COMMUNICATIONES INSTITUTI FORESTALIS FENNIAE 115

PESTS ON LODGEPOLE PINE (PINUS CONTORTA) IN FINLAND

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SELOSTE

KONTORTAMÄNNYN TUHOT SUOMESSA

HELSINKI 1983

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Cover (front & back): Scots pine (*Pinus sylvestris* L.) is the most important tree species in Finland. Pine dominated forest covers about 60 per cent of forest land and its total volume is nearly 700 mil. cu.m. The front cover shows a young Scots pine and the back cover a 30-metre-high, 140-year-old tree.

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A survey study on the occurrence of different pests, especially insects, on lodgepole pine (*Pinus contorta* Douglas ex Loudon) was carried out in three successive years in 31 localities. *Hylobius* weevils were the main insect pest during the first growing season, seriously damaging about 20 % of the seedlings treated with lindane on reforestation areas. Although many insect species were found to feed on young lodgepole pines, they were of only minor importance. On the other hand, one to ten-year-old plantations were often damaged by voles and moose. In northern Finland young plantations were infested by pathogenic fungi (*Phacidium infestans* Karst., *Gremmeniella abietina* (Lagerb.) Morelet). Moreover, young trees were often damaged by abiotic agents. The main insect pest of older lodgepole pines was *Neodiprion sertifer* (Geoffr.). Severe defoliation in successive years was considered to be the main reason for the death of trees in some stands. Lodgepole pine timber was attacked by many insect species originally breeding in Scots pine (*Pinus sylvestris* L.) or Norway spruce (*Picea abies* (L.) Karst.). However, the reproduction of most insect species was low, including ones of economic importance. Some differences were found between lodgepole pine and Scots pine, as well as between different provenances of lodgepole pine, as regards susceptibility to damage.

Tutkimuksessa pyrittiin selvittämään, mitä hyönteisiä Suomessa esiintyy kontortamännyllä, ja kuinka vakavaa tuhoa ne voivat saada aikaan tällä puulajilla. Taimikoita tutkittaessa otettiin huomioon myös muiden eläinten ja sienitautien aiheuttamat tuhot sekä muut, lähinnä ilmastotekijöitten aiheuttamat viotukset. Tutkimuksessa verrataan myös kontortamännyn tuhonalttiutta kotimaiseen mäntyyn.

Kontortamännyn taimien pahimmiksi tuholaisiksi Etelä-Suomen avohakkuualoilla osoittautuivat tukkikärsäkkäät (*Hylobius*), jotka vioittivat vakavasti noin viidennestä taimista ensimmäisen kasvukauden aikana. Tulokset eivät kuitenkaan osoita, että kontortamänty olisi tälle tuholaiselle alttiimpi kuin kotimainen mänty. Muita tuhoja esiintyi jokseenkin vähän. 1 — 10 vuotta vanhoissa taimikoissa tärkeimmät tuholaiset olivat tukkikärsäkkäät, myyrät ja hirvi. Sienitautien (lumikariste, versosyöpä) merkitys tuhonaiheuttajina oli Keski-Suomessa, mutta varsinkin Pohjois-Suomessa, huomattavasti suurempi kuin Etelä-Suomessa. Myös erilaisten abioottisten tekijöitten aiheuttamia vioituksia esiintyi Pohjois-Suomessa verrattain paljon. Kuitenkin ainoastaan myyrätuhoille kontortamänty näyttää olevan ainakin Pohjois-Suomessa alttiimpi kuin kotimainen mänty.

Varttuneissa kontortamännyissä esiintyvistä hyönteisistä oli tärkein ruskea mäntypistiäinen, jonka neulastuhojen arveltiin johtaneen puitten kuolemiseen eräissä metsiköissä. Kaikesta päätellen kontortamänty kestää selvästi huonommin tämän hyönteisen tuhoja kuin kotimainen mänty. Puutavaraan iskeytyi monia kotimaisessa männyssä ja kuusessa eläviä lajeja, mutta niiden lisääntyminen oli yleensä varsin vähäistä.

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CONTENTS

PREFACE

Many people in Finnish forestry companies (Tehdaspuu Oy, G.A. Serlachius Oy, Kajaani Oy) and the National Board of Forestry have assisted in collecting the material for the present study. Provenance trials established by the Department of Forest Genetics, the Finnish Forest Research Institute, and the National Board of Forestry were kindly put at our disposal. Dr. Timo Kurkela and Dr. Lalli Laine gave valuable help in the identification of the pathogenic fungi. Kari Arra surveyed insect occurrence on the lodgepole pine seedlings. The authors are very grateful for all the assistance received during the study. We also wish to thank all members of the Nordic Forest Entomologists' Research Group for valuable discussions on the subject. The study was carried out at the Finnish Forest Research Institute.

Of the authors, Erkki Annila planned the general outline of the study and prepared the manuscript. Kari Heliövaara, Kari Puukko and Matti Rousi collected the material in the field and prepared the data for the tables.

1. INTRODUCTION

In recent years the cultivation of lodgepole pine, *Pinus contorta* Douglas ex Loudon (var. *latifolia* Engelm. ex Wats.) has increased in the Nordic Countries, especially in Sweden.

In Finland the first experimental stands for practical forestry were established in the 1920s and 1930s. During the next forty years little attention was paid to this North-American tree species. Lodgepole pine again attracted interest in the 1970s and new stands were planted in various parts of Finland. Provenance trials were also established for scientific studies. However, the total area of *P. contorta* stands in Finland is still quite small, about 6 000 ha in 1982 (Lähde et al. 1982).

Lodgepole pine is attacked by many insects throughout its natural range in the north-western parts of North America (Furniss and Carolin 1977). Until now none of these insects have been introduced into the Nordic Countries, although many of them are potential pests outside the original distribution area of *P. contorta* (Lindgren 1980). On the other hand, many native insects breeding on Scots pine (*Pinus sylvestris* L.) or Norway spruce (*Picea abies* (L.) Karst.) have been found to infest lodgepole pine (e.g. Krol and Michalski 1961, Juutinen 1967, Dominik 1972, Ehnström et al. 1974, Lindelöw 1975, Viitasaari 1975).

Although 57 insect species have been reported on lodgepole pine in the Nordic Countries (Eidmann 1982), there is little information available about the abundance, extent of damage or economic importance of these insects. Lindelöw (1975) investigated the damage caused in Sweden by *Hylobius* weevils on the seedlings of *P. contorta* and *P. sylvestris,* and the attack density and brood production of some scolytids and cerambycids. Finer (1978) reported insect damage (*Hylobius, Pissodes, Rhyacionia*) on lodgepole pine seedlings in Finland. Cones of lodgepole pine are known to be destroyed by the larvae of the pine cone weevil, *Pissodes validirostris* (Sahlb.) in Finland (Annila 1975). Eidmann (1982) reported the intensity of insect infestation on the felled trees of lodgepole pine, Scots pine and Norway spruce. Pine beauty moth, *Panolis flammea* (Den. & Schiff.) has not caused any serious damage in the Nordic Countries, but in Scotland this insect defoliated young lodgepole pines in the late 1970s and killed trees over an area of 300 ha (Stoakley 1977, 1979).

In addition to insects, young lodgepole pines may be attacked by voles and moose (Finer 1978, Hansson and Lavsund 1982, Karlman 1982).

Some of the pathogens which infest Scots pine in the Nordic Countries (*Phacidium infestans* Karst., *Gremmeniella abietina* (Lagerb.) Morelet) have been found to attack lodgepole pine (von Weissenberg 1975, Finer 1978, Martinsson 1982). However, no damage of any great economic importance has yet been reported. The root rot fungus, *Heterobasidion annosum* Bref., may cause serious problems in mature or semi-mature stands of lodgepole pine in the future (Laine 1976, Martinsson 1982).

Owing to the increasing interest shown by the practical forestry sector in lodgepole pine, the Nordic Forest Entomologists' Research Group decided in 1977 to carry out a survey study on the occurrence of insects on lodgepole pine in each of the member countries: Denmark, Finland, Norway, and Sweden. Some articles have already been published on the subject (Austarå 1982, Eidmann 1982). The material presented in the present study was collected in Finland during the period 1978 — 1981. Nevertheless, an investigation on the occurrence of pathogenic fungi on lodgepole pine is currently being carried out in Finland, damage caused by agents other than insects, including pathogens, was recorded on young lodgepole pines. Special attention was paid to subsequent differences in pest occurrence between lodgepole pine and Scots pine, as well as between different provenances of lodgepole pine.

2. MATERIAL AND METHODS

Insect occurrence on lodgepole pine was surveyed in stands at three different ages: seedlings, young trees, and trees about 50 years old. Insects in timber were studied on a smaller scale. Comparisons with Scots pine were made whenever possible.

