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Radioecological investigations in the Faroe Islands 1990-1995
A data report

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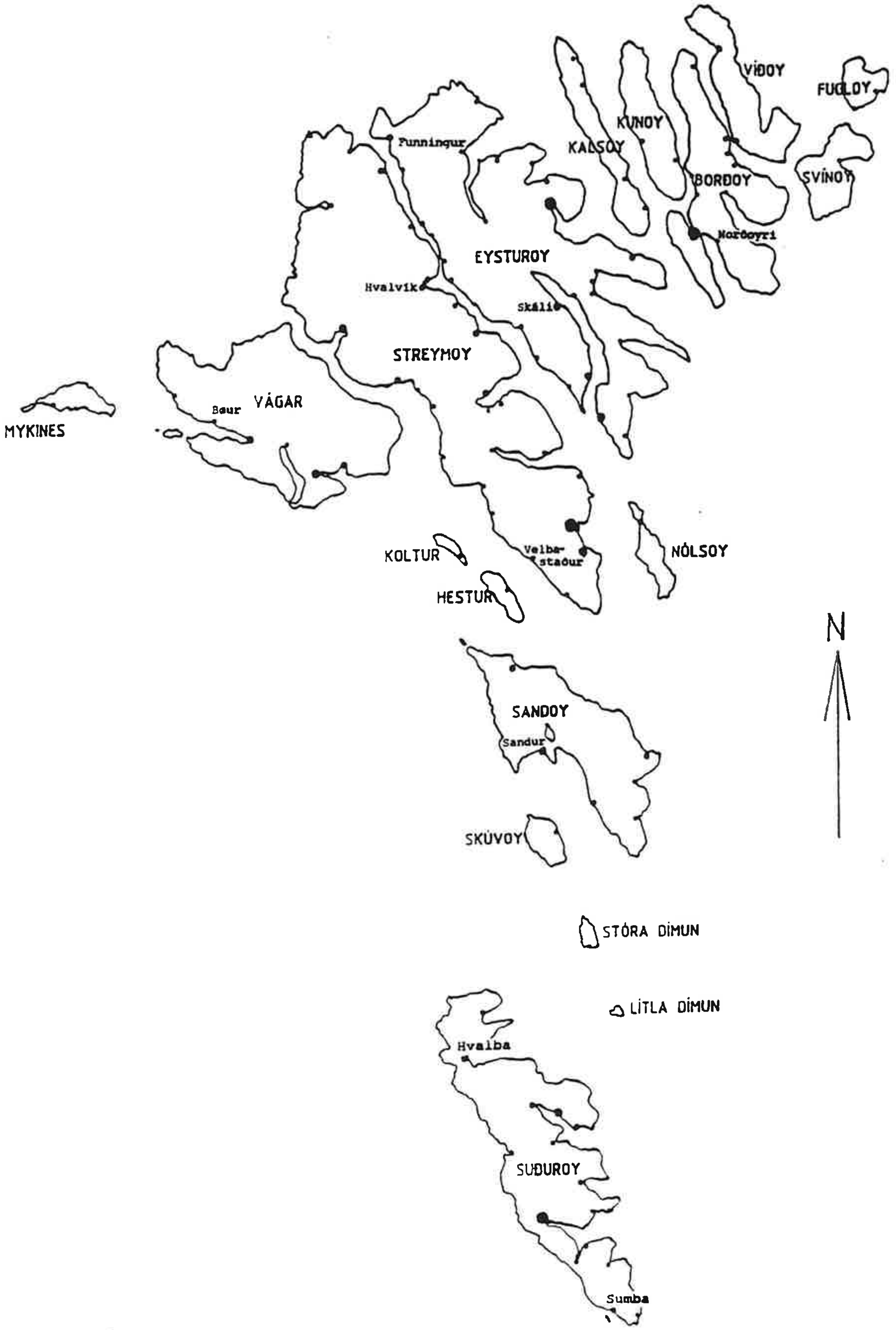
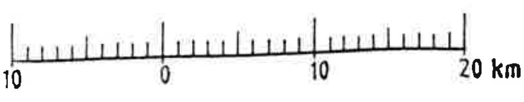
1995



Faroe Islands.



Contents

Radioecological investigations in the Faroe Islands 1990-1995.

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Abstract

The report contains results from the Faroese part of the RAD3-programme and the subsequent EKO-2 programme, being radioecological programmes from 1990 to 1993 and from 1993 to 1997, respectively, under the Nordic Committee for Nuclear Safety research, NKS.

The transfer of radiocaesium from soil to grass and further to lamb has been investigated in 9 uncultivated pastures in the Faroe Islands. Neck muscles and internal organs were used from the lambs. Faeces were sampled in 1995.

The annual per capita consumption in the Faroe Islands of lamb meat is 9.5kg of lamb meat, 0.7kg (total) of liver, heart and kidney, making lamb an important source for the transfer of radiocaesium to man. The sheep is the most abundant domestic animal in the Faroe Islands. There is an additional consumption of imported lamb meat (mainly from Iceland) of 9.6kg per capita.

The ratio between the content of Cs-137 in meat and grass is observed to be lower in the Faroe Islands than in other Nordic countries. A controlled feeding experiment with two male twin lambs confirmed the results. The aggregated transfer factor from soil to meat as well as the observed transfer factor from soil to grass is lower in the Faroe Islands than in other nordic countries with similar soil types as the Faroese.

Despite the limited geographical extent of the Faroe Islands, the geographical variation in the contamination and transfer factors is highly significant.

Estimates of effective ecological halflives of Cs-137 are presented, although the project has been going on for only six years.

Chemical properties of the soil are included in the report.

Introduction

The transfer of radiocaesium from soil to grass and further to lamb has been investigated since 1990 as part of the programmes RAD-3 and EKO-2. They are radioecological programmes under the Nordic Committee for Nuclear Safety research, NKS. Nine uncultivated pastures covering six islands have been selected for the project. Chemical properties of the soil have also been investigated, and the results are included in the report.

1. Material and methods

Nine uncultivated pastures, between 50 and 240 meters above sea level and covering 6 of the 18 islands of The Faroe Islands, have been selected for the project. Samples cover soil, mixed grass and individual plant species, meat and internal organs from lambs. Faeces were sampled in 1995 at the same sites.

In 1990, two or three 1 m^2 areas were randomly chosen in each pasture and divided into four 1/4 m^2 microplots for soil and grass sampling. The soil cores - taken with a corer with 6.0cm inner diameter - were split up into an upper 2cm layer followed by 5cm layers. However, in two pastures, Sandur and Sumba, the samples were taken from four randomly chosen 1/4 m^2 microplots and the cores were split up into 1cm layers down to 5cm followed by two 2.5cm thick layers from 5 to 10cm depth. This technique was requested by the participating laboratories. (Only Sandur and Sumba remained to be sampled when the description of the sampling technique was received).

Since 1991 the soil has been sampled with a (standardized) swedish corer, having inner diameter and length of 5.7cm and 10cm, respectively. Four 1/4 m^2 microplots were randomly selected in each pasture. The cores were split up into an upper and a lower 5cm layer except for 1992, when they were split up into 1cm layers down to 5cm depth and 2.5cm layers further down to 10cm depth.

Measurements were carried out on every core disc in 1990. Three cores were typically taken from each 1/4 m^2 microplot. Since 1991 three cores were taken from each 1/4 m^2 microplot, whereupon one mixed sample was made for each soil layer for measurement.

Chemical analyses have been carried out on the soil samples in addition to the radioactive analyses.

The mixed grass samples were collected every year by cutting the grass in each 1/4 m^2 microplot before the soil sampling. Individual plant species were picked by hand in a much wider area in order to get enough material for measurement.

The stock of sheep in the pastures varied from 65 to 260. When the lambs were slaughtered, meat (neck muscle), liver, kidney and heart were collected according to an arrangement made with the farmers, emphasizing the importance of taking the meat and internal organs from the same lamb. Measurements were carried out on samples from 30-38 lambs each year. The time of slaughter was typically in October when they were about 6 months of age. The carcass weight was around 12-13 kg.

All samples, except for the lamb samples, were dried before measurement. The soil was dried at room temperature. The grass, individual plant species and faeces were dried at 105°C. A lead shielded Ge-detector was used for the measurements. The software OMNIGAM from EG & G Ortec was used for the spectral analyses.

Table 1.1. The stock of sheeps, area and approximate height above sea level of the selected pastures. Local names are included.

	Bøur, N.í Haga	Velbastað, Lambhagi	Hvalvík, Miðdalah.	Skáli, Hegnið	Funning., I. í Haga	Norðoyri, Mið&Lýðh	Sandur, Skálsafjörð	Hvalba, S.í Haga	Sumba, Skúvabøli
Area, km²	3.16	2.01	5.75	3.60	3.67	4.21	4.32	0.96	1.45
Height, m	100	150	50	70	100	160	240	100	200
Stock	128	150	260	105	-	160	200	65	100

2. Climate conditions

Local phenomena do certainly affect the climate conditions in the pastures. There are no weather stations close to the pastures, but the table below with data from the Faroese capital, Tórshavn, may indicate the interannual variation in precipitation and temperature.

Table 2.1 Accumulated precipitation (mm) in Tórshavn, the capital of the Faroe Islands. Data for May-September (i.e. 5 months. Ref: The Danish Met. Institute).

1990	1991	1992	1993	1994	1995	1961-81
330	340	393	286	376	262	426

Table 2.2 Mean temperatures (Celsius) in Tórshavn, the capital of the Faroe Islands. Data for May-September (i.e. 5 months. Ref: The Danish Met. Institute).

1990	1991	1992	1993	1994	1995	1961-88
9.9	10.2	9.8	8.3	8.8	9.1	9.2

3. Results

3.1. Chemical analyses of the soil

The mean values of pH, ignition loss, concentration of easily soluble potassium and sodium in the uppermost 10cm of the soil is presented in tables below and in Figs 3.1.1-3.1.4. The content of potassium is mostly between 300 mg/kg and 600 mg/kg, but values of about 1000 mg/kg are also observed. The concentration of sodium is generally at the same level as for potassium, but higher values are observed in Sumba and particularly in Hvalba. The pH values are generally below 5.3. The soil is organic, as can be seen from the ignition loss. (Chemical analyses remain to be done for 1995-samples).

Table 3.1.1. Results for pH in the 0-10cm soil layer.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	5.0	5.6	4.5	4.8	4.6	4.7	4.6	-	4.8
1991	4.8	5.1	4.8	5.1	5.0	5.0	4.7	5.1	4.9
1992	4.9	5.2	4.8	4.8	4.7	4.8	5.3	5.2	4.8
1993	5.0	5.3	5.0	5.2	5.0	5.3	5.3	5.2	5.2
1994	4.7	4.5	4.7	4.7	-	4.4	4.5	4.8	4.5

Table 3.1.2. The ignition loss (%) in the 0-10cm soil layer.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	40	15	27	67	57	66	59	-	75
1991	67	45	73	60	59	64	73	65	71
1992	48	25	73	65	40	55	37	62	50
1993	63	29	65	64	49	54	33	62	42
1994	55	31	53	53	-	69	50	70	34

Table 3.1.3. Content of easily solluble potassium (mg/kg) in the 0-10cm soil layer.									
Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	547	587	293	469	333	529	430	-	997
1991	340	582	340	868	459	706	604	780	675
1992	457	395	516	493	334	616	486	730	444
1993	873	833	781	1044	694	752	577	1030	723
1994	981	880	847	947	-	919	879	1027	823

Table 3.1.4. Content of sodium (mg/kg) in the 0-10cm soil layer.									
Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	403	460	230	230	230	460	460	-	805
1991	216	546	187	503	244	345	402	1466	748
1992	446	366	323	388	403	558	422	1494	631
1993	560	540	630	490	400	650	450	1550	660
1994	452	439	385	379	-	544	472	1165	512

In 1992 the analyses were carried out for every 1cm layer down to 5cm depth and for each 2.5cm layer further down to 10cm depth. The concentration of calcium has been measured in addition to the parameters mentioned above (in the uppermost 5cm of the soil). The results presented in Table 3.2.8 are based on samples prepared for Cs-134 analyses (cf. § 3.2).

3.2. Radiocaesium in the soil

The soil sampling took place in July every year except for 1990, when it was carried out in August. The measurements of Cs-137 are presented in tables below and in figures at the end of the report. Estimates for the whole country can be found in Table 3.2.1 (all samples are considered as a pool).

Table 3.2.1. Deposition and concentration of Cs-137 in the 0-10cm soil layer (dried material). Overall means ± pooled standard deviations.						
Year	1990	1991	1992	1993	1994	1995
Bq/m^2	5867±1483	5462±1144	5375±1078	5004±954.1	5946±1962	5967±877.0
Bq/kg	228±90.0	283±64.3	240±67.8	238±59.9	317±41.1	282±78.9

The deposition of Cs-137 in the 0-5cm soil layer relative to the deposition in the 0-10cm layer is shown in Table 3.2.2 and Figure 3.2.1. 60-80% of the deposition is found to be in the uppermost 5cm of the soil. The relative distribution between the layers is practically the same every year for most pastures. A declining trend is observed in some pastures (e.g. Bøur).

Table 3.2.2. The deposition of Cs-137 in the top 0-5cm soil layer relative to the deposition in the top 0-10cm layer (in %).

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	60.1	50.9	59.9	65.0	66.5	67.2	80.1	-	66.1
1991	57.8	55.1	59.8	50.5	79.0	63.6	82.1	56.5	65.0
1992	68.8	56.4	55.8	68.2	78.6	62.0	78.3	64.4	78.2
1993	50.9	58.2	63.1	47.6	62.6	55.1	69.1	57.2	62.2
1994	43.7	52.3	47.8	41.2	-	58.8	79.0	48.1	51.9
1995	39.6	66.2	64.1	44.3	-	68.0	73.7	34.5	58.2

The Cs-134/Cs-137 ratio in the uppermost 5cm of the soil is shown in Tables 3.2.3-3.2.4 (-no data for Skáli and Sandur in 1991). Cs-134 was not detected in 1990.

Table 3.2.3. The Cs-134/Cs-137 ratio in the 0-5cm soil layer. (No data for 1990).

