Investigations on the Correlation Pattern in Even-Aged Stands of Larch

V. Phenotypic Correlations Between Neighbouring Observations for *Larix decidua* MILL. (*Larix europaea* DC.), *Larix kaempferi* (LAMB.) CARR. (*Larix leptolepis* (SIEB. et ZUCC.) SIEB. ex GORD.), and *Larix x eurolepis* HENRY[1])

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Summary

For a dynamic description of spatial neighbourhood correlation patterns of stands of larch and an analysis of temporal changes and time trends of such patterns during stand development extensive data sets from a field trial (trial no. 1) with 27 entries of *Larix decidua* MILL. (*Larix europaea* DC.), *Larix kaempferi* (LAMB.) CARR. (*Larix leptolepis* (SIEB. et ZUCC.) SIEB. ex GORD.), and (*Larix* x *eurolepis* HENRY have been used. Single tree measurements of this trial were available for 7 stages of stand development (ages: 11, 13, 18, 19, 42, 49 and 50 years).

Additionally, for a static description of spatial neighbourhood correlation patterns of stands of larch extensive data sets from 9 field trials (trials nos. 2 to 10) with a varying number (8 to 23) of entries have been used which provide an analysis of the correlations between neighbours at only one point in time. These trials are slightly different in their ages (7 to 11 years).

Single tree measurements for all 10 trials were available for the traits height and diameter at breast height (for the 2 ages 42 and 49 of trial no. 1 only diameter measurements were available). Additionally, the diameter values are transformed and analysed as individual basal areas.

The correlative structure for measurements of neighbouring individuals for these trials with regular square spacings (5 m x 5 m for trial no. 1 and 1.5 m x 1.5 m for trials nos. 2 to 10) has been described by 12 different correlation coefficients. These coefficients are defined by considering quite different spatial configurations of competitive neighbourhoods. In these procedures and analyses the diagonally located neighbours of a subject tree and its missing neighbours too are explicitly considered.

The question of this paper is: Are there significant differences among the spatial neighbourhood correlation patterns of the three groups of entries: *Larix decidua* Mill., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY?

Generally valid relationships of consistent differences between certain groups have not been observed – neither for single traits nor for single trials or ages, nor for single spatial neighbourhood correlation coefficients. The very few situations with existing significant differences between groups are distributed over the entire scheme of all possible comparisons without any recognizable regularities. The trials nos. 3, 7, 8, 9 and 10 exhibit even no significant difference. Therefore, it can be concluded that the three groups of entries are not significantly different in their spatial neighbourhood correlation patterns.

Key words: Correlation pattern, neighbourhood correlation, height, diameter, individual basal area, larch.

FDC: 165.41; 165.72; 165.51; 232.13; 174.7 *Larix decidua;* 174.7 *Larix kaempferi.*

Zusammenfassung

Für die dynamische Betrachtung des räumlichen Korrelationsmusters von Lärchenbeständen, d. h. für die Analyse der Nachbarschaftskorrelationen eines Bestandes zu unterschiedlichen Zeitpunkten seiner Entwicklung, wurde eine Versuchsfläche (Versuch Nr. 1) mit 27 Sorten von *Larix decidua* MILL. (*Larix europaea* DC.), *Larix kaempferi* (LAMB.) CARR. (*Larix leptolepis* (SIEB. et ZUCC.) SIEB. ex GORD.) und *Larix* x *eurolepis* HENRY ausgewählt, die zu 7 verschiedenen Zeitpunkten der Bestandesentwicklung (Alter: 11, 13, 18, 19, 42, 49 und 50) einzelbaumweise vermessen wurde. Zusätzlich wurden für eine statische Betrachtung des räumlichen Korrelationsmusters von Lärchenbeständen, d. h. für die einmalige Analyse der Nachbarschaftskorrelationen eines Bestandes zu einem bestimmten Zeitpunkt seiner Entwicklung, 9 weitere Versuchsflächen (Versuche Nr. 2 bis 10) mit einer unterschiedlichen Anzahl (8 bis 23) an Sorten herangezogen, die zu etwas verschiedenen Altersstufen (7 bis 11 Jahre) einzelbaumweise aufgenommen wurden. Die erhobenen Merkmale sind Höhe und Durchmesser (beim Versuch Nr. 1 stehen für die beiden Alter 42 und 49 nur Durchmessermessungen zur Verfügung). Zusätzlich wurden die Durchmesserwerte transformiert und als individuelle Grundflächen ausgewertet.

Die Nachbarschaftskorrelationsstruktur der im quadratischen Verband angelegten Lärchenbestände (5 m x 5 m für Versuch Nr. 1 und 1,5 m x 1,5 m für Versuche Nr. 2 bis 10) wird durch 12 verschiedene Korrelationskoeffizienten beschrieben, die durch die Heranziehung von unterschiedlichen räumlichen Nachbarschaftskonfigurationen definiert werden. Dabei werden auch diagonal entfernt stehende Nachbarn sowie auch fehlende Nachbarn explizit in die Ansätze und Auswertungen mit einbezogen.

In der vorliegenden Arbeit wird die Frage untersucht: Gibt es signifikante Unterschiede des räumlichen Nachbarschafts-Korrelationsmusters zwischen den 3 Materialgruppen: *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR. und *Larix* x *eurolepis* HENRY? Allgemeingültige Gesetzmäßigkeiten bestimmter, konsistenter Materialgruppenunterschiede weist das hier untersuchte Material nicht auf – weder für einzelne Merkmale, noch für einzelne Versuche bzw. Altersstufen, noch für einzelne räumliche Nachbarschafts-Korrelationskoeffizienten. Die in einigen wenigen Einzelfällen gefundenen signifikanten Unterschiede sind ohne erkennbare Regelmäßigkeit über das Gesamttableau aller möglichen Vergleiche verteilt. Die Versuche Nr. 3, 7, 8, 9 und 10 weisen sogar überhaupt keine signifikante Differenz auf. Zusammenfassend kann man daher feststellen, daß sich die drei Materialgruppen in ihrem räumlichen Nachbarschafts-Korrelationsmuster nicht signifikant voneinander unterscheiden!

