Groundtruth collection for the JPL-SAR and ERS-1 campaign in Flevoland and the Veluwe (NL) 1991

M.A.M. Vissers en J.J. van der Sanden

RAPPORT 31

December 1992

Vakgroep Waterhuishouding
Nieuwe Kanaal 11, 6709 PA Wageningen

ISSN 0926-230X

Wageningen Agricultural University (WAU)

Departement of Water Resources
Nieuwe Kanaal 11
6709 PA Wageningen
Telefax: +31 (0)8370-84885
Telex: NL 45015
Earn/Bitnet: VISSERS@RCL.WAU.NL

Vissers, Ir. M.A.M. and Ir. J.J. van der Sanden

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Wageningen Agricultural University (Departement of Water Resources)
Wageningen, The Netherlands, 68 pages & 2 appendices.

CONTENTS

1 INTRODUCTION

In the framework of the SIR-C/X-SAR (space shuttle) project an airborne campaign with the NASA/JPL multiband polarimetric SAR (a prototype of the space shuttle SAR) is carried out over a number of the selected European sites. The campaign (JPL-SAR experiment 1991; 3.2/AO-02) was planned for a six-weeks period on a multi-temporal basis starting the last week of June until the first week of August. Thus it coincided with a substantial part of the agricultural growing season. The Flevoland site has obtained the status of international 'supersite' for the SIR-C/X-SAR project and was visited four times during the campaign (June 15th, July 3rd, July 12th and July 28th 1991). The data acquired will strongly support the development of the application of polarimetric radar data.

Aircraft imaging radar such as SLAR and SAR indicated their use for crop identification. The data also provide information about the physical properties of the surface of the vegetation and the soil. As with radar satellite systems images are obtained on a regular base, they are promising for monitoring purposes. The aim of the project, land use monitoring with ERS-1; 3.2/TO-01, is the development of a monitoring system applying ERS-1 SAR imagery in combination with SPOT and TM, dealing with agricultural crop growth, the occurrence of diseases in forestry and the monitoring of vegetation for nature areas.

Within both projects (3.2/AO-02 and 3.2/TO-01) ground data was collected for soil and vegetation in agricultural areas comprising crops (Flevoland) and grasslands (Veluwe). Forest data was collected in selected study stands in the Horsterwold and Speulderbos. A database will be established suitable for the study of land use and soil moisture mapping.

- Soil moisture was measured by the Heidemij and the Wageningen Agricultural University department of Water Resources (WAU-WR).
- Soil surface roughness was measured by WAU-WR.
field reflectance measurements were taken by the Centre for Agrobiological Research (CABO) and Wageningen Agricultural University department of Landsurveying and Remote Sensing (WAU-LRS).
- Crop observations were made by CABO, WAU-WR, and WAU-LRS.
- Field inventory was done by CABO WAU-WR and Directorate Flevoland (DF).
- The vegetation map was processed by the Winand Staring Centre (WSC), WAU-WR, CABO, Heidemij and DF.
- The Forest stands parameters were collected by WAU-WR.

Other reports closely related with this groundtruth report are Büker et al (1992), Heidemij (1991) and Uenk et al (1992).

These projects were carried out with the financial support of the Dutch Remote Sensing Board (BCRS), projects 3.2/AO-02 and 3.2/TO-01.

2 TEST SITE DESCRIPTION

In the Netherlands the test sites selected for the JPL-SAR and the ERS-1 campaigns were the Horsterwold and Speulderbos sites (both forested) wheras the Flevoland site was cultivated with agricultural crops (fig 2.1). The Speulderbos site was situated on the 'old' land, while the Horsterwold and Flevoland site are situated in the Flevopolder, a polder newly reclaimed from lake IJssel.

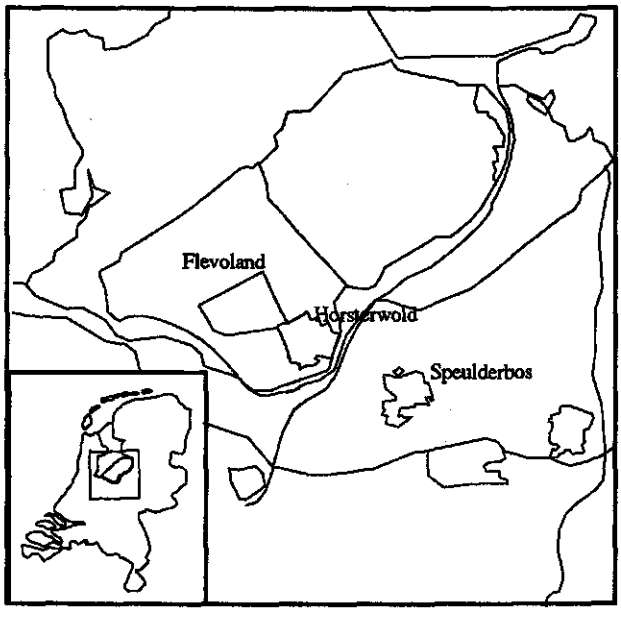


Fig 2.1 The test sites of the JPL-SAR and ERS-1 campaigns

The two forest sites are different with respect to: tree species, tree age, type of forest management and soil type. At the Horsterwold site all forests are plantes in a regular row pattern. The general altitude of the site is 3 meters below sea level (3 m -NAP). The Speulderbos forest is located on an ice-pushed ridge. The altitude of the Speulderbos site varies between 40 and 55 meters above sea level (40 and 55 m +NAP). The Flevoland site is in cultivation by individual farmers and a state owned farm. The fields of the state farm are relatively large, compared to the fields cultivated by private farmers. The general altitude of the site is 3 meters below sea level (3 m -NAP). (Droessen et. al. 1989)

3 COLLECTION OF DATA IN AGRICULTURAL AREA

3.1 SOIL MOISTURE

Soil moisture measurements were carried out with a Time Domain Reflectometry (TDR) system (Heimovaara, 1990 and Roth, 1990). For this a TDR probe, consisting of 2 parallel steel rods, is inserted into the soil layer in a manner that the soil forms the dielectric material of a transmission line (formed by the rods). Steplike electromagnetic signals are transmitted into the soil along the guide, when the signal has travelled to the end of the guide it is reflected back to the instrument where its return is recorded. From this the dielectric permittivity and the volumetric soil water content can be calculated.

Soil moisture measurements were recorded on the dates of the SAR overflights except on 14 June. No recordings were taken that day due to continual rainfall. Data were collected in four different crops (beet, potato, wheat and maize), three fields per crop. In potato fields measurements were taken on the ridge and in the furrow seperately. In each field six random measurements were taken at 50 m intervals along two transects at a depth of 0-5 cm and 0-10 cm. The average values are given in tables 3.1.1 and 3.1.2

			DATE							
Field	CROP	Depth	23-05	03-07	12-07	28-07	02-08	19-09	25-09	01-10
59	SBT	0-5	24.2	28.4	34.3	23.3	19.4	20.1	30.2	29.7
		0-10	31.3	32.8	35.0	24.4	25.2	25.0	28.6	32.3
53	SBT	0-5	14.9	32.9	29.2	22.4	21.0	16.7	24.8	31.5
		0-10	26.6	36.8	30.9	25.8	27.0	23.9	27.6	32.3
224	SBT	0-5	27.2	40.2	33.2	25.0	17.2	16.2	27.9	26.2
		0-10	29.2	41.8	33.9	27.6	20.4	19.6	28.1	30.9
46	POT_R	0-5	5.6	28.3	*	9.8	6.6	11.4	19.2	21.3
		0-10	9.2	27.5	*	11.4	8.7	15.3	22.3	24.6
	POT_F	0-5	14.6	41.3	*	27.6	28.8	23.1	27.6	32.8
		0-10	25.7	47.4	*	32.9	32.8	28.7	31.5	37.4
56	POT_R	0-5	3.5	31.0	*	9.5	8.6	9.9	19.5	19.6
		0-10	9.4	31.1	*	11.9	9.8	14.0	22.0	22.1
	POT_F	0-5	10.5	45.6	*	15.8	13.3	20.0	28.3	29.8
		0-10	23.6	49.5	*	21.2	20.2	23.0	31.8	32.9
223	POT_R	0-5	7.4	20.6	*	11.9	8.6	10.0	16.8	22.5
		0-10	11.8	32.5	*	13.7	10.5	13.5	17.4	27.4
	POT_F	0-5	13.7	32.6	*	22.2	14.2	22.7	22.7	31.5
		0-10	21.9	39.9	*	24.5	16.7	24.6	26.4	32.9
48	WHE	0-5	12.7	43.6	29.0	22.9	20.8	13.1	*	25.3
		0-10	18.1	45.2	31.9	26.8	19.8	18.5	*	27.3
50	WHE	0-5	9.8	38.8	25.6	18.8	20.8	18.9	26.9	29.5
		0-10	22.1	42.3	30.2	25.1	23.4	22.3	30.9	31.3
221	WHE	0-5	12.1	29.8	26.6	22.1	13.9	17.1	21.9	27.3
		0-10	16.5	32.9	28.6	26.0	14.8	20.3	25.8	30.2
43	MAI	0-5	18.0	31.4	20.3	18.3	15.2	22.2	26.0	32.0
		0-10	24.9	36.5	29.7	26.1	19.2	23.8	29.3	32.4
158	MAI	0-5	13.4	33.6	29.2	23.8	16.8	14.8	*	30.4
		0-10	26.2	35.6	33.0	28.3	23.3	24.1	*	32.1
220	MAI	0-5	9.8	25.3	26.4	23.4	16.3	20.9	22.6	28.7
		0-10	22.1	29.7	30.7	28.8	24.1	21.4	25.3	30.5

Table 3.1.1 Average volumetric soil moisture measurements (#1)

			DATE							
Field	CROP	Depth	07-10	13-10	19-10	25-10	31-10	29-11	06-12	13-12
59	SBT	0-5	26.8	32.5	31.2	28.2	17.5	28.3		7.5
		0-10	31.9	34.3	33.1	31.6	24.5	31.5	26.2	10.3
53	SBT	0-5	26.4	28.2	29.5	28.3	22.4	32.0	21.0	8.7
		0-10	31.7	33.0	31.8	29.3	27.5	35.0	29.7	12.2
224	SBT	0-5	20.6	31.1	31.1	27.5	22.2	28.1	18.4	8.6
		0-10	29.8	32.4	33.5	30.5	26.6	29.9	24.0	11.1
46	POT_R	0-5	13.8	24.3	29.5	19.8	11.2	27.7	21.0	8.0
		0-10	16.0	30.1	35.1	23.0	16.5	31.3	30.0	11.2
	POT_F	0-5	31.3	34.8	*	*	*	*	*	*
		0-10	31.8	35.9	*	*	*	*	*	*
56	POT_R	0-5	13.5	29.4	23.4	17.1	12.3	25.1	17.3	5.4
		0-10	17.0	31.3	28.3	22.8	14.9	29.1	20.4	11.8
	POT_F	0-5	24.0	34.0	33.8	30.5	28.3	31.7	25.8	*
		0-10	30.0	36.1	39.2	32.3	30.1	39.7	32.1	*
223	POT_R	0-5	13.7	31.2	24.5	13.5	9.5	20.3	14.1	4.6
		0-10	16.2	33.7	29.2	20.1	16.0	22.8	21.5	7.8
	POT_F	0-5	24.7	33.9	35.5	26.7	19.1	29.8	22.2	*
		0-10	29.7	38.0	38.9	30.4	21.8	33.2	33.7	*
48	WHE	0-5	16.2	26.2	26.5	20.3	16.6	25.1	16.9	7.0
		0-10	18.9	30.7	29.0	21.5	19.5	28.8	22.8	9.3
50	WHE	0-5	19.7	31.1	31.0	14.8	12.7	23.4	19.6	8.5
		0-10	20.9	33.4	33.5	19.5	19.8	28.7	24.6	11.0
221	WHE	0-5	15.5	29.4	27.9	15.0	9.4	23.4	13.8	6.1
		0-10	18.5	31.2	30.1	15.7	14.1	26.8	16.1	8.2
43	MAI	0-5	26.5	28.7	27.6	22.9	15.9	27.9	23.2	10.5
		0-10	29.2	31.5	30.9	27.4	20.7	30.4	28.7	14.2
158	MAI	0-5	22.9	32.7	32.6	25.1	21.0	30.9	23.2	8.6
		0-10	29.4	35.2	34.5	28.9	28.5	32.8	31.8	11.7
220	MAI	0-5	21.2	29.5	33.1	32.0	20.4	28.6	19.9	9.1
		0-10	27.3	32.4	35.9	33.1	29.7	31.6	26.7	10.7

Table 3.1.2 Average volumetric soil moisture measurements (#2)

3.2 SOIL SURFACE ROUGHNESS

The soil surface roughness was measured with the a specially designed needle board, see figure 3.2.1. The needle board consist of two alligned area's of measurement each with a different density of needles. Macro roughness can be measured with low density sampling (1 needle per cm) and micro roughness can be measured with high density sampling (3 needles per cm). Each measurement gives 151 samples in both high and low density, where the high density is measured over 50 cm and the low density over 150 cm.

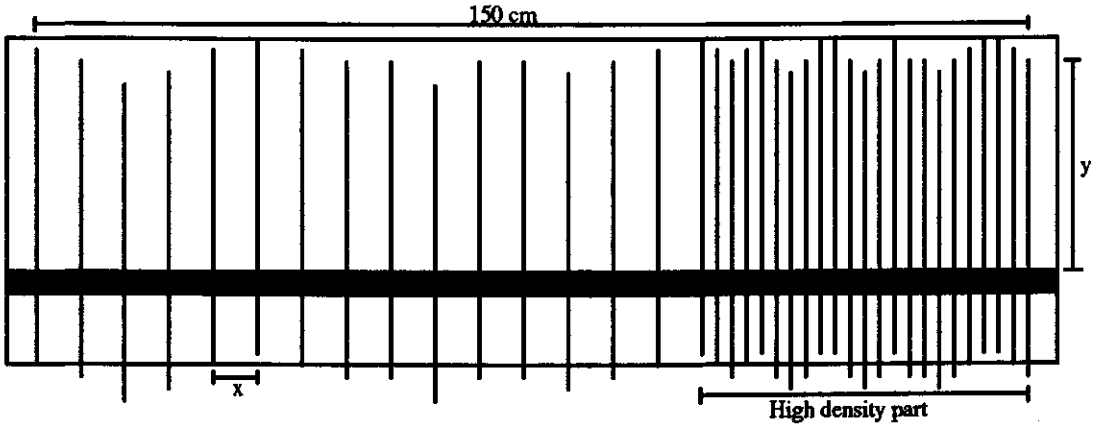


Fig 3.2.1 Surface profile meter (schematically)

The measurements itself went as follows. The board is level placed over the surface (fig. 3.2.2), the needles are lowered so the top of the needles construct the profile of the soil surface. The board is photographed and the profile is digitized from the photo. This gives two sets of X-Y coordinates where X stands for the distance between the needles and Y for the height of the needles. In this experiments a minimum of two measurements for each direction and two directions (parallel and perpendicular to the cultivation direction) were made.

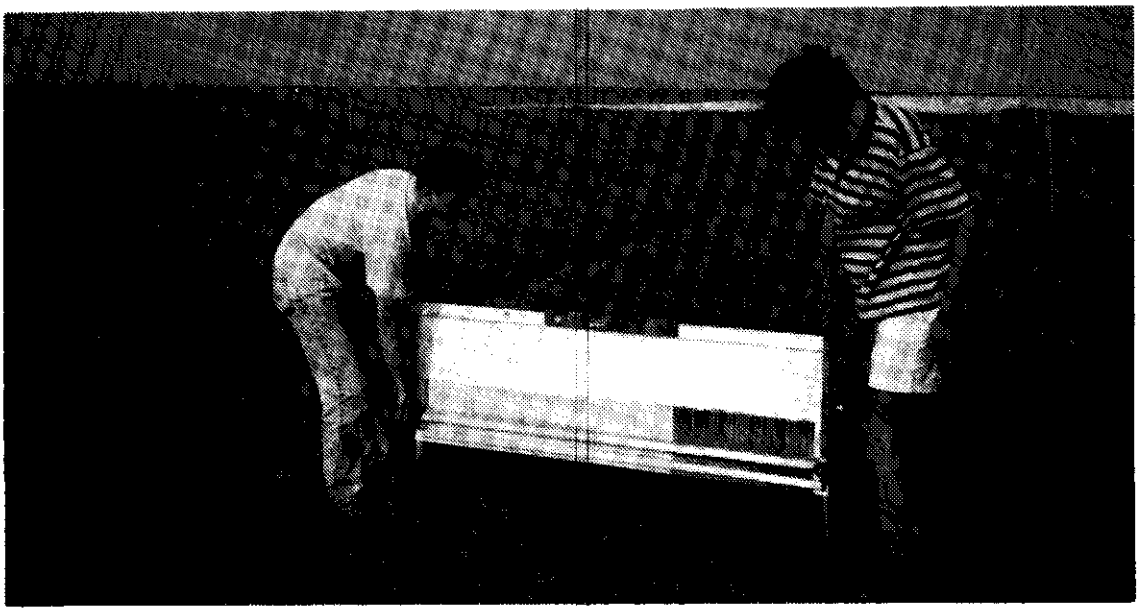


Fig 3.2.2 Positioning of the profile meter over the surface

During the growing season the soil roughness fields with the crops: beet, potato, wheat and maize are measured. Since the cultivation of these crops have little differences between fields, the measurements are valid for all fields with the same crop. At the end of the season the soil roughness of four bare soil fields, each differently cultivated was measured. These four field are:
Field 240: east-west sown winter-wheat (small roughness) fig. 3.2.3 and fig. 3.2.4
Field 43: east-west ploughed field (moderate roughness) fig. 3.2.5 and fig. 3.2.6
Field 223: east-west ploughed and harrowed field (moderate roughness) fig. 3.2.7 and fig. 3.2.8
Field 220: north-south ploughed field (large roughness) fig. 3.2.9 and fig. 3.2.10

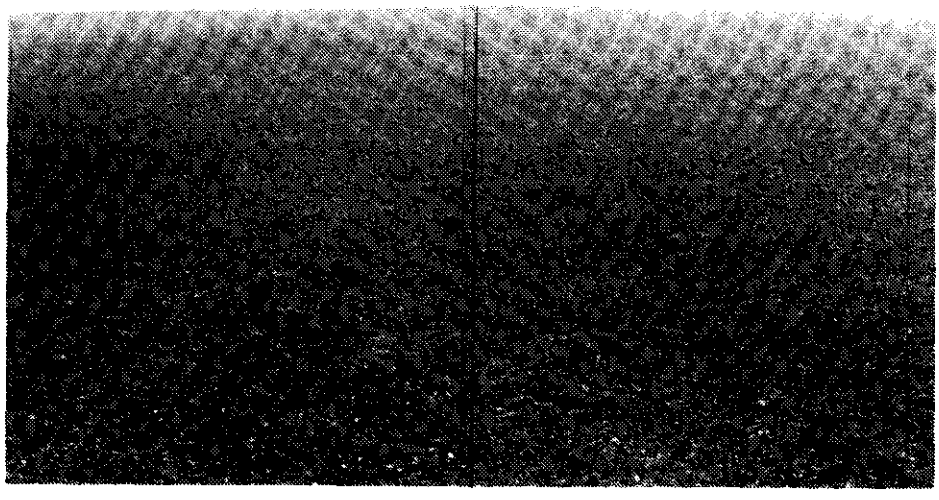


Fig. 3.2.3 View over field 240 (east-west directed)

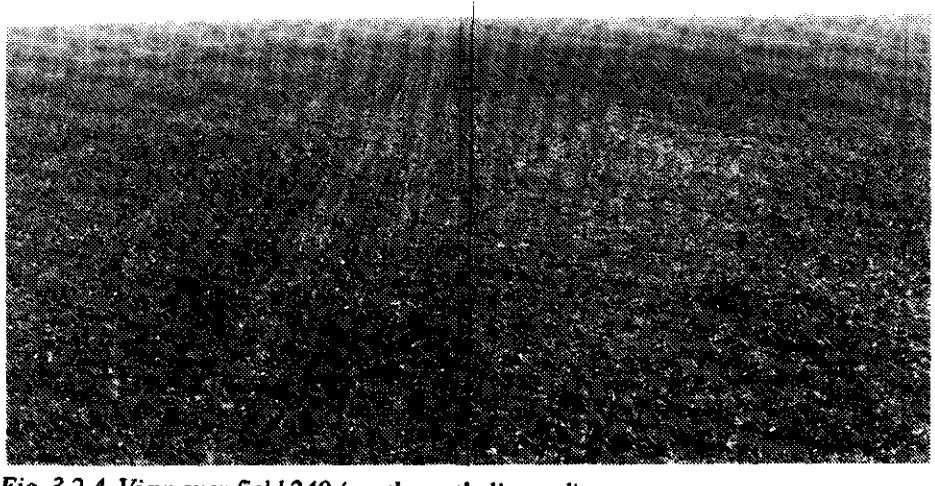


Fig. 3.2.4 View over field 240 (north-south directed)

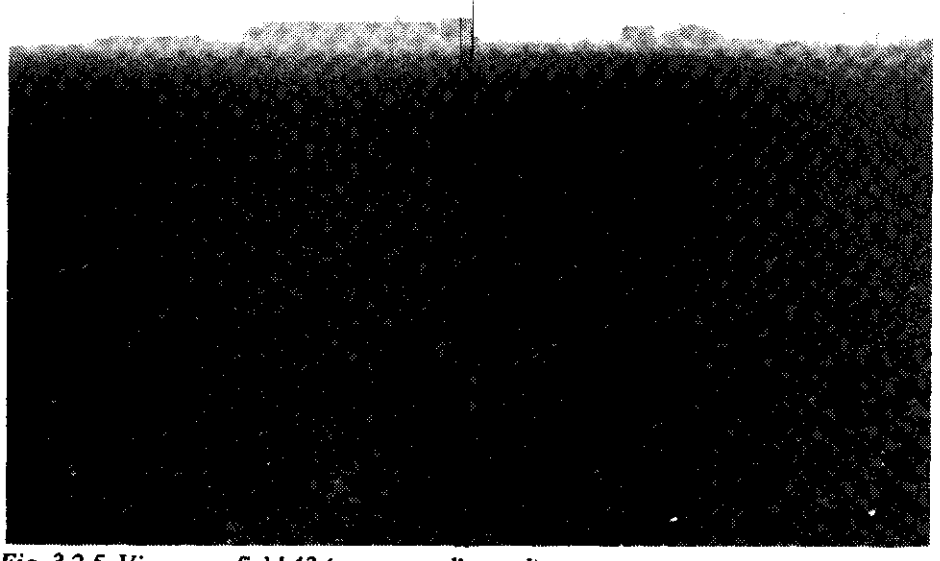


Fig. 3.2.5 View over field 43 (east-west directed)

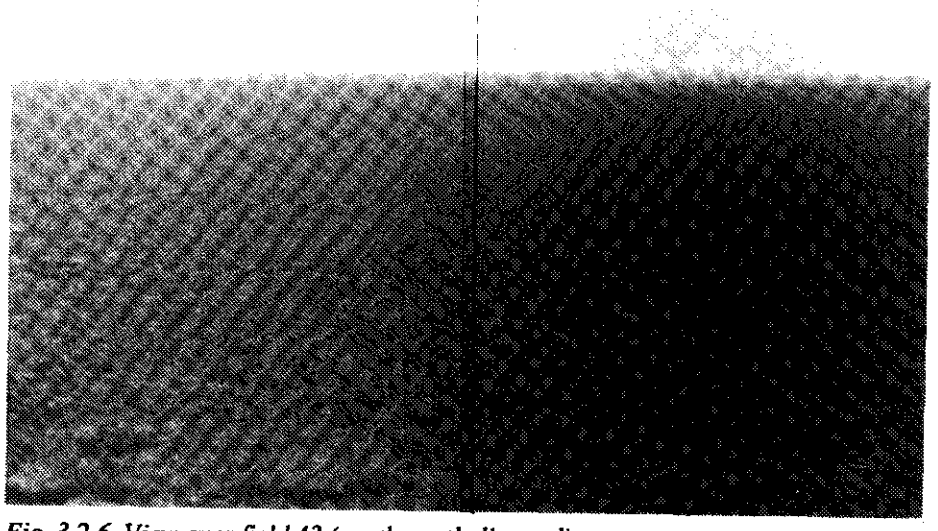


Fig. 3.2.6 View over field 43 (north-south directed)

Fig. 3.2.7 View over field 223 (east-west directed)

Fig. 3.2.8 View over field 223 (north-south directed)

