Appendix B

Appendix B. – 11 year old DBH data for a 6 x 6 half-diallel mating in radiata pine at two sites (E1 and E2).

I[a]	J	R	T	E1	E2	I	J	R	T	E1	E2	I	J	R	T	E1	E2	I	J	R	T	E1	E2
1	2	1	1	213	.	1	5	3	2	154	164	2	5	2	3	154	242	3	6	1	4	214	.
1	2	1	2	185	.	1	5	3	3	184	203	2	5	2	4	177	191	3	6	2	1	163	214
1	2	1	3	197	.	1	5	3	4	.	203	2	5	3	1	202	200	3	6	2	2	187	150
1	2	1	4	211	.	1	6	1	1	195	201	2	5	3	2	168	.	3	6	2	3	167	144
1	2	2	1	186	220	1	6	1	2	187	223	2	5	3	3	191	.	3	6	2	4	171	220
1	2	2	2	175	207	1	6	1	3	.	.	2	5	3	4	178	262	3	6	3	1	.	179
1	2	2	3	172	235	1	6	1	4	194	246	2	6	1	1	173	133	3	6	3	2	161	60
1	2	2	4	173	237	1	6	2	1	229	206	2	6	1	2	165	171	3	6	3	3	134	231
1	2	3	1	186	218	1	6	2	2	205	.	2	6	1	3	183	197	3	6	3	4	164	240
1	2	3	2	187	215	1	6	2	3	175	210	2	6	1	4	170	.	4	5	1	1	174	183
1	2	3	3	167	.	1	6	2	4	182	196	2	6	2	1	.	185	4	5	1	2	183	247
1	2	3	4	188	.	1	6	3	1	139	235	2	6	2	2	165	192	4	5	1	3	187	227
1	3	1	1	163	212	1	6	3	2	180	118	2	6	2	3	188	212	4	5	1	4	191	225
1	3	1	2	177	164	1	6	3	3	196	254	2	6	2	4	185	205	4	5	2	1	188	.
1	3	1	3	165	205	1	6	3	4	159	.	2	6	3	1	157	248	4	5	2	2	182	159
1	3	1	4	184	170	2	3	1	1	202	203	2	6	3	2	156	213	4	5	2	3	195	154
1	3	2	1	169	176	2	3	1	2	151	142	2	6	3	3	165	236	4	5	2	4	199	203
1	3	2	2	172	.	2	3	1	3	183	198	2	6	3	4	147	.	4	5	3	1	179	207
1	3	2	3	166	224	2	3	1	4	184	220	3	4	1	1	172	255	4	5	3	2	212	209
1	3	2	4	174	186	2	3	2	1	178	224	3	4	1	2	216	179	4	5	3	3	188	159
1	3	3	1	188	212	2	3	2	2	160	216	3	4	1	3	188	225	4	5	3	4	152	225
1	3	3	2	188	61	2	3	2	3	175	204	3	4	1	4	.	224	4	6	1	1	179	.
1	3	3	3	181	218	2	3	2	4	154	236	3	4	2	1	.	147	4	6	1	2	158	217
1	3	3	4	196	235	2	3	3	1	169	60	3	4	2	2	183	170	4	6	1	3	163	223
1	4	1	1	169	199	2	3	3	2	177	286	3	4	2	3	190	224	4	6	1	4	186	223
1	4	1	2	170	239	2	3	3	3	158	159	3	4	2	4	187	252	4	6	2	1	178	245
1	4	1	3	199	123	2	3	3	4	174	.	3	4	3	1	.	241	4	6	2	2	148	271
1	4	1	4	219	159	2	4	1	1	192	.	3	4	3	2	158	216	4	6	2	3	185	.
1	4	2	1	179	192	2	4	1	2	179	260	3	4	3	3	141	.	4	6	2	4	146	.
1	4	2	2	128	195	2	4	1	3	159	216	3	4	3	4	189	241	4	6	3	1	154	227
1	4	2	3	198	204	2	4	1	4	181	.	3	5	1	1	174	.	4	6	3	2	153	217
1	4	2	4	170	205	2	4	2	1	187	203	3	5	1	2	185	.	4	6	3	3	163	215
1	4	3	1	186	227	2	4	2	2	183	219	3	5	1	3	168	.	4	6	3	4	185	.
1	4	3	2	158	196	2	4	2	3	144	.	3	5	1	4	190	225	5	6	1	1	192	.
1	4	3	3	139	.	2	4	2	4	215	242	3	5	2	1	170	.	5	6	1	2	170	182
1	4	3	4	191	.	2	4	3	1	.	254	3	5	2	2	201	.	5	6	1	3	176	262
1	5	1	1	.	178	2	4	3	2	157	.	3	5	2	3	150	175	5	6	1	4	171	.
1	5	1	2	189	.	2	4	3	3	179	.	3	5	2	4	175	216	5	6	2	1	160	201
1	5	1	3	196	215	2	4	3	4	179	227	3	5	3	1	191	.	5	6	2	2	185	238
1	5	1	4	152	228	2	5	1	1	192	214	3	5	3	2	182	214	5	6	2	3	177	214
1	5	2	1	.	192	2	5	1	2	196	222	3	5	3	3	176	.	5	6	2	4	175	.
1	5	2	2	201	187	2	5	1	3	168	200	3	5	3	4	197	283	5	6	3	1	211	.
1	5	2	3	178	216	2	5	1	4	195	.	3	6	1	1	182	128	5	6	3	2	193	210
1	5	2	4	198	213	2	5	2	1	176	.	3	6	1	2	172	196	5	6	3	3	193	177
1	5	3	1	164	.	2	5	2	2	197	.	3	6	1	3	178	210	5	6	3	4	185	226

[a]) I and J are first and second parent for diallel crosses, reciprocal effect was not considered, therefore I or J could be male or female; R-replication; T-tree number within plot; E1 and E2 represent DBH (mm) data for two sites and . indicating missing value.

Genetic Subdivisions of the Range of Scots Pine (*Pinus sylvestris* L.) Based on a Transcontinental Provenance Experiment

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Summary

Studies were continued on the variability of 113 Scots pine provenances based on an experiment established at 33 locations in the former USSR in 1974 to 1976. Following on the analysis presented earlier for height measurements (SHUTYAEV and GIERTYCH, 1997) now an analysis is made of data on survival, stem diameter and stem straightness. A synthetic volume estimate (based on height, diameter and survival) was evaluated for phenotypic stability. On the basis of growth performance in various environments the range of Scots pine in the former USSR is divided into 10 regions (A- to J) and these divisions are compared with earlier attempts at subdividing this vast area. There is agreement in the opinions about

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Table 1. – Survival percentage of Scots pine Populations of various provenance and at various locations.

Loc. no.	Mu 1	Ark 2	Vol 3	Ko 4	Kar 5	Kar 6	St. 7	Ps 8	Est 9	Lit 10	Go 11	Kh 12	Kh 13	Lvi 14	Zhi 15	Val 16	Vor 17	Pe 18	Vol 21	Tat 22	Ufa 23	Per 24	Svi 25	Kur 26	Sa 27	No 29	Kra 30	Kra 31	Bur 32	Am 34	Ko 35	Se 36	Azer 37		Mean surv.
Age	13	11	11	12	17	13	15	15	11	17	15	12	6	11	15	5	6	17	17	17	17	17	17	17	17	20	17	17	15	3	2	4	12		
Proven.																																		N	%
1	86	89		66	31	63																					23	33						7	55,9
2	77	85		45	19	65										84	51	10					60				54	48	40					12	53,2
3	68	80		59	32	53																	72				53	9	56			51		10	53,3
4	35	58	89	23	6	34	68	39	13	90						86	76					22	73			28	50		37	75				18	50,1
7																																			
8	35		78	13		44	60		39																				26					7	42,1
9	26	48	84	24	3	34	62	37	25	88	92					70				58		32	69				62							16	50,9
10	59					62	60		15																		29	0	53		84			8	45,3
12	58	75		40	35	65																					38	1		86		61		9	51,0
13	18					70																												2	44,0
14	36	67	80	53	13	47	68	46	20							82	87															31		12	52,5
15	56	80	82	33	12	54	73	60	24	72	88					74	80										53		41	86				16	60,5
16	30	62	85	27	6	39	67		28	78	95		45			79	91										40	23	21					16	51,0
17	25	70	89	41	5	48	65	64	30		92																54							11	53,0
18	28				3	16										60													50					5	31,4
19		16	50	14	0	20	70	53	16	75	90																							10	40,4
21			52			3	64	52	18	67	85				25	53	80	84									69					57		13	54,5
22		5	65			8	62	51	21	69	91					65	85					28												11	50,0
23		5	64			13	60	41	23	72	89		33			45	62																	11	46,1
24			77			8	55	34	27	78	87		42		30	31	82										7							12	46,5
25			73				56	20	18	68	90		13		19	42	97	79		65	11				65		18							15	48,9
26							60	15	16	71	87		59		31	34	65	60		49	6				61							63		14	48,4
27							56	17	12	74	87	50	50		28	28	72	65																11	49,0
28							60	20	27	85	88		50		30	64	70	70																10	56,4
29							45	19	6	76	86	44	62	46	32	26	72	71														50		13	48,8
30							52	23	7	71	92		60		32	35	83	70														54		11	52,6
33										38	92	37	44	50	38	42	74	75	36	49	14				46				36				64	15	49,0
34												45	57	54	29	59	64	82	42													58	57	10	54,7
35												49	56	43	29	57	68	61	56														75	9	54,9
36											83	53	20	47	32	34	74	90	35			3										49	61	12	48,4
37										44	78	49	58	39	27	39	80	80		31	8				45		5						55	14	45,6
38										63	86	21	54	59	30	46	74	70	52	48	9				43		4						77	15	49,1
39										41	76	53	18	63	23	19	68	87	51														48	11	49,7
40												30	10	7	23	19	46	50	54														82	9	35,7
41						2	55	20	9	48	88	28	37	54	16	59	78	58		48	10	13			50									17	39,6
42		7	82			16	68	39	30	66	82					69	68	78		57		19			50				20					15	50,1
43	4		70		0	5	58	46	14	75	93	34	10	47	32	48	79	78	33	50	14	18	73	14	48	30	33	1	21			39	68	29	39,1
44	1		80		18	17	56	26	8		82	39				28				52	11		67				59					44		15	39,2
45			85			8	60	47	23	79	83		30		20	64	81	90		61		36	67		49		48		11					18	52,3
45a																26	73				11		67		42									5	43,8
46			78				62	40	8	80	87	36	36	39	27	48	78	85		60	7	18	67	18	37							73		20	49,2
47		25	75	6		16	52	26	21	86	88					71				51	7	24	67		31				11			51		17	41,6
48		16	71	6		19	65	43	17	81	85					62	91	96		52	10	29	81		32		54	8						19	48,3
49							40	32	6	79	77	62	14	46	22	45	93	64	32	49	12				40									16	44,6
50			54				56	42	16	60	80	73	37	44	28	45	84	88	29	49	11	35		18	38		35		12				45	22	44,6
51							45	40	6	72	84	36	53	44	27	29	78	80	26	52	9	20					38		15			63	51	20	43,4
52										49	89	37	47	49	32	19	64	59	43	52													69	12	50,8
54			52				45	30	5	74	81	45	11	38	33	43	66	67	38	51	7	23	61	34	46	23	36		14			51	76	25	42,0
55									7	50	90	59	45	35	33	32	52	67	48	45	10	38			51	34	28		24			44	76	20	43,4
56												59	33	36	28	36	67	77	31	48	14				44							45	73	13	45,5
57			51				47	34	6	45	80	39	28	39	22	64	62	82	56	48	17	27	68	12	56	29	39		10			59	72	25	43,7
59							32	19	4	65	76	54	12	40	24	43	62	72	53	33	9	43	60	32	59	45	33		12			58	65	24	41,9
60												62	33	19	27	34		68	57													56	71	9	47,4
62												49	27	25	23	50	60	77	56		8			26	46	19			64			51	70	15	43,4
64												56	28	31		41	80	58	47	27	12			31	50	30	22					46	68	15	41,8
65			48				36	49	14	61	70	41	38	35	38	40	79	49	49	44	13	46	80	14	56	41	25					69		23	45,0
66a	18		31					35	4	68		69	37	35	22	42	82	81	43	43	14	44	56	50	56			0	22			49		22	41,0
67		10	60	7		20	59	43	15	90						48	87	75		43	12	42	74	30	37		66		9					19	43,5
68	17	34	88		2	49	65	52	16	71	76					71	76	69		49	16	24	75	29	40		28							20	47,4
69			68				30	18	3	72	78	45	17	19	27	68	73	80		54	22	57	69	11	32	31	57		32			47	79	24	45,4
69a																93																		1	93,0
70									7								80			44	13		76	12					19					7	35,9
71												60				56	70			51	15	46	79	23	35		36					60	56	12	48,9
71a																49	57	83		55	16	41	76									35	75	9	54,1
72												58		5		12	73	76		40	14		80	23	42	38	57						65	13	44,8
73						48	35		20																		40		64					5	41,4
74	49					67	65		22																									4	50,8
76																57	67				14	63	70	24	45	30	54	0						10	42,4
77	15	11		8	0	28										60	66			61	18	41	76	32	45		54	0						15	34,3
78	27	30		5	5	3															19	49	85	30	48									10	30,1
79																6	80	69	51	48	9	54	62	27	52	32	39		31				78	14	45,6
80																						50										50		2	50,0
81	73	68	75	26	26	57										41	66						72	31		18	36							12	49,1
82	21	6	70	50	0	6										16	71	68				24	73	39			28	0	33					15	33,7
83							20	7	2	52	68	58		20	23	46		76	34	41	13		54	44	58	29	12						80	19	38,8
84																39	69				14	26	73	33		25	44					54		9	41,9
85																71	70							27		35	22	0						6	37,5