Introduction and Problem

For applications in forest genetics, forest tree improvement and silviculture a knowledge on the amount of phenotypic

[1]) Dedicated to Prof. Dr. W. LANGNER on his 90th birthday.

Note: This paper is dedicated to Prof. Dr. W. LANGNER although he himself serves as a co-author. This publication is a result of common research between the senior author and Prof. Dr. W. LANGNER who prepared the extensive data sets from some of his trials with larch as an empirical basis for these correlation studies.

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correlations between measurements for neighbouring individuals is of particular interest. Static as well as dynamic descriptions (both theoretical and applied) of spatial neighbourhood correlation patterns in even-aged stands of larch have been published in some foregoing papers of this series (HÜHN and LANGNER, 1992, 1995 and 1996; LANGNER and HÜHN, 1995). These investigations were based on extensive data sets from 10 field trials with a varying number of entries from 3 groups of entries with different origin: *Larix decidua* MILL. (*Larix europaea* DC.), *Larix kaempferi* (LAMB.) CARR. (*Larix leptolepis* (SIEB. et ZUCC.) SIEB. ex GORD.), and *Larix* x *eurolepis* HENRY.

The spatial neighbourhood correlative structures of these trials for single tree measurements of neighbouring individuals (for the traits height, diameter at breast height, and individual basal area) have been described by 12 different PEARSON correlation coefficients. These coefficients are defined by forming different spatial configurations of competitive neighbourhoods. In these approaches the diagonally located neighbours of a subject tree (in a regular square spacing) and its missing neighbours too were explicitly considered.

In HÜHN and LANGNER (1995) (dynamic description of spatial neighbourhood correlation patterns of one field trial with several measurements during stand development) and LANGNER and HÜHN (1995) (static description of spatial neighbourhood correlation patterns of 9 field trials each with only one measurement) the 12 spatial neighbourhood correlation coefficients have been calculated and discussed for the collected total plant material of all included entries, i. e. no separate calculation of the correlation coefficients for individual entries or for groups of entries have been carried out.

In this paper, for the same plant material these 12 spatial neighbourhood correlation coefficients were separately calculated for each of the following 3 groups of entries: *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY. The question of this paper is: Are there significant differences among the spatial neighbourhood correlation patterns of these three groups of entries?

Material and Methods

The studies are based on data sets of single tree measurements for height and diameter at breast height for 10 even-aged larch populations. For trial no. 1 single tree measurements were available for 7 stages of stand development (ages: 11, 13, 18, 19, 42, 49 and 50 years) while trials nos. 2 to 10 have been measured only once. For the 2 ages 42 and 49 of trial no. 1 only diameter measurements were available. Values for individual basal area have been calculated (based on the measurements of diameter). The plant material of the 10 field trials consists of 3 groups of entries with different origin: *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY.

The 10 field trials have been established as regular square spacings with quite different distances (1.5 m x 1.5 m for trials nos. 2 to 10 and 5 m x 5 m for trial no. 1) and with different numbers of entries (27 entries for trial no. 1 and 8 to 23 entries for trials nos. 2 to 10). For a detailed description of the trials (sites, entries, dates of establishment of the plantations, replications, plot sizes, plant distances, measurements, population sizes, design and analysis etc.) we refer to the foregoing cited papers of this series. A decomposition of the total plant material into the 3 groups: *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY is given in HÜHN and LANGNER (1992).

Simple product moment or PEARSON correlation coefficients were calculated between each single tree measurement and several measures reflecting the competitive pressure caused by the neighbourhood of a single subject tree. These measures are defined by constructing different spatial configurations of neighbours which are assumed to be effectively competing neighbours of the subject tree. The spatial correlation patterns are described by the following 12 correlation coefficients (*Figure 1*):

r_1, r_2, and r_3 = correlation between subject tree X and sum of its direct, diagonal, and total neighbours.

r_4, r_5, and r_6 = sum in the previous definition is replaced by mean.

r_7, r_8, and r_9 = correlation between subject tree X and one of the direct, diagonal, or total neighbours.

r_{10}, r_{11}, and r_{12} = correlation between subject tree X and number of missing values among the direct, diagonal, or total neighbours.

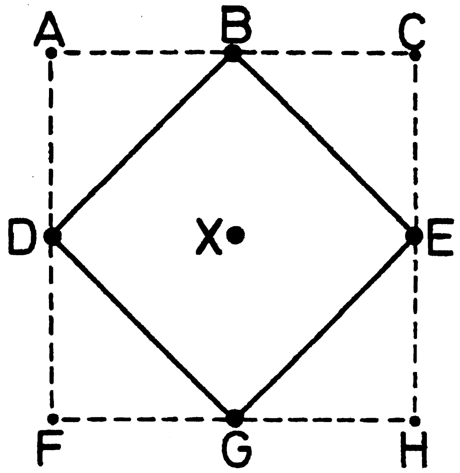

Figure 1. — Competing neighbours (direct and diagonal) for the subject tree X.

In this terminology, the neighbours D, B, E, and G of the subject tree X in *figure 1* are direct neighbours, while the neighbours A, C, H, and F are diagonal neighbours (*Fig. 1*).

The correlation coefficients r_1, r_2, …, r_{12} were calculated as simple phenotypic correlations based on the individual phenotypic measurements. These calculations have been separately carried out for each of the 3 groups: *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY, i. e. the individual entries of each group were collected and analysed as one homogeneous group and the correlations r_1, r_2, …, r_{12} were calculated for each group on the whole. Tests of significance for the correlation coefficients r_1, r_2, …, r_{12} were carried out by standard procedures from elementary statistics with ***), **) and *) = significance at 1%, 5% and 10% level of probability, respectively.

For statistically sound comparisons among the spatial neighbourhood correlation patterns of the 3 groups one needs replications within groups. In this paper, we used the following approach:

1. Each group consists of a varying number of individual entries. The spatial neighbourhood correlations r_1, r_2, …, r_{12} were calculated for each entry separately, i. e. within groups we identify entries = replications.