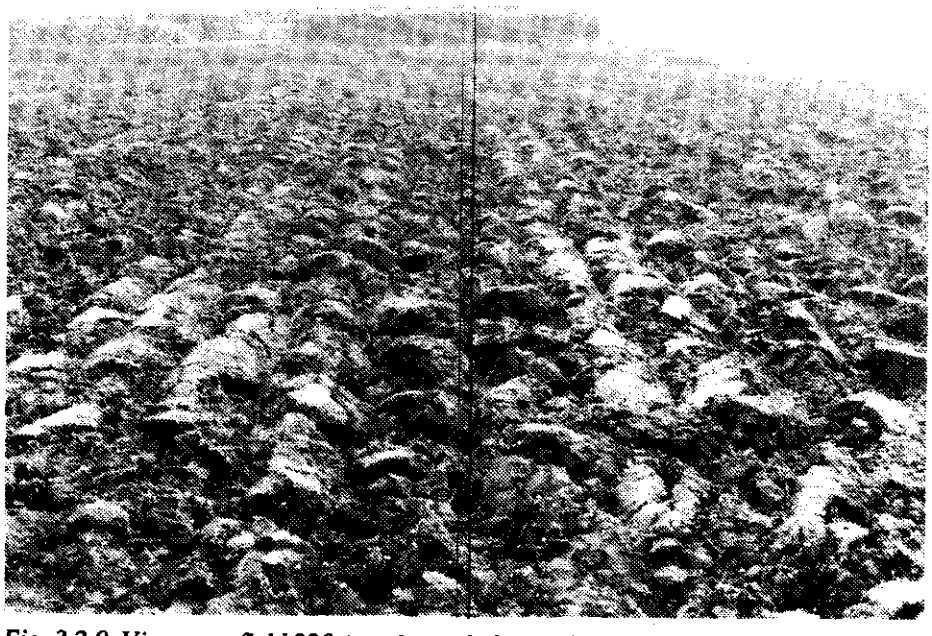


Fig. 3.2.9 View over field 220 (north-south directed)

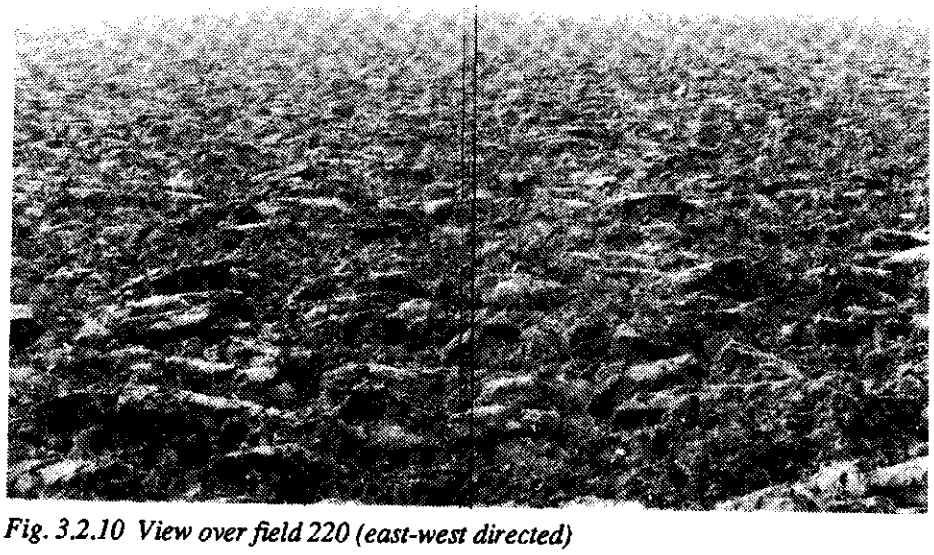


Fig. 3.2.10 View over field 220 (east-west directed)

3.2.2 DATA ANALYSIS

For all fields the Root Mean Square (RMS) (mm) and the Autocorrelation length (cm) was calculated. Results are presented in table 3.2.1. For all fields the Power Density Spectrum and the Autocorrelation function is plotted for all measurement directions. These graphs are presented in figures 3.2.1 - 3.2.4. The Power Density Spectrum was calculated using the Fast Fourier Transform (FFT), and the Autocorrelation function was calculated by an inverse FFT. Both algorithms were used from Numerical Recipes (1990).

	Autocorrelation length	RMS High density	RMS Low density
Beet (par)	8.48	0.51	0.53
Beet (per)	13.21	0.62	1.21
Potato (par, ridge)	2.21	0.85	1.06
Potato (par, furrow)	5.42	0.39	0.40
Potato (per)	12.66	5.06	7.17
Wheat (par)	3.63	0.94	1.44
Wheat (per)	5.28	1.44	1.74
Maize (par)	4.90	0.31	0.57
Maize (per)	11.17	1.53	1.43
Field 240 (par)	1.95	0.63	0.79
Field 240 (per)	5.43	1.04	1.53
Field 43 (par)	3.45	1.82	1.92
Field 43 (per)	6.73	1.45	2.05
Field 223 (par)	6.74	1.65	1.85
Field 223 (per)	15.06	1.88	3.43
Field 220 (par)	10.77	4.33	4.83
Field 220 (per)	6.88	3.34	4.24

Table 3.2.1 Soil profile analysis results (in cm)

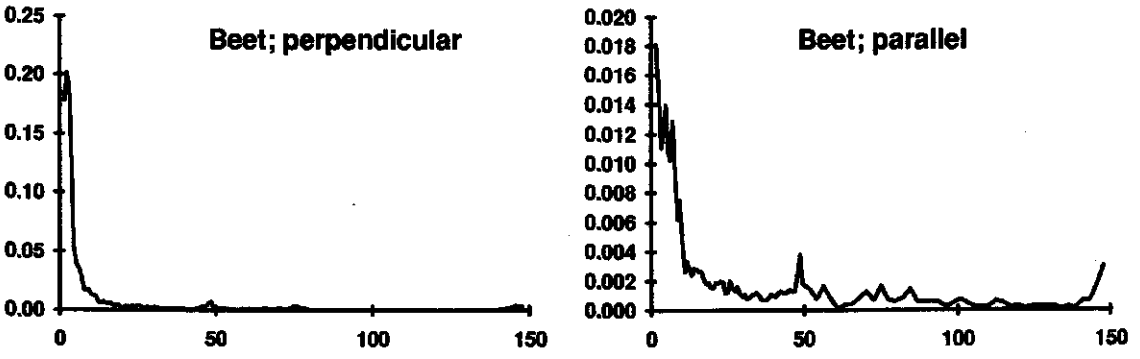


Fig. 3.2.1 Power Density Spectrum of Beet versus Frequency (Hz)

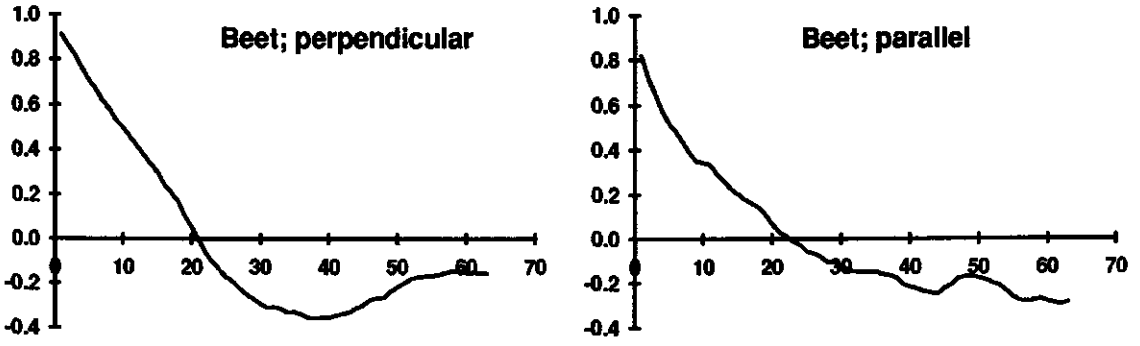


Fig. 3.2.2 Autocorrelation of Beet versus length (cm)

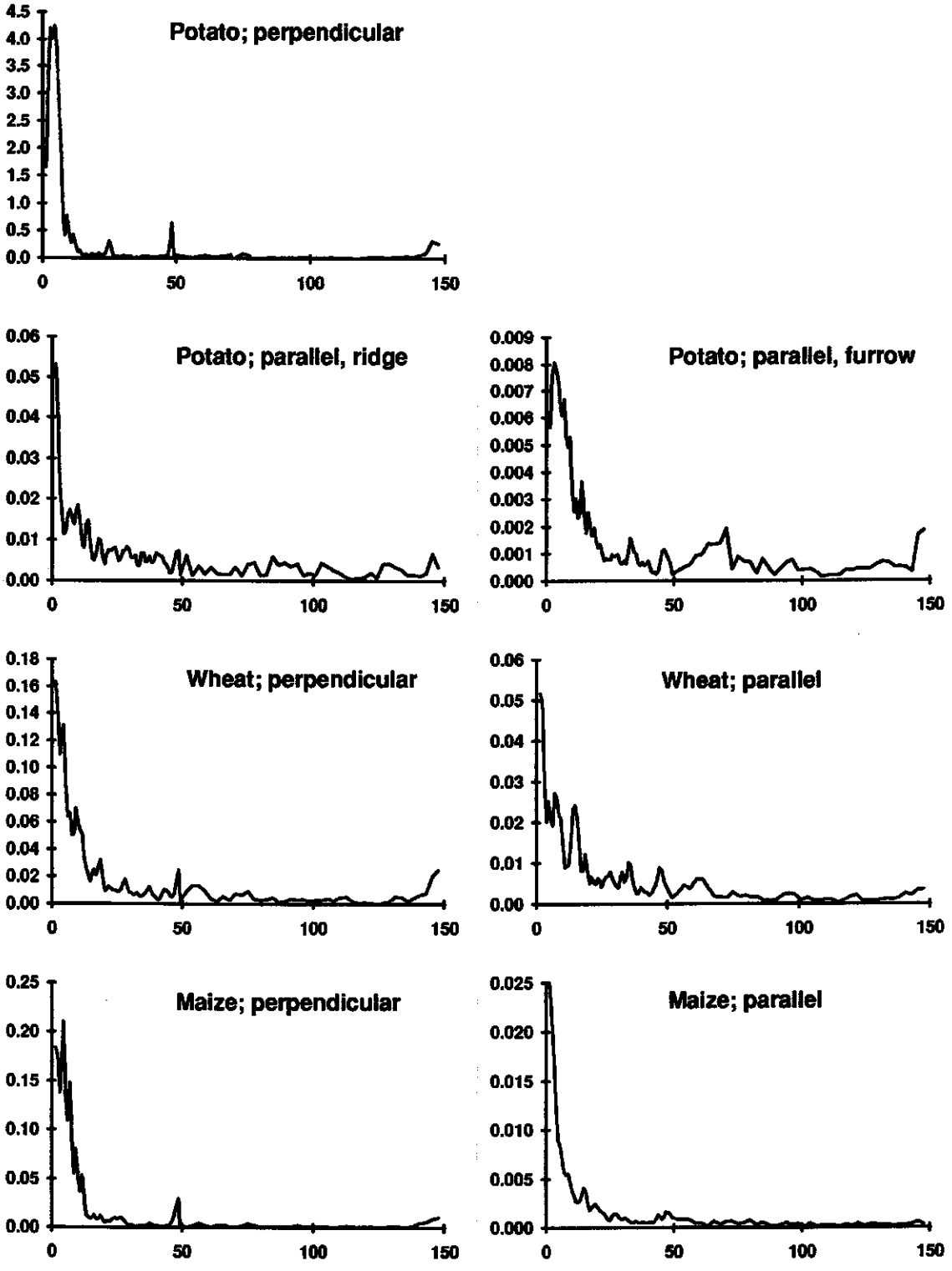


Fig. 3.2.3 Power Density Spectrum of Potato, Wheat and Maize versus Frequency (Hz)

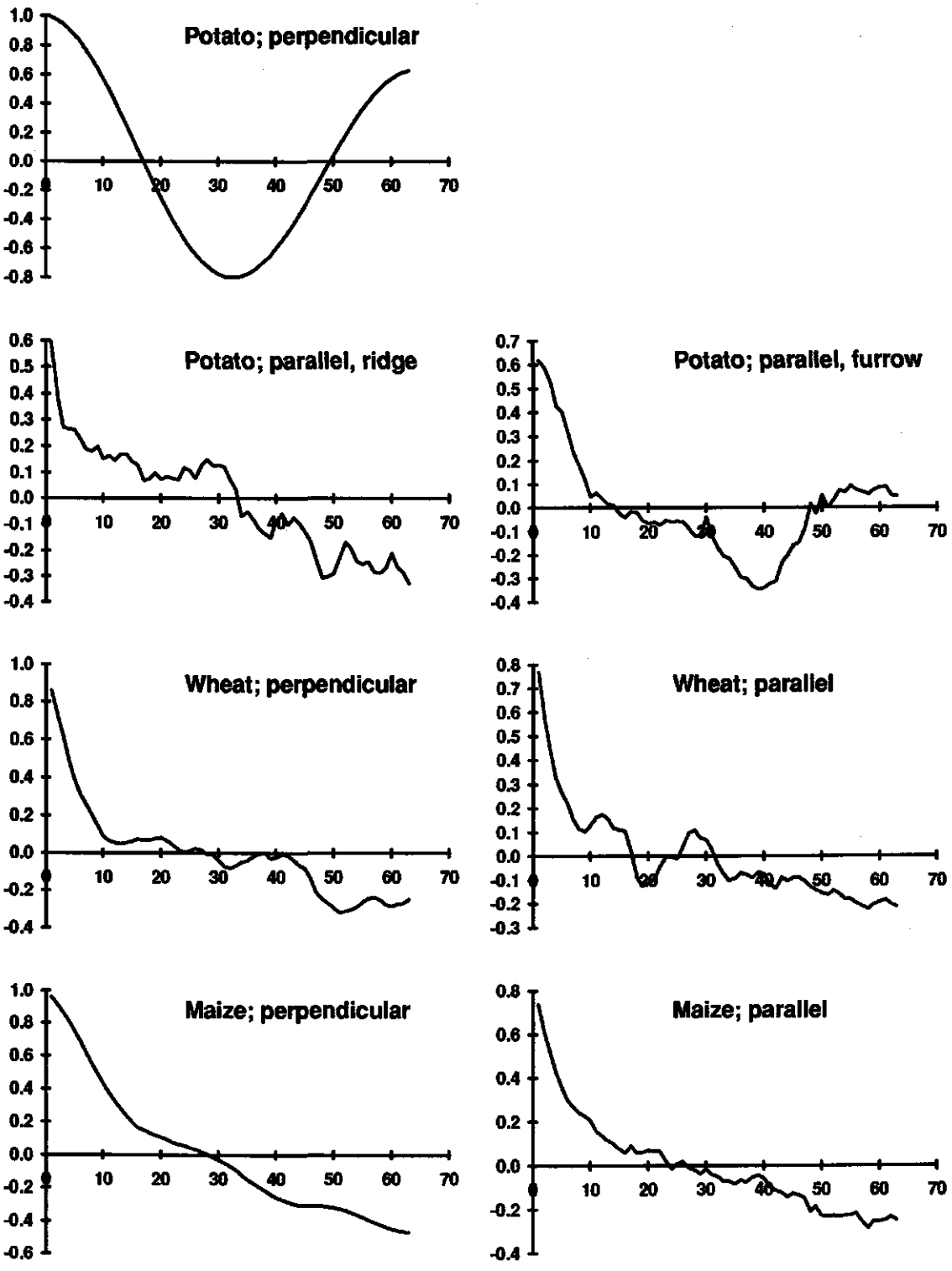


Fig. 3.2.4 Autocorrelation of Potato, Wheat and Maize versus length (cm)

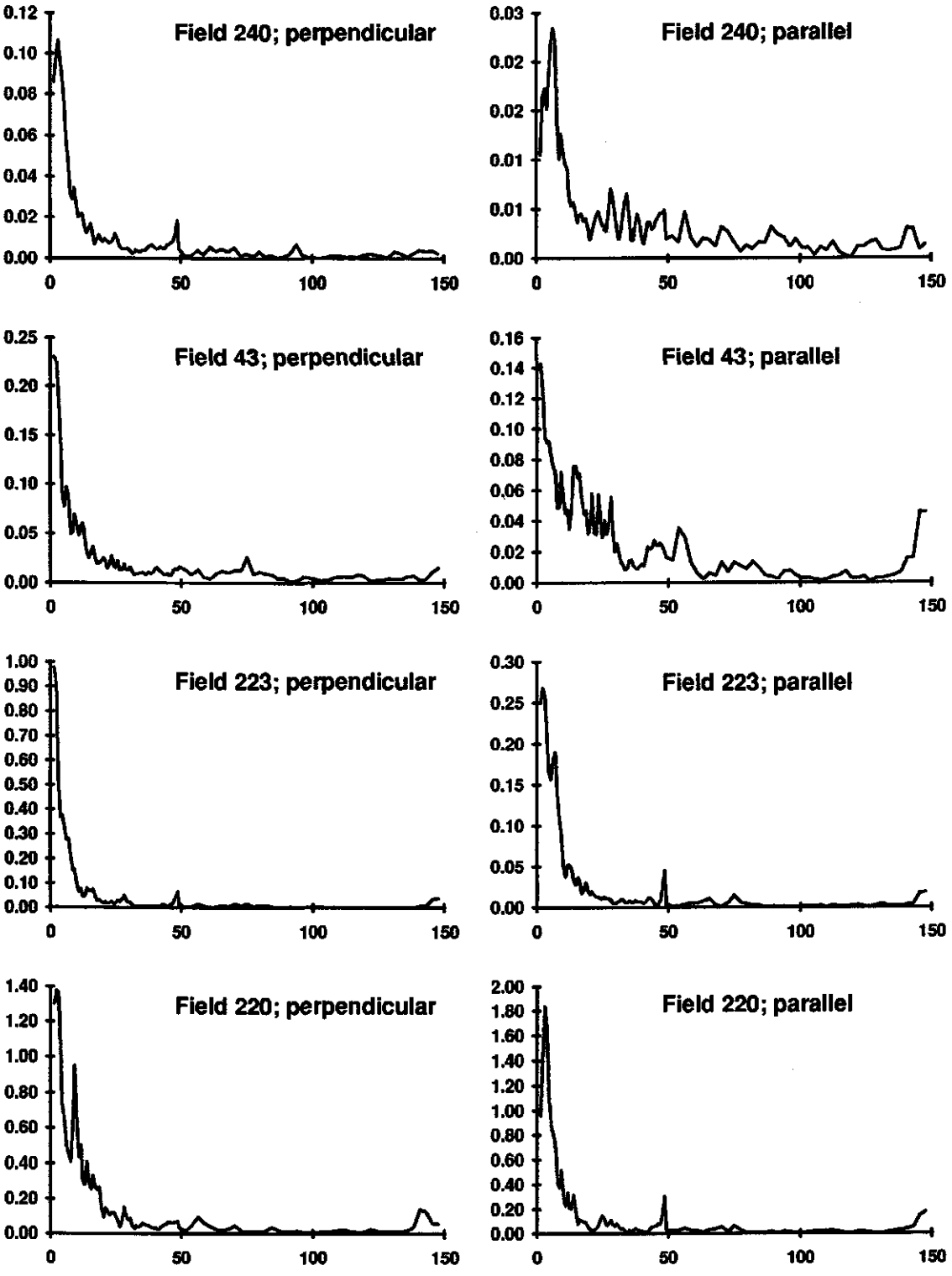


Fig. 3.2.5 Power Density Spectrum of Fields 240, 223, 220 and 43 versus Frequency (Hz)

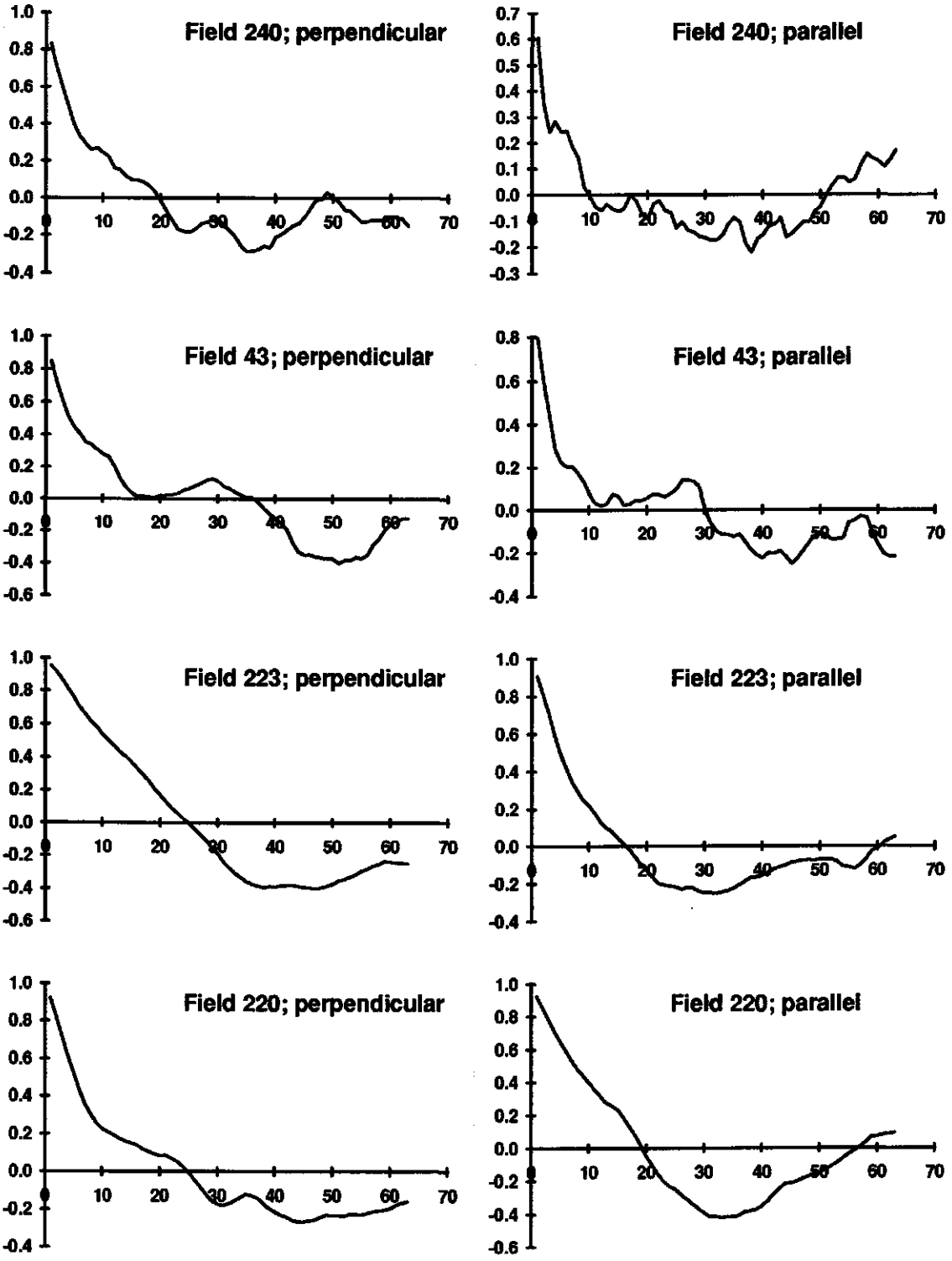


Fig. 3.2.6 Autocorrelation of fields 240, 43, 223 and 220 versus length (cm)

3.3 REFLECTION MEASUREMENTS

Reflection measurements of the crops were carried out by the CABO and the WAU-LRS.
From May 13 till July 3 the reflection of the crops was measured by the CABO using a portable CROPSCAN radiometer (Skye Instruments Ltd., Llandrindod Wells, Powys, UK) with 8 spectral band filters. In the period of July 10 till July 30 reflection measurements obtained by the WAU-LRS (Büker, 1992) were used. These measurements were taken with a similar CROPSCAN but with different spectral bands. Specifications of the spectral bands of both CROPSCAN radiometers are given in table 3.3.1.
The reflection measurements of both CABO and WAU-LRS are given in tables 3.3.2 - 3.3.9.
From these reflection measurements several crop parameters like WDVI, LAI and soil cover can be derived (Uenk etal, 1992. Reflectiemetingen aan landbouwgewassen).