(Continuation *Table 1*)

86	21		71			6	49	14	4	72	80	53	25	40	14	68	94	62	42	51	13	44	63	19	69	33	41	0	59			44	69	28	43,6
87																82	97	90						8		29	35	0						7	48,7
88		41			0	41										53	91	95						26		36	64	0						10	44,7
89																63	80									33	34					46	72	6	54,7
90												12		28		4		20	61	29				7			62		14			53		10	29,0
91																										19	50	0			80			4	37,3
92						10			8							35	77									19	85	0	36		82	51	65	11	42,5
93	48					69																						0	48					4	41,3
94	26		82		0	14										52	78	71								37	39	0	59	70		59		13	45,2
95																											43	0			80			3	41,0
98												27				43	60		56				77			41	61	0	40			50		10	45,5
99																	85	50								34	22	7	34		75			7	43,9
100													30			65	67	64	46				65			23	43		51			54	66	11	52,2
101																43	71									16		0						4	32,5
102	51		78		0	34										72	30									4	27		47					9	38,1
103	63		41		23	45										71	29									8	53	1						9	37,1
104	54					68																					13	0	16					5	30,2
105													33			21	35	60	46							27	38	0	54			53		10	36,7
106	44		80	6	0											9	39										63	14	31					9	31,8
107																28	85										59		30					4	50,5
108													46			23	67									28	75	0	37					7	39,4
109	71	8		16	0	36										65											57							7	36,1
110	28			13	0											68	83										51							6	40,5
111																30	72										52	0	37	71		29		7	41,6
112																											25	10	56		80			4	42,8
113																											40		60	82		34		4	54,0
114																55	62										36	0			73			5	45,2
116																14	65										31	10	58	88		39		7	43,6
117	46			2	0	15										26	51										17		43	77				9	30,8
118	38	11			0	37											32										24	1	41	74		57		10	31,5
119													36			73	66										68	0	50	87		50	64	9	54,9
120																20	76										30	0	17			50		6	32,2
122	35	6			0												20										24		78			50		7	30,4
123												12		16		34	55	76	34					10	40	19					68	51	77	12	41,0
124												23	26		9	1	51	66	34					27	42	27			35		85	56	83	14	40,4
125												38		7		36	48	57						23	59	24	46				71	54	72	12	44,6
126																	35		43														59	3	45,7
N	35	26	35	23	29	45	41	37	45	41	41	38	42	33	37	90	86	55	32	38	38	32	34	32	38	35	73	36	51	10	10	47	35	1320	
Mean survival in %	40	39	70	25	8	33	55	35	15	69	85	45	36	36	27	47	70	71	44	48	12	34	70	25	47	28	41	5	36	80	78	51	68		44,54

productivity of the populations. It is high in populations from the south-west and from the East European plain, poor from the north, south and far east and medium from central latitudes in Asia. When based on other features the proposed subdivisions give a different picture. In stem straightness a distinct geographic differentiation is observed, however it is unrelated to growth performance and only slightly correlated with survival, thus for this trait a different split up the range is proposed into four regions (I to IV). This split up of the range does not resemble in any way any of the previous divisions.

Key words: Genotype-environment interaction, phenotypic stability, seed zones.

Introduction

This article is a continuation of a previous paper (SHUTYAEV and GIERTYCH, 1997) where basic information about a series of provenance experiments with Scots pine (*Pinus sylvestris* L.) established in 1976 on the territory of the former USSR has been given. The present paper has to be read in conjunction with it since it is not possible to repeat all the basic information. To recapitulate, this series of provenance trials includes 33 planting sites and 113 seed lots, though the actual number of provenances tested on each site differs with only one area having the maximum number of seed lots. The choice of provenances tested depended on the location and the presumed utility of various populations there.

After 1990 some of the sites fell outside the boundaries of Russia. The number of planting sites located in Russia is 23. The remaining 10 are located as follows; four (nos. 12, 13, 14 and 15) in the Ukraine, two (nos. 35 and 36) in Kazakhstan and one each in Estonia (no. 9), Lithuania (no. 10), Belarus (no. 11), and Azerbaijan (no. 37).

Reports for age 15 of the trials have been placed with the Scientific Research Institute of Forest Genetics and Selection (NIILGiS, Voronezh), where the first author and former co-ordinator of the study works. These reports supplied the basic information and preliminary results used here. They are quoted in SHUTYAEV and GIERTYCH (1997). There have been few other published papers based on these trials (SHUTYAEV, 1990, 1998; ABRAITS and ERIKSSON, 1996, 1998; GYIERUSHINS'KIÍ et al., 1983; GYIERUSHINS'KIÍ and KRINITS'KIÍ, 1995). To the extent possible data contained in them has been incorporated into our present evaluation.

Our 1997 paper dealt with height growth only. Now we present information on survival, stem diameter and stem straightness.

Materials and Methods

Data averaged per provenance and location, as available from the reports presented by field co-operators, was used for the analyses discussed in this paper. *Tables 1, 2* and *3* present this for survival percentage, stem diameter and stem straightness respectively. For ideographic presentation the data was converted to units of standard deviation from the location mean (normalised). For each trait and provenance a separate map was constructed plotting the ideographs at the planting sites at which the given provenance is represented. Each ideograph is a histogram, up or down from a dot, the radius of which corresponds to ± 0.15 standard deviation form

Table 2. – Diameter breast height (DBH) in cm of Scots provenances at various locations.

Loc.	Arkh	Volo	Kom	St.	Psk	Gom	Kher	Khar	L'vo	Zhit	Vald	Voro	Pen	Volg	Tata	Per	Svie	Kurg	Nov	Kras	Azer		Mean
no.	2	3	4	7	8	11	12	13	14	15	16	17	18	21	22	24	25	26	29	30	37		DBH
Age	15	15	15	15	15	15	16	15	20	15	17	17	17	18	17	17	17	17	20	17	12		incr.
Proven.																						N	mm/yr
1	3,9		1,2																	2,6		3	1,64
2	4,2		2,0								4,6	4,2	1,8				6,1			4,7		7	2,39
3	4,4		3,2														6,1			4,3		4	2,80
4	5,3	5,7	3,7	6,0	5,1						8,3	5,8				7,3	7,7		10,4	5,3		11	3,88
8		6,4	2,9	6,3																		3	3,47
9	4,4	6,0	4,0	6,2	6,1	7,2					9,2				9,7	8,1	7,7			6,2		11	4,24
10				3,9																3,8		2	2,42
12	4,2		2,0																	4,2		3	2,20
13																						0	
14	4,9	6,8	3,1	6,0	5,4						8,1	6,3										7	3,71
15	4,6	6,4	3,5	6,3	5,7	7,0					8,7	6,7								4,6		9	3,79
16	4,8	6,5	2,5	6,4		6,8		6,1			7,9	6,5								5,0		9	3,72
17	4,8	6,9	1,9	6,8	5,3	7,5														5,0		7	3,58
18											10,5											1	6,18
19	4,9	5,6	3,7	7,2	7,5	7,3																6	4,02
21		5,9		6,7	8,0	7,5				8,3	10,9	7,2	7,1							4,3		9	4,62
22	3,0	6,2		7,0	6,2	7,5					11,1	6,9				7,4						8	4,36
23	4,1	6,0		6,8	7,5	7,2		8,1			10,7	6,8										8	4,60
24		5,5		6,2	6,7	7,5		8,8		7,4	10,6	6,7								2,1		9	4,39
25		5,6		6,6	7,1	7,5		9,2		7,6	10,9	7,0	6,8		9,7					4,5		11	4,72
26				6,3	6,8	8,5		9,4		6,6	11,6	8,0	7,0		10,3							9	5,20
27				7,7	8,2	8,0	9,4	10,4		7,9	13,3	7,6	7,0									9	5,60
28				6,7	8,9	7,5		8,9		6,7	11,4	8,2	7,3									8	5,20
29				7,2	8,8	7,9	10,6	10,3	10,1	7,7	11,8	7,8	6,9									10	5,52
30				8,2	8,4	8,1		10,2		8,0	11,5	7,3	7,0									8	5,47
33						8,7	9,2	7,2	10,2	8,5	11,6	8,0	6,7	12,8	10,4						3,2	11	5,32
34							10,1	8,9	10,7	7,2	9,3	7,6	7,4	10,9							3,0	9	5,03
35							9,0	8,7	11,7	7,9	11,5	6,6	7,0	13,0							2,9	9	5,22
36						8,7	9,5	10,5	10,5	8,1	12,3	7,7	7,0	13,6		8,1					3,0	11	5,46
37						8,1	11,0	9,6	11,4	8,3	12,0	7,7	7,1		12,4					2,0	3,1	11	5,16
38						8,0	7,3	11,3	10,3	8,3	11,3	8,0	7,0	12,6	10,8					2,0	3,2	12	5,06
39						8,7	10,2	11,0	9,9	7,3	13,5	8,8	7,7	9,8							3,3	10	5,52
40							9,3	10,3	11,9	7,3	8,9	8,1	6,9	10,9							2,7	9	5,10
41				6,5	6,2	7,6	10,4	9,6	10,9	6,1	10,9	8,0	7,3		10,6	8,4						12	5,21
42	4,8	4,8		6,3	7,5	7,0					9,9	5,7	6,8		10,0	8,3						10	4,42
43		6,4		6,7	7,4	7,2	7,0	9,3	10,5	7,7	11,1	7,8	7,1	10,1	9,6	8,0	8,6	11,2	11,5	4,4	2,4	19	4,88
44		7,0		7,5	6,8	6,9	9,8				10,6				10,0		8,4			4,6		9	4,98
45		6,7		6,6	5,2	7,2		10,1		7,4	8,8	6,5	6,1		8,4	9,1	8,8			5,0		13	4,60
45a											12,0	6,8					8,8					3	5,41
46		7,1		6,7	7,3	8,0	9,4	9,1	10,1	7,4	10,3	7,7	6,6		9,6	8,2	8,7	11,7				15	5,22
47	4,4	6,0	2,8	6,3	6,4	7,5					9,9				9,9	8,6	8,5					10	4,40
48	4,4	5,7	3,8	6,3	6,1	7,2					9,2	5,9	7,4		10,5	8,6	8,9			4,7		13	4,22
49				7,3	8,6	7,6	7,6	10,3	10,5	7,0	11,2	7,6	7,2	11,0	10,4							12	5,39
50		7,6		7,1	7,8	7,8	8,9	9,7	11,2	6,4	11,6	7,0	7,1	11,1	10,1	9,0		11,8		3,0	2,5	17	5,02
51				8,2	7,5	8,3	9,0	10,0	10,9	7,3	13,0	7,6	8,4	10,3	10,1	9,0				3,5	3,0	15	5,15
52						8,1	11,0	9,5	11,1	7,6	11,9	8,0	7,2	10,4	9,0						2,4	11	5,29
54		7,9		7,6	6,7	7,2	9,0	10,7	10,6	7,9	12,2	8,2	7,3	10,1	9,9	9,6	9,7	11,9	12,6	3,6	2,6	19	5,24
55						8,4	10,1	10,5	11,0	6,9	10,8	8,5	6,5	10,3	10,1	8,9			11,1	3,7	2,9	14	5,09
56							10,0	9,6	11,3	6,4	10,8	9,2	7,1	11,4	10,0						2,9	10	5,31
57		7,4		5,8	6,4	7,3	10,0	8,8	11,1	6,8	11,9	7,9	7,7	10,9	9,7	9,8	9,4	13,1	11,1	6,1	2,7	19	5,18
59				6,8	6,1	9,3	8,4	10,2	10,6	8,8	12,2	8,4	7,0	10,5	11,0	9,4	8,0	11,6	11,0	4,2	2,5	18	5,20
60							8,4	9,3	12,6	7,4	11,3		6,9	11,0							3,2	8	5,27
62							10,6	10,3	12,1	7,2	11,7	8,2	7,5	11,0				10,7	11,8		2,9	11	5,56
64							7,9	10,0	12,2		11,3	7,5	6,4	11,6	10,5			11,1	11,3	3,1	2,7	12	5,12
65		6,8		6,4	5,8	7,3	6,0	10,4	10,7	7,5	10,0	7,9	7,2	11,9	10,2	8,9	8,8	11,6	11,3	5,8		18	5,12
66a		5,3			4,5		6,0	8,9	8,8	7,5	10,1	7,5	7,0	11,9	10,3	9,4	9,3	11,1				14	5,02
67	4,2	5,8	3,5	5,6	3,6						9,9	7,1	7,0		8,8	8,8	9,2	10,8		5,7		13	4,21
68	4,1	4,8		6,0	5,2	8,2					10,0	6,3	5,8		9,7	8,1	9,1	10,9		5,0		13	4,39
69		6,3		5,6	5,7	6,1	6,9	9,0	8,3	7,0	10,7	6,8	6,7		9,2	8,7	8,0	12,3	10,4	3,3	2,5	18	4,49
69a											9,8											1	5,76
70												5,6			9,5		8,5	12,1				4	5,25
71							4,3				9,1	6,1			9,7	7,8	8,2	10,6		4,0	1,7	9	4,08
71a											9,6	5,9	6,1		9,6	8,5	8,5				2,2	7	4,31
72							8,0		8,9		7,6	6,1	5,8		8,8		8,5	9,0	9,6	5,5	2,2	11	4,21
73				3,9																5,1		2	2,80
74				3,4																		1	2,27
76											8,2	6,5				8,3	7,8	10,3	10,5	5,5		7	4,67
77	4,8		2,9								10,5	6,2			8,5	8,6	8,4	10,9		5,5		9	4,40
78	4,0		2,3													7,7	8,4	10,5				5	3,97
79											11,4	6,8	7,1	11,0	9,8	9,0	8,8	12,9	11,0	5,6	2,2	11	5,04
80																8,5						1	5,00
81	4,8	5,2	2,8								5,5	6,4					6,6	8,1	10,2	3,7		9	3,50
82	5,1	5,2	2,3								9,5	5,6	6,2			8,0	8,6	11,4		4,7		10	4,02
83				5,4	6,1	7,7	8,0		11,2	7,6	11,2		6,8	12,1	10,3		9,5	12,9	12,3	3,9	2,7	15	5,05
84											9,9	6,4				8,8	8,9	11,4	11,4	5,7		7	5,11
85											9,2	7,2						10,2	10,3	3,4		5	4,56
86		6,3		5,6	4,6	7,5	9,4	8,2	11,5	7,9	9,4	8,2	6,4	12,5	10,4	9,5	7,3	11,2	11,6	4,0	2,4	19	4,85

