NWPC FIELD TEST WITH WOOD PRESERVATIVES. RESULTS FROM THE TRIAL STARTED IN 1968

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NWPC INFORMATION NO. 22/90

ISSN 0358-707 X

NORDIC WOOD PRESERVATION COUNCIL
1990

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CONTENTS **Page**

ISSN 0358-707 X

Printed in Sweden by P-Kopia, Bandhagen 1990

ABSTRACT

This report gives the results from the NWPC field trial started in 1968. The test has been performed in co-operation with the Danish Technological Institute, the Technical Research Centre of Finland, the Norwegian Institute of Wood Technology and the Department of Forest Products at the Swedish University of Agricultural Sciences. The field trials are carried out according to the NWPC Standard No. 1.4.2.1./71. "Testing of wood preservatives. Mycological tests. Field test - a field test with stakes". The test fields were Hilleröd and Tåstrup in Denmark, Vaasa and Viikki in Finland, Sörkedalen in Norway and Simlångsdalen in Sweden (figure 1). In 1974 all the stakes at Hilleröd were moved to Tåstrup, and in 1986 all the stakes at Vaasa were moved to Viikki. The stakes used in the trials were made from sapwood of European redwood (**Pinus sylvestris** L.), European beech (**Fagus sylvatica** L.), European birch (**Betula** spp.) and alder (**Alnus incana** (L.) Moench). The preservatives tested, chemical formulation and average index of decay are presented in tables 1-6. Index of decay in relation to the retention of the preservatives is shown for European redwood in figure 2. In the appendix (figures 3-34) the rate of decay is presented for every wood species and every preservative tested.

INTRODUCTION

Field tests with wood preservatives have been conducted for many years in each of the Nordic countries. In 1968 the first NWPC test was started. This report gives results from that field trial after 20 years exposure.

The test was carried out by the NWPC in co-operation with the Danish Technological Institute, the Technical Research Centre of Finland, the Norwegian Institute of Wood Technology and the Department of Forest Products at the Swedish University of Agricultural Sciences.

The results of this field trial after 5 years were reported in 1974 by Henningsson (1974). Results after 10 years for European redwood were reported in 1979 by Borsholt (1979).

MATERIALS AND METHODS

The field trials are carried out according to the NWPC Standard No. 1.4.2.1./71. "Testing of wood preservatives. Mycological test. Field test - a field test with stakes". The stakes used in the 1968 trial were made from sapwood of European redwood (**Pinus sylvestris** L.), European beech (**Fagus sylvatica** L.), European birch (**Betula** spp.) and alder (**Alnus incana** (L.) Moench). The size of the stakes was 20 x 50 x 500 mm.

The location of the Nordic test fields is shown in Figure 1. The soil types of the test fields are:

Denmark,	Hilleröd:	Moraine sand
	Tåstrup:	Moraine clay
Finland,	Vaasa:	Forest mould containing much organic material.
	Viikki:	Clay containing organic material
Norway,	Sörkedalen:	Sandy soil containing some organic material
Sweden,	Simlångsdalen	Sandy soil.

The test fields used at the start of the 1968 trial were Simlångsdalen, Hilleröd, Vaasa and Sörkedalen. Stakes of European redwood were set out at all of the four test fields. Each hardwood species was only set out at one of the test fields viz.: European beech at Simlångsdalen, European birch at Vaasa and alder at Sörkedalen.

Twenty stakes were set out at Simlångsdalen and ten stakes at each of the other test fields for every retention level. In 1974 the remaining stakes at Hilleröd were moved to Tåstrup and in 1986, the remaining stakes at Vaasa were moved to Viikki.

Five concentration levels for each preservative were chosen. The medial concentration was that recommended in 1968 for European redwood in ground contact.

Figure 1. Location of the Nordic test fields.

1. Hilleröd
2. Tåstrup
3. Vaasa
4. Viikki
5. Sörkedalen
6. Simlångsdalen

The extent of decay was graded according to the following scale:

Condition	Grading of decay	Index of decay
Sound - no decay	0	0
Slight decay	1	25
Moderate decay	2	50
Severe decay	3	75
Very severe decay (stake rejected, due to failure in bending apparatus).	4	100

By adding up the index of decay for the stakes of each group and dividing the sum by the number of stakes the average index of decay for each preservative and retention level is obtained. When all stakes in a group have failed (average index of decay = 100), the average service life is calculated.

Retentions of preservatives are based on their chemical composition and are presented in the tables.

RESULTS AND DISCUSSION

The preservatives of the 1968 trial and their chemical formulations are listed in Table 1.

Stakes of European redwood treated with the preservatives were set out at all of the four test fields. Index of decay after 5 and 20 years' testing and average service life are shown in Table 2 for test fields Simlångsdalen and Hilleröd/Tåstrup and Table 3 for Vaasa/Viikki and Sörkedalen.

Each hardwood species was only set out at one of the test fields. The results for European beech tested at Simlångsdalen, European birch at Vaasa/Viikki and alder at Sörkedalen are shown in Tables 4, 5 and 6.

Index of decay in relation to the retention of the preservatives after 20 years is shown for stakes of European redwood in Figures 2a and 2b.

Figures 3-34 in the Appendix give the rate of decay for stakes with various retention levels of the preservatives. Results for European redwood are shown in Figures 3-10 and for hardwoods in Figures 11-34.

European redwood

The service life of untreated European redwood stakes was 1.0 year at Vaasa, 3.5 years at Simlångsdalen, 4.5 years at Sörkedalen and 5.1 years at Hilleröd (Tables 2 and 3).

A comparison of the index of decay in relation to the retention of the preservatives after 20 years shows that there are some variation at the different test fields (Figures 2a and 2b).

Treated stakes at Sörkedalen have the lowest index of decay (Table 3, Figure 2b). In fact for all preservatives tested there are still after 20 years of exposure, stakes treated to the lowest concentration remaining in the field (Table 3). A comparison of the preservatives using the medial concentration levels gives the following order in index of decay (in brackets): Boliden K33 (5), Tanalith C (13), Celcure A (15), Wolmanit CB (20), Basilit CFK (23), BP Hylosan (33), creosote (50) and KP Cuprinol (60) (Table 3).

At Simlångsdalen the lowest concentration levels for all preservatives tested have reached an index of decay of 100 (Table 2). The average service life was in the range of 13-16 years at that concentration level for all preservatives except creosote (8.4 years). The order of the preservatives given by increasing index of decay for the medial retention levels used was: Tanalith C (53), Boliden K33 (66), Wolmanit CB (66), Basilit CFK (79), BP Hylosan (80), Celcure A (92), KP Cuprinol (96) and creosote (100) (Table 2).

At Hilleröd/Tåstrup all Celcure A, BP Hylosan and creosote stakes have been rejected at the lowest concentration tested (Table 2). The index of decay for the medial retention levels gives the following order of the preservatives: Tanalith C (23), Celcure A (30), Boliden K33 (33), Wolmanit CB (33), Basilit CFK (38), KP Cuprinol (65), BP Hylosan (73) and creosote (100).

At Vaasa/Viikki, all Basilit CFK, KP Cuprinol and Wolmanit CB stakes have been rejected at the lowest retention level (Table 3). The index of decay for the medial concentration levels used gives the following order for the preservatives:

Boliden K33 (33), Tanalith C (35), BP Hylosan (50), Celcure A (53), Wolmanit CB (60), creosote (73), Basilit CFK (78) and KP Cuprinol (100).

In general the CCA-preservatives have given the best protection closely followed by Basilit CFK, Wolmanit CB and BP Hylosan, The preservatives KP Cuprinol and creosote have been less successful. However, it is well-known that stake tests do not give a fair result for creosote. If stakes and poles are treated to the same retention of either CCA or creosote, the CCA-treated stake will last longer than the creosote stake, while the creosote pole will last as long as or even longer than the CCA-treated pole. The protection of the creosote pole will increase during the service period due to accumulation of the creosote at the base of the pole.

Hardwoods

The treated hardwood stakes deteriorated more rapidly than the treated European redwood stakes.

At Simlångsdalen all the stakes of European beech treated with Boliden K33, Celcure A, KP Cuprinol, Tanalith C and creosote have reached an index of decay of 100 (Table 4). There are still some stakes left in the field treated to the highest retention levels of Basilit CFK, Wolmanit CB and BP Hylosan. At the lowest retention level tested the service life of the preservatives was in the range of 4.3 to 6.4 years. At medial retention levels Wolmanit CB had the longest service life, 14 years, followed by BP Hylosan 9.3 years, KP Cuprinol 9.1 years, Basilit CFK 8.5 years, Tanalith C 6.5 years, creosote 6.4 years, Boliden K33 6.3 years and Celcure A 5.3 years (Table 4). It was earlier shown from Simlångsdalen that the service life of European redwood stakes treated with the lowest concentration was in the range of 13-16 years for all the preservatives tested except creosote. Thus the lowest concentration in stakes of European redwood gave better protection than the two times higher concentration in stakes of European beech.

At Vaasa/Viikki all stakes of European birch treated with KP Cuprinol are now rejected, while there are creosote stakes left in the field at all retention levels (Table 5). A comparison of the preservatives at the lowest concentration level gives the following order of efficacy as indicated by service life: creosote (stakes still left in the field), BP Hylosan 12 years, Boliden K33 9.3 years, Tanalith C 8.1 years, Wolmanit CB 7.9 years, Celcure A 6.0 years, KP Cuprinol 5.9 years and Basilit CFK 5.6 years.

For alder at Sörkedalen all stakes treated with the lowest concentration of the preservatives are now rejected (Table 6). The service life at that concentration reached for Wolmanit CB was 12 years, Basilit CFK 9.6 years, Tanalith C 9.0 years, BP Hylosan 8.9 years, Boliden K33 7.9 years, creosote 7.2 years, KP Cuprinol 5.7 years and Celcure A 5.3 years.

Table 1. NWPC Field trial 1968. Preservatives tested and their chemical formulation.

Wood preservative	Chemical formulation % m/m		Active components % m/m		Manufacturer*
Basilit CFK	$CuSiF_6 . 4 H_2O$	35.9	Cu	8.2	Farbenfabriken
	$(NH_4)_2 Cr_2O_7$	63.1	F	14.7	Bayer AG
	$(NH_4)_2 HPO_4$	1.0	Cr	26.0	
Boliden K33	CuO	14.8	Cu	11.8	Boliden AB
	CrO_3	26.6	Cr	13.8	
	As_2O_5	34.0	As	22.2	
	H_2O	24.6			
Celcure A	$CuSO_4 . 5 H_2O$	23.2	Cu	8.2	Celcure Ltd.
	CuO	2.8	Cr	14.0	
	$Na_2Cr_2O_7 . 2 H_2O$	40.0	As	14.8	
	As_2O_5	22.7			
	H_2O	11.3			
KP Cuprinol	K-salt 91.3 %				Bönnelyche &
	CuO	15	Cu	10.9	Thuröe AB
	NH_3	18	Na-PCP	6.1	
	CO_2	44			
	H_2O	23			
	P-salt 8.7 %				
	C_6HCl_4ONa	70			
	H_2O	30			
Tanalith C (Tancas C)	$CuSO_4 . 5 H_2O$	35	Cu	8.9	Hickson and
	$Na_2Cr_2O_7 . 2 H_2O$	45	Cr	15.7	Welch Ltd.
	$As_2O_5 . 2 H_2O$	20	As	11.3	
Wolmanit CB	CuO	10.8	Cu	8.6	Dr Wolman GmbH
	CrO_3	26.4	Cr	13.3	
	H_3BO_3	25.5	B	4.5	
	$KHSO_4$	37.3			
BP Hylosan	PCP	5	PCP	5	Svenska BP AB
	Water repellents	< 4			
	Solvent	ad 100			
Creosote	Scandinavian specification				-

*Manufacturer that originally ordered the test.

Table 2. NWPC Field trial 1968. Results after 5 and 20 years' testing. Wood species: European redwood (sapwood).

Wood preservative	Concentration % m/m	Retention kg/m^3	Index of decay and average service life ($\bar{x}$) Simlångsdalen (Sweden) Year 5	Year 20	$\bar{x}$	Hilleröd/Tåstrup (Denmark)* Year 5	Year 20	$\bar{x}$
Basilit CFK	1.0	6.7	0	100	14	0	95	
	1.5	10	3	99		3	58	
	2.0	14	0	79		0	38	
	3.0	20	0	51		0	30	
	4.0	27	0	29		0	20	
Boliden K33	1.0	6.6	3	100	15	0	83	
	1.5	10	0	85		0	48	
	2.0	13	0	66		0	33	
	3.0	20	0	38		0	23	
	4.0	27	0	33		0	20	
Celcure A	1.2	7.7	0	100	14	0	100	18
	1.8	12	0	100	16	0	65	
	2.4	16	0	92		0	30	
	3.6	23	0	53		0	8	
	4.8	32	0	39		0	13	
KP Cuprinol	1.4	9.0	5	100	14	0	98	
	2.1	14	0	96		0	75	
	2.7	18	0	96		0	65	
	4.1	27	0	85		0	50	
	5.5	36	0	60		0	25	
Tanalith C (Tancas C)	1.2	8.1	0	100	16	0	55	
	1.8	12	0	83		0	33	
	2.4	16	0	53		0	23	
	3.6	24	0	41		0	13	
	4.8	33	0	28		0	3	
Wolmanit CB	1.5	10	0	100	14	0	60	
	2.3	15	0	95		0	30	
	3.0	20	0	66		0	33	
	4.5	31	0	39		0	13	
	6.0	41	0	31		0	8	
BP Hylosan	17	70	33	100	13	10	100	17
	25	104	9	90		0	90	
	33	126	10	80		5	73	
	50	217	0	45		0	48	
	67	305	0	35		0	38	
Creosote	17	74	54	100	8.4	18	100	12
	25	108	54	100	11	33	100	16
	33	143	35	100	14	10	100	18
	50	194	10	90		5	68	
	67	229	3	61		0	68	
Untreated			100	100	3.5	82	100	5.1

* The stakes were moved from Hilleröd to Tåstrup in 1974.

Table 3. NWPC Field trial 1968. Results after 5 and 20 years' testing. Wood species: European redwood (sapwood).

Wood preservative	Concentration % m/m	Retention kg/m^3	Index of decay and average service life ($\bar{x}$) Vaasa/Viikki /Finland)* Year			Sörkedalen (Norway) Year		
			5	20	$\bar{x}$	5	20	$\bar{x}$
Basilit CFK	1.0	6.7	98	100	3.2	33	83	
	1.5	10	68	100	11	15	43	
	2.0	14	50	78		5	23	
	3.0	20	40	75		10	18	
	4.0	27	28	78		0	3	
Boliden K33	1.0	6.6	33	95		5	38	
	1.5	10	18	75		10	20	
	2.0	13	0	33		5	5	
	3.0	20	0	23		0	0	
	4.0	27	0	33		0	3	
Celcure A	1.2	7.7	40	98		5	28	
	1.8	12	25	63		5	15	
	2.4	16	18	53		3	15	
	3.6	23	10	50		0	3	
	4.8	32	0	48		3	10	
KP Cuprinol	1.4	9.0	98	100	4.5	18	92	
	2.1	14	60	100	8.7	8	93	
	2.7	18	50	100	11	0	60	
	4.1	27	10	95		5	48	
	5.5	36	8	98		3	28	
Tanalith C (Tancas C)	1.2	8.1	35	95		0	25	
	1.8	12	22	70		5	25	
	2.4	16	8	35		3	13	
	3.6	24	3	45		0	3	
	4.8	33	0	35		0	0	
Wolmanit CB	1.5	10	100	100	3.3	13	63	
	2.3	15	55	100		10	33	
	3.0	20	30	60		0	20	
	4.5	31	20	80		5	13	
	6.0	41	0	68		0	8	
BP Hylosan	17	70	5	53		25	75	
	25	104	3	56		20	35	
	33	126	5	50		12	33	
	50	217	0	28		10	23	
	67	305	0	28		5	20	
Creosote	17	74	25	93		25	83	
	25	108	15	68		33	55	
	33	143	13	73		20	50	
	50	194	0	48		10	18	
	67	229	0	43		13	23	
Untreated			100	100	1.0	88	100	4.7

* The stakes were moved from Vaasa to Viikki in 1986.

Table 4. NWPC Field trial 1968. Results after 5 and 20 years' testing. Wood species: European beech.

Wood preservative	Concentration % m/m	Retention kg/m^3	Index of decay and average service life ($\bar{x}$) Simlångsdalen (Sweden) Year 5	20	$\bar{x}$
Basilit CFK	1.0	6.4	93	100	4.8
	1.5	9.5	83	100	6.4
	2.0	12	55	100	8.5
	3.0	19	34	100	13
	4.0	25	19	93	
Boliden K33	1.0	6.3	96	100	4.7
	1.5	9.5	94	100	5.2
	2.0	13	74	100	6.3
	3.0	19	55	100	9.0
	4.0	25	46	100	11
Celcure A	1.2	7.7	99	100	4.3
	1.8	11	99	100	4.4
	2.4	15	91	100	5.3
	3.6	23	78	100	6.0
	4.8	31	78	100	5.9
KP Cuprinol	1.4	8.7	95	100	4.6
	2.1	13	74	100	6.3
	2.7	17	55	100	9.1
	4.1	26	33	100	12
	5.5	36	3	100	15
Tanalith C (Tancas C)	1.2	7.6	94	100	4.8
	1.8	12	90	100	5.5
	2.4	15	71	100	6.5
	3.6	23	48	100	9.4
	4.8	31	34	100	13
Wolmanit CB	1.5	9.6	74	100	6.4
	2.3	14	53	100	9.9
	3.0	19	31	100	14
	4.5	29	15	91	
	6.0	39	4	76	
BP Hylosan	17	59	81	100	5.8
	25	87	63	100	7.5
	33	121	53	100	9.3
	50	181	43	100	11
	67	245	29	98	
Creosote	17	60	91	100	5.7
	25	90	88	100	5.8
	33	119	73	100	6.4
	50	199	49	100	11
	67	282	30	100	13
Untreated		100	100		2.0

Table 5. NWPC Field trial 1968. Results after 5 and 20 years' testing. Wood species: European birch.