Channel	Central wavelength (nm) CABO	Central wavelength (nm) WAU-LRS	Bandwidth (nm) CABO and WAU-LRS
1	500 ± 2	490 ± 2	10 ± 2
2	550 ± 2	550 ± 2	10 ± 2
3	600 ± 2	670 ± 2	10 ± 2
4	650 ± 2	700 ± 2	10 ± 2
5	700 ± 2	740 ± 2	10 ± 2
6	750 ± 2	780 ± 2	10 ± 2
7	800 ± 2	870 ± 2	10 ± 2
8	850 ± 2	1090 ± 2	10 ± 2

Table 3.3.1 Specifications of the spectral bands of the CROPSCAN systems of CABO and WAU-LRS

DATE	Field	500 nm	550 nm	600 nm	650 nm	700 nm	750 nm	800 nm	850 nm
13-05	59	10.2	12.1	12.7	14.1	16.5	17.8	16.6	18.0
23-05	53	11.2	13.7	14.0	15.2	16.5	17.8	17.6	18.3
23-05	59	10.9	13.3	13.6	14.8	15.7	16.9	16.6	17.3
23-05	224	15.6	19.1	19.7	21.4	23.2	24.4	23.8	25.3
23-05	226	14.0	17.0	17.6	19.4	21.2	22.3	21.8	23.0
30-05	231	13.1	16.3	16.7	18.3	19.2	21.8	21.2	22.4
30-05	281	15.2	18.6	19.1	21.2	22.3	23.7	22.9	24.2
30-05	288	12.9	15.8	16.2	18.0	19.1	20.4	19.8	21.1
30-05	436	13.4	16.5	17.5	19.2	20.6	21.6	21.1	22.3
31-05	607	9.4	12.0	12.7	13.8	15.4	17.6	17.3	18.5
31-05	819	9.7	12.3	12.9	13.8	15.4	18.4	18.1	19.3
17-06	53	4.7	8.2	9.1	7.7	8.2	23.7	24.4	25.7
17-06	59	5.4	9.0	10.2	8.8	9.8	23.0	23.0	24.5
17-06	224	5.7	8.9	9.8	9.0	9.7	20.9	21.1	22.3
17-06	226	7.8	10.3	10.8	11.5	12.2	15.5	15.3	16.2
17-06	231	6.9	9.9	11.3	10.5	11.5	20.6	20.3	21.6
17-06	281	6.7	8.8	9.5	9.7	10.6	13.8	13.6	14.4
17-06	288	5.0	6.5	7.6	7.5	8.7	11.7	11.6	12.2
03-07	53	2.0	5.6	8.5	5.5	4.8	30.8	34.7	35.9
03-07	59	2.0	5.6	8.3	5.3	4.8	29.6	32.6	33.9
03-07	224	2.0	5.5	8.0	5.1	4.8	30.6	33.9	35.7
03-07	226	3.5	7.3	8.3	6.6	6.9	24.2	24.8	25.9
03-07	231	2.2	6.5	9.2	5.7	5.4	36.9	40.7	42.6
03-07	288	4.0	6.9	8.0	6.8	7.3	20.0	20.4	21.5

Table 3.3.2 CABO reflection measurements of Beet

DATE	Field	500 nm	550 nm	600 nm	650 nm	700 nm	750 nm	800 nm	850 nm
13-05	49	9.4	11.2	11.6	12.8	14.4	14.9	14.1	15.2
23-05	49	9.9	12.0	12.0	13.0	13.9	15.7	15.3	16.0
23-05	55	9.6	12.2	12.5	13.3	14.8	18.4	18.2	19.0
23-05	157	10.8	13.2	13.6	14.4	15.5	18.2	17.7	18.7
23-05	223	10.3	12.8	13.2	14.6	15.5	17.7	17.3	18.2
23-05	235	9.9	12.2	12.8	13.9	14.8	16.8	16.6	17.3
30-05	229	9.5	12.8	13.0	13.5	14.2	22.4	22.2	23.2
30-05	277	11.2	15.1	15.4	16.2	17.1	25.1	24.9	26.3
30-05	284	10.1	13.5	13.8	14.5	15.3	22.1	21.9	23.1
30-05	431	10.8	14.1	14.8	15.6	16.7	22.1	22.0	23.1
31-05	608	8.8	12.5	13.4	13.1	14.2	24.1	24.2	25.5
31-05	818	7.9	10.9	11.7	11.9	13.2	20.2	20.4	21.5
17-06	49	3.2	8.1	9.8	6.5	6.8	38.2	40.1	42.6
17-06	55	2.8	7.3	9.6	6.1	6.1	38.1	40.5	43.2
17-06	157	3.2	7.7	8.7	6.1	6.1	33.8	35.8	37.3
17-06	223	3.0	7.5	8.8	6.1	6.4	35.0	37.0	39.2
17-06	229	3.2	7.4	9.4	6.6	6.7	32.1	33.7	35.7
17-06	235	2.9	6.9	8.4	5.9	5.7	30.7	32.8	34.3
17-06	277	2.8	7.0	8.7	5.9	5.8	32.2	34.4	36.1
17-06	284	2.5	7.1	9.5	6.1	6.3	38.2	40.8	43.2
03-07	49	3.5	10.4	13.3	8.0	7.4	59.0	64.1	67.4
03-07	55	3.3	9.0	12.7	7.9	6.9	57.2	64.7	67.5
03-07	223	3.5	9.5	12.9	7.9	7.2	57.0	63.0	66.0
03-07	229	3.6	9.8	12.4	7.7	7.3	58.8	63.8	67.4
03-07	235	3.9	9.6	12.8	8.0	7.5	56.0	61.7	65.0
03-07	284	3.6	9.1	11.9	7.4	7.1	55.5	61.0	64.3

Table 3.3.3 CABO reflection measurements of Potato

DATE	Field	500 nm	550 nm	600 nm	650 nm	700 nm	750 nm	800 nm	850 nm
13-05	50	1.9	5.0	8.6	5.6	5.2	40.6	52.1	56.4
23-05	48	2.0	5.0	9.1	5.8	5.1	38.9	52.8	55.7
23-05	50	2.5	6.2	10.1	6.5	5.6	43.8	58.3	61.4
23-05	221	1.2	3.2	7.9	4.8	3.7	31.8	47.0	49.4
23-05	227	2.0	4.7	8.6	5.5	4.4	35.9	49.3	52.1
30-05	228	1.2	3.5	8.7	5.1	3.5	33.8	48.7	50.7
30-05	280	1.6	3.9	8.6	5.2	4.0	33.8	49.0	51.6
30-05	286	1.1	2.9	8.0	4.6	3.3	31.1	48.2	50.9
30-05	432	1.2	3.2	8.1	4.8	3.4	31.6	47.5	50.3
31-05	609	1.8	4.3	9.6	5.8	5.1	37.9	53.3	56.5
17-06	48	2.0	4.8	10.3	6.4	5.4	38.3	52.0	55.9
17-06	50	2.0	5.0	10.4	6.4	5.2	38.7	52.9	56.6
17-06	221	1.3	3.3	8.5	5.3	4.0	31.2	46.4	48.9
17-06	227	1.6	3.7	8.3	5.1	3.8	31.4	45.9	48.4
17-06	228	1.3	3.1	9.0	5.4	3.8	29.6	43.0	45.4
17-06	280	1.6	4.1	9.2	5.6	4.3	33.5	47.9	50.7
17-06	286	1.4	3.4	8.6	5.2	4.0	31.8	46.7	49.7
03-07	48	2.2	5.0	10.2	6.3	5.1	35.5	49.3	52.8
03-07	50	2.0	4.6	10.0	6.1	4.8	34.2	47.7	50.9
03-07	221	2.2	4.5	9.7	6.1	4.9	32.5	46.1	49.2
03-07	227	2.1	4.4	9.0	5.7	4.7	31.0	43.9	47.0
03-07	228	2.1	4.5	8.9	5.6	4.7	29.7	40.4	42.7
03-07	286	2.1	4.4	9.1	5.8	4.7	31.7	44.9	48.3

Table 3.3.4 CABO reflection measurements of Wheat

DATE	Field	500 nm	550 nm	600 nm	650 nm	700 nm	750 nm	800 nm	850 nm
23-05	158	12.3	14.0	14.0	15.0	15.7	16.4	15.8	16.8
23-05	220	12.1	14.8	15.2	17.1	18.3	19.4	18.8	19.9
30-05	435	14.5	17.9	18.6	20.6	21.9	23.4	22.7	24.1
31-05	927	10.7	13.1	13.6	14.7	16.0	17.4	17.2	18.3
17-06	43	7.9	10.1	11.1	11.6	13.0	15.3	15.2	16.5
17-06	158	7.3	11.0	11.8	11.2	11.5	22.7	23.3	24.2
17-06	220	8.0	10.3	11.1	11.7	12.7	15.5	15.2	16.1
03-07	43	6.7	9.0	10.0	10.2	11.0	15.6	15.7	16.7
03-07	220	5.7	7.9	8.7	8.6	9.2	13.7	13.6	14.2

Table 3.3.5 CABO reflection measurements of Maize

DATE	Field	490 nm	550 nm	670 nm	700 nm	740 nm	780 nm	870 nm	1090 nm
10-07	53	2.8	8.3	3.1	4.8	37.2	49.7	52.2	52.3
10-07	59	3.5	9.0	4.0	5.9	35.4	45.3	47.4	47.9
10-07	224	2.2	7.2	2.6	4.2	33.7	45.5	47.8	47.5
10-07	231	2.8	8.3	3.2	4.9	35.8	46.7	48.8	49.2
10-07	281	2.4	7.3	3.4	4.5	28.0	34.5	35.9	31.8
10-07	288	3.2	7.5	4.1	5.3	26.0	31.7	33.1	33.0
10-07	436	3.4	9.5	4.3	6.3	33.9	41.1	42.3	41.5
10-07	607	2.6	8.2	3.2	5.0	34.3	44.3	45.9	45.1
10-07	819	2.6	7.4	3.0	4.6	32.1	42.7	44.1	42.5
29-07	53	2.6	7.1	2.6	4.1	35.2	51.6	54.3	53.8
29-07	59	2.4	7.1	2.5	3.9	35.1	48.8	51.6	51.9
29-07	224	2.4	7.0	2.6	4.1	35.6	50.5	53.4	52.8
29-07	226	2.4	7.1	2.6	4.2	36.8	53.0	56.2	55.2
29-07	231	2.2	7.1	2.4	3.9	36.4	50.9	54.0	54.3
29-07	281	2.6	7.5	2.9	4.5	36.6	51.2	53.8	53.9
29-07	288	2.7	7.6	3.0	4.6	34.4	46.0	48.1	49.1
29-07	436	2.8	8.4	3.0	4.8	40.1	55.3	58.0	57.4
29-07	607	2.4	7.3	2.5	4.2	37.3	52.8	55.7	54.4
29-07	819	2.8	7.5	2.9	4.4	37.0	53.5	56.5	55.7

Table 3.3.6 WAU-LRS reflection measurements of Beet

DATE	Field	490 nm	550 nm	670 nm	700 nm	740 nm	780 nm	870 nm	1090 nm
10-07	49	3.4	8.3	3.6	5.4	38.6	50.2	52.4	53.2
10-07	55	3.6	8.4	3.5	5.1	41.0	56.5	58.9	59.6
10-07	223	3.3	9.0	3.3	5.0	46.2	64.3	67.6	68.7
10-07	229	4.2	10.0	4.3	5.9	44.0	56.3	59.8	63.5
10-07	235	3.1	8.5	3.2	4.8	40.9	55.7	58.0	59.0
10-07	277	3.5	9.6	4.3	4.8	46.5	64.1	66.9	61.9
10-07	284	4.6	9.8	4.7	6.2	45.7	63.8	67.7	70.5
10-07	431	3.6	10.0	3.7	5.8	44.8	59.3	61.4	61.3
10-07	608	3.4	9.7	3.5	5.4	45.3	60.7	63.4	64.8
10-07	818	3.6	9.0	3.6	5.2	43.6	60.3	62.4	62.5
29-07	49	3.7	9.8	3.8	6.0	38.8	50.0	52.0	52.0
29-07	55	2.8	7.7	2.9	4.4	40.6	58.1	62.1	64.4
29-07	223	2.7	8.0	3.2	4.8	36.7	48.6	52.0	53.9
29-07	229	3.2	9.7	3.6	5.5	41.1	52.0	55.0	55.0
29-07	235	3.1	7.6	3.3	4.6	38.2	53.4	57.3	58.9
29-07	277	3.1	7.6	3.2	4.5	39.2	57.0	61.4	61.6
29-07	284	2.8	7.3	2.9	4.5	35.9	51.4	54.5	55.6
29-07	431	3.3	9.3	3.4	5.6	38.2	49.8	52.1	52.6
29-07	608	2.9	7.9	3.0	4.5	41.6	58.8	62.4	64.4
29-07	818	4.2	8.5	3.9	5.4	38.7	54.7	57.4	57.6

Table 3.3.7 WAU-LRS reflection measurements of Potato

DATE	Field	490 nm	550 nm	670 nm	700 nm	740 nm	780 nm	870 nm	1090 nm
10-07	50	2.5	5.5	3.0	4.0	25.3	41.1	46.9	49.1
10-07	221	2.3	5.0	2.7	3.5	23.5	39.1	44.8	45.6
10-07	227	2.6	5.1	2.8	3.6	21.7	37.1	42.2	43.0
10-07	228	2.4	5.0	2.9	3.7	20.3	30.6	35.1	37.3
10-07	280	2.3	5.4	3.0	3.7	25.4	43.9	49.7	47.9
10-07	286	2.2	5.0	2.6	3.5	23.6	42.2	48.2	49.4
10-07	432	2.5	5.2	3.0	4.0	22.4	38.1	43.8	44.3
10-07	609	2.8	5.4	2.9	3.9	22.7	39.6	44.6	44.1
29-07	48	3.9	8.8	7.5	9.6	29.7	35.3	41.3	44.3
29-07	50	4.4	10.1	9.3	11.9	31.5	35.7	41.8	46.0
29-07	221	3.3	7.0	5.7	7.6	22.5	28.5	33.7	35.9
29-07	227	3.6	7.4	6.0	7.4	24.9	31.5	37.3	40.7
29-07	228	3.7	7.2	5.8	7.8	21.8	28.0	32.1	33.5
29-07	280	4.1	8.5	6.9	8.8	28.6	37.3	42.9	44.1
29-07	286	3.9	8.0	5.9	8.0	26.0	34.8	40.0	41.6
29-07	432	4.4	7.9	8.2	10.3	20.9	24.5	30.3	34.3
29-07	609	3.4	7.1	5.3	7.3	23.7	32.4	37.9	39.4

Table 3.3.8 WAU-LRS reflection measurements of Wheat

DATE	Field	490 nm	550 nm	670 nm	700 nm	740 nm	780 nm	870 nm	1090 nm
10-07	220	6.5	10.2	8.9	9.8	22.7	27.1	28.6	29.2
10-07	435	6.4	9.7	9.4	10.4	20.2	23.7	25.4	26.9
30-07	220	2.6	5.9	2.8	3.5	26.2	42.9	46.1	46.8
30-07	435	2.9	6.4	3.3	4.1	26.5	41.7	44.8	45.9

Table 3.3.9 WAU-LRS reflection measurements of Maize

3.4 CROP OBSERVATIONS

Some crop observations and parameter measurements were made during the campaign by the Wageningen Agricultural University departement of Landsurveying and Remote Sensing (Büker,et al, 1992) and the Centre for Agrobiological Research (CABO). The parameters measured and observed are:
- row distance (cm)
- plantdensity (1000 / ha)
- crop coverage (%)
- crop height (cm)
- soil condition

The results of these observations are presented in tables 3.4.1 - 3.4.6.

Beet	50
Potato	75
Wheat	12
Maize	60

Table 3.4.1 Row distance for all crops (cm)

Beet field #		Potato field #		Maize field #	
53	79	49	35-48	220	90
59	65	55	35	435	90
224	72	223	36-43		
226	80	229	36		
231	70-80	235	36		
281	90	277	40		
288	80	284	39		
436	95	431	37		
607	70	608	38		
819	60	818	36-40		

Table 3.4.2 Plant density (1000/ha)

	DATE	11-06	24-06	03-07	10-07	22-07	29-07	06-08
53	COVER %	*	*	*	75	80	85	90
	HEIGHT cm	*	*	*	37	42	45	50
	SOIL con.	*	*	*	dry	dry	dry	dry
59	COVER %	*	*	50	70	75	90	90
	HEIGHT cm	*	*	27	35	37	45	45
	SOIL con.	*	*	dry	dry	dry	dry	dry
224	COVER %	*	*	55	75	80	90	90
	HEIGHT cm	*	*	30	35	40	50	50
	SOIL con.	*	*	dry	dry	dry	dry	dry
226	COVER %	*	*	40	75	80	90	95
	HEIGHT cm	*	*	20	35	38	40	45
	SOIL con.	*	*	dry	dry	dry	dry	dry
231	COVER %	*	*	65	80	80	95	95
	HEIGHT cm	*	*	30	35	42	50	50
	SOIL con.	*	*	dry	dry	dry	dry	dry
281	COVER %	*	15	40	65	80	90	90
	HEIGHT cm	*	15	22	32	40	45	45
	SOIL con.	*	moist	moist	moist	dry	dry	dry
288	COVER %	*	15	40	40	65	85	90
	HEIGHT cm	*	10	23	25	32	45	48
	SOIL con.	*	moist	dry	moist	dry	dry	dry
436	COVER %	5	20	35	50	80	85	90
	HEIGHT cm	10	15	22	30	37	50	50
	SOIL con.	dry	moist	moist	moist	dry	dry	dry
607	COVER %	8	25	60	75	90	90	95
	HEIGHT cm	10	20	25	32	45	45	45
	SOIL con.	dry	moist	dry	moist	dry	dry	dry
819	COVER %	15	25	50	65	80	90	90
	HEIGHT cm	15	20	35	40	42	43	45
	SOIL con.	dry	moist	moist	moist	dry	dry	dry

Table 3.4.3 Crop observations of Beet

	DATE	11-06	24-06	03-07	10-07	22-07	29-07	06-08
49	COVER %	*	*	*	95	95	95	90
	HEIGHT cm	*	*	*	60	57	45	55
	SOIL con.	*	*	*	moist	dry	dry	dry
55	COVER %	*	*	*	95	95	95	90
	HEIGHT cm	*	*	*	65	65	60	60
	SOIL con.	*	*	*	moist	dry	dry	dry
223	COVER %	*	*	95	95	95	90	90
	HEIGHT cm	*	*	60	60	58	55	50
	SOIL con.	*	*	moist	moist	dry	dry	dry
229	COVER %	*	*	87	90	95	90	90
	HEIGHT cm	*	*	60	55	52	50	50
	SOIL con.	*	*	moist	moist	dry	dry	dry
235	COVER %	*	*	90	95	95	95	90
	HEIGHT cm	*	*	60	65	63	60	60
	SOIL con.	*	*	moist	moist	dry	dry	dry
277	COVER %	*	80	95	95	95	95	95
	HEIGHT cm	*	40	55	57	60	60	55
	SOIL con.	*	moist	w	moist	dry	dry	dry
284	COVER %	*	80	95	95	95	95	90
	HEIGHT cm	*	40	60	65	60	60	50
	SOIL con.	*	moist	moist	moist	dry	dry	dry
431	COVER %	30	70	95	95	90	90	90
	HEIGHT cm	24	35	50	60	65	55	55
	SOIL con.	dry	moist	moist	moist	dry	dry	dry
608	COVER %	40	80	95	95	95	95	90
	HEIGHT cm	26	40	60	65	67	55	55
	SOIL con.	dry	moist	moist	moist	dry	dry	dry
818	COVER %	25	80	95	95	95	90	85
	HEIGHT cm	22	40	50	55	60	55	50
	SOIL con.	dry	moist	moist	moist	dry	dry	dry

Table 3.4.4 Crop observations of Potato

	DATE	11-06	24-06	03-07	10-07	22-07	29-07	06-08
48	COVER %	*	*	*	*	95	95	90
	HEIGHT cm	*	*	*	*	75	80	90
	SOIL con.	*	*	*	*	dry	dry	dry
50	COVER %	*	*	*	95	95	95	90
	HEIGHT cm	*	*	*	85	85	90	95
	SOIL con.	*	*	*	moist	dry	dry	dry
221	COVER %	*	*	95	95	95	90	90
	HEIGHT cm	*	*	90	90	90	95	100
	SOIL con.	*	*	moist	moist	dry	dry	dry
227	COVER %	*	*	85	95	95	95	90
	HEIGHT cm	*	*	95	95	95	95	100
	SOIL con.	*	*	moist	moist	dry	dry	dry
228	COVER %	*	*	85	95	95	90	90
	HEIGHT cm	*	*	80	82	85	87	90
	SOIL con.	*	*	moist	moist	dry	dry	dry
280	COVER %	*	95	95	95	95	90	90
	HEIGHT cm	*	80	95	95	95	100	100
	SOIL con.	*	moist	moist	moist	dry	dry	dry
286	COVER %	*	95	95	95	95	95	90
	HEIGHT cm	*	85	95	95	95	100	100
	SOIL con.	*	moist	moist	moist	dry	dry	dry
432	COVER %	90	95	95	95	95	95	90
	HEIGHT cm	75	80	85	90	90	90	90
	SOIL con.	moist	moist	moist	moist	dry	dry	dry
609	COVER %	90	95	95	95	95	95	90
	HEIGHT cm	72	83	90	93	95	95	95
	SOIL con.	moist	moist	moist	moist	dry	dry	dry

Table 3.4.5 Crop observations of Wheat

	DATE	11-06	24-06	03-07	10-07	22-07	29-07	06-08
220	COVER %	*	*	*	15	55	75	90
	HEIGHT cm	*	*	*	45	105	160	200
	SOIL con.	*	*	*	dry	dry	dry	dry
435	COVER %	4	5	8	15	50	75	90
	HEIGHT cm	10	10	25	45	100	160	200
	SOIL con.	dry	moist	moist	dry	dry	dry	dry

Table 3.4.6 Crop observations of Maize

3.5 VEGETATION MAP

A vegetation map was constructed by the Winand Staring Centre (WSC) and the Wageningen Agricultural University department of Water Resources (WAU-WR) based on observations and inventory done by Heidemij, Directorate Flevoland (DF), Centre for Agrobiological Research (CABO) and WAU-WR.
This inventory reflects only a situation in July, therefore fields at a later stage can differ in size.
Two maps are included as annexes:
- a crop color-coded map (annex 1)
- a fieldnumber coded map (annex 2)

Tables 3.5.1 - 3.5.2 gives a list of the fieldnumbers and the crop identification used in annex 1 and 2.
For a cross-reference with Uenk et al, 1992, where observations of a number of fields during the growing season are presented, the third colomn in the tables present the fieldnumbers used in Uenk et al, 1992.
The crop identification is as follows:

SBT:	beet
POT:	potato
WHE:	wheat
BAR:	barley
MAI:	maize
GRA:	grass
LUZ:	lucerne
FAL:	flax
OAT:	oats
ONI:	onions
RAP:	rapeseed
BEA:	beans
PEA:	peas
FRU:	fruit trees
?:	unknown

1	SBT		51	SBT	225	101	WHE	16	151	POT		201	?	
2	?		52	BAR	3	102	WHE		152	WHE		202	FRU	
3	POT	167	53	SBT		103	?		153	ONI	51	203	?	
4	GRA	221	54	WHE		104	POT		154	POT		204	POT	
5	GRA		55	POT		105	LUZ	17	155	?		205	WHE	55
6	?		56	POT		106	?		156	GRA		206	GRA	
7	BAR		57	FLA		107	?		157	POT		207	WHE	
8	BAR		58	PEA		108	?		158	MAI	50	208	SBT	
9	BAR	4	59	SBT		109	BAR	18	159	WHE		209	?	
10	BAR	6	60	RAP	5	110	?		160	SBT		210	POT	171
11	?		61	RAP	5	111	?		161	POT		211	WHE	
12	?		62	RAP		112	?		162	WHE		212	POT	
13	WHE	8	63	GRA		113	?		163	ONI	48	213	SBT	
14	?		64	POT		114	?		164	BAR		214	WHE	52
15	?		65	?		115	WHE		165	WHE		215	SBT	
16	LUZ	169	66	?		116	POT	154	166	SBT		216	?	
17	LUZ	151	67	RAP	7	117	OAT	20	167	POT		217	SBT	
18	LUZ	153	68	GRA		118	?		168	SBT		218	POT	
19	?		69	?		119	?		169	?		219	POT	
20	WHE		70	POT		120	WHE		170	WHE	47	220	MAI	
21	?		71	GRA		121	WHE	21	171	BAR	45	221	WHE	
22	LUZ	170	72	WHE		122	WHE	22	172	BAR	43	222	?	
23	FLA	15	73	BAR	11	123	GRA		173	WHE	41	223	POT	
24	WHE	19	74	MAI		124	GRA		174	RAP	39	224	SBT	
25	OAT		75	GRA		125	MAI		175	BAR	37	225	PEA	
26	LUZ		76	GRA		126	POT		176	RAP	35	226	SBT	
27	SBT		77	BAR	12	127	?		177	WHE	33	227	WHE	
28	SBT	191	78	GRA		128	POT		178	WHE	31	228	WHE	49
29	OAT	120	79	WHE		129	?		179	WHE	29	229	POT	
30	LUZ	97	80	BAR	12	130	GRA		180	WHE	27	230	PEA	
31	WHE		81	WHE		131	?		181	WHE		231	SBT	
32	RAP		82	?		132	?		182	WHE		232	BAR	
33	RAP	1	83	?		133	SBT	256	183	?		233	WHE	
34	PEA	96	84	LUZ	152	134	WHE	54	184	POT		234	BEA	
35	GRA	95	85	?		135	GRA		185	?		235	POT	
36	GRA		86	SBT		136	GRA		186	SBT	250	236	LUZ	46
37	POT		87	?		137	WHE		187	BEA	139	237	BEA	138
38	POT		88	POT		138	SBT		188	?		238	BAR	
39	POT		89	BAR	13	139	?		189	WHE		239	BAR	44
40	WHE	2	90	?		140	WHE		190	?		240	RAP	42
41	SBT		91	GRA		141	SBT	172	191	POT	173	241	RAP	40
42	GRA		92	POT		142	POT	192	192	?		242	BAR	38
43	MAI		93	GRA		143	GRA		193	WHE		243	BAR	36
44	POT	168	94	WHE	14	144	POT		194	?		244	RAP	34
45	?		95	GRA		145	GRA		195	SBT	237	245	WHE	32
46	POT		96	MAI		146	MAI		196	?	53	246	WHE	30
47	MAI		97	?		147	POT		197	GRA	53	247	WHE	28
48	WHE		98	MAI		148	GRA		198	SBT	53	248	BAR	26
49	POT		99	WHE	16	149	SBT		199	?		249	BAR	25
50	WHE		100	?		150	?		200	?		250	BAR	107

