2484

NATURENS TÅLEGRENSER

Miljøverndepartementet

FAGRAPPORT NR. 11 b

Critical loads for soils in Norway

Analyses of soils data from eight Norwegian catchments

Norwegian Institute for Water Research NIVA

NIVA – REPORT

Norwegian Institute for Water Research NIVA

Main Office
P.O.Box 33, Blindern
N-0313 Oslo 3
Norway
Phone (47 2) 23 52 80
Telefax (47 2) 39 41 29

Regional Office, Sørlandet
Grooseveien 36
N-4890 Grimstad
Norway
Phone (47 41) 43 033
Telefax (47 41) 42 709

Regional Office, Østlandet
Rute 866
N-2312 Ottestad
Norway
Phone (47 65) 76 752

Regional Office, Vestlandet
Breiviken 5
N-5035 Bergen - Sandviken
Norway
Phone (47 5) 95 17 00
Telefax (47 5) 25 78 90

Report No.: 0-89153
Sub-No.:
Serial No.: 2484
Limited distribution:

Report Title:

CRITICAL LOADS FOR SOILS IN NORWAY

Analyses of soils data from eight Norwegian catchments.

Date: Oct. 1990

Author (s):

John O. Reuss

Topic group: Acid precipitation

Geographical area: Norway

Number of pages (incl. app.) 78

Contractor: Norwegian Directorate for Nature Managment

Contractors ref. (or NTNF-No)

Abstract:

Assessment of critical loads for soils at the catchment scale requires estimates of soil properties characteristic of the catchment. Soils data collected in routine soil surveys must thus be aggregated both spatially and with depth. Several procedures for such aggregation are used to arrive at characteristic values of soil properties for 8 Norwegian catchments. These values serve as input parameters for dynamic models such as MAGIC. An accompanying report uses these values to estimate critical loads for soils at these catchments.

4 keywords, Norwegian

1. Tålegrenser
2. Sur nedbør
3. Jordkjemi
4. Vannkjemi

4 keywords, English

1. Critical load
2. Acid deposition
3. Soil chemistry
4. Water chemistry

Project leader

Richard F. Wright

For the Administration

Bjørn Olav Rosseland

ISBN 82-577-1797-5

Norwegian Institute for Water Research

Critical loads for soils in Norway
Analyses of soils data from eight Norwegian catchments

John O. Reuss

Department of Agronomy
Colorado State University
Fort Collins, CO 80523
USA

Prepared under contract for the Norwegian Directorate for Nature Management

PREFACE

The work reported in this report was conducted in 1989-90 on subcontract to the Norwegian Institute for Water Research (NIVA) as part of a contract from the Norwegian Directorate for Nature Management (DN). This report is a supporting document to the main report "Critical loads for soils in Norway. Preliminary assessment based on data from 9 calibrated catchments soils" by R.F. Wright, A.O. Stuanes, J.O. Reuss, and M.B. Flaten. Both the main report and this data report comprise part of a comprehensive analysis of critical loads for terrestrial and aquatic ecosystems in Norway being conducted by the Ministry of Environment (MD), the Norwegian State Pollution Control Authority (SFT), and the Norwegian Directorate for Nature Management (DN). The Norwegian work is in turn an integral part of critical load mapping now underway under the auspices of the Nordic Council of Ministers (NMR) and the United Nations Economic Council for Europe (ECE).

This report is based on soils data collected independently as part of SFT's National Environmental Monitoring Programme. We thank SFT and NISK for use of unpublished data.

TABLE OF CONTENTS

PREFACE i

1. KAARVATN 1

2. STORGAMA 13

3. LANGTJERN 21

4. BIRKENES 26

5. GAULARVASSDRAGET 37

6. VIKEDAL 48

7. NAUSTDAL 57

8. DALEELVA 69

1. KAARVATN

1.1 PLOT DATA

The initial analysis were done using the KA-FELT2 data set consisting of four samples taken at each depth from each of four plots in the catchment. Horizons sampled were:

O(0-2)
O(2-)
E
Bh
Bs

The Bh horizon was not represented at location #1, which causes some problems in the analysis. However, overall this appears to be an excellent data set with surprisingly low variability. Parameters considered include:

CEC (1) mmol/kg
Ca saturation %
Mg " "
Na " "
K " "
Density g/l

These parameters were selected because they are essential inputs to the MAGIC model, and they seem to provide a reasonable set to use to establish protocols and procedures for the analyses. The saturation percentage for the individual bases was based on Extraction (1).

The low variability can be seen from Table 1.1. The standard errors are admittedly a bit confusing, so some clarification is in order. Both the "standard deviation among" and the "standard error within" are based on the plot means for each depth. Thus, the basic unit is the estimate of the parameter for a single plot, and the two estimates of variability are directly comparable. The "s.e. within" parameter includes only the variation among the four subsamples taken from each plot. The "s.d. among" includes both this in plot variation and the variation among plots.

They are presented in this manner in order to show the relative magnitudes of the variation within and among plots. The actual standard error of the means for a given depth averaged over the four plots would be one-half the "s.e. among" value.

The patterns shown in Table 1.1 are similar for CEC and for the degree of saturation by base cations. Therefore, a similar approach was used for estimating central tendency and confidence intervals for these patterns. The pattern for density is somewhat different and is discussed separately below.

As noted previously, the variation for CEC and the base cation saturations is generally quite low. We note, however, that the means, "s.e. within", and "s.d. among" all vary greatly with depth, and thus it is not appropriate to pool variances over depths. Also, the variation within a plot is much less than that among plots, so we cannot pool the within and among plot variances. The net result is that if we use these data in this form we must calculate our confidence interval separately for each depth. We are left with only three degrees of freedom for each estimate, which requires that we use values of 3.182 for $t_{(0.05)}$ or 5.841 for $t_{(0.01)}$ in our calculation of the confidence interval.

If the s.d. values are plotted against the mean we find a reasonably linear relationship for both CEC and the base cation saturations (Figures 1.1 and 1.2, respectively). Also, when the s.d. is expressed as a percentage of the mean, we find that there is little or no consistent pattern with either depth or the mean. This suggests that the standard deviations are proportional to the means, and the distributions are approximately lognormal. When the s.d.'s of the natural logarithms are plotted against the means (Figure 1.3) there seems to be little relationship to the means.

The antilog of the mean of the logarithms is the geometric mean. The geometric mean for each depth differs only very slightly from the arithmetic means (Table 1.2), so little or no distortion is introduced in the depth means by use of the lognormal distribution. However, since the variances are now independent of depth, we may now use a standard error derived from a variance pooled over depths to calculate our confidence intervals. The antilog of the standard error of the depth means from the AOV performed on the logarithms gives us an estimate of the standard error as function of the mean, as shown by the solid line in Figure 1.1.

Use of this pooled variance substantially reduces the confidence intervals applicable at each depth as the number of degrees of freedom for error now increases from 3 to 18, with $t_{(0.05)}$ and $t_{(0.01)}$ values 2.101 and 2.878, respectively. The confidence intervals as given in Table 1.2 for CEC, and the degree of saturation by Ca, Mg, Na and K are applied to the geometric means, and the geometric mean is taken as the overall estimate of central tendency.

For density, there is no clear pattern suggesting that the standard deviations are functionally related to the mean. Therefore, no tranformation was used in calculating the means or confidence intervals shown in Table 1.3. However, the variances used to calculate the confidence intervals were pooled over depth.

1.2 PIT DATA (KA-FELT3)

These samples were apparently taken from pits at or near the same locations as the plots from which the above samples were taken. As the plots seem to be the more intensive sampling (four separate subsamples analyzed for each plot) they are considered to be the basic samples. The pit samples are used for two purposes, 1) as a check on the plot samples, and 2) for estimates of the properties of the deep horizons not sampled in the plots.

Results are shown in Table 1.4. As these pits were sampled by horizons, some problems arise from the fact that there were differences in the horizons encountered, and in the horizon depths, at the various locations. This is particularly noticeable in the surface or near surface layers (O or A horizons), and in the deepest layers (BC or C horizons). For purposes of Table 1.4, all O and A horizon layers sampled were lumped in a single mean, as were all horizons below the Bs.

As shown by Table 1.4, results from the plots and the pits are quite consistent, perhaps surprisingly so for completely independent sampling. The mean CEC(1) on a weight basis is somewhat higher for the pits , but this is partially compensated by the lower density. Also we find that the Ca saturation goes up very substantially in the BC and C horizons, as compared to the B horizons. The CEC is very low so the capacity effect of this increased base saturation is probably small. Na and K saturation increase as well, but not to the same extent. Mg saturation does not increase in the C horizon.

1.3 MISCELLANEOUS RELATIONSHIPS

A couple of miscellaneous relationships are of interest. Density is negatively related to CEC (Figure 1.4), undoubtedly reflecting the major role of organic matter in CEC. There are, however, small differences in density among the mineral horizons that do not seem to be related to CEC. For example, density is about the same for th E, Bh and Bs horizons, but the CEC is consistently lower in the E horizon than in the Bh or Bs.

Total carbon is available for the pit data, so the relationship between percent carbon and CEC can be examined (Figures 1.5 and 1.6). Clearly, organic matter is the major factor in determining the charge. However, when only the mineral horizons are considered (Figure 1.6), it is apparent that there are differences other than those due to organic matter. For example, within the Bh samples there are substantial differences in CEC that are linearly related to carbon, with each percent C contributing about 17 mmoles/kg to the charge. This relationship is not nearly as apparent for the other mineral horizons. Both carbon and CEC are very low In the BC and C horizons, but what charge is present seems to be mostly mineral. In the E horizon, the charge per percent carbon is lower than for the other mineral horizons, perhaps due to protonation of organic charge in these acid horizons. Conversely, the charge per unit of C seems a bit higher in the Bs horizons.

1.4 DETAILS OF CALCULATIONS

The statistical analysis are independent for each chemical parameter. Operationally, the "s.d. among" and "s.e. within" values are derived from a one-way analysis of variance performed on the plot means, for each depth. The "s.e. within" values are calculated from the error term. As there are four subsamples in each plot mean, the "s.e. within" is given by the square root of (error mn sq/4). In the program used (STATGRAPHICS) this is printed out as the "pooled standard error". The "s.d. among" value is the same as a standard deviation calculated from the 4 (3 in the case of the Bh horizon) plot means. It may be obtained from the above AOV by dividing the "among groups" mean square by the number of observations in the location mean (4), and taking the square root. Again, if the STATGRAPHICS program is used it may also be obtained from a one way AOV performed over depths on the plot means. In this case it is the "internal standard error" multiplied by the square root of the number of plot means in the depth mean. For these data the multiplier would be $(4)^{1/2}$, (or $(3)^{1/2}$ in the case of the Bh horizon).

The confidence intervals are derived from a one-way AOV performed over depth on the means for each location. The confidence intervals for the logarithms are calculated directly by the program and the values reported are obtained by simply taking the antilogs. In all cases natural logs are used.

Table 1.1. Standard errors within locations and standard deviations among locations, both in absolute terms and expressed as a percentage of the mean.

Parameter	Depth	Mean	s.d. Among	s.e. Within	s.d. Among %	s.e. Within %
CEC (1) mmol/kg	1	212.86	38.48	8.267	18.08	3.88
	2	189.01	9.88	8.136	5.23	4.30
	3	29.56	5.58	1.091	18.88	3.69
	4	89.29	3.67	2.430	4.11	2.72
	5	59.64	7.83	2.755	13.13	4.62
Ca Sat. %	1	19.01	1.48	1.07	7.76	5.64
	2	14.91	2.78	1.10	18.68	7.36
	3	7.12	1.36	0.18	19.16	2.55
	4	2.72	0.63	0.08	23.31	2.85
	5	2.96	0.62	0.24	21.08	8.17
Mg Sat. %	1	20.36	3.29	0.43	16.17	2.10
	2	17.62	1.59	0.77	9.04	4.35
	3	4.72	0.35	0.19	7.37	4.00
	4	1.70	0.17	0.05	10.24	2.69
	5	1.68	0.39	0.24	23.10	14.31
Na Sat. %	1	1.42	0.37	0.04	25.92	2.71
	2	1.44	0.38	0.04	26.53	2.57
	3	1.13	0.23	0.11	20.53	9.79
	4	0.48	0.01	0.01	2.50	2.99
	5	0.61	0.04	0.03	7.21	4.17
K Sat. %	1	7.53	3.75	0.32	49.80	4.22
	2	4.52	1.71	0.41	37.79	9.01
	3	2.29	0.37	0.10	16.07	4.58
	4	0.61	0.10	0.02	16.89	2.50
	5	0.79	0.38	0.06	48.10	7.53
Density g/l	1	331	16.11	55.25	4.87	16.70
	2	418	16.73	18.94	4.00	4.53
	3	990	9.73	76.94	0.98	7.77
	4	978	9.77	43.47	1.00	4.44
	5	1026	22.05	129.74	2.15	12.64

Table 1.2. Arithmetic means, geometric means, and confidence intervals for Kaarvatn. Confidence intervals based on lognormal distribution with variance pooled over depth.

Horizon		Plots	n per plot	CEC (1) mmol/kg	Ca	Mg	Na	K
					--------Saturation %--------			
Arithmetic means								
1	O	4	4	212.86	19.01	20.36	1.42	7.53
2	O	4	4	189.01	14.91	17.62	1.44	4.52
3	E	4	4	29.56	7.12	4.72	1.13	2.29
4	Bh	3	4	89.29	2.72	1.70	0.48	0.61
5	Bs	4	4	59.64	2.96	1.68	0.61	0.79
Geometric Means								
1	O	4	4	210.51	18.97	20.16	1.38	6.97
2	O	4	4	188.82	14.70	17.73	1.39	4.29
3	E	4	4	29.19	7.02	4.70	1.12	2.26
4	Bh	3	4	89.21	2.67	1.70	0.49	0.60
5	Bs	4	4	59.27	2.90	1.66	0.60	0.73
Confidence Intervals (95%)								
1	O	4	4	182.73	15.38	17.34	1.09	4.83
				242.50	23.41	23.44	1.75	5.12
2	O	4	4	163.91	11.92	15.11	1.10	2.97
				217.52	18.14	20.43	1.77	6.19
3	E	4	4	25.34	5.69	4.04	0.88	1.57
				33.63	8.66	5.47	1.42	3.20
4	Bh	3	4	75.76	2.09	1.43	0.37	0.39
				105.05	3.40	2.02	0.64	0.92
5	Bs	4	4	51.45	2.35	1.43	0.48	0.50
				68.28	3.57	1.93	0.77	1.05
Confidence Intervals (99%)								
1	O	4	4	172.97	14.18	16.34	0.99	4.19
				256.18	25.37	24.87	1.96	11.59
2	O	4	4	155.15	10.99	14.24	1.00	2.58
				229.79	19.67	21.68	1.98	7.14
3	E	4	4	23.99	5.25	3.81	0.80	1.36
				35.52	9.39	5.80	1.55	3.76
4	Bh	3	4	71.11	1.91	1.34	0.33	0.33
				111.92	3.74	2.17	0.71	1.08
5	Bs	4	4	48.70	2.17	1.35	0.43	1.07
				72.13	3.88	2.05	0.84	1.21

Table 1.3. Arithmetic means and confidence intervals for Density (g/l) at Kaarvatn.

		C.I. (95%)		C.I. (99%)	
Depth	Mean	Lower	Upper	Lower	Upper
1	331	249	413	217	445
2	418	336	500	304	532
3	990	908	1073	876	1104
4	978	883	1073	846	1110
5	1026	944	1108	912	1141

Table 1.4. Comparison of arithmetic means as estimated from the cores as shown in Tables 2 and 3 and from samples taken from soil pits. Kaarvatn.

Horizons	Depth code	CEC(1) mmol/kg Pits	Cores	Density g/l Pits	Cores
O,A	1	296	213	290	331
	2		187		418
E	3	24	30	971	990
Bh	4	79	89	961	978
Bs	5	48	60	1137	1026
BC,C	6	16		1502	

Horizons	Depth code	Ca Sat. % Pits	Cores	Mg Sat. % Pits	Cores
O,A	1	21.1	19.0	21.7	20.4
	2		14.9		17.6
E	3	6.6	7.1	4.3	4.7
Bh	4	2.4	2.7	1.5	1.7
Bs	5	4.5	3.0	1.0	1.7
BC,C	6	21.0		0.7	

Horizons	Depth code	Na Sat. % Pits	Cores	K Sat. % Pits	Cores
O,A	1	2.0	1.4	6.3	7.5
	2		1.4		4.5
E	3	2.2	1.1	0.024	2.3
Bh	4	0.8	0.5	0.8	0.6
Bs	5	1.1	0.6	0.6	0.8
BC,C	6	3.2		1.2	

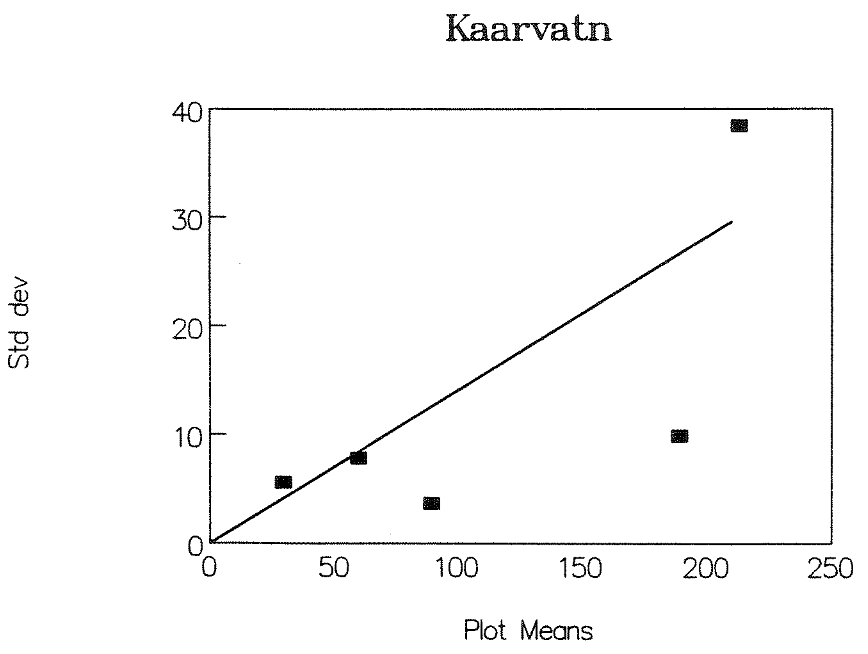

Figure 1.1 The relationship between the standard deviation of the location means and overall mean CEC values for the five depths. The s.d.'s are clearly dependent on the mean.

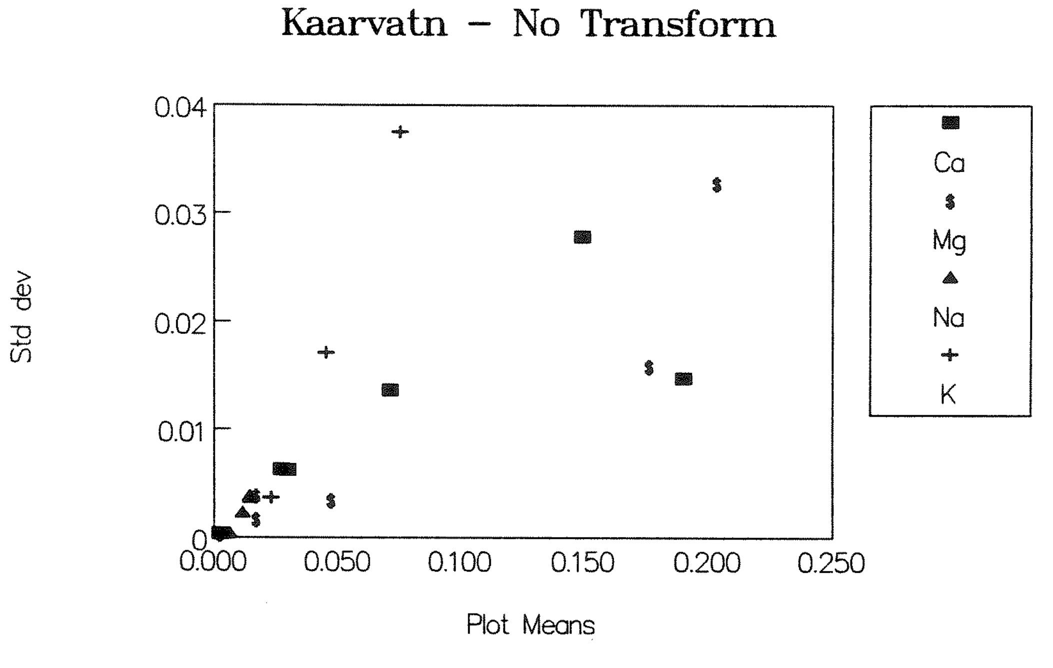

Figure 1.2. The relationship between the standard deviation of the location means and overall means for Ca, Mg, Na, and K saturation values for the five depths.

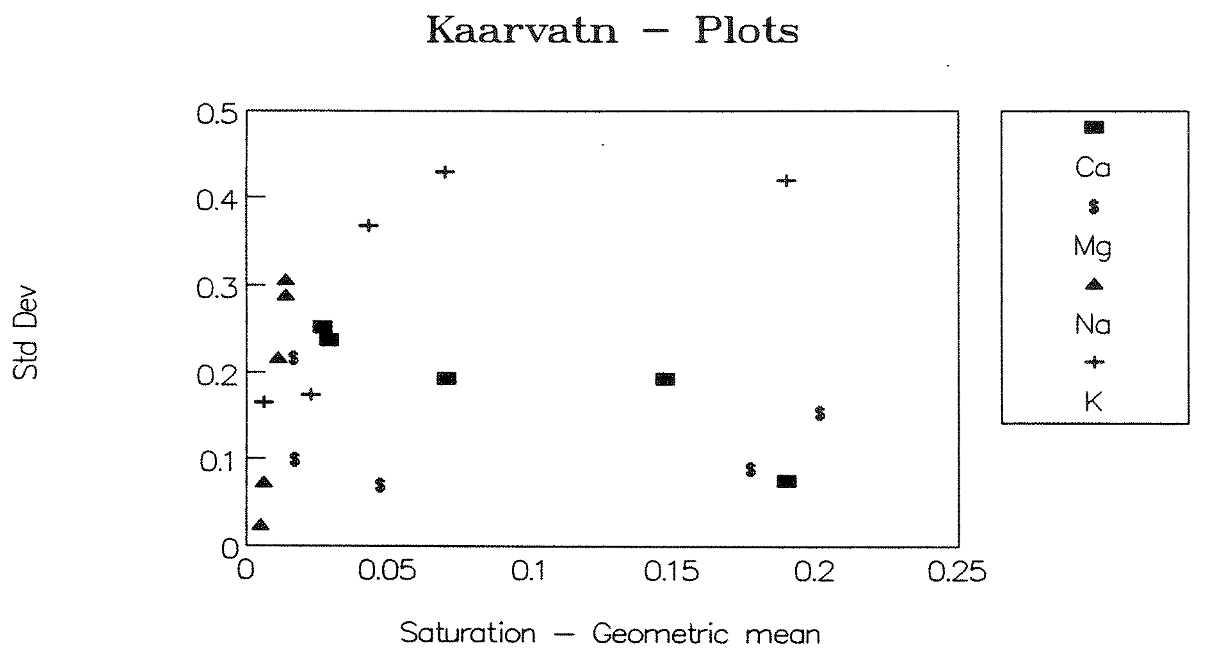

Figure 1.3. The relationship between the standard deviation of the log(e) of the plot means and the geometric means for the base saturation data.