	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sand.	Hvalba	Sumba
1991	0.045	0.056	0.036	-	0.029	0.044	-	0.050	0.065
1992	0.029	0.037	0.039	0.023	0.018	0.037	0.030	0.049	0.040
1993	0.027	0.024	0.028	0.017	0.018	0.024	0.020	0.035	0.034
1994	0.022	0.023	0.014	0.010	-	0.023	0.013	0.026	0.025
1995	0.013 N=2	0.023 N=1	N.D.	0.010 N=1	-	N.D.	0.011 N=1	0.021 N=3	0.018 N=4

Table 3.2.4. The Cs-134/Cs-137 ratio in the 5-10cm soil layer. (N.D.: Cs-134 not detected).									
	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sand.	Hvalba	Sumba
1993	N.D.	N.D.	N.D.	0.013 N=1	N.D.	0.011 N=2	N.D.	0.018 N=1	N.D.
1994	N.D.	N.D.	0.014 N=2	0.008 N=3	-	0.019 N=1	N.D.	0.022 N=1	0.009 N=1
1995	0.013 N=2	N.D.	N.D.	0.008 N=1	-	N.D.	N.D.	0.013 N=1	N.D.

The Cs-137 concentration and deposition in the uppermost 10cm of the soil are presented in Figures 3.2.2 and 3.2.3, respectively. The error bars represent one standard error. More detailed results can be found in Tables 3.2.5 - 3.2.6.

Table 3.2.5. The concentration (Bq/kg ± 1 stds) of Cs-137 in the 0-10cm soil layer.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	166±22.4	95±15	286±174	331±44.1	257±96.5	233±85.6	269±20.0	-	377±51.7
1991	260±53.2	226±54.7	299±27.3	254±60.6	217±55.1	414±70.0	241±86.8	290±47.3	343±97.3
1992	236±65.8	132±37.0	274±86.1	214±33.1	194±31.7	355±111	180±75.4	269±31.7	303±85.4
1993	263±22.5	123±23.3	241±39.4	305±81.3	243±75.5	264±83.7	188±73.2	255±12.5	258±35.3
1994	286±31.2	104±14.0	330±21.0	336±77.1	-	385±50.1	282±26.8	322±29.8	388±29.0
1995	155±56.0	128±13.5	284±53.4	312±34.9	-	301±173	257±35.6	352±43.6	435±50.5

Table 3.2.6. The deposition (Bq/m^2 ± 1 stds) of Cs-137 in the 0-10cm soil layer.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	3338±377	8147±1082	8004±2927	4710±1266	5845± 618	4396±1135	5029±1181	-	4362±1016
1991	5592±399	4701± 908	6344±1632	4839± 958	5247± 458	7770±1260	4466±1676	5105±1140	4944± 942
1992	5732±923	5320± 769	4652± 923	4563±1084	6409±2098	6031±1278	5706± 539	4956± 298	5009± 757
1993	4943±578	4829± 876	4055± 828	5957±1194	5563±1186	5824±1000	3759± 635	4270± 623	5835± 934
1994	4617±188	4181± 576	5812±3655	8613±1832	-	6609±2748	6804± 922	3676±1269	6373±1161
1995	5521±295	4899± 111	4155±1064	8315±991	-	7267± 457	6053± 628	4475± 177	6456±1600

In order to get enough material for Cs-134 detection in 1992, mixed samples were prepared for each soil layer. Cs-134 has only been measured in the uppermost 5cm except for Norðoyri, where the Cs-134/Cs-137 ratio was found to be 0.017 in the 5-10cm layer. In 1992 the soil cores were split up in a 0-5cm layer and a 5-10cm layer only in Norðoyri. Results from mixed samples from each 1/4m^2 area can be found Table 3.2.7.

Table 3.2.7 . Results from chemical and radioactive analyses in 1992. Sampling dates are included.

	Depth cm	Ign. loss %	pH	Sodium mg/kg	Potassium mg/kg	Calsium mg/kg	Cs-137 Bq/(gK)	Cs-137 Bq/kg	Cs-137 Bq/m2	Chernobyl Cs-137 Bq/kg	Fallout Cs-137 Bq/kg	Cs-134/ Cs-137
Bøur 16/7-92	0-1	72.1	4.9	933	922	681	256	236	415	160	76	0.0528
	1-2	62.3	4.8	447	589	616	637	375	834	267	109	0.0552
	2-3	64.2	4.7	670	662	616	627	415	918	127	288	0.0238
	3-4	60.5	4.8	533	516	474	748	386	861	69	317	0.0139
	4-5	52.8	4.9	564	422	310	743	314	903	56	257	0.0140
	5-7.5	41.2	5.0	402	450							
	7.5-10	35.0	5.1	240	260							
			4.9									
Velbastad 13/7-92	0-1	37.0	5.4	493	1300	1840	125	162	390	73	89	0.0350
	1-2	32.9	5.2	392	537	1430	330	177	572	92	85	0.0403
	2-3	30.8	5.3	381	402	1660	426	171	673	71	100	0.0325
	3-4	32.4	5.2	392	339	1330	501	170	690	77	93	0.0353
	4-5	27.0	5.2	321	287	1060	549	158	680	89	69	0.0437
	5-7.5	23.5	5.2	420	380							
	7.5-10	17.3	5.0	300	260							
			5.2									
Hvalvik 19/7-92 1.FERD	0-1	80.9	4.8	493	1420	1030	136	193	200	114	80	0.0457
	1-2	69.9	4.8	371	1070	1030	333	357	573	208	149	0.0454
	2-3	82.6	4.8	412	714	867	550	393	687	202	190	0.0401
	3-4	80.8	4.8	295	547	714	655	358	640	177	182	0.0383
	4-5	78.2	4.8	348	516	627	593	306	602	121	185	0.0307
	5-7.5	74.4	4.9	324	420							
	7.5-10	64.4	4.8	252	200							
			4.8									
Skáli 13/7-92	0-1	87.8	4.9	751	1350	1430	198	268	406	142	126	0.0411
	1-2	79.2	4.7	665	849	1060	520	442	692	169	272	0.0298
	2-3	76.6	4.7	432	558	812	895	499	825	118	382	0.0184
	3-4	71.6	4.8	356	402	834	1035	416	790	91	325	0.0170
	4-5	67.2	4.7	356	339	485	1038	352	776	80	271	0.0178
	5-7.5	58.5	4.9	312	430							
	7.5-10	59.0	4.7	312	320							
			4.8									
Funningur 13/7-92	0-1	80.1	4.7	427	1220	996	350	427	701	292	135	0.0531
	1-2	60.1	4.6	700	630	703	897	565	1312	130	435	0.0179
	2-3	53.8	4.6	624	526	539	976	513	1316	97	416	0.0147
	3-4	49.4	4.7	311	318	376	1235	393	1190	51	342	0.0101
	4-5	49.7	4.7	300	277	332	1016	281	879	29	252	0.0081
	5-7.5	31.7	4.8	378	330							
	7.5-10	27.5	5.0	360	120							
			4.7									
Sandur 15/7-92	0-1	67.4	5.3	462	1570	1860	162	255	541	223	32	0.0680
	1-2	50.8	5.3	427	672	965	430	289	906	141	148	0.0379
	2-3	42.2	5.2	386	433	823	719	311	1096	98	213	0.0246
	3-4	39.5	5.3	392	350	681	765	268	1037	60	207	0.0176
	4-5	36.2	5.2	381	287	648	692	199	806	49	150	0.0192
	5-7.5	29.1	5.2	462	450							
	7.5-10	32.1	5.3	432	380							
			5.3									
Hvalba 14/7-92	0-1	79.6	5.7	1140	1510	1900	183	277	403	272	5	0.0764
	1-2	74.6	5.4	984	697	1170	601	419	611	399	20	0.0741
	2-3	71.0	5.4	1030	634	1360	688	436	702	295	141	0.0526
	3-4	66.2	5.3	1430	707	1500	657	464	777	217	247	0.0363
	4-5	63.9	5.2	1370	551	1260	678	374	743	111	262	0.0231
	5-7.5	55.8	4.9	1722	650							
	7.5-10	53.3	4.4	1728	700							
			5.2									
Sumba 14/7-92	0-1	69.7	5.1	700	1390	1040	408	567	755	438	128	0.0601
	1-2	65.0	4.9	705	734	910	1074	788	1035	687	102	0.0677
	2-3	61.0	4.9	675	474	627	1230	583	815	216	367	0.0288
	3-4	60.6	4.8	786	381	627	1379	525	726	107	418	0.0159
	4-5	56.2	4.8	650	318	507	1271	404	582	43	362	0.0082
	5-7.5	45.7	4.7	660	350							
	7.5-10	37.6	4.4	510	260							

3.3 Mixed grass

The Cs-137 activity in mixed grass is presented in Figure 3.3.1 as mean values and +1 standard error, showing a decreasing trend with time. The overall means for the country and for each pasture are presented in Tables 3.3.1 and 3.3.2, respectively. The yield can be seen in Table 3.3.3.

Table 3.3.1. The Cs-137 concentration (Bq/kg;dw) in mixed grass. Overall means ± pooled standard deviations.

1990	1991	1992	1993	1994	1995
162±92.0	106±65.0	63.1±34.9	45.3±27.4	41.0±35.4	48.1±28.7

Table 3.3.2. The concentration of Cs-137 in mixed grass in each pasture. Mean values ± 1 standard deviation (Bq/kg;dw).

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	91.0±35.0	70.0±43.8	302 ±179	119± 70.6	247 ±95.2	236 ±87.7	217± 105	20.0±6.10	97.0±68.1
1991	48.2±27.8	56.5±83.5	225 ±120	61.8±34.5	249 ±75.1	88.0±26.3	109± 67.3	11.0±5.10	106 ±61.0
1992	43.9±19.6	31.2±41.3	177±57.3	69.1±46.7	98.0±26.6	51.2±34.9	9.56±4.38	10.3±3.11	77.5±37.9
1993	30.0± 8.8	13.0± 5.4	152±42.0	68.0±40.0	80.0±54.0	22.0± 7.2	16.0±15.6	9.60±2.20	17.3± 9.6
1994	8.56±5.0	-	92.8±80.4	71.6±16.1	-	63.0±14.7	5.40 (N=1)	12.3±7.30	39.0±36.5
1995	14.1±14.5	27.2±32.7	142±57.1	50.1±22.1	-	59.7±22.0	9.93±6.74	10.4±4.33	37.9±17.3

Table 3.3.3. The yield of mixed grass in the pastures (g(dw)/m^2). Mean values ± 1 standard deviation.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	40±10	28±18	52±16	70±18	29±8.3	182±17	79±53	53±16	49±17
1991	97±58	172±28	67±23	121±7.5	37±10	267±16.7	154±37	184±51	137±35
1992	48±16	113±28	78±17	55±32	42±12	108±58	93±64	116±31	46±19
1993	58±8.4	97±26	72±31	85±48	37±4.1	72±22	92±45	189±30	171±39
1994	95±44	103±3.1	78±17	71±7.1	-	222±18.6	84±10	148±29	127±23
1995	115±20.4	131±29.5	50±18	40±10	-	127±35.4	58±13	143±30	152±37

The Cs-134/Cs-137 ratio is presented in Table 3.3.4. Cs-134 was not detected in 1992. In 1993 Cs-134 was only observed in a sample from Hvalvík; the Cs-134/Cs-137 ratio was

0.051. Cs-134 has not been detected in grass samples since 1993.

Table 3.3.4. Cs-134/Cs-137 ratio in mixed grass.

	Bøur	Velbastað	Hvalvík	Skáli	Funningur	Norðoyri	Sandur	Sumba
1990	0.188	0.172	0.080	0.120	0.032	0.112	0.139	0.171
1991	-	0.041	0.059	-	0.027	-	-	0.095

Since the concentration of radiocaesium in the grass is time dependent, grass sampling was carried out several times in 1991 and 1992 and two times in 1993. The results for Cs-137 as well as the yield (g(dw)/m²)) can be found below. The highest concentration is between mid July and August.

Table 3.3.5. Time variation of the Cs-137 *concentration* ± 1 standard deviation (Bq/kg(dw)) in mixed grass.

1991, Cs-137 Bq/kg(dw)	Week 26	Week 28	Week 29	Week 32	Week 38	Week 39
Velbastað		56.5 ± 83.5				52.1 ± 87.0
Hvalvík	142.7 ± 59.7		224.6 ±120.5	259.1 ± 94.8	160.7 ± 42.7	
Skáli		61.8 ± 34.5			59.2 ± 34.4	
Funningur		249.1 ± 75.0			280.0 ± 82.4	
Sandur		109.3 ± 67.4				40.5 ± 41.1

Table 3.3.6. Time variation of the *yield* ± 1 standard deviation (g(dw)/m²). Results based on mixed grass samples.

1991, Yield g(dw)/m²	Week 26	Week 28	Week 29	Week 32	Week 38	Week 39
Velbastað		172.2 ± 28.2				181.9 ± 25.2
Hvalvík	32.7 ± 5.5		67.0 ± 22.5	61.0 ± 16.0	43.2 ± 20.2	
Skáli		120.5 ± 7.5			40.9 ± 24.1	
Funningur		36.6 ± 10.1			36.8 ± 8.9	
Sandur		154.2 ± 36.9				184.7 ± 28.0

Table 3.3.7. Time variation of the Cs-137 *concentration* ± 1 standard deviation (Bq/kg(dw)) in mixed grass. (*): Results based on *one* sample from a *1 m²* sampling area.

1992, Cs-137 Bq/kg(dw)	Week 27	Week 28	Week 33	Week 38	Week 41	Week 44	Week 45
Velbastað		31.2±41.3	70.1 (*)			7.5 (*)	
Skáli		69.1±46.7	46.7 (*)	28.5 (*)			
Funningur		98.0±26.6	55.0 (*)				
Norðoyri	51.2±34.9				60.2 (*)		
Sandur		9.6±4.4					7.3 (*)
Hvalba		10.3±3.1					16.3 (*)
Sumba		77.5±37.9					19.8 (*)

Table 3.3.8. Time variation of the Cs-137 *yield* ± 1 standard deviation (g(dw)/m²) of mixed grass. (*): Results based on *one* sample from a *1 m²* sampling area.

1992, Cs-137 g(dw)/m²	Week 27	Week 28	Week 33	Week 38	Week 41	Week 44	Week 45
Velbastað		113.1±27.7				54.7 (*)	
Skáli		54.8±32.3	15.6 (*)	25.3 (*)			
Funningur		41.5±11.8	19.1 (*)				
Norðoyri	134.2±12.4				44.7 (*)		
Sandur		92.8±64.0					55.9 (*)
Hvalba		116.3±30.8					41.6 (*)
Sumba		46.0±18.5					50.4 (*)

Special attention was given to Hvalvík in 1992, where sampling was carried out from June to October with a high frequency. (Hvalvík was chosen for practical reasons).

Table 3.3.9. Time variation of the Cs-137 *concentration* ± 1std (Bq/kg(dw)) in mixed grass from Hvalvík **(1992)**. (*): Result based on *one* sample from a *1 m²* sampling area.