2. Each calculated correlation coefficient r is transformed by FISHER's z-transformation: $z = 0.50 \ln [(1+r)/(1-r)]$ (SACHS, 1969).

3. Traditional one-way analysis of variance is carried out (sources: between groups and within groups) by weighted least squares technique where each correlation coefficient is weighted by its reciprocal variance, i. e. weight = sample size minus 3.

Table 1. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for diameter at the 7 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix decidua* MILL. group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.29***	0.25***	0.33***	0.21***	0.20***	0.24***	0.19***	0.14***	0.17***	-0.25***	-0.21***	-0.27***
	13	0.23***	0.24***	0.28***	0.20***	0.22***	0.24***	0.18***	0.15***	0.17***	-0.19***	-0.18***	-0.22***
	18	0.21***	0.22***	0.25***	0.19***	0.10	0.18***	0.17***	0.07*	0.12***	-0.17***	-0.19***	-0.21***
1	19	0.13**	0.23***	0.21***	0.23***	0.26***	0.32***	0.22***	0.21***	0.22***	-0.08	-0.14**	-0.13**
	42	-0.26***	0.07	-0.16**	0.02	0.02	0.03	0.03	0.03	0.03	0.28***	-0.01	0.17***
	49	-0.25***	0.07	-0.15**	0.00	0.05	0.04	0.02	0.05	0.04	0.27***	0.00	0.17***
	50	-0.27***	0.10	-0.15**	0.03	0.09	0.09	0.02	0.06	0.04	0.28***	-0.02	0.16**
2	11	-0.41***	-0.15	-0.38***	-0.31***	-0.24**	-0.41***	-0.18***	-0.10*	-0.14***	0.29***	0.05	0.22**
3	9	-0.24	0.02	-0.12	-0.18	-0.04	-0.16	-0.11	-0.07	-0.08	0.20	-0.11	0.05
4	11	0.17	-0.58***	-0.48**	0.05	-0.61***	-0.36*	0.09	-0.49***	-0.21**	-0.11	0.36*	0.26
5	7	0.18	0.36***	0.33***	0.30**	0.26**	0.33***	0.19***	0.18***	0.19***	-0.07	-0.32***	-0.23*
6	9	0.33***	0.18*	0.32***	0.33***	0.11	0.28***	0.16***	0.05	0.11***	-0.17*	-0.18*	-0.22**
7	9	0.15	0.22**	0.25***	0.14	0.19**	0.22**	0.08	0.12***	0.10***	-0.08	-0.08	-0.13
8	10	0.00	0.24***	0.16*	0.19**	0.24***	0.27***	0.09*	0.14***	0.12***	0.15	-0.12	0.02
9	9	-0.35**	0.07	-0.15	-0.17	0.34**	0.09	-0.08	0.22**	0.07	0.28*	0.18	0.30*
10	9	-0.16	-0.16	-0.19	-0.12	-0.14	-0.23*	-0.03	-0.08	-0.05	0.09	0.12	0.13

Table 2. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for diameter at the 7 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix kaempferi* (LAMB.) CARR. group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.30***	0.22***	0.28***	0.46***	0.38***	0.49***	0.35***	0.28***	0.32***	-0.08**	-0.10***	-0.11***
	13	0.30***	0.22***	0.30***	0.47***	0.40***	0.51***	0.36***	0.31***	0.34***	-0.12***	-0.10***	-0.13***
	18	0.26***	0.23***	0.29***	0.41***	0.35***	0.44***	0.31***	0.27***	0.29***	-0.16***	-0.15***	-0.18***
1	19	0.27***	0.24***	0.31***	0.42***	0.32***	0.44***	0.34***	0.26***	0.30***	-0.17***	-0.19***	-0.22***
	42	-0.20***	-0.02	-0.13***	0.07*	0.10**	0.11***	0.04*	0.05*	0.04**	0.21***	0.02	0.14***
	49	-0.27***	-0.06	-0.20***	0.05	0.06	0.07**	0.03	0.03	0.03*	0.27***	0.05	0.20***
	50	-0.27***	-0.07*	-0.22***	0.06	0.05	0.08**	0.04*	0.02	0.04**	0.28***	0.07*	0.22***
2	11	-0.27**	-0.30**	-0.31**	-0.14	0.19	-0.04	-0.07	0.04	-0.01	0.30**	0.31**	0.38***
3	9	0.73	-0.47	0.17	0.73	-0.54	-0.33	0.73	-0.49*	-0.24	-0.14	0.27	0.15
4	11	-0.41**	-0.10	-0.43***	-0.17	-0.15	-0.13	-0.17	-0.10	-0.12*	0.30*	0.02	0.26
5	7	0.38***	0.44***	0.51***	0.48***	0.48***	0.54***	0.31***	0.29***	0.30***	0.00	-0.14	-0.11
6	9	0.44***	0.56***	0.54***	0.37**	0.57***	0.54***	0.24***	0.35***	0.29***	-0.51***	-0.38**	-0.49***
7	9	0.15	-0.19	-0.05	0.11	-0.27	-0.14	0.04	-0.15*	-0.05	-0.13	-0.13	-0.17
8	10	-0.01	-0.35**	-0.26	0.07	-0.21	-0.10	0.14	-0.19*	-0.03	0.19	0.26	0.32*
9	9	0.02	0.10	0.09	0.18	0.13	0.22*	0.12*	0.10	0.11**	0.12	0.00	0.07
10	9	-0.37**	-0.27*	-0.39**	-0.32**	-0.20	-0.41***	-0.15*	-0.14*	-0.15**	0.20	0.18	0.21