Wood preservative	Concentration % m/m	Retention kg/m^3	Index of decay and average service life ($\bar{x}$) Vaasa/Viikki (Finland)* Year 5	20	$\bar{x}$
Basilit CFK	1.0	5.9	88	100	5.6
	1.5	8.9	55	100	11
	2.0	12	50	95	
	3.0	18	33	83	
	4.0	24	28	80	
Boliden K33	1.0	6.1	50	100	9.3
	1.5	9.1	53	100	13
	2.0	13	50	100	13
	3.0	18	45	95	
	4.0	24	30	90	
Celcure A	1.2	7.1	50	100	6.0
	1.8	10	50	100	7.3
	2.4	14	53	100	8.3
	3.6	21	28	100	13
	4.8	29	23	95	
KP Cuprinol	1.4	8.2	78	100	5.9
	2.1	12	73	100	7.4
	2.7	16	58	100	10
	4.1	24	48	100	14
	5.5	33	40	100	14
Tanalith C (Tancas C)	1.2	7.3	53	100	8.1
	1.8	11	43	100	12
	2.4	14	40	100	14
	3.6	21	28	85	
	4.8	30	10	75	
Wolmanit CB	1.5	8.8	70	100	7.9
	2.3	13	28	93	
	3.0	18	23	76	
	4.5	27	20	73	
	6.0	36	3	65	
BP Hylosan	17	66	40	100	12
	25	105	15	93	
	33	137	5	95	
	50	208	8	68	
	67	275	0	48	
Creosote	17	69	63	98	
	25	109	50	97	
	33	147	50	98	
	50	221	38	68	
	67	314	13	43	
Untreated			100	100	1.5

* The stakes were moved from Vaasa to Viikki in 1986.

Table 6. NWPC Field trial 1968. Results after 5 and 20 years' testing.
Wood species: Alder.

Wood preservative	Concentration	Retention	Index of decay and average service life ($\bar{x}$) Sörkedalen (Norway)		
	% m/m	kg/m^3	Year 5	20	$\bar{x}$
Basilit CFK	1.0	8.0	58	100	9.6
	1.5	12	45	98	
	2.0	16	33	95	
	3.0	24	20	63	
	4.0	32	10	38	
Boliden K33	1.0	7.8	53	100	7.9
	1.5	12	40	95	
	2.0	16	33	100	16
	3.0	24	13	80	
	4.0	32	8	58	
Celcure A	1.2	9.4	85	100	5.3
	1.8	14	60	100	6.6
	2.4	19	50	100	9.1
	3.6	28	28	90	
	4.8	38	20	68	
KP Cuprinol	1.4	11	75	100	5.7
	2.1	16	58	100	8.5
	2.7	22	40	100	11
	4.1	32	28	100	15
	5.5	44	18	97	
Tanalith C (Tancas C)	1.2	9.5	55	100	9.0
	1.8	14	38	98	
	2.4	19	30	93	
	3.6	29	10	45	
	4.8	39	8	40	
Wolmanit CB	1.5	12	53	100	12
	2.3	18	40	85	
	3.0	24	25	63	
	4.5	36	20	48	
	6.0	48	10	35	
BP Hylosan	17	91	43	100	8.9
	25	140	33	83	
	33	187	28	75	
	50	281	15	48	
	67	377	15	38	
Creosote	17	94	65	100	7.2
	25	143	43	100	11
	33	198	38	90	
	50	315	18	45	
	67	428	3	18	
Untreated			100	100	2.8

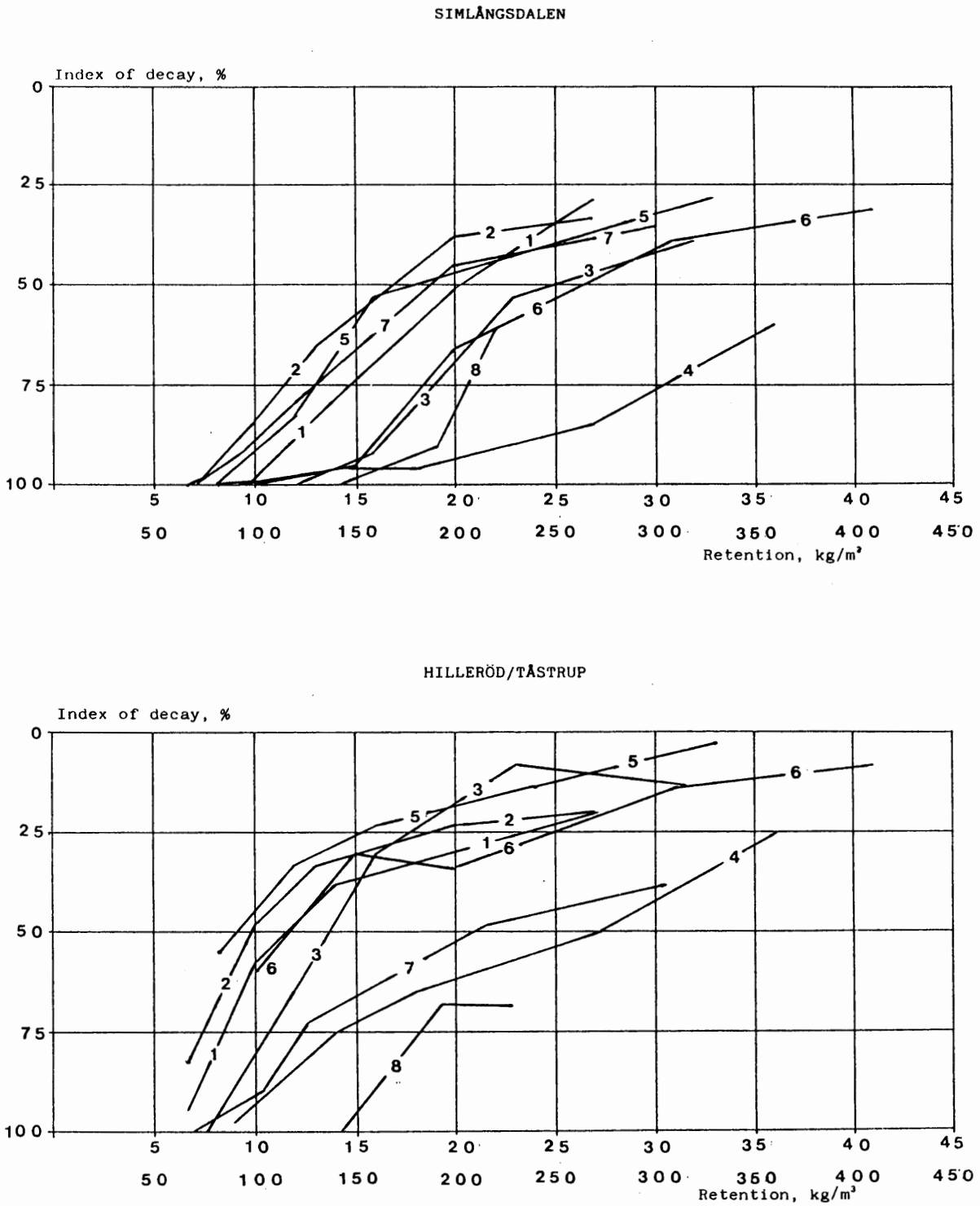

Figure 2a. Index of decay in relation to the retention after 20 years. Wood species: European redwood (sapwood). Retention 0-45 kg/m^3: 1. Basilit CFK, 2. Boliden K33, 3. Celcure A, 4. KP Cuprinol, 5. Tanalith C, 6. Wolmanit CB. Retention 0-450 kg/m^3: 7. BP Hylosan, 8. creosote.

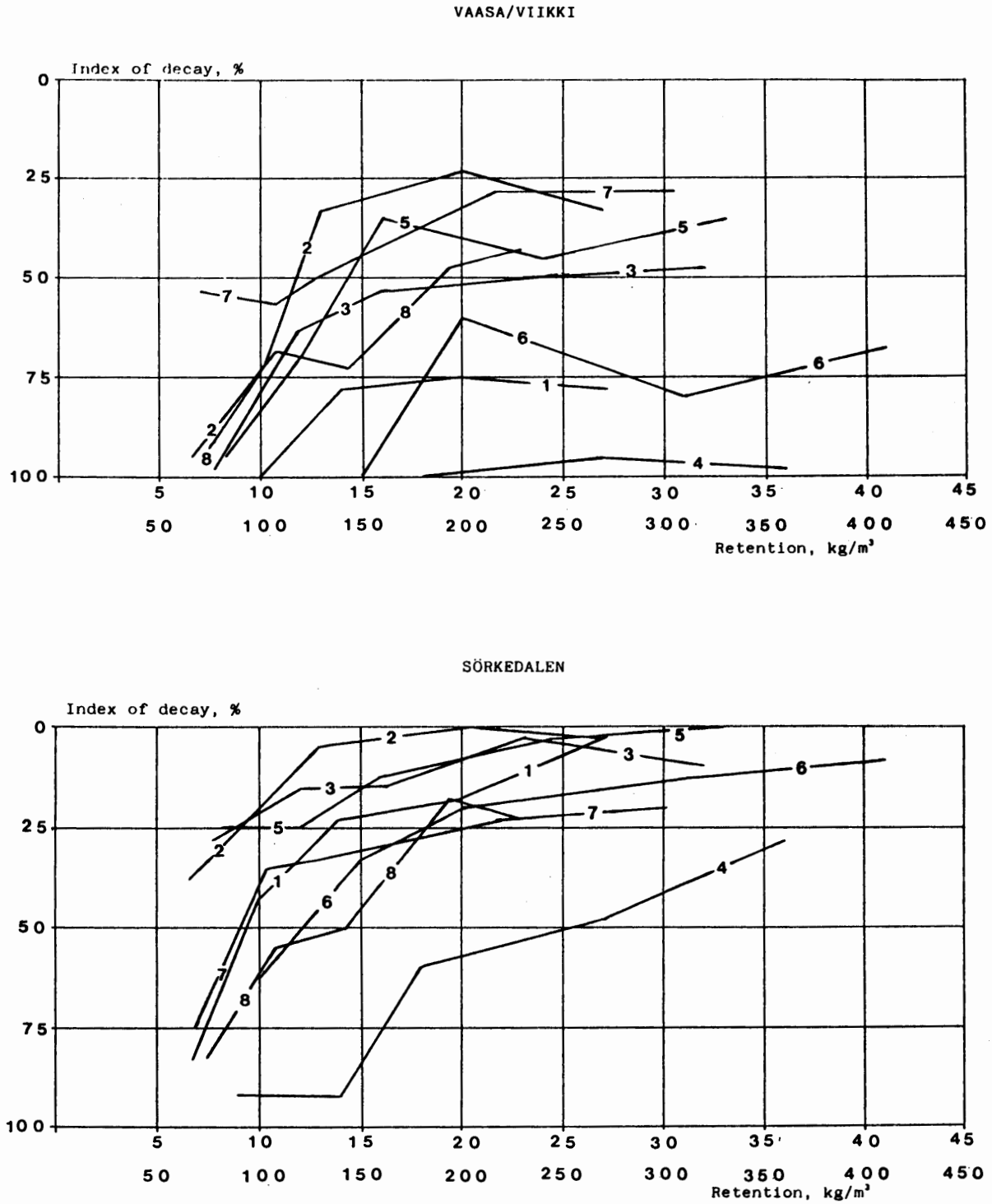

Figure 2b. Index of decay in relation to the retention after 20 years. Wood species: European redwood (sapwood). Retention 0-45 kg/m^3: 1. Basilit CFK, 2. Boliden K33, 3. Celcure A, 4. KP Cuprinol, 5. Tanalith C, 6. Wolmanit CB. Retention 0-450 kg/m^3: 7. BP Hylosan, 8. creosote.

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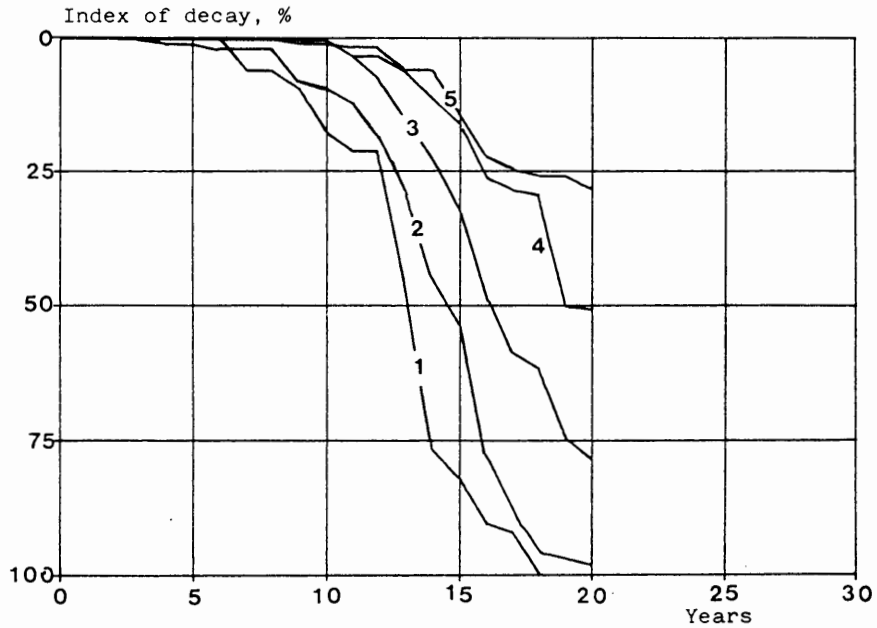
APPENDIX

S I M L Å N G S D A L E N



H I L L E R Ö D/T Å S T R U P

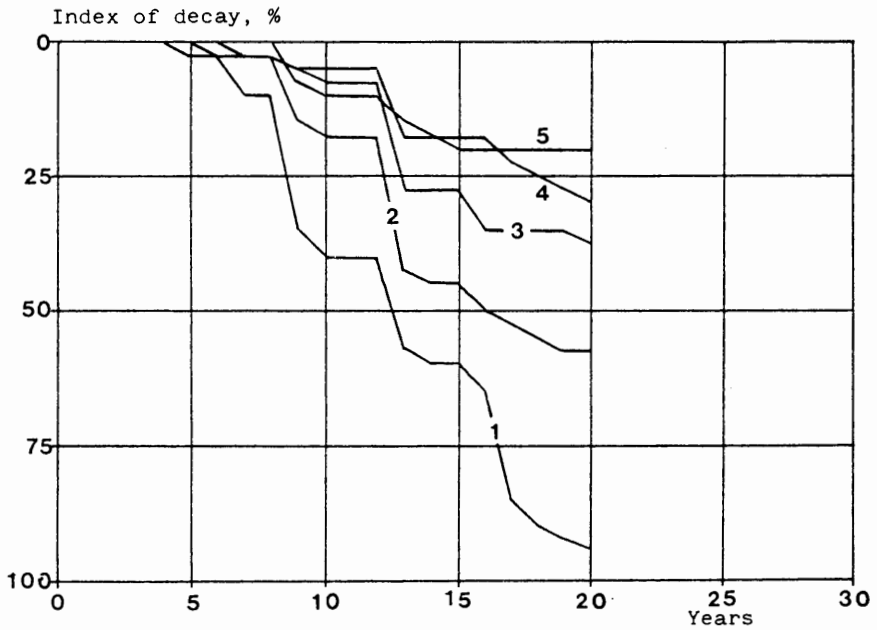
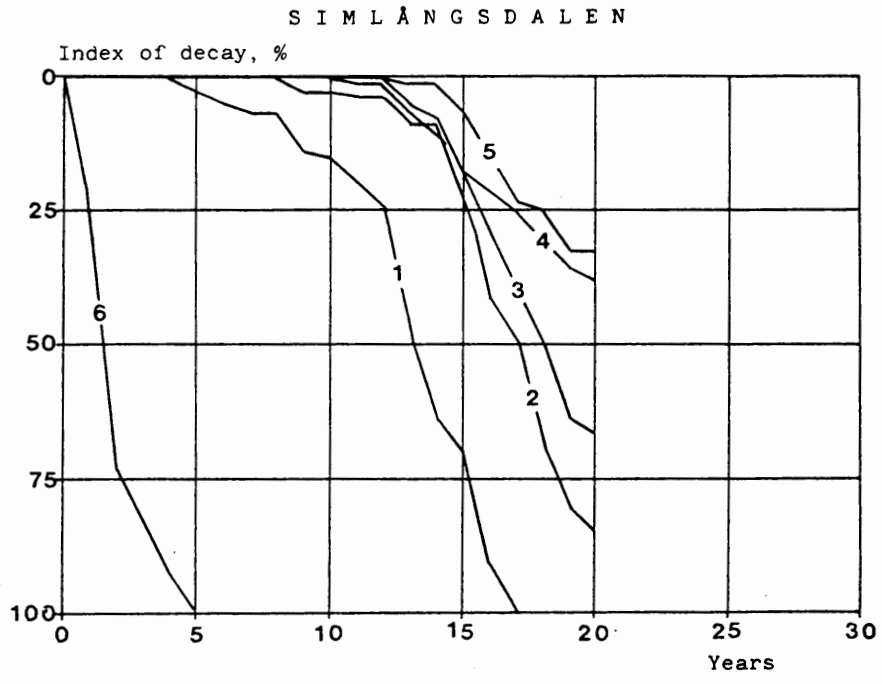


Figure 3a. Rate of decay for stakes of European redwood treated with Basilit CFK at the following retentions (kg/m^3): 1, 6.7; 2, 10; 3, 14; 4, 20; 5, 27.