22/6-92	6/7-92	19/7-92	3/8-92	17/8-92	1/9-92	14/9-92	28/9-92	11/11-92
160±74	170±29	177±57	242±19	173±29	221±124	95±27	113±46	90 (*)

Table 3.3.10. Time variation of the Cs-137 *yield* ± 1std (Bq/kg(dw)) in mixed grass from Hvalvík (**1992**). (*): Result based on *one* sample from a *1 m²* sampling area.

22/6-92	6/7-92	19/7-92	3/8-92	17/8-92	1/9-92	14/9-92	28/9-92	11/11-92
46±15	52±5.0	81±13	91±30	114±40.0	90±29	105±26	73±15	44 (*)

In 1993 a later grass sampling was carried out in most pastures in September/October. The results from the measurements are presented in Tables 3.3.11 and 3.3.12.

Table 3.3.11. The Cs-137 *concentration* in mixed grass ±1 standard deviation (Bq/kg(dw)). Second sampling in 1993. (*: refers to measurement on a single mixed sample).

Bøur 1/9-93	Velbastað 2/10-93	Hvalvík 10/10-93	Skáli 26/9-93	Hvalba 6/11-93	Sumba 6/11-93
28±12	13±5.3	167±132	57±30	16*	13*

Table 3.3.12. The *yield* of mixed grass ±1 standard deviation ($g(dw)/m^2$). Second sampling in 1993. (*: refers to measurement on a single mixed sample).

Bøur 1/9-93	Velbastað 2/10-93	Hvalvík 10/10-93	Skáli 26/9-93	Hvalba 6/11-93	Sumba 6/11-93
124±46.8	114±24.5	74.1±13.2	34.1±10.4	21.6±9.64	25.6±6.21

3.4. Individual plant species

Some individual plant species have been collected. The content of Cs-137 in the species is shown in Tables 3.4.1 - 3.4.3.

Table 3.4.1. Content of Cs-137 in individual plant species in 1991.

Cs-137 Bq/kg, 1991	Potentilla erecta	Festuca rubra	Anthoxanthum odoratum	Nardus stricta	Deschampsia flexuosa	Dactylorchis maculata
Bøur	41.9	26.8	98.2		32.9	93.8
Velbastað	12.5		13.9	10.4		
Hvalvík	265.8	114.9	237.2			
Skáli	139.0		67.0	45.5		
Funningur				71.5		
Norðoyri	96.7	14.0	38.5			
Sandur	133.7	10.8	12.9			
Hvalba	24.3		10.2			
Sumba	75.3	33.2		51.9		

Table 3.4.2. Content of Cs-137 in individual plant species in 1992.

Cs-137 Bq/kg, 1992	Potentilla erecta	Festuca rubra	Anthoxanthum odoratum	Nardus stricta
Bøur	28.0	19.0	22.7	
Velbastað	11.9		9.9	
Hvalvík	73.8	55.6	138.0	
Skáli	33.8			64.7
Funningur				28.6
Norðoyri	37.6	33.9	15.9	
Sandur	30.0	32.8	26.6	
Hvalba	Bel.Det.Lim.		Bel.Det.Lim.	
Sumba	34.1	37.3	65.1	

Table 3.4.3. Content of Cs-137 in individual plant species in 1993.			
Cs-137 Bq/kg, 1993	Potentilla erecta	Festuca rubra	Anthoxanthum odoratum
Bøur	24.2	10.2	26.3
Velbastað	9.0		
Hvalvík	76.2	67.6	123.6
Skáli	49.9		
Norðoyri	20.5	32.7	

3.5. Lamb

The results for lamb meat and entrails 1990-1994 are presented in Figs. 3.5.1-3.5.2. A decreasing trend with time is observed. The results are shown in more detail in the tables below. Lamb samples from 1995 remain to be analyzed.

The overall mean concentration of Cs-137 in meat and internal organs, based on single lamb measurements, are presented in Table 3.5.1. The time of slaughter was from late September to early November.

Table 3.5.1. Content of Cs-137 (Bq/kg;fw) in lamb meat and internal organs. Overall means ± pooled standard deviations.

Year	1990	1991	1992	1993	1994
Meat	28.8±19.1	19.8±19.6	10.6±3.50	9.4±5.0	19.8±13.0
Liver	15.0±6.00	14.4±9.60	7.3±2.3	6.5±3.1	16.6±10.4
Heart	15.2±5.40	12.4±7.60	7.5±2.3	6.2±3.1	16.6±11.8
Kidney	28.6±10.6	18.7±16.0	14.0±18.2	10.7±5.7	30.9±20.7

Information about the carcass weights can be found in Tables 3.5.2.

Table 3.5.2. Carcass weight (kg;fw). Overall means (from single lambs). Minimum and maximum weights are included.

1990			1991			1992			1993			1994		
Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
12.7	9.5	16.5	12.9	10.0	16.5	12.2	9.5	18.5	12.4	8.0	17.5	13.9	10.5	21.0

Table 3.5.3. Cs-137 (Bq/kg;fw) in *meat* from the neck of the lambs. Mean values ± 1 standard deviation.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	7.6±6.2	4.8±2.3	60.8±37.4	54.0±13.0	-	28.0±22.0	33.0±1.41	4.1	16.0±3.70
1991	8.7±7.8	4.6±1.8	60.3±40.6	30.9±25.9	-	13.1±6.40	17.4±11.9	3.2±1.0	18.1
1992	7.3±2.1	4.3±3.4	17.5±5.50	21.5±1.90	-	13.8±4.30	8.5	2.9±0.62	13.7
1993	6.8±3.2	2.6±0.92	19.2±10.4	26.0±10.2	-	7.8±2.2	10.4±2.20	3.2±0.96	5.5±3.0
1994	6.3±5.0	3.1±2.2	13.5±11.6	49.5±19.8	-	45.7±26.7	25.0±2.98	3.4±1.7	10.7±3.19

Table 3.5.4. Cs-137 (Bq/kg;fw) in *liver*. Mean values ± 1 standard deviation.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	5.5±4.3	2.5±1.1	-	34.5±7.50	-	-	28.0±9.60	1.8	-
1991	7.8±8.6	2.7±0.87	44.3±10.6	18.8±18.0	-	12.4±7.31	10.7±7.91	3.3±1.1	9.9
1992	4.6±1.7	-	11.3±3.06	11.8±3.19	-	8.2±2.5	-	2.4±0.28	-
1993	3.6±2.6	1.9±1.2	12.4±6.89	16.3±5.44	-	6.1±2.2	7.7±2.4	3.4±0.60	4.8±2.6
1994	6.4±4.1	1.9±1.0	30.4±16.1	30.7±14.1	-	26.8±16.4	19.6±1.03	3.3±1.2	6.6±1.7

Table 3.5.6. Cs-137 (Bq/kg;fw) in *heart*. Mean values ± 1 standard deviation.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	3.7±3.0	4.0±2.4	-	37.9±8.10	-	-	20.9±0.42	3.40	-
1991	7.6±6.4	2.2±0.82	32.3±9.23	19.0±13.4	-	12.2±6.77	10.1±6.96	2.82±1.54	11.7
1992	4.8±1.4	-	13.3±3.53	11.6±2.29	-	7.1±2.4	-	2.32±0.66	-
1993	3.6±2.1	1.9±0.9	11.7±6.42	16.6±4.30	-	5.8±2.2	6.4±1.5	4.00±1.56	3.86±2.84
1994	3.5±1.6	1.6±0.66	29.4±12.9	33.8±14.9	-	28.8±22.2	15.9±1.52	3.17±1.18	4.41±2.10

Table 3.5.7. Cs-137 (Bq/kg;fw) in *kidney*. Mean values ± 1 standard deviation.

Year	Bøur	Velbastað	Hvalvík	Skáli	Funning.	Norðoyri	Sandur	Hvalba	Sumba
1990	16.0±10.2	8.0±2.1	-	62.5±14.0	-	-	36.9±3.80	7.60	-
1991	13.9±11.3	5.2±1.4	35.4±4.65	41.2±37.5	-	12.0±5.64	18.7±11.8	4.94±1.91	17.2
1992	8.4±2.6	-	25.2±7.32	20.1±3.39	-	13.8±3.83	-	4.71±1.02	-
1993	7.6±5.3	2.8±2.1	21.2±12.2	27.2±5.11	-	8.5±2.5	11.1±3.55	6.80±2.24	6.93±5.04
1994	7.5±3.7	2.72 (N=1)	53.1±18.2	58.3±22.2	-	52.7±41.4	36.4±9.89	3.96±1.93	9.78±3.43

The average **Cs-134/Cs-137 ratio** in meat, based on single lamb measurements, was 0.117 in 1990 and 0.067 in 1991. The Cs-134 concentration could be measured significantly in only 5 lambs in 1992 (all from different pastures), giving the mean value 0.065. In 1991 the Cs-134/Cs-137 ratio in kidney, heart and liver was 0.053, 0.075 and 0.074, respectively (-no data for other years).

3.6. Concentration ratios and transfer factors

The observed concentration ratios are presented in Figs. 3.6.1-3.6.2 and in Tables 3.6.1.-3.6.6.

For each 1/4 m^2 microplot (cf. § 1) in a particular pasture, the grass/soil concentration ratio has been calculated from the concentraion (Bq/kg(dw)) in the 0-10cm soil layer and the concentration in grass. The average of these ratios is used as an estimate for the pasture.

For each pasture the meat/grass concentration ratio is calculated from the ratio between the concentration in each lamb (Bq(kg(fw)) and the mean concentration in grass. The meat/soil concentration ratio is calculated from the ratio between the concentration in each lamb and the mean concentration in the 0-10cm soil layer of the pasture.

The observed soil-to-grass (m^2/kg(dw)) and soil-to-meat transfer factors (m^2/kg(fw)) are presented in Figs. 3.6.3- 3.6.4 and Tables 3.6.7-3.6.9. The factors have been calculated in the same way as the concentration ratios, using the deposition (Bq/m^2) in the 0-10cm soil layer.

Mean values for the country can be found in Table 3.6.10.

Table 3.6.1. Observed concentration ratios in 1990.

1990	Concentration ratio*10^3 Soil-Grass transfer			Concentration ratio *10^3 Grass-Meat transfer			Concentration ratio *10^3 Soil-Meat transfer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Bøur	531.2	333.1	682.1	83.5	30.8	200.0	45.7	16.9	109.5
Velbastað	393.4	233.3	678.4	68.6	41.4	115.7	49.8	30.1	84.0
Hvalvík	1009.2	410.9	1840.5	202.0	119.5	387.1	213.5	74.2	409.1
Skáli	530.0	420.0	640.0	454.0	280.7	570.6	163.2	101.0	205.2
Funningur	969.4	400.0	1746.1	-	-	-	-	-	-
Norðoyri	586.6	478.9	673.0	119.0	38.1	280.1	120.0	38.5	283.2
Sandur	616.8	541.0	645.2	151.0	146.0	155.0	121.4	117.8	125.0
Hvalba	-	-	-	-	-	-	-	-	-
Sumba	310.6	77.0	499.7	165.0	127.0	201.0	42.4	32.6	51.7

Table 3.6.2. Observed concentration ratios in 1991

1991	Concentration ratio *10^3 Soil-Grass transfer			Concentration ratio *10^3 Grass-Meat transfer			Concentration ratio *10^3 Soil-Meat transfer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Bøur	217.6	173.0	275.0	181.0	32	437	33.6	6.0	81.0
Velbastað	242.2	43.5	770.0	82.0	29.7	119	20.6	7.45	29.9
Hvalvík	734.7	506.5	1200.6	268.4	100.3	518.6	201.9	75.5	390.0
Skáli	260.3	158.2	368.3	500.3	98.7	1160.0	121.9	24.1	282.6
Funningur	960.1	795.1	1278.3	-	-	-	-	-	-
Norðoyri	224.9	112.7	342.6	149.0	99.0	27.6	31.7	24.0	58.7
Sandur	510.7	180.5	934.1	158.8	33.4	231.6	71.9	15.1	104.9
Hvalba	37.4	15.5	45.9	287.2	157.6	409.1	10.9	9.61	15.5
Sumba	330.3	63.9	433.2	170	-	-	43.6	-	-

Table 3.6.3. Observed concentration ratios in 1992.									
1992	Concentration ratio *10^3 Soil-Grass transfer			Concentration ratio *10^3 Grass-Meat transfer			Concentration ratio *10^3 Soil-Meat transfer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Bøur	200.3	82.6	385.4	166.0	113.1	235.5	30.8	21.0	43.8
Velbastað	236.7	65.7	496.5	138.8	34.9	320.3	32.7	8.23	75.4
Hvalvík	750.8	382.2	1338.4	98.8	57.1	138.9	63.9	36.9	89.7
Skáli	320.4	111.3	648.2	311.2	287.7	337.8	100.5	91.2	109.0
Funningur	490.4	392.4	754.8	-	-	-	-	-	-
Norðoyri	133.6	49.3	189.7	268.6	135.7	355.8	38.8	19.6	51.4
Sandur	60.3	19.3	109.8	889.1	-	-	47.1	-	-
Hvalba	38.4	23.6	51.1	277.5	212.1	353.1	10.6	8.11	13.5
Sumba	256.8	184.5	425.9	176.4	-	-	45.2	-	-

Table 3.6.4. Observed concentration ratios in 1993									
1993	Concentration ratio *10^3 Soil-Grass transfer			Concentration ratio *10^3 Grass-Meat transfer			Concentration ratio *10^3 Soil-Meat transfer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Bøur	113.5	76.8	142.4	225.4	110.1	398.3	25.7	12.6	45.5
Velbastað	101.9	67.5	140.0	202.3	73.3	283.0	20.9	7.56	29.2
Hvalvík	653.8	386.9	942.8	126.5	45.5	226.9	79.7	28.7	143.1
Skáli	230.9	103.5	433.5	385.5	229.8	511.7	86.2	51.4	114.4
Funningur	324.3	180.0	559.7	-	-	-	-	-	-
Norðoyri	85.9	69.4	115.2	350.0	244.9	529.6	29.6	20.7	44.9
Sandur	86.4	38.3	179.0	637.8	504.3	850.7	55.6	43.9	74.1
Hvalba	37.9	26.1	47.6	328.4	238.4	469.4	12.4	8.98	17.7
Sumba	66.8	33.3	105.0	318.1	121.1	543.7	22.5	8.57	38.5

Table 3.6.5. Observed concentration ratios in 1994.						
1994	Concentration ratio *10^3 Soil-Grass transfer			Concentration ratio *10^3 Grass-Meat transfer		
	Mean	Min	Max	Mean	Min	Max
Bøur	27.8	9.7	40.2	730.8	110.0	1450
Velbastað	-	-	-	-	-	-
Hvalvík	255.0	46.4	501.5	145.4	70.0	290.0
Skáli	196.0	171.5	273.7	691.0	230.0	970.0
Funningur	-	-	-	-	-	-
Norðoyri	123.0	80.3	212.4	724.5	240.0	1340
Sandur	10.1			4632	3870	5180
Hvalba	31.0	10.5	46.1	277.6	120.0	460.0
Sumba	76.0	7.71	140.1	275.4	150.0	350.0

Table 3.6.6. Observed concentration ratios in 1995. Meat samples from 1995 remain to be analysed.						
1995	Concentration ratio *10^3 Soil-Grass transfer			Concentration ratio *10^3 Grass-Meat transfer		
	Mean	Min	Max	Mean	Min	Max
Bøur	40.0	6.35	66.7			
Velbastað	322	98.4	546			
Hvalvík	532	210	822			
Skáli	157	94.5	222			
Funningur	-	-	-	-	-	-
Norðoyri	153	71.1	257			
Sandur	34.1	18.5	49.6			
Hvalba	32.0	19.1	52.7			
Sumba	89.0	29.4	120			

Table 3.6.7. Observed transfer factors ($m^2/kg(dw)$) in 1990 and 1991.