Table 3. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for diameter at the 7 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix* x *eurolepis* HENRY group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.24***	0.22***	0.28***	0.19***	0.24***	0.26***	0.16***	0.18***	0.17***	-0.19***	-0.19***	-0.21***
	13	0.21***	0.15***	0.23***	0.24***	0.22***	0.27***	0.19***	0.17***	0.18***	-0.12**	-0.14***	-0.15***
	18	0.13**	0.09*	0.18***	0.13**	0.12**	0.16***	0.08***	0.09***	0.09***	-0.11**	-0.14***	-0.15***
1	19	0.10*	0.09	0.16***	0.13**	0.10*	0.17***	0.09***	0.06*	0.08***	-0.09*	-0.17***	-0.15***
	42	-0.29***	-0.24***	-0.39***	0.30***	0.24***	0.35***	0.17***	0.19***	0.18***	0.40***	0.34***	0.46***
	49	-0.30***	-0.25***	-0.41***	0.36***	0.25***	0.37***	0.23***	0.20***	0.22***	0.44***	0.35***	0.49***
	50	-0.31***	-0.24***	-0.43***	0.36***	0.26***	0.39***	0.23***	0.20***	0.22***	0.46***	0.35***	0.51***
2	11	-0.35***	-0.09	-0.34***	-0.20***	-0.06	-0.23***	-0.16***	-0.06	-0.11***	0.28***	0.12**	0.26***
3	9	0.19**	0.05	0.18**	0.06	0.03	0.09	0.03	0.01	0.02	-0.25***	-0.05	-0.18**
4	11	-0.15*	-0.07	-0.33***	0.14*	-0.08	0.00	0.10*	-0.10**	0.00	0.28***	0.05	0.33***
5	7	0.29***	0.26***	0.32***	0.37***	0.39***	0.43***	0.26***	0.26***	0.26***	-0.02	-0.01	-0.02
6	9	0.19***	0.13***	0.19***	0.17***	0.12***	0.19***	0.09***	0.07***	0.08***	-0.10**	-0.06	-0.11***
7	9	0.20***	0.17***	0.22***	0.21***	0.19***	0.23***	0.12***	0.11***	0.12***	-0.02	0.00	-0.02
8	10	0.19***	0.17***	0.23***	0.27***	0.21***	0.30***	0.16***	0.13***	0.15***	-0.01	-0.01	-0.02
9	9	-0.04	0.01	-0.02	-0.08*	0.14***	0.04	-0.03	0.09***	0.02*	0.02	0.08*	0.06
10	9	-0.11**	0.04	-0.07	-0.09**	0.08*	0.00	-0.07***	0.04*	-0.01	0.09**	0.01	0.07

Table 4. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for height at the 5 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix decidua* MILL. group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.38***	0.30***	0.40***	0.36***	0.39***	0.41***	0.32***	0.29***	0.31***	-0.33***	-0.22***	-0.32***
	13	0.34***	0.30***	0.37***	0.33***	0.36***	0.39***	0.30***	0.28***	0.29***	-0.28***	-0.22***	-0.30***
1	18	0.37***	0.33***	0.42***	0.36***	0.33***	0.39***	0.31***	0.27***	0.29***	-0.32***	-0.27***	-0.35***
	19	0.33***	0.30***	0.39***	0.43***	0.46***	0.52***	0.40***	0.38***	0.39***	-0.26***	-0.23***	-0.29***
	50	0.06	0.12*	0.18***	0.29***	0.12*	0.31***	0.19***	0.08*	0.14***	-0.01	-0.19***	-0.15**
2	11	-0.04	-0.04	-0.05	0.12	-0.24*	-0.04	0.06	-0.05	0.00	0.07	0.02	0.05
3	9	0.00	0.19	0.09	0.00	0.01	0.00	0.01	0.02	0.02	0.05	-0.20	-0.09
4	11	0.00	-0.31	-0.33	0.18	-0.40*	-0.09	0.11	-0.22*	-0.05	0.05	0.24	0.29
5	7	0.41**	0.29	0.39**	0.72***	0.44**	0.66***	0.51***	0.28***	0.40***	0.13	-0.11	-0.02
6	8	0.48***	0.39***	0.49***	0.52***	0.32***	0.47***	0.30***	0.19***	0.24***	-0.22**	-0.27***	-0.32***
7	8	0.22**	0.21**	0.28***	0.24**	0.19**	0.28***	0.14***	0.12**	0.13***	-0.04	-0.07	-0.09
8	10	0.00	0.27***	0.19**	0.24***	0.33***	0.38***	0.16***	0.19***	0.18***	0.21**	-0.12	0.04
9	9	-0.30*	-0.13	-0.20	-0.12	0.18	0.02	-0.06	0.12	0.02	0.25	0.17	0.28*
10	9	-0.06	0.08	0.05	-0.12	0.15	-0.01	-0.02	0.12	0.05	0.00	0.01	0.01

This analysis is performed by using the procedure GLM of SAS (SAS Institute Inc., 1990; SACHS, 1969).

4. Pairwise mean comparisons among the 3 groups have been carried out by traditional multiple simultaneous testing using the BONFERRONI-HOLM-procedure (SONNEMANN, 1982) with***), **) and *) = significance at 1%, 5% and 10% level of probability, respectively.

If a spatial neighbourhood correlation coefficient of an individual entry is based on a very small number n of observations, this entry was eliminated from the analyses. We used the condition $n \geq 12$, i. e. all entries with $n < 12$ were eliminated from the analyses. For a justification of this approach, see HÜHN and LANGNER (1996). By this reduction of the really existing number of entries due to a statistical criterion, in some cases the group size shrinks up to only one remaining entry. These groups have been excluded from pairwise comparisons. In these cases, the 2 remaining groups were only compared. These degenerated/deleted cases are

Larix kaempferi (LAMB.) CARR. for trial no. 3: $r_1, r_2, \ldots, r_{12}$ for height, diameter and individual basal area.

Larix kaempferi (LAMB.) CARR. for trial no. 5: $r_1, r_2, \ldots, r_6$ and r_{10}, r_{11} and r_{12} for height.