The seedling stands formed part of an extensive experimental series established by the Finnish Forest Research Institute in 1981 for the study of the site requirements and optimal growth densities of *Pinus contorta* (Fig. 1). The seed was of Wonowon origin, British Columbia, Canada. The experimental plots (about 0,5 ha in size) were established on areas clear-cut during the previous winter, with two replicates on each site. The seedlings were sprayed with lindane (0,8 % a.i.) in the nursery before transport to the planting site. *Pinus sylvestris* was planted on each experimental site, except at Padasjoki and Joutseno where *Picea abies* was planted. The seedlings (1M+1A) were planted in early summer 1981 and surveyed in September the same year. Insect damage on both tree species was recorded by inspecting every second seedling on the plots (2 000 plants per hectar).

The stands consisting of young trees had been established in 1969—1977 and were surveyed in July or August in three successive years from 1978 to 1980. The country was roughly divided into three different areas: southern, central, and northern Finland (Fig. 1). Stands in southern and central Finland were selected from among the plantations established by private forestry companies (Tehdaspuu Oy, G.A. Serlachius Oy, Kajaani Oy). In northern Finland the stands consisted of provenance trials planted by the Finnish Forest Research Institute and the National Board of Forestry.

The provenances of the lodgepole pines and other information about the plantations are presented in Appendices 1 and 2. The trees within circular sample plots (r = 3,26 m), located using the systematic line plot method, were examined. The distance between plots varied from 25 to 60 m depending on the size of the plantations. The average height of the lodgepole pine plantations at different ages is presented in Figure 2. The average density varied considerably both within and between stands (Appendix 2). Generally speaking, the density of the Scots pine plantation was slightly higher than that of the lodgepole pine ones. This was evidently caused by the fact that there were wildings among the planted Scots pines.

Trees were classified into three different groups according to their general condition: good, bad, or dead. All kinds of damage on the trees were recorded. Damage on Scots pine was studied in those places where both tree species had been planted side-by-side. Some of the stands were mixed plantations where the tree density could not be calculated for each tree species (Appendix 2). The total number of trees inspected during three years was 17 900 *P. contorta* and 3 856 *P. sylvestris*.

Insect occurrence on older lodgepole pines was studied in two stands at Punkaharju and in one stand at Rovaniemi (Kivalo) in 1980. The stands belong to the provenance trials planted with four-year-old transplants in 1932 or 1937 at Punkaharju, and in 1934 at Rovaniemi. The size of the trials are as follows: 1,35 ha and 2,04 ha at Punkaharju, and 1,5 ha at Rovaniemi. All the stands have been thinned several times. Samples were taken twice during the summer: the first time at the end of June or the beginning of July, the second time in August. Nine branches were cut from each tree: three

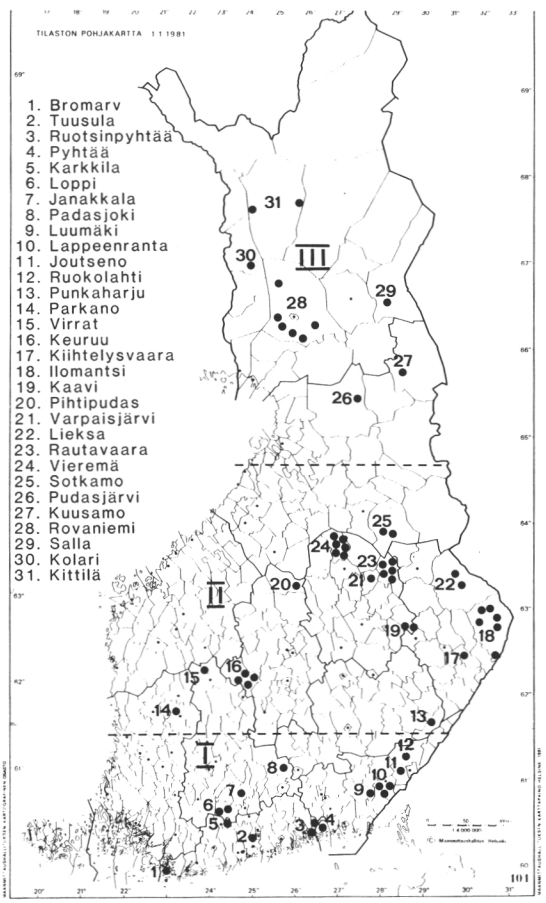

Fig. 1. Research localities and experimental stands (●). I=southern Finland, II=central Finland, III=northern Finland.

Kuva 1. Tutkimuspaikkakunnat ja tutkimusmetsiköt (●). I = Etelä-Suomi, II = Keski-Suomi, III = Pohjois-Suomi.

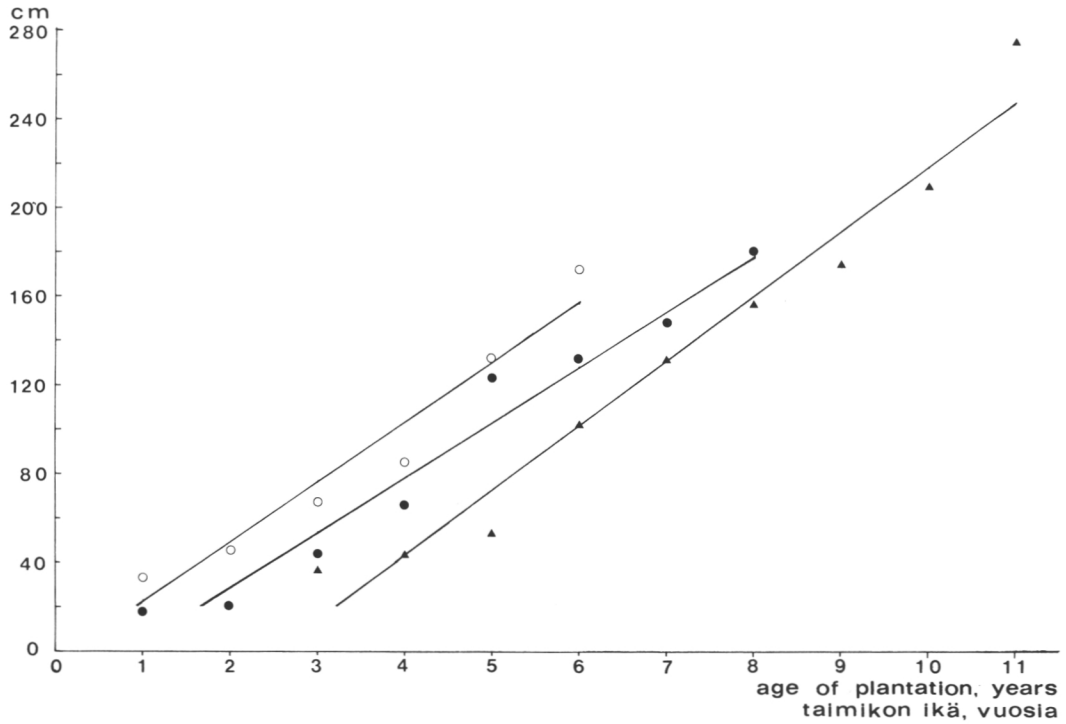

Fig. 2. Average height of the trees in lodgepole pine plantations of different age. o—o=southern Finland, ●—●=central Finland, ▲—▲=northern Finland.

Kuva 2. Tutkimuksen kohteena olleitten eri-ikäisten kontortamännyn taimikoitten keskipituus. o—o = Etelä-Suomi, ● — ● = Keski-Suomi, ▲ — ▲ = Pohjois-Suomi.

from the upper, middle, and lower part of the crown. Samples were taken from 152 trees at Punkaharju and from 16 at Rovaniemi.

Studies on insect occurrence in lodgepole pine timber were conducted at Punkaharju, Tuusula (Ruotsinkylä), and Bromarv (Solböle) in 1978—1979. Lodgepole pines and Scots pines in the Punkaharju experimental forest were felled in winter 1977—78, cut into logs 2 m long, piled in three different places, and left in the forest until the next autumn. The average diameter of the logs was 13,3 (± 0,4) cm and bark thickness 1,2 (± 0,05) mm in lodgepole pine, and 9,9 (± 0,5) cm and 1,4 (± 0,1) mm in Scots pine, respectively. The logs were debarked in late summer and all insects and their galleries recorded. Insect production was calculated by counting the number of adult beetles under the bark and exit holes along a section 0,5 m long at both ends of the logs. The number of logs was 73 for *P. contorta* and 30 for *P. sylvestris*. In addition to timber, six windthrown lodgepole pines with a diameter at breast height of 19 to 33 cm and bark thickness 1 to 2 mm, were studied for insect attack. The trees were cut into sections 2 m long, debarked and examined.

The lodgepole pines at Tuusula and Bromarv were felled in April 1978, cut into pieces of different length, debarked and examined in August. The mean diameter of the logs was 14,2 (±0,4) cm and bark thickness 2,7 (± 0,07) mm at Tuusula, and 13,8 (± 1,1) cm and 2,3 (± 0,08) mm at Bromarv, respectively. The number of samples (0,5 — 2 m long) was 134 at Tuusula and 10 at Bromarv.

Besides the material collected specifically for the present study, some earlier observations made by authors on insect occurrence on *P. contorta* were included.