Figure 3b. Rate of decay for stakes of European redwood treated with Basilit CFK at the following retentions (kg/m^3): 1, 6.7; 2, 10; 3, 14; 4, 20; 5, 27.



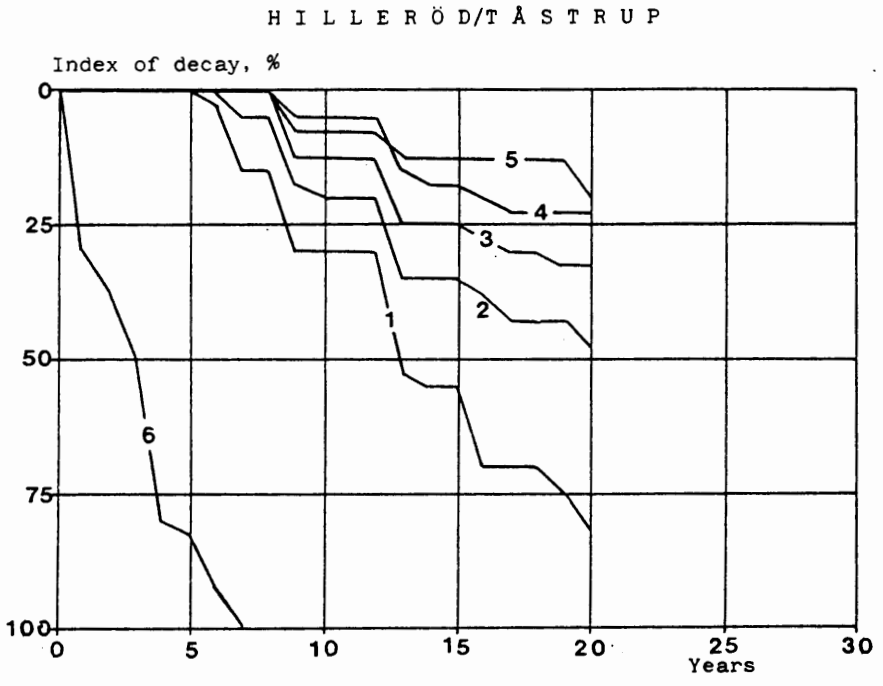


Figure 4a. Rate of decay for stakes of European redwood treated with Boliden K33 at the following retentions (kg/m^3): 1, 6.6; 2, 10; 3, 13; 4, 20; 5, 27; 6, Untreated stakes.

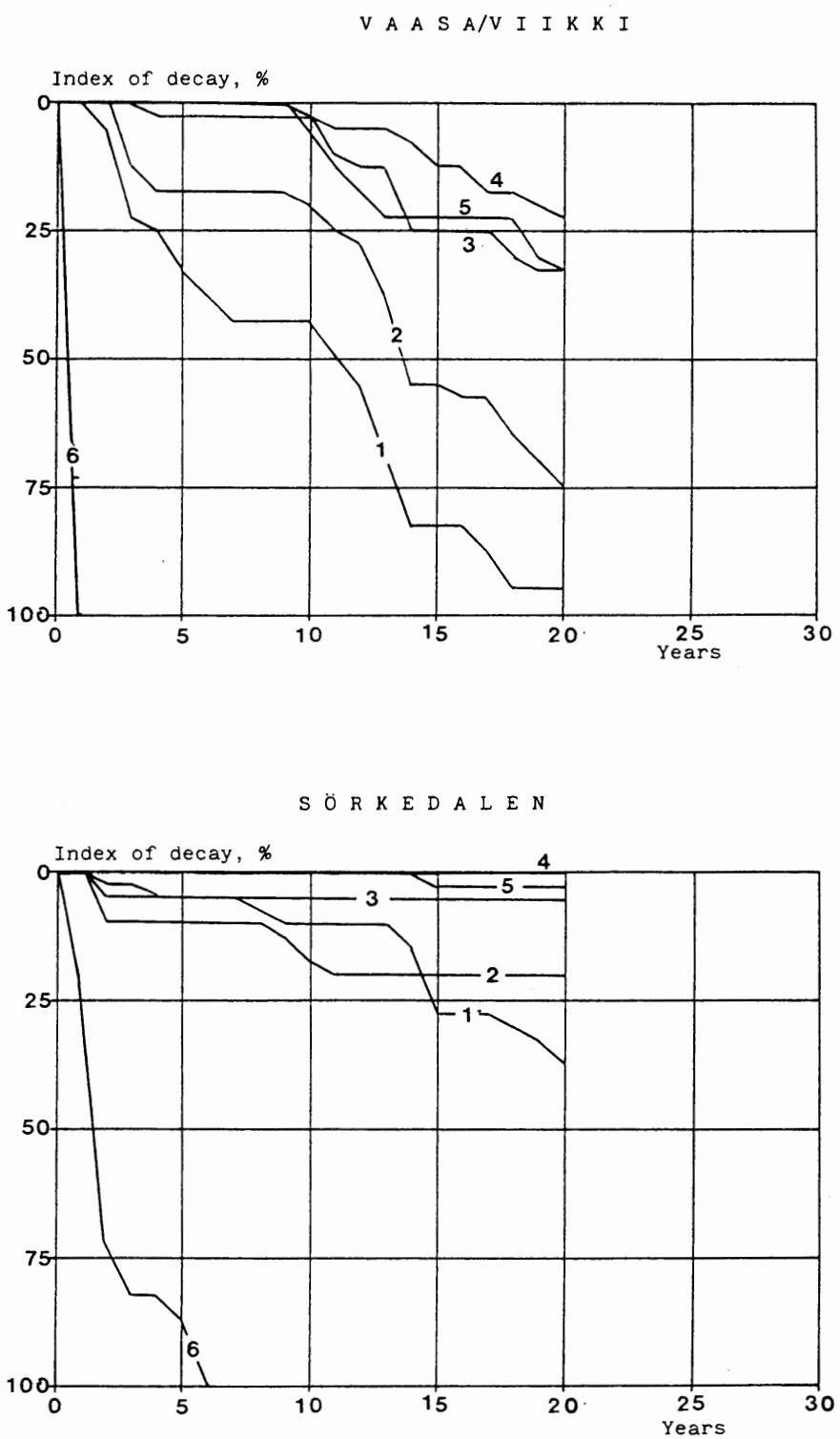
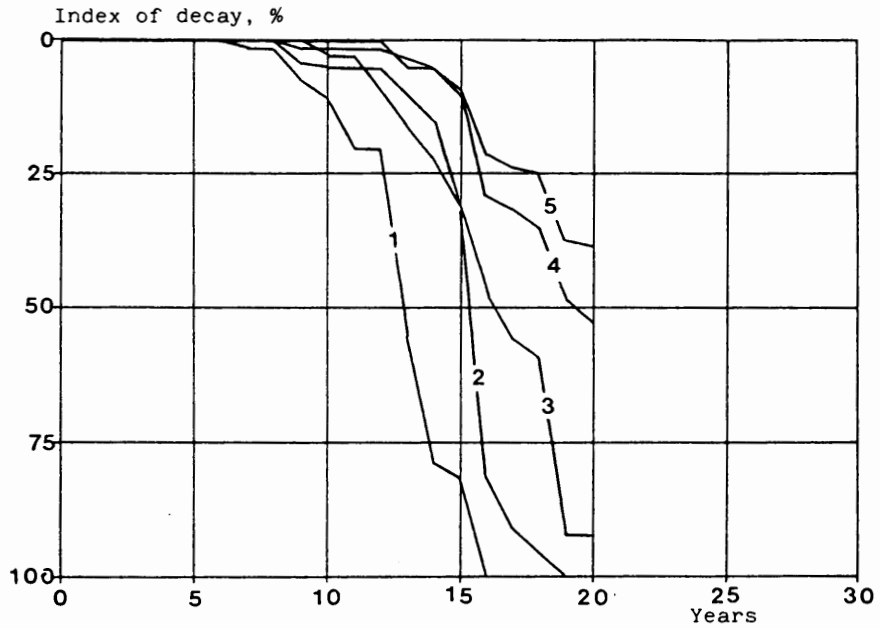


Figure 4b. Rate of decay for stakes of European redwood treated with Boliden K33 at the following retentions (kg/m^3): 1, 6.6; 2, 10; 3, 13; 4, 20; 5, 27; 6, Untreated stakes.

S I M L Å N G S D A L E N



H I L L E R Ö D/T Å S T R U P

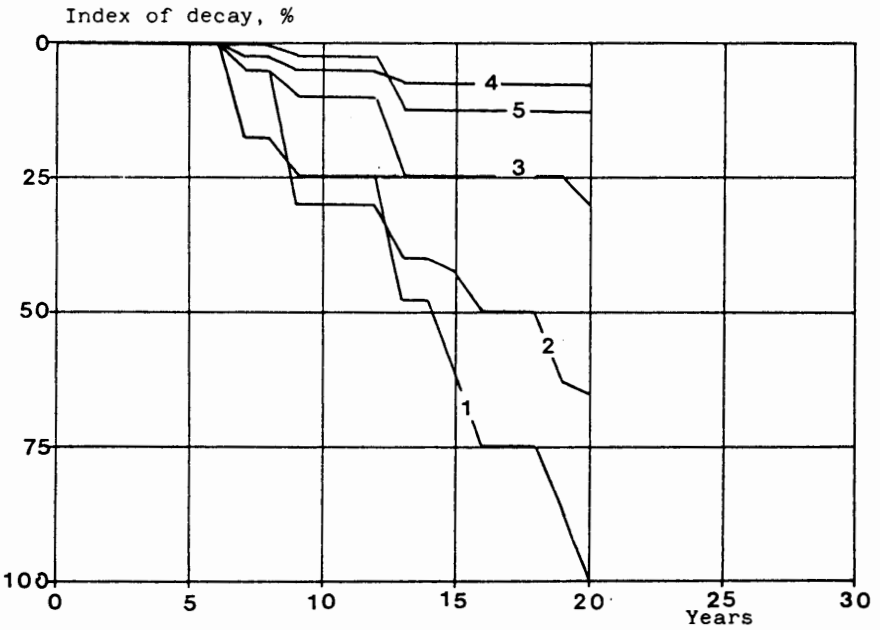


Figure 5a. Rate of decay for stakes of European redwood treated with Celcure A at the following retentions (kg/m^3): 1, 7.7; 2, 12; 3, 16; 4, 23; 5, 32.

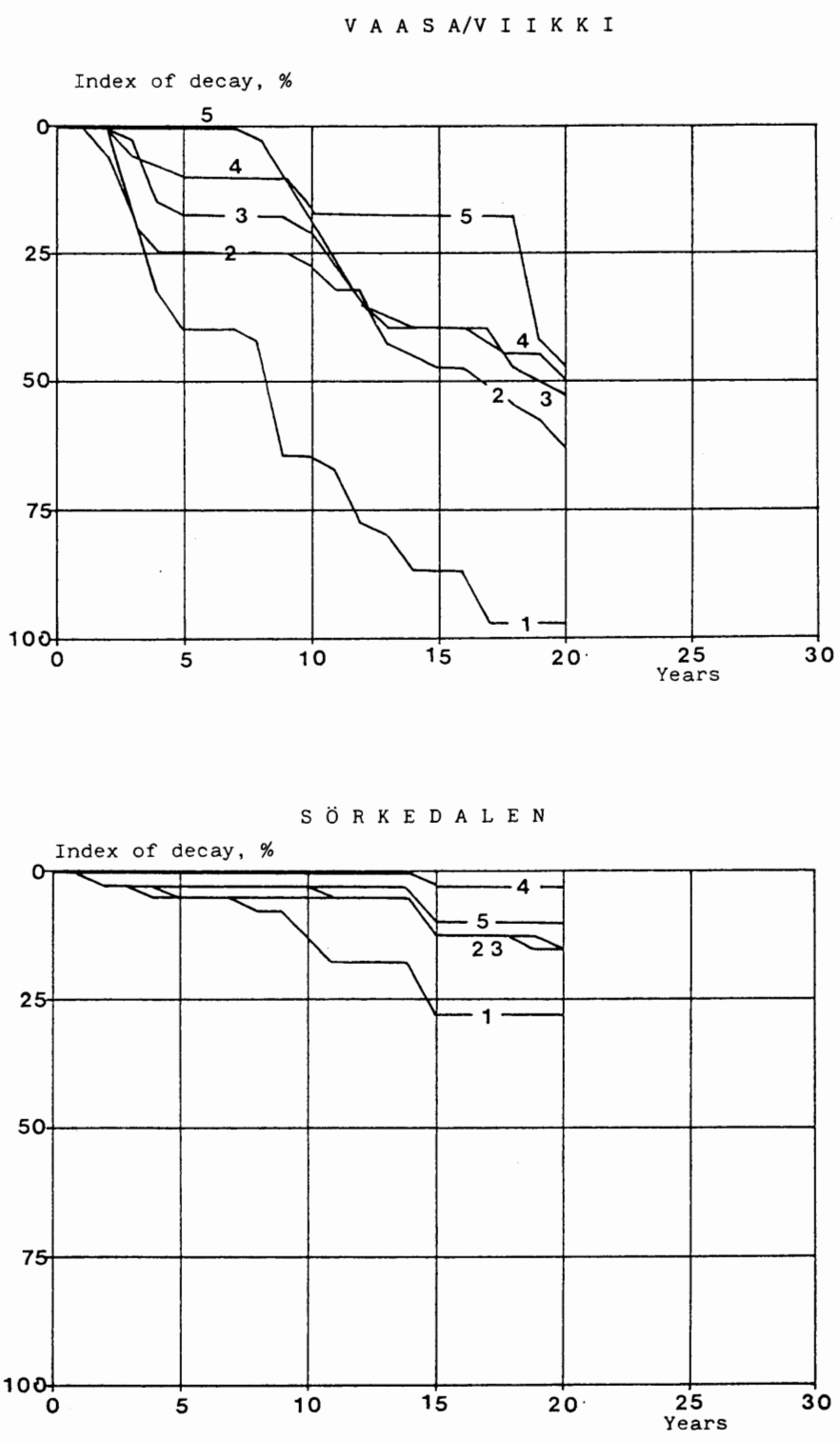


Figure 5b. Rate of decay for stakes of European redwood treated with Celcure A at the following retentions (kg/m^3): 1, 7.7; 2, 12; 3, 16; 4, 23; 5, 32.

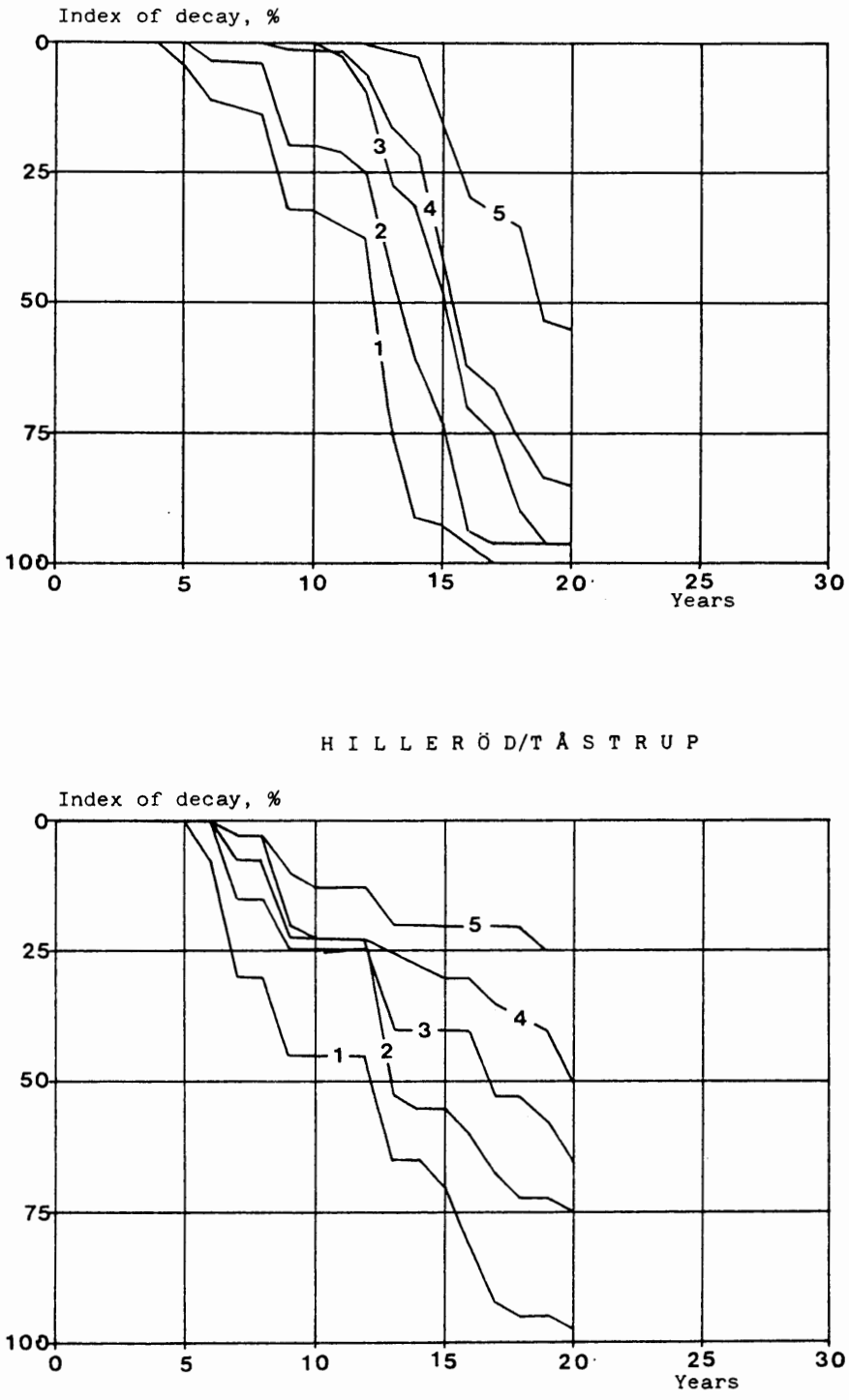


Figure 6a. Rate of decay for stakes of European redwood treated with KP Cuprinol at the following retentions (kg/m^3): 1, 9.0; 2, 14; 3, 18; 4, 27; 5, 36.