(Continuation *Table 2)*

87											10,0	6,9	7,2					12,2	11,6	4,0		6	4,92
88	4,3										7,6	6,3	5,7					9,6	10,1	5,8		7	4,07
89											10,1	6,5							10,6	5,6	2,3	5	4,06
90							7,9		9,4		10,1		6,7	10,9	10,8			11,6		5,7		8	5,26
91																			9,4	4,1		2	3,56
92											10,0	5,9							9,1	4,8	2,2	5	3,71
93																						0	
94		5,5									7,7	6,6	5,7						9,8	4,7		6	3,85
95																				3,5		1	2,06
98							6,5				8,4	6,6		9,0			8,1		10,7	5,6		7	4,47
99												6,5	6,7						10,0	4,0		4	3,78
100								5,2			10,5	7,0	7,2	12,1			8,5		11,4	6,2	1,8	9	4,51
101											6,7	5,3							11,2			3	4,22
102		4,3									6,7	5,2							9,1	4,6		5	3,42
103		4,3									6,0	5,2							9,3	3,8		5	3,27
104																				4,0		1	2,35
105								6,2			10,0	7,4	7,3	10,5					9,9	6,2		7	4,73
106		4,7	2,4								7,3	5,6								4,3		5	2,97
107											7,5	6,2								5,4		3	3,75
108								5,1			6,8	5,9							10,5	5,8		5	3,91
109	3,5		1,6								8,3									5,9		4	2,94
110			1,9								8,3	6,4								6,4		4	3,42
111											7,5	5,7								5,0		3	3,57
112																				3,9		1	2,29
113																				5,0		1	2,94
114											8,3	6,1								4,5		3	3,71
116											4,3	5,6								5,5		3	3,02
117			1,2								5,2	4,9								4,5		4	2,35
118	2,9											3,8								5,3		3	2,43
119								5,3			7,9	5,0								5,8	2,1	5	3,26
120											9,2	7,0								4,5		3	4,06
122	3,9											3,1								4,5		3	2,36
123							7,5		8,9		9,9	7,2	6,3	10,5				13,4	10,8		2,0	9	4,85
124							9,7	6,0		8,9	5,0	7,1	6,3	10,4				9,6	10,2		2,3	10	4,53
125							4,8		8,1		8,8	7,6	5,6					10,9	11,4	3,8	2,1	9	4,01
126												4,8		10,9							2,5	3	3,65
N	26	35	23	41	37	41	38	42	33	37	90	86	55	32	38	32	34	32	35	73	35	895	
Mean DBH increment mm/yr	2,9	4,0	1,8	4,3	4,4	5,1	5,4	6,0	5,3	5,0	5,7	4,0	4,0	6,2	5,9	5,0	4,9	6,6	5,4	2,7	2,2		4,602

the location mean. Also average deviations for each trait and provenance were calculated over all the planting sites. These are given in *table 4* and for values based on more than 3 planting sites they are plotted onto a map (*Figs. 1* to *3*).

A synthetic value was constructed for volume per hectare, defined as the product of survival percentage, tree height (as presented in SHUTYAEV and GIERTYCH, 1997) and the square of average stem diameter. Multiplied by a constant (0.0013828) this value is corrected for units, form factor (assumed 0.33) and initial number of trees per ha (5333) giving an approximation in m^3/ha, however since this is only a relative function the correction is not really necessary and for the purpose of obtaining normalised values (*Fig. 4*) it has not been used. It was used only for the tabular presentation of location means relative to other traits (bottom line of *Table 4*) and for the ranking of environments on the basis of yield in m^3/ha/yr for phenotypic stability analysis.

Phenotypic stability of a provenance was evaluated by b the coefficient of FINLAY and WILKINSON (1963) and deviation from linearity by Vd, the coefficient of EBERHART and RUSSEL (1966) using the following formulae:

$$b = (\Sigma xy - \Sigma x\, \Sigma y/N)/(\Sigma x^2 - (\Sigma x)^2/N)$$

$$Vd = [(\Sigma y^2 - (\Sigma y)2/N) - b(\Sigma xy - \Sigma x\, \Sigma y/N)]/(N-2)$$

where:

$x = \log_{10}$ mean location yield;

$y = \log_{10}$ provenance yield at each location;

N = number of locations at which the provenance is tested.

This calculation was done for provenances represented at at least 5 locations. It is normally assumed that a close to one ($b \approx 1$) value of the FINLAY and WILKINSON coefficient indicates adequate stability. Values of $b<1$ indicate very consistent performance (good or bad) regardless of the environments and $b>1$ indicates reactivity, ability to take advantage of better sites (good adaptability). At $b \approx 1$ the Eberhart and Russel coefficient (Vd) corresponds to ecovalence. High Vd values indicate unpredictable response. The obtained values of Vd and b are given in *table 4* and are plotted in *figures 5* to *6* (as Vd and b-1).

Between all the studied traits (in normalised form) a correlation coefficient was calculated for the provenance averages and for the individual values at each location. Since from some planting sites not all traits have been reported, depending on the pair of traits compared the number of provenances varies from 108 to 113 and the number of provenance x location figures vary from 679 to 1245. The results are presented in *table 5*.

On all figures the approximate location of provenances is shown. They can be identified through numbers shown in *figures 7* and *8* and detailed data in SHUTYAEV and GIERTYCH (1997).

Results

Growth performance

The basic result of this investigation is a series of maps showing the normalised performance of individual provenances at all planting sites at which they are represented. There are 113 provenances and 5 traits (including height and the synthetic value for volume), i.e. 565 maps. Some of these maps

Table 3. – Stem straightness as % of straight stems of Scots pine provenance at various locations.