3. RESULTS

31. Seedlings

The number of insects on lodgepole pine seedlings during the first summer, as well as the intensity of the damage, was not especially high. This was as expected because the seedlings had been sprayed with lindane before planting and it is generally known that lindane protects seedlings quite well against insect damage for at least one growing season.

About half of the seedlings were attacked by *Hylobius*, which was the most numerous insect pest during the first summer (Table 1). However, the proportion of seedlings seriously injured was only 20 %. The differences in the amount, as well as in the severity of the damage between lodgepole pine and Scots pine were not statistically significant.

14,9 % of the lodgepole pine seedlings were damaged by moose which had grazed on the experimental plots, 2,4 % by the larvae of *Acantholyda hieroglyphica* (Chr.) and 2,4 % by the adults of *Pissodes* weevils; *P. pini* (L.) and *P. castaneus* Deg. were found feeding on the seedlings. Both tree species were damaged to the same extent by moose and insects. Other insect species occasionally found on the lodgepole pine seedlings were *Strophosoma capitatum* Deg., *Brachyderes incanus* (L.), *Magdalis violacea* (L.), *Rhyacionia duplana* Hb., *R. pinivorana* (Lien. & Zell.), and *Blastesthia posticana* (Zett.).

Although the average mortality of the lodgepole pine seedlings was slightly higher than that of Scots pine, there was no significant difference between the two tree

Table 1. Damage by *Hylobius* in the lodgepole pine and Scots pine seedlings on the experimental plots during the first growing season. Degree of damage: 1=light, 2=moderate, 3=heavy.
Taulukko 1. Tukkikärsäkästuhot kontortamännyn ja kotimaisen männyn taimissa koeruuduilla ensimmäisen kasvukauden aikana. Vioitusaste: 1=lievä, 2=keskinkertainen, 3=ankara.

Locality / *Paikkakunta*		Degree of damage — *Tuholuokka* 1		2		3		Total — *Yht.*	
		con.	syl.	con.	syl.	con.	syl.	con.	syl.
		%							
Janakkala	I	5,1	9,0	8,2	15,2	4,6	10,6	17,9	34,8
	II	3,1	5,6	11,7	10,0	4,9	3,6	19,7	19,2
Padasjoki[1)]	I	8,5	—	17,3	—	18,0	—	43,8	—
	II	6,2	—	21,8	—	51,8	—	79,8	—
Joutseno[1)]	I	3,1	—	9,2	—	10,6	—	22,9	—
	II	1,9	—	10,3	—	56,1	—	68,3	—
Ruokolahti	I	14,0	11,6	29,4	26,3	26,1	13,7	69,5	51,6
	II	14,5	13,7	32,9	29,2	30,0	17,1	77,4	60,0
Parkano	I	13,1	13,8	20,5	22,4	6,9	4,3	40,5	40,5
	II	17,3	14,6	25,6	13,7	5,4	6,8	48,3	35,1
Virrat	I	15,6	10,8	29,5	23,1	14,4	47,6	59,5	81,5
	II	22,4	21,0	17,9	25,1	19,7	12,6	60,0	58,7
Average / *Keskimäärin*		10,4	12,5	19,5	20,6	20,7	14,5	50,6	47,7

χ^2=0,04; no significant difference between lodgepole and Scots pine
ei merkitsevää eroa kontortamännyn ja kotimaisen männyn välillä
1) not included in Chi-square test
eivät sisälly Chi-neliötestiin

Table 2. The quality of lodgepole pine and Scots pine seedlings in the autumn after the first growing season. Condition of seedlings: 1=good, 2=bad, 3=dead.

Taulukko 2. Kontortamännyn ja kotimaisen männyn taimien kunto syksyllä ensimmäisen kasvukauden jälkeen. Kuntoluokka: 1=hyvä, 2=huono, 3=kuollut.

Locality	Condition class — *Kuntoluokka*					
Paikkakunta	1		2		3	
	con.	syl.	con.	syl.	con.	syl.
	%					
Janakkala I	80,5	83,5	15,5	14,5	4,0	2,0
II	73,5	88,0	21,5	10,0	5,0	2,0
Padasjoki[1)] I	61,5	—	24,5	—	14,0	—
II	38,0	—	29,0	—	33,0	—
Joutseno[1)] I	72,5	—	23,5	—	4,0	—
II	31,5	—	33,5	—	35,0	—
Ruokolahti I	59,5	73,5	35,5	26,0	5,0	0,5
II	58,5	76,5	34,0	23,0	7,5	0,5
Parkano I	63,0	44,0	30,0	41,5	7,0	14,5
II	63,0	71,0	21,0	23,0	16,0	6,0
Virrat I	68,0	75,0	28,0	21,0	4,0	4,0
II	74,0	82,0	21,5	10,0	4,5	8,0
Average *Keskimäärin*	62,0	74,2	26,5	21,1	11,6	4,7

χ^2=1,44; no significant difference between lodgepole pine and Scots pine
ei merkitsevää eroa kontortamännyn ja kotimaisen männyn välillä

1) not included in Chi-square test
ei sisälly Chi-neliötestiin

species as regards their overall condition (Table 2). *Hylobius* weevils were the primary cause of seedling mortality; 75,6 % of the total mortality in *P. contorta* and 78,2 % in *P. sylvestris.* The rest were killed by moose or abiotic agents.

32. Young stands

The number of insect species on the one to ten-year-old lodgepole pines was about the same in southern and central Finland, but much lower in northern Finland (Tables 3, 4, 5). The frequency of most species was very low throughout the course of the study. The number of trees attacked by *Hylobius* was relatively high compared with the number of trees infested by other insects. Damage caused by *Hylobius* in northern Finland was negligible. Larvae of *Acantholyda hieroglyphica* and *Petrova resinella* (L.) were found each year, although in small numbers. Buds of lateral shoots were quite often destroyed by larvae of tortricids *Rhyacionia (pinivorana* or *duplana)* and *Blastesthia (posticana* or *turionella* (L.)). Other insect species were found only occasionally and were of no economic importance.

Damage by voles was relatively common especially in northern Finland (Table 5), where voles, mainly the root vole (*Microtus oeconomus* Pall.), had a strong occurrence peak in winter 1977—78 (Korhonen 1981). Moose damage was slightly more frequent in southern and central Finland than in northern Finland where the moose population was lower. Trees less than 0,4 m high were not damaged by moose during wintertime. In taller stands the extent of damage was positively correlated with the average height of the trees.

Pathogens were rare in southern Finland except for *Melampsora pinitorqua* (Braun) Rostr. which was observed on Scots pine each year. Canker fungus (*Gremmeniella abietina*) and snow blight fungus (*Phacidium infestans*) were quite common on both tree species in central and northern Finland. Several kinds of injuries caused by abiotic

Table 3. Occurrence of different damaging agents (infested trees) in young lodgepole pines and Scots pines in southern Finland.

Taulukko 3. Eri tuhonaiheuttajien ja vikojen esiintymisrunsaus (prosentteina tutkituista taimista) kontortamännyn ja kotimaisen männyn taimikoissa Etelä-Suomessa.

Damaging agent	Tree species — *Puulaji*					
	Pinus contorta			*Pinus sylvestris*		
	Year — *Vuosi*					
Tuhonaiheuttaja tai vika	1978	1979	1980	1978	1979	1980
	%					
Aphids, *Kirvat*	0	0	0	0,5	3,4	6,8
Cryptocephalus pini	0	0	+[1)]	0	0	0
Strophosoma capitatum	0	0	2,3	0	0	0
Brachyderes incanus	0	0	+	0	0	0
Hylobius spp.	9,3	5,6	11,1	5,7	12,6	0
Anthonomus phyllocola	0	0	1,6	0	0	0
Tomicus piniperda	0	0	+	0	0	0
Acantholyda hieroglyphica	1,6	0,7	0,8	1,4	0	0
Neodiprion sertifer	0	0	21,0	0	0,3	4,5
Diprion pini	0	0	+	0	0	+
Microdiprion pallipes	0	0	+	0	0	0
Exoteleia dodecella	0	0	+	0	0	0
Archips oporanus	0	0	+	0	0	0
Petrova resinella	0	1,7	2,1	0	0,7	1,4
Blastesthia+Rhyacionia	1,6	3,3	8,9	1,4	2,4	2,1
Dioryctria mutatella	0	0	+	0	0	0
Voles, *Myyrät*	0,3	5,4	2,4	0,2	0	0,6
Moose, *Hirvi*	2,4	3,4	15,9	0,7	0	23,4
Gremmeniella abietina	0	0	+	0	0	0
Melampsora pinitorqua	0	0	0	5,7	4,8	2,3
Armillaria mellea	0	0	+	0	0	0
Phacidium infestans	0	0	0	0,2	0	0
Chlorosis, *Kloroosi*	1,1	0,6	0	0,2	4,3	0
With several stems *Monirunkoinen*	0	11,3	1,3	0	22,5	1,1

1)+ < 0,1 %

agents occurred in many trees in northern Finland.