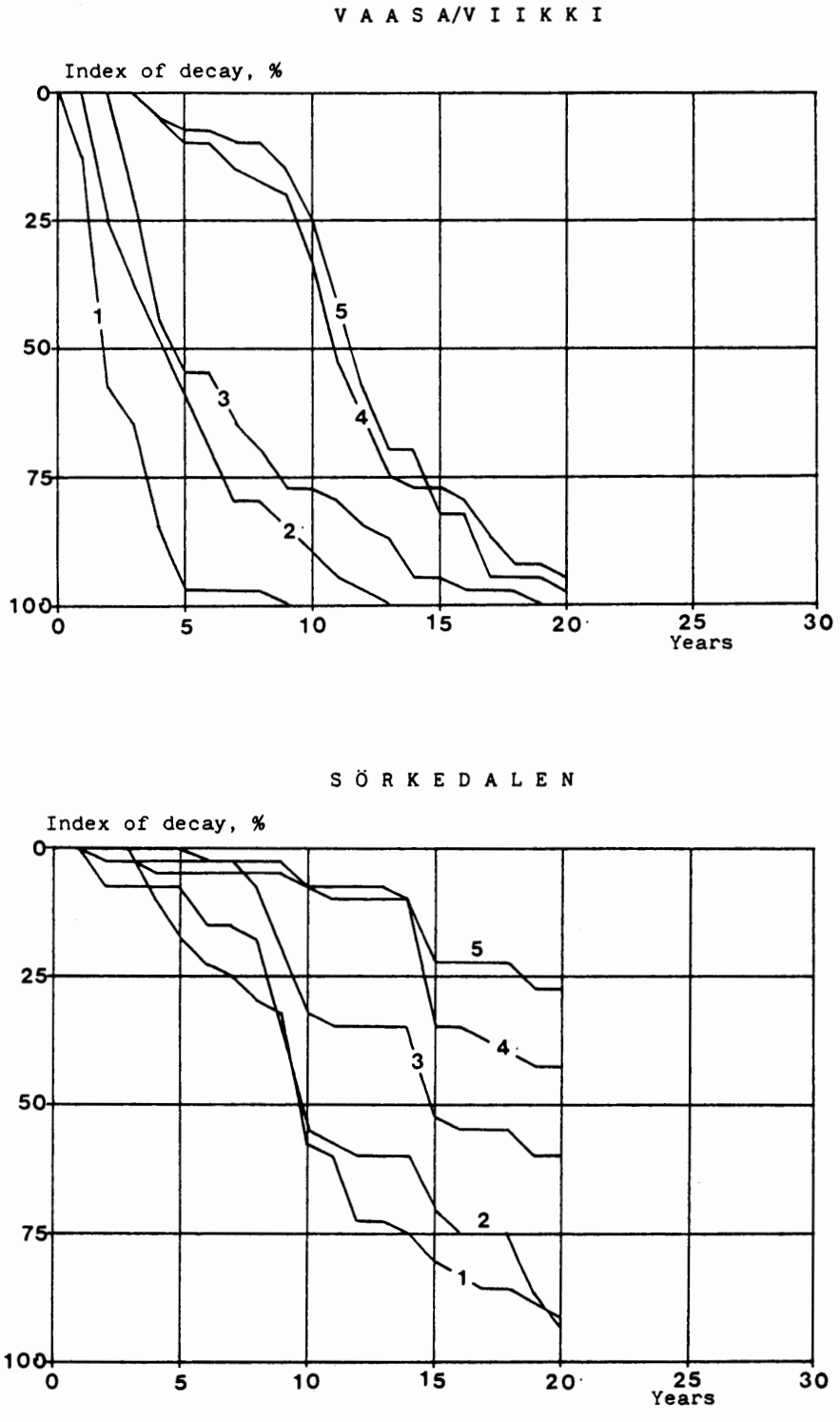
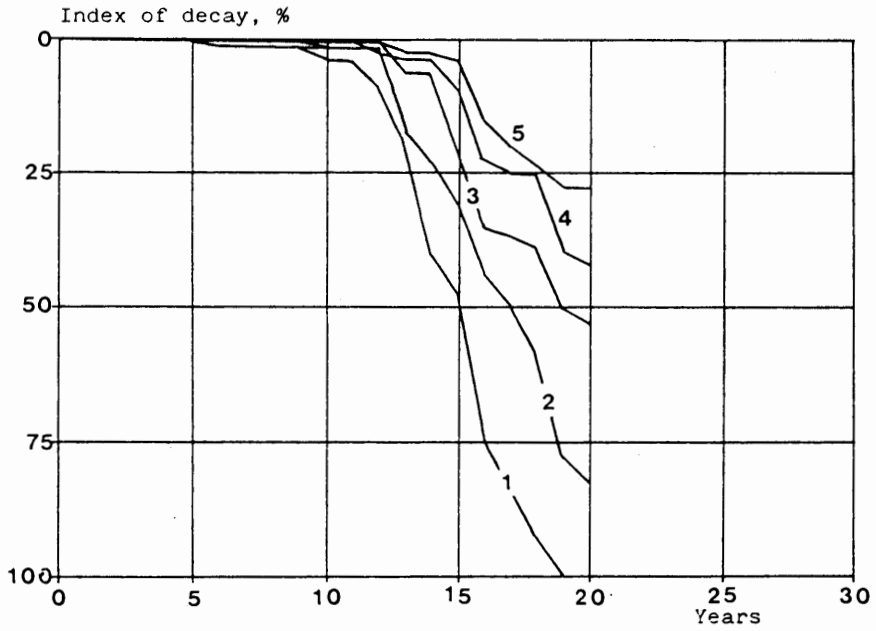


Figure 6b. Rate of decay for stakes of European redwood treated with KP Cuprinol at the following retentions (kg/m^3): 1, 9.0; 2, 14; 3, 18; 4, 27; 5, 36.

S I M L Å N G S D A L E N



H I L L E R Ö D/T Å S T R U P

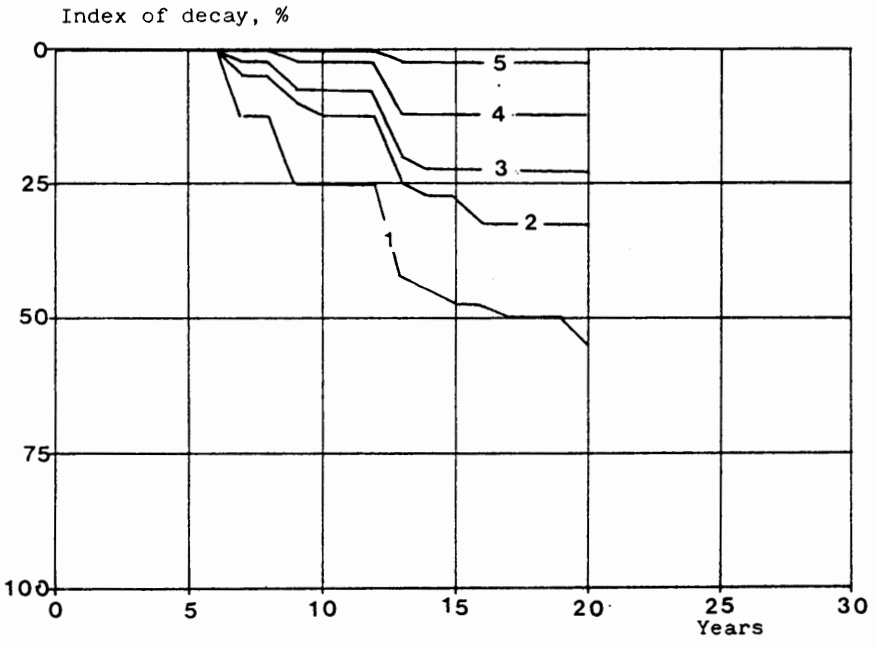
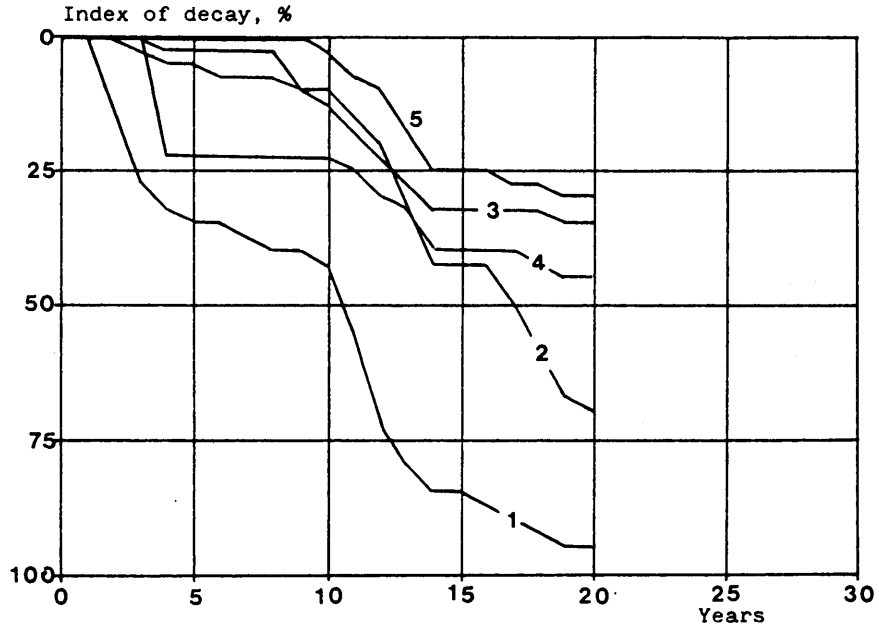


Figure 7a. Rate of decay for stakes of European redwood treated with Tanalith C at the following retentions (kg/m^3): 1, 8.1; 2, 12; 3, 16; 4, 24; 5, 33.

V A A S A/V I I K K I



S Ö R K E D A L E N

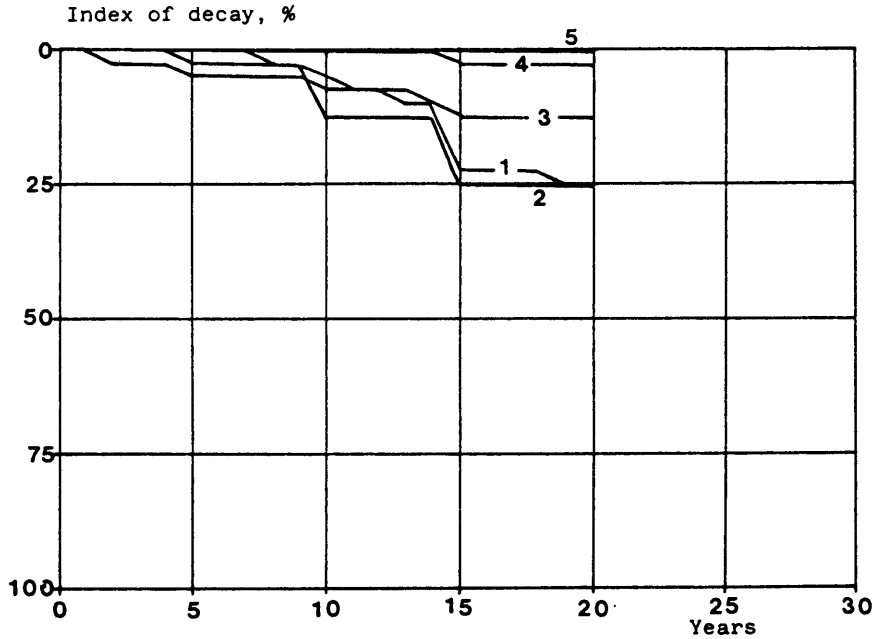


Figure 7b. Rate of decay for stakes of European redwood treated with Tanalith C at the following retentions (kg/m^3): 1, 8.1; 2, 12; 3, 16; 4, 24; 5. 33.

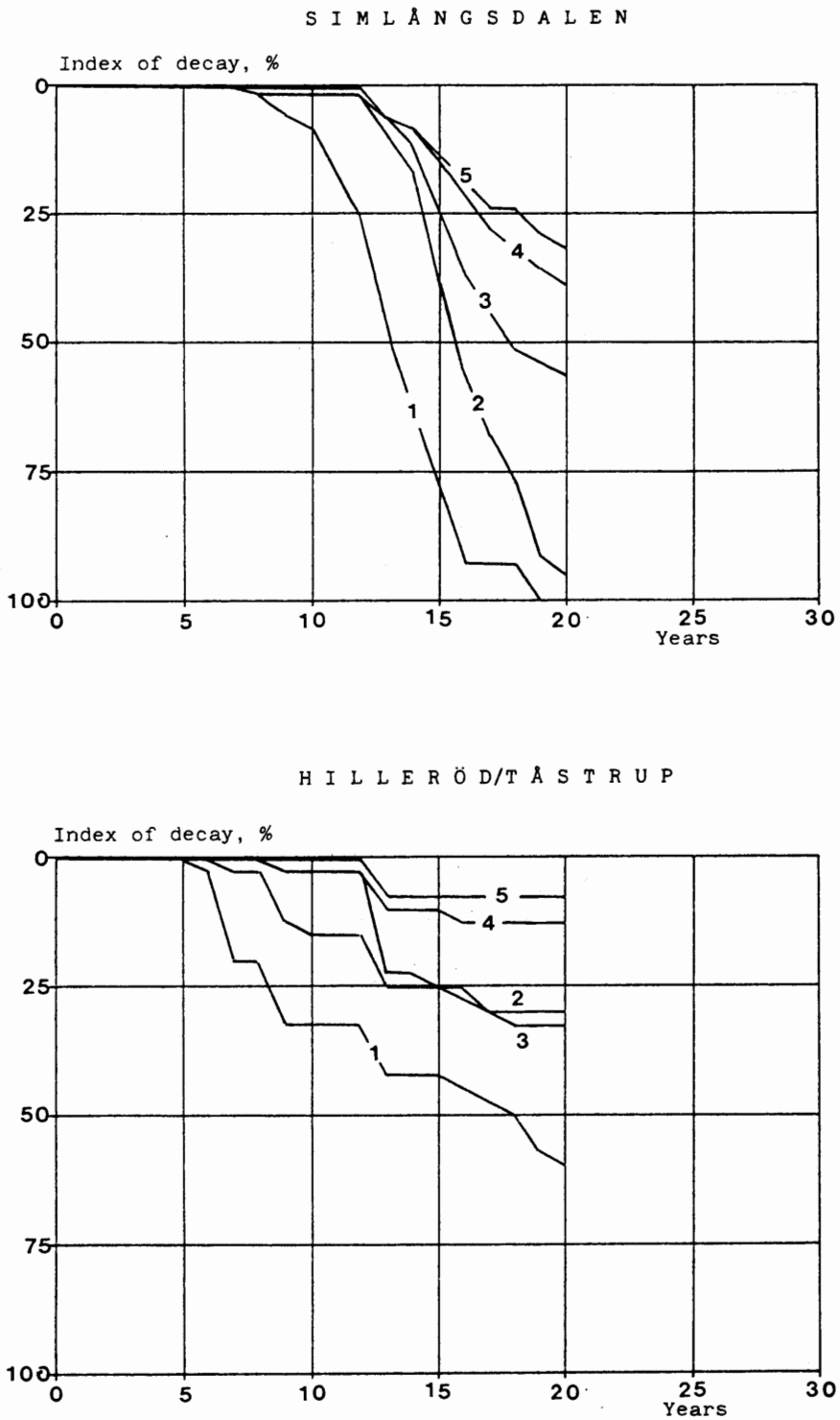
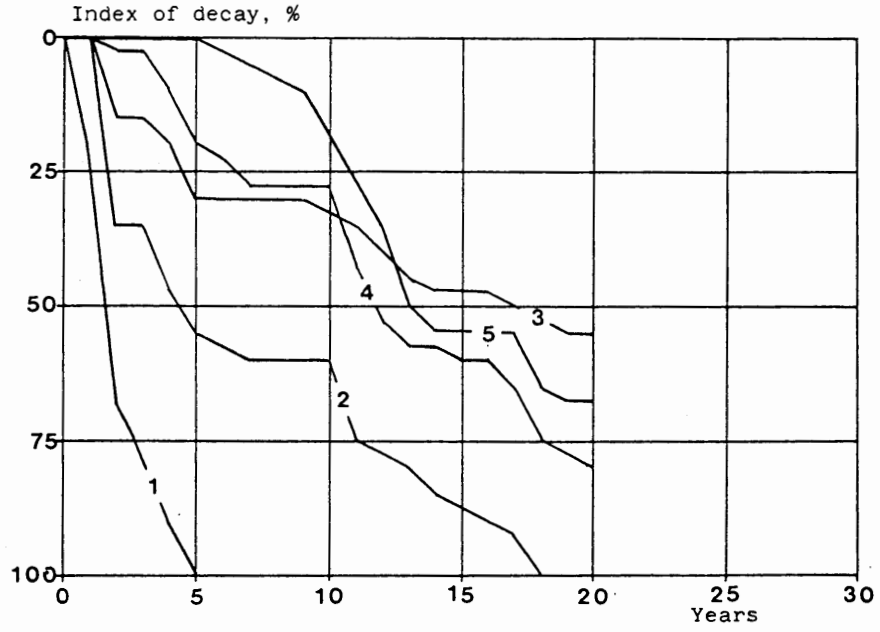


Figure 8a. Rate of decay for stakes of European redwood treated with Wolmanit CB at the following retentions (kg/m^3): 1, 10; 2, 15; 3, 20; 4, 31; 5, 41.