Results and Discussion

The spatial neighbourhood correlations $r_1, r_2, \ldots, r_{12}$ for the 10 field trials (trial no. 1 with 7 measurements for diameter and individual basal area, but only 5 measurements for height; trials nos. 2 to 10 with only one measurement for each trait) are presented in *tables 1* to *9*:

Table 1 (*Larix decidua* MILL.), *Table 2* (*Larix kaempferi* (LAMB.) CARR.), *Table 3* (*Larix* x *eurolepis* HENRY) — diameter

Table 4 (*Larix decidua* MILL.), *Table 5* (*Larix kaempferi* (LAMB.) CARR.), *Table 6* (*Larix* x *eurolepis* HENRY) — height

Table 7 (*Larix decidua* MILL.), *Table 8* (*Larix kaempferi* (LAMB.) CARR.), *Table 9* (*Larix* x *eurolepis* HENRY) — individual basal area

In this paper, we are mainly interested in pairwise comparisons of the spatial neighbourhood correlation patterns of the 3 groups: *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY. That means: *Tables 1* to *3* should be compared among themselves leading to 3 comparisons: *Table 1*-*Table 2*, *Table 1*-*Table 3* and *Table 2*-*Table 3*. The same, of course, must be carried out for *Tables 4* to *6* and for *Tables 7* to *9*.

A first very rough insight into the agreement or disagreement of the correlation coefficients $r_1, r_2, \ldots, r_{12}$ for the 3 groups

Table 5. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for height at the 5 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix kaempferi* (LAMB.) CARR. group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.25***	0.17***	0.24***	0.42***	0.38***	0.48***	0.31***	0.29***	0.30***	-0.12***	-0.12***	-0.15***
	13	0.29***	0.22***	0.31***	0.43***	0.39***	0.49***	0.34***	0.32***	0.33***	-0.20***	-0.15***	-0.21***
1	18	0.31***	0.28***	0.34***	0.43***	0.41***	0.50***	0.33***	0.34***	0.34***	-0.24***	-0.22***	-0.28***
	19	0.31***	0.30***	0.37***	0.46***	0.43***	0.51***	0.37***	0.36***	0.37***	-0.24***	-0.24***	-0.30***
	50	0.23***	0.20***	0.29***	0.52***	0.44***	0.55***	0.44***	0.36***	0.41***	-0.17***	-0.20***	-0.24***
2	11	0.17	-0.20	-0.01	0.21	0.41**	0.35*	0.12	0.20	0.16*	-0.13	0.25	0.08
3	9	0.86*	-0.09	0.44	0.86*	0.41	0.63	0.86*	0.20	0.32	-0.16	0.42	0.28
4	11	-0.29*	0.06	-0.28*	0.04	0.04	0.08	-0.07	0.02	-0.01	0.35**	-0.05	0.23
5	7	0.69***	0.56**	0.74***	0.72***	0.83***	0.79***	0.65***	0.59***	0.62***	-0.02	-0.18	-0.18
6	8	0.66***	0.68***	0.69***	0.60***	0.65***	0.67***	0.43***	0.45***	0.44***	-0.62***	-0.53***	-0.65***
7	8	0.27	-0.29*	-0.04	0.20	-0.35**	-0.16	0.07	-0.19**	-0.06	-0.21	0.00	-0.15
8	10	-0.05	-0.27	-0.22	0.10	-0.08	0.01	0.18*	-0.11	0.02	0.20	0.24	0.31*
9	9	-0.04	0.07	0.03	0.04	0.13	0.11	0.02	0.08	0.05	0.06	-0.02	0.02
10	9	-0.18	-0.06	-0.13	-0.06	0.03	-0.01	-0.05	0.01	-0.01	0.15	0.09	0.13

Table 6. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for height at the 5 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix* x *eurolepis* HENRY group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.19***	0.15***	0.21***	0.22***	0.24***	0.29***	0.19***	0.20***	0.19***	-0.13**	-0.13**	-0.15***
	13	0.20***	0.12**	0.22***	0.30***	0.24***	0.33***	0.24***	0.20***	0.23***	-0.12**	-0.14**	-0.15***
1	18	0.24***	0.17***	0.28***	0.30***	0.24***	0.34***	0.23***	0.17***	0.20***	-0.19***	-0.21***	-0.23***
	19	0.23***	0.17***	0.28***	0.31***	0.23***	0.37***	0.25***	0.15***	0.21***	-0.18***	-0.22***	-0.23***
	50	0.14**	0.10*	0.14**	0.70***	0.67***	0.74***	0.61***	0.57***	0.59***	0.02	0.03	0.03
2	11	0.22**	0.17*	0.23**	0.23**	0.07	0.10	0.12**	0.04	0.04	-0.22**	-0.10	-0.20**
3	9	0.35***	0.28***	0.43***	0.21***	0.31***	0.36***	0.12***	0.24***	0.18***	-0.42***	-0.20***	-0.38***
4	11	-0.06	0.00	-0.17**	0.14*	0.07	0.14*	0.14**	0.03	0.08**	0.20***	0.03	0.24***
5	7	0.38***	0.33***	0.42***	0.56***	0.49***	0.59***	0.37***	0.34***	0.35***	0.00	-0.08	-0.06
6	8	0.40***	0.34***	0.42***	0.41***	0.33***	0.43***	0.26***	0.22***	0.24***	-0.15***	-0.15***	-0.20***
7	8	0.39***	0.35***	0.43***	0.46***	0.38***	0.46***	0.29***	0.24***	0.26***	0.04	-0.01	0.01
8	10	0.27***	0.23***	0.30***	0.39***	0.29***	0.41***	0.25***	0.19***	0.22***	-0.02	-0.06*	-0.05
9	9	0.12***	0.02	0.09**	0.12***	0.13***	0.17***	0.09***	0.08***	0.08***	-0.06	0.04	-0.01
10	9	0.26***	0.25***	0.29***	0.27***	0.26***	0.33***	0.19***	0.18***	0.18***	-0.15***	-0.15***	-0.20***