There was no great difference in the extent of damage between lodgepole pine and Scots pine except for that caused by *Melampsora pinitorqua* (Tables 3, 4, 5) which is known to infest *P. sylvestris* but not *P. contorta* (Martinsson 1975). Lodgepole pine was attacked by voles slightly more frequently than Scots pine. However, the differences between the two tree species could not be tested statistically because of the heterogeneity of the material; plantations of the different tree species at most localities had not been established on the same kind of site type, both tree species were not present at every locality etc. The internal variation in both tree species was so great that there were hardly any significant differences between lodgepole pine and Scots pine.

The number of dead trees on the sample plots during the three-year-period was much higher in northern than in central and southern Finland (Table 6). Voles, canker fungus, and snow blight fungus were the main causes of mortality in northern Finland. In southern Finland a part of the seedlings, planted one to three years before the survey, had been seriously injured by *Hylobius.* This was the only insect species of economic importance. In some cases *Blastesthia* or *Rhyacionia* larvae had destroyed all the buds, apparently resulting in the death of some of the small seedlings. In many cases the cause of death remained unknown, especially in northern Finland.

No statistical comparisons could be made

Table 4. Occurrence of different damaging agents (infested trees) in young lodgepole pines and Scots pines in central Finland.
Taulukko 4. Eri tuhonaiheuttajien ja vikojen esiintymisrunsaus (prosenteina tutkituista taimista) kontortamännyn ja kotimaisen männyn taimikoissa Keski-Suomessa.

Damaging agent	Tree species — *Puulaji*					
	Pinus contorta			*Pinus sylvestris*		
	Year — *Vuosi*					
Tuhonaiheuttaja tai vika	1978	1979	1980	1978	1979	1980
	%					
Aphids, *Kirvat*	0,1	0	0,3	0,3	0,3	1,6
Ernobius nigrinus	0	0	+	0	0	0
Pogonochaerus fasciculatus	0	0	+	0	0	0
Calomicrus pinicola	0	0,1	0	0	0	0
Strophosoma capitatum	0	0	1,7	0	0	0,8
Brachyderes incanus	0	0	0,2	0	0	0
Hylobius spp.	8,4	15,7	10,0	0,3	3,3	2,8
Pissodes spp.	0	0,1	0	0	0	0
Anthonomus phyllocola	0	0	0,3	0	0	0
Tomicus piniperda	0	0	0,2	0	0	0
Acantholyda hieroglyphica	0	0,9	3,1	0	0	1,6
Neodiprion sertifer	0,1	+	0,7	0	0	1,2
Diprion pini	0	0,1	0,1	0	0	0
Microdiprion pallipes	0	0	+	0	0	0
Gilpinia pallida	0	0,1	+	0	0	0
Macrodiprion nemoralis	0	0	+	0	0	0
Exoteleia dodecella	0	0	1,6	0	0	0
Archips oporanus	0	0	0,1	0	0	0
Petrova resinella	0,1	2,6	4,3	0,3	1,4	4,8
Blastesthia+Rhyacionia	0,8	3,6	9,2	0,5	2,4	2,8
Dioryctria mutatella	0	0,1	0,6	0	0	0
D. splendidella	0	0	0,1	0	0	0,8
Orgyia recens	0	0	0,1	0	0	0
Voles, *Myyrät*	5,1	1,2	4,4	1,3	0,1	0
Moose, *Hirvi*	2,0	2,6	6,9	0,3	1,8	6,8
Gremmeniella abietina	11,3	12,4	1,9	0,5	4,2	0,8
Melampsora pinitorqua	0	0	0	77,4	39,4	40,0
Phacidium infestans	6,3	4,3	11,2	19,2	2,1	17,2
Chlorosis, *Kloroosi*	1,3	1,1	0	0	0,3	0
With several stems *Monirunkoinen*	6,1	4,1	3,6	36,1	9,2	3,2

between different geographical races of lodgepole pine in southern and central Finland because the provenances had not been planted side-by-side at the same site. However, no large differences were apparent in the overall condition of the living trees (Table 7). No exact information about the total mortality during the years after planting was obtained. The average density of the trees on the sample plots is the only fact indicating the survival rate of different provenances. On the average, there were 1563 trees per hectar in southern Finland and 1502 in central Finland in the last year of the survey. The proportion of plantations with less than 1300 trees/ha was 14,3 %. Considering that in most cases 2000 seedlings had been planted per hectar, the average mortality was roughly estimated as 22 % in southern Finland and 25 % central Finland. However, there was considerable variation in density between sample plots and between different plantations. Bearing in mind that there might be wildings among the Scots pines, there were no drastic difference in survival between lodgepole pine and Scots pine.

There was great variation in the number of dead trees as well as in the average tree density between different lodgepole pine provenances in northern Finland (Table 7). These values are not fully comparable with

Table 5. Occurrence of different damaging agents (infested trees) in young lodgepole pines and Scots pines in northern Finland.
Taulukko 5. Eri tuhonaiheuttajien ja vikojen esiintymisrunsaus (prosentteina tutkituista taimista) kontortamännyn ja kotimaisen männyn taimikoissa Pohjois-Suomessa.

Damaging agent	Tree species — *Puulaji*					
	Pinus contorta			*Pinus sylvestris*		
	Year — *Vuosi*					
Tuhonaiheuttaja tai vika	1978	1979	1980	1978	1979	1980
	%					
Aphids, *Kirvat*	0,1	+	0	2,1	0,9	0
Hylobius spp.	0,2	0	0	0	0	0
Pissodes spp.	0	+	0	0,3	0,1	0
Tomicus piniperda	0	0,1	0,5	0	0	0
Pityogenes spp.	0	0,1	0	0	0	0
Neodiprion sertifer	0,1	0,1	0	0	0	0
Petrova resinella	0,6	1,1	0,5	0,3	0,9	0,3
Blastesthia+Rhyacionia	0	0,5	2,7	0	0,3	1,5
Voles, *Myyrät*	20,1	12,1	5,5	5,6	1,0	0
Moose, *Hirvi*	2,3	1,8	1,0	2,7	3,2	0,3
Gremmeniella abietina	23,9	7,7	0,6	6,4	1,3	0
Melampsora pinitorqua	0	0	0	16,4	14,9	0
Phacidium infestans	23,4	14,3	16,0	40,8	28,0	18,0
Chlorosis, *Kloroosi*	3,7	3,8	5,5	0	2,0	0,3
Frost damage, *Pakkastuho*	6,5	20,2	30,3	0	5,3	3,5
Snow damage, *Lumituho*	0	1,1	6,6	1,1	1,3	1,0
With several stems, *Monirunkoinen*	16,1	12,0	13,8	22,5	14,8	13,7
Crooked stem, *Mutkarunkoinen*	1,8	8,8	8,8	4,6	4,4	3,0

Table 6. Mortality of young lodgepole pines caused by different agents.
Taulukko 6. Eri tekijöitten aiheuttama kontortamäntyjen kuolleisuus.

Damaging agent	Southern Finland *Etelä-Suomi*			Central Finland *Keski-Suomi*			Northern Finland *Pohjois-Suomi*		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Tuhonaiheuttaja	Mortality, % — *Kuolleisuus, %*								
Hylobius spp.	2,3	0,4	0,4	+	0,1	0,1	0	0,1	0
P. resinella	0,1	0	0	0	0	0,1	0	0	0
Voles, *Myyrät*	0	0,8	0,8	1,0	0,2	0,5	4,5	2,1	2,5
Moose, *Hirvi*	0	0	0,6	0	0,1	0,2	0	0,1	+
P. infestans	0	0	0	1,2	0,4	1,3	5,2	0,7	0,9
G. abietina	0	0	0	0,8	1,2	0,1	2,0	3,9	0,5
A. mellea	0	0	0,1	+	0	0	0	0	0
Frost heaving, *Rouste*	0	0	0	0	+	+	0,1	0,3	0,1
Excess moisture, *Liika kosteus*	0,7	4,1	0	0	+	0	0	0	0
Frost, *Pakkanen*	0	0	0,2	0	0	0,2	0	0,1	1,0
Unidentified, *Tunnistamaton*	0,2	1,1	0,1	2,3	0,5	0,3	2,1	9,2	13,0
Total *Yhteensä*	3,3	6,4	2,2	5,4	2,6	2,8	13,9	16,6	18,1

Table 7. Number of trees per hectar and frequency distribution of young trees into condition classes in the different provenances of lodgepole pine and in the local provenances of Scots pine.
Taulukko 7. Taimien lukumäärä hehtaarilla ja jakaantuminen kuntoluokkiin eri alkuperää olevissa kontortamännyn ja paikallista alkuperää olevan kotimaisen männyn viljelmissä.