Location	Mur	Arkh	Volo	Kom	St.	Esto	Lithu	Kher	Khar	Zhit	Vald	Voro	Pen	Tata	Per	Svie	Kurg	Nov	Azer		Mean
no.	1	2	3	4	7	9	10	12	13	15	16	17	18	22	24	25	26	29	37		St.str.
Age	6	15	6	15	12	5	5	16	15	15	17	17	17	17	17	17	17	20	12		
Proven.																				N	%
1	76	97		74																3	82,3
2	85	93		88							41	63	44			95				7	72,7
3	45	91		93												95				4	81,0
4	43	93	46	80	94	56	94				94	81			74	79		50		12	73,7
8	85		43	58	80	48														5	62,8
9	72	96	43	84	92	53	91				72			68	95	89				11	77,7
10	87				78	55														3	73,3
12	42	100		89																3	77,0
13	89																			1	89,0
14	27	81	51	87	90	58					76	85								8	69,4
15	51	97	50	86	93	36	90				58	72								9	70,3
16	16	97	34	67	89	56	77		85		27	78								10	62,6
17	10	96	39	79	90	54														6	61,3
18	10										55									2	32,5
19		79	68	80	98	53	91													6	78,2
21			50		95	37	86			73	34	69	77							8	65,1
22		60	26		91	48	80				60	71			52					8	61,0
23		64	51		100	47	89		89		41	67								8	68,5
24			55		86	46	96		86	96	12	69								8	68,3
25			60		91	50	88		81	81	34	69	85	64						10	70,3
26					76	16	93		81	65	0	67	73	61						9	59,1
27					81	48	93	99	80	78	16	61	75							9	70,1
28					89	33	88		93	75	28	81	82							8	71,1
29					88	12	85	89	78	66	12	66	73							9	63,2
30					79	18	84		79	79	16	59	79							8	61,6
33							67	74	77	82	0	55	78	55					97	9	65,0
34								57	89	78	0	45	61						96	7	60,9
35								77	100	72	13	59	80						94	7	70,7
36								53	95	64	7	39	66		60				84	8	58,5
37							94	67	86	72	0	58	76	41					82	9	64,0
38							78	57	91	82	0	55	74	53					91	9	64,6
39							93	64	73	62	14	41	76						92	8	64,4
40								35	64	62	80	67	65						80	7	64,7
41					81	39	94	86	73	84	46	51	83	66	60					11	69,4
42		76	56		87	40	97				59	76	89	66	70					10	71,6
43	14		60		75	33	91	66	89	69	29	65	87	65	74	72	36	42	90	17	62,2
44	0		65		83	33		89			30			70		86				8	57,0
45			49		80	48	91		97	83	64	63	86	72	74	84				12	74,3
45a											42	70				84				3	65,3
46			55		74	64	98	58	98	95	44	67	87	73	90	84	42			14	73,5
47		75	55	50	95	34	97				98			70	78	86				10	73,8
48		86	49	66	82	33	92				65	61	83	63	64	84				12	69,0
49					58	24	96	80	95	80	55	43	75	48						10	65,4
50			66		89	43	88	88	97	88	27	61	81	68	76		61		91	14	73,1
51					83	22	94	62	77	87	20	67	79	69	64				90	12	67,8
52							94	70	93	75	37	55	72	70					88	9	72,7
54			68		67	34	88	86	72	84	18	67	80	70	54	68	58	55	90	16	66,2
55						18	96	85	78	90	38	65	75	61	84			37	91	12	68,2
56								84	85	81	16	65	73	77					87	8	71,0
57			59		62	18	90	77	84	77	28	76	83	75	64	84	24	38	92	16	64,4
59					60	50	88	70	88	71	28	62	73	52	90	77	61	52	88	15	67,3
60								65	77	65	12		76						88	6	63,8
62								79	86	96	18	35	65				84	29	92	9	64,9
64								73	87		7	45	80	59			60	36	84	9	59,0
65			57		56	33	83	54	88	98	61	69	77	66	82	82	62	48		15	67,7
66a	74		67			34	92	76	91	93	54	62	83	74	84	88	48			14	72,9
67		68	65	55	54	29	97				82	77	83	77	60	68	74			13	68,4
68	20	77	50		76	35	97				72	74	78	81	82	89	76			13	69,8
69			41		68	38	92	63	80	91	44	73	63	75	80	86	44	37	84	16	66,2
69a											89									1	89,0
70						33						84		75		86	48			5	65,2
71								69			86	52		59	76	76	34		93	8	68,1
71a											32	63	67	74	84	87			90	7	71,0
72								91			50	59	67	85		88	70	48	94	9	72,4
73					50	36														2	43,0
74	95				55	44														3	64,7
76											76	59			58	83	60	49		6	64,2
77	51	29		64							76	65		69	90	94	58			9	66,2
78	46	63		81											94	88	72			6	74,0
79											27	61	69	69	84	77	36	38	88	9	61,0
80															70					1	70,0
81	59	93	30	97							37	73				86	88	51		9	68,2
82	41	47	47	75							60	48	74		76	69	32			10	56,9
83					52	20	89	59		84	42		86	70		82	36	31	86	12	61,4
84											76	66			82	88	70	47		6	71,5
85											62	63					64	50		4	59,8
86	85		53		58	26	90	89	86	97	51	67	58	63	50	74	40	58	89	17	66,7

(Continuation *Table 3)*

87											74	55	72				65	65		5	66,2
88		84									56	84	78				80	46		6	71,3
89											28	43						45	91	4	51,8
90								38			14		81	69			60			5	52,4
91																		48		1	48,0
92						22					21	49						47	90	5	45,8
93	94																			1	94,0
94	60		44								33	57	71					40		6	50,8
95																				0	
98								67			47	62				75		36		5	57,4
99												65	75					42		3	60,7
100									77		44	59	71			70		38	83	7	63,1
101											17	63						42		3	40,7
102	52		52								60	58						21		5	48,6
103	38		38								14	78						32		5	40,0
104	92																			1	92,0
105									56		0	59	66					50		5	46,2
106	0		40	75							57	60								5	46,4
107											66	73								2	69,5
108									63		23	68						68		4	55,5
109	36	42		76							62									4	54,0
110	14			49							30	60								4	38,3
111											62	45								2	53,5
112																				0	
113																				0	
114											0	65								2	32,5
116											0	51								2	25,5
117	28			10							0	44								4	20,5
118	72	65										44								3	60,3
119									63		16	23							75	4	44,3
120											0	55								2	27,5
122	59	50										60								3	56,3
123								33			25	52	79				38	44	78	7	49,9
124								69	72	44	0	35	53				80	35	88	9	52,9
125								37			0	57	57				66	41	91	7	49,9
126												43							92	2	67,5
N	35	26	35	23	41	45	41	38	42	37	90	86	55	38	32	34	32	35	35	800	
Mean stem straightness																					
%	50,5	76,9	50,9	72,3	78,7	37,9	90,0	69,3	82,8	78,9	37,7	61,1	74,5	66,9	74,2	82,4	57,1	43,9	88,5		67,09

for height were presented earlier (SHUTYAEV and GIERTYCH, 1997) as samples representing typical response for regions. Comparing the average results over all planting sites for DBH (*Fig. 2*) and volume (*Fig. 4*) with the average results for height (*Fig. 3* in SHUTYAEV and GIERTYCH, 1997) one can see that the overall pattern is very similar. There is good correlation of height, DBH and volume both at provenances and provenance in locations levels (*Table 5*).

Analysis of the DBH and volume traits generally confirmed the division of the study area into regions proposed on the basis of height growth, with minor corrections. The regions (defined A to J) are drawn into the Eurasian range of Scots pine (*Fig. 7*) with the location of provenances and their identifying numbers indicated.

Variation in survival is different (*Fig. 1*). This trait correlates with volume since it is part of that synthetic trait (*Table 5*). The correlation with height is much weaker and for DBH it does not exist. Trees with good survival may be slightly taller but they are not thicker. There may have occurred a nullifying effect of two opposite trends – more viable trees grow better, but with more trees per unit area diameter growth is slower. Survival is certainly a different trait than growth performance as is obvious from a comparison of *figure 1* with *figures 2, 4* (and *Fig. 3* in SHUTYAEV and GIERTYCH, 1997). However in spite of the difference geographic zoning of the survival result is obvious (*Fig. 1*) and the division of the populations into regions on the basis of survival is comparable to that proposed for growth. Thus survival will be discussed jointly with the growth traits.

In the following discussion the divisions proposed in *figure 7* need to be compared with the mean results for survival (*Fig. 1*), DBH (*Fig. 2*) and volume (*Fig. 4*) as well as for tree height (*Fig. 3* in SHUTYAEV and GIERTYCH, 1997). However the divisions proposed are based not only on the data presented in these figures but also on the ideographic record for individual provenances and traits available in the map archive.

A. North-western region (including northern Siberia)

As was mentioned in SHUTYAEV and GIERTYCH, (1997) the limited number of northern Siberian populations included in the trial have some affinity to the NW region and thus are included here since they are too few to merit a separate region.

Growth of populations from this region is good within the region, i.e. in the north, but absolutely nowhere else, thus their average performance is extremely low, especially for height and DBH. For volume the mean value is also low but not as low as for height and DBH because populations from that region generally have very good survival on all sites except in the extreme south.

B. Baltic region

Populations from this region have good height and DBH within the region and in the northern part of regions C and E, but not elsewhere. It was suggested that good height growth can be expected at European locations between latitudes 50 °N and 60 °N, that is throughout regions C and E, but this has to be reduced to regions with a latitude >52 °N, primarily because of poor survival of these populations not only in the extreme

Table 4. – Mean normalised data for provenances averaged over all (N) locations and the coefficients of EBERHART and RUSSEL (Vd) and FINLAY and WILKINSON (b) for the volume estimate based on data from at least 5 locations.

