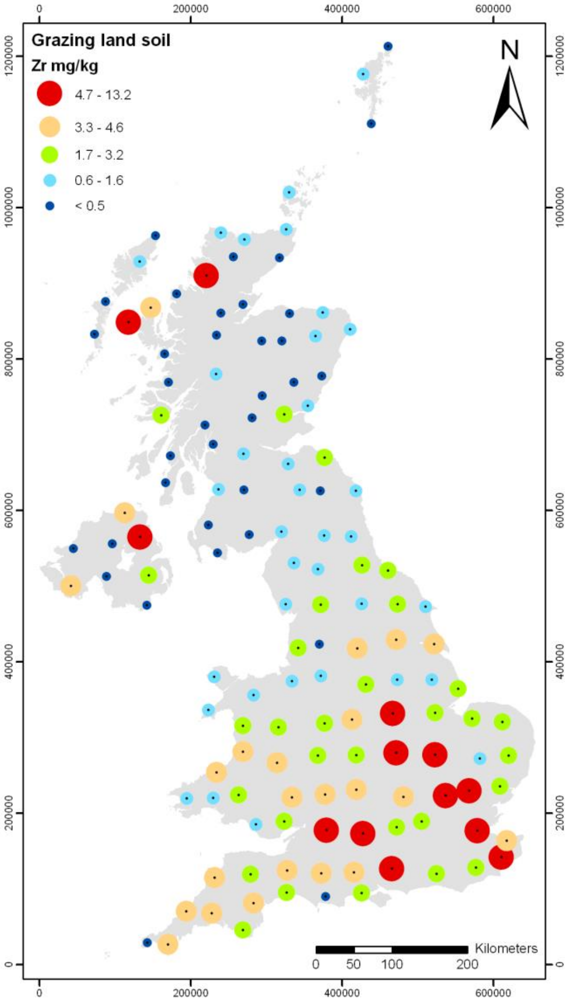

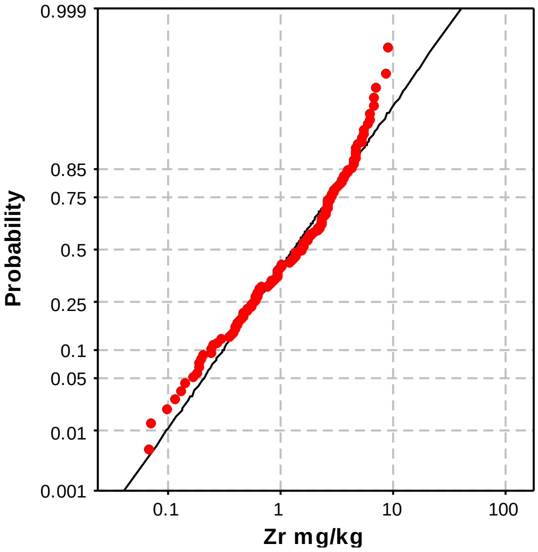

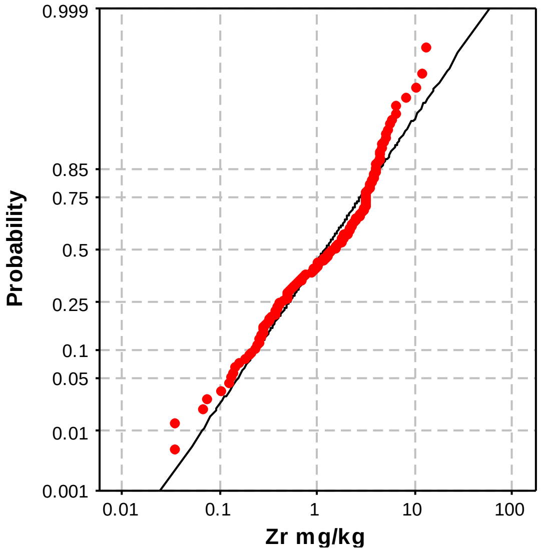

4 Conclusions

This report presents low density geochemical data of agricultural and grazing land soil for the UK following aqua regia extraction and analysis by ICP. By displaying the data as a series of graduated coloured dot maps alongside basic summary statistics, this report provides an initial overview of the data with the objective to enhance further studies and highlight elements that pose the opportunity for more detailed investigations.

In this first interpretation phase, this new UK-wide baseline data for arable and grazing land soils show some very interesting features and spatial variability within the datasets of the two sample types. Adding to that, the data include many elements that have either not at all or only for small areas been reported for soils collected as part of the G-BASE project. These findings will be discussed in more detail in later reports and publications.

These GEMAS data, based on aqua regia and ICP analyses, therefore provides an additional baseline information that supplements the existing G-BASE soil data, which are routinely reported as total element concentrations by XRFS.

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

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