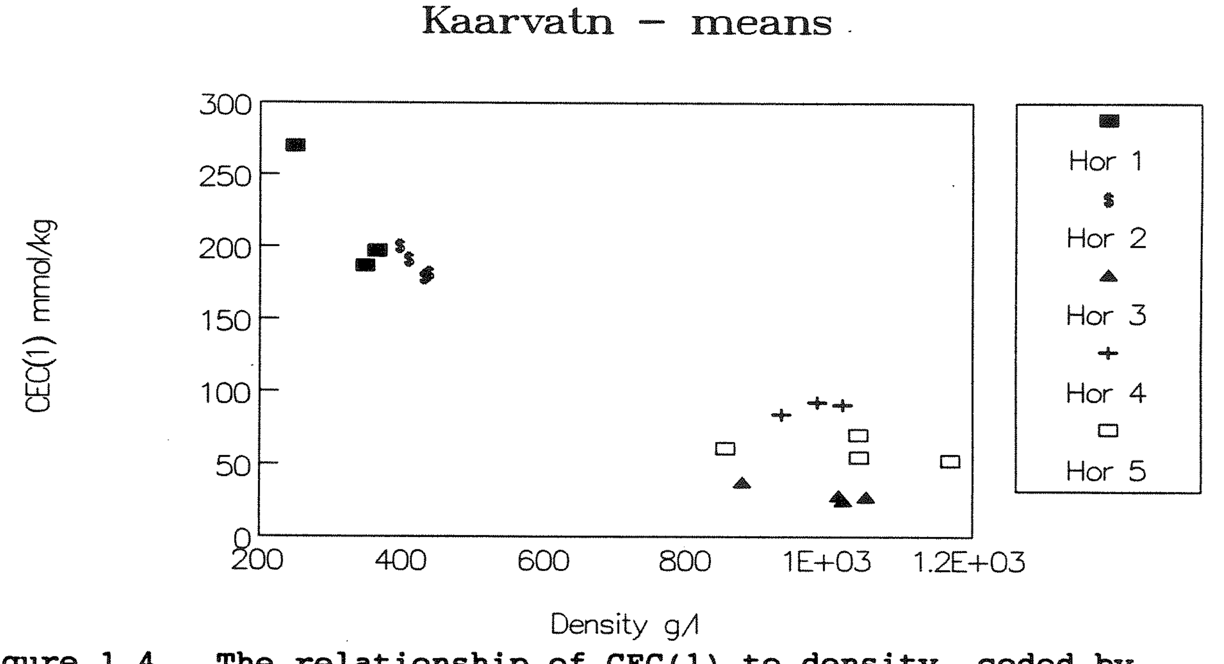

Figure 1.4. The relationship of CEC(1) to density, coded by horizon. Points represent the mean value for each plot.

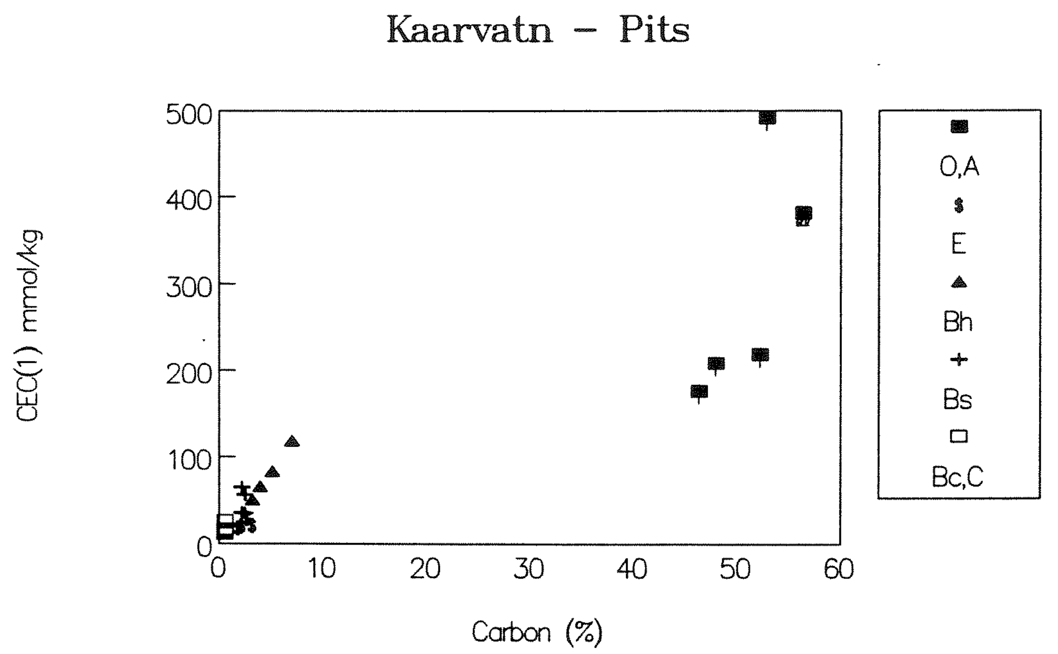

Figure 1.5. The relationship of CEC(1) to percent carbon coded by horizon. Data are from the pits.

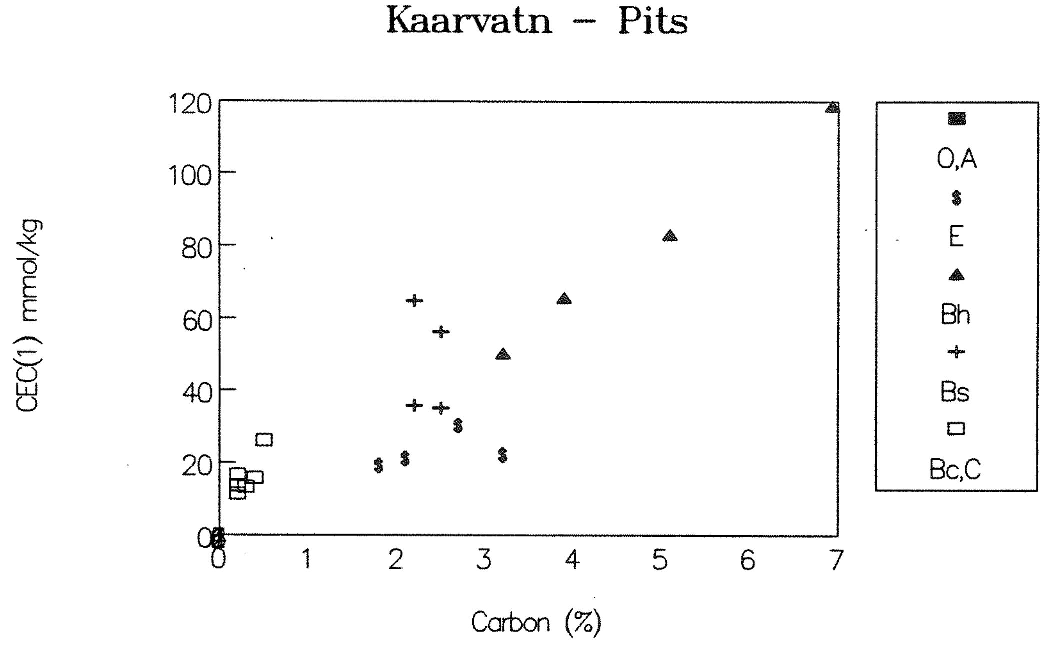

Figure 1.6. The relationship of CEC(1) to percent carbon coded by horizon for the mineral horizons. Expansion of the lower left corner of Figure 1.5.

2. STORGAMA

2.1 PLOT DATA

Serious problems arise in the interpretation of the Storgama data. Means, standard deviations among plots, and standard errors within plots are shown in Table 2.1. These are calculated in the same manner as the Kaarvatn data, and again are presented on the basis of a single plot mean, so that the among and within variation are directly comparable. Again, the within plot variation is relatively small. However, at this site the variation among plots at each depth is relatively large. This is particularly a problem for CEC, Ca saturation and Mg saturation. As this among plot variation is very large, confidence intervals based on arithmetic means (not shown) are huge.

In this case there is little tendency for the within plot variation to be related to the mean, but there is a tendency for the among plot standard deviation to vary with the mean. Therefore, as was done for the Kaarvatn data, a log transformation was used on the plot means in order to calculate geometric means and confidence intervals as shown in Table 2.2. There is more difference between the geometric means and the arithmetic means than was observed at Kaarvatn. Confidence intervals are so large they are virtually meaningless, even at the 95% level. Therefore, the 99% intervals are not reported.

The problem can be better understood by looking at the individual plot means for each depth shown in Table 2.3. All plots have high carbon levels at the 0-2 cm depth. However, the highest carbon level (52%) is found in plot site 3. This is pure organic matter. Furthermore, while the carbon levels decrease rapidly with depth in the other plots, high carbon is maintained at all depths in plot 3. These higher carbon levels are, of course, reflected in high CEC, and low density. They are also reflected in very high base saturation, particularly for Ca. Both the arithmetic and geometric means are completely dominated by the values from a single plot, resulting in the very wide confidence intervals observed.

2.2 PIT DATA

The pit data is quite limited at this site, with one set from profile 3 and two sets from profile 4 (Table 2.4). Furthermore, these were sampled by horizon rather than fixed depths. There is some tendency for the high base saturation in plot 3 in the plot samples to be reflected in the H1 horizon here as well, but it is not nearly as strong as in the plots. The H1 seems to be about 30 cm thick here, so all 5 depths of plot samples would have come from this horizon.

2.3 RECOMMENDATIONS

The author would not recommend use of the plot means for the model input, as they appear to be distorted by a single plot. The pit samples taken by horizons appear much more consistent. Unfortunately, it is not possible to calculate a meaningful confidence interval from the few pit samples, but as the confidence intervals from the plot data do not seem to be useful, this is probably the best that can be done. In order to use the pit data some sense of how the relative horizon thickness is distributed in the catchment will be required. This can best be supplied by someone familiar with the catchment. Also, as for all catchments, an estimate of fraction of bare rock is needed.

2.4 MISCELLANEOUS

The relationships among CEC, carbon and Ca saturation were examined in an attempt to understand the very high base saturations in plot 3. Ca saturation goes up rapidly with CEC, and this can be described by a straight line if a log scale is used for Ca saturation (Figure 2.1). On a linear scale, of course, the increase in Ca saturation per unit of CEC goes up as CEC increases (Figure 2.2). Mathematically this may be described by,

$$\text{Casat} = (2.95\times10^{-6})(\text{CEC})^{1.94}$$

$$R^2 = 0.73.$$

Furthermore, because

$$\text{Casat} = (\text{Xchg Ca})/(\text{CEC})$$

$$\text{Xchg Ca} = (2.95\times10^{-6})(\text{CEC})^{2.94}$$

Thus, the degree of Ca saturation varies by nearly the square of CEC, i.e. $(\text{CEC})^{1.94}$, while the amount of exchangeable Ca varies by nearly the cube of Ca. A similar relationship exists with carbon but the R^2 value is not as high ($R^2 = 0.56$). One would presume, however, that the basic relationship is with carbon. Incidentally, the above equation and the figures assume Ca saturation is expressed as a fraction rather than percent.

The implications of this are not completely clear. However, we have previously noted that base saturation is higher in the surface layers, and it appears that Ca and Mg are much more tightly held on organic exchangers than on the mineral exchangers deeper in the profile. This is reflected in lower values of the selectivity coefficient for the organic materials.

Table 2.1. Standard errors within locations and standard deviations among locations expressed as a percentage of the mean. Storgama.

Parameter	Depth	Mean	s.d. Among	s.e. Within	s.d. Among %	s.e. Within %
CEC (1)	0-2	257.1	77.93	11.93	30.31	4.64
mmol/kg	2-4	197.0	110.93	12.86	56.31	6.53
	4-6	164.8	114.94	16.46	69.75	9.99
	8-10	143.0	72.28	17.18	50.55	12.01
	12-14	130.2	48.70	14.46	37.40	11.11
Ca sat.	0-2	16.53	11.09	0.63	67.09	3.81
%	2-4	11.87	10.58	0.63	89.13	5.31
	4-6	8.64	9.55	0.36	110.53	4.17
	8-10	5.62	6.88	0.59	122.42	10.50
	12-14	3.32	3.89	0.68	117.17	20.48
Mg sat.	0-2	7.39	5.09	0.15	68.88	2.03
%	2-4	7.22	6.32	0.28	87.53	3.88
	4-6	6.32	7.04	0.24	111.39	3.80
	8-10	4.40	5.76	0.23	130.91	5.23
	12-14	2.55	2.95	0.26	115.69	10.20
Na sat.	0-2	0.75	0.19	0.06	25.33	8.40
%	2-4	0.73	1.00	0.04	136.99	5.75
	4-6	0.68	0.90	0.05	132.35	6.76
	8-10	0.53	0.14	0.05	26.42	8.87
	12-14	0.47	0.07	0.06	14.89	12.55
K sat.	0-2	4.20	1.13	0.21	26.90	5.00
%	2-4	3.66	0.63	0.20	17.21	5.46
	4-6	2.81	0.49	0.24	17.44	8.54
	8-10	1.68	0.49	0.18	29.17	10.71
	12-14	1.09	0.40	0.19	36.70	17.43
Density	0-2	249.7	39.1	10.16	15.66	4.07
g/l	2-4	397.0	118.21	28.35	29.78	7.14
	4-6	497.2	162.56	47.59	32.70	9.57
	8-10	574.8	148.46	59.34	25.83	10.32
	12-14	612.0	108.62	54.56	17.75	8.92

Table 2.2. Arithmetic means, geometric means, and confidence intervals for Storgama. Confidence intervals based on lognormal distribution with variance pooled over depth. There are 4 observations at plots 1, 2, and 3, and 8 observations at plot 4.

Depth	n plots	CEC (1)	Ca	Mg	Na	K
			---------Saturation %---------			
Arithmetic means						
0-2	4	257.1	16.53	7.39	0.75	4.20
2-4	4	197.0	11.87	7.22	0.73	3.66
4-6	4	164.8	8.64	6.32	0.68	2.81
8-10	4	143.0	5.62	4.40	0.53	1.68
12-14	4	130.2	3.32	2.55	0.47	1.09
Geometric Means						
0-2	4	249.0	13.56	6.41	0.73	4.09
2-4	4	179.1	8.69	5.61	0.72	3.62
4-6	4	142.8	5.74	4.31	0.68	2.78
8-10	4	131.8	3.58	2.60	0.52	1.62
12-14	4	123.2	2.12	1.70	0.47	1.02
Confidence Intervals (95%)						
0-2	4	155.0	4.92	2.44	0.59	2.98
		399.9	37.34	16.26	0.89	5.61
2-4	4	111.5	3.15	2.18	0.59	2.64
		287.7	23.93	14.49	0.89	4.97
4-6	4	88.9	2.08	1.67	0.55	2.02
		229.3	15.80	11.13	0.83	3.81
8-10	4	82.1	1.30	1.01	0.42	1.18
		211.7	9.86	6.72	0.63	2.23
12-14	4	76.7	0.77	0.66	0.38	0.74
		197.9	5.85	4.38	0.58	1.40

Table 2.3. Arithmetic means by depth and plot for Storgama.

Depth cm	Plot	CEC(1) mmol/kg	Ca	Mg	Na	K	Density g/l	C %
			-------Saturation %--------					
0-2	1	257	18.5	6.6	0.6	2.9	261	41.9
	2	214	11.4	4.8	0.6	3.8	278	42.5
	3	366	31.0	14.7	0.8	4.4	192	52.2
	4	191	5.1	3.3	0.9	5.6	266	38.3
2-4	1	140	12.1	5.9	0.6	2.8	490	24.2
	2	136	5.4	3.7	0.6	4.1	446	30.7
	3	363	26.7	16.5	0.8	3.6	224	52.3
	4	148	3.2	2.7	0.8	4.1	428	25.4
4-6	1	106	6.3	3.6	0.7	2.1	600	16.6
	2	99	3.1	2.7	0.6	3.2	544	19.8
	3	337	22.7	16.8	0.8	3.0	256	51.3
	4	118	2.4	2.1	0.7	3.0	588	23.3
8-10	1	127	2.3	1.7	0.4	1.1	612	22.7
	2	91	2.3	1.5	0.4	1.5	647	20.5
	3	249	15.9	13.0	0.7	2.2	356	41.0
	4	105	1.9	1.4	0.5	1.9	684	16.2
12-14	1	177	1.6	1.2	0.4	0.5	520	22.8
	2	92	0.8	0.8	0.5	1.1	623	20.5
	3	167	9.1	6.9	0.5	1.2	544	41.0
	4	84	1.8	1.1	0.5	1.6	760	16.2

Table 2.4. Arithmetic means by horizons from pits at Storgama.

Prof	Hor	Depth cm	CEC(1)	Na	K	Mg	Ca	Den g/l	C %
				------Saturation % ------					
3	H1	37-7	215	0.83	0.83	6.47	12.90	371	54.6
	H2	7-0	283	0.32	0.32	0.48	1.70	386	53.6
	Bs	0-18	37	0.36	0.36	0.49	1.69	1286	2.7
4a	H1	15-9	306	1.36	1.36	5.44	6.76	100	48.6
	H2	9-0	211	0.69	0.69	4.48	3.81	322	45.4
	Ah	0-3	42	0.71	0.71	2.08	2.46	904	4.8
4b	H1	8-0	256	0.82	0.82	2.01	2.84	233	45.6
	Ah	0-6	26	0.78	0.78	1.02	1.88	1060	2.1
Horizon Means									
	H1		259	1.00	1.00	4.64	7.50	235	49.6
	H2		247	0.50	0.50	2.48	2.76	354	49.5
	Ah,Bs		35	0.62	0.62	1.20	2.01	1083	3.2

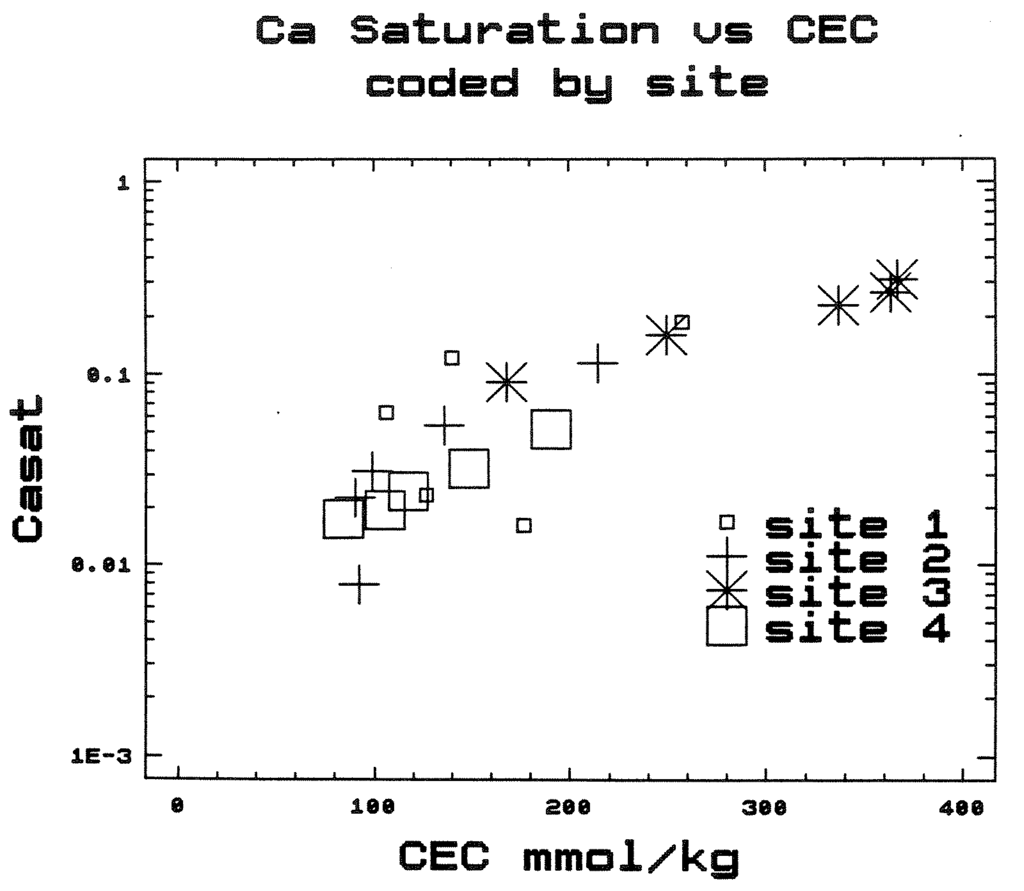

Figure 2.1. Semi-log plot of the relationship between Ca saturation and CEC, coded by site. Points are plot means.

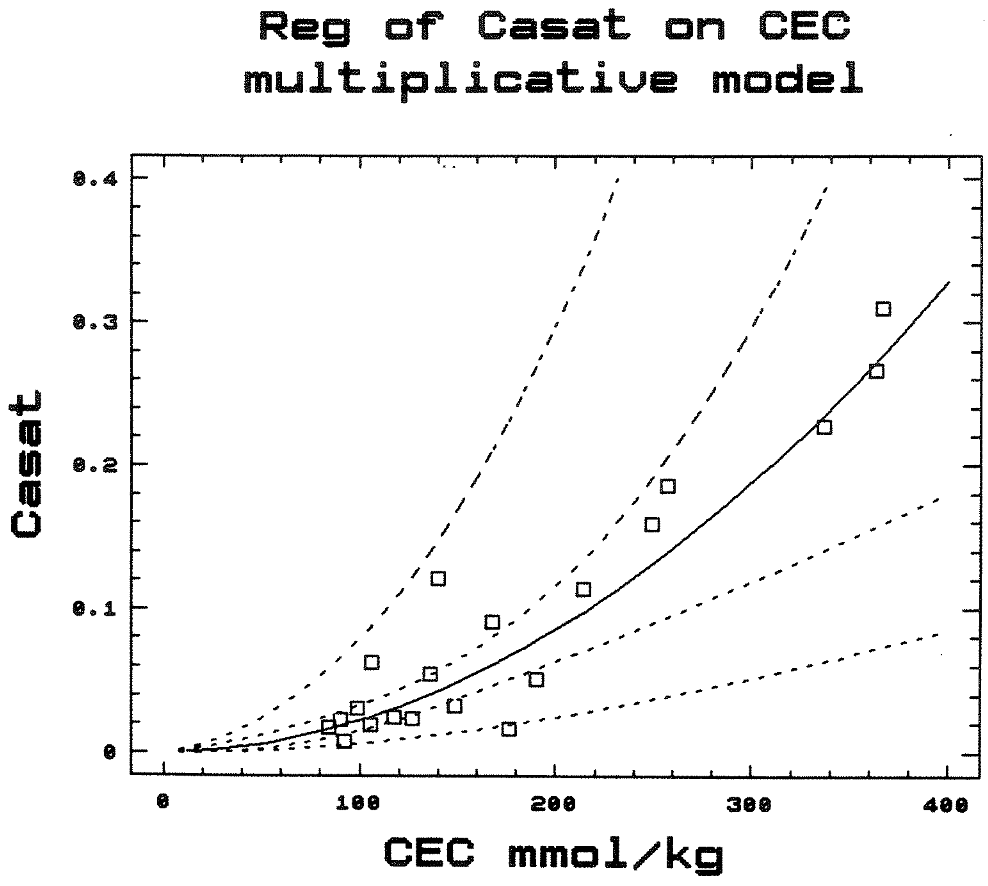

Figure 2.2. Relationship between Ca Saturation and CEC on a linear scale. Regression line represents the relationship $y = (2.95\times10^{-6})(CEC)^{1.94}$.