Table 7. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for individual basal area at the 7 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix decidua* MILL. group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.31***	0.28***	0.35***	0.23***	0.23***	0.27***	0.20***	0.16***	0.18***	-0.24***	-0.21***	-0.27***
	13	0.25***	0.28***	0.31***	0.20***	0.26***	0.26***	0.18***	0.18***	0.18***	-0.17***	-0.18***	-0.21***
	18	0.23***	0.24***	0.27***	0.21***	0.14**	0.22***	0.18***	0.10**	0.14***	-0.15**	-0.18***	-0.20***
1	19	0.16***	0.25***	0.24***	0.23***	0.27***	0.32***	0.21***	0.21***	0.21***	-0.06	-0.12**	-0.11*
	42	-0.24***	0.08	-0.14**	0.00	0.04	0.03	0.02	0.04	0.04	0.29***	0.00	0.17***
	49	-0.23***	0.08	-0.14**	0.00	0.07	0.04	0.01	0.06	0.04	0.28***	0.00	0.17***
	50	-0.26***	0.11*	-0.13**	0.02	0.12*	0.09	0.01	0.08*	0.05	0.29***	-0.01	0.17***
2	11	-0.40***	-0.18*	-0.44***	-0.31***	-0.24**	-0.40***	-0.18***	-0.10*	-0.14***	0.27***	0.05	0.21**
3	9	-0.25	0.00	-0.14	-0.17	-0.05	-0.16	-0.10	-0.06	-0.07	0.17	-0.11	0.03
4	11	0.09	-0.53***	-0.43**	0.00	-0.53***	-0.30	0.07	-0.40***	-0.17**	-0.04	0.30	0.26
5	7	0.23*	0.39***	0.38***	0.30**	0.29**	0.35***	0.18***	0.20***	0.19***	-0.03	-0.29**	-0.20*
6	9	0.30***	0.14	0.28***	0.30***	0.10	0.26***	0.14***	0.05	0.09***	-0.15	-0.14	-0.18*
7	9	0.13	0.22**	0.22**	0.13	0.18*	0.21**	0.07	0.12**	0.09***	-0.07	-0.08	-0.11
8	10	0.05	0.25***	0.20**	0.15	0.22**	0.24**	0.07	0.13**	0.10***	0.13	-0.14	0.00
9	9	-0.27*	0.27*	0.00	-0.14	0.35**	0.14	-0.06	0.22**	0.10	0.28*	0.17	0.29*
10	9	-0.12	-0.20	-0.21	-0.07	-0.18	-0.23*	0.00	-0.08	-0.04	0.12	0.16	0.16

Table 8. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for individual basal area at the 7 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix kaempferi* (LAMB.) CARR. group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.38***	0.29***	0.36***	0.47***	0.37***	0.49***	0.35***	0.28***	0.32***	-0.07**	-0.10***	-0.10***
	13	0.38***	0.28***	0.37***	0.48***	0.39***	0.51***	0.37***	0.30***	0.34***	-0.10***	-0.08**	-0.11***
	18	0.33***	0.29***	0.35***	0.42***	0.35***	0.45***	0.32***	0.27***	0.30***	-0.15***	-0.15***	-0.18***
1	19	0.33***	0.29***	0.36***	0.43***	0.32***	0.44***	0.34***	0.26***	0.30***	-0.16***	-0.18***	-0.21***
	42	-0.19***	-0.02	-0.13***	0.07*	0.09**	0.11***	0.05*	0.05*	0.05***	0.23***	0.03	0.16***
	49	-0.24***	-0.05	-0.19***	0.04	0.06	0.07*	0.03	0.03	0.04**	0.28***	0.06	0.21***
	50	-0.25***	-0.06	-0.21***	0.06	0.05	0.08**	0.05*	0.03	0.04**	0.29***	0.08**	0.23***
2	11	-0.18	-0.19	-0.20	-0.08	0.28**	0.03	-0.02	0.08	0.02	0.28**	0.29**	0.37***
3	9	0.51	-0.69	-0.28	0.51	-0.68	-0.49	0.51	-0.60**	-0.37	-0.05	0.29	0.19
4	11	-0.48***	-0.09	-0.40**	-0.12	-0.06	-0.04	-0.16	-0.04	-0.08	0.31*	0.06	0.29*
5	7	0.41***	0.52***	0.55***	0.46***	0.47***	0.53***	0.30***	0.29***	0.30***	0.04	-0.15	-0.09
6	9	0.42**	0.47***	0.50***	0.38**	0.48***	0.50***	0.22**	0.27***	0.24***	-0.49***	-0.35**	-0.46***
7	9	0.08	-0.21	-0.11	0.06	-0.25	-0.16	0.02	-0.14*	-0.05	-0.12	-0.16	-0.18
8	10	0.08	-0.26	-0.14	0.05	-0.16	-0.06	0.14	-0.15	-0.02	0.16	0.18	0.24
9	9	0.08	0.11	0.14	0.19	0.10	0.21*	0.13*	0.08	0.10**	0.15	0.00	0.10
10	9	-0.38**	-0.28*	-0.42***	-0.32**	-0.22	-0.41***	-0.15*	-0.15*	-0.15**	0.20	0.17	0.21

Table 9. — Correlation coefficients $r_1, r_2, \ldots, r_{12}$ for individual basal area at the 7 stages of stand development (for trial no. 1) and for the one measurement of trials nos. 2 to 10 for the *Larix* x *eurolepis* HENRY group of entries.