Provenance	No. of trees/ hectar	Year — *Vuosi*								
		1978			1979			1980		
		Condition class — *Kuntoluokka*								
Alkuperä	*Taimia kpl/ha*	1	2	3	1	2	3	1	2	3
		%								
Southern Finland — *Etelä-Suomi*										
Prince George	1585	92,1	6,1	1,8	86,3	12,8	0,9	81,8	14,4	3,8
Stuart Lake	1373	95,1	2,8	2,1	45,9	38,4	15,7	87,6	10,8	1,6
Dog Creek	1301	84,2	8,1	7,7	61,4	34,3	4,3	74,7	24,7	0,6
Alaska Highway Mile 81—83	1993	98,0	2,0	0,0	90,4	9,6	0,0	—	—	—
P. sylvestris	1790	92,4	5,0	2,6	69,2	29,8	1,0	76,3	22,6	1,1
Central Finland — *Keski-Suomi*										
Falkland	1325	77,2	21,7	1,1	70,7	28,5	0,8	94,6	4,5	0,9
Prince George	1490	71,2	28,8	0,0	95,1	4,9	0,0	83,2	16,0	0,8
Gwillim Lake	1660	68,3	24,4	7,3	69,7	24,7	5,6	77,4	17,9	4,7
Nation River	1456	71,3	24,1	4,6	82,9	15,0	2,1	78,0	18,7	3,3
Moberly Lake	1514	64,4	26,4	9,2	87,2	12,8	0,0	86,6	12,6	0,8
Alaska Highway Mile 81—83	1832	100,0	0,0	0,0	97,1	2,9	0,0	96,7	3,3	0,0
Wonowon	1237	83,3	16,7	0,0	92,3	7,7	0,0	83,5	16,5	0,0
P. sylvestris	1653	28,7	67,0	6,3	67,6	29,9	2,5	84,0	15,6	0,8
Northern Finland — *Pohjois-Suomi*										
Gwillim Lake	1249	39,7	50,0	10,3	27,3	65,9	6,8	61,0	34,8	4,2
Wonowon	941	49,3	31,0	19,7	43,8	30,8	25,4	50,7	26,0	23,3
Summit Lake	1186	40,2	41,8	18,0	50,9	37,4	11,7	45,7	33,5	20,8
Testa River	1303	58,7	32,3	9,0	60,8	29,5	9,7	57,1	30,6	12,3
Muncho Lake	1351	46,2	35,5	18,3	48,5	38,5	13,0	51,2	30,4	18,4
4—4,5 miles SE Cottonwood River Bridge	1971	84,9	15,1	0,0	65,5	18,0	16,4	87,5	10,7	1,8
Atlin Magnussens Road	2045	84,1	11,4	4,5	64,2	26,4	9,4	65,5	29,3	5,2
Lower Post Mile 624	1248	61,2	30,0	8,8	56,3	36,1	7,6	58,6	24,0	17,4
Kalder Lake	823	41,2	47,0	11,8	42,9	28,5	28,5	25,8	38,7	35,5
Wenthworth Creek Road	448	45,5	18,2	36,6	53,3	13,3	33,4	41,2	17,6	41,2
Mount Watt	1820	82,0	14,0	4,0	76,1	19,6	4,3	85,4	14,6	0,0
Swan Hills	599	37,0	40,7	22,3	18,2	30,3	51,5	14,8	48,2	37,0
Cypress Hills	250	31,8	31,8	36,4	13,3	20,0	66,7	22,2	22,2	55,6
Ethel Lake	1659	87,8	10,2	2,0	83,9	11,5	4,6	95,6	2,2	2,2
Takhini River	1451	60,2	32,7	7,1	61,3	34,0	4,7	65,9	25,9	8,2
Francess Lake	1846	87,8	10,2	2,0	83,3	16,7	0,0	83,6	14,6	1,8
Carmacks	1729	74,5	22,4	3,1	73,4	23,4	3,2	73,4	19,9	6,7
Annette Airfield	0	0,0	33,3	67,7	0,0	0,0	100,0	0,0	100,0	0,0
Petersburg	113	0,0	60,0	40,0	0,0	33,3	66,7	0,0	23,1	76,9
Sitka	50	11,8	58,8	29,4	0,0	39,1	60,9	0,0	6,7	93,3
Skagway	374	8,7	47,8	43,5	5,9	52,9	41,2	0,0	60,0	40,0
Yakutat	150	14,8	37,0	48,2	0,0	33,2	66,7	0,0	26,3	73,7
P. sylvestris	1367	48,8	38,9	12,3	60,5	27,5	12,0	83,0	13,7	3,3

each other since every provenance was not represented in all the trials. Furthermore, the original planting density was not exactly the same, but varied from 2000 to 2500 seedlings/ha in the different trials. Nevertheless, Table 7 clearly shows that the survival of some provenances was much higher than that of others'. The provenances with a density of more than 1500 trees/ha can be concidered to have thrived satisfactorily.

Statistical comparisons between lodgepole pine provenances and Scots pine could be made with those trials in northern Finland where the different provenances had been planted on the same site. The occurrence of some pests in six different provenances and a local provenance of Scots pine in six replicates were compared (Table 8). In most cases the differences were small, without any statistical significance. However, the trees of "Carmacks" origin and local Scots pine were not damaged by voles as severely as other provenances. Owing to the great variation between the different trials, "Carmacks" and Scots pine differed significantly (at 5 % level, Duncan's multiple range test) only from "Muncho Lake" and "Summit Lake" provenances, which were most severely affected. Scots pine was infested more intensively by *Phacidium infestans* than any of the lodgepole pine provenances, although the difference was not statistically significant.

When all the provenances tested in northern Finland are compared, it can be seen that the following provenances have survived better than the others: all the provenances from Yukon territory, "Mount Watt" from Alberta, "Atlin Magnussens Road" and "4 — 4,5 miles SE Cottonwood River Bridge" from British Columbia. Provenances from the Alaska coastal area and southern provenances from Alberta and British Columbia have suffered the most.

33. Older stands

Most of the older lodgepole pines at Punkaharju were infested by the European pine sawfly, *Neodiprion sertifer* (Geoffr.), and the pine cone weevil, *Pissodes validirostris* (Table 9). In addition, *Tomicus piniperda* (L.), *Petrova resinella* and *Panolis flammea* were relatively common. Significant differences occurred between different provenances in

Table 8. Frequency of the most serious pests (infested trees) in some provenances of lodgepole pine and local provenances of Scots pine in northern Finland in 1978—80.

Taulukko 8. Tärkeimpien tuhonaiheuttajien ja vikojen esiintymisrunsaus (prosentteina tutkituista taimista) eräissä kontortamännyn alkuperissä ja pohjoissuomalaista alkuperää olevassa kotimaisessa männyssä Pohjois-Suomessa vuosina 1978–80.

Damaging agent	Provenance — *Alkuperä*						
	Summit Lake	Testa River	Muncho Lake	Lower Post M	Takhini River	Carmacks	P.sylvestris
Tuhonaiheuttaja tai vika	%						
Petrova resinella	0,9	0,3	1,4	0,6	1,4	0,3	0,6
Blastesthia + *Rhyacionia*	0,0	1,0	0,2	0,7	2,1	1,2	0,6
Voles, *Myyrät*	29,6	20,8	37,4	21,8	22,3	6,7	1,9
Moose, *Hirvi*	0,0	0,0	1,6	0,9	3,8	2,3	2,3
G. abietina	4,6	4,1	8,3	5,2	8,0	3,2	2,3
P. infestans	14,2	21,3	21,3	14,5	20,1	10,6	35,4
Chlorosis *Kloroosi*	3,5	5,4	5,4	5,3	7,6	5,8	1,0
Frost damage *Pakkasvaurio*	24,5	31,3	24,5	21,0	17,0	26,5	3,4
With several stems *Monirunkoinen*	15,9	11,7	18,9	14,5	14,5	12,0	16,5
Crooked stem *Mutkarunkoinen*	5,3	9,7	6,9	8,6	6,9	9,2	4,1

Table 9. Occurrence of some pest insects in a mature lodgepole pine stand at Punkaharju in 1980.
Taulukko 9. Eräiden tuhohyönteisten esiintymisrunsaus varttuneessa kontortamännikössä Punkaharjulla v. 1980.

Provenance *Alkuperä*	No.of trees *Puita kpl*	No.of branches *Oksia kpl*	No.of cones *Käpyjä kpl*	Insect species — *Hyönteislaji* *T.pini-perda*	*N.ser-tifer*	*P.resi-nella*	*P.flam-mea*	*P.vali-dirostris*
				Samples infested, % — *Esiintyi näytteissä, %*				
Alberta:								
Red Deer River	8	72	145	1,4	51,4a	6,9	0,0	61,4ab
Cypress Hills	8	72	265	1,4	13,9b	2,8	4,2	69,8a
Olds	24	216	383	3,7	50,5a	12,5	0,9	61,6ab
Spirit River	10	90	82	8,5	47,2ab	6,9	2,8	23,2b
Br. Columbia:								
Nicola Forest	40	360	528	7,8	32,2ab	6,1	3,3	29,5b
Mount Ida	8	72	166	0,0	34,7ab	11,1	4,2	36,1ab
Salmon Arms	16	144	184	6,3	38,9ab	6,8	4,2	30,4b
Upper Hat Creek	13	117	125	4,6	45,4ab	7,4	0,0	38,4b
Long Lake	25	225	268	7,4	33,8ab	5,6	4,2	52,2ab
Total/Average *Yht./Keskimäärin*	152	1368	2146	5,6	38,2	6,9	2,8	46,1

Percentages followed by the same letter are not significantly different at the 1% level according to Duncan's multiple range test.
Prosenttiluvut, joiden jäljessä on sama kirjain, eivät eroa merkitsevästi toisistaan (P>0,01).

the number of larval colonies of *N. sertifer* (F = 2,950**) as well as in the proportion of cones infested by *P. validirostris* (F = 5,288***). The number of larval colonies in the "Cypress Hills" provenance was significantly smaller than that in other provenances. On the other hand, the proportion of infested cones was highest in this provenance. Other insect species found feeding on lodgepole pine foliage were *Diprion pini* (L.), *D. virens* (Klug), *Sphinx pinastri* L. and *Brachonyx pineti* (Payk.). Larval tunnels of a cerambycid, *Pogonochaerus fasciculatus* (Deg.) occurred abundantly on dead lower branches. Adults of a weevil, *Magdalis duplicata* Germ., were occasionally found feeding on shoots.

