Effect of clay content on the growth of southern Swedish oaks

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Svensk sammanfattning

Eken är ett av svenska mest djup-rotade trädslag som kan växa under bred variation av markförhållanden. Detta gör eken till en bra kandidat för område med förhjöd lera halten. Ekens tillväxt på sådana marker kan dock negativt påverkas av markens vattenfyllning och hypoxy som kan skada ekarnas finrötter och, som följd av detta, leda till netgångar i tillväxten och vitaliteten. Klimatiska modeller förutsäger ökning av perioder med extrema väderförhållanden, till och med frekvensen av perioder med extremt nederbörd. Det är därför viktigt att kvantifiera sambandet mellan markegenskaper (bl. a. lerahalten) och ekarnas tillväxtrespons i de kommersiella ekbestånden i Sydsverige.

I projektet ska vi göra en sammanställning av tidigare insamlade och nya dendrokronologiska mätningar samt markanalyser för att svara på två specifika frågor:

(1) vilken lerhalt kan vara indikativ för förhöjd risk av tillväxt- och vitalitetsnedgångar i ekbestånden?

(2) hur beståndsålder påverkar sambandet mellan ektillväxtrespons och lerahalten?

Sammanfattningsvis kan man påstå att ekar som växter över analyserat gradient i lera halten (0.8 till 11 %) verkar inte vara drabbade under periods med förhöjd nederbörd. Det finns tre möjliga förklaringar till att studie visade inget mönster mellan lerhalten och tillväxten.

Först, analyserat gradient i lerhalt inte sträcker sig över de tyngre jordar, där denna effekt skulle kunna upptäcks. Relativt få platser med lerhalt över 5% i vår databas kan också spela en roll här, vilket minskar kraften i statistiska metoder för att upptäcka en signifikant trend. För det andra, förbättrad näring i lerrika jordar kan lindra den potentiell negativ effekt av perioders med förhöjd nederbörd. För den tredje, en negativ effekt av förhöjd nederbörd är starkt kopplad till effekterna av andra faktorer som inte bevakas i denna studie. En av dessa faktorer kan vara närvaro av *Phytophthora*, en jord-födda patogen av ek, som rapporterats att orsaka nedgångar i träd vitalitet och tillväxt i Sydsverige. Det är dock svårt att studera effekter av *Phytophthora* för att dess närvaro (alt. frånvaro) i beståndets jordar kväver det långsiktiga observationer.

Background and rationale

Oak is one of the most deep-rooted forest trees in Sweden and can tolerate a relatively wide range of soil conditions (Rosengren & Stjernquist 2004; Bespalov & Os'kina, V 2006), making this species a good candidate for sites on the soils with increased clay content. Since the soil clay content is inversely related to acidification and litter accumulation, oaks growing on clay rich soils (content by volume above 5%) enjoys generally non-acidified conditions, higher soil water availability during dryer periods, and, possibly, a high level of microbial activity in the soil (DeForest & Scott 2010).

In Scandinavia both the growth and mortality of oak is driven largely by availability of summer precipitation (Drobyshev et al. 2008) with years of abundant precipitation resulting in high growth and drought years - in growth declines and delayed mortality (Drobyshev et al. 2007). However, oak stands growing on clay-rich soils may experience an increased incidence of *Phytophthora* spp. infection (Jonsson et al. 2005) and an increased risk of waterlogging eventually damaging oak fine root system. Although English oak (*Quercus robur* L.) commonly grows on heavy soils both in Southern Scandinavia and in the rest of Europe and is considered as "moderately flood tolerant" (Schmull & Thomas 2000; Kreuzwieser et al. 2002), growth of oak on clay-rich soils is strongly reduced during seasons with high precipitation (Leuschner et al. 2002; Rozas & Garcia-Gonzalez 2012) likely reflecting reduced capacity of roots to supply nutrients, in particular, nitrogen (Colinbelgrand et al. 1991; Kreuzwieser et al. 2002).

In southern Swedish forestry, productive sites with higher clay are often planted with oak (*Quercus robur* L.) thanks to its higher tolerance to waterlogging, as compared to the most common silvicultural alternative of oak, the Norway spruce (*Picea abies* (L.) Karst.). However, oak stands on heavy soils may be at risk during periods of excessive soil water content, e.g. during springs and periods of high summer precipitation (Vincke & Delvaux 2005). The effect was exemplified by dieback of young oak stands in the Häckaberga estate in Skåne, following a rainy summer of 1998.