Proven. no.	Survival		Height		DBH		Volume estimate				Stem straightness	
	N	Mean	N	Mean	N	Mean	N	Mean	E&R Vd	F&W b	N	Mean
1	7	1,60	7	–0,64	3	–1,51	3	–0,50			3	0,67
2	12	0,62	12	–1,52	7	–2,04	7	–1,16	0,683	0,212	7	0,21
3	10	1,01	9	–0,58	4	–0,55	4	0,15			4	0,84
4	18	0,33	18	–0,31	11	–0,28	11	–0,01	0,032	0,716	12	0,64
8	7	0,39	7	–0,06	3	0,21	3	0,10			5	0,11
9	16	0,49	16	0,16	11	–0,02	11	0,36	0,018	0,746	11	0,72
10	8	0,45	6	–0,81	2	–1,65	2	–1,35			3	0,85
12	9	0,92	8	–0,33	3	–0,48	3	–0,02			3	0,60
13	2	0,33	2	–0,70	0		0				1	1,33
14	12	0,58	11	0,16	7	–0,02	7	0,58	0,019	0,682	8	0,75
15	16	0,86	16	0,03	9	–0,06	9	0,38	0,007	0,756	9	0,47
16	16	0,67	16	–0,08	9	–0,32	9	0,05	0,038	0,910	10	–0,08
17	11	0,85	11	0,09	7	0,06	7	0,55	0,026	1,004	6	0,15
18	5	–0,06	5	0,22	1	0,40	1	0,94			2	–0,37
19	10	–0,01	9	0,26	6	0,46	6	0,35	0,081	1,021	6	0,81
21	13	0,27	12	0,26	9	0,37	9	0,56	0,021	0,888	8	0,08
22	11	0,20	11	–0,13	8	–0,40	8	0,15	0,109	2,273	8	–0,41
23	11	–0,05	11	0,06	8	–0,01	8	–0,09	0,087	1,812	8	0,33
24	12	0,06	12	0,02	9	–0,37	9	–0,20	0,178	2,436	8	0,49
25	15	0,13	15	0,29	11	0,05	11	0,09	0,028	1,478	10	0,37
26	14	0,11	13	0,38	9	0,34	9	0,35	0,018	1,406	9	–0,50
27	11	–0,03	11	1,09	9	0,88	9	0,75	0,014	1,201	9	0,24
28	10	0,48	10	0,73	8	0,41	8	0,62	0,014	1,153	8	0,35
29	13	0,00	12	0,56	10	0,69	10	0,58	0,022	0,985	9	–0,36
30	11	0,22	10	1,14	8	0,89	8	1,11	0,015	0,912	8	–0,42
33	15	0,08	15	0,59	11	0,71	11	0,88	0,016	0,820	9	–0,54
34	10	0,34	9	0,58	9	0,27	9	0,56	0,007	0,977	7	–0,42
35	9	0,47	9	0,66	9	0,59	9	0,83	0,014	0,969	7	0,32
36	12	–0,20	11	0,78	11	0,82	11	0,57	0,199	0,963	8	–0,89
37	14	–0,50	14	0,28	11	0,81	11	0,60	0,421	1,677	9	–0,62
38	15	–0,01	15	0,59	12	0,48	12	0,86	0,481	1,546	9	–0,52
39	11	–0,42	11	0,58	10	0,81	10	0,60	0,032	0,962	8	–0,49
40	9	–0,77	9	0,07	9	0,34	9	–0,53	0,045	0,782	7	–0,88
41	17	–0,43	17	–0,11	12	0,18	12	0,09	0,043	1,748	11	0,05
42	15	0,15	15	–0,10	10	–0,22	10	–0,06	0,058	1,542	10	0,55
43	29	–0,19	27	0,13	19	0,01	19	0,04	0,056	1,010	17	–0,16
44	15	–0,28	14	–0,07	9	0,28	9	0,13	0,016	0,860	8	0,16
45	18	0,24	18	0,27	13	–0,17	13	0,03	0,014	1,003	12	0,48
45a	5	–0,42	5	0,11	3	0,57	3	0,11			3	0,37
46	20	0,11	19	–0,16	15	0,21	15	0,27	0,022	0,945	14	0,64
47	17	–0,27	16	0,03	10	0,00	10	–0,07	0,015	1,346	10	0,45
48	19	0,23	19	0,15	13	0,09	13	0,21	0,015	1,264	12	0,09
49	16	–0,27	16	–0,03	12	0,35	12	0,03	0,028	0,874	10	–0,26
50	22	–0,20	22	0,12	17	0,25	17	0,21	0,042	1,340	14	0,49
51	20	–0,26	19	0,35	15	0,58	15	0,45	0,052	1,130	12	–0,05
52	12	–0,07	12	0,20	11	0,30	11	0,13	0,015	1,022	9	0,09
54	25	–0,37	24	0,52	19	0,62	19	0,26	0,038	1,108	16	–0,05
55	20	–0,07	19	0,39	14	0,32	14	0,40	0,047	1,116	12	0,10
56	13	–0,05	12	0,63	10	0,43	10	0,38	0,035	0,903	8	0,18
57	25	–0,18	24	0,23	19	0,53	19	0,19	0,027	0,987	16	–0,08
59	24	–0,32	23	0,17	18	0,56	18	0,12	0,042	1,178	15	–0,10
60	9	0,15	8	0,59	8	0,50	8	0,35	0,011	0,845	6	–0,49
62	15	–0,05	14	0,43	11	0,68	11	0,41	0,016	1,000	9	–0,10
64	15	–0,22	14	0,38	12	0,27	12	–0,06	0,063	1,234	9	–0,42
65	23	0,02	22	0,47	18	0,28	18	0,22	0,042	0,993	15	0,11
66a	22	–0,11	20	–0,28	14	–0,08	14	–0,09	0,063	1,540	14	0,59
67	19	0,03	19	0,17	13	–0,11	13	–0,05	0,086	1,230	13	0,12
68	20	0,13	20	–0,49	13	–0,30	13	–0,23	0,018	1,178	13	0,51
69	24	–0,10	23	–0,01	18	–0,52	18	–0,39	0,056	1,053	16	–0,10
69a	1	2,25	1	1,37	1	0,05	1	2,48			1	1,95
70	7	–0,28	7	–0,59	4	–0,18	4	–0,63			5	0,48
71	12	0,23	11	–0,59	9	–0,96	9	–0,48	0,068	1,349	8	–0,13
71a	9	0,25	8	–0,78	7	–0,42	7	–0,31	0,016	1,180	7	0,23
72	13	–0,03	13	–0,96	11	–0,85	11	–0,76	0,123	0,898	9	0,66
73	5	0,22	5	–0,07	2	–1,01	2	–1,08			2	–1,09
74	4	0,90	4	–0,39	1	–3,03	1	–2,00			3	0,11
76	10	0,32	10	0,21	7	–0,32	7	0,10	0,014	0,606	6	0,13
77	15	0,12	13	–0,01	9	–0,03	9	0,02	0,048	1,239	9	0,22
78	10	0,21	10	–0,52	5	–0,61	5	–0,11	0,023	1,532	6	0,47
79	14	0,05	14	0,41	11	0,36	11	0,18	0,078	0,990	9	–0,30
80	2	0,53	1	0,99	1	–0,12	1	1,05			1	–0,34
81	12	0,38	12	–0,34	9	–0,97	9	–0,70	0,065	0,693	9	0,50
82	15	–0,30	13	0,08	10	–0,22	10	–0,42	0,090	1,036	10	–0,56
83	19	–0,63	19	–0,04	15	0,37	15	–0,18	0,135	1,338	12	–0,42
84	9	0,11	9	0,19	7	0,41	7	0,17	0,015	0,843	6	0,72
85	6	0,12	5	0,41	5	–0,48	5	0,09	0,010	1,970	4	0,53
86	28	–0,11	26	0,13	19	0,10	19	0,01	0,072	1,203	17	–0,10
87	7	0,34	6	–0,03	6	0,35	6	0,33	0,080	1,460	5	0,65
88	10	0,49	8	–0,30	7	–0,53	7	–0,01	0,031	0,653	6	0,83
89	6	0,25	5	–0,06	5	0,03	5	0,05	0,008	1,142	4	–0,31
90	10	–1,02	11	–0,54	8	0,11	8	–0,96	0,253	0,289	5	–0,34
91	4	–0,13	2	–0,59	2	–1,00	2	–0,86			1	0,43
92	11	–0,03	9	–0,37	5	–0,64	5	–0,58	0,063	0,844	5	–0,45
93	4	0,58	4	–0,54	0		0				1	1,51
94	13	0,05	11	–0,37	6	–0,66	6	–0,50	0,015	0,849	6	–0,27
95	3	0,02	2	–0,05	1	–1,08	1	–0,74			0	
98	10	0,25	9	–0,27	7	–0,51	7	–0,20	0,082	0,529	5	–0,31
99	7	–0,16	7	–0,09	4	–0,43	4	–0,51			3	0,06
100	11	0,00	11	–0,15	9	0,04	9	–0,06	0,121	1,154	7	–0,62
101	4	–0,47	3	–1,15	3	–0,75	3	–1,18			3	–0,27
102	9	–0,42	8	–1,03	5	–1,35	5	–1,42	0,141	0,437	5	–0,33
103	9	–0,26	9	–0,98	5	–1,53	5	–1,50	0,042	0,368	5	–0,48
104	5	–0,19	5	–0,47	1	–0,59	1	–1,13			1	1,44
105	10	–0,35	9	–0,53	7	–0,07	7	–0,54	0,056	0,540	5	–0,91
106	9	–0,30	8	–0,67	5	–0,88	5	–1,04	0,246	0,947	5	–0,40
107	4	0,20	4	–0,26	3	–0,28	3	–0,16			2	1,03
108	7	0,15	6	–0,58	5	–0,75	5	–0,22	0,113	–0,218	4	0,15
109	7	0,17	6	–0,18	4	–0,55	4	–0,17			4	–0,30
110	6	0,09	5	–0,10	4	–0,05	4	0,20			4	–0,73
111	7	–0,60	5	–0,62	3	–0,56	3	–0,66			2	–0,21
112	4	0,29	3	–0,04	1	–0,68	1	–0,93			0	
113	4	–0,06	3	0,69	1	0,40	1	0,03			0	
114	5	–0,34	3	–0,60	3	–0,47	3	–0,64			2	–0,55
116	7	–0,10	6	0,05	3	–0,97	3	–0,98			2	–1,14
117	9	–0,67	8	–1,04	4	–1,46	4	–1,33			4	–1,75
118	10	–0,51	8	–0,58	3	–1,49	3	–1,21			3	–0,43
119	9	0,40	8	–0,29	5	–0,96	5	–0,44	0,205	0,709	4	–2,20
120	6	–0,53	5	0,03	3	–0,05	3	–0,54			2	–0,97
122	7	–0,55	5	–1,02	3	–1,37	3	–1,34			3	–0,40
123	12	–0,83	12	–0,09	9	–0,26	9	–0,94	0,058	0,994	7	–0,90
124	14	–0,48	13	–0,76	10	–0,51	10	–0,93	0,574	0,569	9	–1,08
125	12	–0,39	12	–0,68	9	–0,79	9	–0,95	0,082	0,935	7	–0,71
126	3	–1,09	3	–0,25	3	–0,73	3	–0,79			2	–0,40
Mean units	survival % 44,54		ht.incr. cm/yr 25,74		DBH incr. mm/yr 4,602		Volume incr. m3/ha/yr 1,371				Stem Str. % 67,09	

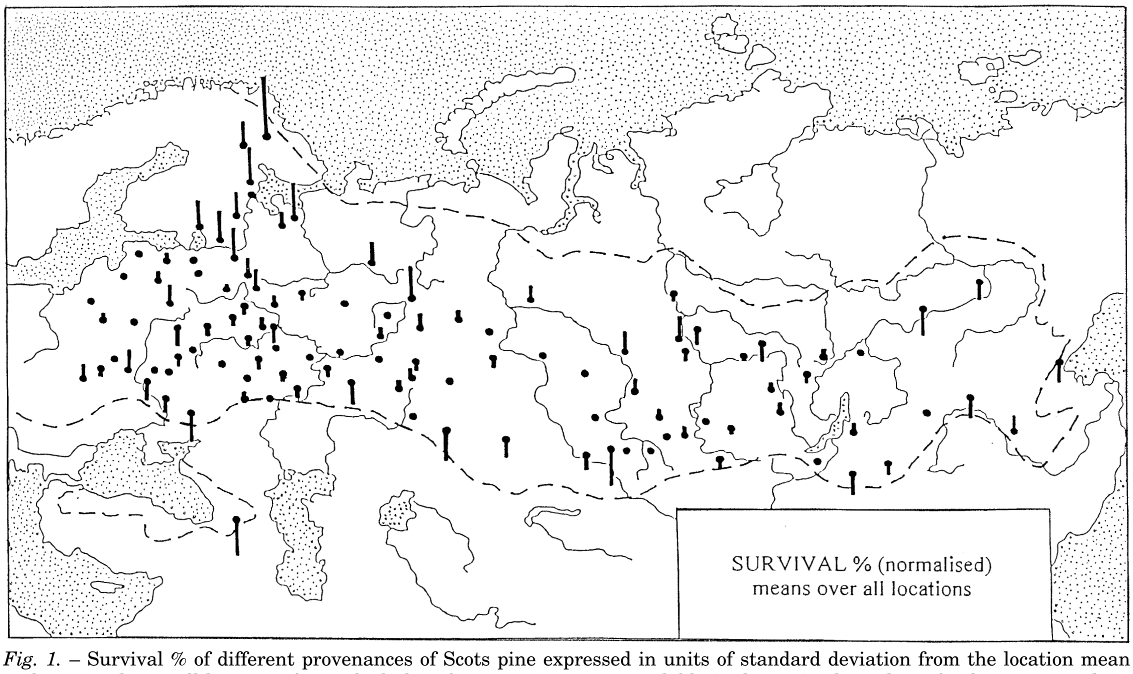

Fig. 1. – Survival % of different provenances of Scots pine expressed in units of standard deviation from the location mean and averaged over all locations from which data for a provenance is available (at least 3). The radius of a dot corresponds to ± 0.15 standard deviations.

north and south, and east of the Urals, but often also in Europe at latitudes <52 °N. Consequently mean survival of populations from this region (*Fig. 1*) is medium.

C. Western continental region

Scots pine populations from this region covering the mixed forest zone of Belarus and the Ukraine are characterised by the best growth in height on European locations but not so good east of the Urals. This conclusion is confirmed on DBH and volume data in spite of the fact that in terms of survival the performance is much poorer, especially in the north and extreme east and south. The definition of the region is almost the same as was proposed based on height alone. Provenance no. 40 (Slavyansk, Donetsk) which is probably non indigenous, is relegated to region H because of its poor overall volume production.

D. Northern Russia

This is an enormous region corresponding more or less to the taiga, extending from St. Petersburg to Yakutiya, but not

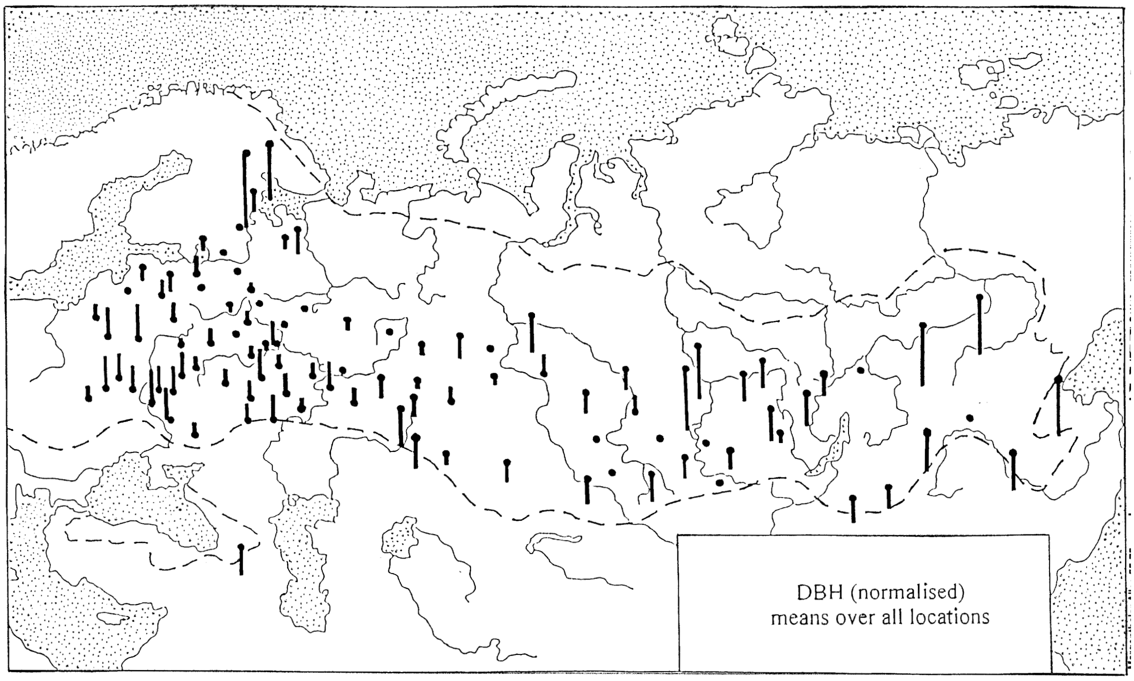

Fig. 2. – Diameter at breast height (DBH) of different provenances of Scots pine expressed in units of standard deviation from the location mean and averaged over all locations from which data for a provenance is available (at least 3). The radius of a dot corresponds to ± 0.15 standard deviations.