3. LANGTJERN

3.1 PLOTS

The Langtjern data also present a number of difficulties. The E and B horizons are represented in only two of the four plots. As with the other sites the variation among plots is much greater than the variation within plots (Table 3.1.) Again, with most of the parameters there is a tendency for the standard deviation (among) to vary with the mean. I have not made plots of this tendency, but it can be seen clearly in Table 3.1, even though the estimates of standard deviation are highly variable. This variability seems to be largely due to the small number of sites represented in many of the estimates.

As for the previous data sets, a log transformation was used to calculate geometric means and confidence intervals as shown in Table 2.2. Density confidence intervals are based on untransformed data and apply to the arithmetic means. These confidence intervals are generally very wide, again largely due to the fact that the standard errors are from a very few means. Unfortunately, there doesn't seem to be any credible way to achieve narrower confidence intervals.

3.2 PIT DATA

At this site there are also data from four profiles. By combining some horizons, a similar analysis has been carried out on the pit data, as shown in Table 3.3. Unfortunately, the resulting confidence intervals tend to be very wide from this data set as well. Furthermore, the results from the plots and the profiles are not as consistent as we might like. For example, the estimate of Ca saturation of the E horizon is 7.80% from the plots and 2.25% from the profiles. While we have estimates at all four locations in the profile data, the location estimate is generally derived from a single sample, which seems to increase the variability. Also the base saturation from location #4 seems to be considerably higher than that found at the other locations, and this contributes to the wide confidence intervals.

I would recommend use of the plot data for estimates, although it might depend on which can be aggregated most easily over depth.

Table 3.1. Standard errors within plots and standard deviations among plots at Langtjern. The % columns refer to percent of the mean.

Param.	Depth/Hor cm	n plots	Mean	s.d. Among	s.d. Within	s.d. Among %	s.d. Within %
CEC mmol/kg	0-2	4	292.7	17.92	18.2	6.12	6.22
	2-4	4	268.5	57.42	21.14	21.39	7.87
	4-6	3	221.4	43.06	21.93	19.45	9.91
	8-10	2	127.6	44.36	9.08	34.76	7.11
	12-14	2	75.8	18.34	8.55	24.20	11.29
	E	2	36.7	2.32	1.81	6.31	4.93
	Bs	2	39.9	7.34	4.27	18.41	10.71
Ca Sat. %	0-2	4	31.85	4.15	2.679	13.02	8.41
	2-4	4	22.43	0.79	2.761	3.53	12.31
	4-6	3	14.29	2.79	1.545	19.54	10.82
	8-10	2	4.97	3.81	0.413	76.67	8.31
	12-14	2	2.36	1.59	0.236	67.35	10.01
	E	2	7.83	1.00	0.569	12.72	7.27
	Bs	2	6.29	3.23	0.213	51.41	3.39
Mg Sat. %	0-2	4	7.98	0.80	0.382	10.06	4.79
	2-4	4	6.75	1.51	0.362	22.41	5.36
	4-6	3	4.64	1.84	0.389	39.70	8.38
	8-10	2	2.11	1.36	0.183	64.30	8.68
	12-14	2	0.99	0.40	0.069	40.41	6.94
	E	2	2.64	0.64	0.09	24.25	3.41
	Bs	2	2.09	0.12	0.167	5.81	7.98
Na Sat. %	0-2	4	0.47	0.068	0.047	14.51	10.00
	2-4	4	0.52	0.081	0.078	15.78	15.12
	4-6	3	0.51	0.036	0.045	6.91	8.75
	8-10	2	0.38	0.028	0.031	7.22	8.12
	12-14	2	0.38	0.006	0.038	1.47	9.90
	E	2	0.71	0.037	0.021	5.20	2.97
	Bs	2	0.71	0.052	0.078	7.23	10.92
K Sat. %	0-2	4	6.86	1.921	0.288	28.01	4.20
	2-4	4	5.12	1.218	0.259	23.79	5.06
	4-6	3	3.19	0.160	0.201	5.00	6.30
	8-10	2	1.67	0.029	0.106	1.74	6.35
	12-14	2	1.09	0.249	0.074	22.75	6.76
	E	2	3.52	1.860	0.23	52.93	6.54
	Bs	2	3.05	1.754	0.368	57.52	12.07

Table 3.1. (Continued)

Param.	Depth/Hor cm	n plots	Mean	s.d. Among	s.d. Within	s.d. Among %	s.d. Within %
Density g/l	0-2	4	211	26.50	13.34	12.55	6.32
	2-4	4	283	74.22	18.89	26.24	6.68
	4-6	3	369	46.95	25.12	12.73	6.81
	8-10	2	666	114.37	33.75	17.18	5.07
	12-14	2	911	3.18	48.46	0.35	5.32
	E	2	1016	67.53	21.53	6.65	2.12
	Bs	2	940	4.42	20.26	0.47	2.16

Table 3.2. Arithmetic means, geometric means and confidence intervals for Langtjern. Confidence intervals (except for density) based on lognormal distribution with variance pooled over depth.

Depth/Hor cm	n loc.	CEC mmol/kg	Ca	Mg	Na	K	Dens g/l
			-------Saturation % ---------				
Arithmetic Means							
0-2	4	292.7	31.85	7.98	0.47	6.86	211
2-4	4	268.5	22.43	6.75	0.52	5.12	283
4-6	3	221.4	14.29	4.64	0.51	3.19	369
8-10	2	127.6	4.97	2.11	0.38	1.67	666
12-14	2	75.8	2.36	0.99	0.38	1.09	911
E	2	36.7	7.83	2.64	0.71	3.52	1016
Bs	2	39.9	6.29	2.09	0.71	3.05	940
Geometric Means							
0-2	4	292.3	31.62	7.95	0.47	6.67	210
2-4	4	263.8	22.42	6.62	0.51	5.02	276
4-6	3	218.4	14.10	4.42	0.51	3.19	367
8-10	2	123.7	4.18	1.88	0.38	1.67	661
12-14	2	74.6	2.07	0.95	0.38	1.08	911
E	2	36.7	7.80	2.60	0.71	3.26	1015
Bs	2	39.5	5.86	2.09	0.71	2.79	940
Confidence Intervals (95%)							
0-2	4	236.0	20.93	5.66	0.41	4.81	*148
		362.0	47.78	11.18	0.53	9.27	244
2-4	4	213.0	14.84	4.71	0.45	3.62	219
		326.7	33.87	9.31	0.58	6.98	346
4-6	3	170.6	8.76	2.99	0.44	2.18	295
		279.0	22.71	6.55	0.59	4.66	442
8-10	2	91.4	2.33	1.16	0.32	1.05	576
		167.4	7.48	3.04	0.45	2.65	755
12-14	2	55.2	1.16	0.59	0.32	0.68	821
		101.0	3.71	1.54	0.46	1.72	1100
E	2	27.1	4.35	1.61	0.59	2.05	926
		49.7	13.97	4.21	0.84	5.19	1105
Bs	2	29.2	3.27	1.29	0.60	1.75	850
		53.5	10.50	3.39	0.85	4.43	1029

* Confidence intervals for density apply to arithmetic means.

Table 3.3. Arithmetic means, geometric means and confidence intervals for Langtjern using the L-FELT2 data (pits). Confidence intervals (except for density) based on lognormal distribution with variance pooled over depth. Four sites are represented at each depth.

Horizon	CEC mmol/kg	Ca	Mg	Na	K	Dens g/l
		-------Saturation % ---------				
Arithmetic Means						
Ol/f	352.5	31.90	7.98	0.43	6.44	178
Oh, O	273.1	2.31	2.27	0.53	4.11	331
E	28.0	3.06	1.51	0.58	2.08	1173
Bh, Bs	60.9	1.85	1.54	0.73	2.48	883
2CB, 2C	9.3	4.88	0.89	1.96	2.33	1437
Geometric means						
Ol/f	351.5	31.55	7.89	0.42	6.42	178
Oh, O	269.3	1.78	2.27	0.53	4.09	326
E	27.7	2.25	1.25	0.57	1.97	1172
Bh, Bs	47.6	1.38	1.18	0.55	1.71	874
2CB, 2C	8.7	4.80	0.79	1.85	2.05	1437
Confidence Intervals (95%)						
Ol/f	207.9	14.49	4.26	0.25	3.51	88*
	594.2	68.70	14.62	0.69	11.74	270
Oh, O	146.9	0.73	1.11	0.30	2.04	227
	494.0	4.38	4.63	0.95	8.21	436
E	15.1	0.42	0.61	0.32	0.98	1067
	50.8	5.53	2.55	1.03	3.96	1278
Bh, Bs	28.1	0.64	0.63	0.33	0.94	792
	80.4	3.01	2.18	0.91	3.13	973
2CB, 2C	4.7	1.96	0.39	1.03	1.02	1332
	16.0	11.80	1.60	3.32	4.11	1541

* Confidence intervals for density apply to arithmetic means.

4. BIRKENES

4.1 PLOT DATA

From the available data it has not been possible to devise a really satisfactory aggregation. The data are very good in the sense that different samples from the same plot give similar results. However, the plots are very different, and it seems to be virtually impossible to come up with an aggregation that has reasonable and defensible confidence limits.

Table 4.1 shows the within plot and among plot variation in the same manner as was done for the other sites. The within plot s.d. is almost always within 10% of the mean, but the between plot variation is often very high. In order to be consistent the geometric means and confidence intervals have again been calculated using a pooled variance (Table 4.2). Again, the confidence intervals are so wide as to be virtually meaningless. The problem can be better understood from the bar graph of CEC by plot and depth shown in Figure 4.1. The figure is admittedly a bit confusing in that for plots 1 and 2 the five bars represent, the 0-2, 2-4, 4-6, 8-10, and 12-14 cm depths, respectively; while for plots 3 and 4 the first three bars again represent the 0-2, 2-4, and 4-6 cm depths, but the 3rd and 4th bars represent the E and Bs horizons. At any rate, the inconsistency of CEC among depths and horizons is clear. The situation for the other parameters is similar, as can be seen from the bar graph for density (Figure 4.2). These wide swings result in very wide confidence intervals. While there is a tendency for large values of most parameters to be associated with large s.d. (among) values, in the combined analysis using the log transformation shown in Table 2.2 the large differences at some depths tend to overwhelm the error terms and result in very wide confidence intervals.

The analysis for the untransformed data is not shown, but confidence intervals are very wide and many of the lower bounds are negative. Pooling of variances for the untransformed data is clearly inappropriate in most cases, while the limited number of observations generally make meaningful variance estimates impossible. The 8-10, and 12-14 cm depths and the E and Bs horizon estimates all have only 2 observations, so the confidence interval must be calculated using a $t_{(0.05)}$ value of 12.71 ($t_{(0.05)}$ with 1 d.f.). Such confidence intervals are clearly meaningless.

4.2 PIT DATA

The profile data (Tables 4.3, 4.4, and 4.5) seem a bit more consistent, probably because when sampled by profile rather than depth, more similar things are being combined. However, similar horizons are of different thickness at different sampling points, and some are not present at all points. This will introduce another source of error in the estimation of catchment values.

In order to construct Table 4.3 and 4.4, a few samples have been combined to obtain a single value for each of the horizons shown. The O, E, and Bh, horizons are represented at all four locations, while the Bs and C (including BC) horizons are each present at two locations. The CEC values by profile and horizon are also shown in bar graph form in Figure 4.3. They appear to be somewhat more consistent than the plot samples discussed earlier. However, there are still wide disparities among plots in the Ca saturation data (Figure 4.4).

The horizon means for the base saturation values in Table 4.3 are probably as good an estimate of central tendency as can be made. An attempt was made to calculate confidence intervals for the profile data using a log transformation and pooled variance (Table 4.4). Even though these are very wide they are probably the best we have. Most of the geometric means are quite similar to the arithmetic means in Table 4.3. Confidence intervals were also calculated for the arithmetic means using variances derived from individual depths (Table 4.4), but I would not recommend their use.

4.3 MISCELLANEOUS

An effort was made to generate a represenative depth profile of the various parameters based on density. It hasn't seemed to work out in that context. However, the relationship between density and CEC is truly remarkable, and can be descibed by,

$$CEC = 397{,}758(den)^{-1.306}$$
$$R^2 = 94.5\%.$$

The log plot of this relationship is shown in Figure 4.5. There is also quite a good relationship between Ca saturation and density, which may be described by,

$$(Casat) = 18{,}582(den)^{-1.208}$$
$$R^2 = 73.2\%.$$

4.4 SUMMARY

The best values seem to be the horizon means in Table 4.3. They still need to be combined to single values for the catchment. After a lot of work the author does not feel that we can put meaningful confidence intervals on these. The best of the lot are probably those in Table 4.4, but they are so wide as to be virtually meaningless.

Table 4.1. Standard errors within locations and standard deviations among locations for Birkenes plot data. The % columns refer to percent of the mean.

Param.	Depth/Hor cm	n plots	Mean	s.d. Among	s.d. Within	s.d. Among %	s.d. Within %
CEC mmol/kg	0-2	4	311.3	93.90	13.54	30.16	4.35
	2-6	4	273.0	163.38	12.62	59.85	4.62
	4-6	4	229.9	152.62	14.10	66.39	6.13
	8-10	2	140.7	125.37	9.97	89.10	7.09
	12-14	2	118.9	98.22	2.99	82.60	2.51
	E	2	33.6	0.92	1.94	2.73	5.77
	Bs	2	66.8	1.27	2.20	1.91	3.29
Ca Sat. %	0-2	4	30.34	3.92	0.919	12.92	3.03
	2-6	4	23.21	6.18	1.112	26.63	4.79
	4-6	4	17.85	7.84	1.489	43.92	8.34
	8-10	2	7.51	5.56	0.571	74.01	7.60
	12-14	2	7.17	5.53	0.321	77.12	4.48
	E	2	7.86	0.35	0.503	4.52	6.40
	Bs	2	1.95	0.37	0.117	19.15	6.00
Mg Sat. %	0-2	4	11.59	2.42	0.269	20.88	2.32
	2-6	4	10.75	3.62	0.286	33.67	2.66
	4-6	4	8.93	4.40	0.465	49.27	5.21
	8-10	2	4.21	2.80	0.263	66.51	6.25
	12-14	2	3.48	2.56	0.211	73.56	6.06
	E	2	3.76	1.02	0.222	27.08	5.90
	Bs	2	1.11	0.05	0.043	4.46	3.87
Na Sat. %	0-2	4	1.41	0.29	0.046	20.28	3.26
	2-6	4	1.69	0.37	0.063	22.01	3.73
	4-6	4	1.68	0.40	0.087	23.81	5.18
	8-10	2	1.50	0.65	0.057	43.65	3.80
	12-14	2	1.78	0.68	0.106	38.37	5.96
	E	2	1.77	0.06	0.074	3.64	4.18
	Bs	2	0.82	0.02	0.058	2.93	7.06
K Sat. %	0-2	4	5.04	0.53	0.248	10.56	4.92
	2-6	4	3.45	0.78	0.134	22.49	3.88
	4-6	4	2.82	0.61	0.075	21.49	2.66
	8-10	2	2.20	0.03	0.131	1.35	5.95
	12-14	2	1.63	0.15	0.173	9.46	10.61
	E	2	2.85	0.69	0.120	24.17	4.21
	Bs	2	1.32	0.20	0.024	15.11	1.82

Table 4.1 (Continued)

Param.	Depth/Hor cm	n plots	Mean	s.d. Among	s.d. Within	s.d. Among %	s.d. Within %
Density g/l	0-2	4	213	66	15.9	31.04	7.47
	2-6	4	357	194	26.7	54.27	7.48
	4-6	4	467	266	35.5	56.93	7.60
	8-10	2	628	432	14.5	68.80	2.31
	12-14	2	669	419	11.1	62.57	1.66
	E	2	1042	21	15.1	1.97	1.45
	Bs	2	903	9	13.4	1.02	1.49

Table 4.2. Arithmetic means, geometric means and confidence intervals for Birkenes plot data. Confidence intervals based on lognormal distribution with variance pooled over depth.

Depth/Hor cm	n site	CEC mmol/kg	Ca	Mg	Na	K	Dens g/l
			-------Saturation % ---------				
Arithmetic Means							
0-2	4	311.3	30.34	11.59	1.41	5.04	213
2-6	4	273.0	23.21	10.75	1.69	3.45	357
4-6	3	229.9	17.85	8.93	1.68	2.82	467
8-10	2	140.7	7.51	4.21	1.5	2.20	628
12-14	2	118.9	7.17	3.48	1.78	1.63	669
E	2	33.6	7.86	3.76	1.77	2.85	1042
Bs	2	66.8	1.95	1.11	0.821	1.32	903
Geometric Means							
0-2	4	297.7	30.17	11.38	1.39	5.02	206
2-6	4	228.1	22.44	10.19	1.66	3.38	322
4-6	3	181.9	16.00	8.00	1.64	2.77	415
8-10	2	109.2	6.40	3.72	1.42	2.20	548
12-14	2	96.4	1.20	2.97	1.71	1.63	600
E	2	33.6	7.85	3.69	1.77	2.81	1042
Bs	2	66.8	1.93	1.11	0.82	1.31	902
Confidence Intervals (95%)							
0-2	4	140.4	18.14	6.85	1.04	4.14	123
		631.2	50.17	18.90	1.85	6.10	347
2-6	4	107.6	13.49	6.14	1.24	2.79	191
		484.2	37.33	16.93	2.21	4.11	541
4-6	3	85.8	13.92	4.82	1.23	2.28	247
		385.6	26.61	13.29	2.18	3.36	697
8-10	2	37.7	3.12	1.81	0.95	1.67	263
		316.1	13.14	7.63	2.14	2.89	1142
12-14	2	33.3	2.93	1.45	1.14	1.24	288
		279.2	12.34	6.10	2.57	2.14	1250
E	2	11.6	3.83	1.80	1.18	2.14	500
		97.4	16.14	7.56	2.66	3.70	2171
Bs	2	23.1	0.94	0.54	0.55	1.00	433
		193.4	3.97	2.28	1.23	1.73	1880

Table 4.3. Birkenes profile data. Combined to 5 horizons.

Plot	Hor	cm	cecl mmol/kg	Ca	Mg	Na	K	den g/l	C %
				-----Saturation % ------					
1	O	40-0	295.5	12.68	9.57	1.88	2.38	330	45.3
1	E	0-15	13.8	1.45	0.43	2.46	1.45	1191	1.9
1	Bh	15-28	18.2	2.53	0.66	2.31	0.77	1048	3.9
1	Bs	(Not present)							
1	C	28-48+	5.6	1.99	0.89	3.64	1.80	1568	0.7
2	O	6-0	281.9	6.90	3.51	0.80	3.81	279	38.4
2	E	0-5	69.4	4.27	2.31	1.01	2.05	916	6.9
2	Bh	5-55	52.9	4.27	1.59	1.15	1.32	1000	5.8
2	Bs	(Not present)							
2	C	55+	7.7	2.34	0.52	2.34	1.30	1552	0.6
3	O	4-0	272.2	29.94	12.80	1.41	6.12	234	40.0
3	E	0-3	31.2	6.22	3.78	1.96	4.90	950	4.0
3	Bh	3-7	64.6	1.73	1.83	0.80	2.09	964	4.5
3	Bs	7-37	28.6	1.75	1.33	2.10	2.24	1086	3.8
3	C	(Not present)							
4	O	14-0	437.0	25.87	10.56	1.87	2.74	221	48.3
4	E	0-7	29.6	4.59	1.62	1.66	2.43	1194	2.5
4	Bh	7-13	75.9	0.84	0.90	0.91	1.24	841	6.3
4	Bs	13-34	21.5	0.74	1.21	1.77	2.09	971	4.9
4	C	(Not present)							
	Horizon Means								
	O		321.6	18.85	9.11	1.49	3.76	266	43.0
	E		36.0	4.13	2.04	1.77	2.71	1063	3.8
	Bh		52.9	2.34	1.24	1.29	1.36	963	5.1
	Bs		25.1	1.25	1.27	1.93	2.17	1029	4.3
	C		6.6	2.16	0.70	2.99	1.55	1560	0.3

Table 4.4. Geometric means and confidence intervals for Birkenes profile data, using pooled variances.

Hor	n	cec1 mmol/kg	Ca	Mg	Na	K	den g/l
			-------Saturation %-----------				
Geometric means							
O	4	315.5	16.14	8.21	1.41	3.51	263
E	4	30.7	3.65	1.57	1.69	2.44	1055
Bh	4	46.6	1.99	1.15	1.18	1.27	960
Bs	2	24.8	1.14	1.27	1.93	2.16	1027
C	2	6.6	2.16	0.68	2.92	1.53	1560
Confidence Intervals (95%)							
O		181.3	8.05	4.08	0.92	2.23	227
		549.1	32.33	16.52	2.17	5.53	304
E		17.6	1.82	0.78	1.09	1.55	912
		53.4	7.31	3.16	2.60	3.84	1220
Bh		26.8	0.99	0.57	0.77	0.81	830
		81.1	3.99	2.31	1.82	2.01	1111
Bs		11.3	0.43	0.47	1.05	1.14	835
		54.3	3.04	3.41	3.55	4.11	1262
C		3.0	0.81	0.25	1.58	0.80	1269
		14.4	5.77	1.83	5.38	2.91	1917

Table 4.5. Arithmetic means and confidence intervals for Birkenes profile data using individual variances.