A recent increase in the hardwood silviculture in Sweden (Löf 2001) highlights the need to better understand the relationship between soil properties and oak growth response. A point of particular interest is effects of the extreme precipitation events during the growing season. Such events increase soil water table, cause prolonged anaerobic conditions, fine root mortality, and subsequent stand decline. It has been earlier reported that waterlogged stands may be more sensitive to other damaging factors, e.g. insect defoliation and summer drought (Donita et al. 1993; Delb 1999).

The future of precipitation dynamics in Scandinavia remains unclear (Rowell & Jones 2006), although it is likely that the region will exhibit a higher frequency of extreme climate events, including precipitation anomalies (Alexander et al. 2009). It is therefore of importance to identify stand conditions associated with increased risks of growth declines following periods of excessive precipitation.

Objective

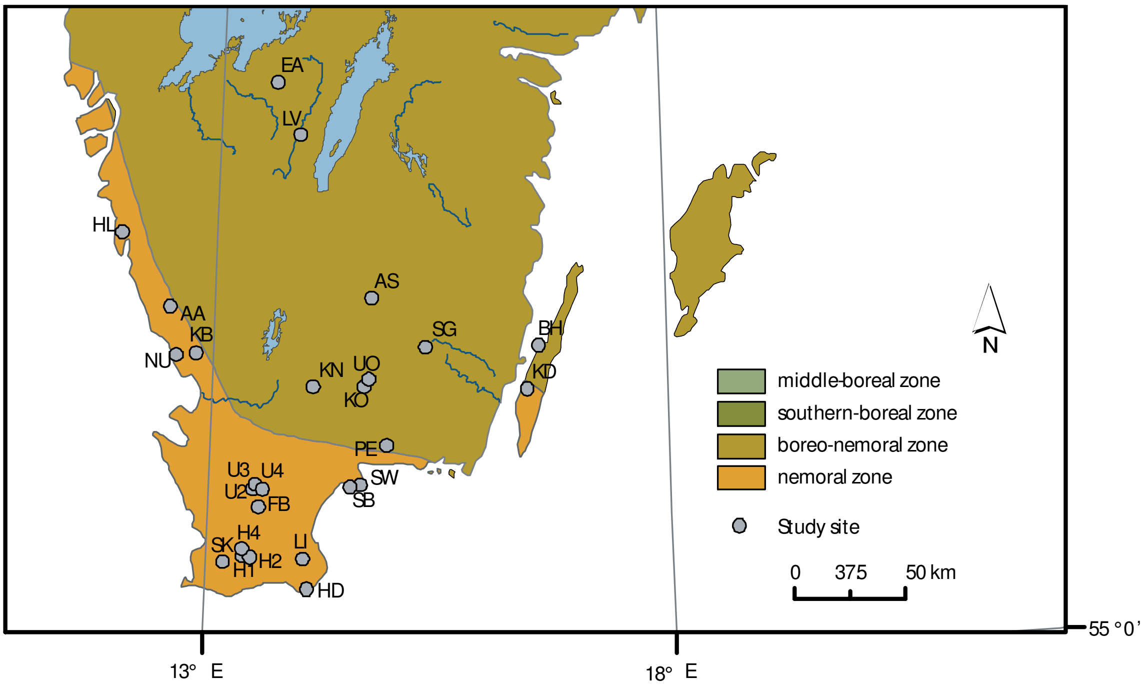
In this project we evaluated the effect of clay content on the growth of oaks in an attempt to identify the thresholds in the clay content, which foresters may consider while deciding upon planting oaks on sites with heavier soils.

Material and Methods

Site selection

Field sampling took place across a range of sites located in Southern Sweden. The site selection was aimed to cover a range of soil conditions representative of monodominant or mixed oak stands in the region (Fig. 1).

Fig. 1. Location of the sampled sites. Also shown are different bioclimatic zones of Southern Sweden.



Climate data

We obtained climate data for each site for the time period 1953-2013 using the *BioSIM* 10.3 software (Régnière 1996; Régnière & St-Amant 2007). *BioSIM* is a collection of bioclimatic models and daily weather database, which can generate climate variables at various temporal resolutions, using a user-supplied list of locations. For each site, *BioSIM* interpolated data from the eight closest weather stations using inverse distance weighting output, while adjusting for differences in latitude, longitude and elevation between the stations and the sites. Since we were particularly interested in the effects of precipitation, we calculated summer precipitation (June through July) and so-called *water ration*, which is the ration between precipitation over a period, divided by evapotranspiration for the same period. Evapotranspiration was estimated by the Hamon formula (Hamon 1961, http://nest.su.se/mnode/Methods/penman.htm).