	1991						1990					
	Transfer factor *10^3 Soil-Grass transfer			Transfer factor *10^3 Soil-Meat transfer			Transfer factor *10^3 Soil-Grass transfer			Transfer factor *10^3 Soil-Meat transfer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Bøur	10.4	6.62	14.9	1.56	0.42	3.76	26.5	17.9	34.1	2.28	0.78	4.92
Velbastað	15.5	1.41	53.2	0.99	0.36	1.44	4.66	2.60	8.20	0.59	0.32	0.90
Hvalvík	38.0	22.3	75.3	9.50	3.55	18.4	35.5	15.4	60.5	7.62	2.39	13.2
Skáli	14.2	6.38	18.4	6.39	1.26	14.8	37.2	34.4	40.0	11.5	6.40	13.0
Funningur	39.7	30.4	47.1	-	-	-	42.5	17.4	67.9	-	-	-
Norðoyri	11.7	5.70	15.2	1.69	1.12	31.3	32.9	29.0	36.1	6.37	1.85	13.6
Sandur	32.0	9.77	79.4	3.89	0.82	5.67	30.3	24.7	38.8	6.50	6.30	6.70
Hvalba	2.19	0.82	2.91	0.62	0.34	0.88	-	-	-	-	-	-
Sumba	24.7	3.84	37.0	2.62	-	-	28.4	7.40	55.6	3.67	2.82	4.47

Table 3.6.8. Observed transfer factors ($m^2/kg(dw)$). 1993 compared to 1992

	1993						1992					
	Transfer factor *10^3 Soil-Grass transfer			Transfer factor *10^3 Soil-Meat transfer			Transfer factor *10^3 Soil-Grass transfer			Transfer factor *10^3 Soil-Meat transfer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Bøur	6.28	3.57	8.73	1.37	0.67	2.42	7.47	3.54	10.1	1.27	0.87	1.80
Velbastað	2.60	1.70	3.57	0.53	0.19	0.74	6.60	1.45	22.0	0.81	0.20	1.88
Hvalvík	39.5	18.3	50.2	4.75	1.71	8.52	37.7	30.5	49.2	3.76	2.17	5.27
Skáli	12.2	5.73	25.4	4.40	2.63	5.85	18.2	3.88	44.4	4.72	4.28	5.12
Funningur	15.0	8.13	31.9	-	-	-	17.1	9.60	30.9	-	-	-
Norðoyri	3.81	3.31	5.10	1.34	0.94	2.03	8.72	1.93	13.8	2.28	1.15	3.02
Sandur	4.83	1.96	12.9	2.77	2.19	3.70	1.69	0.78	2.79	1.49	-	-
Hvalba	2.17	1.60	2.76	0.74	0.54	1.06	2.07	1.26	2.57	0.58	0.44	0.73
Sumba	3.08	1.17	5.09	0.79	0.30	1.35	15.3	10.2	15.0	2.73	-	-

Table 3.6.9. Observed transfer factors ($m^2/kg(dw)$) in 1994 and 1995. Meat from 1995 remains to be analysed.

	1995						1994					
	Transfer factor $*10^3$ Soil-Grass transfer			Transfer factor $*10^3$ Soil-Meat transfer			Transfer factor $*10^3$ Soil-Grass transfer			Transfer factor $*10^3$ Soil-Meat transfer		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Bøur	1.35	0.19	2.14				1.83	0.63	2.59	1.35	0.20	2.69
Velbastað	8.04	2.71	13.4				-	-	-	0.74	0.28	1.50
Hvalvík	38.5	12.1	49.7				22.0	3.10	50.3	2.32	0.65	4.63
Skáli	6.15	3.04	9.43				8.85	6.45	14.8	5.75	1.95	8.04
Funningur	-	-	-	-	-	-	-	-	-	-	-	-
Norðoyri	7.11	4.57	9.46				11.2	5.80	20.7	6.91	2.32	12.8
Sandur	1.66	1.00	2.33				0.94			3.68	3.07	4.11
Hvalba	2.36	1.62	3.63				3.02	1.04	4.84	0.92	0.39	1.52
Sumba	6.64	1.72	11.5				6.64	0.74	14.0	1.68	0.91	2.14

The arithmetic means of the concentration ratios and the transfer factors are presented in Table 3.6.10.

Table 3.6.10	Concentration ratios $* 10^3$			Transfer factors $* 10^3$ m^2/kg	
	Grass/Soil	Meat/Grass	Meat/Soil	Grass/Soil	Meat/Soil
Faroes 1990	618	181	108	29.7	5.51
Faroes 1991	390	225	68	20.9	3.54
Faroes 1992	276	291	46	12.8	2.21
Faroes 1993	189	322	42	9.95	2.09
Faroes 1994	103	406 *)		7.78	2.92
Faroes 1995	170			8.97	

*) Sandur excluded (cf. Table 3.6.5)

The observed grass-to-meat ratios are low compared to other Nordic countries with similar soil types as the faroese. However, it should be considered that (for practical reasons) the grass has been collected in July (August 1990) while the meat is from the time of slaughter, i.e. typically in October. Taking account of the time variation of the activity in the grass, this time delay affects the estimate for the grass-to-meat transfer.

To test the "delay effect", extra grass sampling was carried out in some pastures within about a month from the time of slaughter. The results are in Tables 3.6.11 and 3.6.12, giving the arithmetic mean $617 \cdot 10^{-3}$ (or $431 \cdot 10^{-3}$ if the extreme value for Sandur resulting from the very low activity in the grass is excluded) for 1992 and $270 \cdot 10^{-3}$ for 1993. The averages for the same pastures based on the results in Tables 3.6.3 and 3.6.4 are $309 \cdot 10^{-3}$ (or $212 \cdot 10^{-3}$ if Sandur is excluded) in 1992 and $264 \cdot 10^{-3}$ in 1993. Thus it may be concluded that the time delay between the sampling of grass and meat is not a single explaining factor for the low concentration ratio between the meat and the grass.

Table 3.6.11. The observed grass-to-meat concentration ratio $*10^3$, based on the **second** grass sampling in **1992**. The time of sampling is noted.

Velbastað Grass 30/10 Meat 17/10	Hvalvík Grass 28/9 Meat 31/10	Skáli Grass 20/9 Meat 9/10	Norðoyri Grass 7/10 Meat 25/9	Sandur Grass 29/10 Meat "Oct"	Hvalba Grass 7/11 Meat 20/10	Sumba Grass 7/11 Meat "Oct"
579	154	756	229	1735	176	692

Table 3.6.12. The observed grass-to-meat concentration ratio $*10^3$, based on the **second** grass sampling in **1993**. The time of sampling is noted.

Bøur Grass 1/9 Meat 7/9	Velbastað Grass 2/10 Meat 3/11	Hvalvík Grass 10/10 Meat 13/11	Skáli Grass 26/9 Meat 16/10	Hvalba Gras 6/11 Meat 21/10	Sumba Grass 6/11 Meat 12/10
238	202	115	458	194	416

4. Feeding experiment

A feeding experiment was set up in 1993 to check the low ratios between the concentrations of Cs-137 in grass and lamb meat.

Two lambs, male twins, grazed in a fenced area from 1 September 1993 to 17 September 1993, whereupon they were feeded with grass from the fenced area in a stable at Royndarstøðin í Kollafirði (the Faroese Agricultural Research Station) until 18 October 1993. They were slaugthered on 19 October 1993, about 6 months of age. The amount of food is registrated in Table 4.1. Royndarstøðin í Kollafirði was responsible for the feeding.

Table 4.1. Feeding pr. day of twin lambs. Food from the same grass sample was used for 3 days.

Date	g(**fw**) of food to both lambs	g(**dw**) of food to both lambs	Dry-weight percent
20.09.93	3250	611	18.8
21.09.93	3310	622	18.8
22.09.93	3410	641	18.8
23.09.93	3190	600	18.8
24.09.93	3080	647	21.0
25.09.93	3070	645	21.0
26.09.93	3150	662	21.0
27.09.93	3180	668	21.0
28.09.93	3650	748	20.5
29.09.93	4040	828	20.5
30.09.93	4110	842	20.5
01.10.93	3940	894	22.7
02.10.93	3840	872	22.7
03.10.93	3725	846	22.7
04.10.93	3690	1100	29.8
05.10.93	3330	992	29.8
06.10.93	3210	957	29.8
07.10.93	3090	921	29.8
08.10.93	3010	897	29.8
09.10.93	2890	861	29.8
10.10.93	2780	828	29.8
11.10.93	2820	750	26.6
12.10.93	2805	746	26.6

13.10.93	2790	742	26.6
14.10.93	2705	720	26.6
15.10.93	2680	817	30.5
16.10.93	2700	824	30.5
17.10.93	2780	848	30.5
18.10.93	2810	857	30.5

The Cs-137 activity in the grass can be seen in Table 4.2.

Table 4.2. The Cs-137 activity in the food. The 1 std counting uncertainty is included.

Date	20.09.93	24.09.93	28.09.93	01.10.93	04.10.93	07.10.93	15.10.93
Bq/kgdw	137.0±5.04	93.0±6.06	91.5±4.47	109.8±5.06	87.9±4.46	87.0±3.96	63.2±3.63

The quality of the was analyzed by the Agricultural University of Norway. The results are presented in Table 4.3.

Table 4.3. Chemical analyses of the food used in the feeding experiment. All data have the unit g/kg.

Date	Dry Matter	Ash	Ether-extract	Fibers	Kjeldahl-N	Potass-ium	Sodium	Calsium
24.09.93	940	48	21.9	293	13.3	9.4	1.6	2.8
28.09.93	939	56	20.0	275	13.0	13.2	1.6	3.0
01.10.93	937	59	22.3	263	13.3	12.2	1.7	4.0
04.10.93	940	45	21.1	296	12.6	9.7	1.3	2.3
07.10.93	938	53	20.0	265	12.7	9.9	3.1	3.2
11.10.93	938	52	19.2	293	11.9	9.0	2.1	2.7
15.10.93	939	57	16.7	272	13.9	11.4	1.8	2.9

The content of Cs-137 in muscles and internal organs is presented in Table 4.4. The distribution is practically identical except for testicle. Control measurements of the testicles gave the same results.

Using the average concentration of Cs-137 in grass for the period 1 October - 15 October (87.0 Bq/kg) we get concentration ratios between grass and meat consistent with the results in §3.6.

The carcass weights are low relative to the age of the lambs.

Table 4.4. The Cs-137 activity in the lambs ± counting uncertainty (Bq/kg(fw)±1std). LH: left hand. RH: right hand.			Observed grass-to-meat concentration ratio $*10^3$	
Organ	**Lamb 1**	**Lamb 2**	Lamb 1 Meat/Grass	Lamb 2 Meat/Grass
Heart	20.3±1.31	22.3±1.30	233	256
Liver	23.6±1.17	23.4±1.25	271	269
Kidney	29.4±1.32	31.8±1.62	338	366
Testicle	14.7±0.95	24.0±0.94	169	276
Lung	16.8±1.45	17.9±1.09	193	206
Belly cover	18.4±1.34	20.7±0.98	211	238
LH rear leg	41.6±1.13	42.8±1.43	478	492
RH rear leg	40.8±1.77	39.7±1.10	469	456
LH foreleg	37.1±1.20	30.5±1.36	426	351
RH foreleg	36.2±1.52	33.9±1.53	416	390
Neck	31.7±1.29	29.5±1.45	364	339
Carcass weight	8 kg	11 kg	8 kg	11 kg

The highest activity is observed in rear leg. The neck, which is used by the Faroe Islands in both the RAD-3 and the EKO-2 programme, has an activity in the high end of the activity range from about 17 Bq/kg(fw) to about 40 Bq/kg(fw). The mean activities of 28.2 Bq/kg(fw) in lamb 1 and 28.8 Bq/kg(fw) in lamb 2 indicate that neck muscles repressent the animal fairly well.

It is noted that the concentration ratios in Table 4.4 and the observed concentration ratios between meat and grass reported in §3.6 (e.g. Table 3.6.10) are of the same order of magnitude. Thus the feeding experiment does not answer the question about the low values, but confirms the results found in the RAD-3 and EKO-2 programmes.

Soil sampling was carried out in the fenced area on 18 November 1993 according to the method described under "Material and methods". The results are presented in Table 4.5.

Table 4.5. Concentration (Bq/kg(dw)) and deposition (Bq/m^2) of Cs-137 in soil from the fenced area used for the feeding experiment. 1 st.dev. is included.

	0-5cm layer	5-10cm layer	0-10cm layer
Concentration	281.8 ± 147.8	294.6 ± 224.4	288.9 ± 184.1
Deposition	2162 ± 888	1992 ± 1388	4154 ± 1729

The **aggregated transfer** factor, based on the average concentration of Cs-137 in the neck muscle of the two lambs (30.6 Bq/kg) and the deposition in the 0-10cm soil layer (Table 4.5), is 7.37 m^2/kg. This should be compared to the results in Table 3.6.8.

Mixed grass from the fenced area was also sampled on 11. June 1993 according to our "standard" method, using four 1/4m^2 microplots in the fenced area. The concentration and deposition of Cs-137, including 1 standard deviation, was found to be 154±31 (Bq/kg(dw)) and 14.6±7.1 (Bq/m^2), respectively.

5. Halflife

Assuming an exponential decrease with time of the activity (Bq/kg) and doing a linear regression analysis of the semi-logarithmic relation between time and activity gives the results in Table 5.1 which includes R^2, i.e. the square of the linear regression coefficient. It has not been possible to distinguish between the halflife for Chernobyl- and fallout-caesium, because the Cs-134 activity was often below the detection limit.

Table 5.1. Effective ecological halflives on the assumption of exponential decay. R^2 from the linear regression between time and natural logarithm of activity is shown in paranthesis. No data if R^2<0.49.