Hor	n	cecl mmol/kg	Ca	Mg	Na	K	den g/l
			---------Saturation %-----------				
Arithemtic means							
O	4	321.65	18.85	9.11	1.49	3.76	266
E	4	36.00	4.13	2.04	1.77	2.71	1063
Bh	4	52.90	2.34	1.24	1.29	1.36	963
Bs	2	25.05	1.25	1.27	1.93	2.17	1029
C	2	6.65	2.16	0.70	2.99	1.55	1560
Confidence Intervals (95%)							
O		198.3	1.59	2.79	0.68	1.08	187
		445.0	36.11	15.42	2.30	6.44	344
E		-1.6	0.98	-0.19	0.81	0.30	823
		73.6	7.28	4.26	2.73	5.12	1302
Bh		13.2	0.02	0.36	0.19	0.49	823
		92.6	4.66	2.12	2.40	2.23	1104
Bs		-20.1	-5.17	0.51	-0.16	1.21	298
		70.2	7.66	2.03	4.03	3.12	1759
C		-6.7	-0.06	-1.65	-5.27	-1.63	1458
		20.0	4.39	3.05	11.25	4.73	1662

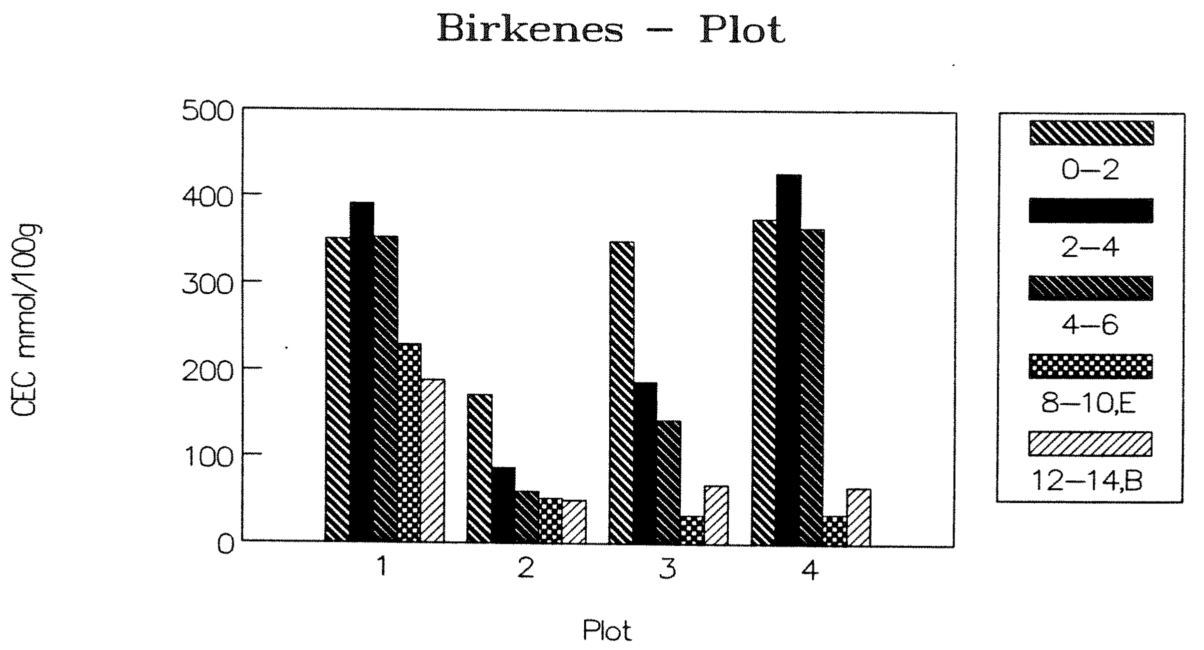

Figure 4.1. Cation exchange capacity (CEC1) by plot and depth.

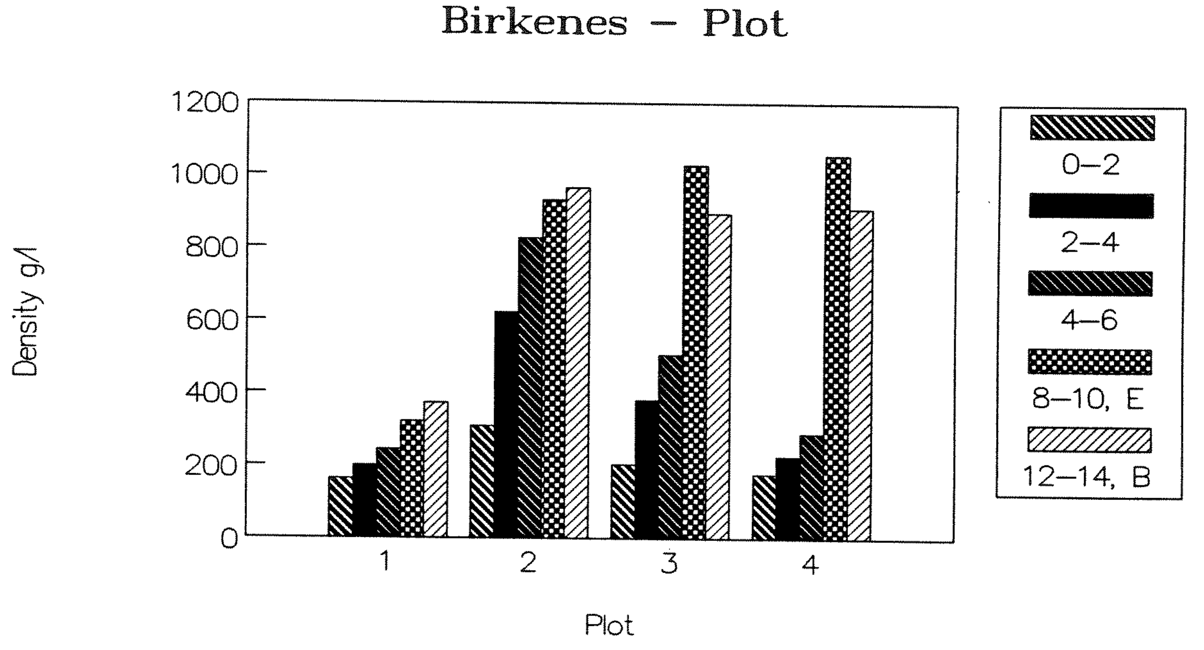

Figure 4.2. Density data by plot and depth.

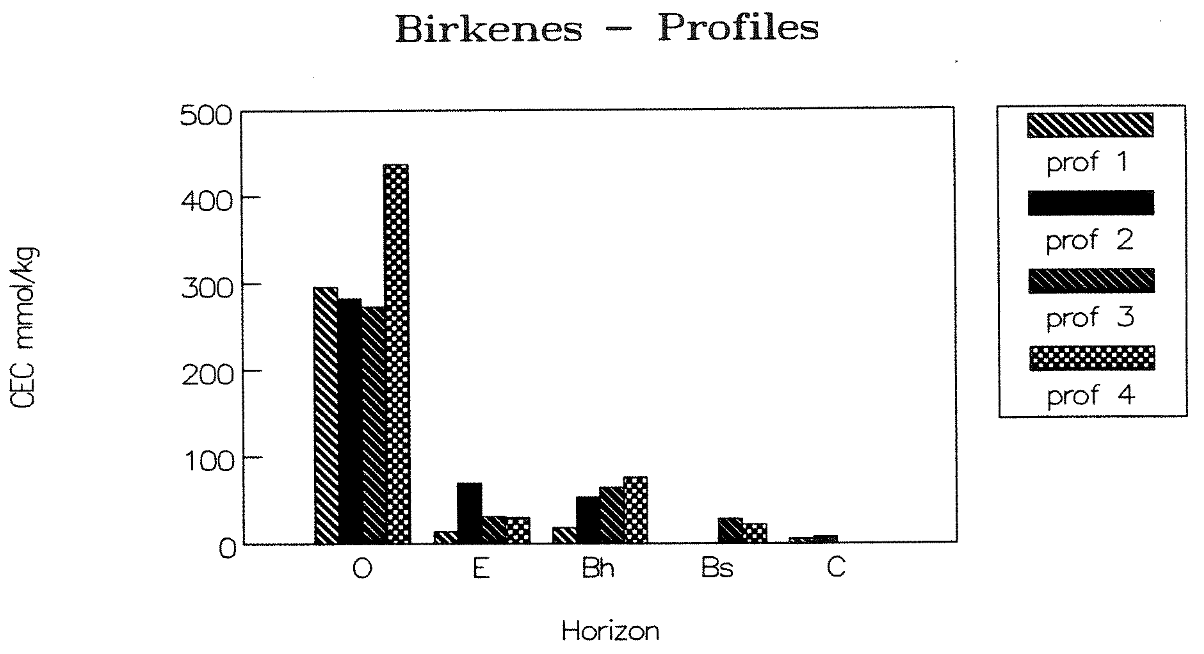

Figure 4.3. Cation exchange capacity by horizon and profile.

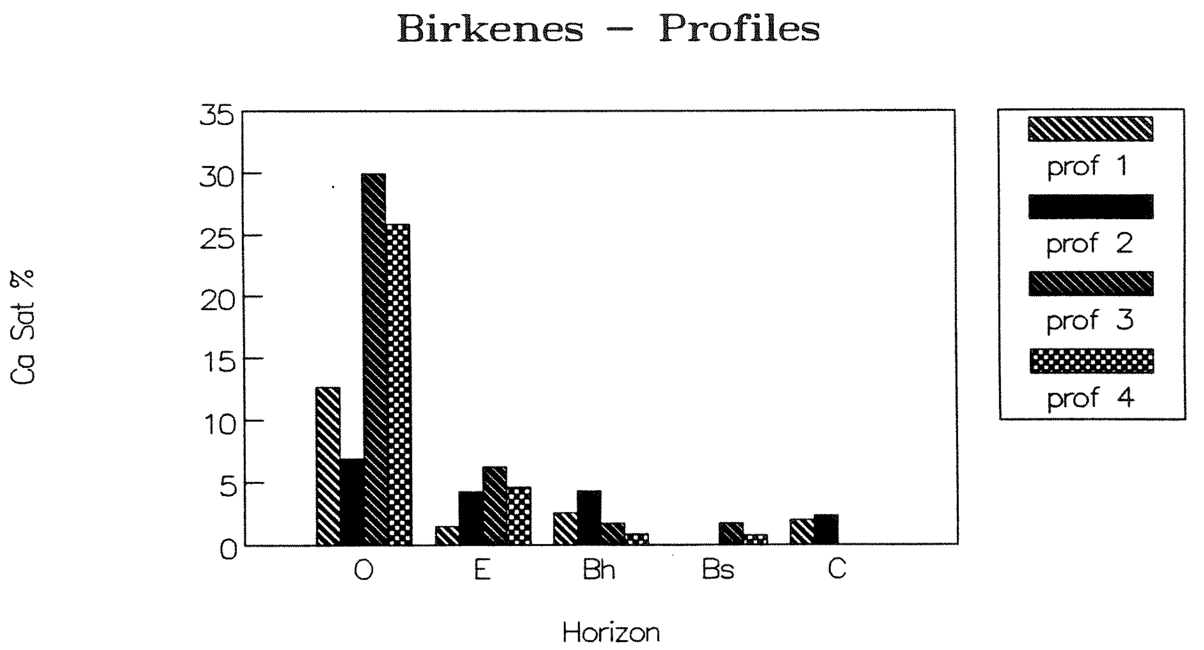

Figure 4.4. Calcium saturation data by horizon and profile.

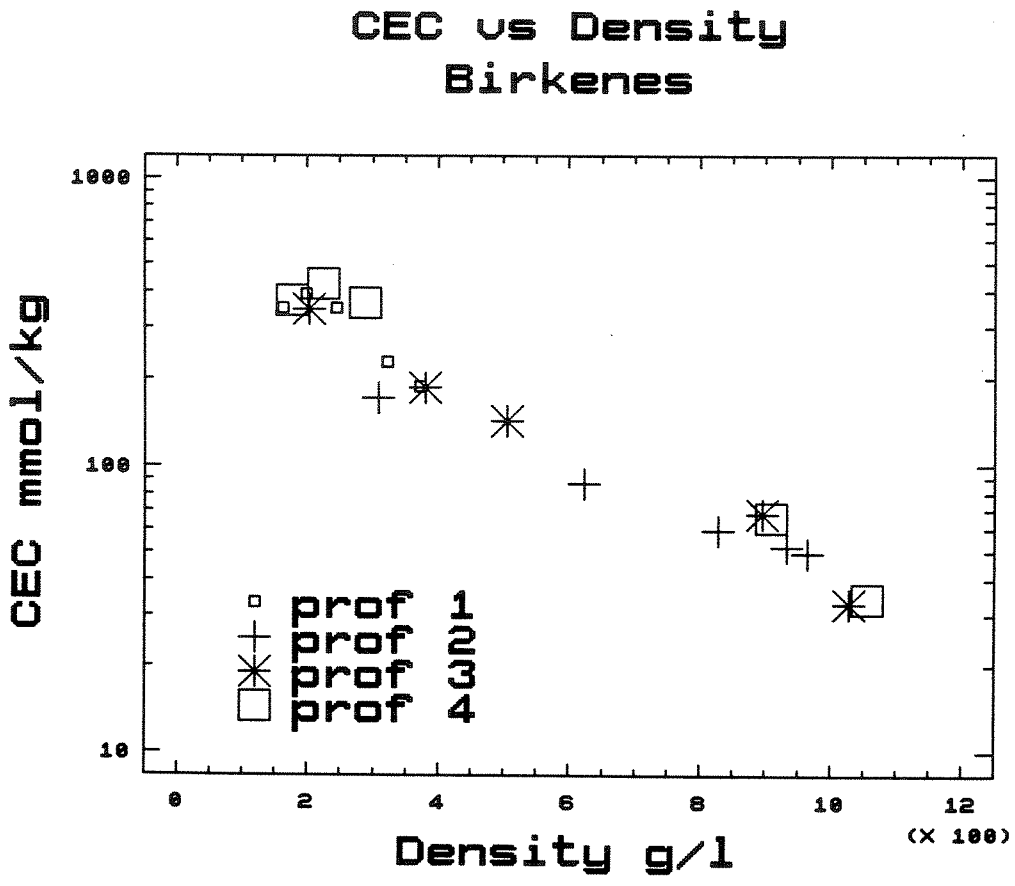

Figure 4.5. Plot of CEC vs Density on a log scale.

5. GAULARVASSDRAGET

5.1 PLOT DATA

This site presents problems similar to those found at several others, and there does not seem to be any really satisfactory solution. The most serious problem is that plot number 2 is very different from the other plots. This can be seen from the CEC data plotted in Figure 5.1. While the other three plots have a thick O horizon (sampled in several layers) over E and B horizons, plot 2 has a thin O over a thick C which was sampled in several layers. A somewhat more uniform set can be obtained by simply working with plots 1, 3, and 4. CEC data from the plot sampling from these three plots are shown in Figure 5.2 and Ca saturation data in Figure 5.3. In the O horizon, both CEC and Ca saturation are lower at each depth in plot 1 than the other plots, but this variation is not unreasonable considering what has been encountered at the other locations. Where more than one B horizon was sampled, the values shown are depth weighted means, and these values have been used in the subsequent analyses.

Using three plots, the arithmetic means, standard deviations among plots, and standard error within plots have been compiled in the same manner as was done for the other locations (Table 5.1) Again, the within plot variation is consistently very low, with within plot s.d. values generally less than 10% of the mean. The between plot variation is much higher, with 28 of the 36 values above 20% of the mean and a few above 40%. Calculation of confidence intervals for the arithmetic means is impractical because the variances cannot be combined and if internal variances are used the limited degrees of freedom result in values that are useless.

As was done at the other locations, an analysis was performed using log transformations and calculating confidence intervals for the geometric means (Table 5.2). Density is an exception, as pooling of variances using the untransformed data for this parameter is clearly more appropriate than for the transformation. Therefore the density values in Table 5.2 are arithmetic means and the confidence intervals are based on untransformed data. The confidence intervals in Table 5.2 may be marginally useful. However, we still have the problem that The C horizons are not represented and the plot 2 data were not used in the analyses.

5.2 PIT DATA

The profile data has the advantage that the C horizons were sampled at all locations. The disadvantage is that only one sample was taken from each profile, while in the plot data each plot is represented by four samples. This is not a serious limitation. As between plot variation tends to be much greater than within plot variation, within plot replication contributes little to the overall characterization of the catchment. The original values for key parameters are shown in Table 5.3. Data in Table 5.4 have been combined to main horizons using depth weighted means. Furthermore, the saturation values were calculated from the depth weighted means of the bases and the CEC rather than using means of the saturation values. Plots of CEC, Ca saturation, and density by horizon for each profile are shown in Figures 5.4, 5.5, and 5.6, respectively.

The high CEC values in the organic horizons and the low values in the E and C horizons are very apparent in Figure 5.4. Unfortunately, the Ca saturation is quite variable among plots. Analyses of variance were performed both on original data and log transforms. Means and confidence intervals are shown in Tables 5.5 and 5.6. For purposes of this analysis the H horizon of profile 1 was included in the O horizons. This may have been a mistake, in that it tends to increase the variability and widen the confidence intervals. However, it does avoid the problem of an "orphan" horizon. The orphan Ah horizon in profile 2 is only 2 cm thick and can probably be ignored.

Arithmetic means (Table 5.5) and geometric means (Table 5.6) are generally quite similar. Except in the case of density, the confidence intervals applied to the arithmetic means in Table 5.4 are inappropriate due to non-homogeneity of variance, and should not be used. The log transformed values in Table 5.6, are more appropriate. The density values are best derived from the untransformed data as shown in Table 5.5.

There seems to be some over-correction in the use of the log transform. From Table 5.5 it is apparent that the standard deviations are highly dependent on the mean. However, it also appears that the percentage of the mean is higher for the low values than the high values. As a result the variances for the log transforms will tend to be dominated by variation in the low values and the confidence intervals for the high values will be too wide. There doesn't seem to be a cure for this. Square root transforms (not shown) were tried but these seem to under correct. In spite of the limitations the log transforms seem to be the most appropriate.

5.3 RECOMMENDATIONS

Use Table 5.5 for density, Table 5.6 for other parameters.

Table 5.1. Standard errors within locations and standard deviations among locations. The % columns refer to percent of the mean. Gaularvassdraget plot data.

Param.	Horizon (Depth) cm	n plots	Mean	s.d. Among	s.e. Within	s.d. Among %	s.d. Within %
CEC mmol/kg	O(0-2)	3	365.6	73.39	4.21	20.07	1.15
	O(2-4)	3	350.6	111.39	7.11	31.77	2.03
	O(4-6)	3	309.7	110.25	10.51	35.60	3.39
	O(8-10)	3	280.5	86.31	14.10	30.77	5.03
	E	3	14.4	3.00	0.39	20.83	2.71
	B	3	52.1	14.73	2.11	28.26	4.05
Ca Sat. %	O(0-2)	3	37.04	8.28	0.686	22.36	1.85
	O(2-4)	3	31.83	7.08	0.486	22.23	1.53
	O(4-6)	3	28.41	8.20	0.423	28.87	1.49
	O(8-10)	3	24.26	9.87	0.322	40.68	1.33
	E	3	7.67	2.95	0.254	38.46	3.31
	B	3	3.71	1.15	0.216	30.95	5.82
Mg Sat. %	O(0-2)	3	17.80	1.79	0.540	10.08	3.03
	O(2-4)	3	19.90	1.21	0.516	6.08	2.59
	O(4-6)	3	20.58	1.02	0.281	4.95	1.37
	O(8-10)	3	18.71	4.56	0.534	24.38	2.85
	E	3	3.24	1.80	0.160	55.70	4.94
	B	3	1.25	0.46	0.105	36.58	8.40
Na Sat. %	O(0-2)	3	0.90	0.39	0.06	43.45	6.69
	O(2-4)	3	1.19	0.47	0.043	39.74	3.61
	O(4-6)	3	1.33	0.44	0.061	33.02	4.60
	O(8-10)	3	1.35	0.38	0.065	28.04	4.80
	E	3	1.60	0.54	0.249	33.84	15.59
	B	3	0.67	0.29	0.055	42.91	8.21
K Sat. %	O(0-2)	3	7.18	0.68	0.259	9.46	3.61
	O(2-4)	3	6.37	1.71	0.150	26.86	2.35
	O(4-6)	3	5.81	1.82	0.177	31.24	3.05
	O(8-10)	3	3.94	0.95	0.314	24.05	7.97
	E	3	4.42	1.56	0.152	35.27	3.44
	B	3	1.72	0.36	0.093	21.15	5.41
Density g/l	O(0-2)	3	187	35.80	6.7	19.11	3.57
	O(2-4)	3	252	56.90	4.2	22.55	1.66
	O(4-6)	3	318	65.32	10.6	20.56	3.35
	O(8-10)	3	343	48.60	18.2	14.16	5.30
	E	3	1094	31.49	9.0	2.88	0.82
	B	3	909	111.09	15.8	12.22	1.74

Table 5.2. Geometric means and confidence intervals for Gaularvasdraget plot data from plots 1, 3, and 4. Confidence intervals based on lognormal distribution using a pooled variance.

Horizon (depth) cm	n plots	CEC mmol/kg	Ca	Mg	Na	K	Dens* g/l
			--------Saturation %			--------	
Geometric Means							
O(0-2)	3	360.4	36.40	17.74	0.83	7.16	187
O(2-4)	3	339.6	31.26	19.79	1.12	6.21	252
O(4-6)	3	297.2	27.50	20.56	1.27	5.60	318
O(8-10)	3	270.3	22.65	18.29	1.31	3.87	343
E	3	14.2	7.27	2.86	1.53	4.22	1094
B	3	50.8	3.59	1.18	0.62	1.70	909
Confidence Intervals (95%)							
O(0-2)		251.2	23.67	11.58	0.48	5.08	107
		517.0	55.98	27.17	1.42	10.09	268
O(2-4)		236.7	20.33	12.98	0.65	4.41	271
		487.2	48.07	30.44	1.93	8.75	323
O(4-6)		207.2	17.89	13.42	0.74	3.98	238
		426.4	42.29	31.50	2.19	7.90	398
O(8-10)		188.4	14.73	11.94	0.76	2.75	263
		387.8	34.83	28.02	2.26	5.46	424
E		9.9	4.73	1.87	0.89	3.00	1013
		20.4	11.17	4.38	2.63	5.95	1174
B		35.4	2.34	0.77	0.36	1.20	829
		72.8	5.53	1.81	1.07	2.39	929

* Density values are arithmetic means, confidence intervals calculated using untransformed data.

Table 5.3. Profile Sampling at Gaularvassdraget.

Plot/ Hor	Depth cm	CEC mmol/kg	Ca	Mg	Na	K	Den g/l	C %
			----- % Saturation ------					
1 H	25-0	216.5	15.37	15.90	1.61	3.45	397	58.4
1 E	0-1.8	12.8	4.22	0.78	2.66	2.89	1035	1.7
1 Bh	1.8-8.8	43.5	2.07	0.23	0.71	0.99	1030	3.2
1 Bs	8.8-15.	37.8	2.65	0.32	1.01	1.16	942	3.4
1 BC	15.3-25	15.9	6.42	0.50	1.95	1.32	1166	0.9
1 2C	25.3-47	3.1	23.23	2.58	4.52	5.81	1393	0.1
2 O	2.3-0	371.7	42.49	21.72	0.85	8.11	154	44.3
2 Ah	0-2.3	107.1	20.15	13.31	0.85	4.31	658	7.2
2 Cw	2.3-22.	24.1	20.66	2.24	2.90	4.15	1092	0.7
2 2Cw	22.3-32	7.4	28.65	0.81	3.92	5.54	1642	0.1
2 3Cw	32-39	9.1	27.91	0.88	3.52	5.27	1423	0.1
2 4Cw	39-57	4.9	21.63	1.22	4.29	6.73	1622	0.1
2 5Cw	57-61	11.5	18.43	0.70	1.74	4.70	1440	0.4
2 6Cw	61-80	6.2	16.13	0.97	1.29	3.87	1624	0.2
3 Of	19-9	436.9	31.65	10.91	1.46	6.59	104	53.6
3 Oh	9-0	463.9	32.61	17.52	1.49	2.65	229	53.9
3 E	0-18	9.7	4.12	0.82	2.78	2.89	1251	0.5
3 Bs	18-42	10.0	4.00	1.00	1.70	3.00	1028	2.6
3 Bmsh	42-68	36.3	2.42	0.28	0.88	0.85	992	4.7
3 BC	68-78	8.2	4.88	0.98	1.83	1.10	1476	0.6
3 C	78+	5.5	11.27	1.09	3.27	3.27	1545	0.2
4 Of	6.5-2.5	409.3	43.67	12.57	0.73	5.99	185	52.9
4 Oh	2.5-0	249.4	21.64	13.14	1.22	4.19	396	44.2
4 E	0-7	10.0	7.60	1.60	2.40	3.50	1180	0.7
4 Bh	7-14	82.7	3.10	1.11	0.69	1.55	830	10.0
4 Bs	14-24	25.4	5.35	0.39	1.54	1.14	1070	3.6
4 BC	24-42	16.7	7.31	0.48	1.98	1.26	1197	1.0
4 C	42+	7.8	18.21	0.77	2.95	1.15	1637	0.2

Table 5.4. Depth weighted means for major horizons from profiles at Gaularvassdraget.