Soil sampling and analyses

To characterize soil conditions at the sites, soil samples were taken with the Haglöf soil-borer at 25–30 random points within the plot. The borer was inserted into the soil down to a depth of 30 cm and samples from three soil layers (0–10, 10–20, and 20–30 cm) were collected for chemical analyses. The samples were combined in the field to give one sample per plot for each layer.

In the laboratory soil samples were sieved through a 2-mm sieve and dried at an ambient

temperature of 40°C for 2 days. Twenty grams of dry soil were extracted in 100 ml 0.1 M BaCl2 at room temperature for 2 hours. The pH of the BaCl2 filtrate was measured. Concentrations of aluminium (Al), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), manganese (Mn), and iron (Fe) were obtained using an inductively coupled plasma analyser (VarioMax CN, Elementar Analysensysteme GmbH, Hanau, Germany). Total nitrogen was determined by the Kjeldahl method and a CR 12 method. A LECO instrument was used for the determination of total soil carbon. The concentration of C was normalized to the dry matter content at 40°C. All data are presented in *Appendix A*.

Statistical analyses

Realizing that the negative effects of precipitation are likely to be manifested after the periods with excessive rains, we analyzed site-specific climate data to identify three the most rainy growing seasons over the study period. We then extracted the growth patterns prior and following these years to evaluate whether the oak growth response is correlated with the amount of clay at the 10 to 20 cm soil depth.

To assess growth performance of oaks following potentially unfavourable period with increased precipitation amounts and water ration we calculated resistance coefficient, which is a ratio between the growth during and before an extreme event (year, with increased precipitation), following Lloretet al. (2011). Value of the resistance coefficient below 1 would be indicative of suppressed growth. For this calculations we adopted 3 year time frame.

Since the identification of climatic (precipitation) anomalies took place at site scale (i.e. no region-wide years were selected, instead, site-specific climate data were analysed), the degree of anomaly likely varied across sites. To address this issue, we ran partial correlation analyses. For each of the extreme years (i.e. the years with the highest anomaly, the second highest anomaly, and the third highest anomaly) we ran partial regression including resistance coefficient, clay content and the deviation of the water ration (alternatively - precipitation) from the long-term mean.

Apart from analyzing oak response to climatically extreme periods, we also evaluated relationship between monthly climate and growth over the complete period with overlapping growth and climate data. To this end, we ran response function analysis for spring and summer months of the current growing season. Prior to this analysis, tree-ring data were detrended with 32-year spline functions to enhance annual variability in the record.

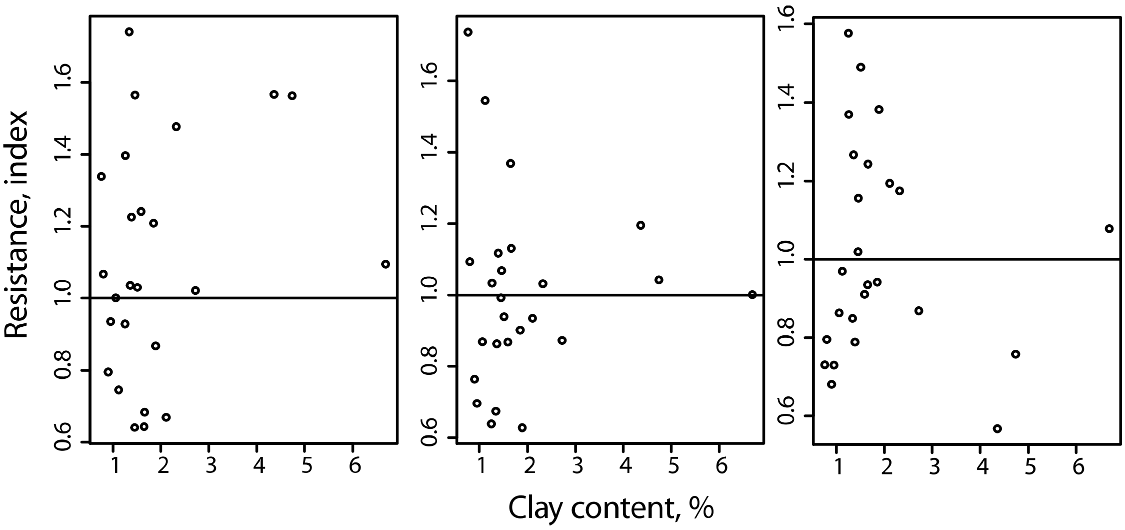
To understand the relationship between clay content (*Appendix B*) and other soil conditions we run redundancy analysis (RDA) involving a range of cation measurements (*Appendix A*) and clay content. Prior to analysis, soil data was standardized. All soil measurements used in the analyses referred to the 10-20 cm of the mineral soils.