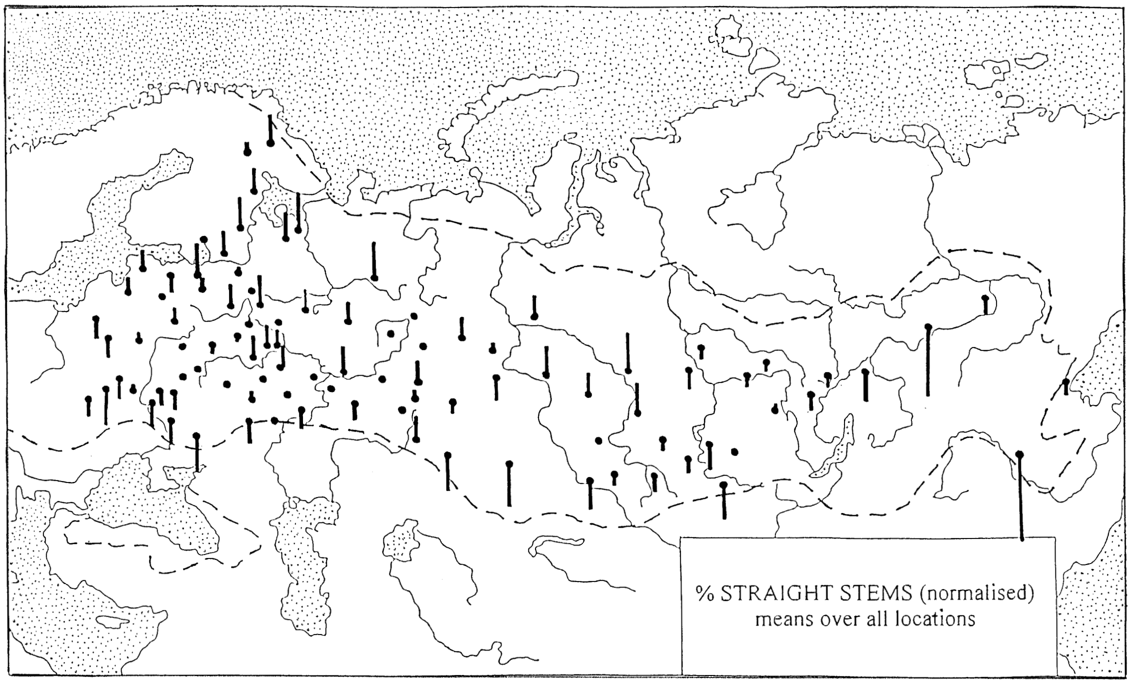

Fig. 3. – Percentage of straight stems for different provenances of Scots pine expressed in units of standard deviation from the location mean and averaged over all locations from which data for a provenance is available (at least 3). The radius of a dot corresponds to ± 0.15 standard deviations.

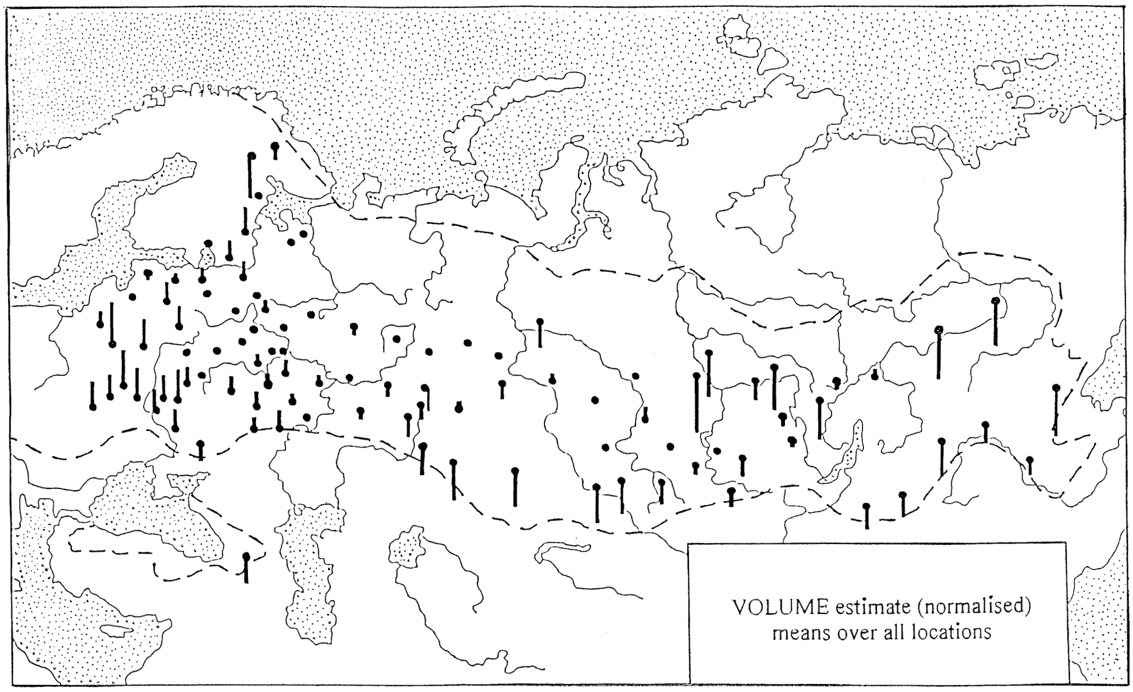

Fig. 4. – Synthetic volume estimate (survival x height x DBH^2) of different provenances of Scots pine expressed in units of standard deviation from the location mean and averaged over all locations from which data for a provenance is available (at least 3). The radius of a dot corresponds to ± 0.15 standard deviations.

including the extreme north of Siberia. This region extends from 59 °N to 65 °N in the west and from 58 °N to 62 °N in the east. It appears that populations from this region exhibit satisfactory growth within the region but not beyond it. This opinion previously expressed based on height data is confirmed based on DBH, survival and volume, but less convincingly so with respect to the more eastern populations, primarily due to a smaller number of locations at which these measurements were made.

E. Central European Russia

This is an eastward extension of region C, covering the mixed-forest zone, with very good populations in height and diameter growth both locally and extending in usefulness further east than populations of region C. It is also akin to region C in having rather poor survival, in fact even poorer, so that the volume estimate for provenances from this region is low. The claim (SHUTYAEV and GIERTYCH, 1997) that populations from this region have a particularly high coefficient of FINLAY

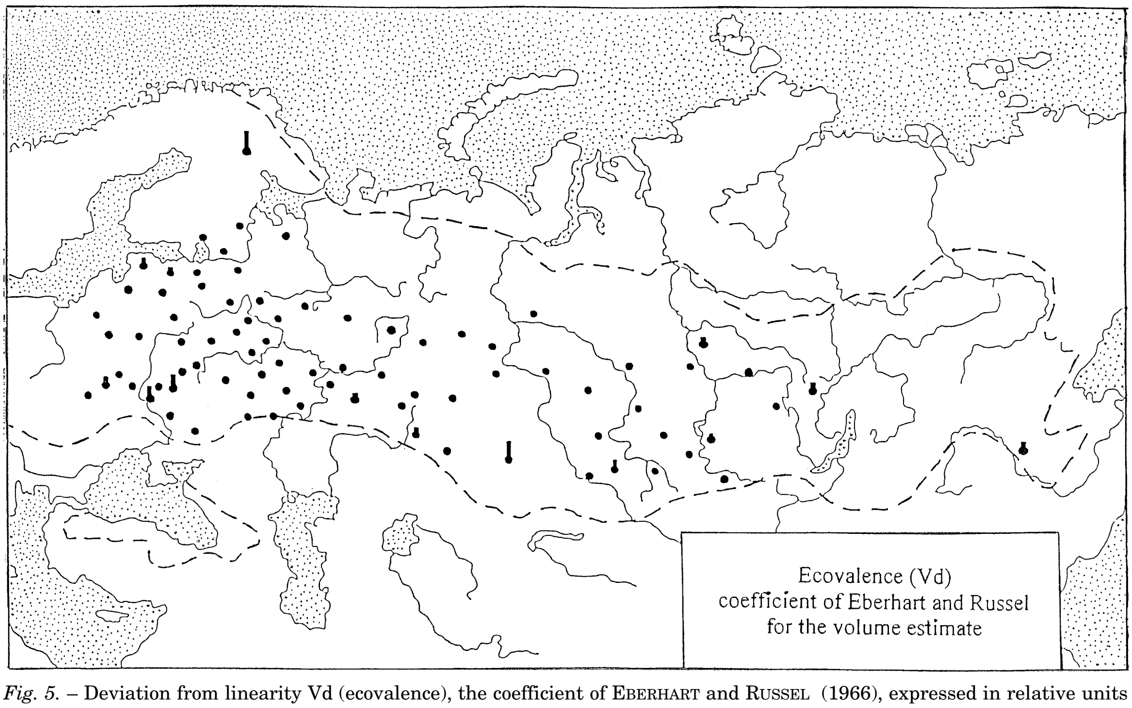

Fig. 5. – Deviation from linearity Vd (ecovalence), the coefficient of EBERHART and RUSSEL (1966), expressed in relative units of the volume estimate for different provenances of Scots pine represented on at least 5 locations.

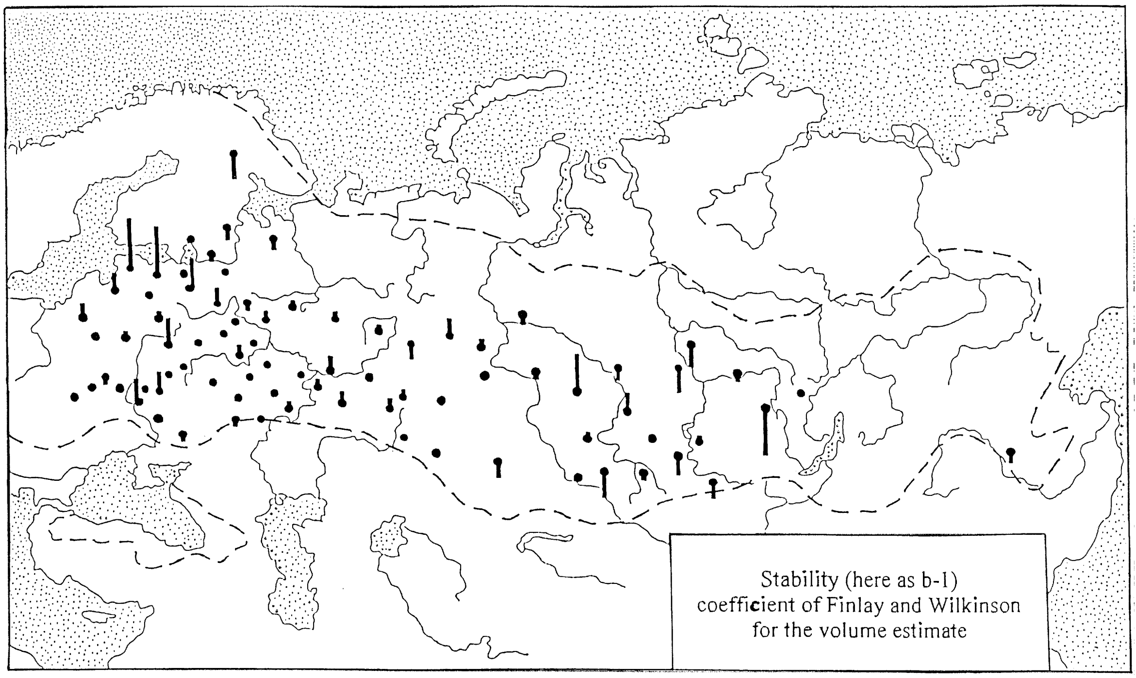

Fig. 6. – Measure of provenance phenotypic stability in units of b, the coefficient of FINLAY and WILKINSON (1963), here expressed in relative units as b-1 for different provenances of Scots pine represented on at least 5 locations.

and WILKINSON is not confirmed on the volume data (*Fig. 6*). Provenance no. 47 (Manturovo, Kostroma) does not fit very well into the region due to much poorer survival and volume estimate, however neither does it belong to region D, since its growth is poor when moved eastwards.