	Bøur	Velbastað	Hvalvík	Skáli	Funningur	Sandur	Hvalba	Sumba
Grass 1990-95	1.63 (0.846)	2.86 (0.490)	3.69 (0.753)	6.24 (0.530)	1.61 (0.861)	1.04 (0.733)		2.64 (0.494)
Meat 1990-94	11.2 (0.653)	4.81 (0.716)	1.67 (0.828)					3.47 (0.447)
Liver 1990-94		7.70 (0.803)					5.59 (0.498)	4.13 (0.498)
Heart 1990-94		3.50 (0.823)						1.94 (0.816)
Kidney 1990-94	3.27 (0.868)	2.48 (0.951)						3.07 (0.567)

Since we do only have data for 5-6 years, it is not possible to give a qualified estimate of the halflives. The observations until now, however, indicate that the decay model is more complicated than simple exponential and that it may be considered to take processes in the soil into account.

6. Faeces

Faeces from lamb have been analysed in 1995. The results are presented in Table 6.1.

Table 6.1. Cs-137 (Bq/kgdw) in faeces, date corrected to 1 July 1995. Sampling dates are included. The *) marks samples from the date of grass and soil sampling.

Bøur	Velbastað	Hvalvík	Skáli	Norðoyri	Sandur	Hvalba	Sumba
57.0 95.06.22	63.8 95.06.27	40.5 95.06.27	120.9 *) 95.07.19	98.2 *) 95.07.20	111.0 *) 95.07.18	33.6 95.06.21	38.8 95.06.23
32.6 *) 95.07.31	59.2 *) 95.07.18	61.5 *) 95.08.07	120.9 95.07.19			23.2 *) 95.08.05	69.0 *) 95.08.06
112.8 95.10.13	13.7 95.10.20	118.6 95.10.23				13.4 95.10.27	43.8 95.10.27

The ratio between the Cs-137 concentration (Bq/kg(dw)) in faeces and mixed grass sampled at the same dates is set up in Table 6.2.

Table 6.2. Upper row: Ratio between Cs-137 (Bq/kgdw) in faeces and in mixed grass (faeces/grass). **Lower row:** Ratio (multiplied by 1000) between Cs-137 concentration in faeces and the Cs-137 deposition (Bq/m^2) in the 0-10cm soil layer.

Bøur	Velbastað	Hvalvík	Skáli	Norðoyri	Sandur	Hvalba	Sumba
2.31	2.18	0.433	2.41	1.64	11.2	2.23	1.82
5.90	12.1	14.8	14.5	13.5	18.3	5.18	10.7

The faeces/grass concentration ratio in Hvalvík and Sandur differ from the values found in other pastures. Concerning the transfer factor from soil to faeces it is noted that Bøur and Hvalba tend to have lower values than other pastures. Further analyses concerning faeces remain to be done, e.g. in relation to analyses of meat samples.

7. Discussion (preliminary)

The report presents Faroese results of measurements carried out for 6 years in the RAD-3 programme and the EKO-2 programme.

Radiocaesium has been measured in soil, grass and lambs from nine uncultivated pastures, 50 to 240 meters above sea level. The reason for using nine pastures is partly to look into the geographical variation and partly to get fairly representative results for the country. The difficulty of getting representative results is well known. The sampling method used in the project makes the estimated transfer from soil to plant reasonable. It is more problematic when it comes to the transfer to lamb, because it is diffucult to know how the sampled grass represent the food of the lambs.

Chemical soil parameters have been measured in addition to radiocaesium. The soil type is peaty with PH below 5.3. The ignition loss is generally around 50-70%. The content of potassium and sodium is mostly in the range 300-600 mg/kg.

The ratio between the depositions in the top 5cm of the soil and the 0-10cm soil layer has a range from 0.5 to 0.8 every year. Profile studies carried out in 1992, when the upper 5cm of the cores were split up into 1cm layers, showed that the content of caesium from Chernobyl was highest in a depth of 1-3cm (cf. Table 3.2.7). The highest Cs-134/Cs-137 ratios were found in the southern part of the country.

A considerable amount of Cs-137 from the weapon tests is still found in the upper soil layers. Chernobyl-caesium as well as fallout-caesium (from the weapon tests) show significant geographical variation (cf. Table 3.2.7). The geographical variety of the ratio between Chernobyl-caesium and fallout-caesium is significant as well. Weather and climate conditions are considered as important explaining factors for the differenses.

The deposition of Cs-137 in the 0-10cm soil layer has not changed significantly from 1990 to 1995. For the country as a hole the value is around 5-6 kBq/m^2.

The level of the concentration of Cs-137 in grass has lowered since 1990. High within pasture variation is observed between the selected $1/4m^2$ microplots, indicating the difficulty of taking representative grass samples. These circumstances may reflect a difference in botanical composition.

In order to investigate the time variation of the activity in grass, sampling was carried out several times in the years 1991, 1992 and 1993. Particular attention was given to Hvalvík (chosen for practical reasons), but grass was also sampled several times in other pastures. The results indicate that the time of maximum activity is between mid July and mid August.

The observed concentration ratios and transfer factors vary significantly both geographically and within the pastures. The average ratio between the concentration (Bq/kg) of Cs-137 in meat and grass is observed to be a factor 2-3 lower in the Faroe Islands than in Norway, having similar soil types as the Faroe Islands. A controlled feeding experiment with two male twin lambs confirmed the observed ratios. The average aggregated transfer factor (m^2/kg) from soil to meat is a factor about 15-20 lower than in Norway, while the average observed transfer factor from soil to grass is a factor 3-10 lower than in Norway. Details of the observations can be found in §3.6.

A scatterplot of some of the obseravtions can be found in Figs. 7.1-7.4 (covering the RAD-3 period). However, in a big plot like this, some graphs make little or no sense. The correlations between the parameters is weak in most cases. The grass/soil concentration ratio is negatively correlated to PH in the soil and possitively correlated to the ignition loss of the soil; to some extent it is negatively correlated to potassium in the soil. The meat/gras concentration ratio tends to be possitively correlated to PH in the soil. A negative correlational trend is found between PH in the soil and the meat/soil concentration ratio and the soil-to-grass and soil-to-meat transfer factors. The Cs-137 concentration in meat, grass and soil tends to be negatively correlated to PH and possitively correlated to the ratio between Bq/kg Cs-137 and grams of sodium in the 0-10cm soil layer.

Estimates of effective ecological halflives are given on the assumption of a simple exponential decrease with time. For mixed grass, covering 6 years of data, the range is 1.04-6.24 years, and for meat and internal organs (covering 5 years) it is 1.94-11.2 years. However, the simple exponential model is found to fit badly to the data in most cases. The decay model will presumeably be more complicated, and it should be considered to take soil processes into account.

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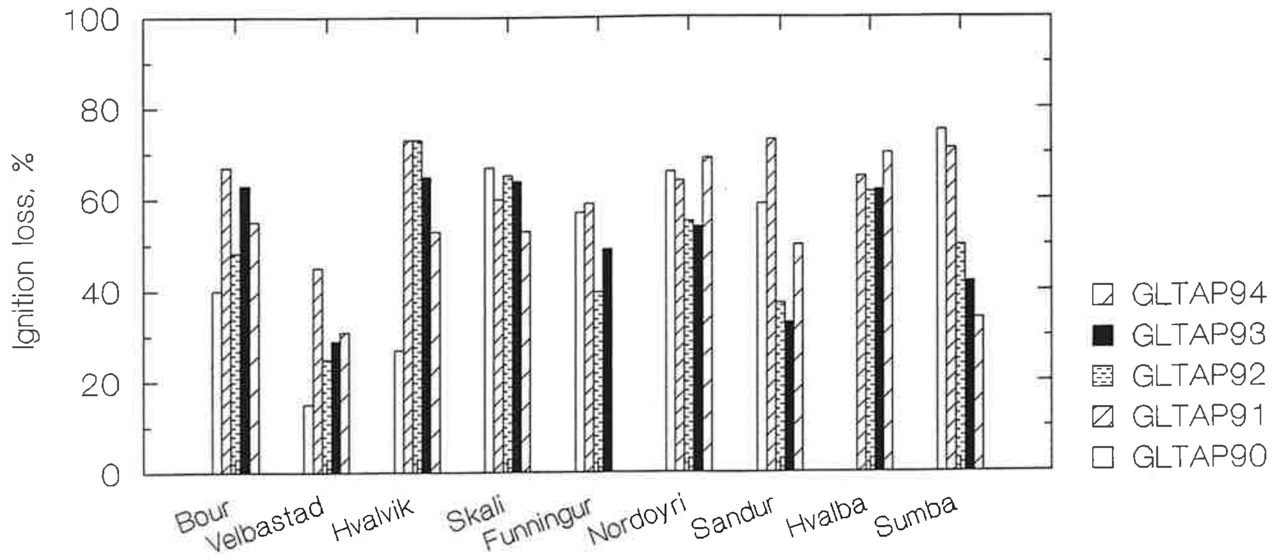

Figure 3.1.1 Ignition loss in the 0-10cm soil layer. Mean values for the pastures.

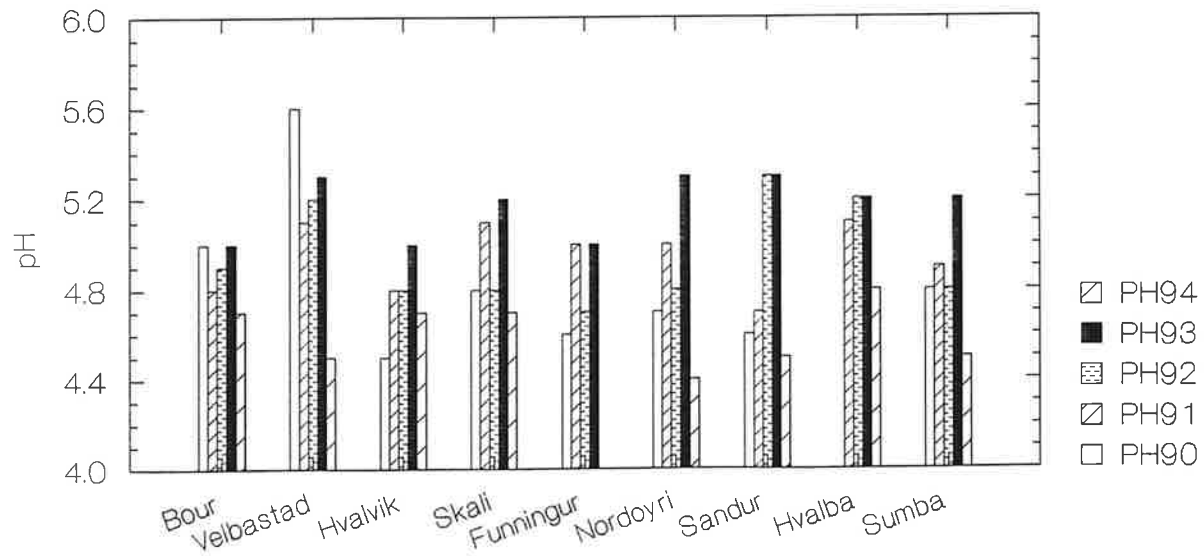

Figure 3.1.2 PH in the 0-10cm soil layer. Mean values for the pastures.

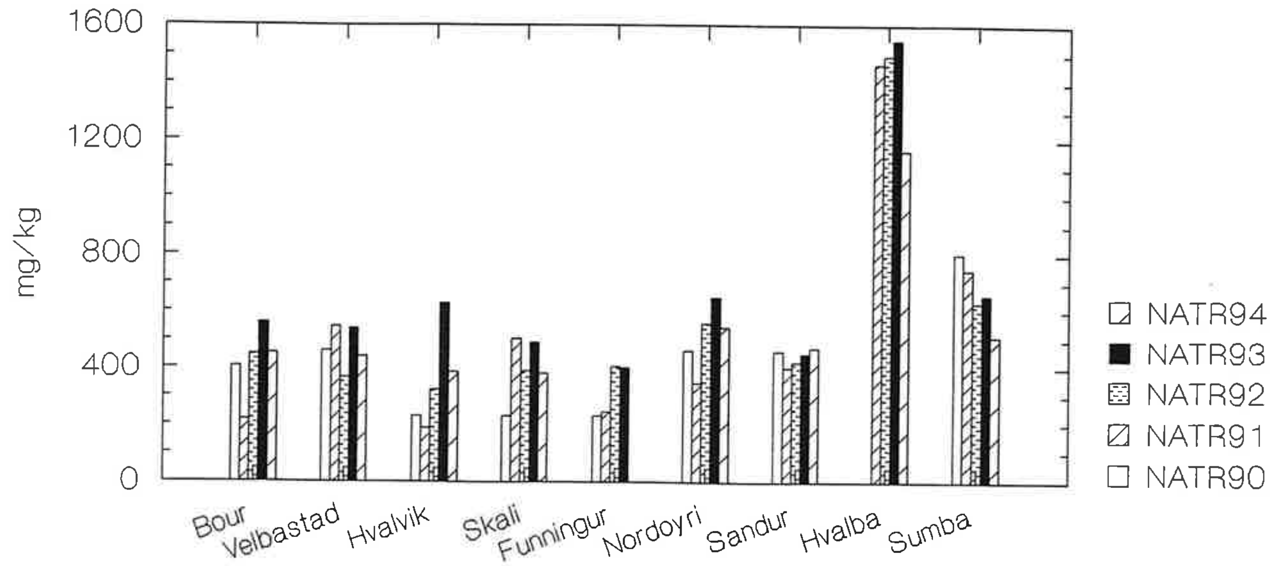

Figure 3.1.3 Sodium in the 0-10cm soil layer. Mean values for the pastures.