Results and Discussion

We detected no effect of clay content on the oak growth performance. For the year with the highest anomaly the partial correlation between clay content and resistance was 0.28 ($p = 0.18$), for the year with the second largest anomaly - 0.01 ($p = 0.96$), and for the third year -0.09 ($p = 0.69$). There were no indication that the effect may include non-linear component and, therefore, "escape" detention by linear partial correlations (Fig. 2). In fact, the partial correlations during the year 1 had a positive, yet insignificant, values, indicating a potentially positive effect of clay content on oak growth.

We run multiple combinations of analyses with varying length of analyzed time frame, e.g. using data for the single vs. aggregated summer and spring months, precipitation vs. water ration as dependent variables. The overall pattern remain the same and here we present only the results for the water ration calculated on the June-July period.

Fig. 2. Resistance of oak growth (resistance ratio between the growth during and before an extreme event) in three the most west years at each of the sampled sites, as a function of the clay content in the 10 to 20 cm of soil profile. Horizontal lines indicate the value of the resistance coefficient indicating no effect of the climate anomaly. Values below 1 indicate growth depression and values above that line indicate growth improvement.



Clay content was strongly correlated with the cation exchange capacity and pH of the soils (Fig. 3). This implied that increased in risk of waterlogging was, at the same time, associated with better soil nutrient status. Indeed, water availability tended to be positively correlated with both growth and the clay content in the analyses of response function coefficients over the whole analyzed period (1970-2000) (Fig. 3).

Fig. 3. RDA analyses on clay content and a range of soil properties. Position of sites in two-dimensional space formed by the first two principal components are indicated by respective site IDs. Red arrows and letters in bold font refer to vectors representing soil variables. soil Amount of variability explained by axes is indicated at the axis caption of the respective axis.

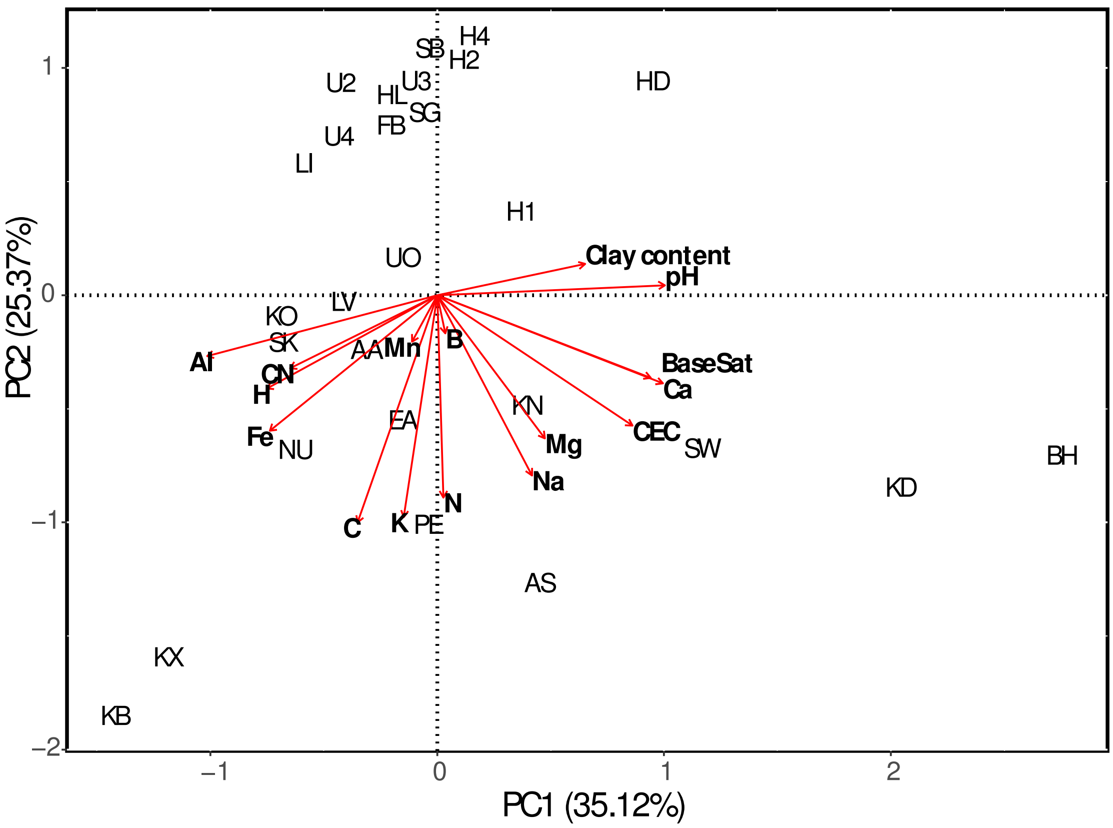
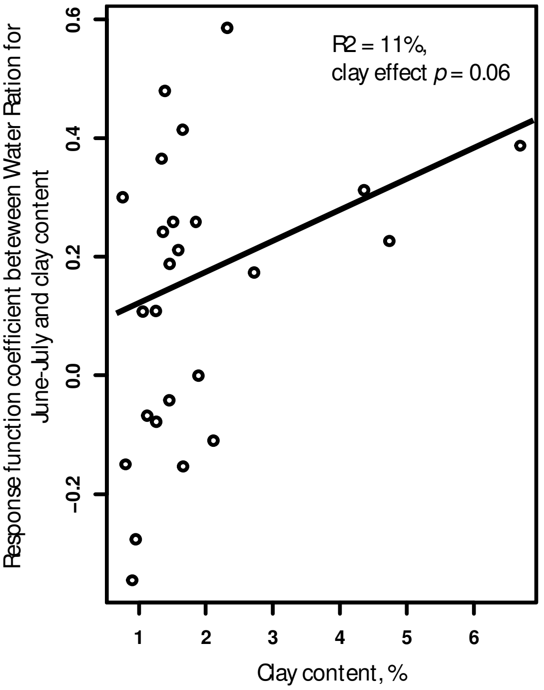