Plot/ Hor	Depth cm	CEC mmol/kg	Ca	Mg	Na	K	Den g/l	C %
			------	% Saturation	------			
1 H	25-0	216.5	15.37	15.90	1.61	3.45	397	58.4
1 E	0-2	12.8	4.22	0.78	2.66	2.89	1035	1.7
1 B	2-15	39.4	2.32	0.27	0.84	1.06	953	3.2
1 C	15-47	7.0	11.52	1.13	2.73	2.68	1310	0.3
2 O	2.3-0	371.7	42.49	21.72	0.85	8.11	154	44.3
2 Ah	0-2	107.1	20.15	13.31	0.85	4.31	658	7.2
2 Cw	2-80	10.4	21.61	1.72	3.02	4.66	1252	0.3
3 O	19-0	449.7	32.12	14.14	1.47	4.66	163	53.7
3 E	0-18	9.7	4.12	0.82	2.78	2.89	1251	0.5
3 B	18-68	23.7	2.74	0.42	1.05	1.29	1009	3.7
3 C	68-78+	22.3	2.88	0.40	1.06	0.90	1234	2.6
4 O	7-0	347.8	37.59	12.72	0.86	5.49	266	49.6
4 E	0-7	10.0	7.60	1.60	2.40	3.50	1180	0.7
4 B	7-24	49.0	3.78	0.89	0.95	1.42	971	6.2
4 C	24-42+	12.3	10.78	0.57	2.29	1.22	1417	0.6

Table 5.5. Arithmetic means and standard deviations for Gaularvassdraget profile data. Pooled variance used for confidence intervals. H horizon has been combined with O horizon.

Horizon	n	Mean	Std Dev	% of Mean	Confid. lower	Interval upper
CEC mmol/kg						
O	4	346.4	96.93	28.0	286.8	406.1
Ah	1	107.1			-12.2	226.4
E	3	10.8	1.71	15.8	-58.0	79.7
B	4	37.4	14.75	39.4	-31.5	106.2
C	4	13.0	6.58	50.6	-49.6	72.6
Ca Saturation %						
O	4	31.89	11.80	37.0	23.23	40.55
Ah	1	20.15			2.83	37.47
E	3	5.31	1.98	37.3	-4.68	15.31
B	4	2.95	0.87	29.4	-7.05	12.94
C	4	11.70	7.68	65.6	3.04	20.36
Mg Saturation %						
O	4	16.12	3.95	24.5	13.66	18.58
Ah	1	13.31			8.40	18.22
E	3	1.07	0.46	43.4	-1.77	3.90
B	4	0.53	0.37	71.0	-2.31	3.36
C	4	0.95	0.60	62.6	-1.50	3.41
Na Saturation %						
O	4	1.20	0.40	33.4	0.61	1.79
Ah	1	0.85			-0.33	2.03
E	3	2.61	0.19	7.4	1.93	3.30
B	4	0.95	0.12	12.8	0.26	1.63
C	4	2.27	0.86	38.0	1.68	2.87
K Saturation %						
O	4	5.43	1.97	36.4	3.82	7.31
Ah	1	4.31			1.09	7.53
E	3	3.09	0.35	11.4	1.24	4.95
B	4	1.26	0.21	16.7	-0.60	3.11
C	4	2.37	1.72	72.5	0.76	3.97
Density g/l						
O	4	245	113.36	46.3	142	348
Ah	1	658			453	863
E	3	1155	110.09	9.5	1037	1274
B	4	978	33.02	3.4	859	1096
C	4	1303	82.48	6.3	1201	1406

Table 5.6. Geometric means and confidence intervals for profile data from Gaularvassdraget. Confidence intervals calculated from a pooled variance using a log transform.

Horizon	n	Geometric Mean	Confid. Interval lower	upper
CEC mmol/kg				
O	4	335.0	223.8	501.2
Ah	1	107.1	47.8	239.9
E	3	10.7	6.7	17.1
B	4	35.8	22.5	57.0
C	4	11.9	7.9	17.8
Ca Saturation %				
O	4	29.80	15.96	55.64
Ah	1	20.15	5.78	70.25
E	3	5.09	2.48	10.47
B	4	2.89	1.40	5.93
C	4	9.38	5.02	17.51
Mg Saturation %				
O	4	15.79	9.03	27.59
Ah	1	13.31	4.36	40.64
E	3	1.01	0.53	1.92
B	4	0.47	0.24	0.89
C	4	0.82	0.47	1.43
Na Saturation %				
O	4	1.15	0.80	1.65
Ah	1	0.85	0.41	1.76
E	3	2.61	1.72	3.97
B	4	0.94	0.62	1.43
C	4	2.12	1.47	3.04
K Saturation %				
O	4	5.17	3.09	8.65
Ah	1	4.31	1.54	12.05
E	3	3.08	1.70	5.58
B	4	1.25	0.69	2.26
C	4	1.92	1.15	3.22
Density g/l				
O	4	227	172	300
Ah	1	658	376	1151
E	3	1152	834	1591
B	4	977	708	1350
C	4	1301	984	1721

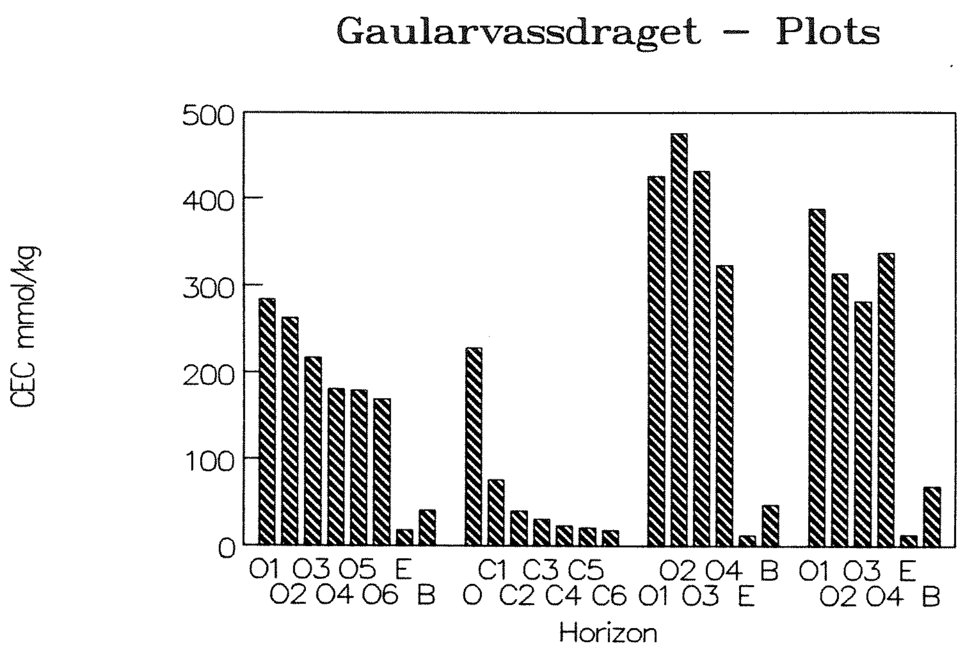

Figure 5.1. Mean CEC values from the plot sampling at Gaularvassdraget. Plots 1 to 4 from left to right.

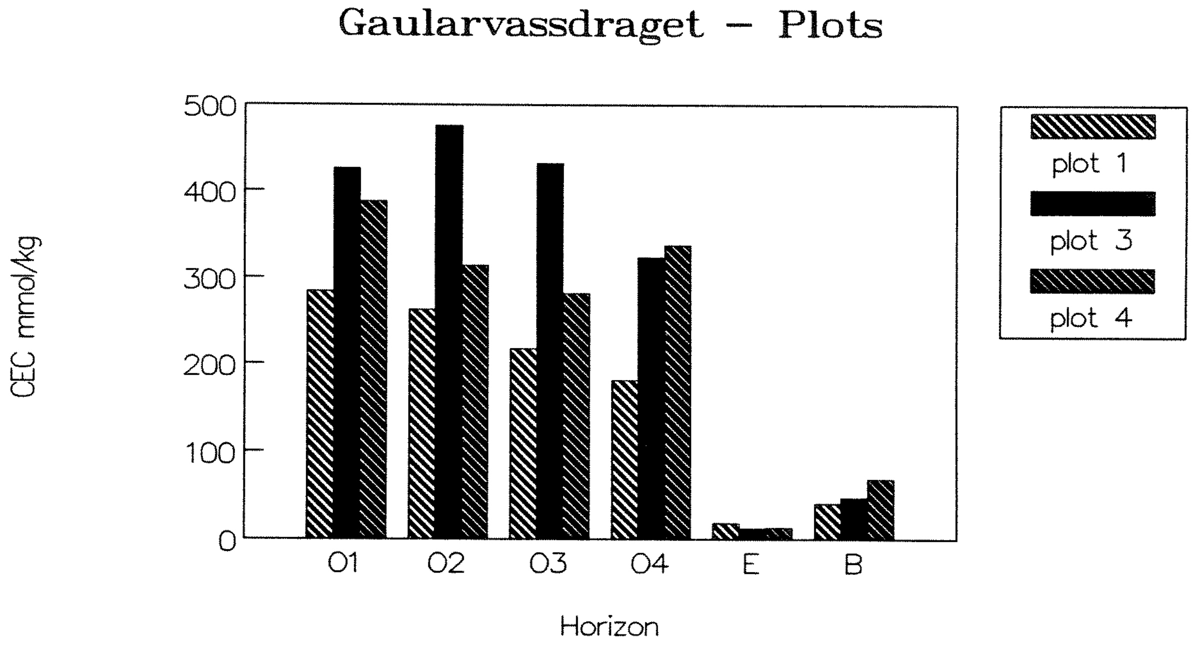

Figure 5.2. Mean CEC values by main horizon from three of the four plots at Gaularvassdraget.

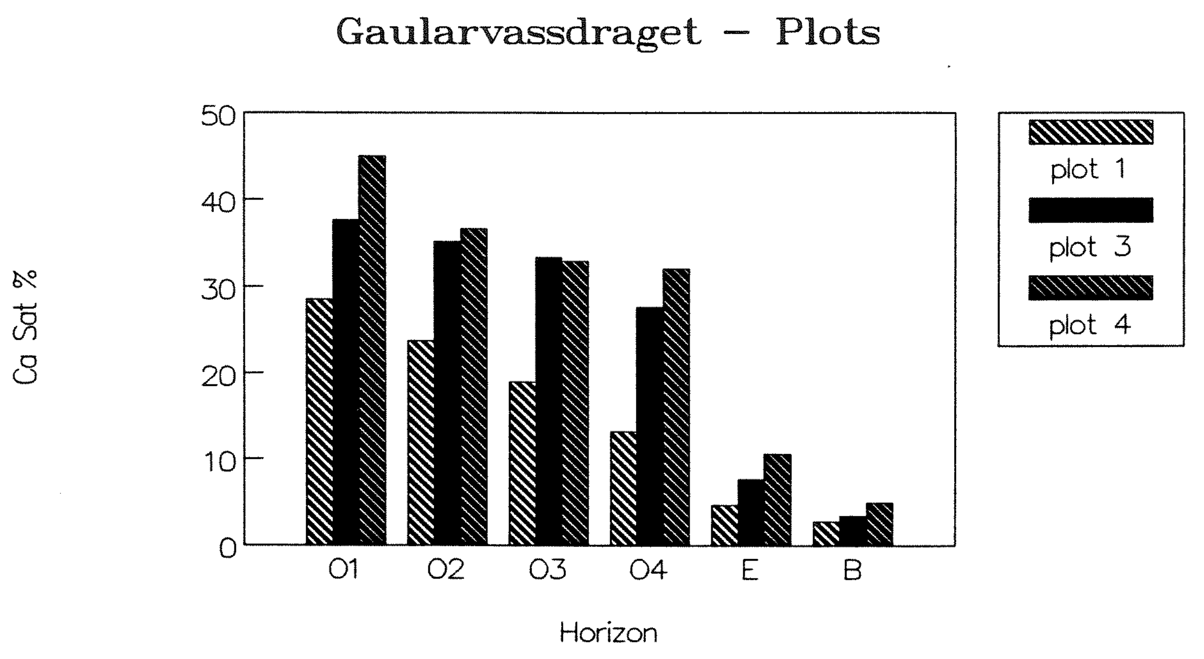

Figure 5.3. Mean Ca saturation percentages from three of the four plots at Gaularvassdraget.

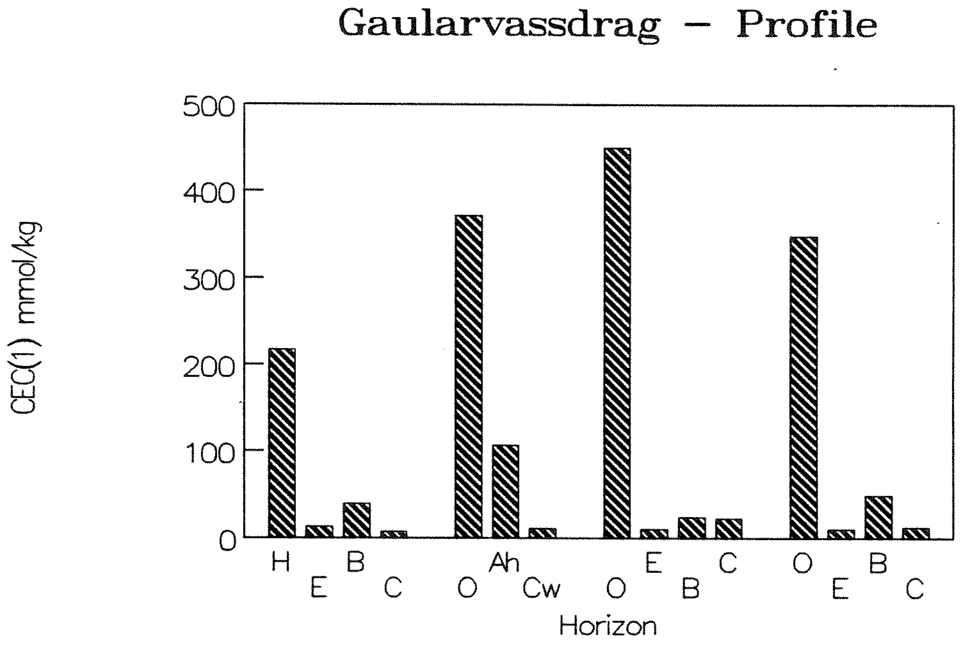

Figure 5.4. CEC by horizon from Gaularvassdraget profile sampling. Profiles 1 to 4 from left to right.

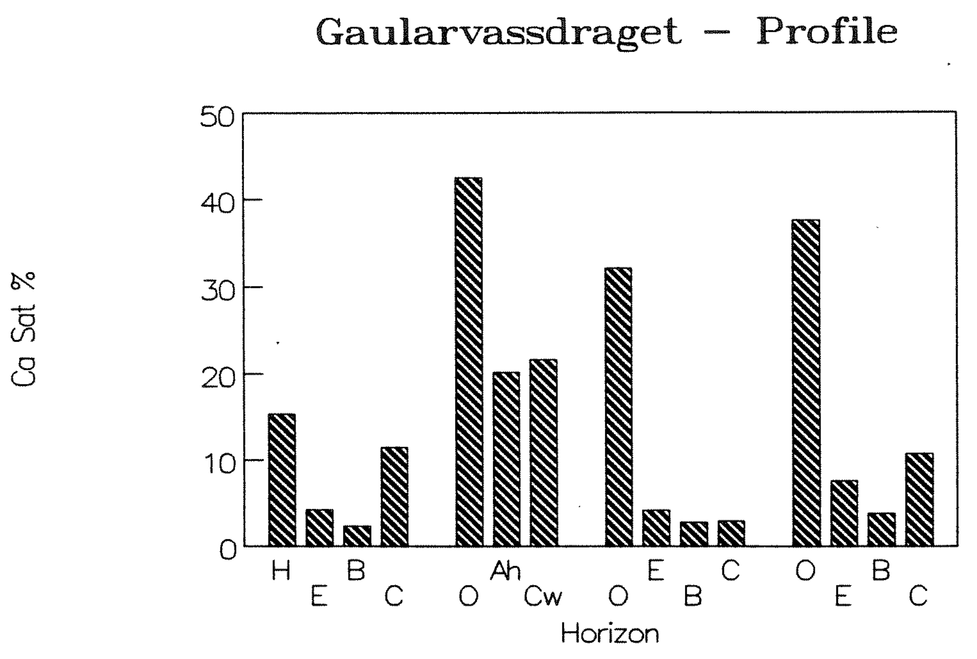

Figure 5.5. Ca saturation by horizon from Gaularvassdraget profile sampling. Profiles 1 to 4 from left to right.

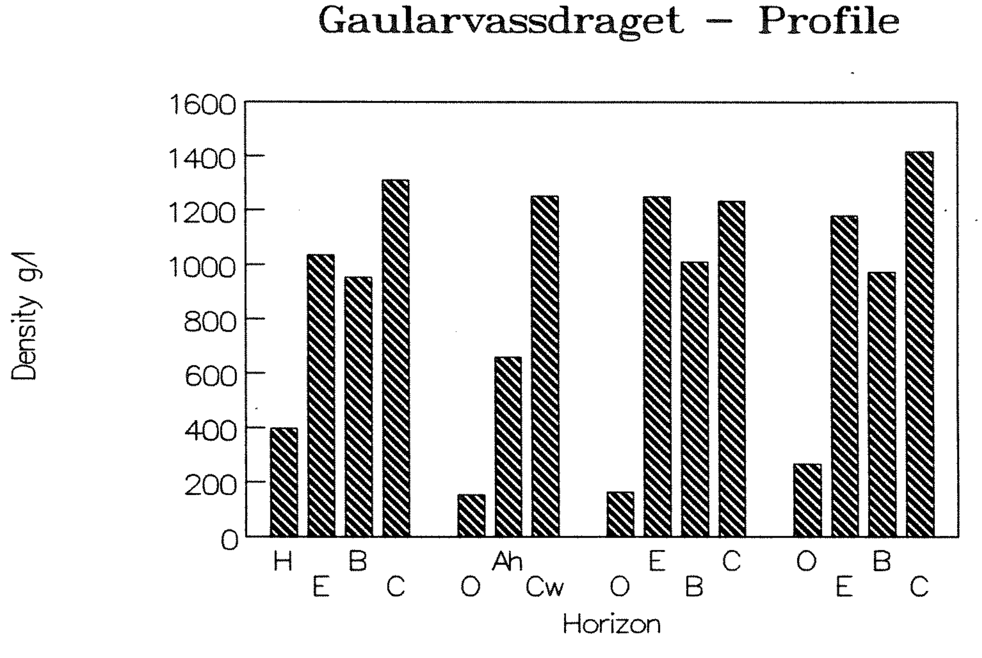

Figure 5.6. Density by horizon from Gaularvassdraget profile sampling. Profiles 1 to 4 from left to right.

6. VIKEDAL

6.1 PLOT DATA

Each of these sites presents its own set of problems. The plot data at the Vikedal site does not seem appropriate for an overall summary. The reasons for this conclusion can be seen from Table 6.1, which shows the plot means for two parameters, CEC and density. The E and B horizons are represented only in plots 1 and 3. Furthermore, the depth distributions are very different for the different plots. There does seem to be some commonality betwen plots 1 and 3 on the one hand and plots 2 and 4 on the other hand, but the two sets are quite different from one another. With only two plots in each group it is not possible to perform any meaningful statistical evaluation. As at the other sites, this data is quite good in the sense that different samples from the same plot and depth give similar values. However, it is not well suited to finding meaningful values for the various horizons. Therefore, the profile data were used for this purpose.

6.1 PIT DATA

The profiles were sampled in considerable detail, and as the horizon subdivisions were different at each location, it was necessary to aggregate by main horizons. This aggregation, shown in Table 6.2, was done by taking a depth weighted mean of the various sub-horizons at each sampling location. The B and C horizons are represented in all four profiles. The O and E horizons were not present in profile 4, where the surface horizon was designated as Ah. As this horizon seems chemically quite distinct form either the O or E horizon it was kept separate. This can be seen from Figure 6.1, which shows CEC by horizon for each of the four profiles. CEC, density, and Ca saturation are shown by horizon (O, E, B, and C), and profile in Figures 6.2, 6.3, and 6.4, respectively. The profile pattern is quite evident, even though the differences among plots are larger than we would like, particularly for Ca saturation. These differences are reflected in the width of the confidence intervals.

The arithmetic means and standard deviations, are shown in Table 6.3. The confidence intervals shown in Table 6.3 are calculated using a pooled variance, and are probably not the most appropriate, as the variances from the O horizons are generally substantially different than those from the deeper layers. As a result, the confidence intervals are unrealistically narrow for the large values, which are generally from the O horizons except in the case of density, and are too wide for the small values. This, is in turn reflected in the problem of negative values for many of the lower bounds.

Two methods were used to try to overcome these difficulties. The first was to use an internally derived variance for the O horizon, while pooling the remaining variances. These confidence intervals are shown in Table 6.4. While the problem of negative lower bounds is substantially reduced, it is still present. The second was to use a logarithmic transform and pool the variances. Geometric means and confidence intervals derived in this way are shown in Table 6.5. Neither method is entirely satisfactory, and in either case many of the confidence intervals are too wide to be useful. However, I would suggest that the geometric means and confidence intervals as shown in Table 6.5 be used.

Once Table 6.5 is selected, (or Table 6.4), one is still faced with the problem of representing the whole catchment with a single set of horizon depths. Furthermore, the question arises as to how much of the catchment is represented by profile 4, which has an Ah horizon rather than an O. If this is a major factor it should be reflected in the catchment values. This judgement should be made in consultation with someone who is familiar with the catchment.

RECOMMENDATION

Use Table 6.5.

Table 6.1. Vikedal plot data for CEC and density. Values are plot means.

Depth cm	Plot 1	Plot 2	Plot 3	Plot 4
	CEC mmol/kg			
0-2	294.3	71.7	336.6	93.7
2-4	280.2	48.1	413.5	52.9
4-6	316.9	35.0		39.8
6-8	297.4			
8-10	272.5	20.1		31.7
10-12	172.5			
12-14		14.5		26.1
16-20		14.6		21.9
E	22.0		35.7	
B(1-3)	59.8		55.5	
B(5-7)	53.5		37.6	
B(9-13)	40.3		16.6	
	Density g/l			
0-2	284	646	168	527
2-4	343	805	206	788
4-6	323	843		885
6-8	327			
8-10	340	937		1006
10-12	317			
12-14		1006		1049
16-20		1038		1086
E	1033		1026	
B(1-3)	1045		967	
B(5-7)	1052		925	
B(9-13)	1090		936	

Table 6.2. Vikedal profile data, combined to main horizons. Combination by depth weighted means.