Table 3.5.1 Field and crop identification (vegetationmap #; crop; CABO field #)

251	?		301	SBT		351	SBT		401	WHE		451	WHE	
252	FLA	57	302	WHE		352	WHE		402	?		452	POT	
253	?		303	GRA		353	?		403	SBT	266	453	GRA	
254	RAP	92	304	POT		354	SBT	252	404	?		454	POT	
255	RAP	58	305	?		355	POT		405	?		455	MAI	
256	?		306	GRA	267	356	WHE		406	WHE	83	456	POT	196
257	BAR	91	307	PEA		357	SBT		407	?	227	457	SBT	
258	BAR	59	308	POT		358	POT		408	WHE		458	POT	
259	?		309	?		359	WHE		409	?		459	SBT	
260	FLA	90	310	?		360	?	199	410	GRA		460	PEA	65
261	FLA	61	311	WHE		361	POT		411	POT		461	ONI	102
262	GRA	98	312	SBT		362	WHE		412	?		462	BEA	182
263	GRA	99	313	PEA	66	363	POT		413	SBT		463	POT	
264	POT	60/176	314	WHE		364	?		414	?		464	WHE	
265	POT		315	POT		365	?		415	?		465	WHE	
266	WHE		316	WHE		366	?		416	?		466	?	
267	POT	177	317	?		367	?		417	SBT	262	467	?	
268	WHE	62	318	?		368	POT		418	GRA		468	WHE	140
269	SBT		319	POT		369	GRA		419	?		469	SBT	
270	POT		320	SBT	241	370	POT	185	420	POT		470	?	
271	SBT		321	RAP		371	WHE		421	?		471	WHE	
272	POT	178	322	?		372	?		422	?		472	?	
273	RAP	56	323	?		373	SBT	200	423	?		473	POT	
274	GRA		324	SBT		374	GRA	259	424	?		474	SBT	
275	?		325	WHE		375	ONI	109	425	?		475	WHE	
276	POT		326	?		376	POT	110/111	426	?		476	SBT	
277	POT		327	SBT		377	GRA	243	427	?		477	POT	197
278	FLA		328	GRA		378	LUZ		428	POT	218	478	?	
279	PEA		329	SBT		379	GRA		429	?		479	WHE	
280	WHE		330	?		380	POT	108	430	WHE		480	POT	
281	SBT		331	SBT	251	381	MAI		431	POT		481	?	
282	BEA	179	332	POT	156	382	POT	184	432	WHE		482	WHE	
283	RAP		333	SBT		383	?		433	ONI		483	?	
284	POT		334	POT		384	?		434	WHE		484	WHE	
285	GRA		335	SBT		385	SBT	244	435	MAI		485	SBT	
286	WHE		336	WHE		386	?		436	SBT		486	GRA	
287	?		337	POT	198	387	BAR	89	437	WHE	64	487	WHE	
288	SBT		338	ONI	105	388	BAR	88	438	SBT	240	488	?	
289	BEA	155	339	PEA	104	389	?		439	POT	180	489	POT	
290	RAP		340	WHE		390	FLA	87	440	WHE	121	490	ONI	
291	POT		341	?		391	FLA	86	441	WHE		491	?	103
292	GRA		342	?		392	?		442	SBT		492	SBT	
293	?		343	SBT		393	?		443	POT		493	POT	
294	POT		344	POT	67	394	FRU		444	WHE		494	WHE	
295	WHE		345	?		395	ONI	85	445	POT		495	?	
296	?		346	?		396	POT	216	446	GRA		496	POT	
297	?		347	?		397	SBT	238	447	WHE	122	497	WHE	
298	?		348	SBT		398	POT	175	448	BEA	181	498	SBT	
299	GRA	101	349	POT		399	SBT	258	449	POT	195	499	SBT	242
300	BAR		350	?		400	POT	194	450	SBT		500	WHE	

Table 3.5.2 Field and crop identification (vegetationmap #; crop; CABO field #)

501	POT		551	?		601	SBT		651	?		701	SBT	
502	?		552	SBT	222	602	POT		652	SBT	231	702	?	
503	?		553	?	112	603	WHE		653	?		703	GRA	81
504	SBT		554	WHE	123	604	BEA		654	POT		704	?	
505	?		555	GRA	114	605	GRA		655	WHE	130	705	?	
506	?		556	POT	201	606	WHE	146	656	ONI		706	POT	
507	?		557	ONI	124	607	POT		657	?		707	POT	128
508	?		558	BEA	158	608	SBT		658	WHE		708	?	
509	GRA		559	WHE	149	609	WHE		659	SBT		709	?	
510	POT	183	560	SBT	223	610	?		660	WHE		710	?	
511	WHE		561	BAR	84	611	?		661	POT	204	711	SBT	
512	SBT		562	FRU		612	GRA	116	662	WHE	125	712	POT	
513	?		563	WHE		613	WHE		663	ONI	78	713	WHE	
514	?		564	POT		614	?		664	WHE	126	714	?	80
515	?		565	?	83	615	WHE		665	SBT	224	715	?	
516	POT		566	POT	174	616	SBT		666	WHE	127	716	SBT	
517	WHE		567	ONI	82	617	?		667	POT	77/203	717	POT	
518	?	228	568	?		618	GRA		668	POT	186	718	WHE	
519	ONI	106	569	FRU		619	POT	188	669	GRA		719	WHE	145
520	WHE	141	570	POT	217	620	SBT		670	GRA		720	GRA	
521	SBT		571	SBT	239	621	?		671	GRA		721	POT	
522	POT		572	FRU		622	?		672	FRU		722	?	
523	?		573	FRU		623	WHE		673	?		723	GRA	
524	SBT		574	?		624	GRA		674	?		724	SBT	234
525	?		575	?	193a/b	625	POT	159	675	FRU		725	POT	
526	SBT		576	?	193a/b	626	?		676	SBT		726	MAI	
527	?	229	577	?	193a/b	627	WHE		677	SBT	257	727	?	
528	?		578	SBT	193	628	POT		678	WHE	100	728	WHE	
529	?		579	POT	190	629	SBT	261	679	ONI	69	729	BEA	207
530	?		580	BEA	150	630	POT		680	SBT		730	FLA	79
531	?		581	?		631	SBT		681	POT	160	731	POT	
532	MAI		582	?		632	?		682	FRU		732	WHE	
533	?		583	?		633	?		683	GRA		733	SBT	
534	SBT		584	?		634	WHE	129	684	FRU		734	WHE	144
535	?		585	FRU		635	?		685	FRU		735	SBT	
536	?		586	FRU		636	?		686	FRU		736	WHE	
537	SBT		587	?		637	?		687	FRU		737	POT	
538	?		588	?		638	POT		688	FRU		738	?	
539	WHE		589	FRU		639	WHE		689	FRU		739	?	
540	POT		590	POT		640	SBT	233	690	?		740	?	
541	GRA	260	591	FRU		641	?		691	POT		741	?	232
542	PEA	113	592	FRU		642	?		692	FRU		742	WHE	
543	ONI	68	593	FRU		643	?		693	FRU		743	POT	
544	POT	157	594	POT		644	SBT		694	FRU		744	WHE	
545	SBT	230	595	SBT		645	WHE		695	FRU		745	BEA	143
546	BEA	202	596	POT		646	POT	206	696	FRU		746	SBT	
547	FRU		597	?		647	WHE		697	?	189	747	POT	
548	?		598	WHE		648	GRA		698	FRU		748	WHE	
549	ONI	115	599	SBT		649	POT		699	FRU		749	BEA	205
550	POT		600	FRU		650	WHE		700	FRU		750	SBT	

Table 3.5.3 Field and crop identification (vegetationmap #; crop; CABO field #)

751	?		801	WHE		851	?		901	MAI	245	951	MAI	
752	POT		802	GRA		852	?		902	POT		952	GRA	
753	WHE		803	PEA	71	853	?		903	GRA		953	MAI	
754	SBT		804	ONI	72	854	?		904	MAI		954	?	
755	POT	187	805	?		855	SBT	253	905	GRA		955	GRA	
756	WHE		806	WHE		856	POT		906	MAI		956	POT	
757	SBT		807	SBT		857	?		907	POT		957	WHE	
758	?		808	GRA		858	?		908	MAI		958	GRA	
759	WHE		809	?		859	SBT	236	909	GRA		959	GRA	
760	WHE	142	810	?		860	?		910	GRA		960	POT	164
761	?		811	SBT		861	POT		911	?		961	GRA	
762	POT		812	POT		862	WHE	135	912	POT		962	POT	
763	SBT		813	WHE	73	863	GRA		913	?		963	?	
764	SBT		814	PEA	137	864	POT		914	GRA		964	MAI	248
765	?		815	BEA		865	WHE	134	915	GRA		965	GRA	
766	GRA		816	BEA		866	GRA		916	MAI		966	?	
767	WHE		817	GRA		867	POT		917	POT	220	967	GRA	
768	POT	161	818	POT		868	WHE	133	918	GRA		968	POT	
769	?		819	SBT		869	SBT		919	GRA		969	POT	165
770	WHE		820	PEA		870	POT		920	MAI		970	MAI	249
771	?		821	ONI	74	871	?		921	GRA		971	GRA	
772	?		822	SBT		872	GRA		922	MAI		972	GRA	
773	SBT	235	823	WHE		873	?		923	GRA		973	?	
774	WHE		824	GRA		874	SBT		924	POT		974	POT	214
775	POT	162	825	POT		875	WHE	132	925	GRA		975	SBT	
776	WHE	148	826	WHE		876	?		926	GRA		976	?	
777	?	117	827	ONI	75	877	SBT		927	MAI		977	WHE	
778	SBT		828	POT		878	WHE	131	928	POT		978	SBT	254
779	POT	208	829	GRA		879	PEA	119	929	GRA		979	?	
780	WHE	147	830	?		880	SBT	215	930	?		980	WHE	
781	POT	163	831	?		881	BEA	166	931	GRA		981	SBT	
782	?		832	POT	211	882	MAI		932	GRA		982	GRA	
783	?		833	WHE		883	GRA		933	POT		983	?	
784	GRA		834	POT		884	POT	209	934	POT		984	POT	
785	POT		835	?		885	POT		935	GRA		985	PEA	118
786	?		836	GRA		886	MAI		936	?		986	?	
787	GRA		837	SBT	212	887	GRA		937	GRA	263	987	WHE	
788	SBT		838	POT		888	GRA		938	GRA		988	SBT	
789	GRA	70	839	GRA		889	POT		939	GRA		989	POT	
790	GRA	70	840	?		890	GRA		940	GRA		990	SBT	255
791	POT	210	841	GRA		891	GRA		941	?		991	?	
792	SBT		842	MAI		892	POT		942	MAI	247	992	?	
793	?		843	POT	76	893	GRA		943	GRA		993	?	
794	WHE		844	SBT		894	SBT		944	MAI		994	SBT	
795	SBT	219	845	GRA		895	GRA		945	GRA		995	POT	
796	?		846	POT		896	GRA	268	946	POT		996	WHE	
797	WHE		847	?		897	GRA		947	?		997	SBT	265
798	POT		848	?		898	GRA		948	POT	213	998	POT	
799	SBT	246	849	WHE	136	899	POT		949	MAI				
800	POT		850	POT		900	GRA		950	GRA				

Table 3.5.4 Field and crop identification (vegetationmap #; crop; CABO field #)

4 COLLECTION OF DATA ON FOREST STANDS

4.1 INTRODUCTION

Within the framework of the 1991 JPL-SAR campaign only a limited set of forest ground data has been collected. There was no need to (re)measure the full set of forest spatial structure parameters (listed in the MAESTRO 89 ground data report; Droesen et al., 1989) as this was done just two years ago. Within that period of time major changes in these parameters cannot be expected. The latter does not hold true for the parameters from stand SP0001 and SP0004 as they have been subject to thinning activities. In addition stand SP0004 has been considerably damaged in the storm of January 1990. As such it cannot be considered a homogeneous stand any longer. With respect to SP0002 it may be interest to note that it did not yet have full canopy coverage at the time of the first flight.
In comparisson to 1989 a larger number of stands has been incorporated in the ground data collection activities. A total of three additional stands (HO0008, HO0009 and HO0010) was selected in the Horsterwold area. Each of these stands comprises a poplar species. Reason for selection was their, apparently, deviating backscatter behaviour in 1989. For these additional stands the full set of ground reference data had to be acquired. Soil and vegetation moisture parameters will change in time and therefore had to be collected during, or close to, each overpass of the JPL-SAR sensor. In the Horsterwold area ground data collection was organized by Heidemij, whereas the Wageningen Agricultural University was responsible for the ground data collection in the Speulder and Sprielder forest.

4.2 FOREST SPATIAL STRUCTURE PARAMETERS

Sampling and measurement methodology have been described in the MAESTRO 89 ground data collection report. The Bitterlich or Point Sampling Method (Vries, 1986) was applied to estimate basal area, volume and number of stems per ha for stand SP0002 and SP0004. In each of the stands 10 point samples, chosen at random, were drawn. Data for the forest stands in the Horsterwold were upgraded with the use of the growth-models 'OPTAB' and 'PEPPEL'. These models have been developed at the Dorschkamp Research Institute for Forestry and Landscape Planning (Faber, 1990).

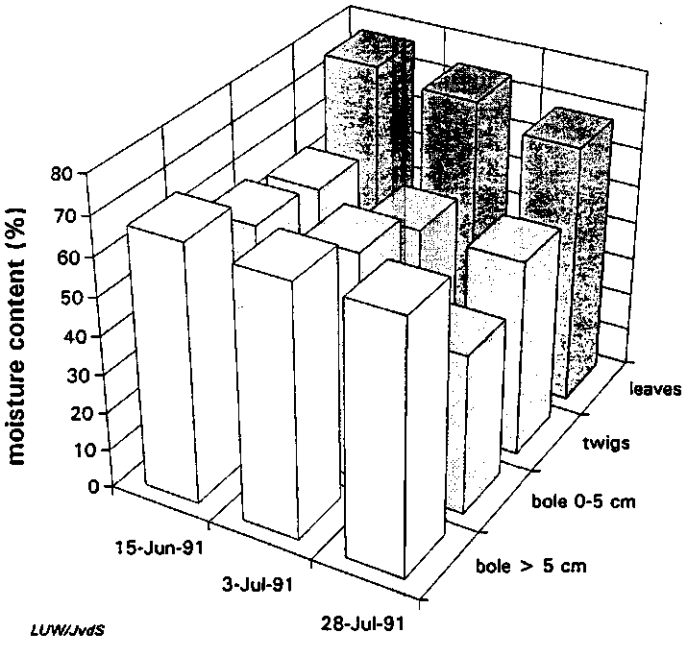
4.3 STAND MOISTURE CONTENT PARAMETERS

Sampling and measurement methodology have been described in the MAESTRO 89 ground data collection report (Droesen et al., 1989). Data were collected on the 15th of June, 3rd of July and 28th of July.

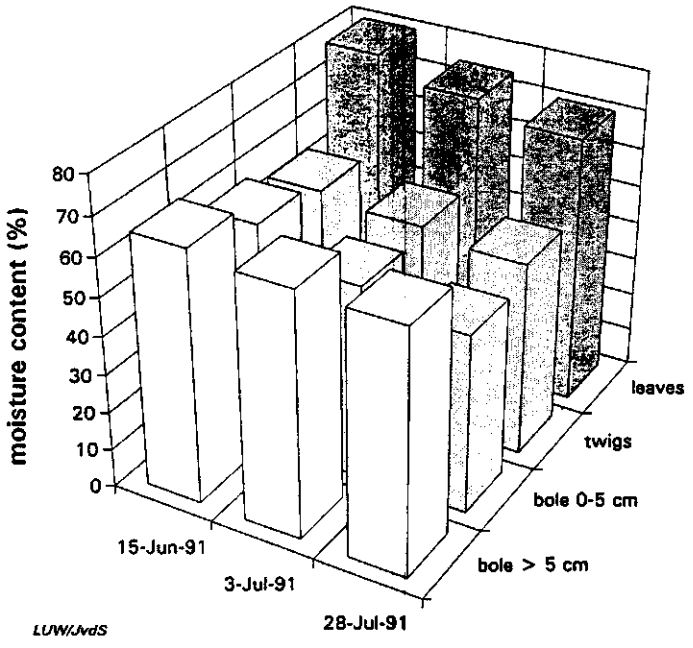
4.4 SOIL MOISTURE CONTENT PARAMETERS

Soil moisture measurements were carried out with a Time Domain Reflectometry system (TDR). This instrument transmits an electromagnetic wave into the soil in order to determine its dielectric permittivity. Based on this value the volumetric water content of the soil can be calculated (Roth et al., 1990). Six sample points were selected, at random, in each of the Horsterwold stands. At each of the sample points a total of two measurements was carried out; one measurement in order to determine the volumetric moisture content of the upper 5 cm of the soil and a second measurement to determine the volumetric moisture content of the upper 10 cm. The soil moisture data for the Speulder and Sprielder forest are based on 15 samples. In this forest the volumetric moisture content of the litter layer was measured in addition to the moisture content of the two mineral soil layers. More information on soil moisture sampling as well as a definition of volumetric moisture content can be found in the MAESTRO 89 ground data report (Droesen et al., 1989). The soil moisture data were collected on or close to the: 15th of June, 3rd of July, 12th of July and 28th of July.