Fig. 4. Relationship between response function coefficient representing a correlation between oak growth and the Water Ration for June-July and the clay content. Line represent regression between two variables (R^2 adjusted = 11%).The positive slope of the function indicates that increased clay content tends to be associated with a more positive correlation between growth and summer water availability.



Overall, oaks growing over the analyzed range of clay content (0.8 to 11.9 %) does not appear suffer from the excessive precipitation amounts during and immediately preceding the growing season. There are three possible explanations of the lack of any pattern revealed in this study:

The range in the soil clay content did not extend over the heavier soils, where this effect could be detected. Relatively few sites with the clay concentration above 5% could also play a role here, reducing the power of the statistical methods to detect a significant trend.

Improved nutrition due to correlation of clay content with cation exchange capacity and pH alleviates a potentially negative effect of waterlogging on soils with moderately increased clay content (Fig. 3).

A negative effect of excessive precipitation is strongly connected to the effects of other factors not monitored in this study. One of such factors could be presence of *Phytophthora*, a soil-born pathogen of oak, which was reported to cause declines in tree vitality and growth across Europe ((Jonsson et al. 2003; Jonsson 2006). Due to a

challenging protocol of *Phytophthora* identification and often non-conclusive results obtained with such protocol, we did not monitor the presence of this pathogen.

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Appendix A.

Results of chemical analyses of soils. The data describes the three soil layers (1 - 0-10 cm, 2 - 10-20 cm, and 3 - 20-30 cm).