F. Upper Don, Middle Volga and Kama region

This region had to be redefined relative to what was proposed on the basis of height data alone. It is reduced not to include populations from Bashkortostan, now placed in region G. As defined in *figure 7* region F contains provenances that have good height and diameter growth within the region as well as when displaced in the northward direction and eastwards to river Ob, sometimes even to lake Baikal. When moved westward or southward growth of these populations is much depressed. Survival is generally poor except locally and near Novosibirsk, however on the basis of volume the general description of populations from this region is confirmed or even reinforced.

Table 5. – Matrix of correlation coefficients r between the mean values of traits for the different provenances.

for means over locations (N-2 is 106-111)

	Ht.	DBH	Vol.	Survival	St.Str.
Ht.	x				
DBH	0,867**	x			
Vol.	0,761**	0,862**	x		
Survival	0,200*	0,090-	0,420**	x	
St. Str.	0,085-	0,084-	0,322**	0,418**	x

for means in locations (N-2 is 677-1243)

	Ht.	DBH	Vol.	Surv.	St.str.
Ht.	x				
DBH	0,753**	x			
Vol.	0,780**	0,683**	x		
Surv.	0,248**	0,061-	0,633**	x	
St.str.	0,170**	0,038-	0,206**	0,288**	x

** signif. 0,01; * signif. 0,05; – not signif.

G. Belaya region

Populations from Bashkortostan have good local growth and when transferred northwards but reduced growth when transferred eastwards. This is particularly obvious for provenances nos. 69, 70 and 71. For provenances 69a and 71a there is no data on eastward transfers and provenance 72 sustains some eastward transfer but otherwise conforms with the rest of the region. Already when discussing height performance we had doubts about the placement of populations 71a and 72 because of poor height growth on all locations, but DBH and survival data have confirmed the populations as satisfactorily growing locally and after northward transfer. Thus the Bashkortostan populations do not fit readily into region F, nor do they belong to the neighbouring regions H or I, so they were placed in a separate region.

H. Southern fringe region

On the basis of height growth this region was defined as having populations growing well locally but not transferable to any distance in any direction. On the basis of DBH the possibilities of transfer appear greater, but the result is less predictable, also locally. Survival is good locally and on transfer south, east or west, but not northward. Since most locations are at more northern latitudes the overall mean for survival (*Fig. 1*) appears very low, but this does not show the strong survival advantage these populations have at southern locations. Overall the volume data give a confirmation of the ability of the populations to grow fairly well locally and after southward transfer, but the longitudinal transfers are less successful, especially for populations from the Asiatic part of this region.

I. Central Trans-Urals region

This is an extensive region spanning from Yekaterinburg in the west to Tuva in the east, running more or less parallel to region D, with slightly declining latitudes as one moves eastwards. On the basis of height the region was defined as having populations that will not loose on growth when transferred within the region but the result is not always predictable. It was noted that some of the populations from Novosibirsk province, nos. 85 and 87, sustain westward but not eastward transfers. The DBH data suggest that some sustain eastward transfers better than westward ones and others in the opposite direction. Provenance no.86, also from Novosibirsk province, was added to the latter group. Survival of populations from this region is generally good within the region but poor beyond it. In terms of volume the conclusions are similar, with some provenances, (e.g. 82, 85, 87 and 99 primarily from the northern part of the region) sustaining westward transfers better while others (e.g. 90, 92, 98 and 105 primarily from the southern part of the region) eastward transfers, the remainder (primarily from the middle zone of the region) sustaining transfers in both directions.

J. Eastern Siberian region

Little information is available about populations from this region because they have been tested on few locations. In terms of height the performance was almost universally very poor. This is confirmed for DBH and volume except that locally sometimes diameter growth is satisfactory. Survival of these populations is generally poor, except that sporadically it is good in central latitudes. The inclusion of provenance no.103 in the region is confirmed for DBH, volume and also in terms of

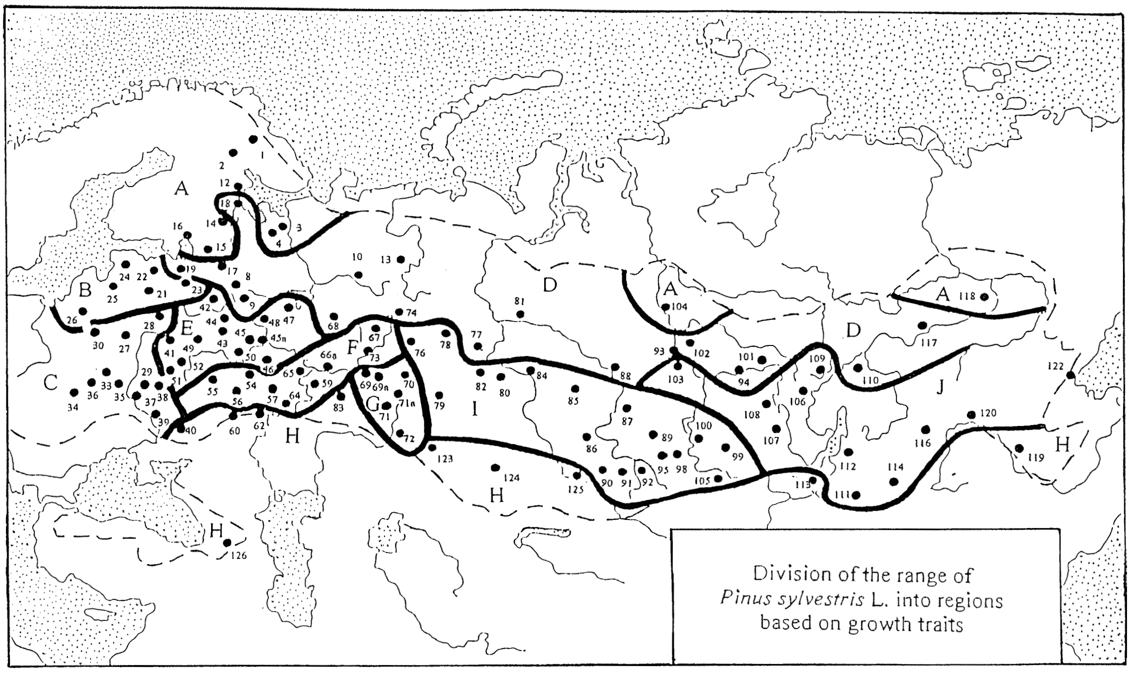

Fig. 7. – Proposed division of the range of Scots pine in the former USSR on the basis of growth traits as observed on 113 sample populations tested at 33 locations.

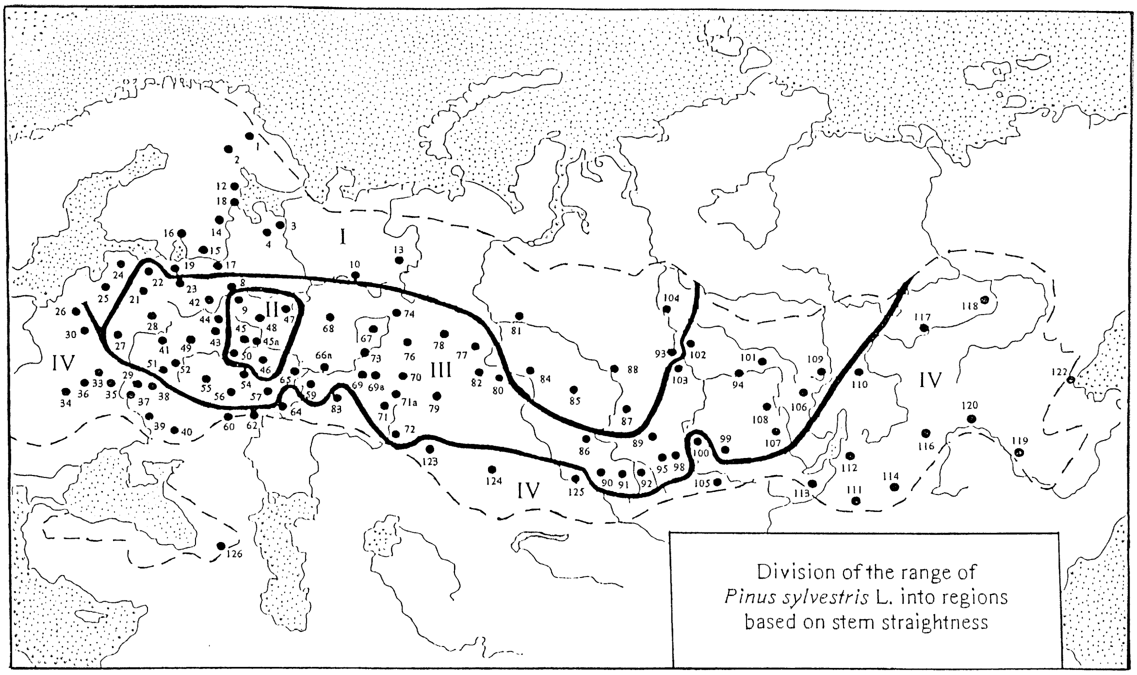

Fig. 8. – Proposed division of the range of Scots pine in the former USSR on the basis of stem straightness as observed on 113 sample populations tested at 33 locations.

survival even though for some reason the population has good survival in Karelia. With fewer data on provenance no. 116 its unconventional status is less obvious. It is fairly well growing within the region, but not beyond it, but it is less certain that it should be excluded from region J.

Relative to the evaluation of provenances on the basis of height generally a confirmation of their growth patterns was obtained with only minor modification of the extent of the regions proposed and with fewer odd populations. This latter claim may be due to having less data (DBH and therefore volume is available from fewer locations than height) and greater tolerance in accepting somewhat irregular responses for populations from a region.

Provenance x site interaction

The calculated EBERHART and RUSSEL coefficient (Vd) for volume (*Table 4* and *Figure 5*) indicates that there are only few provenances deviating much from linearity, primarily along the northern and southern limit of the range of Scots pine (regions A, H and southern part of region C). Results for these provenances are less predictable from the overall averages for the given provenance and location.

The FINLAY and WILKINSON coefficient b (*Table 4*), here plotted as b-1 (*Fig. 6*) indicates a very clear geographic differentiation, but it is very different from what was reported for height growth alone, where the most reactive (b>1) provenances originated from around Moscow (region E in *Fig. 7*). Based on the volume figures the most reactive provenances originate primarily from the west of the range (region B and eastern part of region C) and to some extent also from middle latitudes throughout the range (northern parts of regions F, G and I). These are the adaptive provenances that can utilise benefits of better sites. On the other hand most consistently stable provenances (b<1) come from the north, south and east of the range (regions A, D, H, J and the south-eastern part of region I). In this case stability primarily refers to consistently poor growth. The provenances indicated in *figure 6* as dots only (regions C, E, F, G and most of I) are the ones with adequate stability and not too reactive, that is performing satisfactorily on most sites, but not benefiting particularly from the best ones.