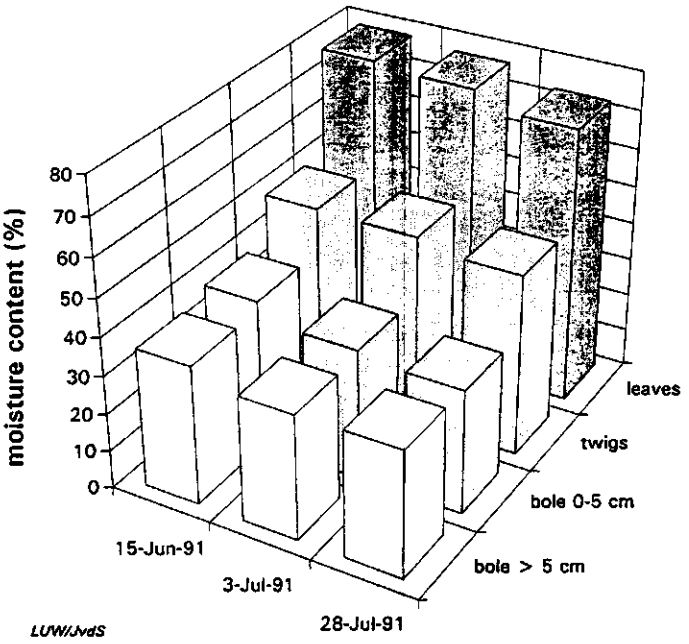
TREE MOISTURE STATUS HO0001



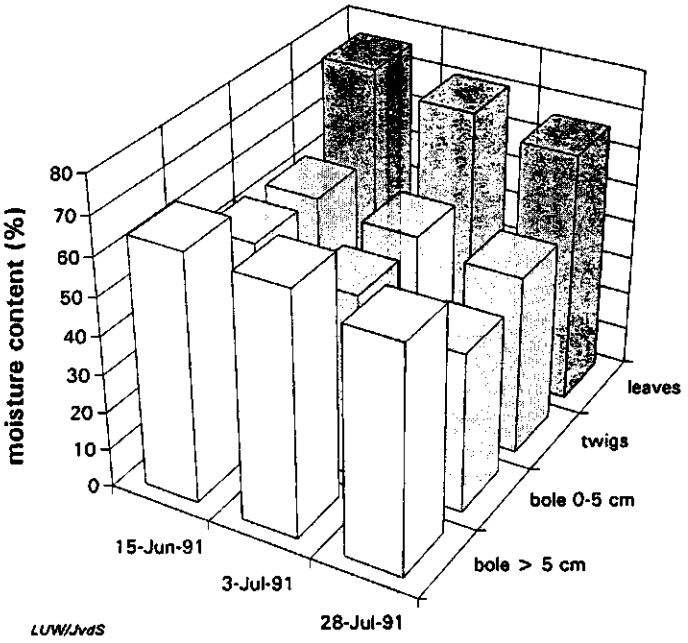
TREE MOISTURE STATUS HO0002



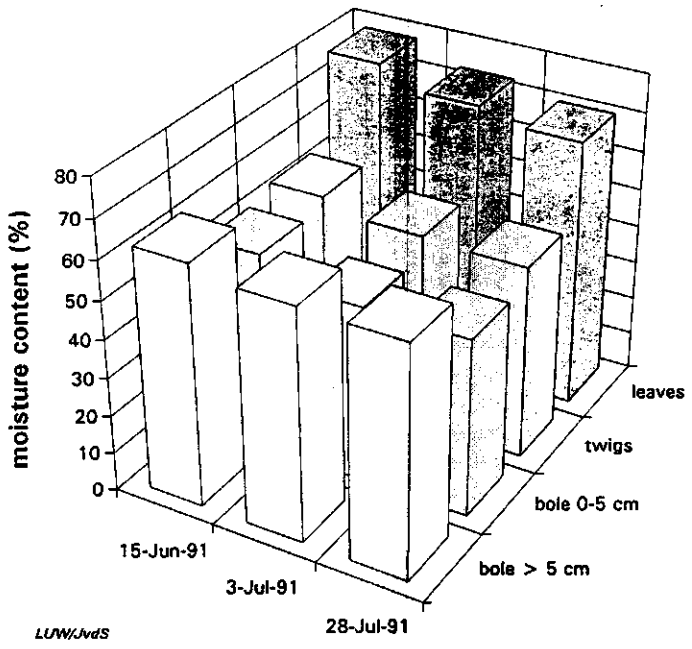
TREE MOISTURE STATUS HO0003



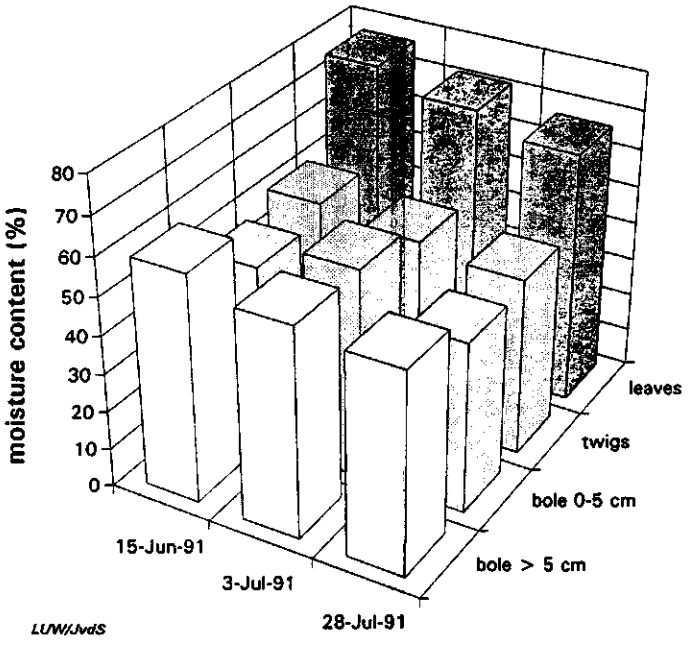
TREE MOISTURE STATUS HO0004



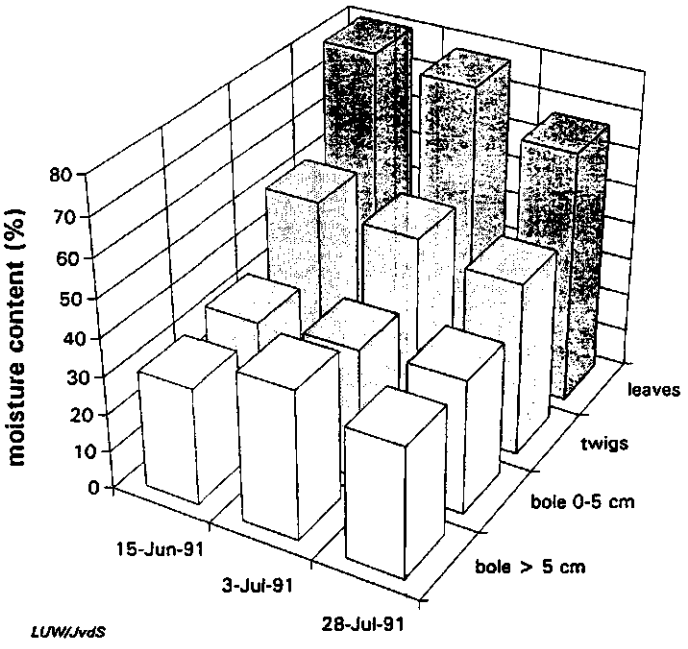
TREE MOISTURE STATUS HO0005



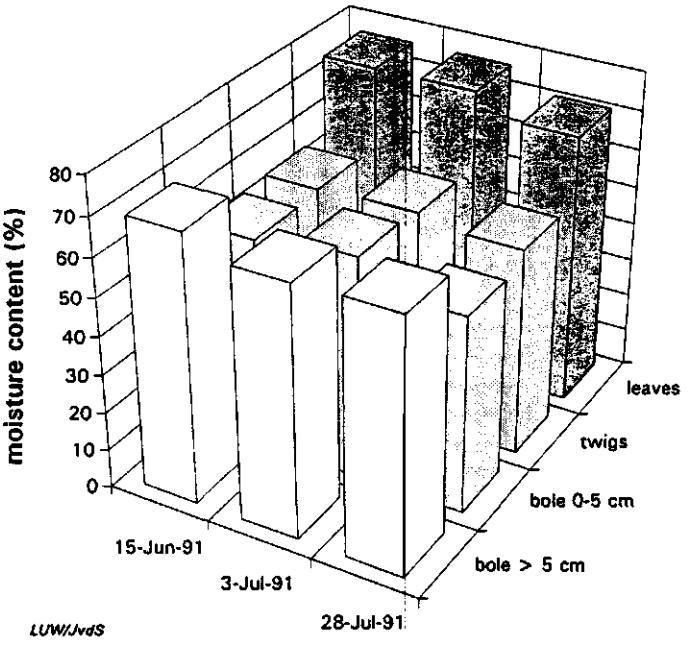
TREE MOISTURE STATUS HO0006



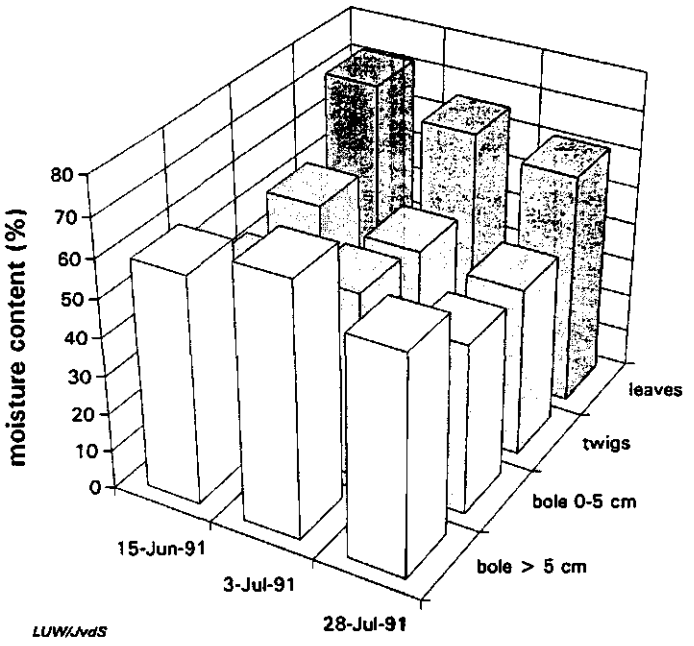
TREE MOISTURE STATUS HO0007



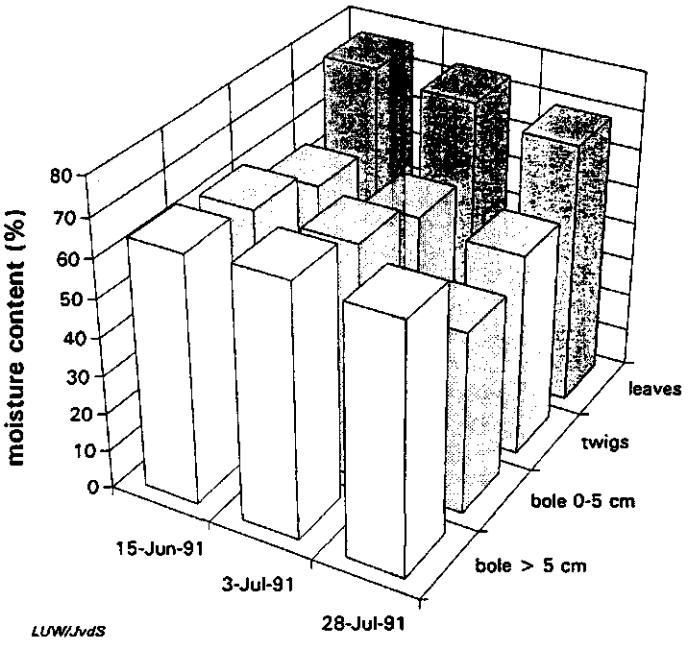
TREE MOISTURE STATUS HO0008



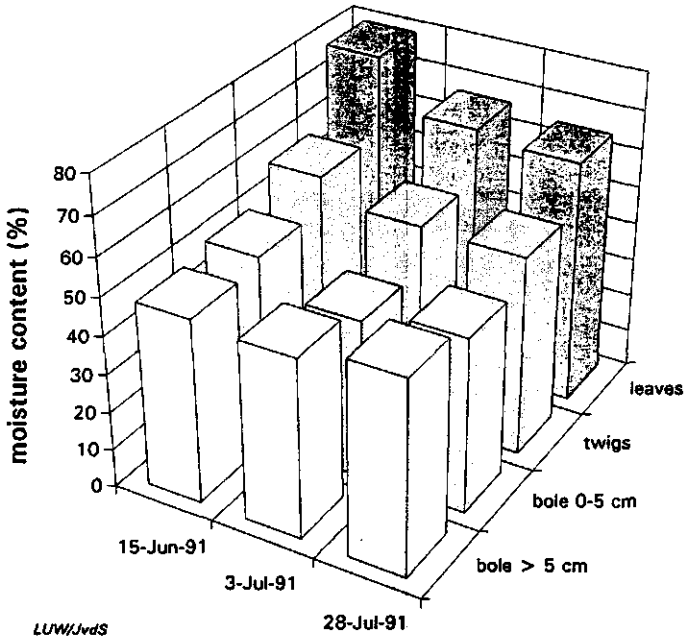
TREE MOISTURE STATUS HO0009



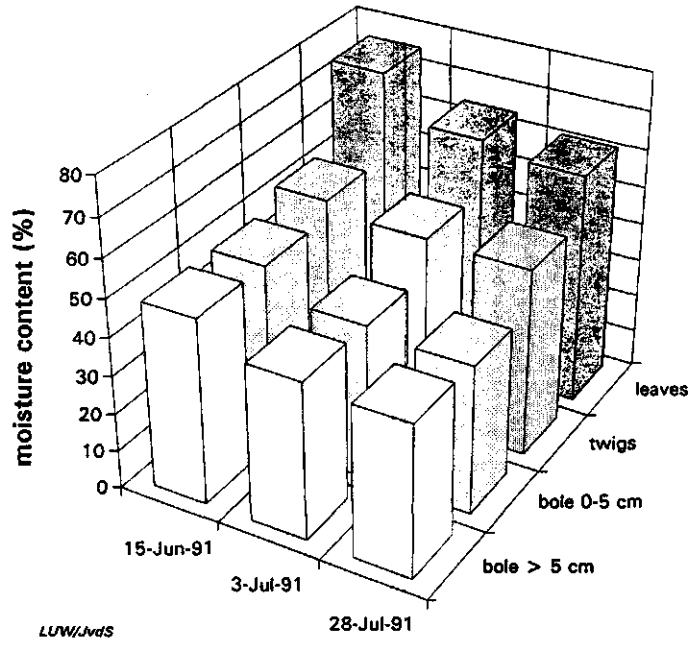
TREE MOISTURE STATUS HO0010



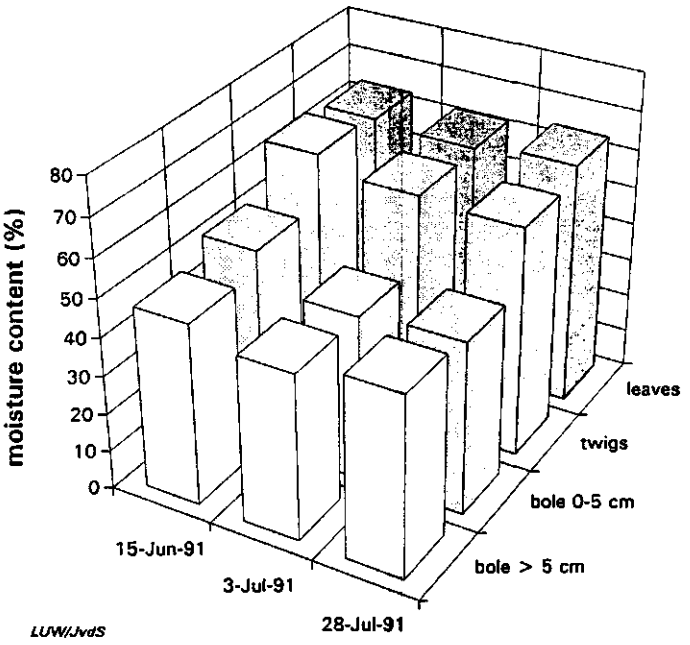
TREE MOISTURE STATUS SP0002



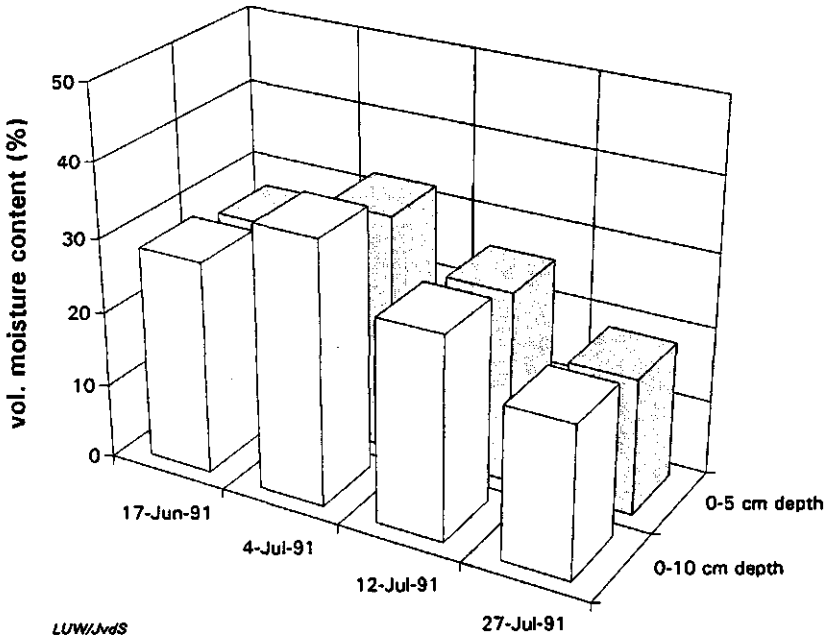
TREE MOISTURE STATUS SP0003



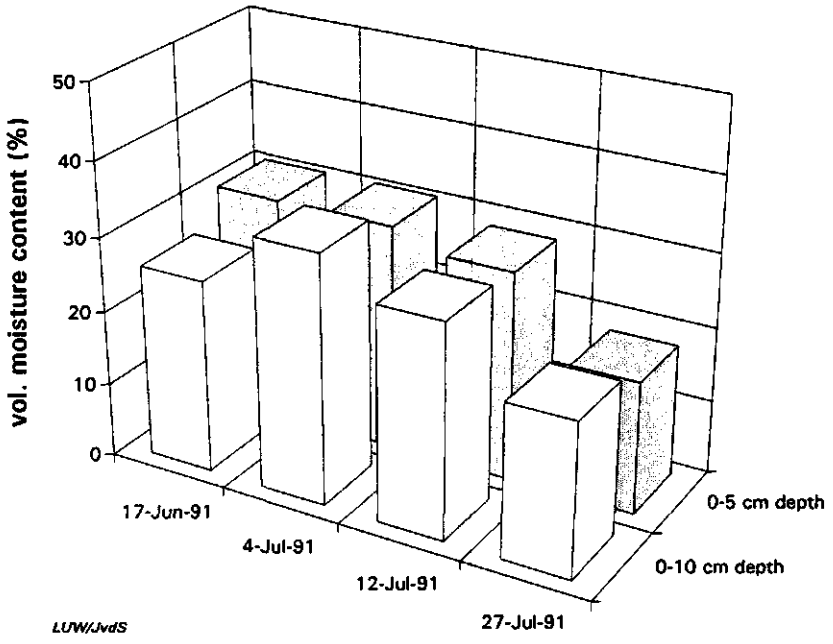
TREE MOISTURE STATUS SP0004



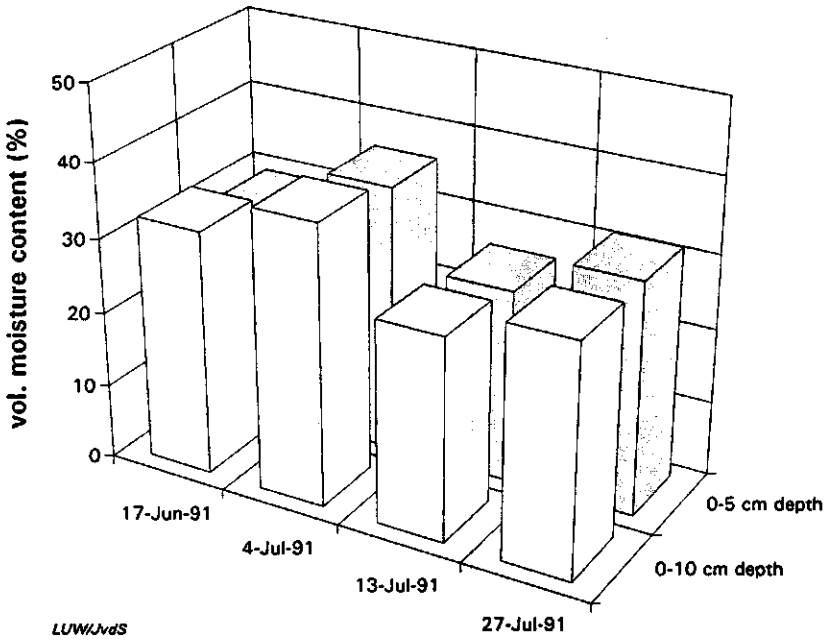
SOIL MOISTURE STATUS HO0001



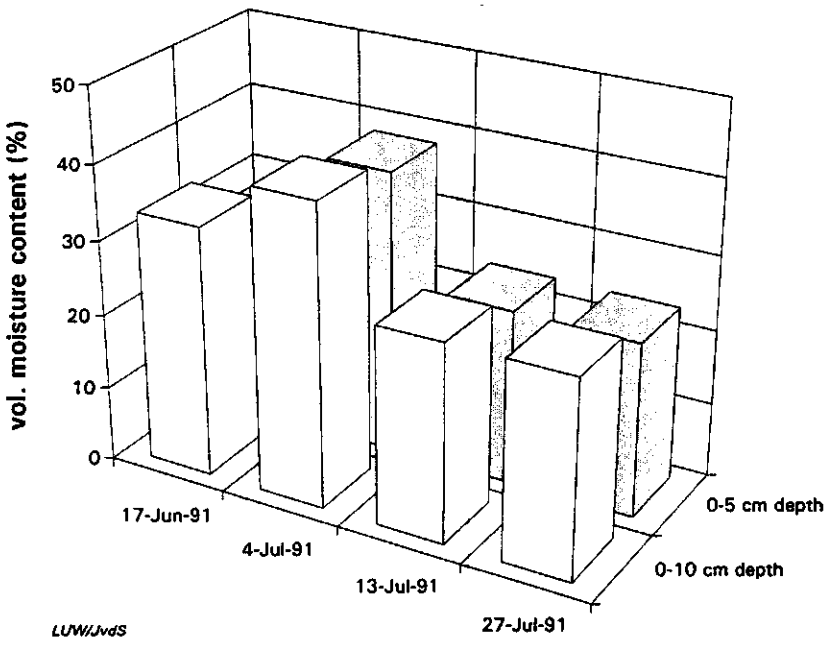
SOIL MOISTURE STATUS HO0002



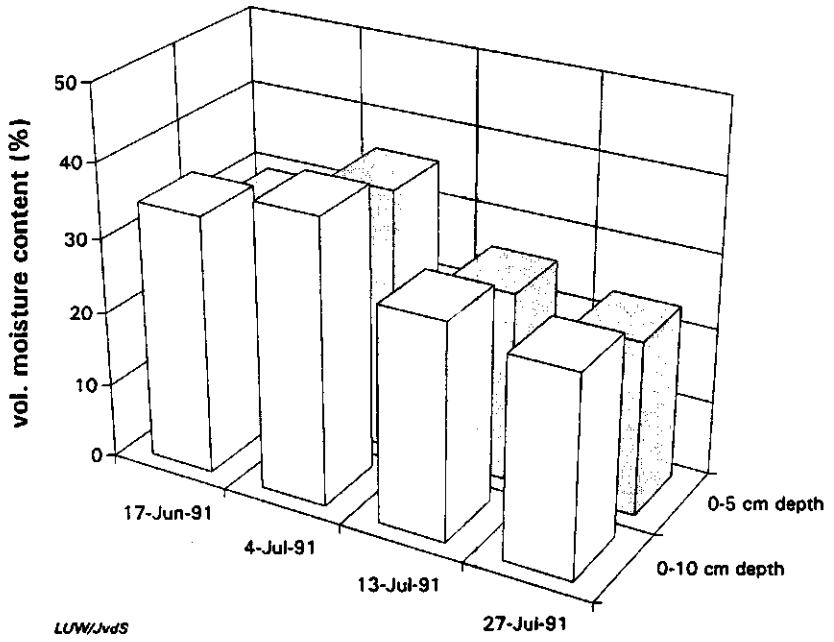
SOIL MOISTURE STATUS HO0003



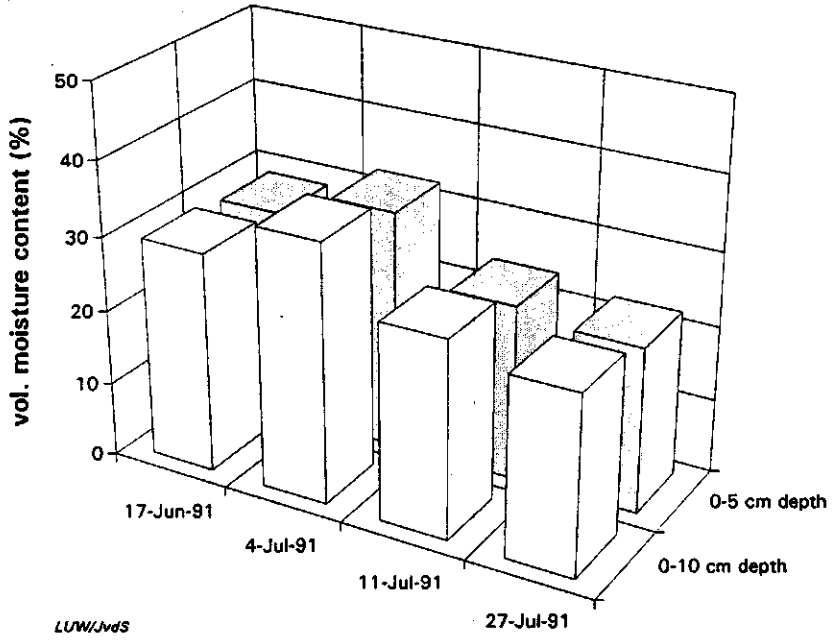
SOIL MOISTURE STATUS HO0004



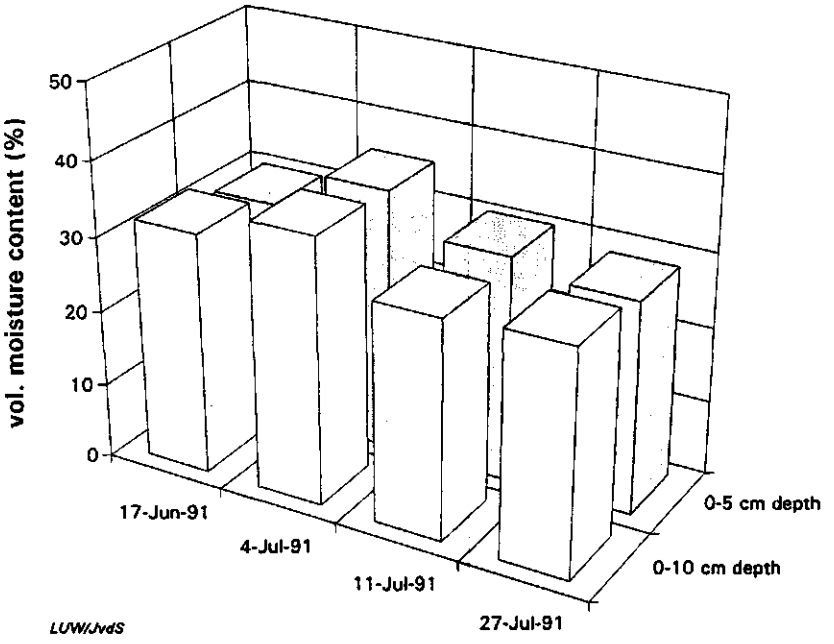
SOIL MOISTURE STATUS HO0005



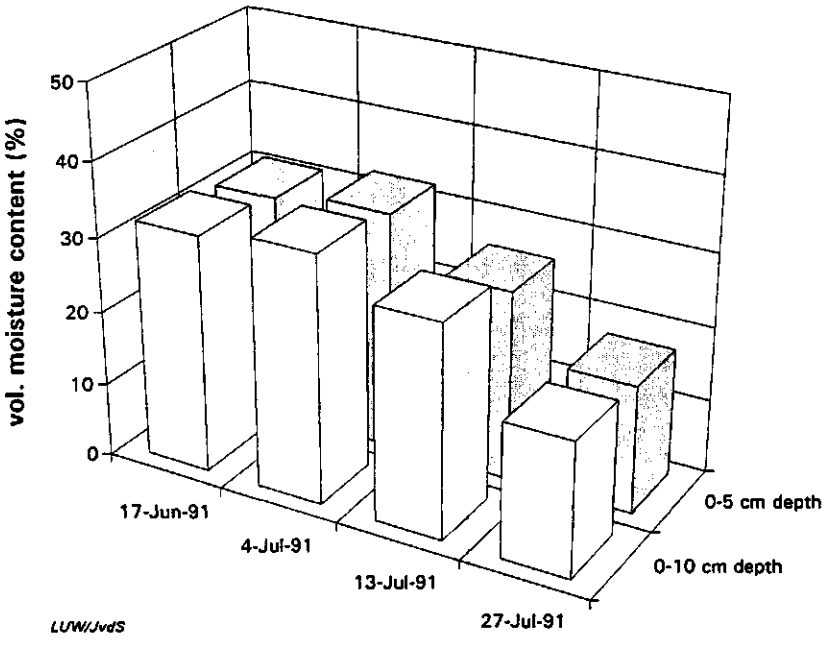
SOIL MOISTURE STATUS HO0006



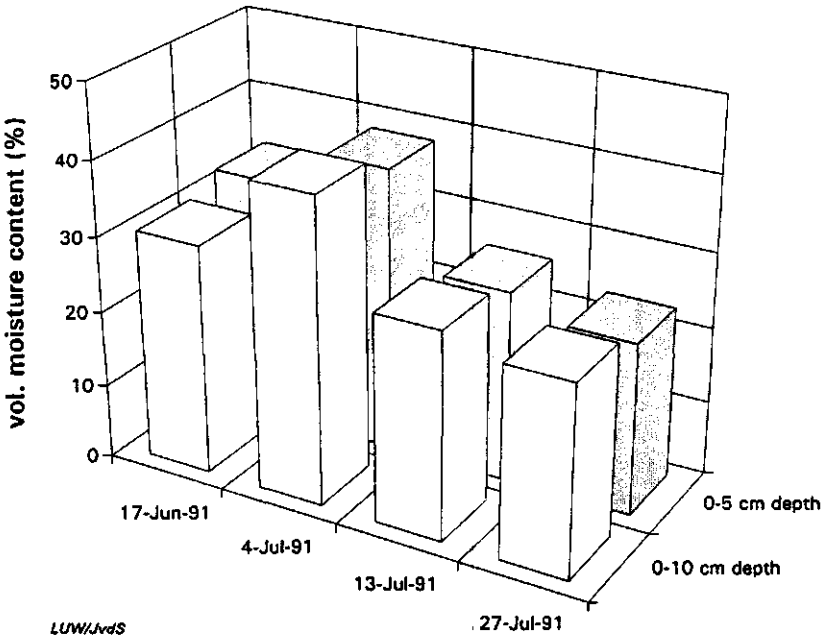
SOIL MOISTURE STATUS HO0007



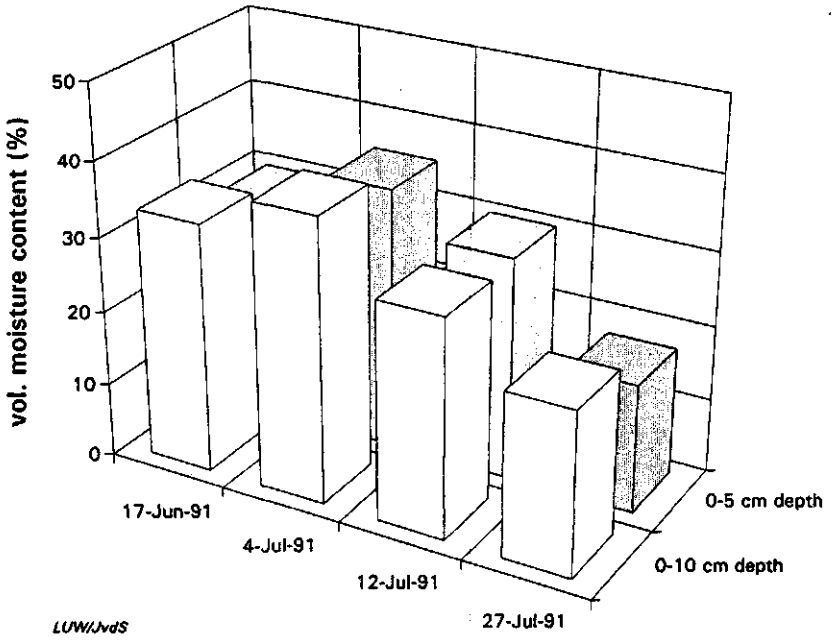