UnitID	SoilLayer	H2O	C	N	CN	pH	H	Na	K	Ca	Mg	Al	Fe	Mn	B	CEC	BaseSat
AA	1	0.731785	65.51702	5.161947	12.69231	3.702	1.001832	12.43709	101	127	40	389	29	36	0	60	21
AA	2	1.62798	51.4584	3.816834	13.48196	3.932	0.596362	9.696882	37	61	16	315	12	10	0	42	14
AA	3	1.837827	40.24649	2.797622	14.38597	4.08	0.425225	9.761046	23	48	9	259	6	7	0	34	12
AS	1	2.68757	117.0669	6.899451	16.96756	4.037	0.474384	16.97659	251	3556	333	12	2	219	1	222	96
AS	2	NA	58.63287	3.50821	16.71304	3.941	0.5804	6.061872	65	1180	69	120	1	50	3	82	81
AS	3	1.21125	55.23279	3.092088	17.86262	3.463	1.747082	8.417836	50	263	27	299	35	67	0	56	30
BH	1	2.965671	111.2984	7.364905	15.11199	4.727	0.097188	24.311	128	5502	321	1	0	39	1	307	99
BH	2	1.477193	33.75391	2.640411	12.78358	5.885	0.006633	16.08359	39	4499	49	0	0	3	0	230	100
BH	3	1.3029	17.53848	1.450847	12.08844	5.821	0.00767	13.4008	36	3069	34	0	0	1	0	157	100
EA	1	1.374293	53.08036	4.319806	12.28767	3.507	1.581874	18.11364	95	1207	118	143	10	100	0	95	77
EA	2	1.14003	31.51656	2.570359	12.26154	3.398	2.027396	11.32568	39	644	58	250	19	39	0	71	54
EA	3	1.133741	26.24899	2.135511	12.29167	3.363	2.197382	10.14947	30	610	47	319	32	18	0	76	47
FB	1	NA	52.17895	3.385348	15.41317	3.726	0.9556	7.377817	57	149	38	280	5	68	1	47	26
FB	2	NA	30.41887	1.844182	16.4945	4.071	0.4288	5.257195	21	36	9	235	3	10	1	30	11
FB	3	NA	29.31186	1.854796	15.80328	4.167	0.3439	4.41967	15	40	8	186	1	10	1	25	13
H1	1	1.490433	52.88979	3.733513	14.16623	3.527	1.51281	14.8773	77	984	110	190	12	110	0	88	69
H1	2	0.844427	20.51529	1.378263	14.88489	3.854	0.706945	10.8474	26	485	47	158	3	32	0	49	60
H1	3	0.69355	15.56132	1.112232	13.99107	3.876	0.670802	12.45695	22	299	28	177	3	29	0	40	46
H2	1	0.813411	30.38085	2.023407	15.01471	3.507	1.571169	5.040298	66	170	36	200	9	53	0	40	34
H2	2	0.714168	12.10294	0.734715	16.47297	4.006	0.497396	4.105608	34	55	9	162	4	17	0	24	19
H2	3	0.543255	4.873381	0.358044	13.61111	4.202	0.316088	3.289079	31	30	5	117	1	7	0	17	17
H4	1	NA	27.93172	1.796187	15.55056	3.739	0.9274	4.729857	64	142	34	214	5	24	0	38	31
H4	2	NA	15.49019	1.077666	14.37383	3.99	0.5177	4.11375	26	37	9	171	3	8	1	23	15
H4	3	0.440308	57.84418	4.350759	13.29519	4.116	0.38483	3.766908	17	19	4	106	2	6	0	14	13
HD	1	0.46083	20.96295	1.692166	12.38824	4.683	0.104322	14.67597	41	1479	84	1	0	9	0	83	99
HD	2	0.283563	11.12835	0.937335	11.87234	4.435	0.184268	9.869671	14	722	36	5	1	10	0	41	97
HD	3	0.301586	7.327834	0.64804	11.30769	4.53	0.148096	10.22418	10	660	23	2	0	6	0	36	98