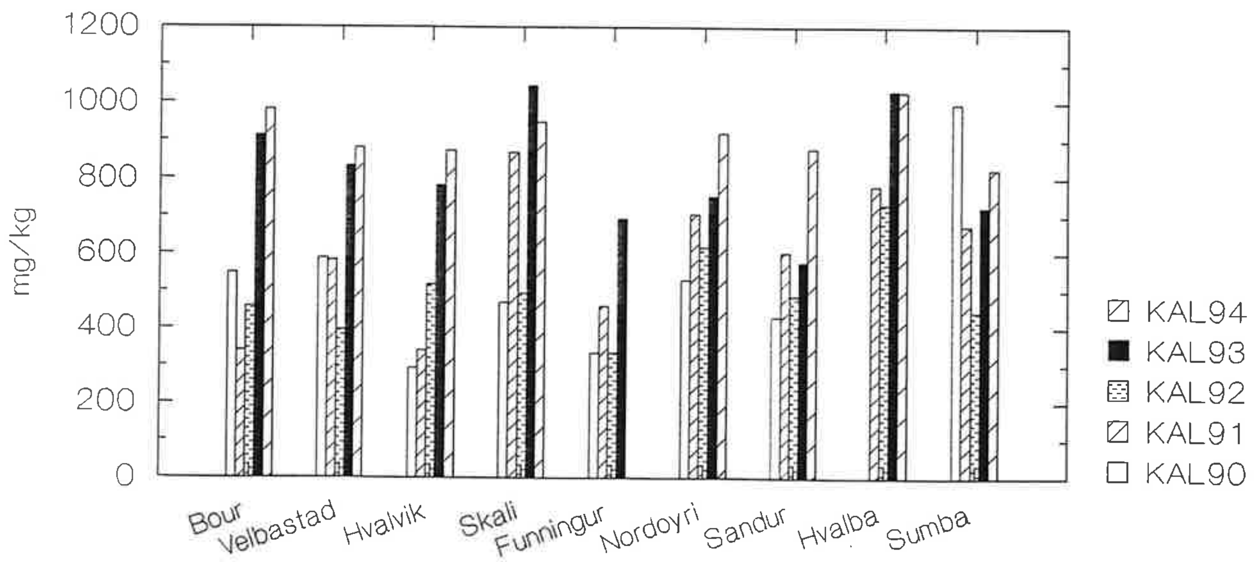

Figure 3.1.4 Easily solluble potassium in the 0-10cm soil layer. Mean values for the pastures.

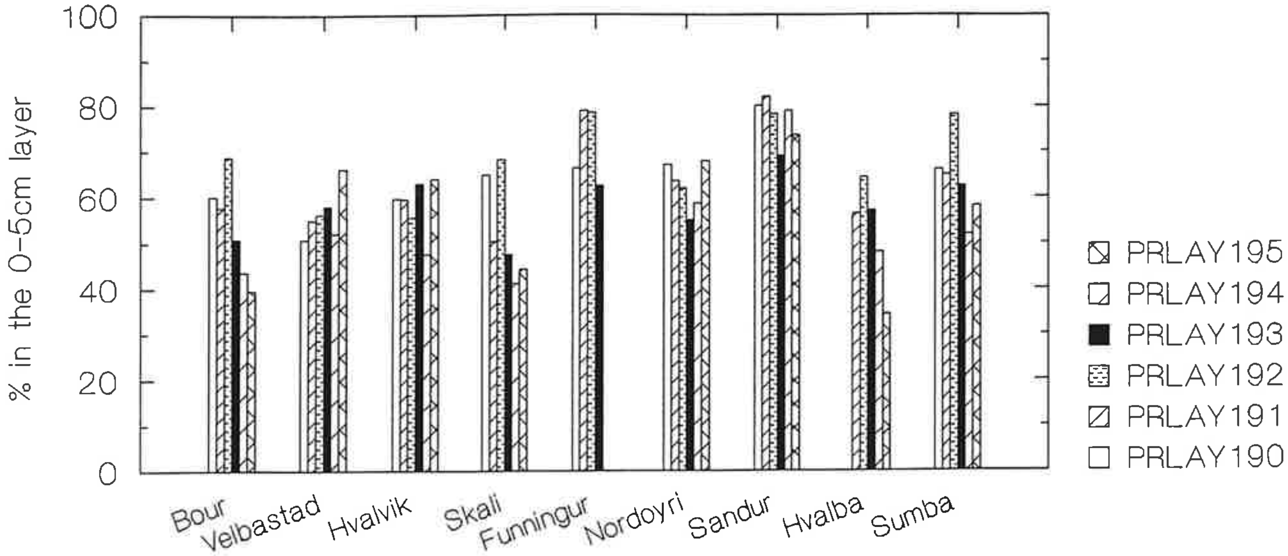

Figure 3.2.1 Cs-137 deposition in the 0-5cm soil layer relative to Cs-137 deposition in the 0-10cm soil layer.

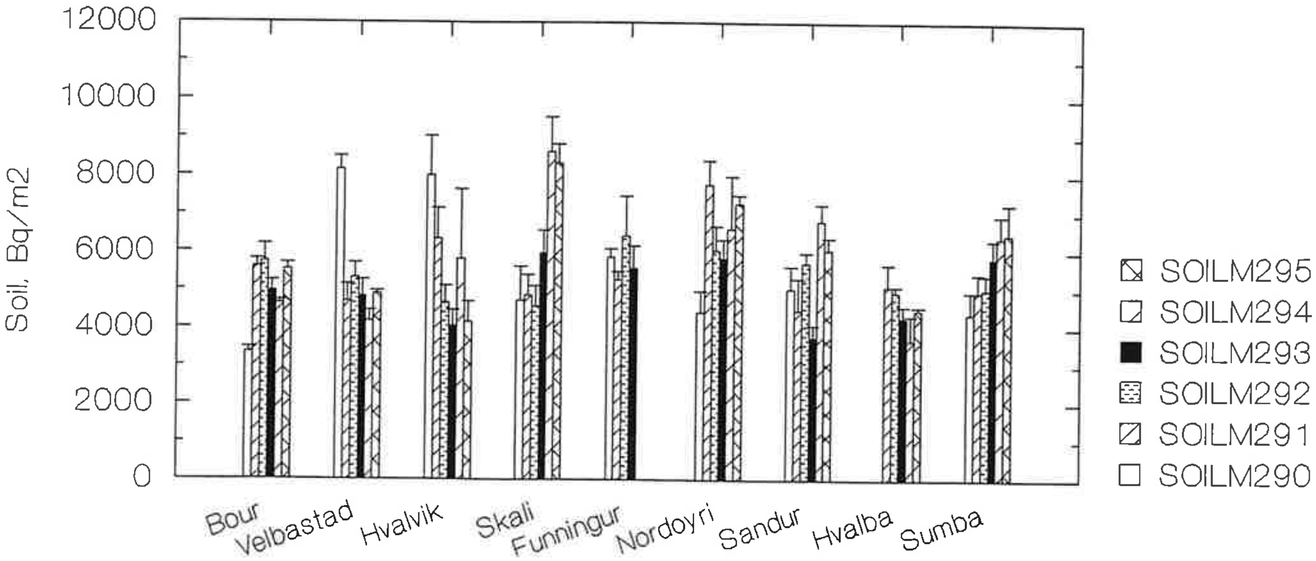

Figure 3.2.2 Cs-137 deposition in the 0-10cm soil layer. The error bars represent 1 standard error.

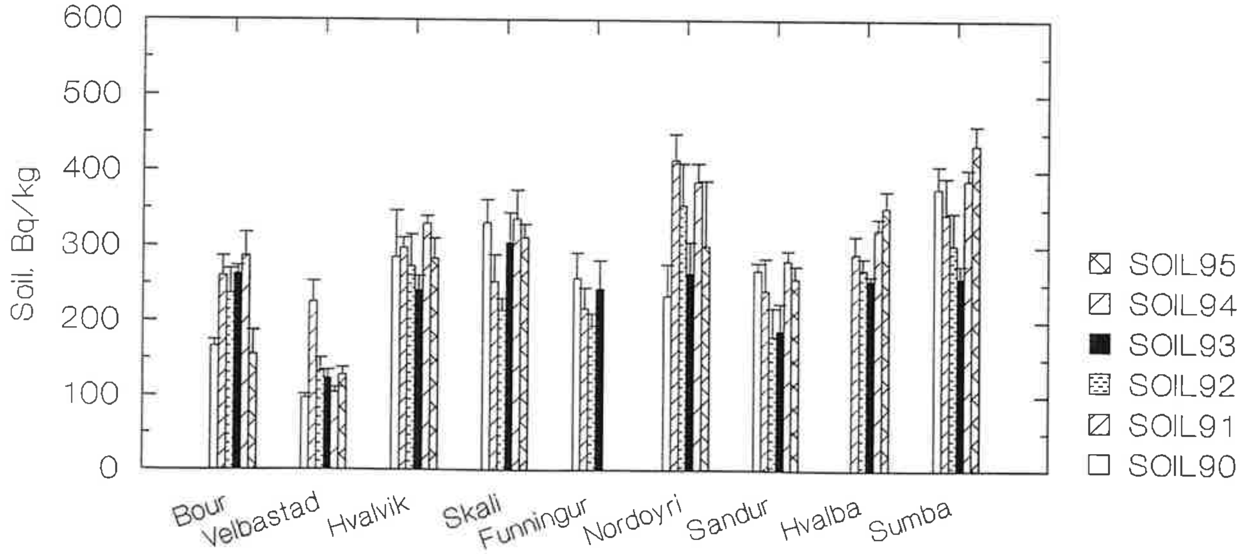

Figure 3.2.3 Concentration of Cs-137 in the 0-10cm soil layer. The error bars represent 1 standard error.

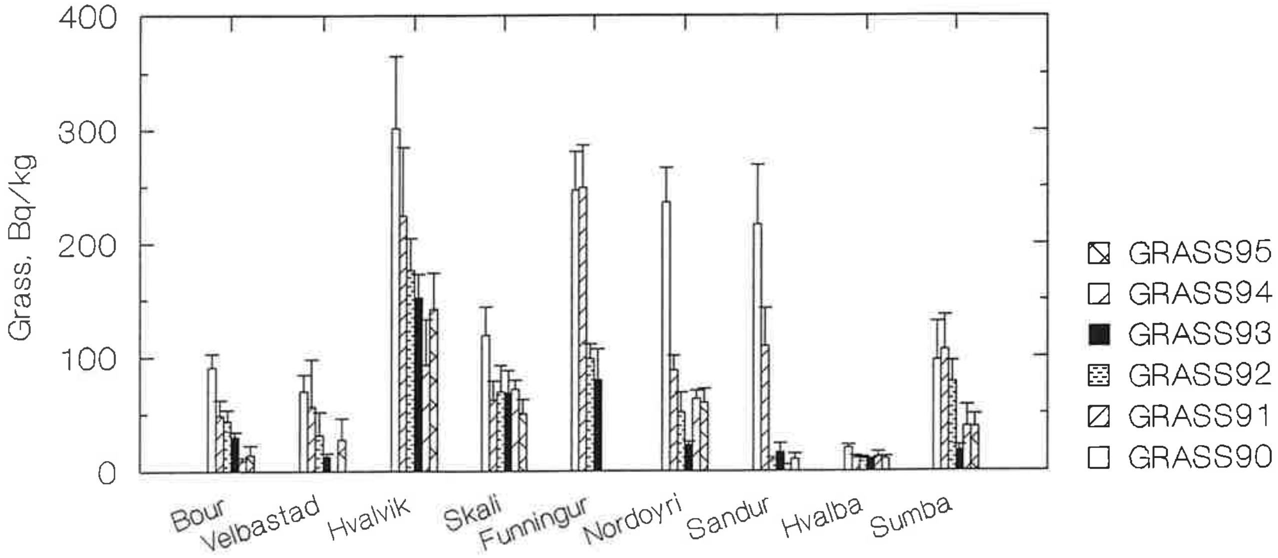

Figure 3.3.1 Concentration of Cs-137 in mixed grass. The error bars represent 1 standard error.

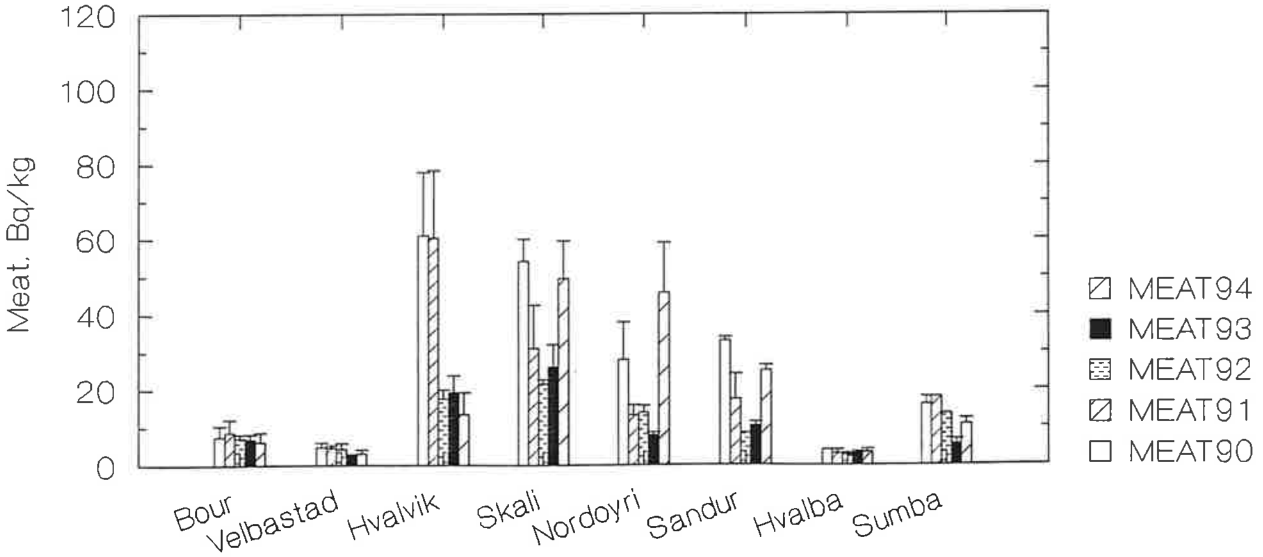

Figure 3.5.1 Concentration of Cs-137 in lamb meat. The error bars represent 1 standard error.