field trial no.	age (in years)	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	0.29***	0.27***	0.32***	0.25***	0.26***	0.31***	0.20***	0.20***	0.20***	-0.18***	-0.18***	-0.20***
	13	0.27***	0.21***	0.29***	0.29***	0.25***	0.32***	0.22***	0.19***	0.21***	-0.12**	-0.14**	-0.15***
	18	0.15***	0.13**	0.20***	0.17***	0.15***	0.20***	0.10***	0.11***	0.10***	-0.10*	-0.14**	-0.14**
1	19	0.12**	0.11*	0.17***	0.17***	0.12**	0.21***	0.11***	0.08**	0.09***	-0.07	-0.15***	-0.13**
	42	-0.18***	-0.16***	-0.29***	0.32***	0.25***	0.36***	0.20***	0.20***	0.20***	0.41***	0.34***	0.46***
	49	-0.17***	-0.16***	-0.29***	0.37***	0.26***	0.38***	0.24***	0.21***	0.23***	0.45***	0.35***	0.49***
	50	-0.18***	-0.15**	-0.31***	0.38***	0.27***	0.40***	0.25***	0.22***	0.24***	0.47***	0.36***	0.51***
2	11	-0.36***	-0.14**	-0.41***	-0.20***	-0.12*	-0.25***	-0.15***	-0.09**	-0.12***	0.29***	0.14**	0.27***
3	9	0.14*	0.03	0.14*	0.04	-0.02	0.02	0.01	-0.01	0.00	-0.23***	-0.06	-0.18**
4	11	-0.05	-0.11	-0.26***	0.14*	-0.09	-0.02	0.10*	-0.11**	-0.01	0.25***	0.06	0.31***
5	7	0.34***	0.33***	0.39***	0.37***	0.41***	0.44***	0.26***	0.27***	0.26***	-0.01	0.00	-0.01
6	9	0.16***	0.10***	0.16***	0.14***	0.09**	0.16***	0.08***	0.05***	0.06***	-0.09**	-0.05	-0.09**
7	9	0.24***	0.18***	0.24***	0.24***	0.18***	0.24***	0.14***	0.11***	0.12***	-0.02	0.00	-0.01
8	10	0.20***	0.17***	0.23***	0.23***	0.18***	0.27***	0.14***	0.12***	0.13***	0.00	-0.01	0.00
9	9	-0.05	0.07	0.01	-0.08*	0.15***	0.05	-0.03	0.10***	0.03*	0.02	0.08*	0.06
10	9	-0.15***	0.02	-0.11**	-0.10**	0.05	-0.03	-0.07***	0.03	-0.02	0.12***	0.04	0.10**

Table 10. — Significant pairwise comparisons among *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY for 12 spatial neighbourhood correlation coefficients and 3 traits. [Abbreviations used: traits: diameter → D, height → H, basal area → B; comparisons: *Larix* x *eurolepis* HENRY – *Larix decidua* MILL. → I, *Larix* x *eurolepis* HENRY – *Larix kaempferi* (LAMB.) CARR. → II, *Larix decidua* MILL. – *Larix kaempferi* (LAMB.) CARR. → III; significance level (type I error): 10% → 1, 5% → 2 and 1% → 3, i. e. D III 1, for example, means: For the trait diameter, the groups *Larix decidua* MILL. and *Larix kaempferi* (LAMB.) CARR. are significantly different at the 10% level of probability].

field trial no.	age (in years)	Spatial neighbourhood correlations r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
	11	DII2 BII3 DIII1 BIII3	-	DII1 BII2 BIII1	DII2 BII2 DIII1 BIII1	-	-	-	-	-	-	-	-
	13	DII2 HII1 BII3 DIII2 HIII2 BIII2	HIII1	BII2	-	HIII1	-	HI1 HIII2	HIII2	HI1 HIII3	-	HIII1	-
	18	-	-	-	-	-	-	HIII1	-	HIII1	-	-	-
1	19	-	HI1 HIII1	-	-	-	-	-	-	-	-	HI2 HIII2	-
	42	-	DI3 BI3 DII1 BII1 DIII2 BIII2	DI1 BI2	-	-	-	-	-	-	-	DI2 BI2 DII1 BII1	-
	49	-	DI3 BI3 DIII2 BII1 BIII2	DI2 BI2 BIII1	-	-	-	-	-	-	-	DI2 BI2	DI1 BI1
	50	-	-	DI2 BI2 DIII2 BIII2	-	-	HI1	-	HIII1	HI1	-	-	DI1 BI1 DIII1 BIII1
2	11	-	-	-	-	HI1 HII1 HIII2	-	-	-	-	-	DI1 DII2 DIII2	-
3	9	-	-	-	-	-	-	-	-	-	-	-	-
4	11	BII2 BIII2	DI1	-	-	DI2	-	BII1	DI1	-	-	-	-
5	7	-	BII1	DII1	-	-	-	-	-	-	-	-	-
6	9	-	-	-	-	DII1	-	-	DII1 DIII1	DII1	-	-	-
7	9	-	-	-	-	-	-	-	-	-	-	-	-
8	10	-	-	-	-	-	-	-	-	-	-	-	-
9	9	-	-	-	-	-	-	-	-	-	-	-	-
10	9	-	-	-	-	-	-	-	-	-	-	-	-

can be easily carried out by comparing only the signs of the correlation coefficients.

For the trait diameter one obtains an excellent agreement of the correlations $r_1, r_2, \ldots, r_{12}$ among the 3 groups for the several measurements of trial no. 1: For the 84 correlation coefficients (12 correlations x 7 measurements/ages) one obtains 79 cases with identical signs for the 3 groups (≅94.0% agreement) [In the calculation of these percentages of agreement or disagreement, correlation coefficients = 0 have been considered as being non-contradictory for agreement if the remaining 2 signs are equal]. For the 108 correlation coefficients for trials nos. 2 to 10 (12 correlations x 9 trials) one obtains 68 cases with identical signs for the 3 groups (≅63.0% agreement) (*Tables 1* to *3*). Compared to the situation of trial no. 1, the agreement for trials nos. 2 to 10 is clearly inferior. But, with regard to trial no. 1, the results of these trials nos. 2 to 10 are, of course, less reliable (smaller sample sizes, only one measurement, heterogeneous environmental conditions). The most important and most relevant results are, therefore, the results for trial no. 1. Emphasis should be given to them.

For the trait height one obtains similar results: An agreement of 95.0% for trial no. 1 and only 49.1% for trials nos. 2 to 10 (*Tables 4* to *6*).

For individual basal area these percentages are: 95.2% for trial no. 1 and 64.8% for trials nos. 2 to 10 (*Tables 7* to *9*).

These results seem to indicate that the spatial neighbourhood correlation patterns of *Larix decidua* MILL., Larix *kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY are not too much different from eachother.

The preceding rough comparisons among the 3 groups by counting and comparing only the signs of the correlation coefficients, however, are particularly vague and unreliable. Correct comparisons based on effective statistical tests of significance are necessary. Such comparisons have been carried out by applying the statistical procedures outlined in 'Material and Methods'. The results are summarized in *table 10*.