UnitID	SoilLayer	H2O	C	N	CN	pH	H	Na	K	Ca	Mg	Al	Fe	Mn	B	CEC	BaseSat
HL	1	0.769391	39.61286	2.480765	15.968	3.369	2.157705	25.4512	108	212	81	83	22	17	0	34	62
HL	2	0.475248	13.16712	0.836008	15.75	3.782	0.830714	9.626148	29	31	13	151	16	2	0	22	17
HL	3	0.339593	8.790048	0.57803	15.2069	3.909	0.619074	5.592606	15	15	6	126	10	1	0	17	11
KB	1	2.634298	171.9478	7.419267	23.17585	2.831	7.61809	29.19353	268	586	219	126	56	89	0	83	67
KB	2	1.618485	75.31105	2.82355	26.67247	3.343	2.314515	13.31787	64	125	38	373	76	20	0	60	19
KB	3	2.021806	45.8342	1.763608	25.98889	4.132	0.378088	9.648043	16	13	7	254	21	1	0	32	6
KD	1	1.875192	55.46996	4.405804	12.5902	5.157	0.03563	23.49938	47	3612	69	0	0	7	0	188	100
KD	2	1.476457	36.97589	3.231572	11.44207	4.972	0.054289	22.46304	35	3578	39	0	0	4	0	184	100
KD	3	1.197659	19.12813	1.758682	10.8764	5.172	0.034138	18.45246	31	2944	28	0	0	1	0	151	100
KN	1	1.62692	55.57095	3.83655	14.48462	3.875	0.679993	14.34395	85	1002	208	128	5	45	0	87	81
KN	2	1.423625	34.09757	2.533413	13.45914	3.911	0.624356	13.64037	42	420	96	168	6	22	0	51	60
KN	3	1.342935	21.77361	1.598244	13.62346	4.155	0.355637	11.56232	18	305	74	97	2	11	0	34	66
KO	1	2.253735	110.16	5.278298	20.87037	3.138	3.739582	30.58002	130	301	101	425	83	33	0	85	33
KO	2	1.449578	46.70304	2.020284	23.11707	3.848	0.722053	12.32455	29	22	13	328	29	1	0	42	8
KO	3	1.300377	25.31645	1.243615	20.35714	4.145	0.363733	8.721741	8	12	5	183	8	1	0	23	7
KX	1	2.375468	137.6506	5.984384	23.00163	2.975	5.450916	25.4564	213	445	147	223	64	76	0	77	53
KX	2	2.022417	71.2199	2.772766	25.68551	3.621	1.226299	15.11866	62	87	32	438	66	13	0	63	15
KX	3	2.460621	49.6573	2.097097	23.67907	4.099	0.410131	10.27423	18	13	7	329	31	1	0	41	5
KY	1	NA	183.4962	7.537	24.34605	2.626	1.198	32.14025	191	374	179	287	70	23	1	77	51
KY	2	NA	50.50772	1.888329	26.74731	3.573	1.356	8.266209	30	31	15	438	69	1	1	58	7
KY	3	NA	45.18561	1.810698	24.9548	4.093	0.4075	8.522573	18	16	7	333	32	0	0	41	5
KZ	1	NA	125.1923	5.115934	24.47106	2.933	6.0181	21.67601	117	255	105	354	66	39	1	76	33
KZ	2	NA	206.7874	8.589786	24.07364	3.769	0.8655	10.16932	32	19	14	489	72	2	1	62	5
KZ	3	NA	57.13054	2.173948	26.27962	4.202	0.3176	7.454884	13	9	6	288	24	1	1	35	4
LI	1	1.05315	57.1517	3.92819	14.54912	3.107	3.958055	8.219938	82	298	52	226	50	77	0	56	38
LI	2	0.734228	19.29727	1.766931	10.92135	3.469	1.713199	3.976194	28	55	13	264	18	26	0	38	13
LI	3	0.693209	12.81058	1.578978	8.113208	3.886	0.65553	3.454769	20	33	6	203	3	21	0	27	10
LV	1	1.62037	103.6921	5.36169	19.33945	3.527	1.5152	17.45299	123	341	85	284	12	263	0	71	39
LV	2	1.316737	46.50942	2.388135	19.47521	3.898	0.642493	11.54251	29	47	16	286	10	33	0	39	13
LV	3	1.481702	31.92978	2.068884	15.43333	4.098	0.406198	10.924	15	28	7	217	11	14	0	29	10
NU	1	2.716523	201.9605	11.06113	18.25858	2.999	5.179455	55.6598	242	1214	292	161	56	47	0	121	77