SOIL MOISTURE STATUS HO0008



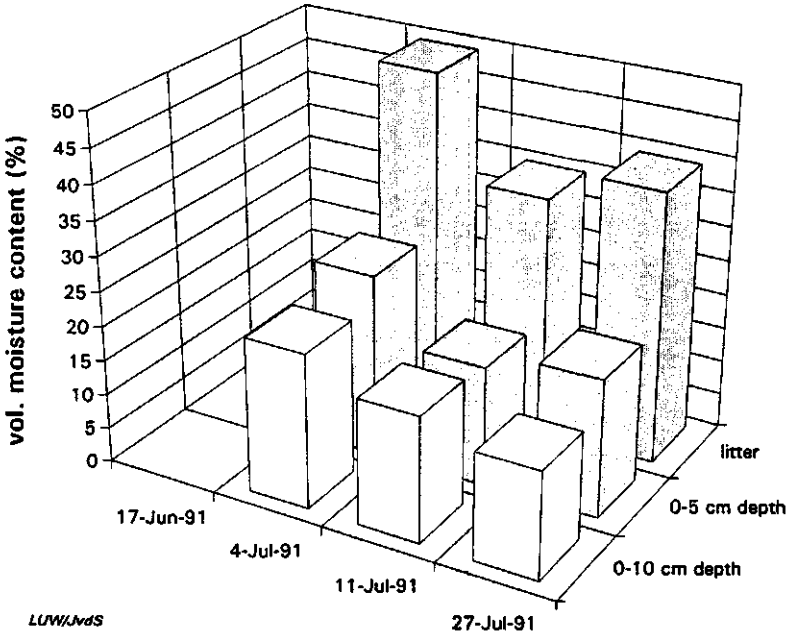
SOIL MOISTURE STATUS HO0009



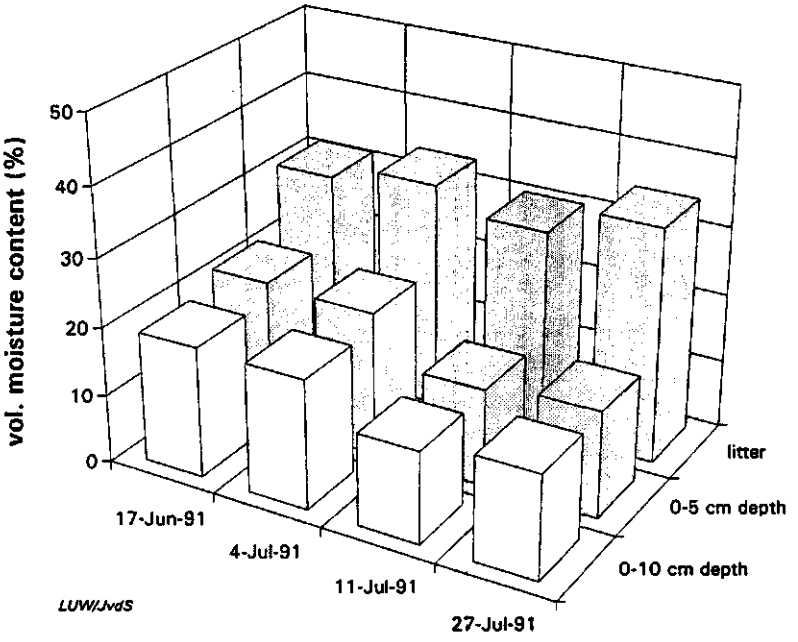
SOIL MOISTURE STATUS HO0010



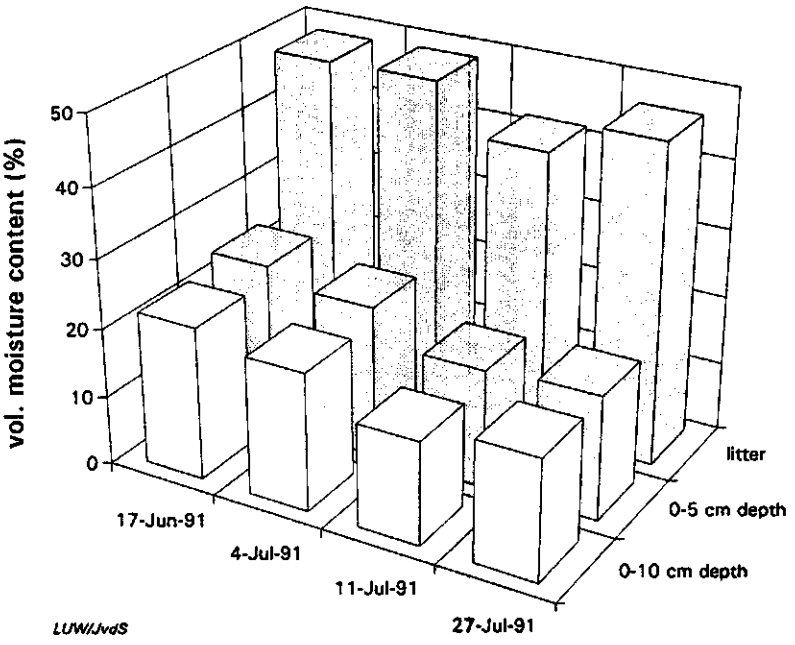
SOIL MOISTURE STATUS SP0001



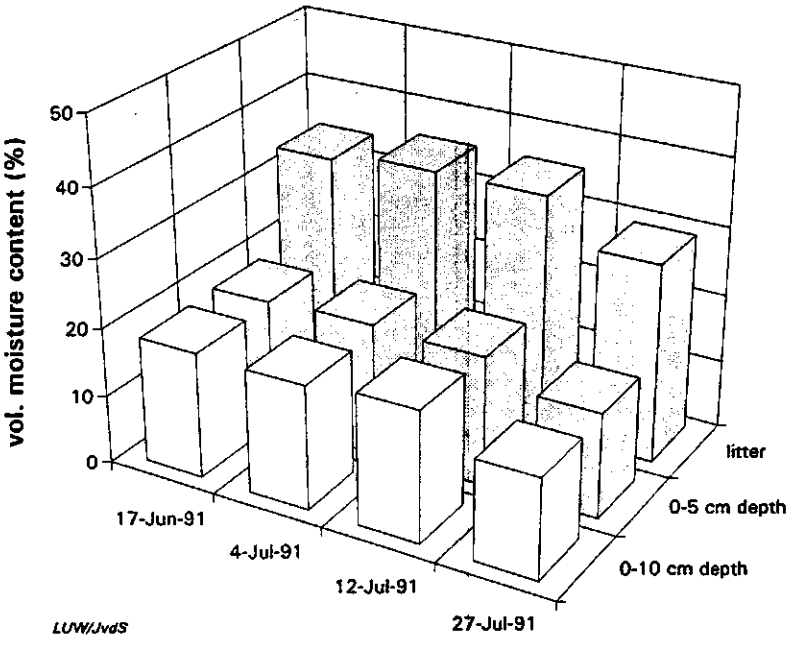
SOIL MOISTURE STATUS SP0002

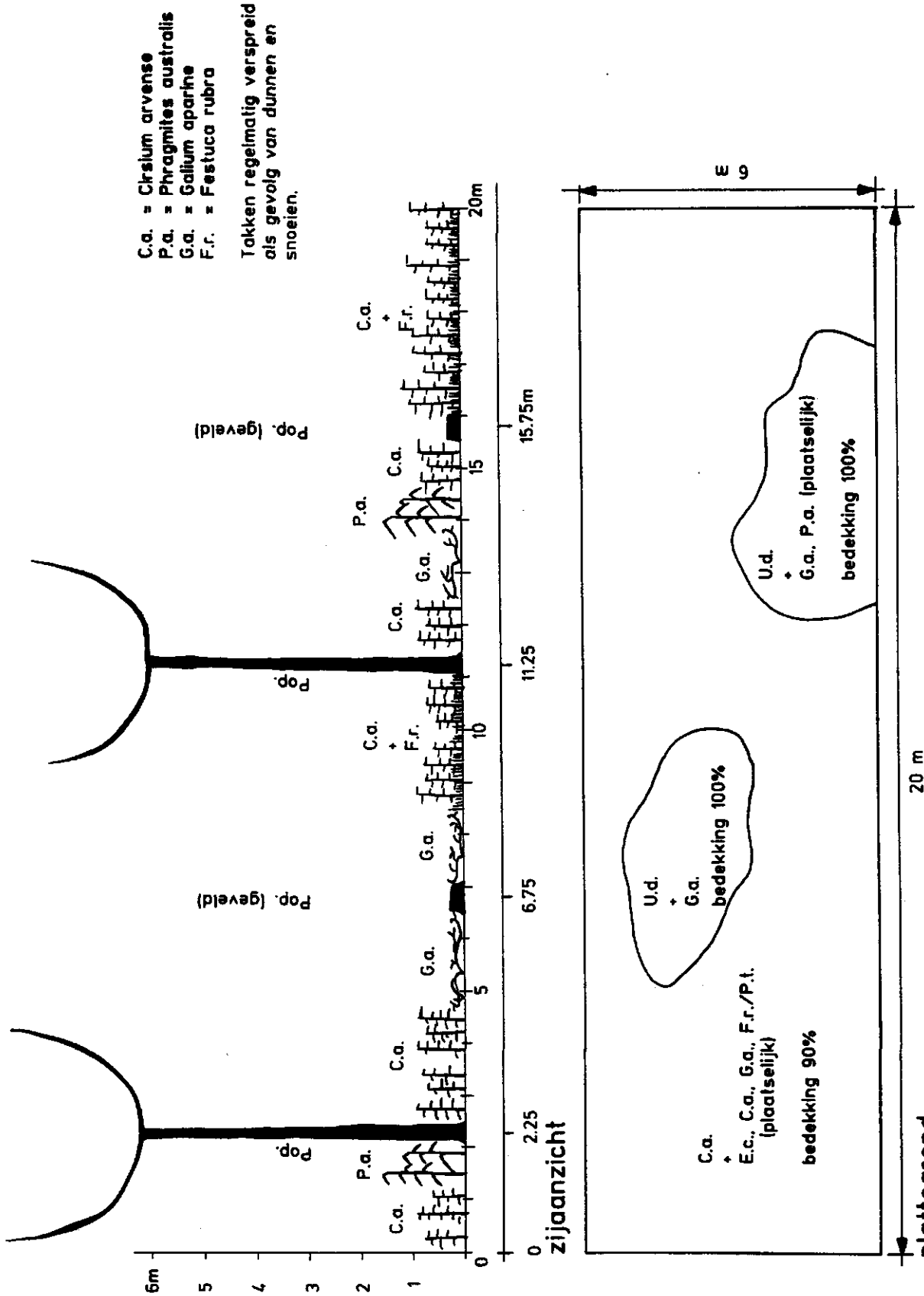


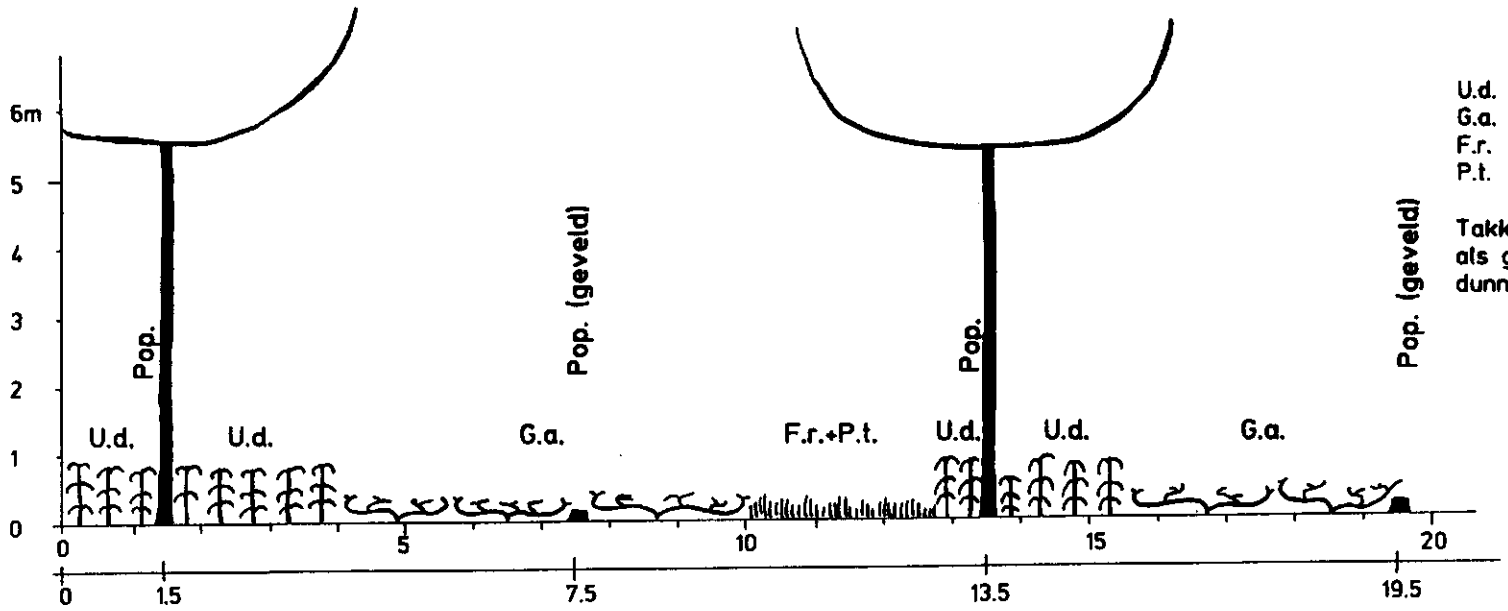
SOIL MOISTURE STATUS SP0003



SOIL MOISTURE STATUS SP0004



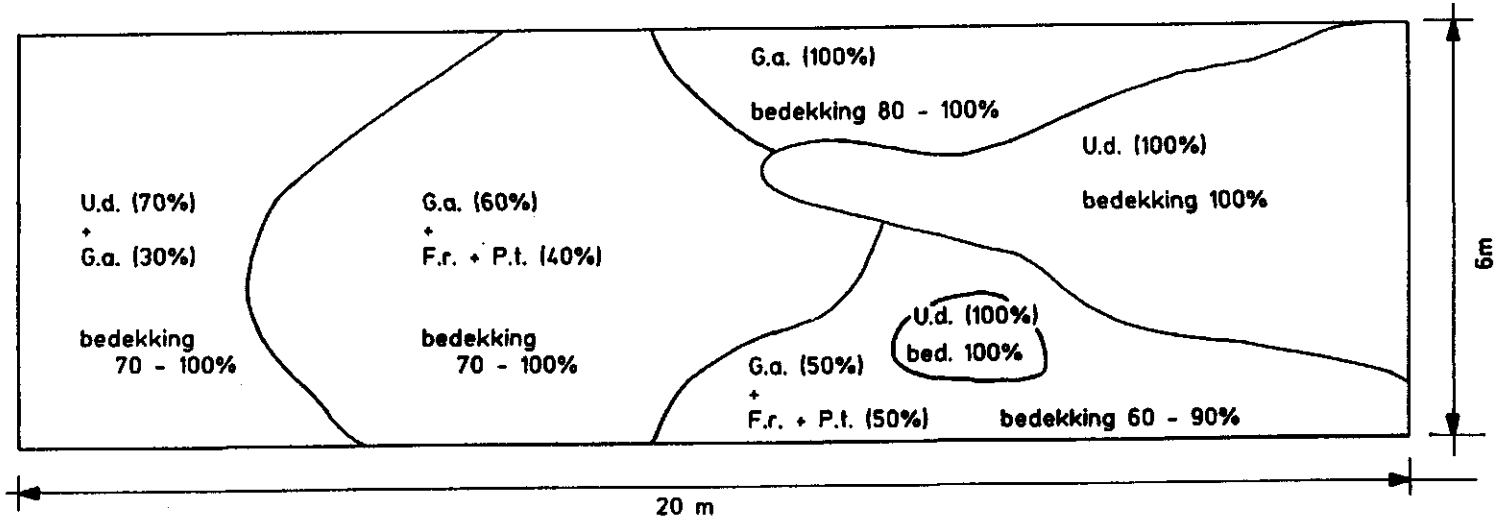

C.a. = Cirsium arvense
P.a. = Phragmites australis
G.a. = Galium aparine
F.r. = Festuca rubra
Takken regelmatig verspreid als gevolg van dunnen en snoeien.
Pop. (geveld)
Pop.
C.a.
P.a.
G.a.
F.r.
6m
0
2.25
6.75
11.25
15.75m
20m
zijaanzicht
U.d.
G.a.
bedekking 100%
C.a.
E.c., C.a., G.a., F.r./P.t.
(plaatselijk)
bedekking 90%
U.d.
G.a., P.a. (plaatselijk)
bedekking 100%
9 m
20 m
plattegrond
Pz 28 j1 Pop. 'Androscoggin'
gedund 50%. 1 cm = 1 m



U.d. = Urtica dioica
G.a. = Galium aparine
F.r. = Festca rubra
P.t. = Poa trivialis

Takken regelmatig verspreid als gevolg van snoeien en dunnen.

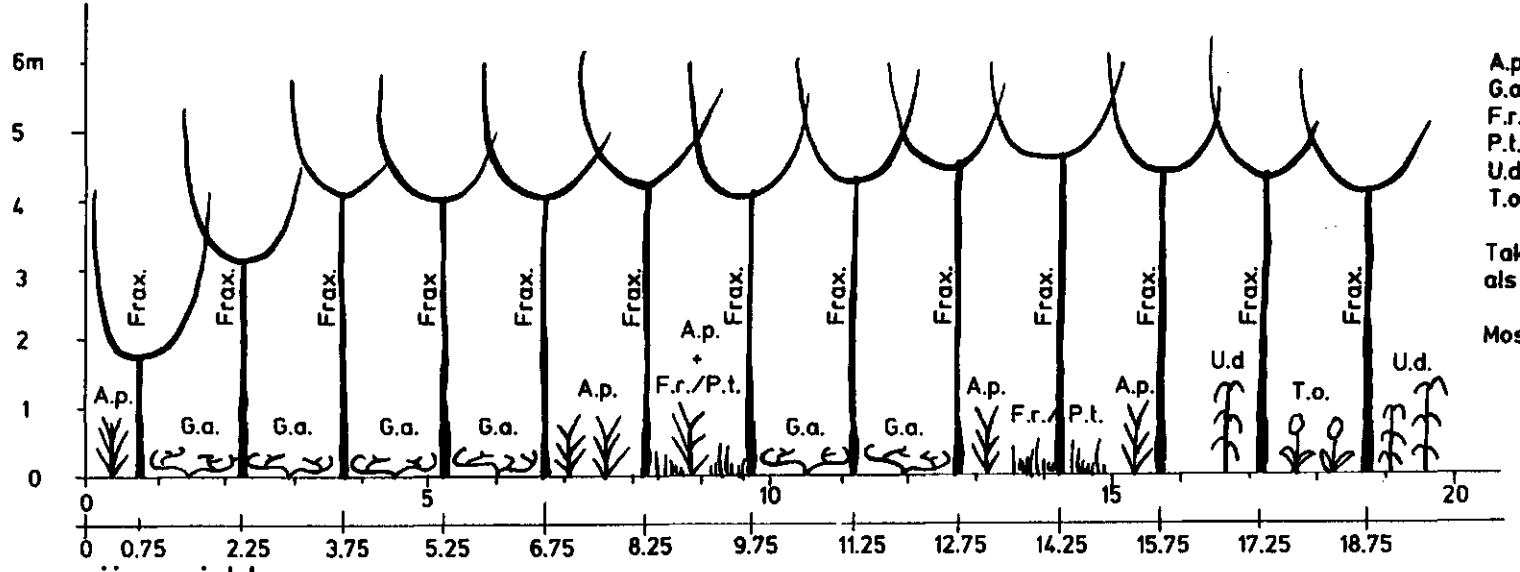
zijaanzicht



plattegrond

Pz 2 g1 Pop. 'Agathe F'

gedund 50%, 1 cm = 1 m

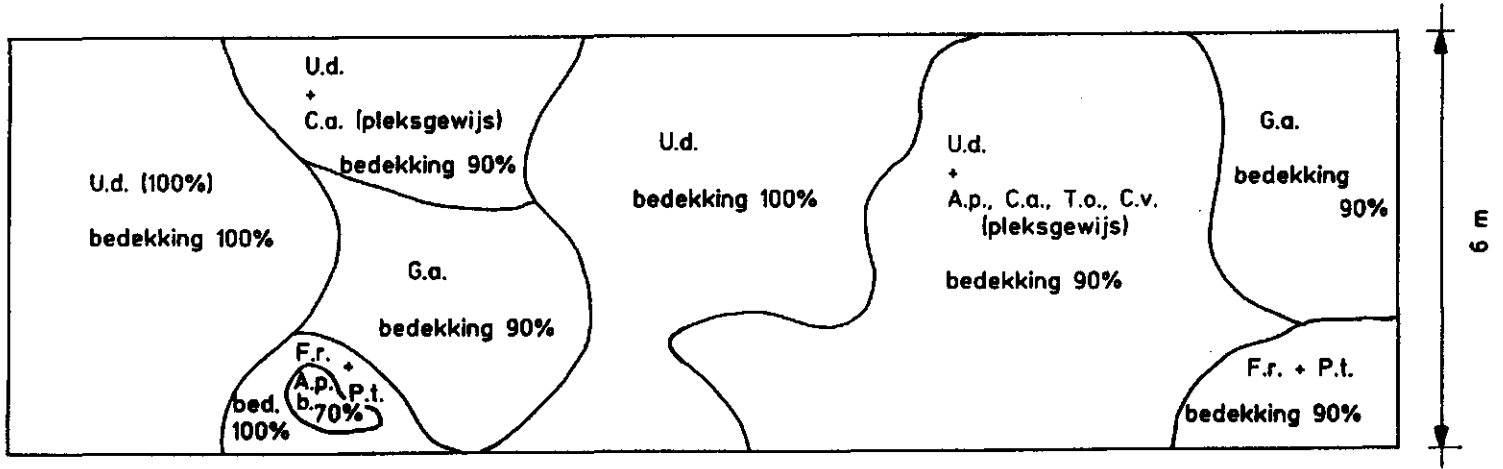


zijaanzicht

A.p. = Atriplex prostrata
G.a. = Gallium aparine
F.r. = Festuca rubra
P.t. = Poa trivialis
U.d. = Urtica dioica
T.o. = Taraxacum officinalis

Takken regelmatig verspreid als gevolg van snoeien.