Only a very few of the numerous possible comparisons are significantly different and these rare significances are distributed over the entire scheme of all possible comparisons without any recognizable regularities, i. e. no relationships or consistencies can be observed. The results of *table 10,* therefore, confirm the preceding assessment of minor or no differences among the spatial neighbourhood correlation patterns of *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY. Some percentages should illustrate these conclusions: For the trait diameter of trial no. 1, for example, the number of possible comparisons is 252 (7 measurements/ages x 12 correlations x 3 comparisons). One obtains 22 significant differences, i. e. 8.7%. The correlation coefficients $r_5, r_6, \ldots, r_{10}$ exhibit no significant differences (for all measurements and for all possible comparisons) (*Table 10*). For the 300 possible comparisons of diameter for trials nos. 2 to 10 [(8 trials x 12 correlations x 3 comparisons) + (1 trial x 12 correlations x 1 comparison) (for trial no. 3 with only 2 existing groups)] only 11 significant comparisons have been observed, i. e. a ratio of 3.7% (*Table 10*). For the trait height one obtains similar results: A ratio of significant comparisons of 10.5% for trial no. 1 and 1.1% for trials nos. 2 to 10 (*Table 10*). For individual basal area these percentages are 10.3% for trial no. 1 and 1.3% for trials nos. 2 to 10 (*Table 10*).

For trials nos. 3, 7, 8, 9 and 10 the 3 comparisons are non-significant for each of the 12 correlation coefficients r_1, r_2, …, r_{12}. For r_4, r_6, r_{10} and r_{12} no comparison among the 3 groups is statistically significant for none of the trials nos. 2 to 10 (*Table 10*).

The large differences of percentages of significant comparisons between trial no. 1 at the one side and trials nos. 2 to 10 at the other side (9% to 4% for diameter, 10% to 1% for height and individual basal area) may be mainly due to the larger sample sizes for trial no. 1 compared to the other trials. By these larger numbers of observations (HÜHN and LANGNER, 1992) smaller differences can be considered as statistically significant.

The calculation and interpretation of the spatial neighbourhood correlation coefficients r_1, r_2, …, r_{12} are based on several simplifying assumptions. A critical discussion of these simplifications has been given in HÜHN and LANGNER (1995) and we refer to this paper.

The preceding very general and rough comparisons and conclusions can be, of course, precised by a more sophisticated separate analysis and discussion of the individual spatial neighbourhood correlation coefficients r_1, r_2, …, r_{12}. Such an extended analysis can be easily carried out based on the results from *tables 1* to *9*. In the context of this paper, however, such a sophisticated analysis is unnecessary: In 'Introduction and Problem' the question of this paper has been stated as: Are there significant differences among the spatial neighbourhood correlation patterns of the 3 groups of entries: *Larix decidua* MILL., *Larix kaempferi* (LAMB.) CARR., and *Larix* x *eurolepis* HENRY? Based on the data sets of this study the answer is: No!

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Results of the IUFRO 1982 Scots Pine (*Pinus sylvestris* L.) Provenance Experiment in Southwestern Germany[1])[2])

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Summary

Seed of 24 provenances of Scots pine (*Pinus sylvestris* L.) from 13 countries within the area of natural distribution was sown in 1983. During the first 3 years in the nursery several traits were measured and assessed, e.g. height growth and the number of twigs in the uppermost whorl. In spring 1986 a field trial (3.3 ha) has been established in forest district of Bensheim, southwestern Germany. During the last years the following traits were measured and assessed: height growth after several vegetation periods, diameter at breast height, branching, stem form, damage by the beetle *Brachyderes incanus* and mortality. Regarding these characters the provenances show a considerable variation and can be divided into at least 6 main groups (clusters).

Key words: Scots pine, provenances, genetic variation, growth characters, insect damage.

FDC: 165.3; 165.5; 232.11; 232.12; 174.7 *Pinus sylvestris;* (430).

Zusammenfassung

Im Rahmen des internationalen IUFRO Herkunftsversuchs 1982 mit Kiefern (*Pinus sylvestris* L.) wurde im Jahre 1986 in Südwest-Deutschland ein Feldversuch mit 3jährigen Pflanzen von 24 Herkünften angelegt. Bis 1991 wurden wiederholt verschiedene Merkmale gemessen (Baumhöhe, Stammstärke, Aststärke) oder bonitiert (Stammform, Befall durch Graurüßler). Eine Auswertung der Daten zeigt, daß zwischen den Herkünften in allen Merkmalen eine große Variation besteht. Die Ergebnisse lassen sich für den Prüfstandort wie folgt zusammenfassen: Herkünfte mit gutem Höhen- und Dickenwachstum stammen aus Gebieten zwischen dem 47. und 55. Breitengrad. Die beste Wuchsleistung hat eine Samenplantagen-Absaat aus Belgien (Groenendaal). Wüchsig sind auch Herkünfte aus Deutschland, Ost-Frankreich, Polen und Ungarn. Allerdings lassen bei einigen dieser Herkünfte, vor allem bei denen aus Frankreich und Südwest-Deutschland, die Stammformen im Vergleich zu den anderen Herkünften zu wünschen übrig. Herkünfte aus südlicheren und nördlicheren Breitengraden sind unter den gegebenen Umweltbedingungen mattwüchsig. Dieses sind Kiefern-Herkünfte aus Schweden, Lettland, Rußland, vom Balkan und aus der Türkei. Allerdings zeichnen sie sich durch gute Stammformen aus. Negativ zu beurteilen ist ihre offenbar große Anfälligkeit für den Kiefern-Graurüßler (*Brachyderes incanus*). Ein besonders schwaches Wachstum, verbunden mit einem starken Graurüßler-Befall und einer

[1]) Dedicated to Professor Dr. WOLFGANG LANGNER on his 90th birthday

[2]) Modified version of a paper presented on the IUFRO Symposium "Scots Pine Breeding and Genetics", Kaunas/Lithuania, September 1994

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