UnitID	SoilLayer	H2O	C	N	CN	pH	H	Na	K	Ca	Mg	Al	Fe	Mn	B	CEC	BaseSat
NU	2	1.055276	46.3655	2.899081	15.99317	3.482	1.669141	17.26118	32	127	36	297	44	3	0	48	23
NU	3	NA	23.52636	1.198475	19.63025	3.865	0.6929	7.358872	14	14	6	244	11	0	0	30	6
PE	1	2.12261	122.6404	7.644224	16.04353	3.518	1.556422	26.72804	168	309	84	385	15	244	0	82	34
PE	2	1.361512	57.02291	5.425117	10.51091	3.8	0.805572	16.51147	50	62	22	287	6	33	0	41	17
PE	3	1.059788	33.11529	1.67209	19.80473	4.073	0.428072	11.08898	20	32	9	184	1	21	0	25	13
SB	1	0.554637	23.43927	1.660738	14.11377	3.652	1.121675	7.524865	73	228	32	131	6	56	0	34	47
SB	2	0.380562	13.14977	0.976271	13.46939	3.884	0.656079	5.905056	24	60	10	133	3	20	0	21	22
SB	3	0.426799	7.527734	0.547653	13.74545	4.082	0.4161	5.136706	15	40	6	107	1	12	0	16	20
SE	1	0.949179	41.38343	2.129593	19.43256	3.477	1.686303	7.765426	89	196	36	190	26	51	0	41	37
SE	2	0.652819	16.06444	0.88419	18.16854	4.082	0.417235	4.76806	16	11	5	152	4	13	0	20	8
SE	3	0.80206	13.29252	0.743985	17.86667	4.281	0.26434	4.925909	12	8	4	99	2	6	0	13	10
SG	1	1.419511	69.89357	4.031942	17.33496	3.662	1.10767	12.99488	106	217	37	290	26	22	0	53	32
SG	2	1.125815	27.30905	1.611649	16.94479	4.179	0.335632	6.316116	23	25	6	171	9	4	0	23	12
SG	3	0.880876	17.76215	1.030839	17.23077	4.321	0.241311	4.09522	10	15	3	89	4	2	0	12	12
SK	1	NA	75.64874	5.126324	14.75692	3.293	2.582	10.76403	89	774	86	200	30	46	2	77	63
SK	2	NA	36.48721	2.618505	13.93436	3.381	2.106	7.782432	31	203	21	326	33	7	1	53	24
SK	3	NA	23.12981	1.582301	14.61783	3.531	1.492	6.027645	19	92	10	281	14	7	1	40	15
SW	1	1.263682	44.50046	3.31754	13.41369	3.848	0.720426	15.92002	65	1455	194	80	9	57	0	103	88
SW	2	1.01829	27.99203	2.157801	12.97248	4.023	0.480063	19.05946	35	1418	108	61	3	21	0	90	91
SW	3	0.948055	18.12651	1.485779	12.2	4.191	0.325784	18.14016	25	1364	89	38	1	13	0	82	94
TY	1	1.403939	65.18185	4.781909	13.63093	4.16	0.351826	19.87729	270	1950	270	14	2	27	0	130	98
TY	2	1.203438	40.78322	2.845341	14.33333	3.788	0.826556	18.46087	174	674	135	168	4	19	0	70	71
U2	1	0.927403	46.92078	2.625424	17.8717	3.239	2.916226	7.612532	70	192	35	210	51	42	0	45	32
U2	2	0.724063	18.89221	1.052325	17.95283	3.831	0.744311	4.521135	20	27	6	277	18	11	0	35	7
U2	3	0.91638	10.57222	0.653952	16.16667	4.266	0.274008	3.673757	9	13	3	134	3	4	0	17	7
U3	1	1.398798	40.55468	2.810134	14.43158	3.652	1.133186	6.635963	45	111	27	290	4	175	0	49	19
U3	2	1.259181	21.56499	1.560105	13.82278	3.996	0.512349	6.680738	16	41	10	269	1	37	0	35	10
U3	3	1.369601	15.93867	1.094797	14.55856	4.153	0.357394	5.331963	7	41	11	253	1	8	0	32	10
U4	1	1.068746	54.04614	2.84922	18.96875	3.203	3.173685	10.80917	79	148	35	162	50	51	0	39	33
U4	2	0.909886	22.50336	1.179172	19.08403	3.838	0.734056	6.766976	28	19	6	245	15	13	0	32	8
U4	3	1.31799	23.04225	1.174316	19.62185	4.137	0.370574	5.823482	16	13	4	218	13	3	0	27	6

UnitID	SoilLayer	H2O	C	N	CN	pH	H	Na	K	Ca	Mg	Al	Fe	Mn	B	CEC	BaseSat
UK	1	1.733456	101.6076	4.765927	21.31959	3.633	1.188687	13.62494	171	1035	119	107	3	431	0	95	70
UK	2	1.093951	34.98307	1.265997	27.63281	3.876	0.674057	6.276361	41	125	16	202	6	81	0	35	25
UK	3	0.900686	25.60726	1.119822	22.86726	3.951	0.565824	11.6104	14	52	12	248	24	0	0	34	13
UO	1	1.187959	59.95914	3.567115	16.80886	3.762	0.877386	12.55756	178	555	130	129	2	159	0	65	67
UO	2	0.877893	28.99322	1.61569	17.94479	3.851	0.712133	10.73707	38	102	31	223	4	37	0	36	25

Appendix B.

Clay content within 10-20 cm soil horizon at the studied sites, in %.

UnitID	Lera
AA	1.34
AS	1.45
BH	6.69
EA	1.89
FB	1.25
H1	2.72
H2	4.74
H4	4.36
HD	0.76
HL	1.65
KB	1.39
KD	2.32
KN	1.12
KO	0.8
KX	0.84
LI	0.95
LV	1.36
NU	0.9
PE	1.59
SB	1.46
SG	0.88
SK	1.06
SW	1.26
TY	11.92
U2	2.11
U3	1.66
U4	1.51
UO	1.85