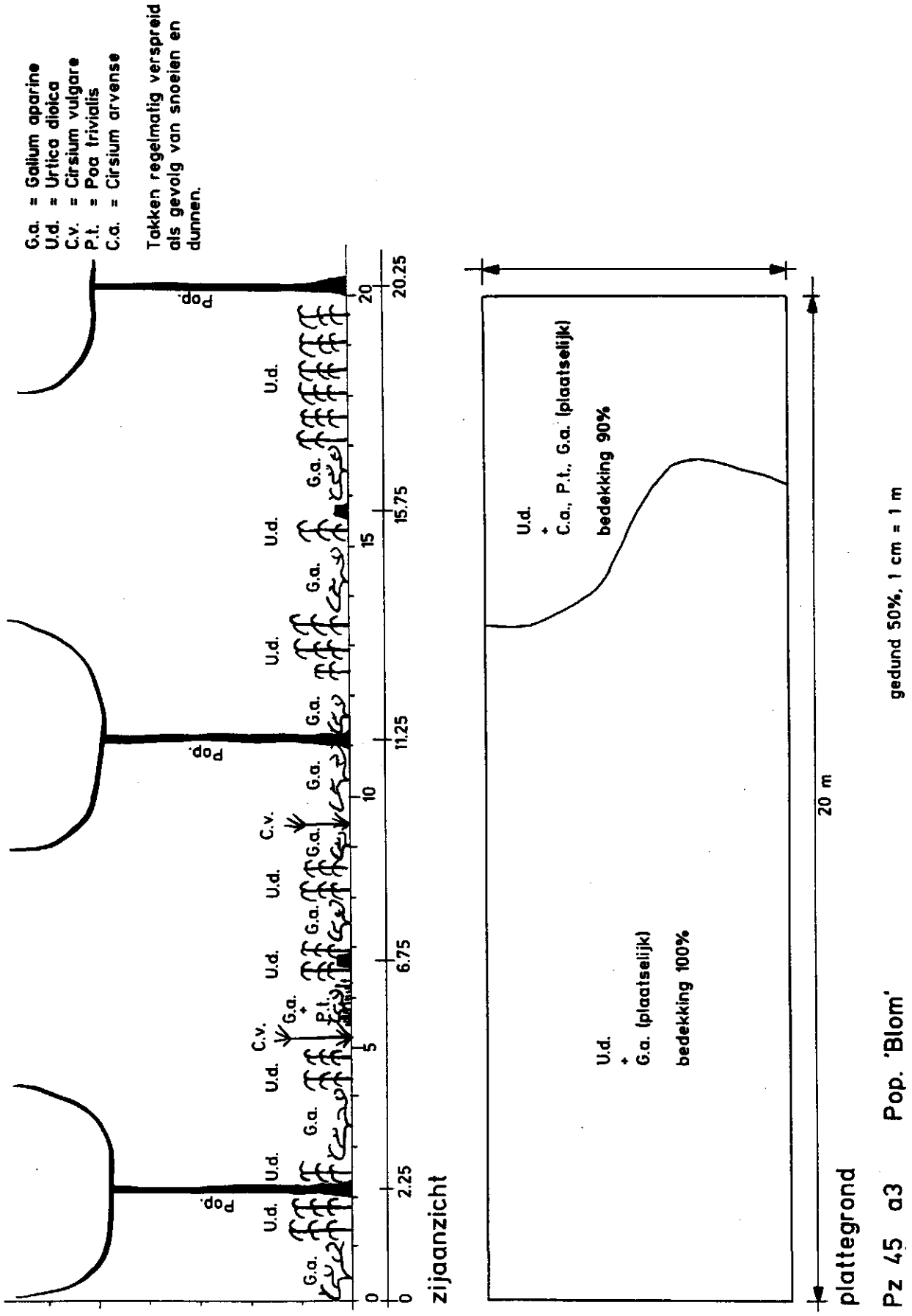
Mos regelmatig verspreid.



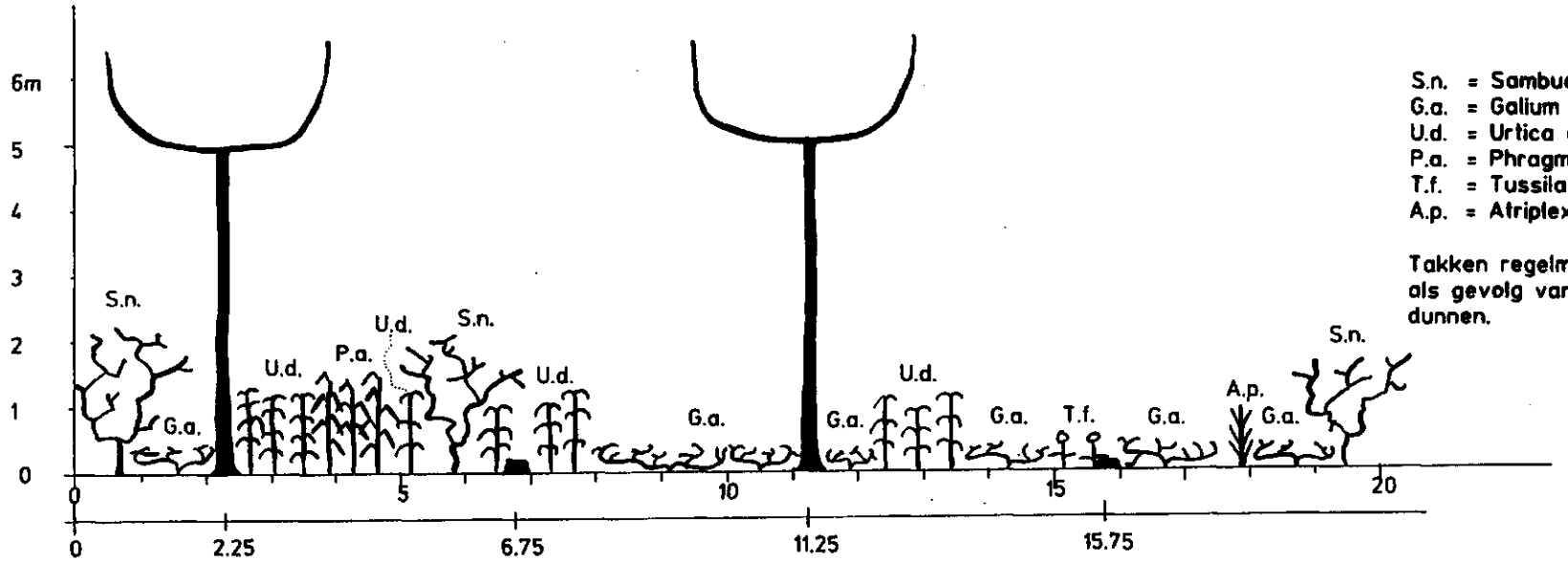
plattegrond

Pz 45 a4 Fraxinus excelsior

1 cm = 1 m



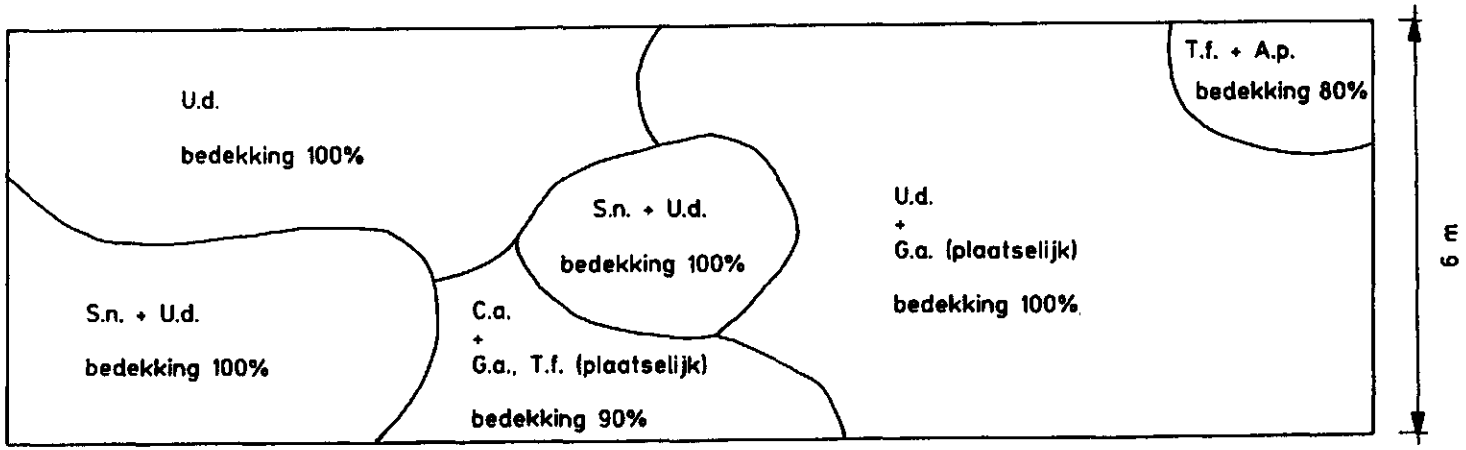
Pz 45 a3 Pop. 'Blom'



S.n. = Sambucus nigra
G.a. = Galium aparine
U.d. = Urtica dioica
P.a. = Phragmites australis
T.f. = Tussilago farfara
A.p. = Atriplex prostrata

Takken regelmatig verspreid als gevolg van snoeien en dunnen.

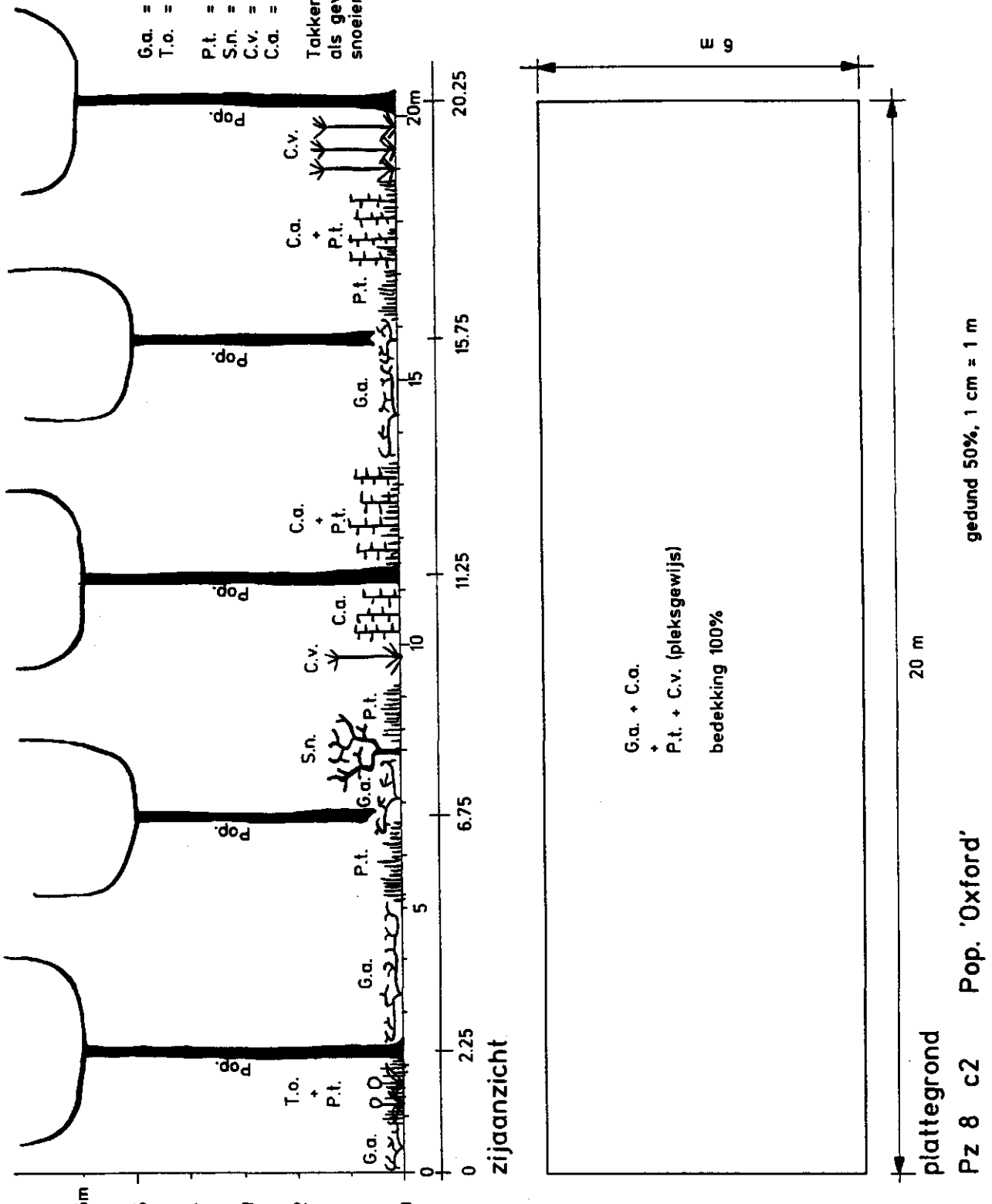
zijaanzicht

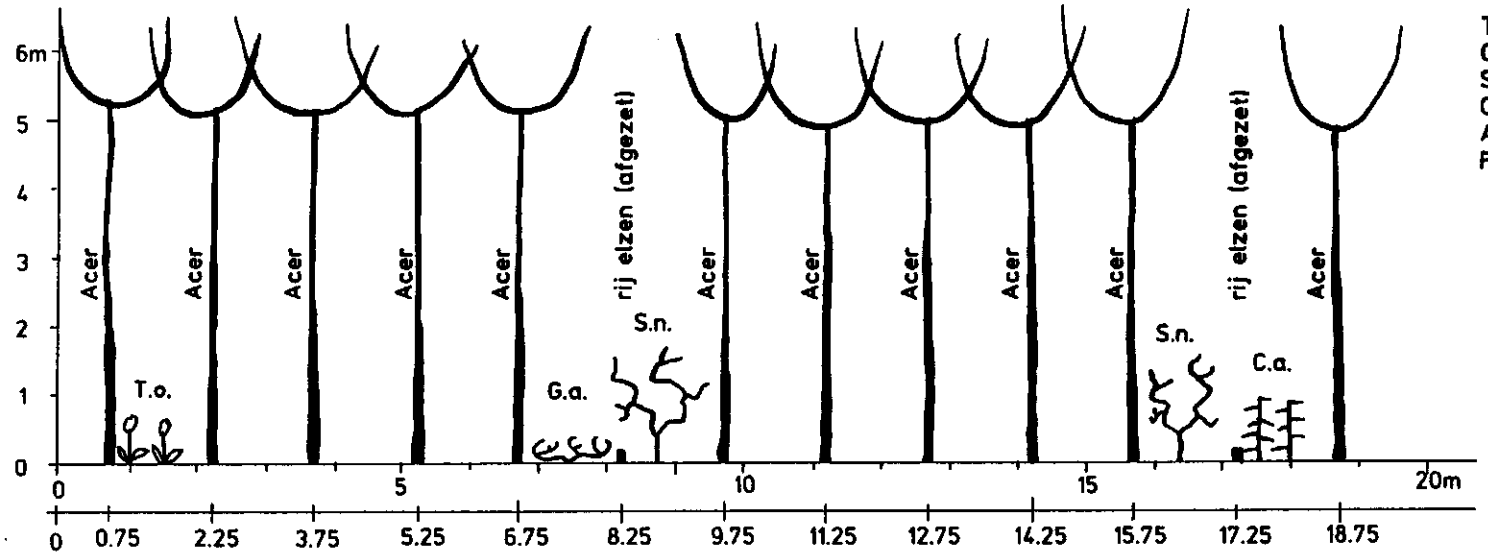


plattegrond

Pz 9 b2 Pop. 'Robusta'

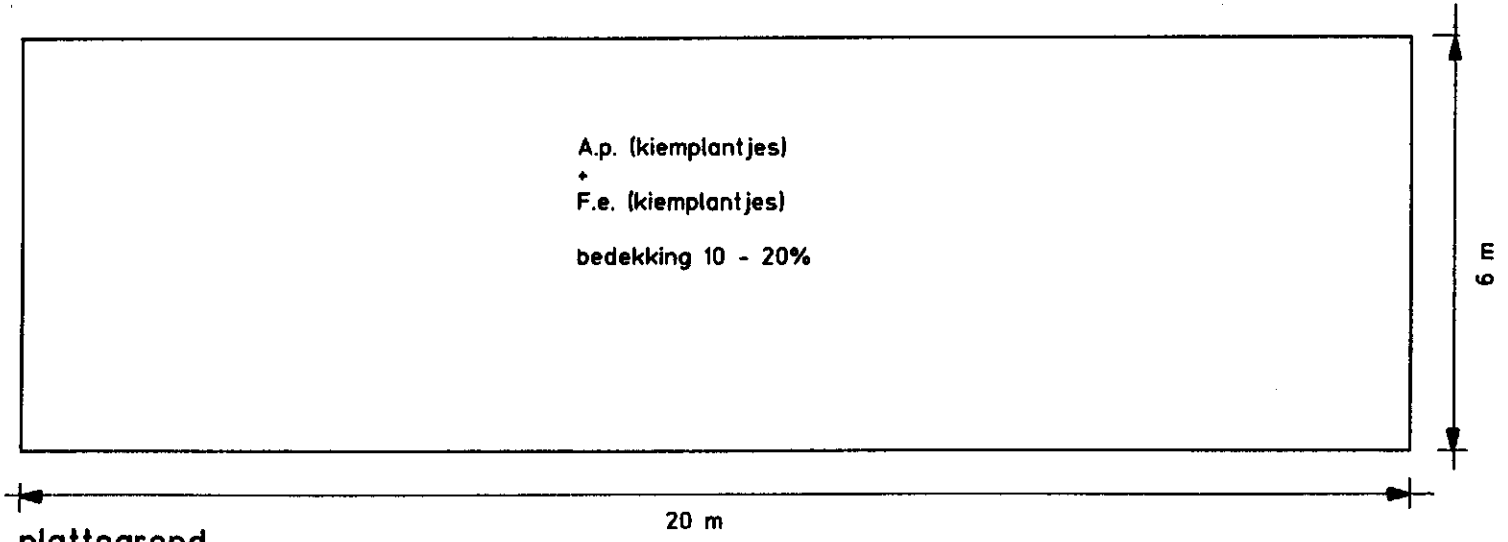
gedund 50 %, 1 cm = 1 m


G.a. = Galium aparine
T.o. = Taraxacum officinalis
P.t. = Poa trivialis
S.n. = Sambucus nigra
C.v. = Cirsium vulgare
C.a. = Cirsium arvense
Takken regelmatig verspreid als gevolg van dunnen en snoeien.
zijaanzicht
plattegrond
G.a. + C.a.
+
P.t. + C.v. (pleksgewijs)
bedekking 100%
20 m
gedund 50%, 1 cm = 1 m
Pz 8 c2 Pop. 'Oxford'



zijaanzicht

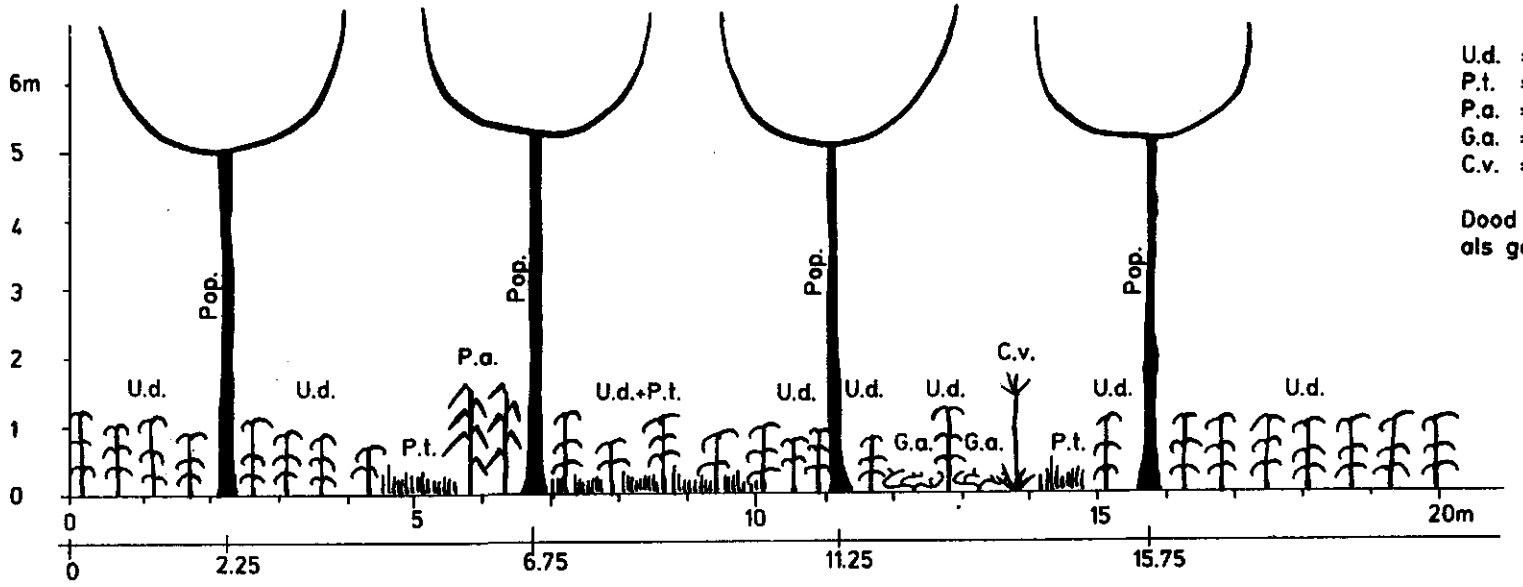
T.o. = Taraxacum officinalis
G.a. = Galium aparine
S.n. = Sambucus nigra
C.a. = Cirsium arvense
A.p. = Acer pseudoplatanus
F.e. = Fraxinus excelsior



plattegrond

Pz 8 b3 Acer pseudoplatanus

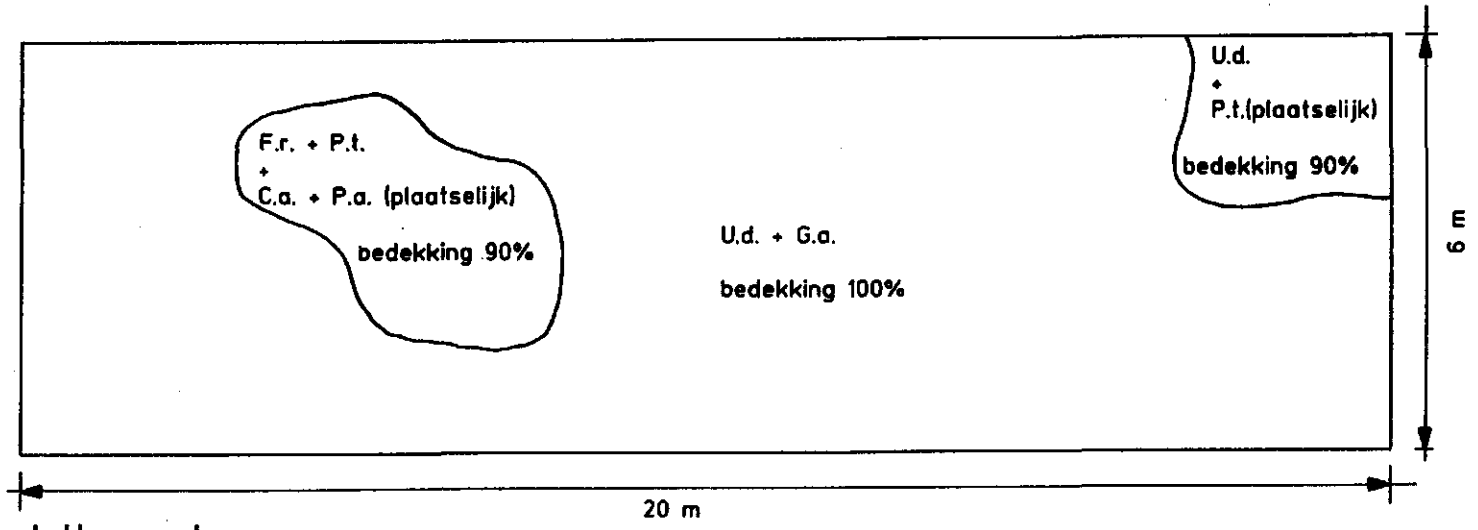
1 cm = 1 m



U.d. = Urtica dioica
P.t. = Poa trivialis
P.a. = Phragmites australis
G.a. = Galium aparine
C.v. = Cirsium vulgare

Dood takhout onder de bomen als gevolg van snoeien.