Plot	Hor	Depth cm	CEC mmol/kg	Ca	Mg	Na	K	Den g/l
				-------Saturation %---------				
1	O	5.5-0	247.7	27.66	25.13	1.75	5.06	336
1	E	0-7	11.2	6.61	6.07	2.86	3.57	1053
1	B	7-33	48.1	1.68	1.02	0.80	0.87	998
1	C	33-55+	30.6	1.57	0.69	1.12	0.98	1145
2	O	4-0	267.2	27.97	17.84	1.64	3.42	264
2	E	0-5	36.2	6.96	6.85	1.27	3.54	929
2	B	5-80	9.1	7.17	3.17	2.37	2.96	1222
2	C	80+	6.1	5.57	2.30	3.28	2.46	1479
3	O	4-0	331.7	23.94	18.09	1.81	4.78	162
3	E	0-5	35.3	2.38	2.95	1.42	1.44	1100
3	B	5-27	24.4	1.72	1.89	2.87	3.03	890
3	C	27+	6.7	3.88	1.19	3.58	2.84	1224
4	Ah	0-7	57.6	10.59	11.11	1.68	5.66	753
4	B	7-41	17.7	1.83	1.58	1.68	1.63	1088
4	C	41-67+	3.9	3.90	0.48	3.12	1.81	1494

Table 6.3. Arithmetic means and standard deviations for Vikedal profile data. Pooled variance used for confidence intervals.

Horizon	n	Mean	Std Dev	% of Mean	Confid. Interval lower	upper
CEC mmol/kg						
O	3	282.2	43.96	15.6	251.8	312.6
Ah	1	57.6			4.9	110.3
E	3	27.6	14.19	51.4	-2.8	58.0
B	4	24.8	16.72	67.4	-1.5	51.1
C	4	11.8	12.58	106.6	-14.5	38.2
Ca Saturation %						
O	3	26.53	2.24	8.4	23.6	29.5
Ah	1	10.59			5.44	15.74
E	3	5.32	2.55	47.9	2.34	8.29
B	4	3.11	2.73	87.8	0.53	5.68
C	4	3.74	1.63	43.6	1.16	6.32
Mg Saturation %						
O	3	20.35	4.14	20.3	17.55	23.15
Ah	1	11.10			6.26	15.96
E	3	5.29	2.07	39.1	2.49	8.09
B	4	1.92	0.93	48.3	-0.50	4.34
C	4	1.17	0.80	68.7	-1.25	3.60
Na Saturation %						
O	3	1.73	0.08	4.8	0.60	2.87
Ah	1	1.68			-0.28	3.65
E	3	1.85	0.88	47.4	0.71	2.98
B	4	1.94	0.90	46.3	0.96	2.93
C	4	2.77	1.13	40.8	1.78	3.75
K Saturation %						
O	3	4.42	0.88	19.8	3.15	5.70
Ah	1	5.66			3.45	7.87
E	3	2.85	1.22	42.7	1.58	4.12
B	4	2.13	1.06	49.7	1.03	3.24
C	4	2.02	0.81	39.8	0.92	3.18
Density g/l						
O	3	254	87.43	34.4	79	429
Ah	1	753			449	1056
E	3	1027	88.40	8.6	852	1202
B	4	1049	140.70	13.4	897	1201
C	4	1335	177.60	13.3	1183	1487

Table 6.4. Internal variance for O horizon, pool remaining variances. Pooled variances used throughout for Na saturation, K saturation, and density.

Horizon	n	Mean	Std Dev	% of Mean	Confid. lower	Interval upper
CEC mmol/kg						
O	3	282.2	43.96	15.6	173.0	391.4
Ah	1	57.6			23.8	91.4
E	3	27.6	14.19	51.4	8.1	47.1
B	4	24.8	16.72	67.4	7.9	41.7
C	4	11.8	12.58	106.6	-5.1	28.7
Ca Saturation %						
O	3	26.53	2.24	8.4	20.96	32.10
Ah	1	10.59			5.22	15.96
E	3	5.32	2.55	47.9	2.22	8.42
B	4	3.11	2.73	87.8	0.42	5.79
C	4	3.74	1.63	43.6	1.05	6.42
Mg Saturation %						
O	3	20.35	4.14	20.3	10.07	30.63
Ah	1	11.10			8.16	14.06
E	3	5.29	2.07	39.1	3.58	6.99
B	4	1.92	0.93	48.3	0.45	3.40
C	4	1.17	0.80	68.7	-0.30	2.64
Na Saturation %						
O	3	1.73	0.08	4.8	0.60	2.87
Ah	1	1.68			-0.28	3.65
E	3	1.85	0.88	47.4	0.71	2.98
B	4	1.94	0.90	46.3	0.96	2.93
C	4	2.77	1.13	40.8	1.78	3.75
K Saturation %						
O	3	4.42	0.88	19.8	3.15	5.7
Ah	1	5.66			3.45	7.87
E	3	2.85	1.22	42.7	1.58	4.12
B	4	2.13	1.06	49.7	1.03	3.24
C	4	2.02	0.81	39.8	0.92	3.18
Density g/l						
O	3	254	87.43	34.4	79	429
Ah	1	753			449	1056
E	3	1027	88.40	8.6	852	1202
B	4	1049	140.70	13.4	897	1201
C	4	1335	177.60	13.3	1183	1487

Table 6.5. Vikedal profile data. Geometric means and confidence intervals using pooled variances.

Horizon	n	Geometric Mean	Confid. Interval lower	upper
CEC mmol/kg				
O	3	280.0	114.9	682.6
Ah	1	57.6	12.3	269.6
E	3	24.3	10.0	59.2
B	4	20.9	9.6	45.1
C	4	8.4	3.9	18.1
Ca Saturation %				
O	3	26.46	12.91	54.23
Ah	1	10.59	3.06	36.71
E	3	4.78	2.33	9.81
B	4	2.48	1.33	4.62
C	4	3.41	1.83	6.35
Mg Saturation %				
O	3	20.09	10.54	38.29
Ah	1	11.11	3.64	33.95
E	3	4.97	2.61	9.46
B	4	1.76	1.01	3.08
C	4	0.99	0.57	1.73
Na Saturation %				
O	3	1.73	0.94	3.20
Ah	1	1.68	0.58	4.87
E	3	1.73	0.93	3.19
B	4	1.75	1.03	2.98
C	4	2.52	1.48	4.28
K Saturation %				
O	3	4.36	2.36	8.07
Ah	1	5.66	1.95	16.43
E	3	2.63	1.42	4.87
B	4	1.90	1.12	3.24
C	4	1.88	1.10	3.21
Density g/l				
O	3	243	188	314
Ah	1	753	482	1176
E	3	1025	792	1325
B	4	1042	834	1303
C	4	1326	1061	1658

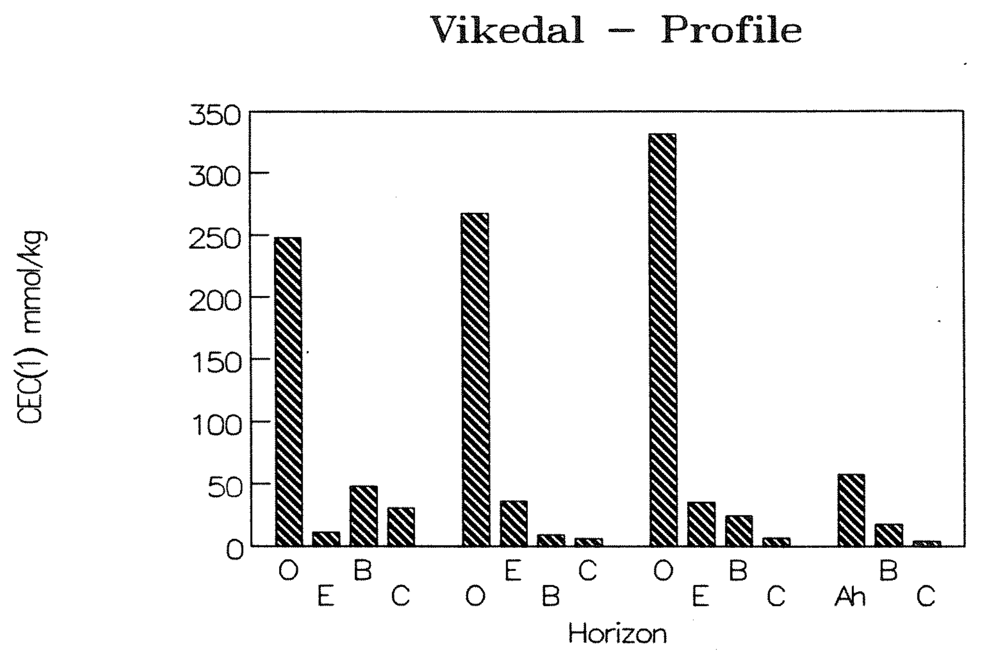

Figure 6.1. CEC by horizon for the four profiles.

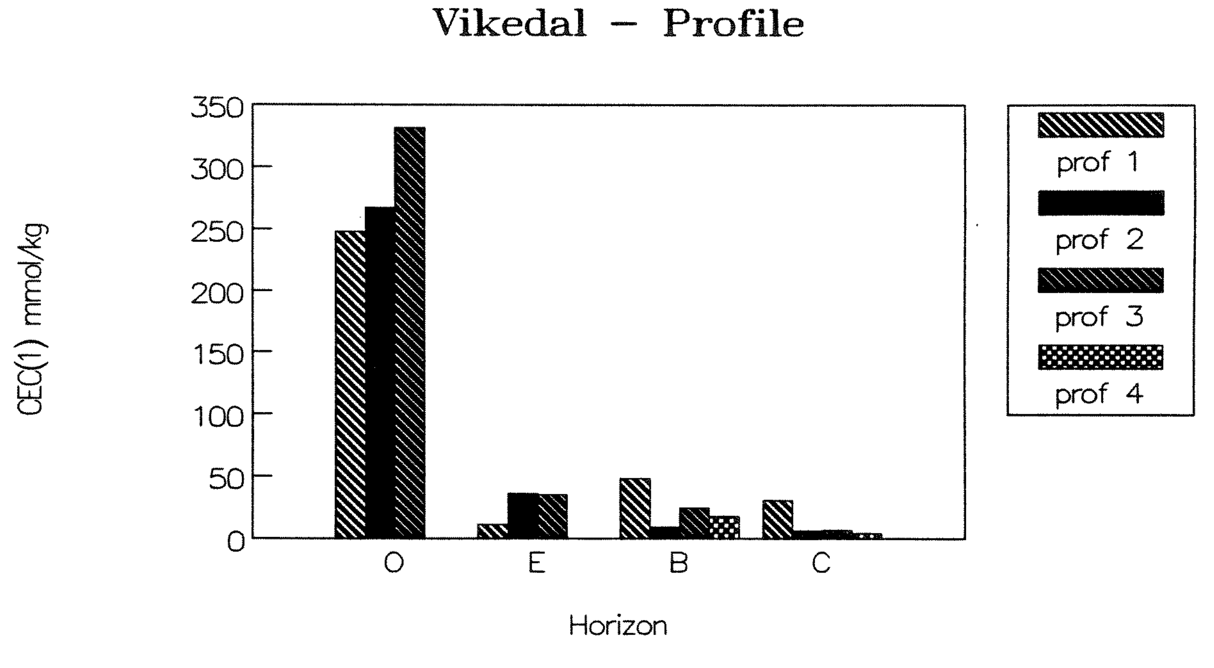

Figure 6.2. Mean CEC for the O, E, B and C main horizons.

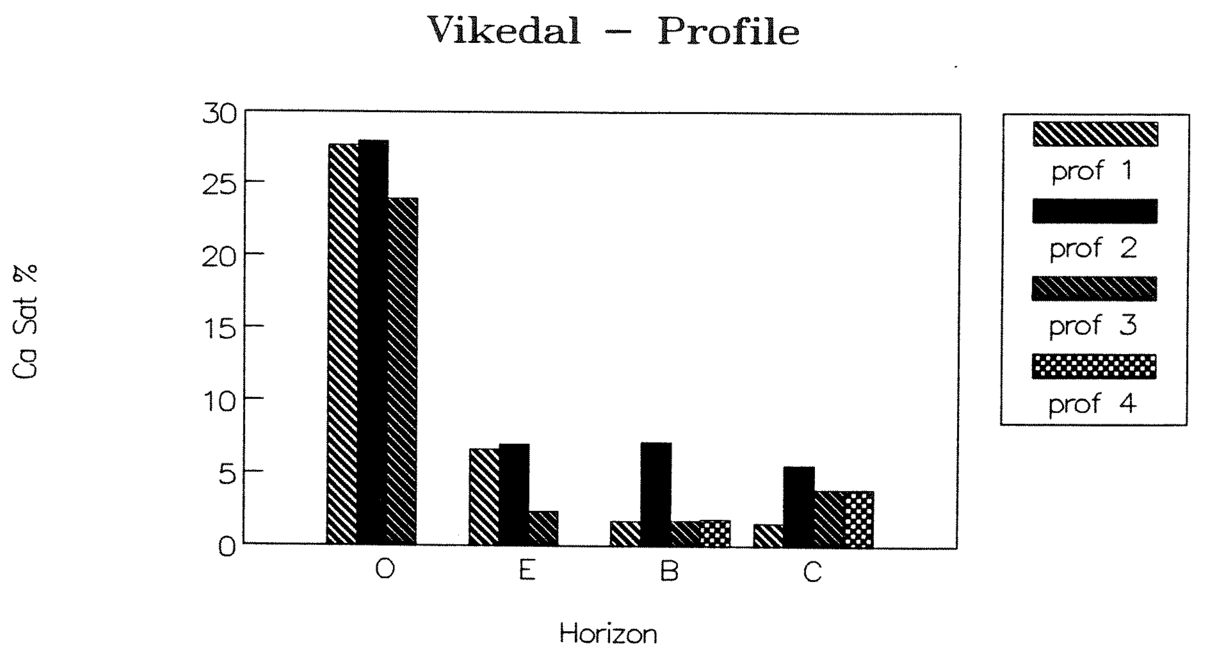

Figure 6.3. Mean Ca Saturation for the O, E, B and C main horizons.

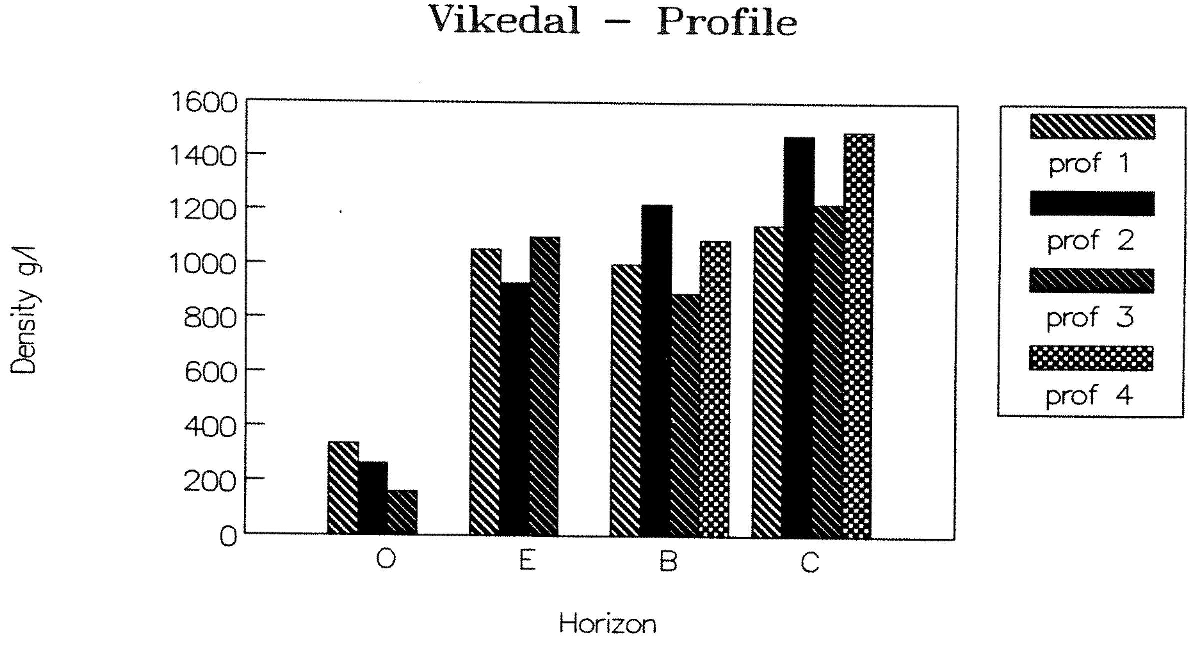

Figure 6.4. Mean density for the O, E, B and C main horizons.

7. NAUSTDAL

Parameter estimates for the Naustdal site may be obtained from either the plot data or the profile data. The advantages of the plot data are that quadruplicate samples were taken from each depth, and in many cases multiple depths were taken from the horizons. Unfortunately, the advantage of multiple samples is relatively small in terms of estimating an overall value for the catchment, as the within plot variability is generally much smaller than the between plot variability. The disadvantage of the plot data is that no samples were taken below the B horizon.

7.1 PLOT DATA

The means, within plot standard errors, and the standard deviation among plots for each depth are shown in Table 7.1. The data for Plot 1 also included O horizon values for 12-14 cm and 16-18 cm, but as these were present in only this one plot they not included in Table 7.1. As at the other sites, both of these values refer to the variation associated with the mean of a single plot so they are directly comparable. As was true at the other sites the within plot variation is generally much smaller than that between plots.

The next step was to combine the depth values into a single value for each horizon. Main horizons averaged over depths were calculated for each plot, and these in turn were averaged to obtain the horizon means shown in Table 7.2. CEC, Ca saturation percentage, and density, for these combined values are shown for each of the plots in Figures 7.1, 7.2, and 7.3, respectively. The standard deviation among plots, shown in Table 7.2 as both absolute values and as percent of the mean, are highly mean dependent, particularly for CEC, Ca saturation, and Mg saturation. As the confidence intervals depend on a pooled variance, these are also unreliable, particularly for the low values found in the E and B horizons. This is also apparent in the near zero and even negative values encountered for the lower bound.

Geometric means (Table 7.3) do not differ much from the arithmetic means. However, some of the confidence intervals are quite different. In general, for large values of each parameter, the confidence intervals on the geometric means (Table 7.3) are wider than those for the arithmetic means (Table 7.2). The log transformation estimates very wide confidence intervals for the CEC, Ca saturation, and Mg saturation in the O horizon. The log transformation confidence intervals tend to be reasonable for the E and B horizon estimates of these parameters, and should be OK for Na saturation and K saturation. The log transformation values (Table 7.3) probably should not be used for density.

7.2 PIT DATA

Prior to analysis the profile data were combined by main horizons using depth weighted means. In this aggregation the base saturation values for each profile were calculated after taking the depth weighted means of the CEC and the exchangeable bases. The CEC data prior to this aggregation are shown in Figure 7.4. As the CEC values for the IIC horizon are consistently lower than those for the C or BC horizons, the IIC horizon was kept separate. Data from the BC horizon were included in the C horizon means. Values after combination are shown in Figure 7.5. It is apparent that the O horizon values from profile 2 are much lower than those from the other plots. As this horizon was only 3 cm deep in profile 2, and in excess of 12 cm in the other profiles, the O horizon data from profile 2 were dropped from the analysis.

Arithmetic means, standard deviations and confidence intervals for the main horizons are shown in Table 7.4, while geometric means and confidence intervals are shown in Table 7.5. The situation is similar to that found for the plot data in that if the arithmetic means are used the confidence intervals are inappropriately wide for the low means, and if the geometric means are used the confidence intervals are probably unrealistically wide for the high values. In general the geometric means are probably more appropriate except for the O horizon values for CEC, Ca saturation and Mg Saturation. Also geometric means and confidence intervals are probably not appropriate for density.

The plot and profile data are compared in Table 7.6. Most are similar, but there are a couple of substantial discrepancies. The mean O horizon CEC from the plots (316 mmol/kg) from the plots is higher than that from the profile (431 mmol/kg). Also the E horizon Ca saturation from the plot data is 7.82%, while the plot value is 13.96%. There is no apparent explanation for these discrepancies. There is also a consistently higher Na saturation in the profiles as compared to the plots. This difference may be real, as changes in this mobile cation may well reflect the sporadic nature of sea salt inputs.

7.3 RECOMMENDATIONS

There is little basis from which to choose between plot and profile values. The author suggests use of the profile data on the basis of availability of the deeper samples. Choosing of confidence intervals is a problem. While it is usually not appropriate to "pick and choose", the author suggests we do so in this case as follows:

CEC, Ca Saturation, and Mg Saturation.
Use arithmetic means and associated confidence intervals (Table 7.4) for O horizons, geometric means (Table 7.5) for deeper layers.

Na Saturation, and K Saturation
Use geometric means and associated confidence intervals (Table 7.5).

Density
Use arithmetic means and associated confidence intervals.

Table 7.1. Standard errors within plots and standard deviations among plots. The % columns refer to percent of the mean. Naustdal plot data.

Param.	Hor/ Depth	n plots	Mean	s.d. Among	s.e. Within	s.d. Among	s.e. Within
	cm					%	%
CEC	O(0-2)	4	400.0	62.95	10.50	15.74	2.63
mmol/kg	O(2-4)	4	363.7	122.67	8.70	33.73	2.39
	O(4-6)	3	369.2	14.61	17.82	3.96	4.83
	O(8-10)	3	264.4	57.45	11.21	21.73	4.24
	E	4	33.9	8.61	3.26	25.40	9.61
	B(2-6)	4	82.1	23.76	4.83	28.94	5.89
	B(8-12)	2	58.5	26.87	2.179	45.93	3.72
Ca Sat.	O(0-2)	4	40.77	7.16	0.47	17.56	1.15
%	O(2-4)	4	34.21	5.12	0.92	14.96	2.69
	O(4-6)	3	27.96	3.91	0.66	13.97	2.37
	O(8-10)	3	21.44	1.30	0.73	6.05	3.43
	E	4	7.90	3.88	0.51	49.18	6.48
	B(2-6)	4	3.38	0.81	0.34	24.15	10.10
	B(8-12)	2	2.68	0.65	0.12	24.27	4.40
Mg Sat.	O(0-2)	4	20.68	2.28	0.413	11.02	2.00
%	O(2-4)	4	22.23	2.49	0.662	11.20	2.98
	O(4-6)	3	23.07	2.94	0.716	12.74	3.10
	O(8-10)	3	21.65	1.68	0.555	7.78	2.56
	E	4	7.15	2.83	0.448	39.52	6.27
	B(2-6)	4	2.65	0.62	0.308	23.56	11.64
	B(8-12)	2	2.29	0.66	0.088	29.03	3.84
Na Sat.	O(0-2)	4	1.13	0.18	0.055	15.53	4.85
%	O(2-4)	4	1.44	0.14	0.042	9.48	2.93
	O(4-6)	3	1.58	0.18	0.064	11.16	4.04
	O(8-10)	3	1.64	0.17	0.068	10.67	4.15
	E	4	1.34	0.31	0.153	23.13	11.42
	B(2-6)	4	0.63	0.14	0.047	22.75	7.42
	B(8-12)	2	0.89	0.47	0.057	52.44	6.40
K Sat.	O(0-2)	4	6.93	0.37	0.248	5.32	3.59
%	O(2-4)	4	6.11	1.02	0.284	16.76	4.64
	O(4-6)	3	5.22	0.35	0.182	6.77	3.48
	O(8-10)	3	5.25	0.81	0.373	15.34	7.12
	E	4	4.20	1.40	0.412	33.30	9.79
	B(2-6)	4	1.55	0.69	0.257	44.58	16.61
	B(8-12)	2	3.02	1.54	0.158	51.04	5.23

Table 7.1. (Continued)

Param.	Hor/ Depth cm	n plots	Mean	s.d. Among	s.e. Within	s.d. Among %	s.e. Within %
Density g/l	O(0-2)	4	189	63.15	10.6	33.38	5.59
	O(2-4)	4	252	116.57	10.2	46.35	4.06
	O(4-6)	3	238	58.45	8.6	24.59	3.62
	O(8-10)	3	320	91.00	14.5	28.44	4.53
	E	4	889	51.19	14.7	5.76	1.66
	B(2-6)	4	749	124.72	15.9	16.66	2.12
	B(8-12)	2	756	36.77	14.0	4.86	1.85

Table 7.2. Means and standard deviations among plots for Naustdal plot data combined by main horizons.