V A A S A/V I I K K I



S Ö R K E D A L E N

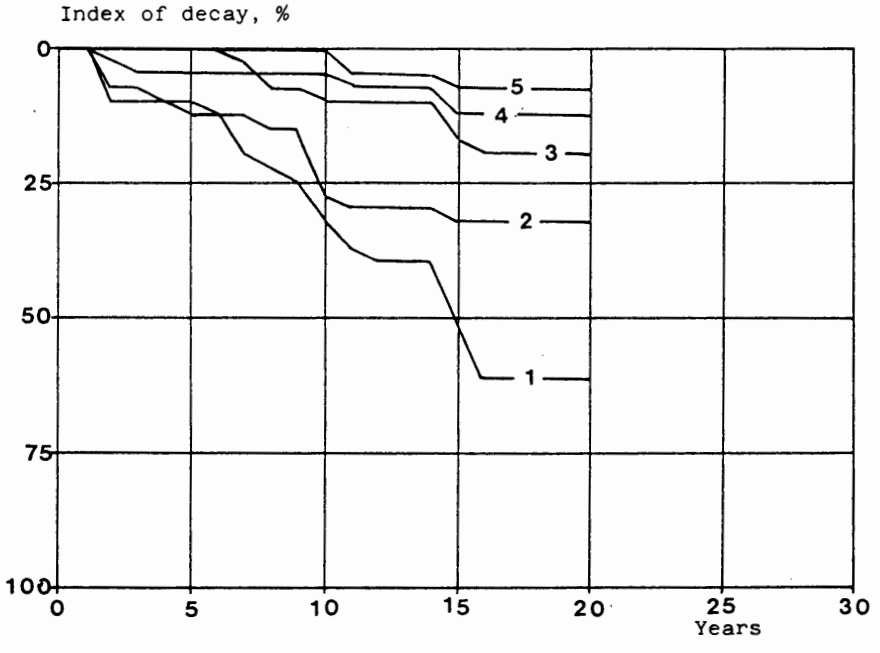
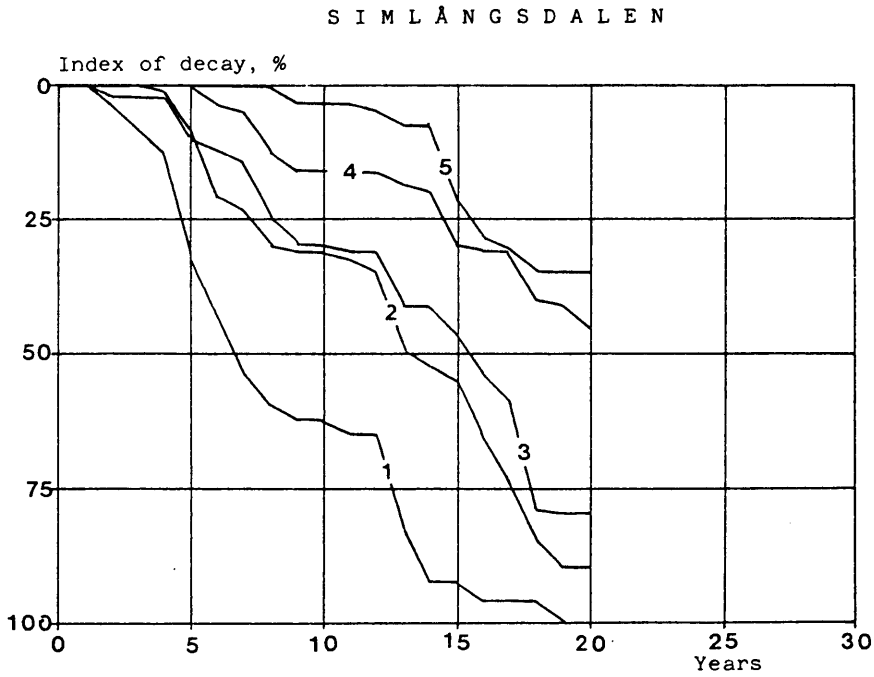


Figure 8b. Rate of decay for stakes of European redwood treated with Wolmanit CB at the following retentions (kg/m^3): 1, 10; 2, 15; 3, 20; 4, 31; 5, 41.



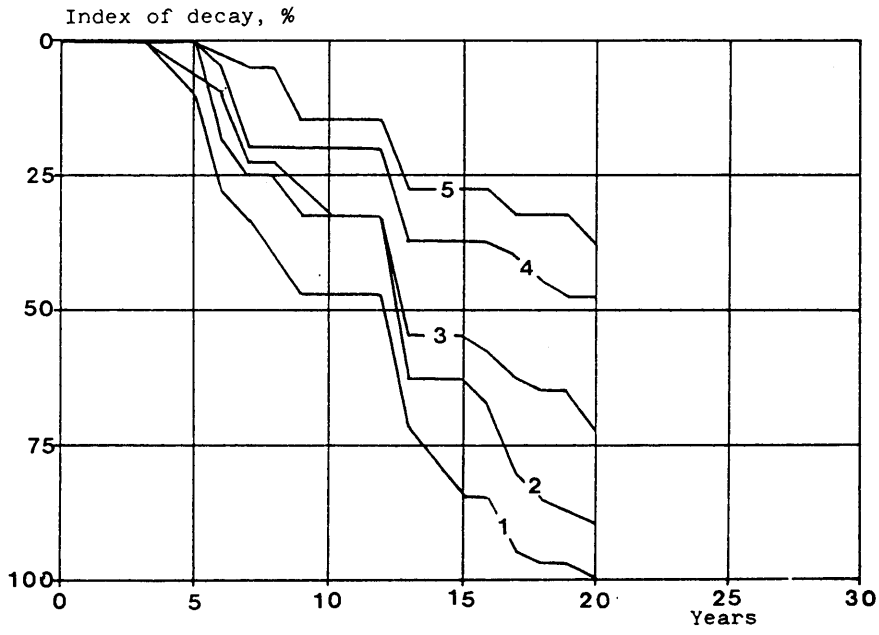
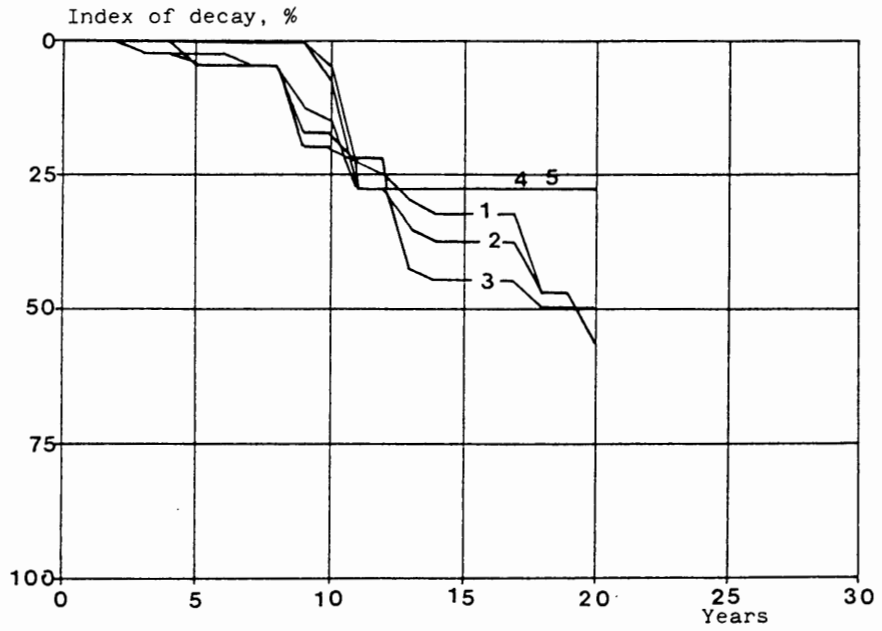


Figure 9a. Rate of decay for stakes of European redwood treated with BP Hylosan at the following retentions (kg/m^3): 1, 70; 2, 104; 3, 126; 4, 217; 5, 305.

V A A S A/V I I K K I



S Ö R K E D A L E N

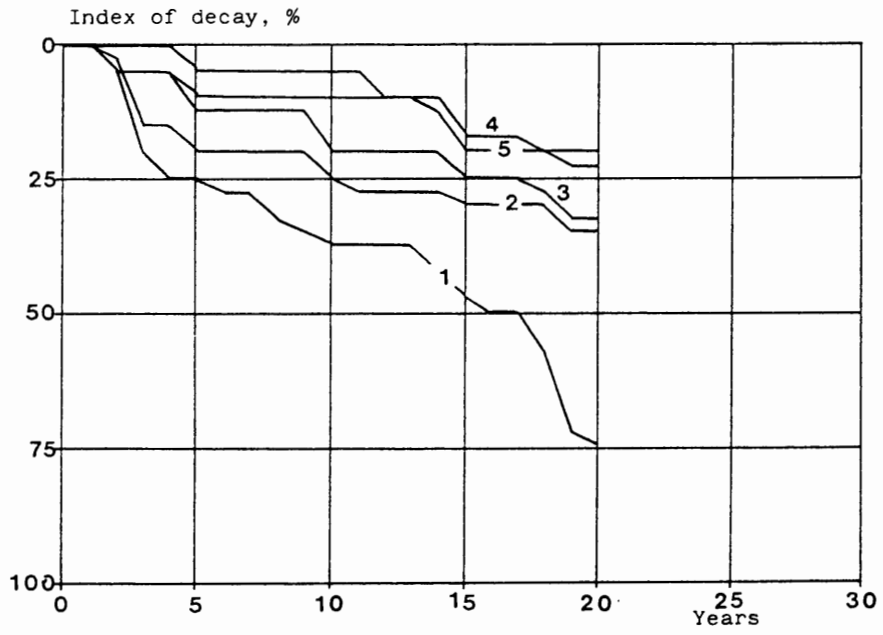
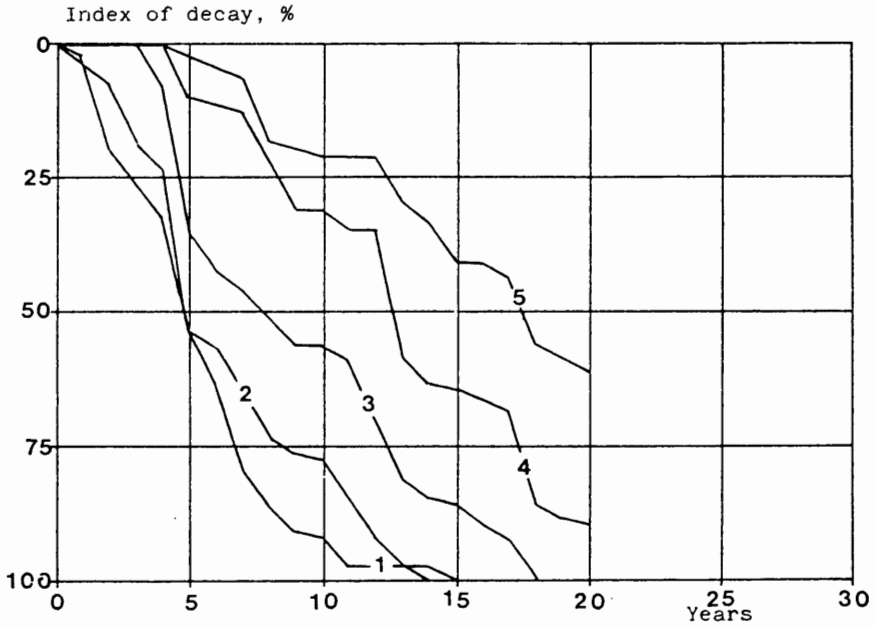


Figure 9b. Rate of decay for stakes of European redwood treated with BP Hylosan at the following retentions (kg/m^3): 1, 70; 2, 104; 3, 126; 4, 217; 5, 305.

S I M L Å N G S D A L E N



H I L L E R Ö D/T Å S T R U P

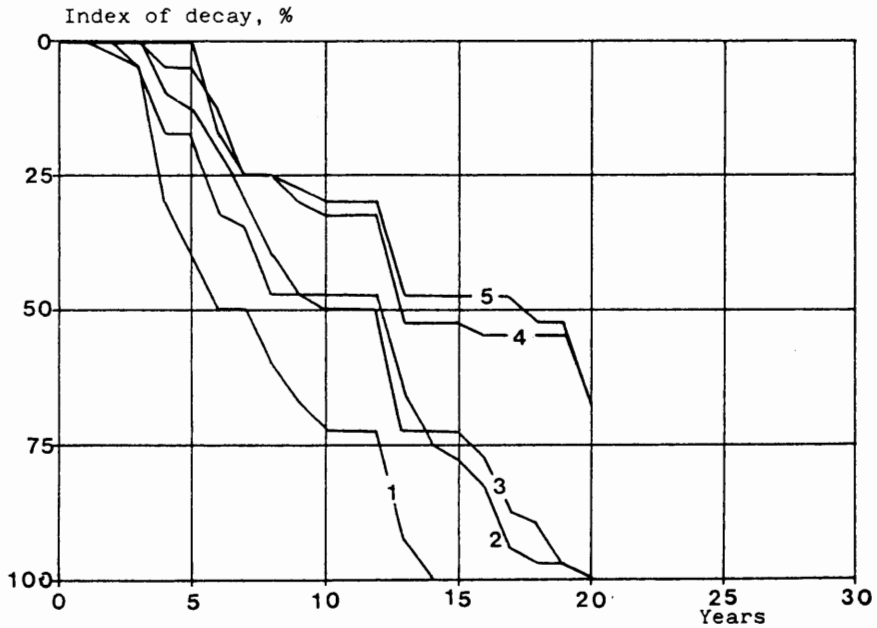
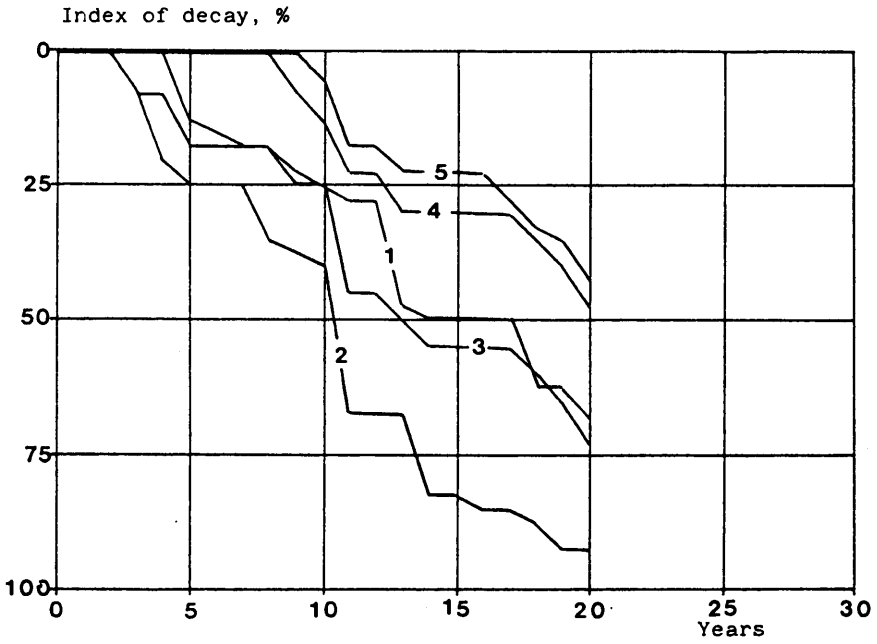


Figure 10a. Rate of decay for stakes of European redwood treated with creosote at the following retentions (kg/m^3): 1, 74; 2, 108; 3, 143; 4, 194; 5, 229.