Insects on trees of "Spirit River" (Alberta) origin were surveyed at Rovaniemi, in northern Finland. The occurrence of different insects was very low; only four larval colonies of *N. sertifer* and two galls of *P. resinella* were recorded. Observations on insects on lodgepole pine were written down in connection with investigations on the biology of *Pissodes validirostris* (Annila 1975). Adults of a bug, *Aradus cinnamomeus* Panz., *Pogonochaerus fasciculatus, Strophosoma capitatum, Brachyderes incanus* and *Pissodes pini* (L.) gathered in great numbers beneath the tanglefoot bands which were used for collecting the adults of *Pissodes validirostris* on lodgepole pine trunks. *Pogonochaerus fasciculatus* was caught in early May, the other species in late May or early June. Larvae of *Dioryctria mutatella* Fuchs were found to be common in cones in late summer. In late autumn full-grown larvae of a geometrid, *Bupalus piniarius* (L.), dropped into the plastic funnels which were set up in lodgepole pine stands for the capture of *Pissodes validirostris.* Some larvae of the moths, *Dasychira pudibunda* (L.) and *Dendrolimus pini* (L.) were also found on lodgepole pine foliage, the former only at Punkaharju.

The occurrence of insects feeding in bark was studied in southern Finland in three lodgepole pine stands weakened by defoliation of *N. sertifer.* An approximately 50-year-old stand at Urjala (Nuutajärvi) was

heavily defoliated by sawflies in the middle of the 1970s, resulting in the death of a considerable number of trees. Other stands situated at Ruovesi (Siikakangas) and Lammi (Evo) were attacked by sawflies in the beginning of the 1980s. No information about the origin of the trees was available. The following bark beetles had attacked the trees: *Tomicus piniperda, Hylurgops palliatus* (Gyll.), *Trypodendron lineatum* (Oliv.), *Pityogenes chalcographus* (L.), *Ips typographus* (L.), *I. duplicatus* (Sahlb.), and *I. amitinus* (Eichh.). *P. chalcographus* and *I. amitinus* were the most common species occurring along the whole trunk. Other scolytids were found only occasionally. Larvae and pupal cells of *Pissodes pini* occurred abundantly in the lower part of most trees (Fig. 3). At Ruovesi the base of many trees was occupied by the larvae of a cerambycid, *Acanthocinus aedilis* (L.). Reproduction of bark beetles seemed to be very low, while the offspring of *P. pini* and *A. aedilis* had survived well.

The base of the trunk had been attacked by insects, most trees still having green foliage and sound phloem on the upper part even one year after the insect attack. It is likely that the heavy defoliation by sawfly larvae reduced the general vigour of the trees to a level where the trees became susceptible to the attack of trunk infesting species.

Fig. 3. Defoliation by *Neodiprion sertifer* and attack by bark insects resulted in the death of lodgepole pines. Photo M. Varama.

Kuva 3. Ruskean mäntypistiäisen ja kuoren alla elävien hyönteisten tappamia kontortamäntyjä. Kuva M. Varama.

34. Timber

Approximately the same insect fauna occurred in fresh lodgepole pine timber and windthrown trees as in the trunks of dying standing trees (Table 10). Most logs were attacked by *Pissodes pini, Tomicus piniperda, Hylurgops palliatus, Trypodendron lineatum, Pityogenes chalcographus, P. quadridens* (Hart.) and *Ips amitinus.* The ratio between the numbers of *P. chalcographus* and *P. quadridens* was 20:1 in timber and 10:1 in windthrown trees. The occurrence of *Tomicus minor* (Hart.), *Dryocoetes autographus* (Ratz.), *Ips typographus,* and *Orthotomicus proximus* (Eichh.) was, occasional. Excluding *Pityogenes,* the average attack intensity, i.e. the bark area infested and number of egg galleries per square metre, was low. The upper side of the logs and trunks lying on the ground were occupied by *Pityogenes* and *I. amitinus,* the under sides by *H. palliatus* and *P. pini.*

No great difference could be found between lodgepole pine and Scots pine as regards those species which originally breed on Scots pine, such as *P. pini, T. piniperda,* and *T. minor.* The species, *H. palliatus, T. lineatum, I. amitinus,* and *O. proximus,* wich can also breed in Norway spruce, were more numerous in lodgepole pine.

The total number of offspring including larvae, pupae and young adults per egg gallery, was moderate apart from *Pityogenes* and *Dryocoetes,* the reproduction of which was low. However, the production of new adults appeared to be average only in *P. pini, H. palliatus* and *I. amitinus.*

Timber was attacked at Bromarv by the following insects: *Rhagium inquisitor* (L.), *Acanthocinus aedilis, P. pini, Hylastes brunneus* Er., *P. chalcographus, I. typographus,* and *O. proximus.* The number of

Table 10. The occurrence and brood production of bark insects in lodgepole pine and Scots pine at Punkaharju (P) and Ruotsinkylä (R). A=lodgepole pine timber, B=windthrown lodgepole pines; C=Scots pine timber.

Taulukko 10. Puutavarassa elävien hyönteisten esiintyminen ja lisääntyminen kontortamännyssä ja kotimaisessa männyssä Punkaharjulla (P) ja Ruotsinkylässä (R). A=kontortamäntypuutavara, B=tuulen kaatamat kontortamännyt, C=mäntypuutavara.

Species *Laji*	Breeding material *Lisääntymismateriaali*	Samples infested, % *Esiintymisrunsaus, %*		Bark area infested, % *Peittävyys, %*		No.of attacks/m² *Syömäkuv./m²*		No.of offspring/attack *Jälkeläisiä/syömäkuvio*	
		P	R	P	R	P	R	P	R
Pissodes pini	A	60,0	58,2	7,6	8,9	8,0	7,1	2,2	0,0
	B	54,2	—	15,0	—	8,1	—	4,7	—
	C	76,7	—	8,5	—	10,0	—	3,3	—
Tomicus piniperda	A	50,0	0,0	8,4	0,0	2,5	0,0	7,2	0,0
	B	10,4	—	10,0	—	0,9	—	10,0	—
	C	26,7		10,6	—	1,5	—	0,8	—
Tomicus minor	A	+	0,0	+	0,0	+	0,0		0,0
	B	4,2	—	10,0	—	0,2	—	28,8	—
	C	6,7	—	3,5	—	0,2	—	0,0	—
Hylurgops palliatus	A	80,0	56,0	20,0	11,1	10,2	21,3	8,7	1,7
	B	22,9	—	1,0	—	0,3	—	10,7	—
	C	0,0	—	0,0	—	0,0	—	0,0	—
Dryocoetus autographus	A	20,0	0,0	1,0	0,0	0,4	0,0	0,0	0,0
	B	4,2	—	1,0	—	0,1	—	0,0	—
	C	0,0	—	0,0	—	0,0	—	0,0	—
Trypodendron lineatum	A	80,0	0,0	—	—	11,8	—	—	—
	B	0,0	—	—	—	0,0	—	—	—
	C	0,0	—	—	—	0,0	—	—	—
Pityogenes ssp.	A	22,0	85,1	6,2	33,7	2,1	16,8	3,5	1,9
	B	72,9	—	45,0	—	68,3	—	1,1	—
	C	46,7	—	6,8	—	11,8	—	0,6	—
Ips amitinus	A	45,0	64,9	13,2	8,2	6,4	11,5	10,6	3,0
	B	60,4	—	13,7	—	6,0	—	13,7	—
	C	0,0	—	0,0	—	0,0	—	0,0	—
Ips typographus	A	0,0	13,4	0,0	32,0	0,0	21,7	0,0	3,7
	B	0,0	—	0,0	—	0,0	—	0,0	—
	C	0,0	—	0,0	—	0,0	—	0,0	—
Orthotomicus proximus	A	13,3	0,0	1,5	0,0	0,8	0,0	10,0	0,0
	B	2,1	—	5,0	—	0,1	—	0,0	—
	C	0,0	—	0,0	—	0,0	—	0,0	—

Acanthocinus larvae was high, on the average 27,5 larvae/m², in some logs even 53 larvae/m². Many adults emerged from the logs stored in plywood boxes the following summer. The larvae of *Rhagium* were small and no evidence of development into adults could be found. Some of the *Pissodes* specimens had reached the pupal stage on August 22, and several adults emerged from the logs during the next summer. Parent beetles and egg galleries of *H. brunneus* occurred in most logs, but no larval tunnels could be found. Egg galleries of *P. chalcographus* and *I. typographus* were without progeny but reproduction of O. *proximus* had been successful since several teneral adults were found. Tree crowns left on the ground after cutting had been attacked by *I. amitinus* and *P. quadridens*, producing adults of a new generation.