Thus one can say that the provenance x site interaction for volume generally confirms the division of the range into the proposed regions.

Stem straightness

With stem straightness the picture is very different indeed. The trait does not correlate (*Table 5*) with height or diameter and the correlation with volume is low. The correlation with survival is a little higher, but still very low. These low correlations suggest that straighter stems have a slight advantage in survival, which is also reflected in the volume estimate.

Again we see very clear geographic zoning in average stem straightness (*Fig. 3*) but it has a completely different pattern than the growth characters (compare *Fig. 3* with *Figs. 2, 4* and with *Fig. 3* in SHUTYAEV and GIERTYCH, 1997). There are some similarities with survival (compare with *Fig. 1*). This pattern is drawn into *figure 8*, defining regions from I to IV.

Region I

Provenances from region I are all straight stemmed, consistently on all locations, except occasionally in the very extreme north and very extreme south. We suspect that the low straightness estimates from these extreme sites may be more a reflection of the dismally poor growth of these populations in these localities, rather than of lack of stem straightness.

Region II

This is a small region, inside region III, all around Nizhegorod, where Scots pine populations are characterised by exceptionally straight stems. Only population no. 48, from Kostroma is somewhat less consistently straight stemmed at some locations. The exceptionality of this region in stem straightness is perhaps the greatest disagreement with the survival pattern (*Fig. 1*).

Region III

This is a most extensive region, central for the range of Scots pine, encompassing regions E,F,G,I, parts of B and C in the west and parts of D and J east of river Yenisei and west of river Lena. The average stem straightness of populations from this region is medium (*Fig. 3*), and in fact as can be seen in the map archive the majority of individual results for each provenance at various locations is close to average (dots or small deviations from them). However there are results at some locations which are distinctly well above or below the location mean, usually these odd results balancing each other out and giving for the provenance an average close to the mean (as can be seen in *Fig. 3*). These odd results are quite unrelated to growth results at the given location, which only confirms the lack of correlation shown in *table 5*. The odd results may in some cases be explained by the composition of provenances at a given location. If those from region I and II dominate the result for the region III provenance may appear to be low on stem straightness whereas if those from region IV dominate the same provenance may appear straight stemmed.

An interesting aspect of the shape of region III is that it appears to extend far north in the region between rivers Yenisei and Lena. Also survival is better in this northern region. This seems to be determined by the shape of region IV. In all cases Region III appears to be intermediate between regions I and IV.

Region IV

The shape of region IV is most interesting. It covers the west with some of the best growing populations of the Baltic region, Belarus and Ukraine, the whole of the southern fringe with populations of only locally satisfactory growth and the east Siberian populations with poor growth everywhere. Populations from this region have consistently crooked stems on almost all locations. Their survival is also generally below average.

Overall the division of the range of Scots pine into regions on the basis of stem straightness is much more straight cut than for growth traits. The number of provenances not quite consistent with the performance of other populations in their region is small and the inconsistencies are not great. For these provenances (nos. 16 and 17 in Region I, 48 in Region II, 22, 92 and 108 in Region III, 35 and 62 in Region IV) the stem straightness score agrees with that typical for the given region at most locations, with odd results only in some places.

Discussion

Evaluation of several growth traits and of stem straightness led to two divisions of the range of Scots pine in Eurasia into distinct regions. To our knowledge there were only five prior attempts at dividing this extensive range into zones, primarily in botanical terms though not exclusively. Comparing these divisions with our proposals is interesting.

The first study comes from Michigan, USA, and is based on seedling traits such as growth, survival, foliage size and colour, phenology and root system evaluated on populations obtained by JONATHAN W. WRIGHT in the fifties. Details of the study were first given by WRIGHT and BULL (1963) followed by a series of papers the latest giving a revised classification being by RUBY and WRIGHT (1976). This study had 33 populations from the USSR, which allowed the authors to make some wide generalisations. The populations are grouped into taxonomic varieties, their characteristics are given and ranges for them are suggested. Ten varieties are proposed for the region under study here. WRIGHT's group did not have any data from our regions C, E, F and G, from where most of our data comes, but otherwise there is some similarity in the designation of regions, and particularly the comparison in terms of growth results are similar.

Var. *lapponica* (FRIES) HARTMAN generally corresponds to our region A, even though the latter extends further south in the west, and in the east WRIGHT's group recognises a separate NE race not formally described as a variety. Var. *septentrionalis* SCHOTT corresponds to our region D. Var. *rigensis* LOUDON, corresponds to our region B which extends a little further eastward to include Pskov and Novgorod. Var. *mongolica* LITVINOF follows fairly close our region J. Our region I includes var. *uralensis* FISCHER in the west, var. *altaica* LEDEB in the south and the unnamed Krasnoyars race in the east. Some extrapolation of var. *altaica* southwards to Kirghizya and Sungaria rather than westwards or north-west is unjustified based on our data. Range of var. *rossica* SVOBODA was based on only 3 populations. It corresponds to the south-western part of our region D, encroaching on the northern part of our region E. The Caucasian pine, var. *armena* K. KOCH, we included with region H.

PRAVDIN (1964) proposed a geographical range for five Scots pine subspecies, based on herbarium collections made during his extensive travels. He primarily observed clinal variation. There is an increase in mean needle length from north to south. In the south-west needles stay on the trees 2 to 3 years, east of the Yenisei river and in the far north the needles stay 6 to 7 years and in the intermediate zone from St. Petersburg to upper Irtish river the needles stay 4 to 5 years. The number of resin canals on a needle cross section ranges from 4 to 8 in the north and between rivers Ob and Yenisei, through 8 to 12 at medium latitudes and in the east to 12 to 16 in the south-east. The proportion of trees with resin canals not only peripherally but also in the parenchyma of the needles is small in the north and east, medium in the west and high in the south-west.

Compared to our divisions (*Fig. 7*) ssp. *lapponica* FRIES corresponds to our zone A and the northern fringe of zone D where we have few data, ssp. *hamata* (STEVEN) FOMIN and ssp. *kulundensis* SUKACZEW more or less correspond to our zone H, and the boundary between ssp. *sylvestris* L. and ssp. *sibirica* LEDEBOUR corresponds to our boundary between zones F and G in the west and zone I in the east, extending northward to split our zone D into a western and eastern part. PRAVDIN's divisions do not utilise to the full the presented data on needles and resin canals. In the south-western part of the range (our zones C and F) pines have shorter lifespan needles, more resin canals and they are more frequently not only peripheral but also in the parenchyma. The northern and far eastern populations characterised by poor growth in our material are also distinguishable on the basis of PRAVDIN's data having longer lifespan needles and paucity of resin canals in the parenchyma.

Next PATLAÍ (1965) proposed a split up of the range of the species in the former USSR into 15 zones, most of them in Europe, based on Scots pine provenance experiments established in south-eastern Ukraine in the late twenties.

These divisions are very mechanical in nature, based on administrative divisions, geographic features and co-ordinates rather than on provenance differences. Since in the description of Scots pine races within them he primarily discusses traits that demonstrate clinal variation (foliage density, branch thickness, stem cleaning, crown size, photosynthetic activity) such an approach is perhaps justified. The general picture in some features is an eastern extension of the divisions of WRIGHT and his group. Both were analysed jointly earlier (GIERTYCH, 1975). PATLAÍ's zonation is somewhat more detailed than ours but generally it conforms with what our study discovered in terms of variation in growth potential and to some extent also in stem straightness. The major difference is that PATLAÍ separates out pine from the Ural Mts., placing them in two latitudinal zones. Also on scanty evidence, not confirmed by our data, he describes a northern and a southern part of Kazakhstan splitting in two what we placed in region I.

Before the currently analysed experiment was started a study was made of turpentine oils extracted from *P. sylvestris* wood originating from 122 locations throughout the former USSR (CHUDNYI and PROKAZIN, 1973). Main differences were observed in the contents of alpha-pinene, beta-pinene and delta-3-carene. On this basis the authors have divided the range of *P. sylvestris* into six major regions:

1. The north of European Russia and of Siberia, which corresponds well to our region A.
2. European Russia excluding the extreme north, which encompasses our regions B,C,E,F and western D.
3. The Caucasus, we placed in region H.
4. Urals/Siberia, a transcontinental zone that includes our regions G, I and J.
5. Kazakhstan/Altai, corresponding to the central part of our region H.
6. The western and eastern Sayan Mts. plus the Yablonovyi range, which correspond to the south-eastern tip of our region I and the south-western part of our region J.

Finally there was an attempt (SHUTYAEV, 1977) to define 23 seed zones of Scots pine in the former USSR on the basis of a complex of traits including natural variation, natural distribution, affiliation with other tree species, productivity in various regions, as well as growth, survival and quality in a 16 year old provenance trial established in 1959 with 94 populations in Voronezh (reported upon several times SHUTYAEV, 1973, 1977; SHUTYAEV et al., 1975; SHUTYAEV and VERESIN, 1990; VERESIN and SHUTYAEV, 1978).

These divisions are very detailed and show some resemblance to our current proposal. In general in Europe the divisions are basically latitudinal with some longitudinal divisions in the west as is true for our *figure 7*, and in Asia the divisions are latitudinal in the west and longitudinal in the east (akin to our *Figure 8*). In between the 1977 proposal places the narrow Urals region, extending from north to south almost throughout the range of the species. This has no equivalent in our current divisions of the range of Scots pine. Specific zone boundaries seldom follow the currently proposed ones but the opinions about productivity of the populations are very much in agreement. Had the 1977 divisions been based primarily on productivity, the similarity of the proposed regions would have been much greater.

The five divisions of the range of Scots pine discussed above (WRIGHT and BULL, 1963; PRAVDIN, 1964; PATLAÍ, 1965; CHUDNI and PROKAZIN, 1973; SHUTYAEV, 1977) have little affinity to the divisions we have obtained on the basis of stem straightness trait (*Fig. 8*) except for the recognition of some N-S cline in stem straightness in the west. However some trace of similarity is observable with another study based on the same material which investigated phenological differentiation in the conditions of Hungary (MÁTYÁS, 1981). While no geographical regions were proposed the author notes that bud burst and bud formation isolines are longitudinal in Europe and latitudinal for most of the range in the former USSR, related in some measure to winter isotherms, reflecting Atlantic influences in the climate of Europe. The shape of the published phenological isolines appear to be parallel to our boundary between regions IV and III in Europe and western Siberia (*Fig. 8*).

Finally a word is needed about isozyme studies. There are two that are pertinent to the region under study here (SEMERIKOV et al., 1993; GONCHARENKO et al., 1994). Neither has identified any convincing geographical pattern to the distribution of allozymes. While some clustering of the Belarus and Baltic populations was indicated, several other distant populations also belong in this cluster and many adjacent populations are very far from each other in the clusters obtained. Thus, as yet the molecular studies have not provided any convincing suggestions for geographic split up of the range of Scots pine, with which we could compare our material. Our conclusion therefore expressed in our previous paper (SHUTYAEV and GIERTYCH, 1997) that geographic patterns do exist when working with growth traits, and as was show above, with quality, anatomic, phenological and chemo-taxonomic traits, but none of this is related in any way to isozyme differentiation that most probably reflects only neutral variation, not affecting functionality of the any of the enzymes studied.

In 1999 based on a directive of Rosleskhoz (Russian Forest Service) an inventory was begun of provenance trials of forest tree species established within the management program of 1973, and this includes trials with Scots pine discussed here. Within the next two or three years it is planned in Russia to make a 25-year old evaluation of these trials on all sites, based on the potential of regional institutes. On the basis of the results that will be obtained, a new program of forest seed regionalization is planned.

These new regional evaluations of the provenance trials will give rich information that will help to confirm or correct the conclusions of our current presentation.

We would like to recommend that simultaneously similar measurements and observations be made at locations of this same experiment in other countries (Azerbaijan, Belarus, Estonia, Kazakhstan, Lithuania, Ukraine). International cooperation in the evaluation of trials established simultaneously with the same planting material and methodology will increase the value of the information produced on the variability of Scots pine.

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