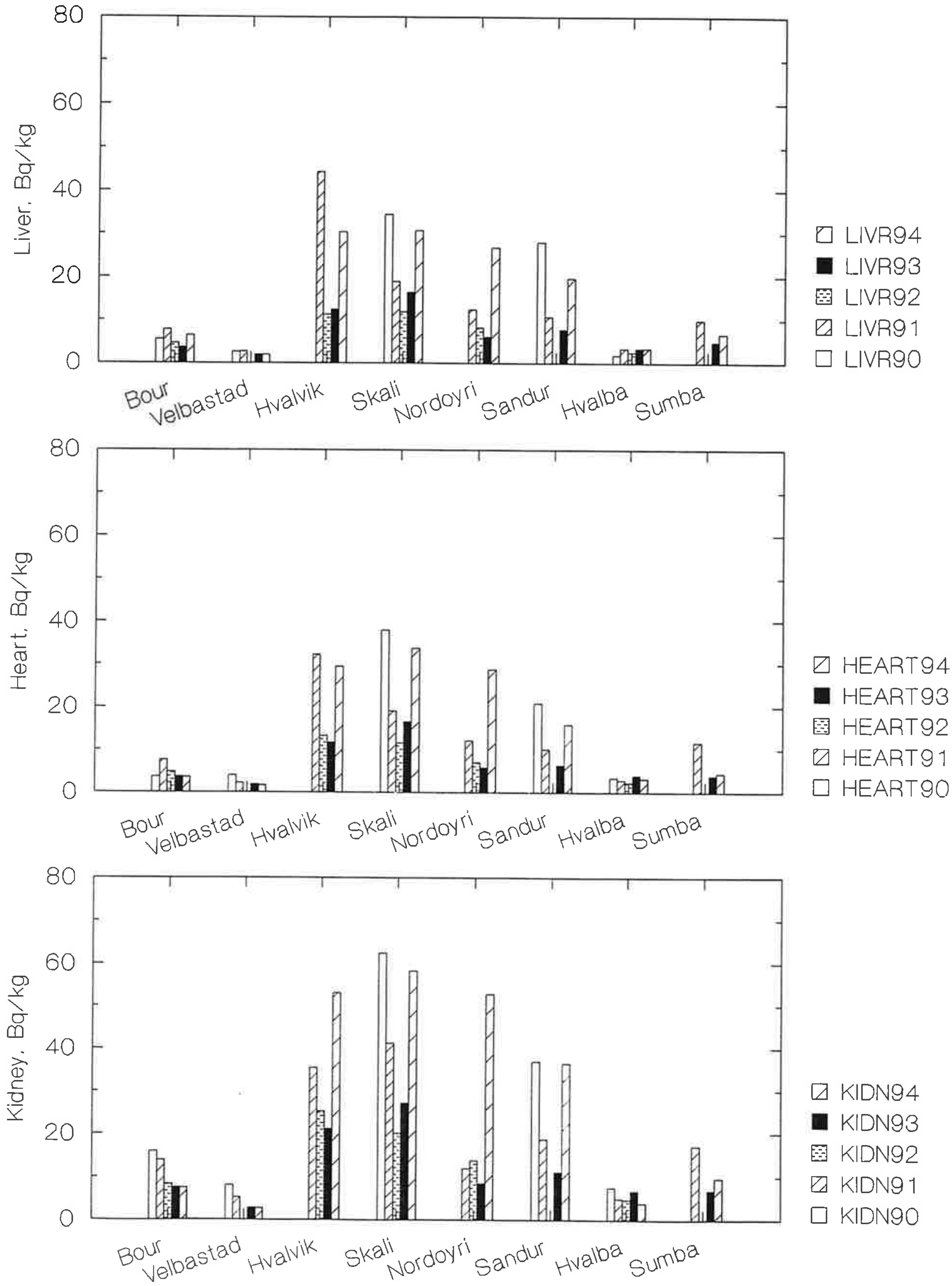

Figure 3.5.2 Concentration of Cs-137 in internal organs of lamb.
More detailed results are found in Tables 3.5.4-3.5.7.

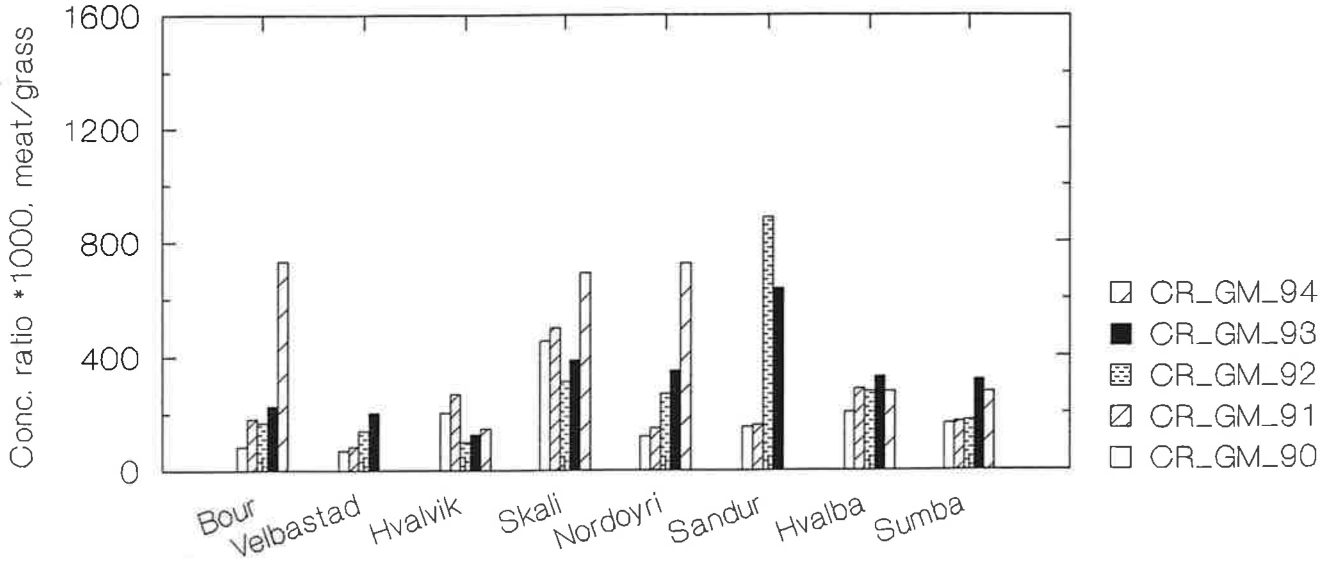

Figure 3.6.1 Meat/grass concentration ratios of Cs-137.
More detailed results are found in Tables 3.6.1-3.6.6.

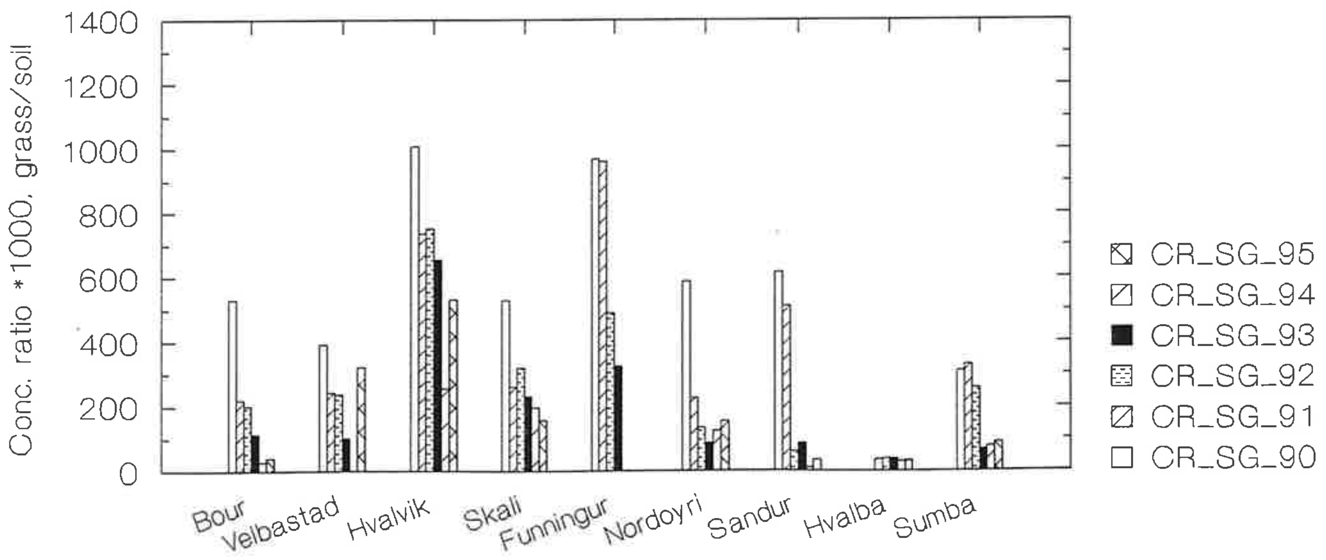

Figure 3.6.2 Grass/soil concentration ratios of Cs-137.
More detailed results are found in Tables 3.6.1-3.6.6.

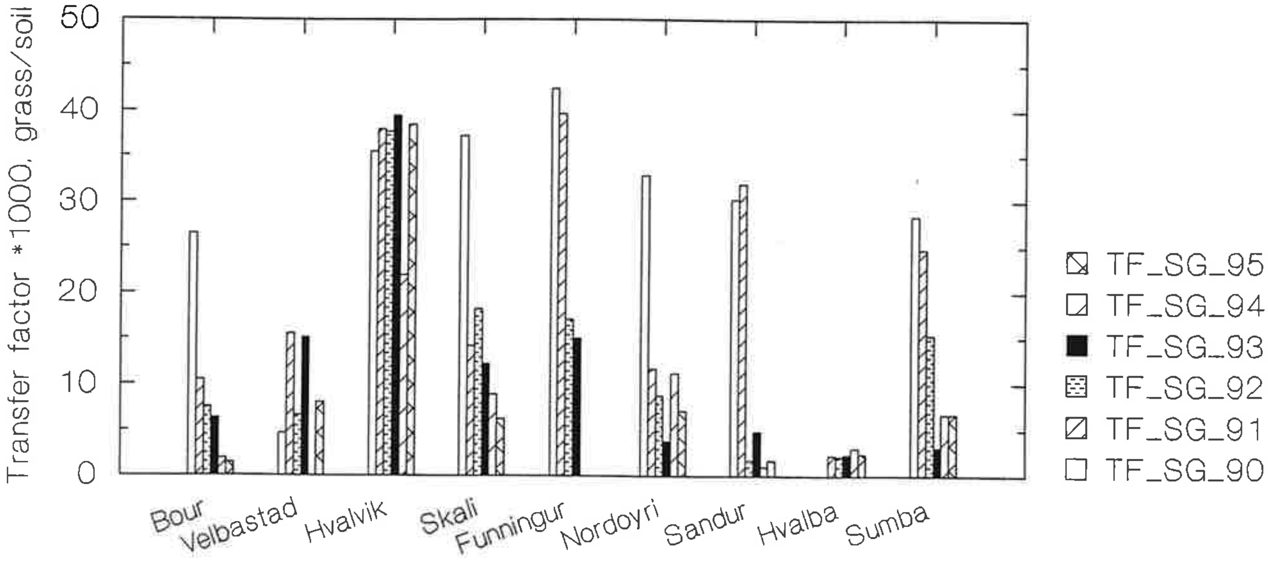

Figure 3.6.3 Soil-to-grass transfer factor of Cs-137.
More detailed results are found in Tables 3.6.7-3.6.9.

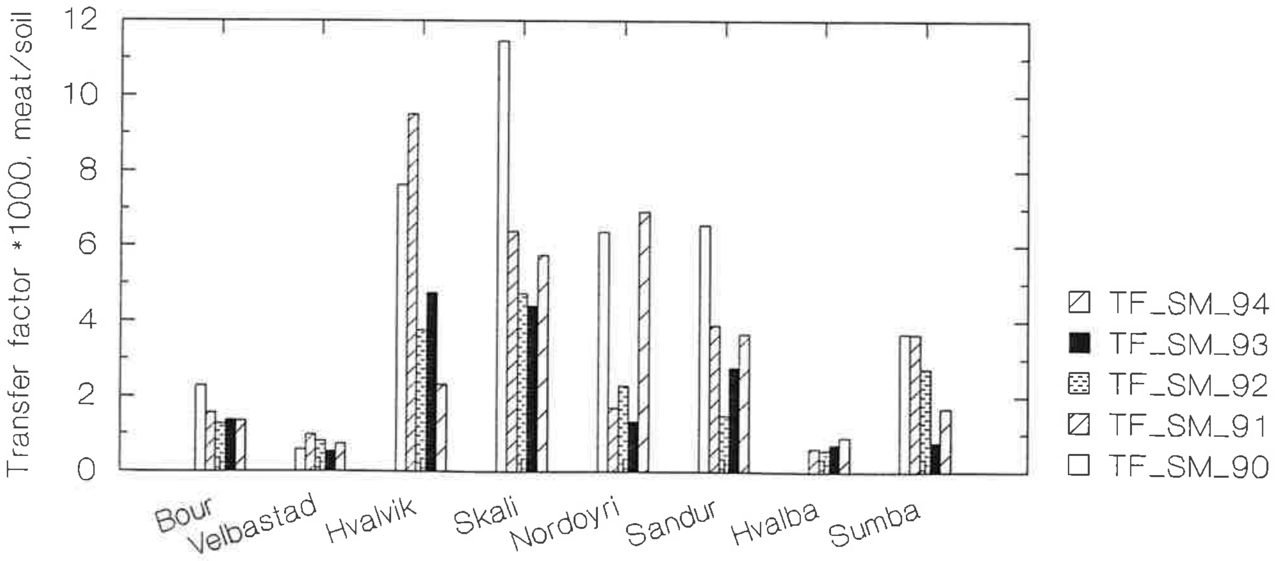

Figure 3.6.4 Soil-to-meat transfer factor of Cs-137.
More detailed results are found in Tables 3.6.7-3.6.9.

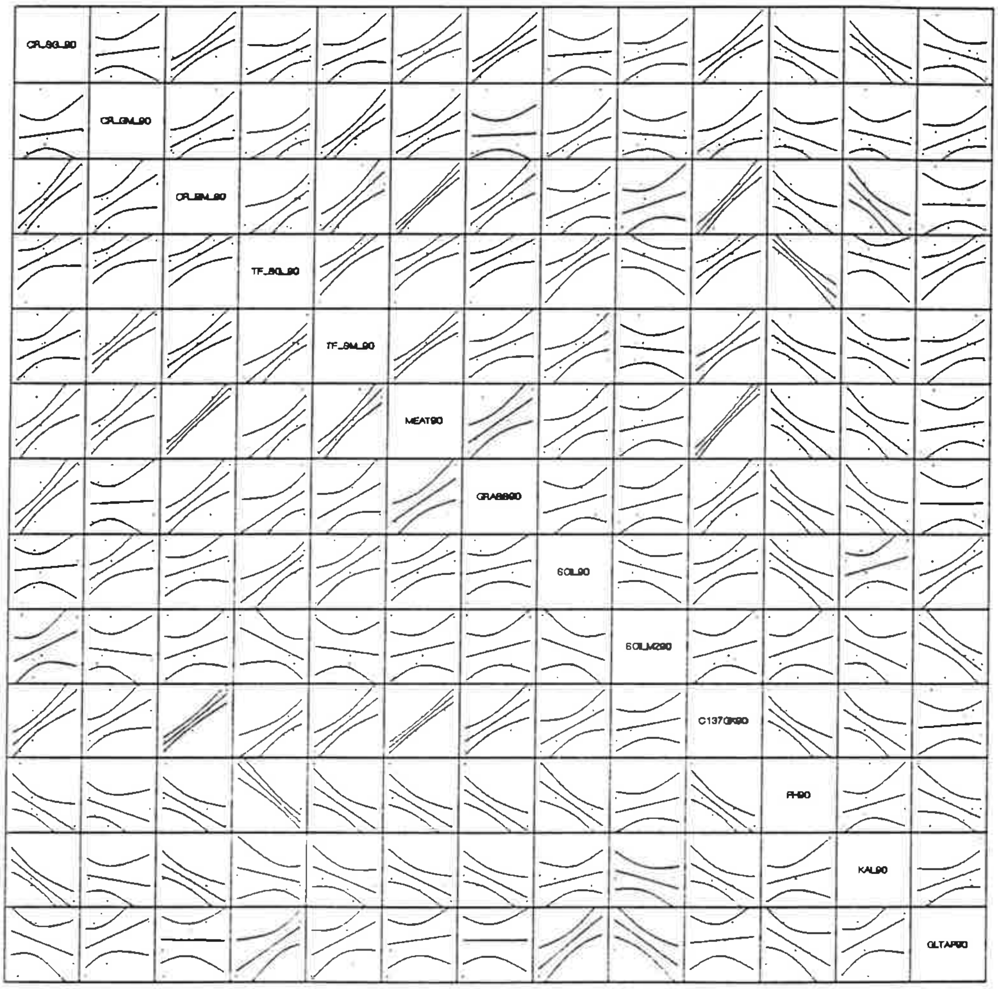

Figure 7.1 Scatter plot of results from 1990. The regression line and the 65% confidence interval is included.