4. DISCUSSION

Hylobius weevils appeared to be the most serious insect pest on lodgepole pine seedlings during the first summer on reforestation areas. However, the results of the present study indicate that there is no significant difference between lodgepole pine and Scots pine as regards the susceptibility to *Hylobius* if the seedlings are treated with lindane just before planting. The results agree with the studies made using untreated seedlings by Lindelöw (1975) in Sweden. The risk of *Hylobius* damage on Scots pine is known to be low in northern Finland (e.g. Heikkilä 1981, Långström 1982) and there is nothing to indicate that it would be higher on lodgepole pine. Several other insect species may feed on lodgepole pine but they seldom kill seedlings. In Sweden the adult weevils of *Strophosomus rufipes* Steph. (= *Strophosoma capitatum* (Deg.)) have occurred abundantly on the foliage of seedlings (Lindelöw 1975), but the species was found only occasionally when the present study was carried out.

Many insect species originally feeding on Scots pine are also able to feed on young lodgepole pines; the foliage, shoots or buds. However, no species appears to be more numerous on lodgepole pine; aphids were even more scarce. The number of insects generally appeared to be low without any fatal consequences for the young trees. In northern Sweden, on the other hand, current year needles of young lodgepole pines were found to be heavily attacked by a weevil, *Anthonomus varians* (= *A. phyllocola* (Herbst.)) (Karlman 1979). In Denmark and Sweden young trees had been heavily attacked by *Rhyacionia buoliana* (Den. & Schiff.) (Bejer-Petersen and Esbjerg 1972, Eidmann 1982) but in Finland this moth is known to be rather scarce (Bakke 1969).

Severe defoliation by the European pine sawfly (*Neodiprion sertifer*) may be fatal to older lodgepole pines. After two years damage the vigour of the trees is sufficiently reduced to allow attack by trunk infesting insects, and a considerable part of the trees may succumb. This insect is therefore to be regarded as the most harmful insect pest of lodgepole pine in Finland.

The larvae of another defoliator, the pine beauty moth (*Panolis flammea*), may also occur frequently on lodgepole pine foliage, but the danger of severe defoliation does not seem to be particularly high even though this moth has caused heavy damage and killed hundreds of hectars of *P. contorta* in Scotland (Stoakley 1977, 1979).

Almost all the cones may be destroyed by the pine cone weevil (*Pissodes validirostris*), as has been earlier reported (Annila 1975), but it does not represent any obstacle to the cultivation of lodgepole pine. Nevertheless, the possible effect of this insect must be taken into consideration in seed production.

Lodgepole pine timber does not seem to be especially good breeding material for bark beetles indigenous to Finland. Although the attack intensity of *Pityogenes chalcographus* may be high, the production of young beetles is mostly rather low. Similar results have been obtained in Sweden (Eidmann 1982). The reproduction of the most serious bark beetles, *Tomicus piniperda* and *Ips typographus* is also very low. Obviously several bark beetles are strongly attracted to lodgepole pine, but the chemical composition of the phloem or the physical characteristics of the bark are not very suitable for the development of the offspring. This is easily understood since lodgepole pine is an exotic tree species and bark beetles native to Finland have not adapted to living on it. On the other hand, the adults of *T. piniperda* do not seem to be able to differentiate between Scots pine and lodgepole pine when attacking young shoots. The species which originally breed in Scots pine and Norway spruce, such as *Hylurgops palliatus* and *Ips amitinus*, can also breed successfully in lodgepole pine, but these species are of only minor economic importance.

P. contorta seems to be a good host for *Pissodes pini* and *Acanthocinus aedilis* since the development from egg to adult takes place without difficulties and the number of new beetles may be quite high. However, these two species are to be considered as secondary pests because both of them breed only in weakened or dying trees, or in timber.

Voles represent a serious threat to young lodgepole plantations during peak years. The period when young trees are susceptible to vole attack is evidently rather long since seven-year-old plantations were severely damaged. Considering that the vole population tends to be high every fourth year in the same locality, lodgepole pines are likely to be exposed to vole attack at least twice before reaching the resistant age. In addition, voles seem to prefer lodgepole pine to Scots pine; a fact which has also been demonstrated in Sweden (Hansson and Boström 1979, Hansson and Lavsund 1982). Karlman (1982) stated that vole damage is the most serious threat to the cultivation of lodgepole pine in northern Sweden.

Besides voles, young lodgepole pine plantations may be seriously damaged by moose. The risk of damage seems to increase at least until the mean height of the trees is about three metres. Scots pine have been found to be damaged by moose when the height of trees varied from 0,5 to 2,5 — 3 metres (Kangas 1937). The results of the present study do not indicate that lodgepole pine would be more susceptible than Scots pine. On the contrary, Karlman (1979) has found in Sweden that moose prefer lodgepole pine to Scots pine. According to Hansson and Lavsund (1982), moose seem to browse on lodgepole pine less than on Scots pine but more often break the branches of lodgepole pine.

Evidently there is some risk of pathogenic fungi in young lodgepole pine plantations in southern Finland. The occurrence of *Gremmeniella abietina* and *Phacidium infestans* increased towards the north and these two pathogens were of great importance in northern Finland. *P. infestans* appeared to be slightly more abundant on Scots pine than on lodgepole pine. Roll-Hansen (1978) stated that lodgepole pine is considerably more resistant than Scots pine to this needle disease. According to the earlier records reviewed by von Weissenberg (1975), damage caused by *G. abietina* is not very common on lodgepole pine in southern Finland but may be a serious threat to the cultivation of this tree species. *P. infestans* was reported on lodgepole pine (von Weissenberg 1975) but no information about its economic importance in Finland is available. In Sweden, young lodgepole pines have been seriously infested by *G. abietina* whereas *P. infestans* has been considered as a minor pest (Martinsson 1978, Karlman 1979). The fact that lodgepole pine is highly resistant to *Melampsora pinitorqua* (Martinsson 1975, Roll-Hansen 1978, Karlman 1982) was confirmed in the present study.

There seems to be rather small differences in the resistance to various pests between the lodgepole pine provenances. However, in northern Finland at least, "Carmacks" appears to be more resistant against vole damage than trees from other localities. "Carmacks" originates from Yukon and was the northernmost of the provenances compared in the present study. Karlman (1982) reported that southern provenances had been more affected by voles than northern ones in Sweden.

It is possible that there are also some differences as regards insect resistance between various provenances. In Denmark, coastal provenances of lodgepole pine have been found to be attacked more frequently by *Rhyacionia buoliana* than inland provenances (Bejer-Petersen and Esbjerg 1972). Eidmann (1982) reported that some provenances may be more susceptible to *N. sertifer* than others. On the other hand, Stoakley (1979) did not find any difference due to provenance in the susceptibility of lodgepole pine to damage by *P. flammea.* The probability that resistance to several insects is high in the same provenance seems to be low. Evidently, the differences between individual trees are greater than those between provenances.

In northern Finland abiotic factors play a decisive role in the survival of lodgepole pine. Considerable differences are to be found between provenances as regards the overall condition or mortality of trees. In addition, trees suffering from frost, snow break, etc. are very susceptible to pathogens. Northern provenances (Yukon) have thrived much better than provenances of southern

origin.

Although many pests native to Finland may infest lodgepole pine, none of them seems to be so destructive that all the trees would be destroyed before reaching the mature stage. By selecting the most resistant trees and provenances for propagation, it will be possible to obtain sufficiently resistant strains for various part of Finland.

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SELOSTE

Kontortamännyn tuhot Suomessa

Johdanto

Tutkimuksen pääasiallisena tarkoituksena on selvittää, mitkä hyönteislajit esiintyvät kontortamännyn (*Pinus contorta*) tuholaisina ja kuinka suuren uhkan ne muodostavat tämän puulajin viljelylle Suomessa. Taimikoita inventoitaessa otettiin huomioon myös muiden eläinten ja sienitautien aiheuttamat tuhot sekä muut taimissa esiintyvät vioitukset. Tutkimuksen tarkoituksena on myös verrata kontortamännyn tuhonalttiutta kotimaiseen mäntyyn, minkä vuoksi aineistoa kerättiin myös viimeksi mainitusta puulajista. Tutkimus on osa yhteispohjoismaisesta kontortamännyllä esiintyviä tuhohyönteisiä selvittelevästä tutkimuksesta.