V A A S A/V I I K K I



S Ö R K E D A L E N

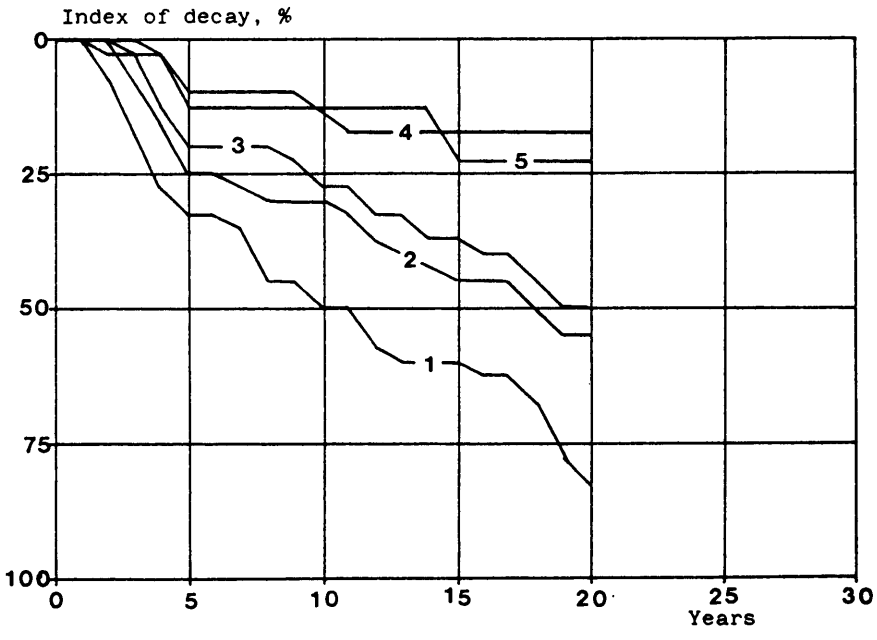


Figure 10b. Rate of decay for stakes of European redwood treated with creosote at the following retentions (kg/m^3): 1, 74; 2, 108; 3, 143; 4, 194; 5, 229.

S I M L Å N G S D A L E N

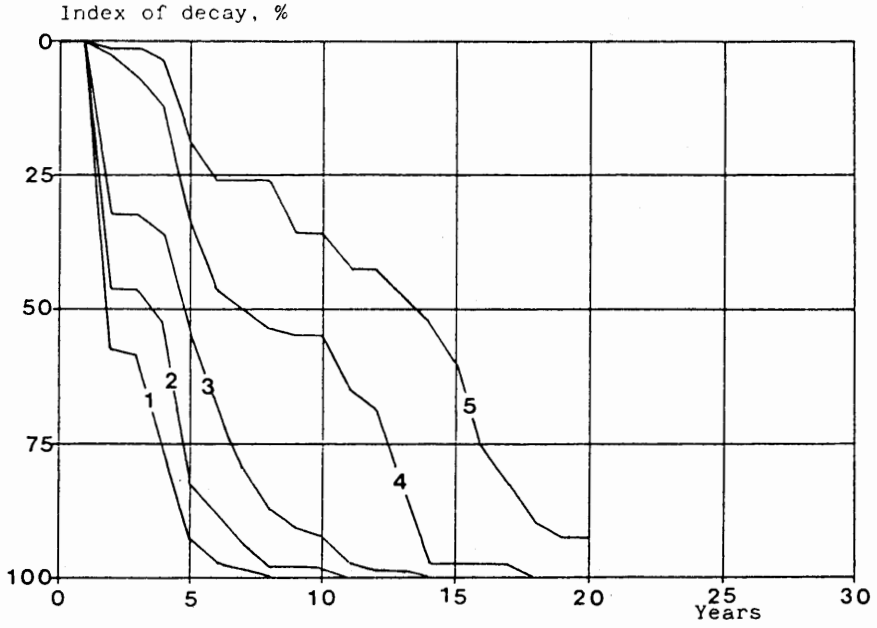


Figure 11. Rate of decay for stakes of European beech treated with Basilit CFK at the following retentions (kg/m^3): 1, 6.4; 2, 9.5; 3, 12; 4, 19; 5, 25.

S I M L Å N G S D A L E N

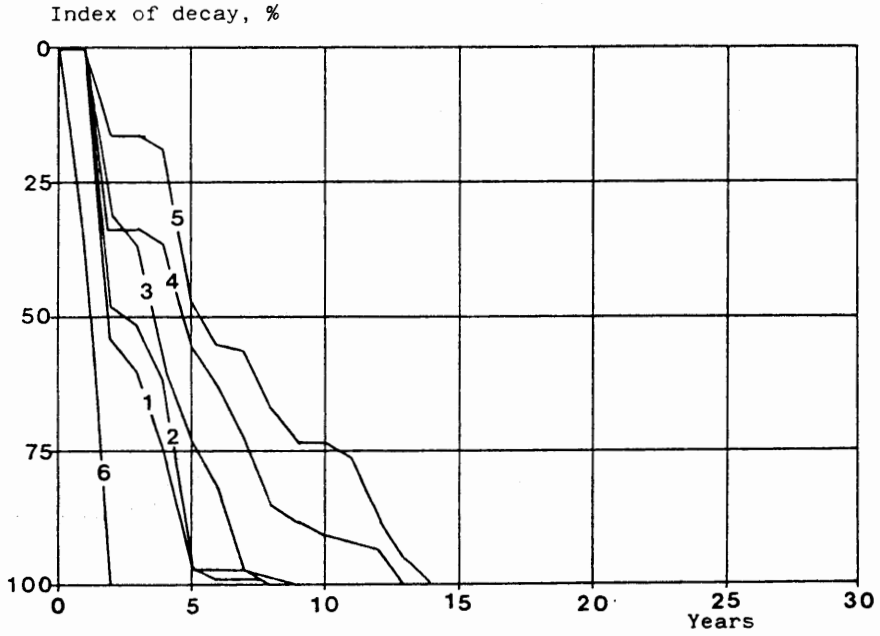


Figure 12. Rate of decay for stakes of European beech treated with Boliden K33 at the following retentions (kg/m^3): 1, 6.3; 2, 9.5; 3, 13; 4, 19; 5, 25; 6, Untreated stakes.

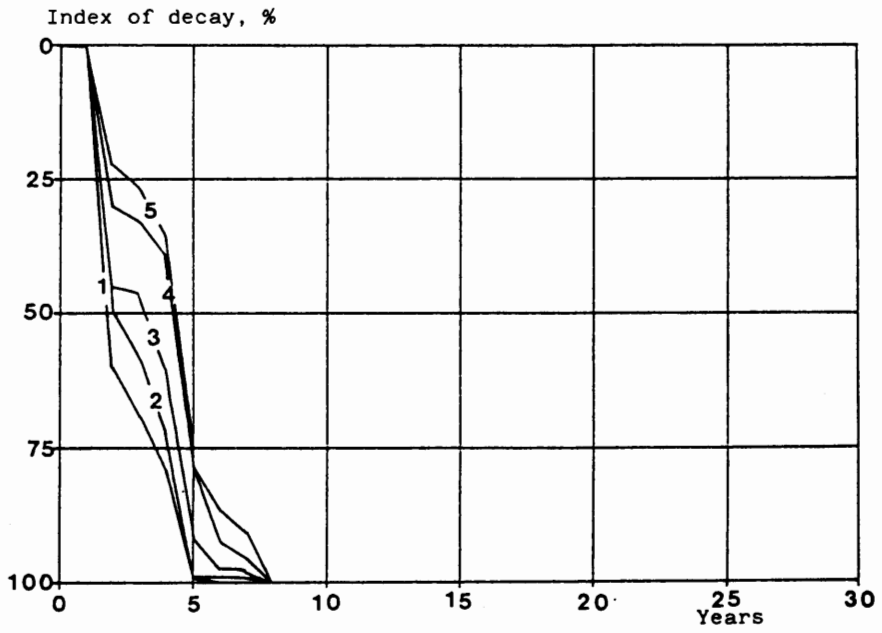


Figure 13. Rate of decay for stakes of European beech treated with Celcure A at the following retentions (kg/m^3): 1, 7.7; 2, 11; 3, 15; 4, 23; 5, 31.

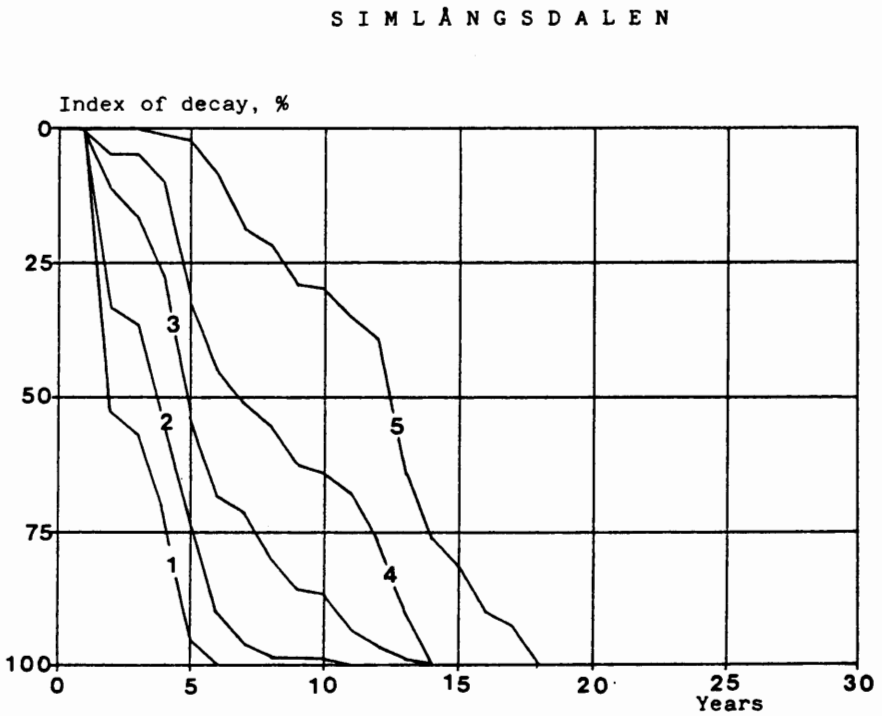


Figure 14. Rate of decay for stakes of European beech treated with KP Cuprinol at the following retentions (kg/m^3): 1, 8.7; 2, 13; 3, 17; 4, 26; 5, 36.

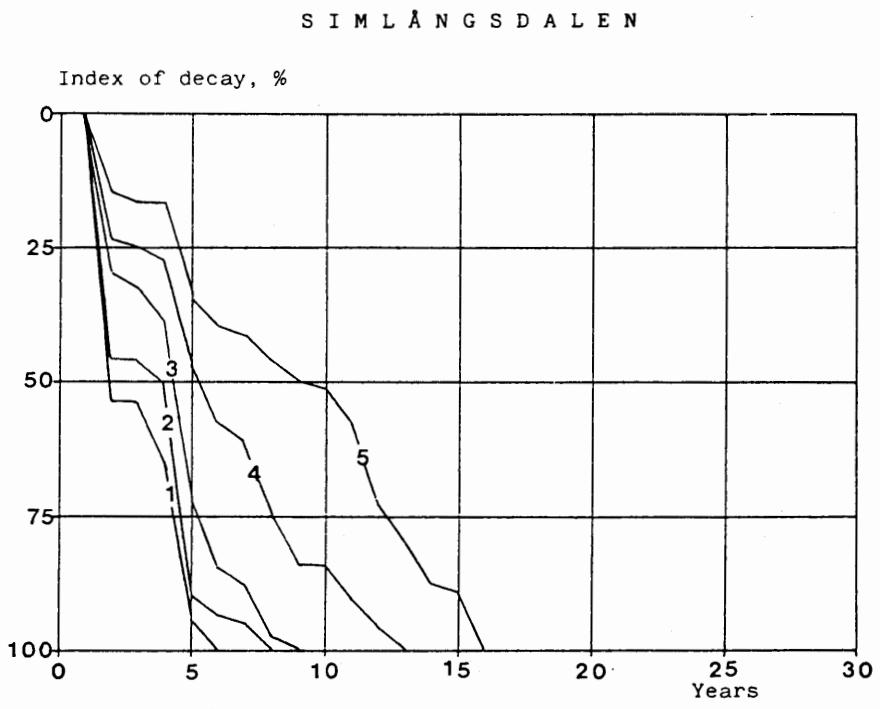


Figure 15. Rate of decay for stakes of European beech treated with Tanalith C at the following retentions (kg/m^3): 1, 7.6; 2, 12; 3, 15; 4, 23; 5, 31.

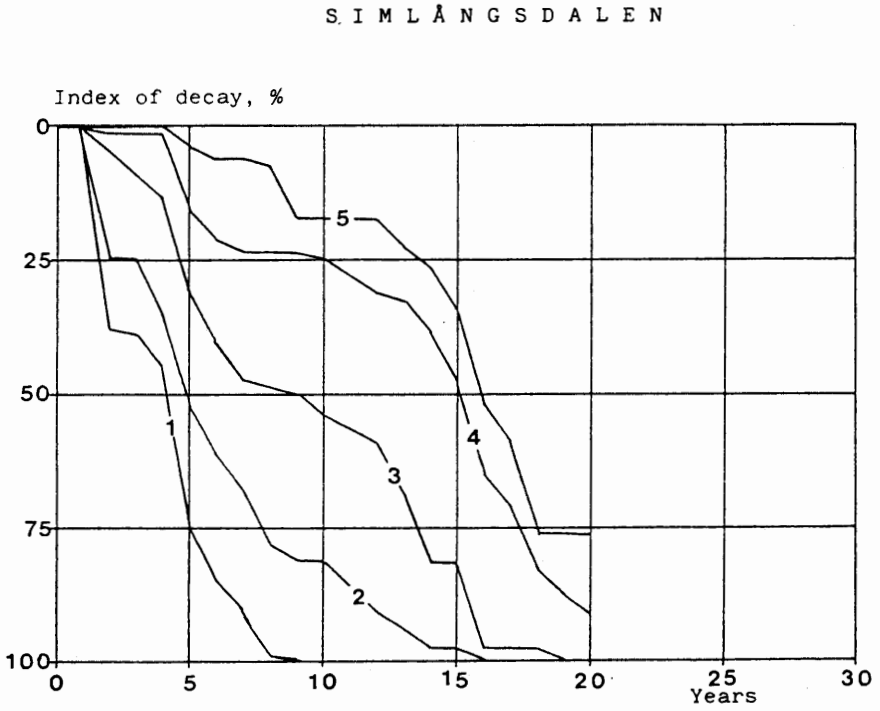


Figure 16. Rate of decay for stakes of European beech treated with Wolmanit CB at the following retentions (kg/m^3): 1, 9.6; 2, 14; 3, 19; 4, 29; 5, 39.

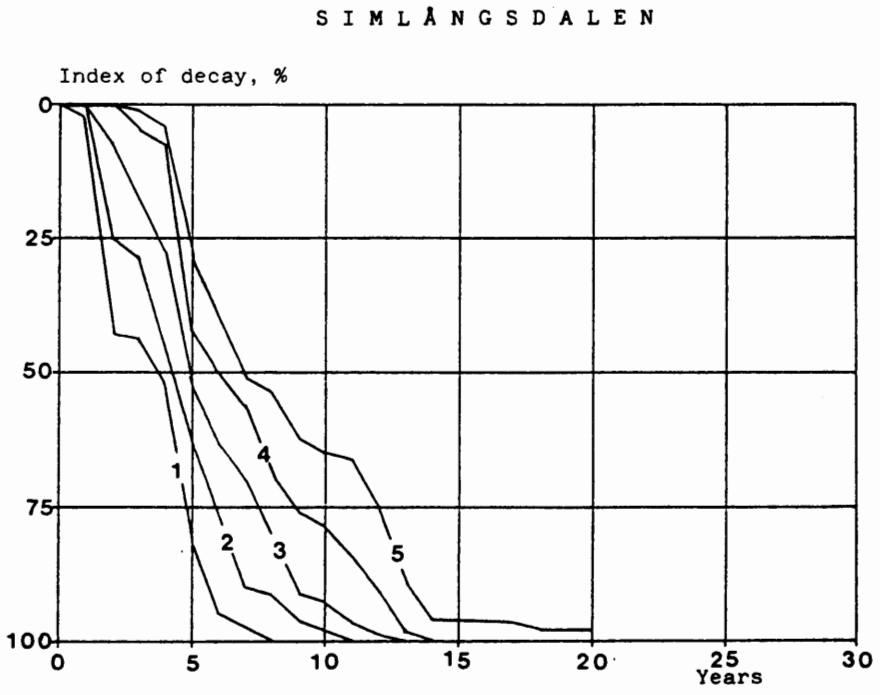


Figure 17. Rate of decay for stakes of European beech treated with BP Hylosan at the following retentions (kg/m^3): 1, 59; 2, 87; 3, 121; 4, 181; 5, 245.