Param.	Hor	n plots	Mean	s.d. Among	s.d. Among %	Confid. Interval lower	upper
CEC mmol/kg	O	4	316.3	57.12	18.06	275.6	356.9
	E	4	33.9	8.61	25.40	-6.8	74.5
	B	4	75.2	23.02	30.63	34.5	115.8
Ca Sat. %	O	4	34.19	8.32	24.34	28.17	40.22
	E	4	7.82	3.92	50.19	1.79	13.84
	B	4	3.18	0.62	19.37	-2.84	9.20
Mg Sat. %	O	4	21.80	2.22	10.18	19.43	24.17
	E	4	7.07	2.84	40.12	4.70	9.43
	B	4	2.50	0.51	20.18	0.14	4.87
Na Sat. %	O	4	1.36	0.23	16.85	1.07	1.65
	E	4	1.32	0.32	24.19	1.03	1.61
	B	4	0.68	0.20	29.06	0.39	0.97
K Sat. %	O	4	5.98	0.77	12.95	4.74	7.21
	E	4	4.14	1.44	34.69	2.90	5.37
	B	4	1.74	0.96	54.94	0.51	2.97
Density g/l	O	4	262	68.43	26.17	164	359
	E	4	889	51.19	5.76	791	987
	B	4	750	122.97	16.41	652	847

Table 7.3. Geometric means and confidence intervals for Naustdal plot data combined to main horizons. Confidence intervals based on lognormal distribution using a pooled variance.

Horizon	n plots	CEC mmol/kg	Ca	Mg	Na	K	Dens g/l
			-------Saturation	%	---------		
Geometric Means							
O	4	312.2	33.43	21.72	1.35	5.94	255
E	4	33.0	7.19	6.67	1.29	3.96	888
B	4	72.5	3.14	2.47	0.66	1.55	441
Confidence Intervals (95%)							
O		232.2	23.27	16.19	1.03	3.84	206
		419.6	48.02	29.12	1.77	9.20	314
E		24.6	5.00	4.97	1.70	2.56	719
		44.4	10.33	8.94	1.70	6.14	1096
B		53.9	2.18	1.84	0.50	1.00	601
		97.4	4.51	3.31	0.87	2.40	916

Table 7.4. Arithmetic means and standard deviations for Naustdal profile data. Use pooled variance for confidence intervals. A thin (3 cm) O horizon from profile 2 has been dropped.

Horizon	n	Mean	Std Dev	% of Mean	Confid. lower	Interval upper
CEC mmol/kg						
O	3	430.8	34.29	8.0	398.9	462.7
E	4	30.5	9.85	32.3	2.9	58.1
B	4	72.8	36.17	49.7	45.2	100.5
C, BC	4	42.8	25.29	59.2	15.1	70.4
IIC	3	15.33	2.31	15.1	-16.6	47.2
Ca Saturation %						
O	3	36.19	7.48	20.7	31.20	41.20
E	4	13.96	4.87	34.9	9.64	18.28
B	4	6.08	1.92	31.6	1.76	10.40
C, BC	4	6.22	1.70	27.3	1.90	10.54
IIC	3	10.36	1.61	15.6	5.37	15.34
Mg Saturation %						
O	3	22.49	0.39	1.7	20.01	24.96
E	4	9.12	3.98	43.7	6.98	11.26
B	4	2.98	0.70	23.6	0.84	5.12
C, BC	4	2.00	0.47	23.6	-0.14	4.14
IIC	3	3.33	0.67	20.1	0.86	5.80
Na Saturation %						
O	3	3.83	1.57	41.1	2.13	5.16
E	4	7.01	1.31	18.7	5.55	8.47
B	4	3.63	1.66	45.8	2.19	5.11
C, BC	4	4.47	1.05	23.4	3.01	5.93
IIC	3	8.40	1.03	12.2	6.71	10.09
K Saturation %						
O	3	5.85	0.96	16.4	4.19	7.50
E	4	4.67	1.93	41.3	3.26	6.12
B	4	2.27	1.30	57.0	0.84	3.71
C, BC	4	2.29	1.00	43.6	0.86	3.73
IIC	3	3.31	0.96	29.0	1.66	4.97
Density g/l						
O	3	196	39.5	20.1	87	304
E	4	886	113.1	12.8	792	980
B	4	760	42.3	5.6	666	854
C, BC	4	1037	129.4	12.5	943	1130
IIC	3	1431	24.3	1.7	1322	1539

Table 7.5. Geometric means and confidence intervals for profile data from Naustal. Confidence intervals calculated from a pooled variance using a log transform.

Horizon	n	Geometric Mean	Confid. lower	Interval upper
CEC mmol/kg				
O	3	429.9	267.7	690.2
E	4	29.3	19.4	44.1
B	4	66.7	44.2	100.5
C, BC	4	38.3	25.4	57.7
IIC	3	15.2	9.5	24.4
Ca Saturation %				
O	3	35.63	25.35	50.10
E	4	13.38	9.97	17.98
B	4	5.88	4.38	7.90
C, BC	4	6.03	4.49	8.10
IIC	3	10.27	7.31	14.44
Mg Saturation %				
O	3	22.49	16.10	31.40
E	4	8.56	6.41	11.43
B	4	2.93	2.19	3.91
C, BC	4	1.95	1.46	2.60
IIC	3	3.28	2.35	4.58
Na Saturation %				
O	3	3.63	2.48	5.31
E	4	6.91	4.97	9.60
B	4	3.40	2.45	4.73
C, BC	4	4.37	3.14	6.07
IIC	3	8.36	5.72	12.23
K Saturation %				
O	3	5.79	3.36	9.98
E	4	4.34	2.71	6.96
B	4	1.99	1.25	3.20
C, BC	4	2.16	1.35	3.46
IIC	3	3.21	1.86	5.53
Density g/l				
O	3	193	166	225
E	4	881	771	1006
B	4	759	664	867
C, BC	4	1030	902	1177
IIC	3	1431	1227	1668

Table 7.6. Comparison of means from Naustdal plot and profile data. Combined by main horizon.

ARITHMETIC MEANS

Horizon	CEC plot mmol/kg	CEC profile mmol/kg	Ca Saturation plot %	Ca Saturation profile %	Mg Saturation plot %	Mg Saturation profile %
O	316.3	430.8	34.19	36.19	21.80	22.49
E	33.9	30.5	7.82	13.96	7.07	9.12
B	75.2	72.8	3.18	6.08	2.50	2.98
C, BC		42.8		6.22		2.00
IIC		15.3		10.36		3.33

Horizon	Na Saturation plot %	Na Saturation profile %	K Saturation plot %	K Saturation profile %	Density plot g/l	Density profile g/l
O	1.36	3.83	5.98	5.85	262	196
E	1.32	7.01	4.14	4.67	889	886
B	0.68	3.63	1.74	2.27	750	760
C, BC		4.47		2.29		1037
IIC		8.40		3.31		1431

GEOMETRIC MEANS

Horizon	CEC plot mmol/kg	CEC profile mmol/kg	Ca Saturation plot %	Ca Saturation profile %	Mg Saturation plot %	Mg Saturation profile %
O	312.2	429.9	33.43	35.63	21.72	22.49
E	33.0	29.3	7.19	13.38	6.67	8.56
B	72.5	66.7	3.14	5.88	2.47	2.93
C, BC		38.3		6.03		1.95
IIC		15.2		10.27		3.28

Horizon	Na Saturation plot %	Na Saturation profile %	K Saturation plot %	K Saturation profile %	Density plot g/l	Density profile g/l
O	1.35	3.63	5.94	5.79	255	193
E	1.29	6.91	3.96	4.34	888	881
B	0.66	3.40	1.55	1.99	441	759
C, BC		4.37		2.16		1030
IIC		8.36		3.21		1431

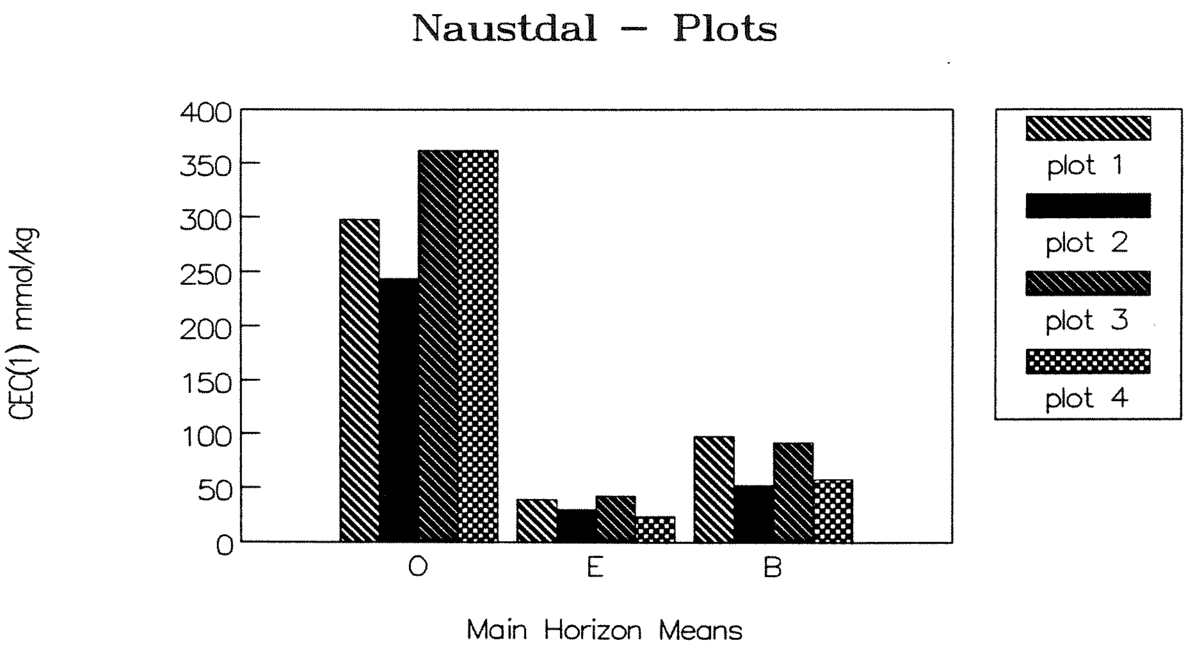

Figure 7.1. CEC by main horizon and plot. Naustdal plot data.

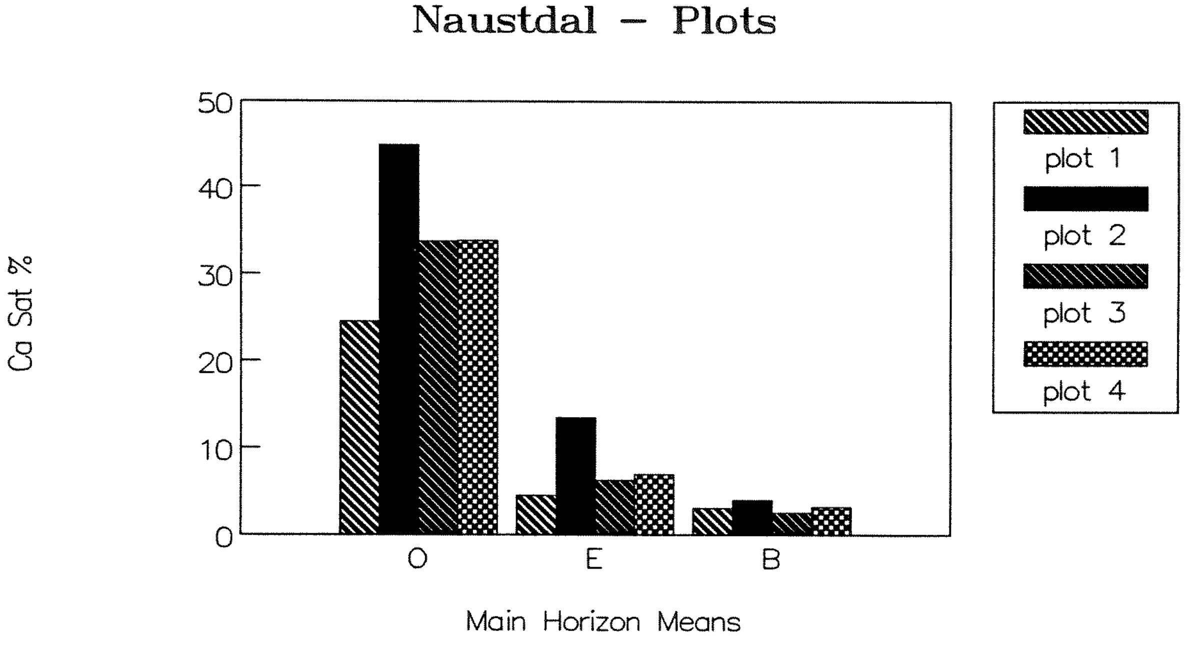

Figure 7.2. Ca saturation by main horizon and plot. Naustdal plot data.

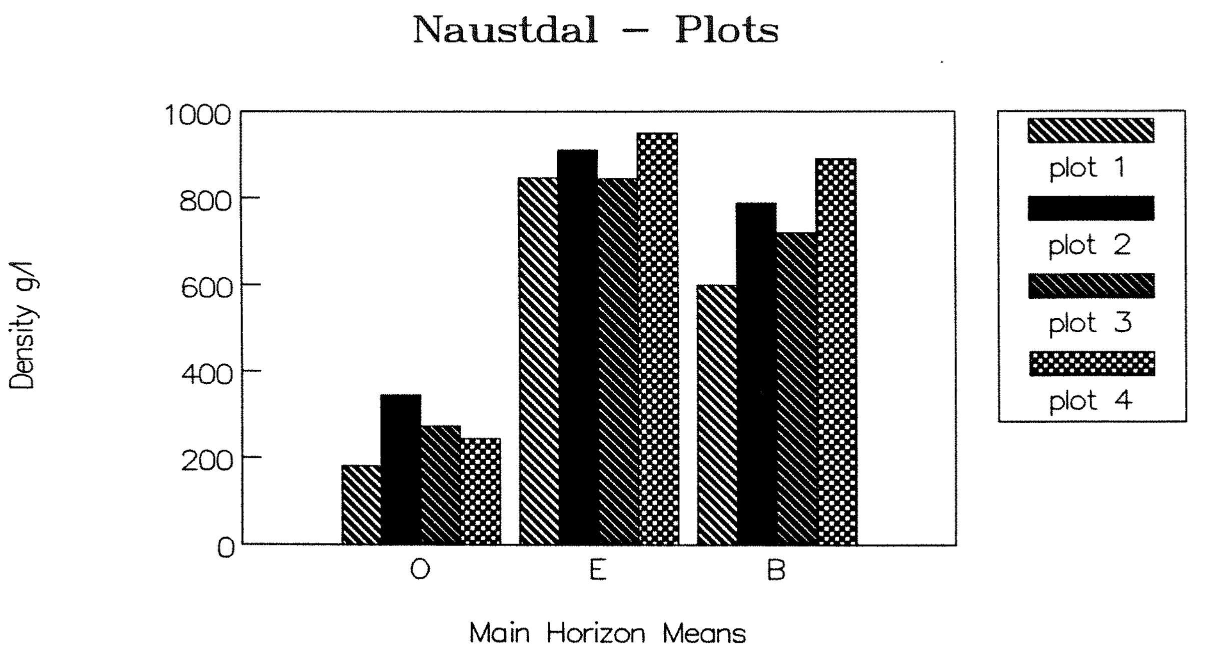

Figure 7.3. Density by main horizon and plot. Naustdal plot data.

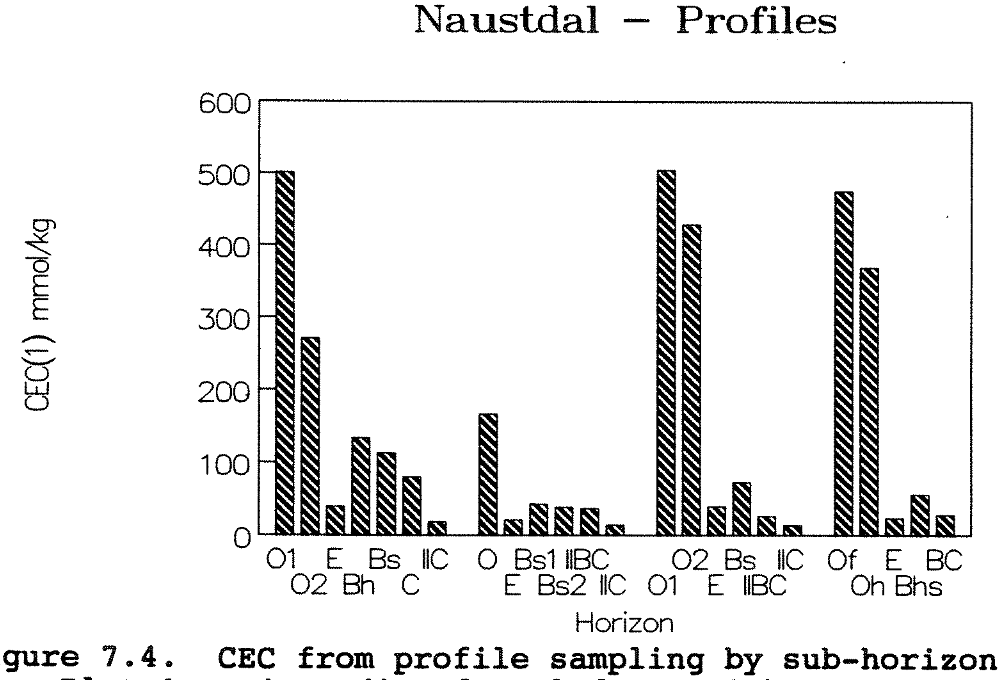

Figure 7.4. CEC from profile sampling by sub-horizon and plot. Plot 1 to 4 reading from left to right.

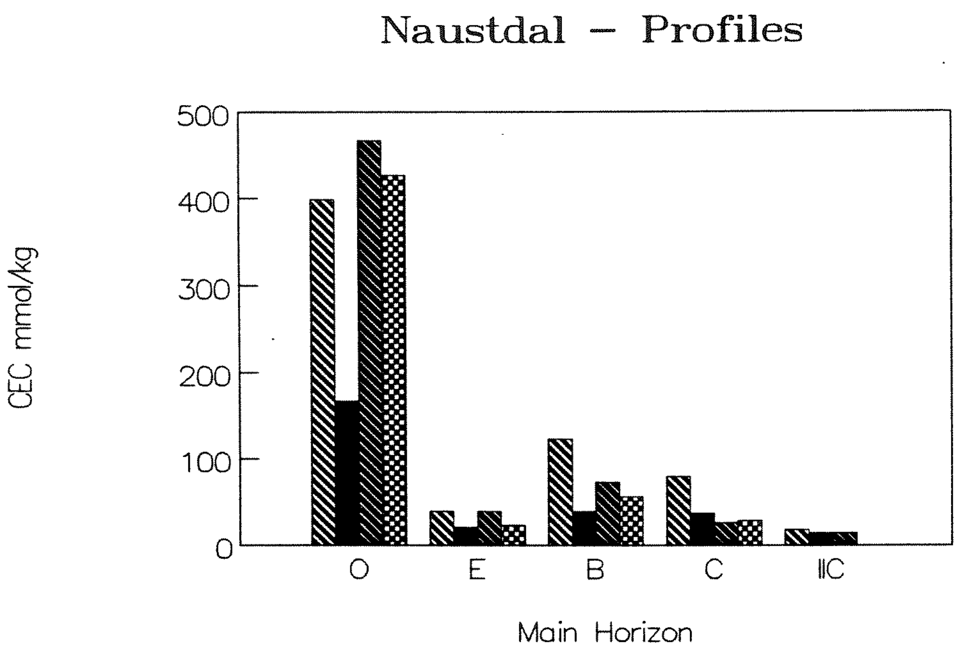

Figure 7.5. CEC from profile sampling by main horizon and plot.

8. DALEELVA

8.1 PLOT DATA

Parameter estimates can be obtained from the plot data for the O, E, and B horizons. Unfortunately, some of the estimates are not very good, and there are real problems with statistical analyses. Plot means by horizon and overall means by horizon are shown in Table 8.1. The problem is that the number of observations in each mean is highly variable. For example there are 16 measurements (4 depths and 4 replications) represented in the O horizon mean for plot 1. Conversely, several of the plot means are derived from a single observation, and in some cases a horizon was not represented. The data for CEC, Ca saturation, and density are shown graphically in Figures 8.1, 8.2, and 8.3, respectively. The high Ca saturation in the E horizon of plot 2 is derived from a single observation while the values for plots 1, 3, and 4 contain 9, 8, and 4 observations, respectively. One could weight the overall means by the number of observations (this was not done in Table 8.1), but this would create problems in statistical analyses.

For these reasons no statistical analyses have been undertaken for the plot data.

7.2 PROFILE DATA

First, main horizons were combined using depth weighted means as shown in Table 8.2. Less than half of the horizons were subdivided, so in most cases these are "means" of a single observation.

We are still plagued with some anomalous values that cause serious problems when we attempt to set confidence intervals. For example, the CEC for the B horizon in profile 2 is very high compared to the B horizon in the other profiles (Table 8.2 and Figure 8.4). This is likely real as it is reflected in a low density (Figure 8.5). In the original data set the CEC and Ca saturation for the IIC horizon of profile 2 was very high. This is contrary to what was observed at Naustdal where low values were found in the IIC horizon. As this horizon occurred in only one Daleelva profile it was dropped for purposes of this analysis, although its exclusion is admittedly somewhat arbitrary.