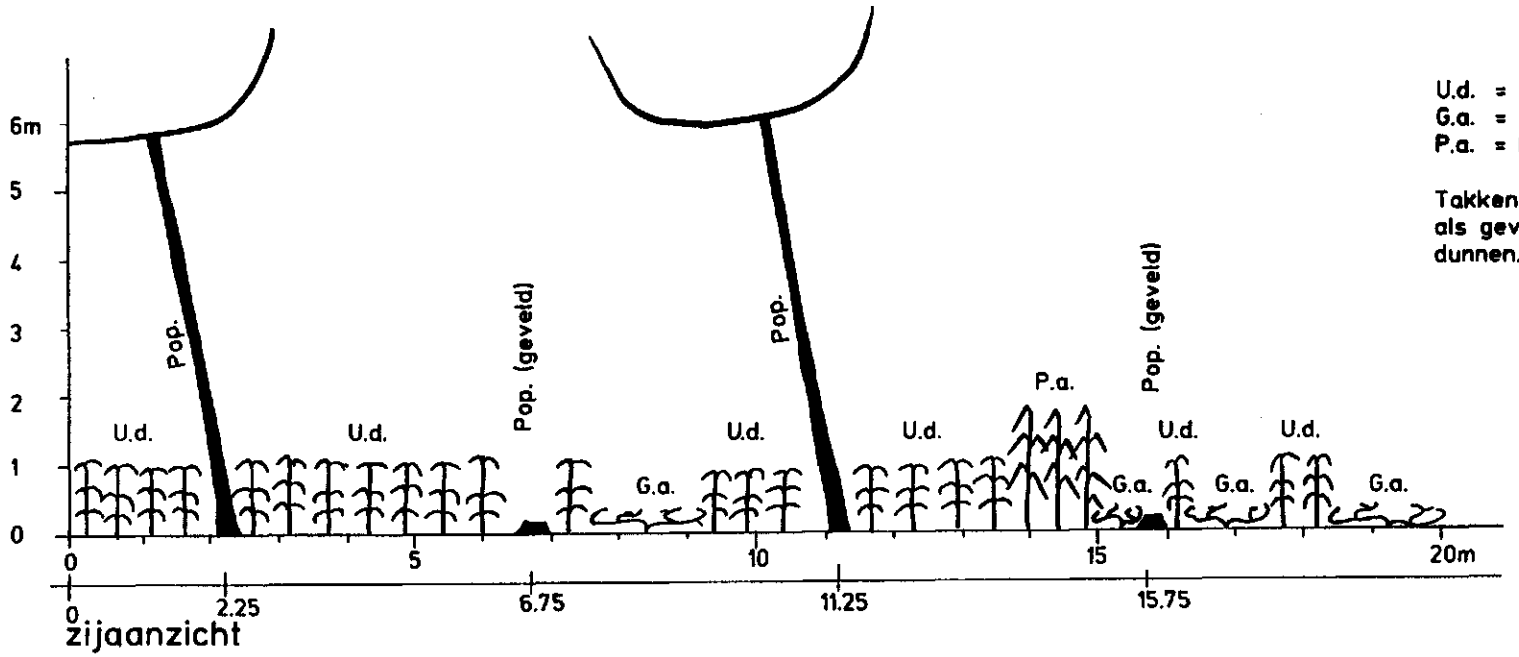
zijaanzicht



plattegrond

Pz 5 b4 Pop. 'Zeeland'

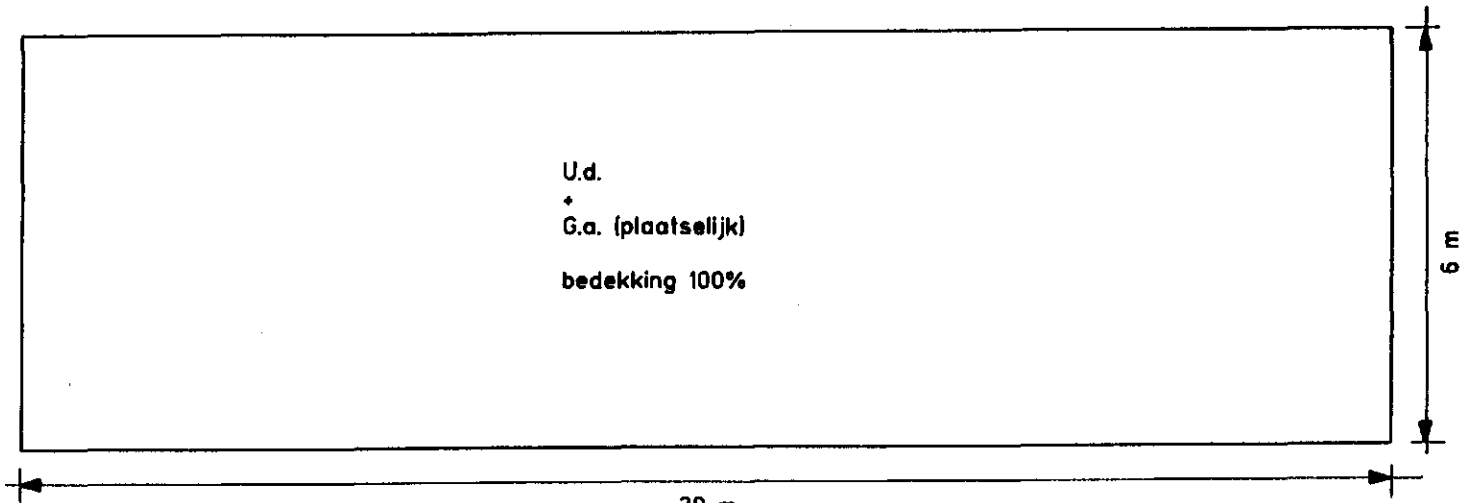
1 cm =1 m



zijaanzicht

U.d. = Urtica dioica
G.a. = Galium aparine
P.a. = Phragmites australis

Takken regelmatig verspreid als gevolg van snoeien en dunnen.



plattegrond

Pz 5 b1 Pop. 'Dorskamp'

gedund, 1 cm = 1 m

Forest spatial structure parameters									
Stand composition parameters									
Stand Ref.	Local Ref.	Species 1	% species 1	Species 2	% species 2	Species 3	% species 3	Age	
HO0001	PZ5 B1	Populus 'Dorskamp'	97	999999	999999	999999	999999	15	
HO0002	PZ5 B4	Populus 'Zeeland'	99	999999	999999	999999	999999	15	
HO0003	PZ8 B3	Acer pseudoplatanus	78	Fraxinus excelsior	8	999999	999999	18	
HO0004	PZ8 C2	Populus 'Oxford'	100	999999	999999	999999	999999	18	
HO0005	PZ9 B2	Populus 'Robusta'	99	999999	999999	999999	999999	18	
HO0006	PZ45 A3	Populus 'Blom'	100	999999	999999	999999	999999	15	
HO0007	PZ45 A4	Fraxinus excelsior	70	Acer pseudoplatanus	4	Alnus glutinosa	10	15	
HO0008	PZ2 G1	Populus 'Agathe F.'	999999	999999	999999	999999	999999	14	
HO0009	PZ28 J1	Populus 'Androscoggin'	999999	999999	999999	999999	999999	17	
HO0010	PZ29 E3	Populus 'Flevo'	999999	999999	999999	999999	999999	17	
SP0001	10 a	Fagus sylvatica	73	Quercus robur	13	999999	999999	125	
SP0002	21 d	Quercus robur	87	Betula pendula	11	999999	999999	40	
SP0003	22 e	Fagus sylvatica	95	999999	999999	999999	999999	125	
SP0004	31 d	Pinus sylvestris	94	Larix kaempferi	4	999999	999999	25	

Forest spatial structure parameters												
Stand composition and dbh parameters												
	Stems/ha				DBH (cm)							
Stand Ref.	Species 1	Species 2	Species 3	Total stems/ha	Species 1	Species 2	Species 3					
HO0001	210	999999	999999	210	30.2	999999	999999					
HO0002	368	999999	999999	368	23.2	999999	999999					
HO0003	2770	280	999999	3050	10.1	13.5	999999					
HO0004	212	999999	999999	212	32.1	999999	999999					
HO0005	216	999999	999999	216	27.3	999999	999999					
HO0006	220	999999	999999	220	30.5	999999	999999					
HO0007	2950	150	420	3520	8.7	9.6	8.5					
HO0008	119	999999	999999	119	33.0	999999	999999					
HO0009	222	999999	999999	222	28.0	999999	999999					
HO0010	444	999999	999999	444	28.5	999999	999999					
SP0001	254	45	999999	299	37.7	31.2	999999					
SP0002	623	109	999999	732	17.5	20.5	999999					
SP0003	208	999999	999999	208	42.4	999999	999999					
SP0004	1268	43	999999	1311	16.4	16.3	999999					

Forest spatial structure parameters							
Stand geometry parameters							
Stand Ref.	Row direct.	Spacing between rows	Spacing within row	Height (m) species 1	Height to 1st branch (m)	Canopy depth (m)	Crown diameter (m)
HO0001	76	9	5	19.4	8.6	10.8	5.9
HO0002	75	4.5	5	17.8	5.3	12.5	4.6
HO0003	166	1.5	1.5	11.3	6.0	5.3	2
HO0004	104	5	5	20.3	6.6	13.7	7
HO0005	166	9	5	21.6	7.5	14.1	4.6
HO0006	164	9	5	17.7	5.4	12.3	6.5
HO0007	165	1.5	1.5	11.3	6.0	5.3	1.9
HO0008	13	12	7	19.6	5.4	14.2	7
HO0009	110	9	5	22.9	7.5	15.4	5.6
HO0010	110	4.5	5	19.8	8.0	11.8	4.7
SP0001	999999	999999	999999	22.7	7.9	14.8	8.8
SP0002	999999	999999	999999	15.0	7.9	7.1	4.5
SP0003	999999	999999	999999	25.2	11.0	14.2	8.6
SP0004	999999	999999	999999	12.25	6.6	5.65	3.6

Forest spatial structure parameters										
Basal area and volume parameters										
	Basal area (m2/ha)				Volume (m3/ha)					
Stand Ref.	Species 1	Species 2	Species 3	Total basal area (m2/ha)	Species 1	Species 2	Species 3	Total volume (m3/ha)		
HO0001	15.1	999999	999999	15.1	115.5	999999	999999	115.5		
HO0002	15.7	999999	999999	15.7	115.2	999999	999999	115.2		
HO0003	24.4	4	999999	28.4	141.4	24.1	999999	165.8		
HO0004	16.3	999999	999999	16.3	129.9	999999	999999	129.9		
HO0005	12.8	999999	999999	12.8	112.5	999999	999999	112.5		
HO0006	16.2	999999	999999	16.2	111.3	999999	999999	111.3		
HO0007	18.8	1.1	2.4	22.3	114.0	5.3	13.1	132.4		
HO0008	10.2	999999	999999	10.2	77.1	999999	999999	77.1		
HO0009	13.7	999999	999999	13.7	127.4	999999	999999	127.4		
HO0010	28.3	999999	999999	28.3	223.9	999999	999999	223.9		
SP0001	32.0	3.6	999999	35.6	269.2	37.2	999999	306.4		
SP0002	15.9	3.6	999999	19.5	112.0	27.4	999999	139.4		
SP0003	31.5	999999	999999	31.5	289.9	999999	999999	289.9		
SP0004	26.7	0.9	999999	27.6	174.0	5.7	999999	179.7		

Forest spatial structure parameters									
Leaf geometry parameters									
Stand Ref.	LAI (m2)	Std.dev.	Leaf length (cm)	Std.dev.	Leaf width (cm)	Std.dev.	Leaf thickness (mm)	Std.dev.	Leaf area (cm2)
HO0001	2.21	0.13	6.49	1.34	6.42	1.32	0.23	0.03	26.74
HO0002	4.67	0.19	8.14	2.56	7.94	2.75	0.22	0.03	44.21
HO0003	5.44	0.85	10.75	3.62	12.41	4.83	0.17	0.36	92.67
HO0004	3.73	1.13	9.54	1.83	6.91	1.72	0.21	0.03	43.26
HO0005	2.29	0.22	8.39	1.65	7.81	1.70	0.22	0.25	32.23
HO0006	2.00	0.32	9.21	2.69	7.00	1.84	0.25	0.06	43.84
HO0007	6.06	0.41	24.39	5.02	15.02	3.06	0.18	0.03	145.60
HO0008	999999	999999	6.43	0.83	6.09	0.92	0.23	0.05	23.25
HO0009	999999	999999	10.41	1.35	9.04	1.47	0.30	0.06	59.23
HO0010	999999	999999	7.29	0.93	7.75	1.07	0.25	0.05	34.37
SP0001	8.37	1.77	7.51	1.33	5.11	0.89	0.08	0.02	26.32
SP0002	4.62	999999	9.18	1.48	5.38	1.05	0.16	0.03	27.76
SP0003	10.84	2.03	7.51	1.33	5.11	0.89	0.08	0.02	26.32
SP0004	3.50	999999	7.42	0.74	999999	999999	0.63	0.08	0.59

HORSTERWOLD						
SOIL MOISTURE DATA						
DATE: 17 juni 1991						
Stand	Moist% 0-5 cm	SE	Moist% 0-10 cm	SE	Number of samples	
HO0001	27.0	1.6	28.6	2.5	6	
HO0002	30.6	1.0	26.1	1.0	6	
HO0003	29.2	2.4	32.7	1.0	6	
H00004	28.4	2.2	33.6	2.7	6	
HO0005	29.4	2.3	34.7	1.9	6	
HO0006	28.6	2.6	29.6	2.8	6	
HO0007	29.9	1.7	32.2	0.6	6	
HO0008	30.8	2.7	32.1	1.9	6	
HO0009	32.8	2.2	30.7	2.0	6	
HO0010	29.7	2.3	33.5	1.9	6	
DATE: 4 juli 1991						
Stand	Moist% 0-5 cm	SE	Moist% 0-10 cm	SE	Number of samples	
HO0001	32.1	1.1	35.5	1.8	6	
HO0002	30.6	1.8	33.6	0.3	6	
HO0003	35.8	1.6	37.5	0.6	6	
H00004	38.2	0.9	40.4	1.3	6	
HO0005	35.5	0.7	38.3	2.0	6	
HO0006	32.3	1.1	34.9	0.6	6	
HO0007	35.2	0.8	35.6	1.1	6	
HO0008	32.2	1.9	33.5	1.2	6	
HO0009	38.0	1.3	40.7	1.7	6	
HO0010	35.3	1.8	38.1	1.8	6	
DATE: 11/12/13 juli 1991		in night from 11 to 12 rain				
Stand	Moist% 0-5 cm	SE	Moist% 0-10 cm	SE	Number of samples	
HO0001	25.7	1.6	27.3	1.4	6	12-Jul-91
HO0002	28.3	1.2	28.9	0.6	6	12-Jul-91
HO0003	26.0	1.5	27.1	0.9	6	13-Jul-91
H00004	23.5	0.9	26.6	0.7	6	13-Jul-91
HO0005	25.6	1.9	29.0	2.5	6	13-Jul-91
HO0006	23.6	0.9	26.5	0.7	6	11-Jul-91
HO0007	30.3	1.1	29.2	1.7	6	11-Jul-91
HO0008	25.7	2.0	28.7	2.6	6	11-Jul-91
HO0009	25.6	1.5	27.7	1.3	6	13-Jul-91
HO0010	30.0	1.3	29.3	1.7	6	13-Jul-91

HORSTERWOLD						
SOIL MOISTURE DATA						
DATE: 27 juli 1991						
Stand	Moist% 0-5 cm	SE	Moist% 0-10 cm	SE	Number of samples	
HO0001	18.3	2.9	20.4	2.7	6	
HO0002	17.9	1.6	20.7	1.2	6	
HO0003	31.2	1.1	30.8	1.7	6	
H00004	23.4	2.2	26.5	1.8	6	
HO0005	23.3	2.9	26.9	3.1	6	
HO0006	22.3	2.0	24.1	2.7	6	
HO0007	28.4	2.1	29.9	2.0	6	
HO0008	17.2	1.3	18.0	2.4	6	
HO0009	23.0	3.1	25.6	2.6	6	
HO0010	17.3	2.0	21.9	2.2	6	

SPEULDER- EN SPRIELDERBOS										
SOIL MOISTURE DATA										
DATE: 17 juni 1991										
Stand	Moist% 0-5 cm	SE	Moist% 0-10 cm	SE	Moist% litter	SE	Litter depth (cm)	SE	Number of samples	
SP001	999	999	999	999	999	999	999	999	999	
SP002	21.6	1.5	19.1	0.8	31.1	2.5	2.9	0.3	10	
SP003	24.3	1.3	22.2	1.0	48.1	2.6	13.4	1.0	10	
SP004	18.8	1.3	18.4	0.9	33.8	1.9	6.8	0.7	9	
DATE: 4 juli 1991										
Stand	Moist% 0-5 cm	SE	Moist% 0-10 cm	SE	Moist% litter	SE	Litter depth (cm)	SE	Number of samples	
SP001	26.4	1.7	22.4	1.2	49.3	1.7	11.2	1.0	5	
SP002	21.1	0.9	18.9	0.9	33.3	1.6	3.8	0.5	15	
SP003	22.1	1.0	20.0	1.0	48.4	3.4	10.1	1.0	15	
SP004	19.4	1.2	18.1	0.9	35.3	1.8	6.1	0.9	15	
DATE: 11/12 juli 1991		in night from 11 to 12 rain								
Stand	Moist% 0-5 cm	SE	Moist% 0-10 cm	SE	Moist% litter	SE	Litter depth (cm)	SE	Number of samples	
SP001	17.3	2.0	18.2	2.2	34.7	5.2	11.6	0.8	5	12-Jul-91
SP002	14.2	0.7	13.4	0.6	30.1	1.0	3.1	0.4	15	11-Jul-91
SP003	17.2	1.5	15.0	1.2	41.6	2.1	10.0	0.7	15	11-Jul-91
SP004	19.0	2.0	19.1	1.8	35.3	2.1	6.5	0.6	15	12-Jul-91
DATE: 27 juli 1991										
Stand	Moist% 0-5 cm	SE	Moist% 0-10 cm	SE	Moist% litter	SE	Litter depth (cm)	SE	Number of samples	
SP001	20.0	1.0	15.5	2.1	39.2	3.3	8.0	1.3	5	
SP002	15.5	0.8	15.1	0.9	34.3	1.5	3.3	0.3	15	
SP003	18.0	0.9	17.5	0.7	46.4	1.8	11.7	0.8	15	
SP004	15.3	0.9	14.5	0.8	29.1	1.3	8.5	0.9	15	

HORSTERWOLD

TREE MOISTURE DATA

DATE: 15 juni 1991

Stand	Moist% bole >5 cm	Moist% bole 0-5 cm	Moist% twigs	SE	Moist% leaves	SE	Number of bole samples	Number of twig/leaf samples
HO0001	67.3	58.6	55.7	0.2	76.6	0.3	1	6
HO0002	65.8	59.0	55.3	0.4	79.7	0.4	1	6
HO0003	36.8	39.2	50.6	0.9	78.1	1.0	1	6
HO0004	64.9	54.0	53.1	0.3	75.6	0.4	1	6
HO0005	63.0	52.0	54.5	0.2	77.9	0.4	1	6
HO0006	59.6	47.9	51.9	0.4	76.5	0.3	1	6
HO0007	31.0	33.6	52.3	1.0	82.7	0.7	1	6
HO0008	69.9	55.0	55.8	0.2	76.2	0.2	1	6
HO0009	59.7	44.8	51.4	0.5	71.7	0.1	1	6
HO0010	64.8	62.7	56.8	0.2	76.1	0.4	1	6

DATE: 3 juli 1991

Stand	Moist% bole >5 cm	Moist% bole 0-5 cm	Moist% twigs	SE	Moist% leaves	SE	Number of bole samples	Number of twig/leaf samples
HO0001	65.6	59.2	52.2	0.7	73.7	0.5	1	6
HO0002	63.9	50.9	53.2	0.8	74.2	0.1	1	6
HO0003	33.2	34.6	50.4	0.5	76.8	0.8	1	6
HO0004	63.8	48.4	50.2	0.3	70.5	0.7	1	6
HO0005	60.5	46.4	51.4	0.4	73.1	0.3	1	6
HO0006	54.9	55.0	49.1	0.1	71.4	0.3	1	6
HO0007	39.4	34.7	50.0	1.4	77.4	1.2	1	6
HO0008	65.2	58.3	56.7	0.4	76.2	0.1	1	6
HO0009	66.4	49.3	46.9	0.8	65.3	0.4	1	6
HO0010	66.0	61.6	55.6	0.7	73.5	0.5	1	6

HORSTERWOLD								
TREE MOISTURE DATA								
DATE: 28 juli 1991								
Stand	Moist% bole >5 cm	Moist% bole 0-5 cm	Moist% twigs	SE	Moist% leaves	SE	Number of bole samples	Number of twig/leaf samples
HO0001	65.6	41.4	51.5	0.7	68.1	0.7	1	6
HO0002	63.2	46.6	50.7	0.6	70.2	0.2	1	6
HO0003	33.5	32.7	48.0	0.8	72.9	1.6	1	6
HO0004	59.2	41.7	47.0	0.7	66.0	0.6	1	6
HO0005	60.1	46.4	50.7	0.5	70.2	0.5	1	6
HO0006	52.7	44.6	46.7	0.7	66.4	0.4	1	6
HO0007	34.4	35.4	45.8	1.8	66.7	0.9	1	6
HO0008	65.8	51.3	54.5	0.3	71.0	0.3	1	6
HO0009	57.2	44.3	44.4	0.9	60.9	0.5	1	6
HO0010	64.8	47.3	53.0	0.9	68.8	1.2	1	6

SPEULDER- EN SPRIELDERBOS

TREE MOISTURE DATA

DATE: 15 juni 1991									Number of	Number of
Stand	Moist% bole >5 cm	SE	Moist% bole 0-5 cm	SE	Moist% twigs	SE	Moist% leaves	SE	bole samples	twig/leaf samples
SP0001	999	999	999	999	999	999	999	999	999	999
SP0002	48.3	1.1	50.6	1.7	58.9	0.8	79.0	1.1	3	6
SP0003	48.8	2.7	48.6	1.3	53.0	0.7	75.1	0.8	3	6
SP0004	47.5	4.5	52.5	3.7	65.1	0.7	63.3	0.9	3	6

DATE: 3 juli 1991									Number of	Number of
Stand	Moist% bole >5 cm	SE	Moist% bole 0-5 cm	SE	Moist% twigs	SE	Moist% leaves	SE	bole samples	twig/leaf samples
SP0001	999	999	999	999	999	999	999	999	999	999
SP0002	46.9	1.1	41.9	1.2	53.1	1.2	66.4	1.4	3	6
SP0003	41.4	2.7	41.0	1.9	50.2	1.0	63.9	1.3	3	6
SP0004	43.5	8.1	43.4	5.3	61.5	1.7	61.9	1.1	3	6

DATE: 28 juli 1991									Number of	Number of
Stand	Moist% bole >5 cm	SE	Moist% bole 0-5 cm	SE	Moist% twigs	SE	Moist% leaves	SE	bole samples	twig/leaf samples
SP0001	999	999	999	999	999	999	999	999	999	999
SP0002	50.8	3.2	45.8	4.0	52.7	0.9	64.3	0.7	3	6
SP0003	40.0	3.1	39.1	3.6	49.7	1.1	61.2	1.3	3	6
SP0004	47.3	1.8	45.2	2.3	60.3	0.6	63.9	0.5	3	6

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