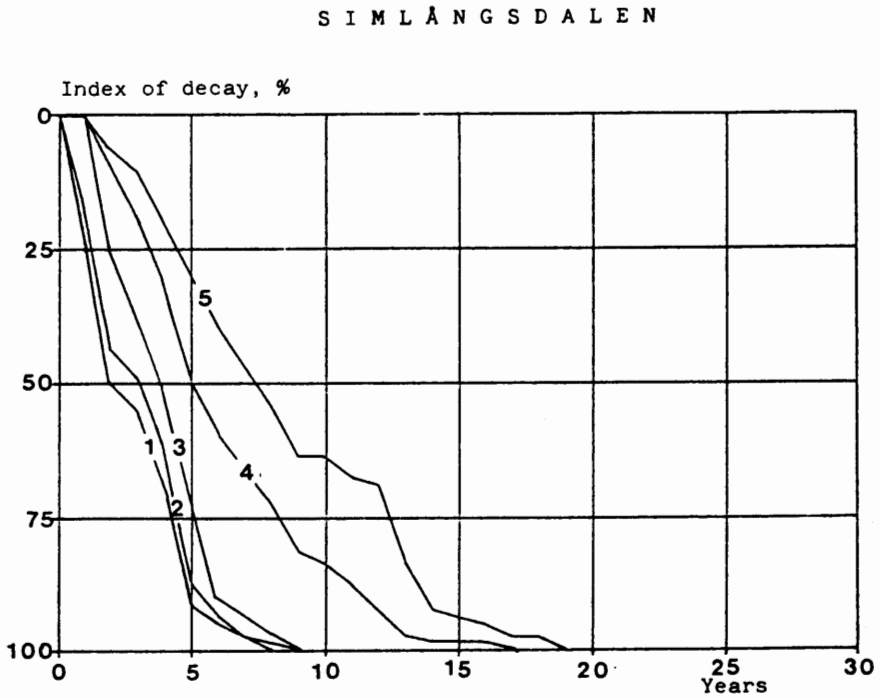


Figure 18. Rate of decay for stakes of European beech treated with creosote at the following retentions (kg/m^3): 1, 60; 2, 90; 3, 119; 4, 199; 5, 282.

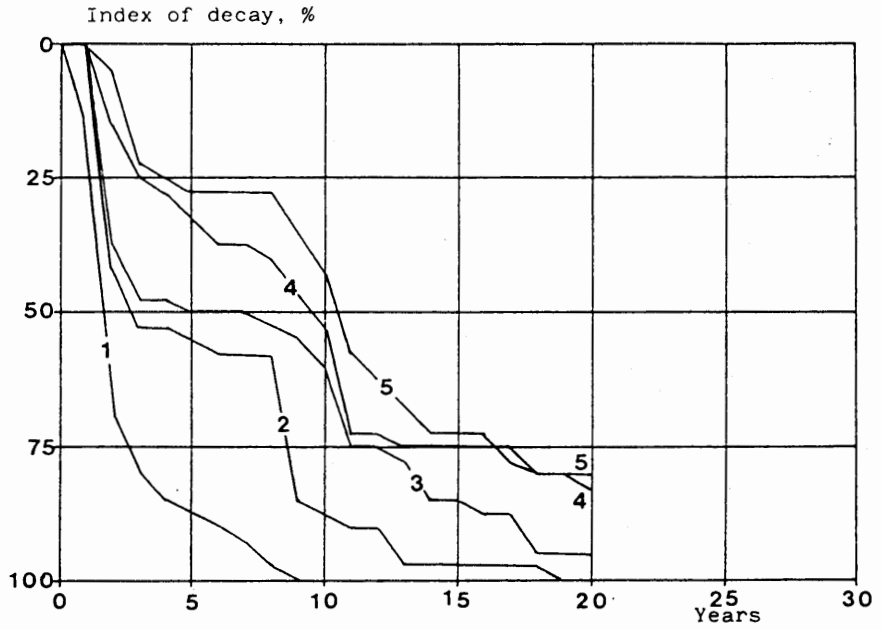


Figure 19. Rate of decay for stakes of European birch treated with Basilit CFK at the following retentions (kg/m^3): 1, 5.9; 2, 8.9; 3, 12; 4, 18; 5, 24.

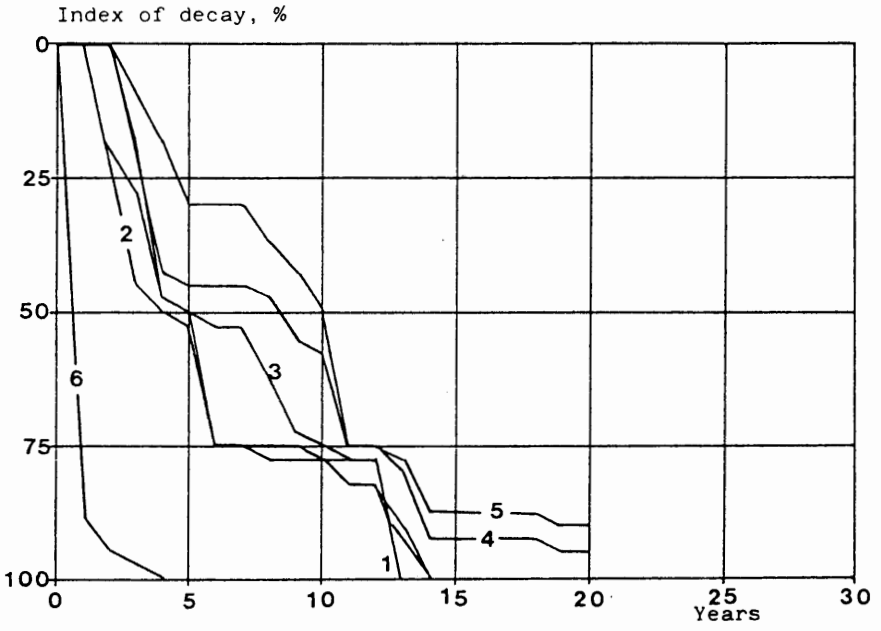


Figure 20. Rate of decay for stakes of European birch treated with Boliden K33 at the following retentions (kg/m^3): 1, 6.1; 2, 9.1; 3, 13; 4, 18; 5, 24; 6, Untreated stakes.

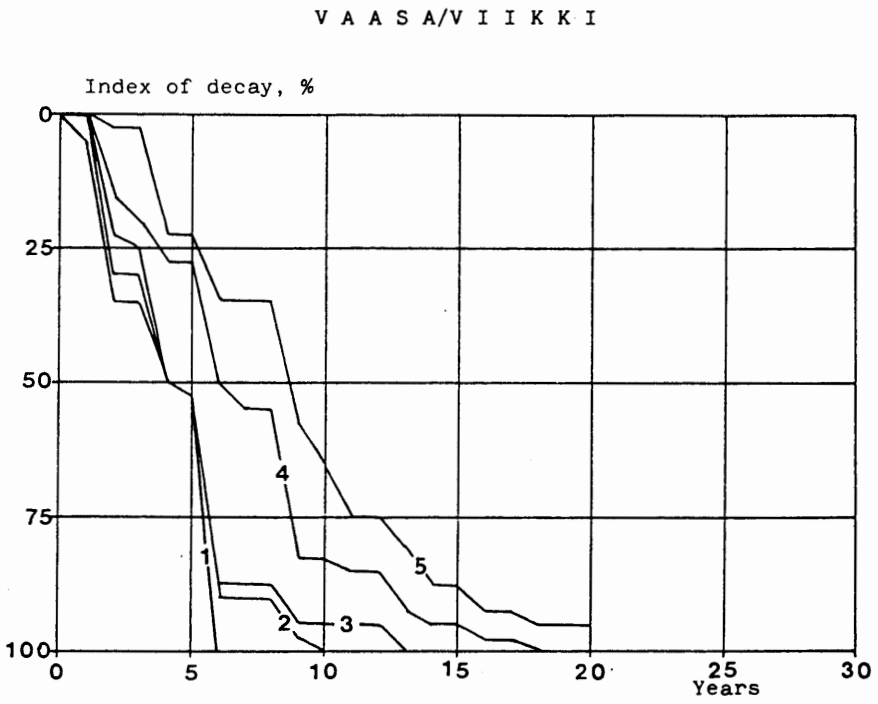


Figure 21. Rate of decay for stakes of European birch treated with Celcure A at the following retentions (kg/m^3): 1, 7.1; 2, 10; 3, 14; 4, 21; 5, 29.

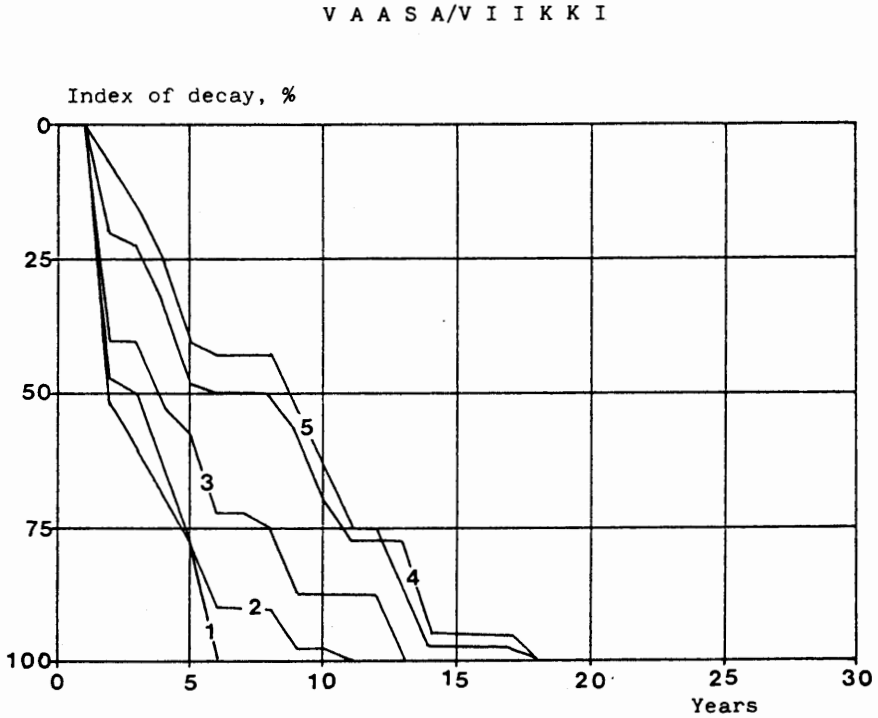


Figure 22. Rate of decay for stakes of European birch treated with KP Cuprinol at the following retentions (kg/m^3): 1, 8.2; 2, 12; 3, 16; 4, 24; 5, 33.

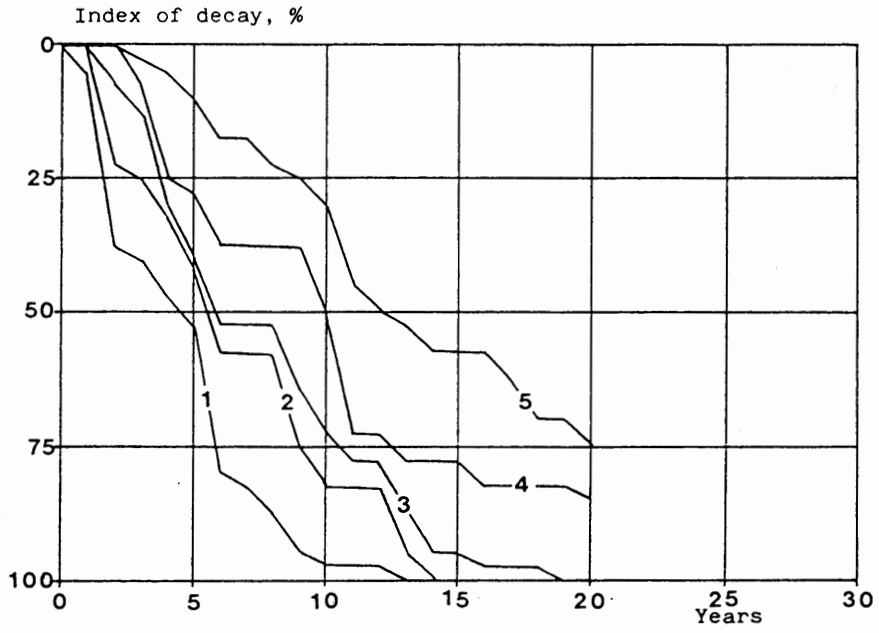


Figure 23. Rate of decay for stakes of European birch treated with Tanalith C at the following retentions (kg/m^3): 1, 7.3; 2, 11; 3, 14; 4, 21; 5, 30.

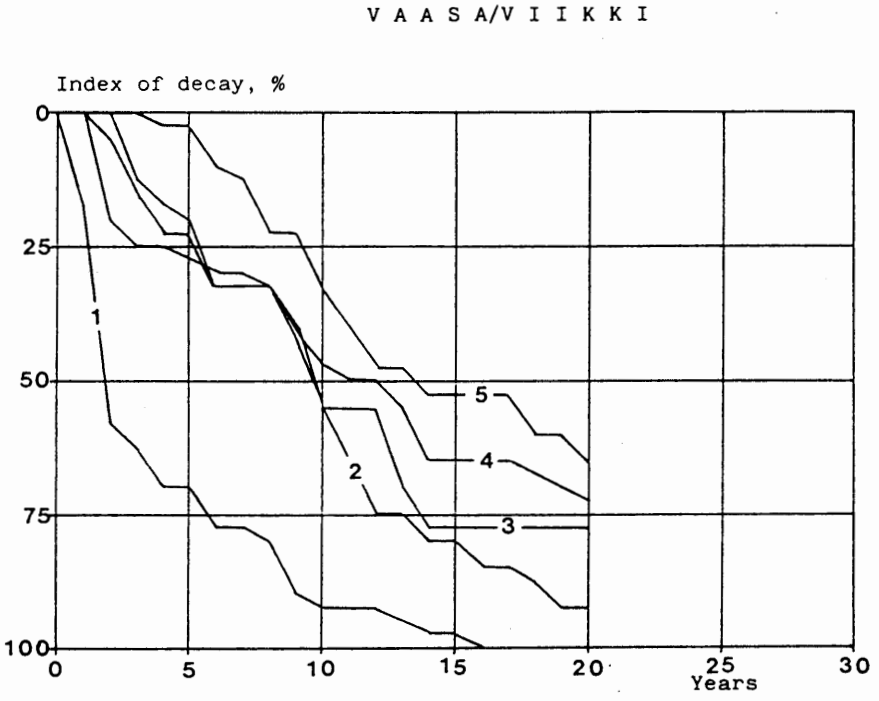


Figure 24. Rate of decay for stakes of European birch treated with Wolmanit CB at the following retentions (kg/m^3): 1, 8.8; 2, 13; 3, 18; 4, 27; 5, 36.

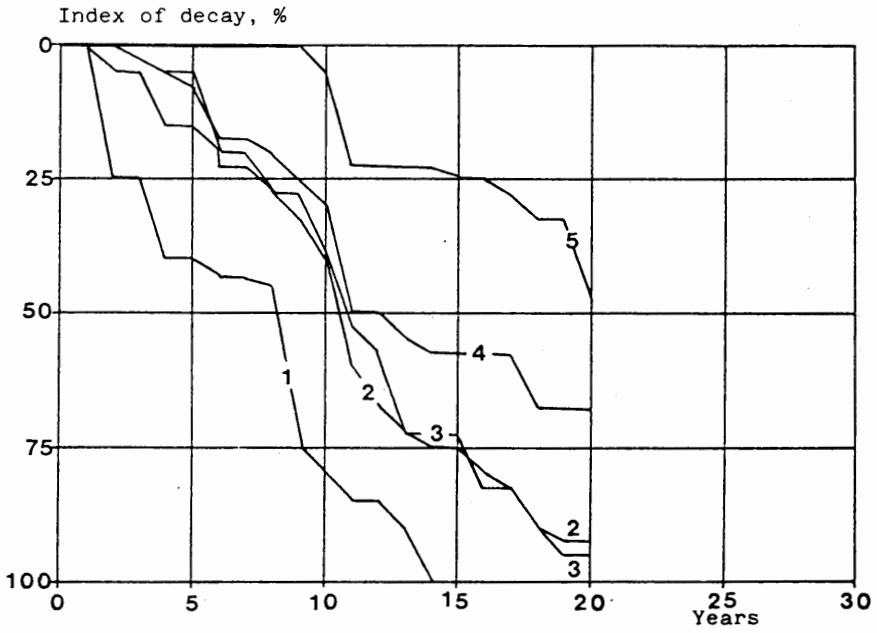


Figure 25. Rate of decay for stakes of European birch treated with BP Hylosan at the following retentions (kg/m^3): 1, 66; 2, 105; 3, 137; 4, 208; 5, 275.

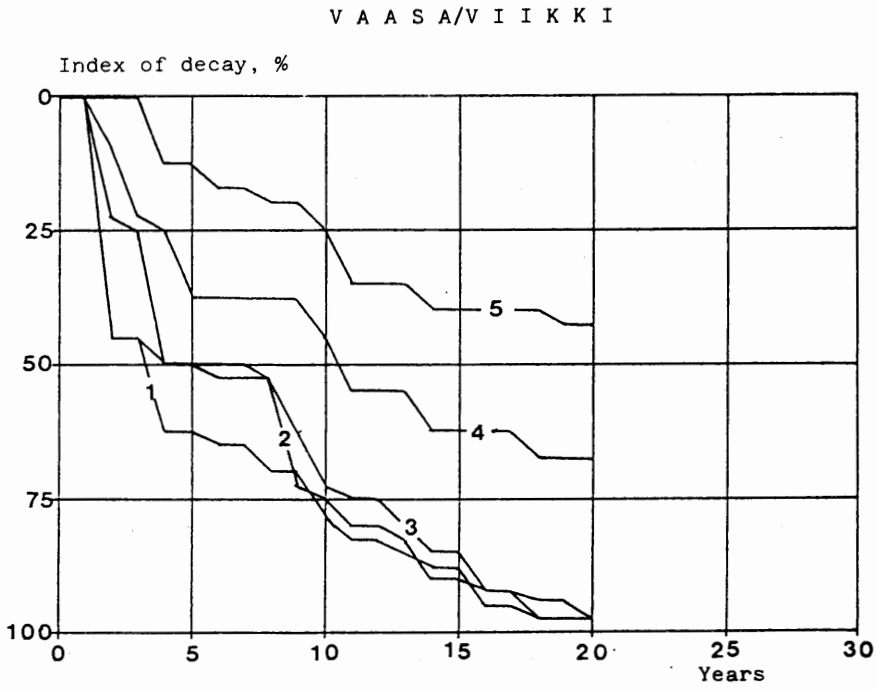


Figure 26. Rate of decay for stakes of European birch treated with creosote at the following retentions (kg/m^3): 1, 69; 2, 109; 3, 147; 4, 221; 5, 314.