As at previous sites, attempts to set confidence intervals have been largely unsuccessful. The arithmetic means and standard deviations are shown in Table 8.3. There is some tendency for standard deviations to vary with the means, but it is by no means consistent. Confidence intervals for the arithmetic means have been calculated using both pooled and internal variances and these are also shown in Table 8.3. Many of the confidence intervals in the set calculated from the internal variances are reasonable. However, in several instances very large variances are encountered and the intervals are so wide as to be useless. If one uses a pooled variance, the large variances tend to dominate and all confidence intervals are wide. In both cases we are plagued by negative values for the lower bound.

The lack of a consistent tendency for standard deviations to vary with the means weakens the case for the use of geometric means and the associated confidence intervals as given in Table 8.4. Some of the standard deviations represent a very high percentage of the mean, and these are generally, but not always, associated with low values of the mean. The variances associated with these values tend to dominate the system when the log transformation is used, resulting in un-realistically wide confidence intervals for values with high means. One does, however, avoid the problem of negative lower bounds, and on an overall basis the geometric means and confidence intervals in Table 8.4 are probably the most appropriate. Again the exception is density, where perhaps the best values are those calculated from the internal variances as shown in Table 8.3.

A comparison of the plot and profile data is shown in Table 8.5. Most of the estimates are reasonably consistent, which perhaps gives us more confidence in the data than would be suggested by the rather unsatisfactory confidence intervals. The exception is the CEC and Ca saturation in the E horizon, both of which are considerably higher in the plot data (Table 8.1) than in the profile data. These high means in the plot data are the result of high CEC and Ca saturations in the E horizon of plot 2. This estimate is derived from a single observation, as apparently the E horizon was encountered at only one of the four sampling sites in this plot, and this was sufficiently thin so that only a single depth was sampled. Values from the other three plots are consistent with those found in the profiles.

7.3 RECOMMENDATIONS

If confidence intervals are absolutely necessary the geometric means as shown in Table 8.4 are probably the best. For density, use arithmetic means and internal confidence intervals from Table 8.3. It might be advisable to use ranges instead of confidence intervals. These are provided in Table 8.2 for the profile data.

Table 8.1. Daleelva plot data combined to main horizons.

plot	Horizon depth/cm		CEC(1) mmol/kg	Ca	Mg	Na	K	Den g/l
				------Saturation %-------				
1	O (8)	16	364.5	33.47	20.74	2.49	5.11	352
1	E (6)	9	23.2	15.82	10.58	6.39	2.70	1064
1	Bs(?)	1	35.9	10.36	4.85	3.59	1.67	1217
2	O (2)	4	434.1	49.87	17.17	1.44	9.01	315
2	E (?)	1	64.8	38.83	16.67	3.95	12.01	608
3	O (6)	12	309.2	37.36	19.45	2.23	5.70	363
3	E (4)	8	31.1	14.75	8.82	5.43	3.80	903
4	O (4)	8	402.6	45.12	23.25	2.16	5.29	311
4	E (?)	4	25.0	19.40	11.40	5.92	4.16	988
4	B (?)	1	57.7	12.86	6.93	2.72	1.58	967
OVERALL MEANS								
	O	40	377.6	41.45	20.15	2.08	6.28	335
	E	22	36.0	22.20	11.87	5.42	5.67	891
	B	2	46.8	11.61	5.89	3.16	1.62	1092

Table 8.2. Daleelva profile data aggregated to main horizons using depth weighted means.

prof	Hor	depth (cm)	CEC(1) mmol/	Ca	Mg	Na	K	Den g/l
				-------Saturation %---------				
1	O	10-0	395.3	29.52	20.35	2.17	6.04	351
1	E	0-18	20.3	11.53	8.87	3.30	3.79	1130
1	B	18-44	15.6	8.09	2.54	2.13	1.98	1415
1	C	44-51	9.7	8.91	2.18	2.90	2.18	1428
2	O	4-0	359.9	41.27	16.97	0.62	11.82	305
2	E	0-36	26.4	15.30	11.82	2.35	11.29	880
2	B	36-57	119.3	16.73	6.66	1.80	2.35	625
2	C	57-68	16.6	15.78	4.58	2.35	3.01	1340
3	O	6-0	405.6	46.41	22.32	1.15	6.44	311
3	E	0-8	20.9	12.06	9.00	1.96	3.68	1145
3	B	8-48	35.4	9.21	3.18	1.18	1.62	1170
3	C	48-60+	9.4	6.70	1.28	3.78	2.87	1431
4	O	7-0	406.5	42.61	21.10	1.34	5.66	280
4	E	0-6	22.6	9.12	6.11	2.74	3.05	1111
4	B	6-14	30	21.80	5.73	2.57	1.97	1043
4	C	14-24	5.3	11.70	2.64	10.75	1.70	1386
RANGE								
	O		359.9	29.52	16.97	0.62	5.66	280
			406.5	46.41	22.32	2.17	11.80	351
	E		20.3	9.12	6.11	1.96	3.05	880
			26.4	15.30	11.82	3.30	11.29	1143
	B		15.6	8.09	2.54	1.18	1.62	625
			119.3	21.80	6.66	2.57	2.35	1415
	C		5.3	6.70	1.28	2.35	1.70	1340
			16.6	15.78	4.58	10.75	3.01	1431

Table 8.3. Arithmetic means, standard deviations, and confidence intervals for Daleelva profile data. Confidence intervals for both pooled and internal variances are shown.

					Confidence Intervals			
			Std	% of	---pooled---		--internal--	
Hor.	n	Mean	Dev	Mean	lower	upper	lower	upper
CEC mmol/kg								
O	4	391.8	21.88	5.6	363.4	420.2	357.0	426.6
E	4	22.6	2.75	12.2	-5.8	5.1	18.2	26.9
B	4	50.1	46.90	93.7	21.7	78.4	-24.5	124.7
C	4	10.3	4.68	45.7	-18.1	38.6	2.8	17.7
Ca Saturation %								
O	4	39.95	7.29	18.2	34.06	45.85	28.35	51.55
E	4	12.00	2.54	21.2	6.11	17.89	7.95	16.05
B	4	13.96	6.48	46.5	8.06	19.85	3.64	24.27
C	4	10.78	3.91	36.3	4.88	16.66	4.55	17.01
Mg Saturation %								
O	4	20.18	2.29	11.4	17.97	22.40	16.54	23.83
E	4	8.95	2.33	26.1	6.73	11.17	5.24	12.66
B	4	4.53	1.98	43.7	2.31	6.74	1.38	7.68
C	4	2.67	1.39	52.2	0.45	4.89	0.45	4.89
Na Saturation %								
O	4	1.32	0.64	48.7	-0.89	3.53	0.30	2.34
E	4	2.59	0.57	22.1	0.38	4.79	1.68	3.50
B	4	1.92	0.59	30.5	-0.29	4.13	0.99	2.85
C	4	4.95	3.92	79.2	2.74	7.15	-1.29	11.18
Saturation %								
O	4	7.49	2.90	38.8	4.81	10.17	2.87	12.11
E	4	5.45	3.91	71.6	2.78	8.13	-0.76	11.67
B	4	1.98	0.30	15.1	-0.70	4.66	1.51	2.45
C	4	2.44	0.61	25.1	-0.24	5.12	1.47	3.41
Density g/l								
O	4	312	29.4	9.4	117	506	265	359
E	4	1067	125.1	11.7	872	1261	867	1266
B	4	1063	330.5	31.1	869	1258	538	1589
C	4	1396	42.8	3.1	1201	1591	1328	1464

Table 8.4. Geometric means and confidence intervals for profile data from Daleelva. Confidence intervals calculated from a pooled variance using a log transform.

Horizon	n	Geometric Mean	Confid. lower	Interval upper
CEC mmol/kg				
O	4	391.3	229.8	666.5
E	4	22.4	13.2	38.2
B	4	37.5	22.0	63.9
C	4	9.5	5.6	16.1
Ca Saturation %				
O	4	39.40	27.40	56.64
E	4	11.80	8.21	16.97
B	4	12.84	8.93	18.46
C	4	10.25	7.13	14.73
Mg Saturation %				
O	4	20.09	13.27	30.38
E	4	8.71	5.76	13.18
B	4	4.19	2.77	6.34
C	4	2.41	1.59	3.65
Na Saturation %				
O	4	1.20	0.72	2.00
E	4	2.54	1.52	4.24
B	4	1.85	1.11	3.08
C	4	4.08	2.45	6.81
K Saturation %				
O	4	7.14	4.75	10.15
E	4	4.68	3.11	7.04
B	4	1.96	1.30	2.95
C	4	2.38	1.58	3.58
Density g/l				
O	4	311	252	383
E	4	1061	860	1307
B	4	1019	827	1256
C	4	1396	1132	1721

Table 8.5. Comparison of means from Daleelva plot and profile data. Combined by main horizon.

ARITHMETIC MEANS

Horizon	CEC plot mmol/kg	CEC profile mmol/kg	Ca Saturation plot %	Ca Saturation profile %	Mg Saturation plot %	Mg Saturation profile %
O	377.6	391.8	41.45	39.95	20.15	20.18
E	36.0	22.6	22.20	12.00	11.87	8.95
B	46.8	50.1	11.61	13.96	5.89	4.53
C		10.3		10.78		2.67

Horizon	Na Saturation plot mmol/kg	Na Saturation profile mmol/kg	K Saturation plot %	K Saturation profile %	Density plot %	Density profile %
O	2.08	1.32	6.28	7.49	335	312
E	5.42	2.59	5.67	5.45	891	1067
B	3.16	1.92	1.62	1.98	1092	1063
C		4.95		2.44		1396

GEOMETRIC MEANS (profile only)

Horizon	CEC plot mmol/kg	CEC profile mmol/kg	Ca Saturation plot %	Ca Saturation profile %	Mg Saturation plot %	Mg Saturation profile %
O		391.3		39.40		20.09
E		22.4		11.80		8.71
B		37.5		12.84		4.19
C		9.5		10.25		2.41

Horizon	Na Saturation plot mmol/kg	Na Saturation profile mmol/kg	K Saturation plot %	K Saturation profile %	Density plot %	Density profile %
O		1.20		7.14		311
E		2.54		4.68		1061
B		1.85		1.96		1019
C		4.08		2.38		1396

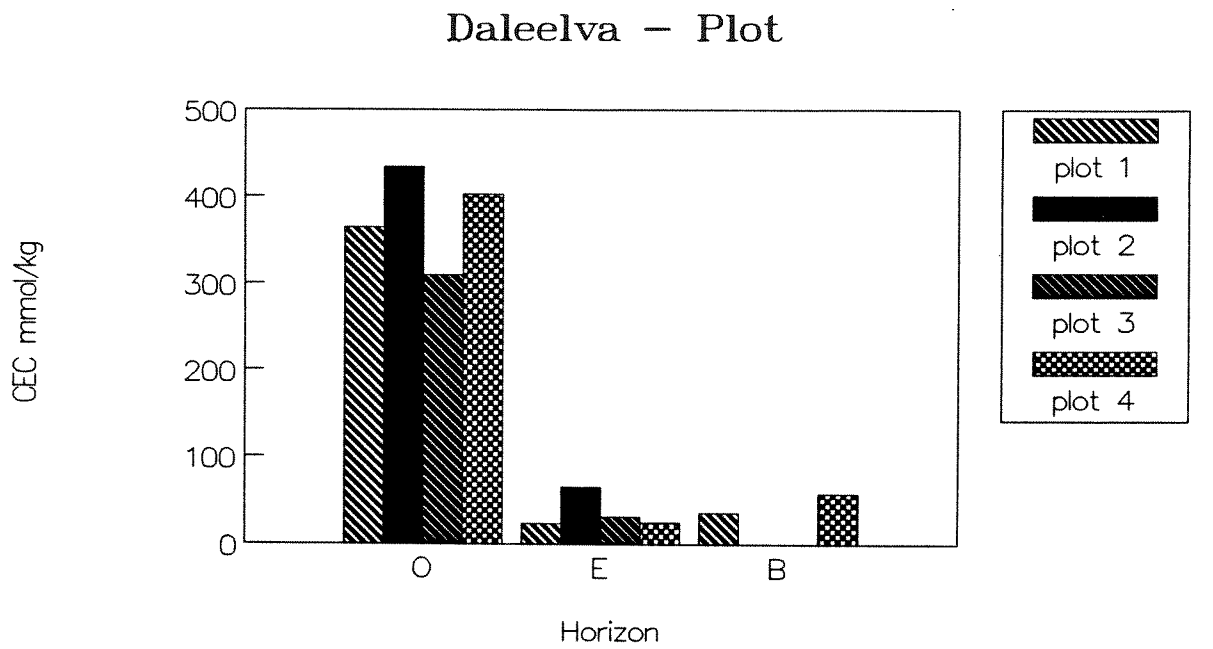

Figure 8.1. CEC by horizon from Daleelva plot data. Values are plot means.

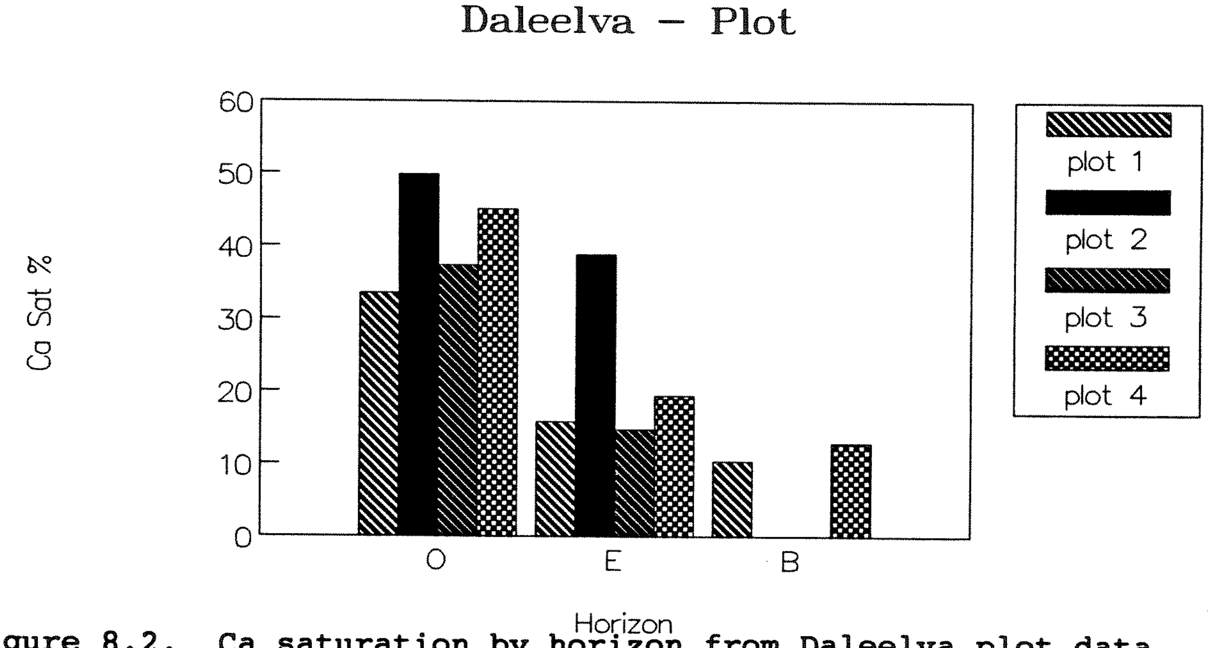

Figure 8.2. Ca saturation by horizon from Daleelva plot data. Values are plot means.

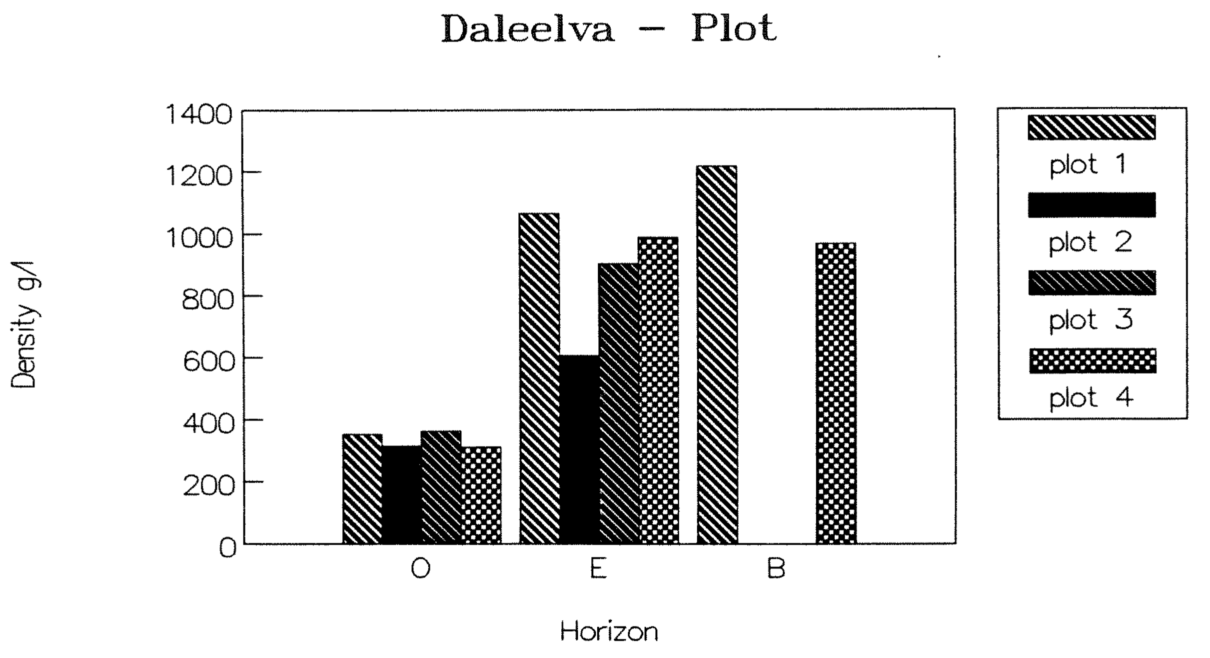

Figure 8.3. Density by horizon from Daleelva plot data. Values are plot means.

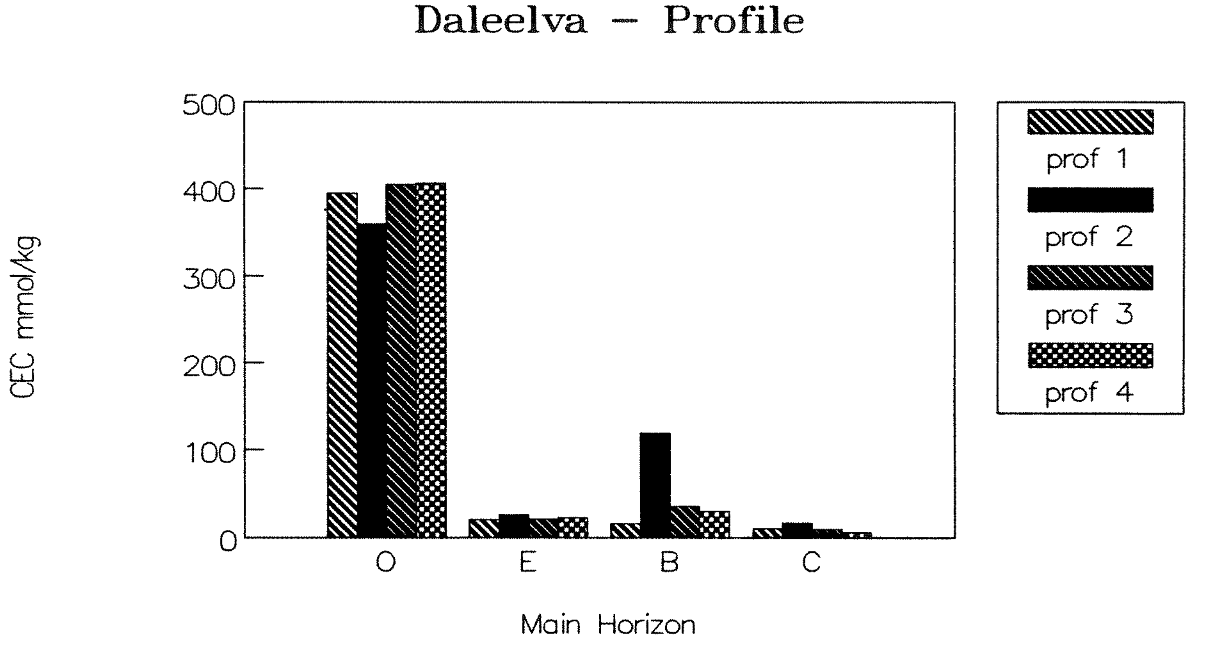

Figure 8.4. CEC by main horizon from Daleelva profiles.

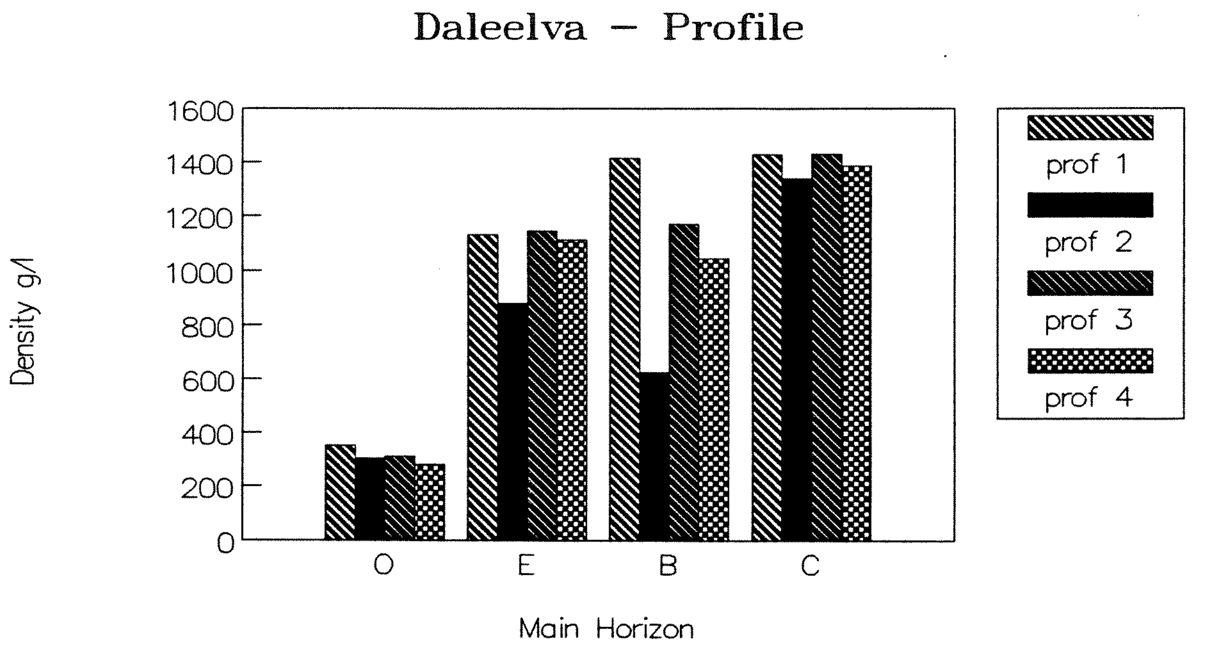

Figure 8.5. Density by main horizon from Daleelva profiles.

Norsk institutt for vannforskning NIVA

Postboks 69, Korsvoll
0808 Oslo 8

ISBN 82-577-1797-5