Abreviations: CR_SG= (Grass Bq/kg)/(Soil Bq/kg). **CR_GM=** (Meat Bq/kg)/(Grass Bq/kg). **CR_SM=** (Meat Bq/kg)/(Soil Bq/kg). **TF_SG=** (Grass Bq/kg)/(Soil Bq/m^2). **TF_SM=** (Meat Bq/kg)/(Soil Bq/m^2). **MEAT**: Bq/kg in meat. **GRASS**: Bq/kg in grass. **SOIL**: Bq/kg in 0-10cm soil. **SOILM2**: Bq/m^2 in 0-10cm soil. **CS137GK**: (Bq/kg Cs-137 in 0-10cm soil)/(gram K in 0-10cm soil). **PH**: pH in 0-10cm soil. **KAL**: Potassium in 0-10cm soil. **GLTAP**: Ignition loss in 0-10cm soil.

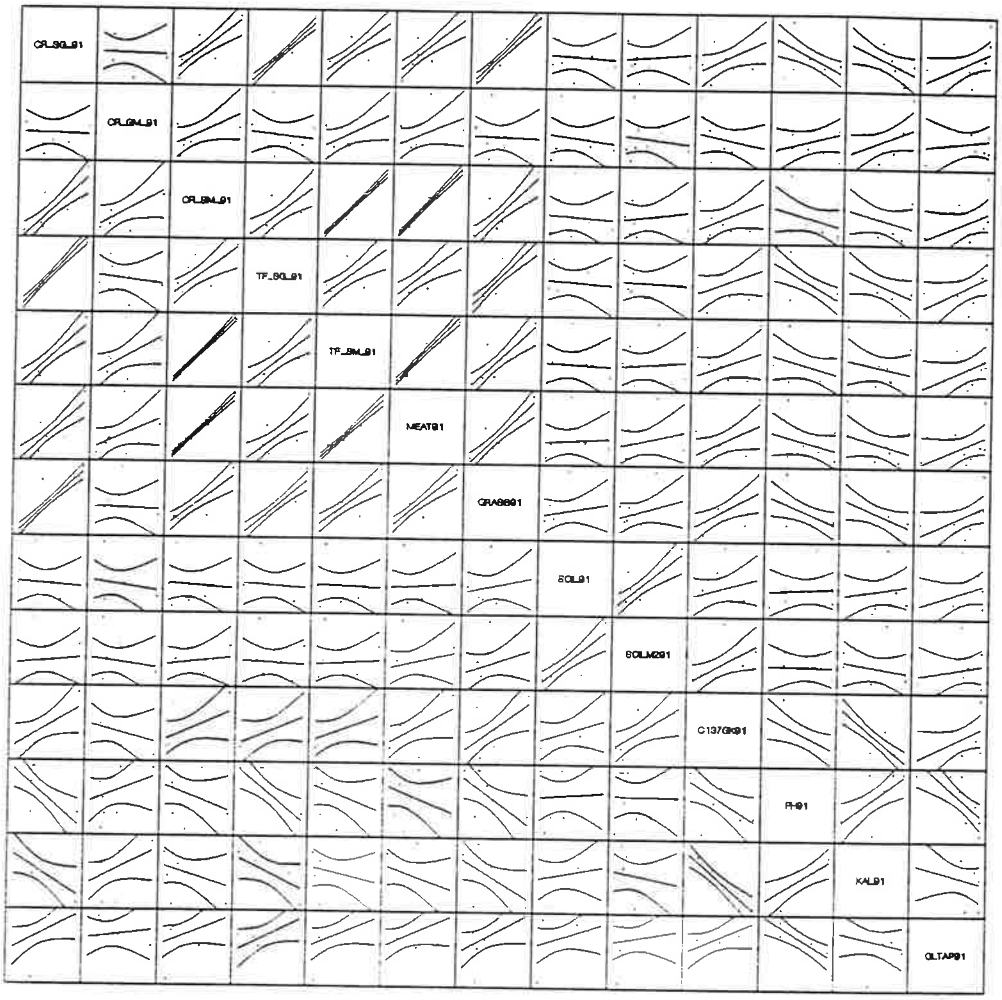

Figure 7.2 Scatter plot of results from 1991. The regression line and the 65% confidence interval is included.

Abreviations: CR_SG= (Grass Bq/kg)/(Soil Bq/kg). **CR_GM=** (Meat Bq/kg)/(Grass Bq/kg). **CR_SM=** (Meat Bq/kg)/(Soil Bq/kg). **TF_SG=** (Grass Bq/kg)/(Soil Bq/m^2). **TF_SM=** (Meat Bq/kg)/(Soil Bq/m^2). **MEAT**: Bq/kg in meat. **GRASS**: Bq/kg in grass. **SOIL**: Bq/kg in 0-10cm soil. **SOILM2**: Bq/m^2 in 0-10cm soil. **CS137GK**: (Bq/kg Cs-137 in 0-10cm soil)/(gram K in 0-10cm soil). **PH**: pH in 0-10cm soil. **KAL**: Potassium in 0-10cm soil. **GLTAP**: Ignition loss in 0-10cm soil.

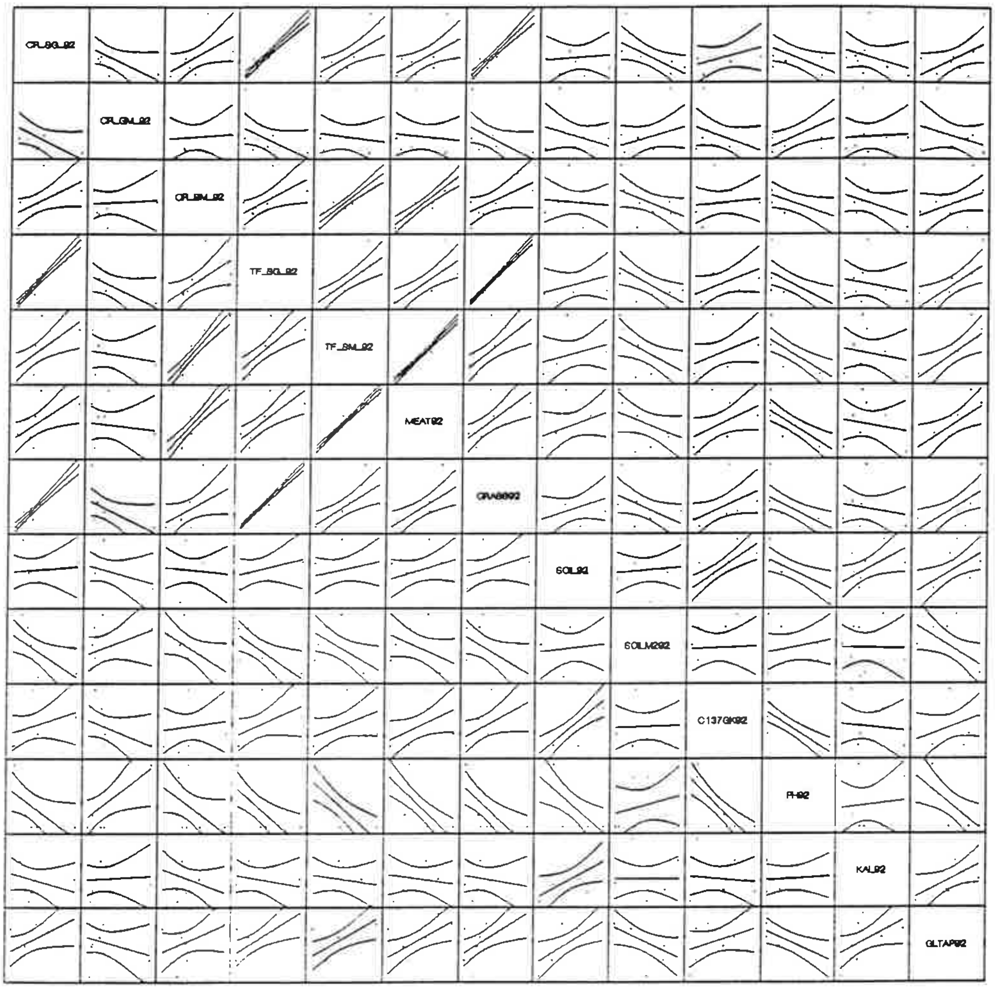

Figure 7.3 Scatter plot of results from 1992. The regression line and the 65% confidence interval is included.

Abreviations: CR_SG= (Grass Bq/kg)/(Soil Bq/kg). **CR_GM=** (Meat Bq/kg)/(Grass Bq/kg). **CR_SM=** (Meat Bq/kg)/(Soil Bq/kg). **TF_SG=** (Grass Bq/kg)/(Soil Bq/m^2). **TF_SM=** (Meat Bq/kg)/(Soil Bq/m^2). **MEAT:** Bq/kg in meat. **GRASS:** Bq/kg in grass. **SOIL:** Bq/kg in 0-10cm soil. **SOILM2:** Bq/m^2 in 0-10cm soil. **CS137GK:** (Bq/kg Cs-137 in 0-10cm soil)/(gram K in 0-10cm soil). **PH:** pH in 0-10cm soil. **KAL:** Potassium in 0-10cm soil. **GLTAP:** Ignition loss in 0-10cm soil.

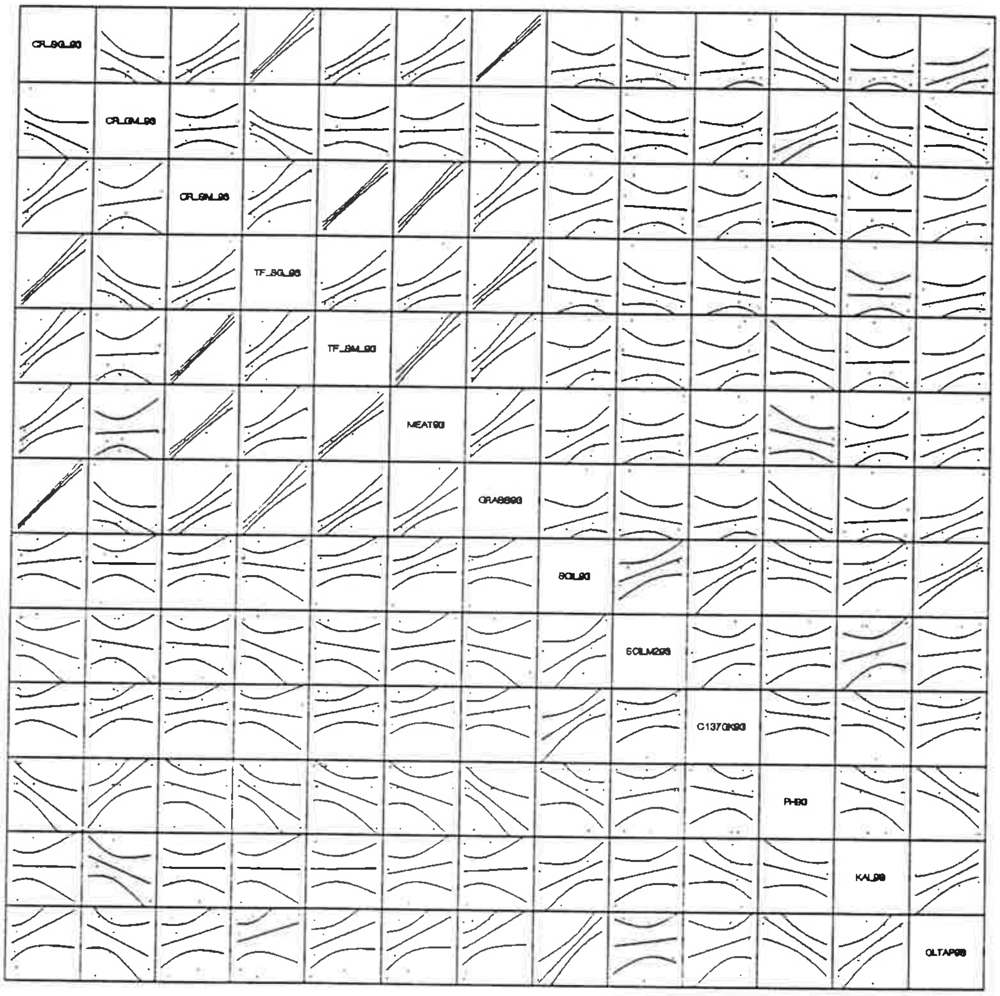

Figure 7.4 Scatter plot of results from 1993. The regression line and the 65% confidence interval is included.

Abreviations: CR_SG= (Grass Bq/kg)/(Soil Bq/kg). **CR_GM=** (Meat Bq/kg)/(Grass Bq/kg). **CR_SM=** (Meat Bq/kg)/(Soil Bq/kg). **TF_SG=** (Grass Bq/kg)/(Soil Bq/m^2). **TF_SM=** (Meat Bq/kg)/(Soil Bq/m^2). **MEAT**: Bq/kg in meat. **GRASS**: Bq/kg in grass. **SOIL**: Bq/kg in 0-10cm soil. **SOILM2:** Bq/m^2 in 0-10cm soil. **CS137GK:** (Bq/kg Cs-137 in 0-10cm soil)/(gram K in 0-10cm soil). **PH**: pH in 0-10cm soil. **KAL**: Potassium in 0-10cm soil. **GLTAP**: Ignition loss in 0-10cm soil.