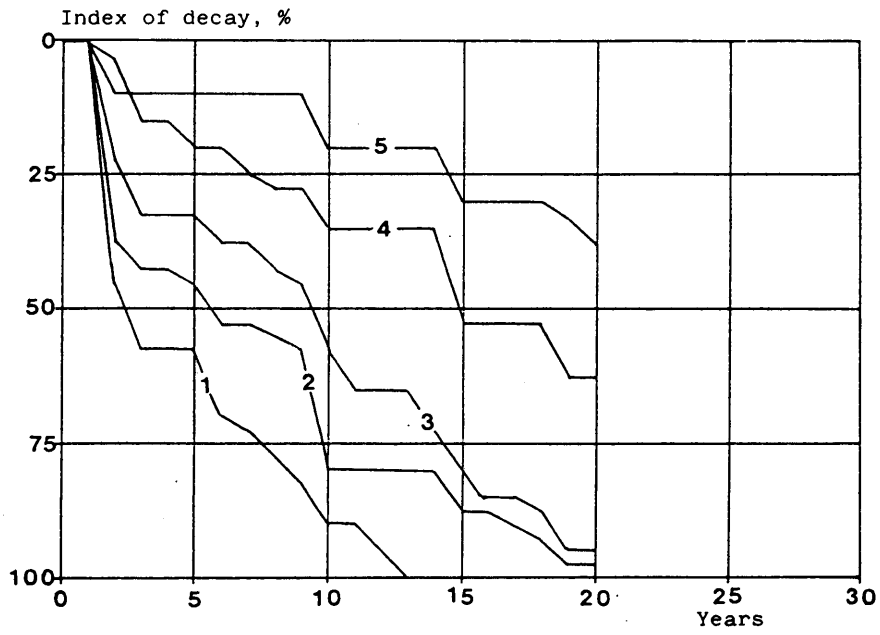


Figure 27. Rate of decay for stakes of alder treated with Basilit CFK at the following retentions (kg/m^3): 1, 8.0; 2, 12; 3, 16; 4, 24; 5, 32.

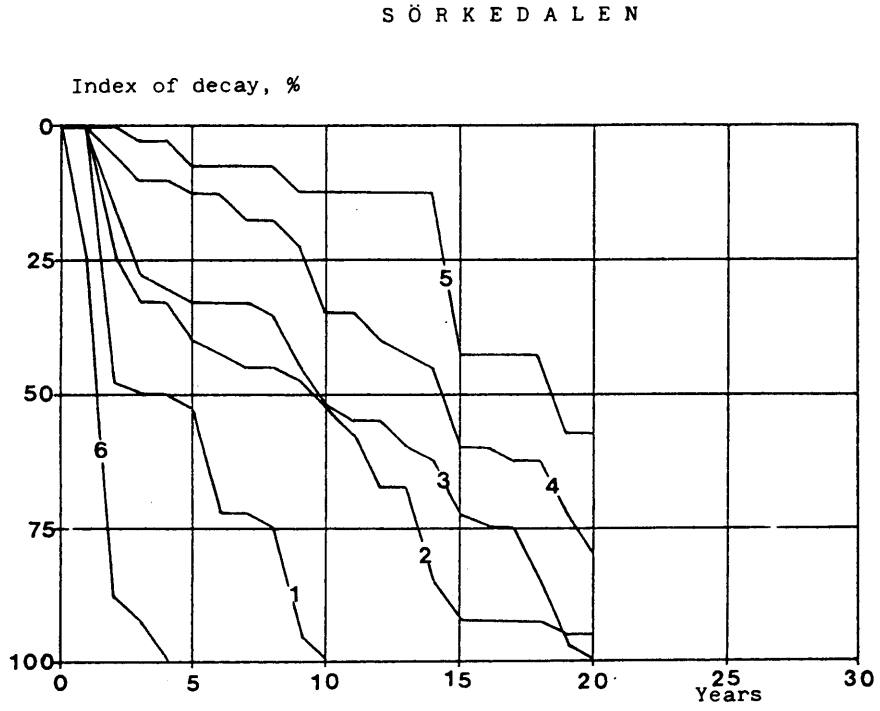


Figure 28. Rate of decay for stakes of alder treated with Boliden K33 at the following retentions (kg/m^3): 1, 7.8; 2, 12; 3, 16; 4, 24; 5, 32; 6, Untreated stakes.

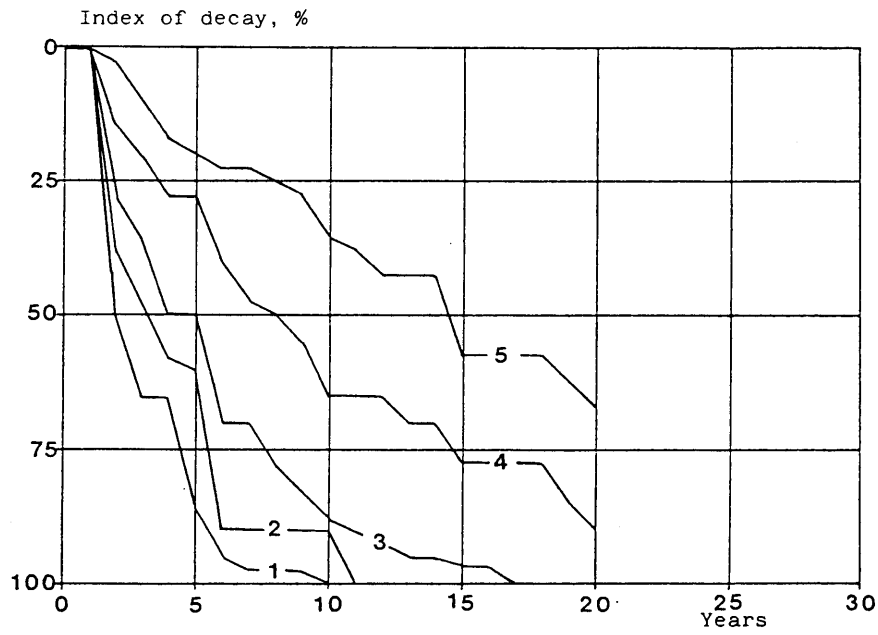


Figure 29. Rate of decay for stakes of alder treated with Celcure A at the following retentions (kg/m^3): 1, 9.4; 2, 14; 3, 19; 4, 28; 5, 38.

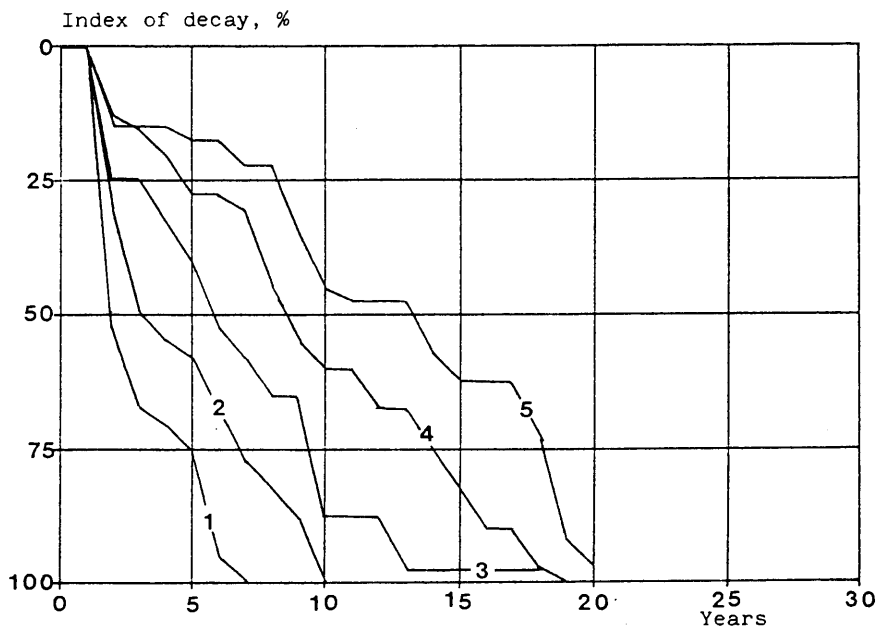


Figure 30. Rate of decay for stakes of alder treated with KP Cuprinol at the following retentions (kg/m^3): 1, 11; 2, 16; 3, 22; 4, 32; 5, 44.

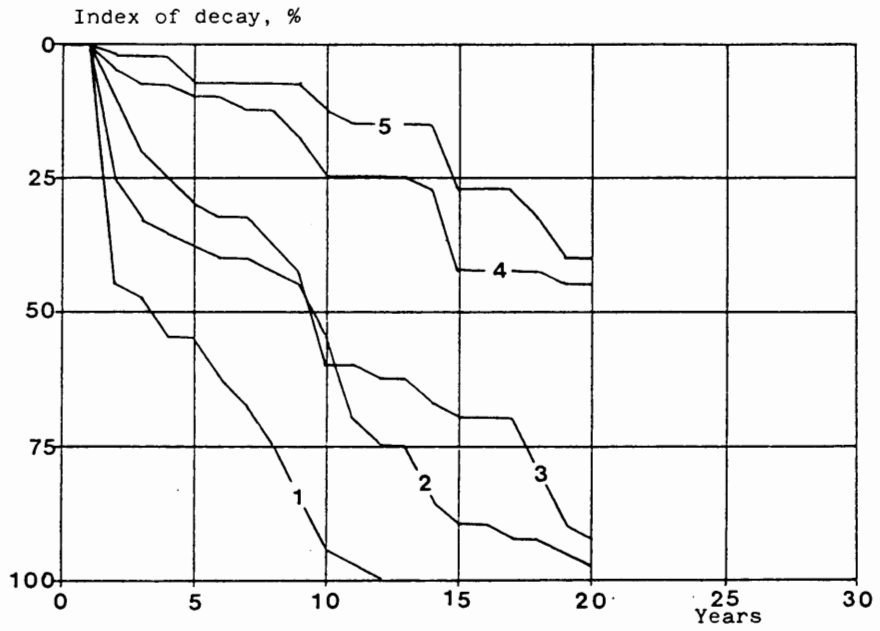


Figure 31. Rate of decay for stakes of alder treated with Tanalith C at the following retentions (kg/m^3): 1, 9.5; 2, 14; 3, 19; 4, 29; 5, 39.

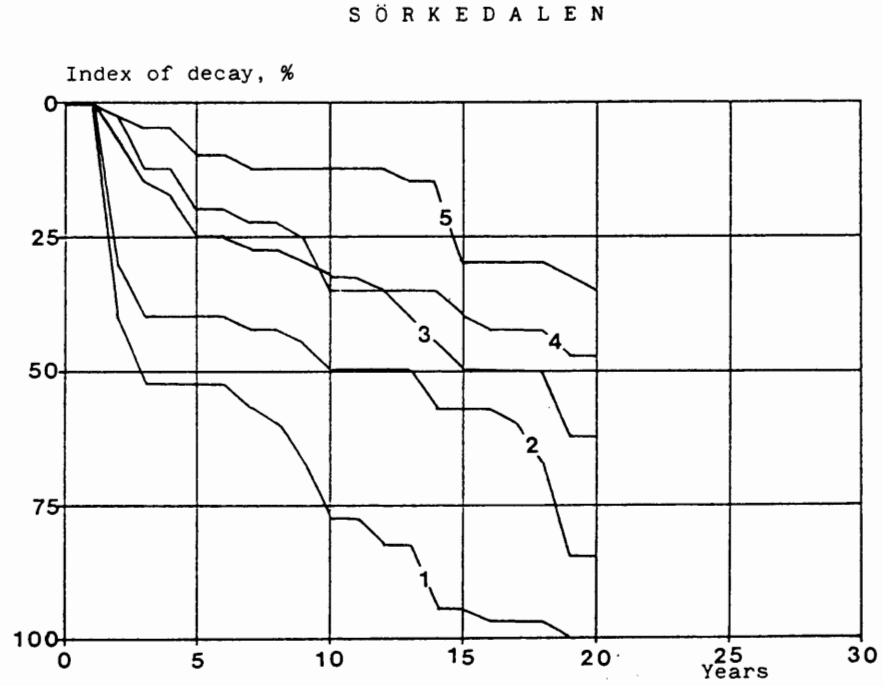


Figure 32. Rate of decay for stakes of alder treated with Wolmanit CB at the following retentions (kg/m^3): 1, 12; 2, 18; 3, 24; 4, 36; 5, 48.

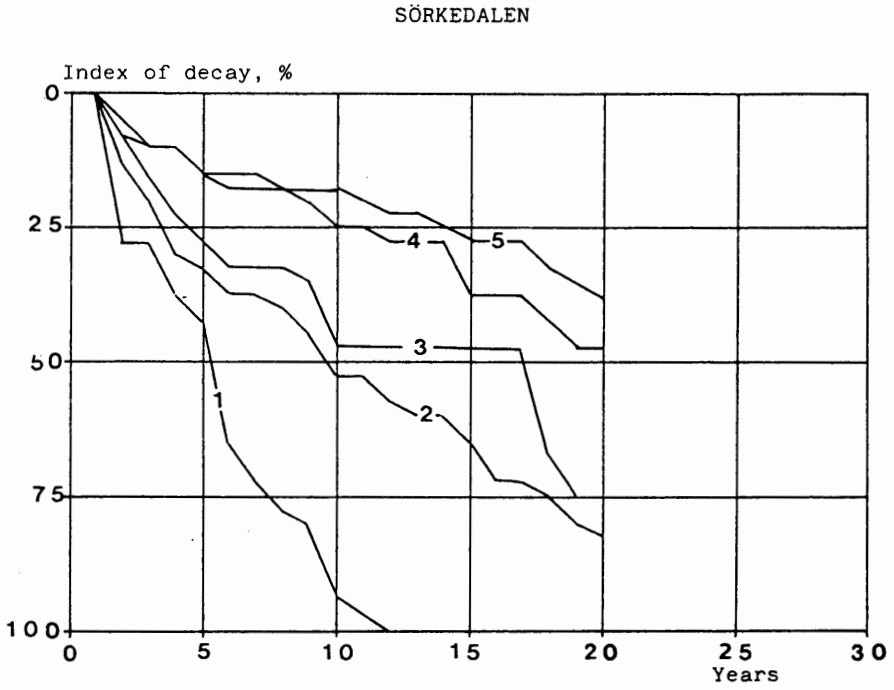


Figure 33. Rate of decay for stakes of alder treated with BP Hylosan at the following retentions (kg/m^3): 1, 91; 2, 140; 3, 187; 4, 281; 5, 377.

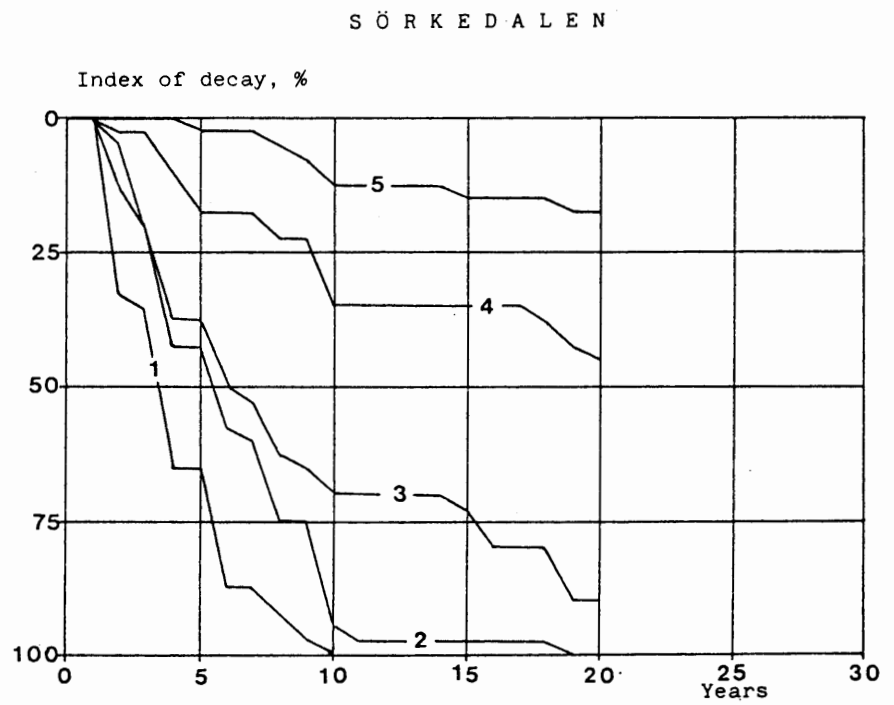


Figure 34. Rate of decay for stakes of alder treated with creosote at the following retentions (kg/m^3): 1, 94; 2, 143; 3, 198; 4, 315; 5, 428.