Aineisto ja menetelmät

Tutkimusaineisto kerättiin vuosina 1978—81 eri puolille Suomea perustetuista kontortamännyn taimikoista ja metsiköistä (kuva 1). Tutkimuksen kohteena olivat tuholaisten ja tuhojen esiintyminen alle 1-vuotiaissa taimikoissa, 1—10-vuotiaissa taimikoissa, noin 50 vuotta vanhoissa metsiköissä ja kontortamännystä valmistetussa puutavarassa. Alle 1-vuotiaat taimikot kuuluivat Metsäntutkimuslaitoksen vuonna 1981 perustamaan kontortamännyn kasvupaikkavaatimuksia sekä optimikasvatustiheyksiä selvittelevään tutkimukseen, johon vertailupuulajina kuului kotimainen mänty. Taimet tarkastettiin ensimmäisen kasvukauden jälkeen syksyllä. Siementen alkuperä oli Wonowon, Brittiläinen Kolumbia, Kanada. 1—10 vuotta vanhat taimikot oli perustettu eri puolille Suomea vuosina 1969—77, ja tähän ryhmään kuuluivat myös Pohjois-Suomeen perustetut alkuperäkokeet. Tietoja taimien alkuperästä ja taimikoitten rakenteesta on esitetty liitteissä 1 ja 2. Taimikoita tutkittaessa käytettiin linjottaista ympyräkoealamenetelmää. Taimet luokiteltiin kuntonsa puolesta kolmeen ryhmään: hyväkuntoiset, huonokuntoiset ja kuolleet, ja kaikki niissä esiintyneet tuhot ja vioitukset merkittiin muistiin. Vastaavat tutkimukset tehtiin männyntaimikoissa niissä paikoissa, joissa kumpaakin puulajia oli istutettu rinnakkain tai sekaisin.

Tuhohyönteisten esiintymistä varttuneissa kontortamännyissä tutkittiin kesällä 1980 Punkaharjulla ja Rovaniemellä (Kivalo). Metsiköt kuuluivat 1930-luvulla perustettuihin alkuperäkokeisiin. Näytteitä otettiin puiden latvuksista kolmelta eri korkeudelta kaksi kertaa kesässä. Puutavarassa lisääntyvien hyönteisten esiintymistä tutkittiin Punkaharjulla, Tuusulassa ja Bromarvissa. Tutkimuksen kohteena oli kaksi metriä pitkiä pölkkyjä ja tuulen kaatamia runkoja.

Tulokset

Ensimmäisen kesän aikana noin puolet kontortamännyn istutustaimista (käsitelty lindaanilla) joutui tukkikärsäkkäiden tuhojen kohteeksi mutta vain 20 % oli pahasti vioitettuja (taulukko 1). Kontortamännyn ja kotimaisen männyn välillä ei todettu merkitsevää eroa tuhojen määrässä tai laadussa. Muita taimia vioittavia hyönteisiä olivat: *Acantholyda hieroglyphica* (Chr.), *Pissodes pini* (L.), *P. castaneus* (Deg.), *Strophosoma capitatum* Deg., *Brachyderes incanus* (L.), *Magdalis violacea* (L.), *Rhyacionia duplana* Hb., *R. pinivorana* (Lien. & Zell.) ja *Blastesthia posticana* (Zett.). Myös hirvet olivat vioittaneet taimia ruokaillessaan istutusaloilla. Taimien kunnossa ja kuolleisuudessa ei todettu mitään merkittäviä eroja eri puulajien välillä (taulukko 2).

1—10 vuotta vanhoissa taimikoissa hyönteisiä tai niiden vioituksia esiintyi Etelä- ja Keski-Suomessa huomattavasti enemmän kuin Pohjois-Suomessa (taulukot 3, 4, 5). Hyönteistuhoilla ei kuitenkaan ollut missään mainittavaa taloudellista merkitystä. Myyrätuhoja sen sijaan esiintyi Pohjois-Suomessa selvästi enemmän kuin muualla mutta hirvituhot olivat yleisimpiä Etelä-Suomessa.

Taimikoissa tavatuista sienituhoista olivat yleisimmät ja tärkeimmät männynversosyöpä (*Gremmeniella abietina* (Lagerb.) Morelet) ja lumikariste (*Phacidium infestans* Karst.), joiden merkitys lisääntyi selvästi etelästä pohjoiseen. Pohjois-Suomessa esiintyi monissa taimikoissa myös pakkasvaurioita ja muita elottoman luonnon aiheuttamia vioituksia.

Taimien kuolleisuus oli Pohjois-Suomessa huomattavasti suurempi kuin Keski- ja Etelä-Suomessa (taulukko 6). Taimia olivat Pohjois-Suomessa tappaneet pääasiassa myyrät, versosyöpä ja lumikariste. Etelä-Suomessa kuolleita taimia tavattiin pääasiassa vain 1—3 vuotta vanhoissa taimikoissa, joissa taimet olivat kuolleet lähinnä tukkikärsäkkäiden vioituksiin. Vaikka Etelä- ja Keski-Suomessa taimien kunnossa ja kuolleisuudessa todettujen erojen merkitsevyyttä ei voitukaan testata ti-

lastollisin menetelmin aineiston hajanaisuuden vuoksi, erot eri kontortamäntyjen alkuperien samoin kuin kontortamännyn ja kotimaisen männyn välillä olivat vähäiset (taulukko 7). Keskimäärin kontortamännyn taimia oli hehtaarilla Etelä-Suomessa 1563 ja Keski-Suomessa 1502. Sen sijaan Pohjois-Suomessa eri alkuperien väliset erot taimien kunnossa olivat varsin huomattavia. Erilaisten tuhojen esiintymisessä ilmenneitä alkuperien välisiä eroja voitiin testata eräissä Pohjois-Suomessa sijaitsevissa kokeissa, joissa samoja alkuperiä oli istutettu useille eri paikkakunnille. Ainoastaan myyrien tekemissä tuhoissa todettiin joitakin merkitseviä alkuperien välisiä eroja siten, että "Carmacks"-alkuperässä, samoin kuin kotimaisessa männyssäkin, tuhoja oli merkitsevästi vähemmän kuin "Muncho Lake" ja "Summit Lake" alkuperissä. Lumikaristetta esiintyi kotimaisessa männyssä keskimäärin enemmän kuin kontortamännyssä mutta ero ei ollut kuitenkaan merkitsevä (taulukko 8). Kaiken kaikkiaan parhaiten olivat menestyneet seuraavat alkuperät: kaikki Yukonista peräisin olevat, "Mount Watt" Albertasta sekä "Atlin Magnussens Road" ja "4—4,5 miles SE Cottonwood River Bridge" Brittiläisestä Kolumbiasta. Eniten olivat kärsineet Alaskan rannikkoseudulta sekä Albertan ja Brittiläisen Kolumbian eteläosista kotoisin olevat taimet.

Varttuneissa kontortamännyissä yleisin hyönteistuholainen oli ruskea mäntypistiäinen (*Neodiprion sertifer* (Geoffr.) (taulukko 9), jonka tuhot eivät kuitenkaan olleet erityisen ankaria tutkimuksen kohteena olleissa metsiköissä. Kivalon kontortametsikössä tavattiin muutaman ruskean mäntypistiäisen toukkaryhmän lisäksi ainoastaan pihkakääriäistä (*Petrova resinella* (L.). Sen sijaan Ruovedellä (Siikakangas) ja Lammilla (Evo) sijaitsevissa metsiköissä ruskean mäntypistiäisen tuhot olivat kesällä 1981 niin ankaria, että huomattava osa puista kuoli. 1970-luvun puolivälissä esiintyi Urjalassa (Nuutajärvi) sijaitsevassa kontortametsikössä samanlaista tuhoa, jota edelsi voimakkaat mäntypistiäistuhot. Tuhon kohteeksi joutuneissa metsiköissä esiintyi kuitenkin sellaisia puita, jotka olivat lähes kokonaan säästyneet tuhoilta. Heikkokuntoisten ja kuolevien puitten runkoihin iskeytyi kaarnakuoriaisia, kärsäkkäitä ja jääriä (kuva 3).

Kontortamännystä valmistettuun puutavaraan ja tuulen kaatamiin puihin iskeytyi monia kotimaisessa männyssä ja kuusessa eläviä hyönteislajeja mutta niiden iskeytymistiheys ja lisääntyminen oli enimmäkseen vähäistä (taulukko 10).

Tulosten tarkastelu

Tutkimustulosten perusteella tukkikärsäkkäät ovat kontortamännyn taimien vahingollisimpia tuholaisia ensimmäisinä vuosina istutuksen jälkeen. Ilman suojaustoimenpiteitä tuhot saattavat olla varsin huomattavia. Tulokset eivät kuitenkaan viittaa siihen, että kontortamänty olisi näille tuhoille alttiimpi kuin kotimainen mänty.

Varttuneemmille taimille hyönteiset eivät näytä muodostavan mainittavaa tuhovaaraa. Sen sijaan myyrät, hirvet ja versosyöpä voivat aiheuttaa taimikoissa tuntuvaa taloudellista vahinkoa. Kuitenkin ainoastaan myyrätuhoille kontortamänty näyttää olevan, ainakin Pohjois-Suomessa, alttiimpi kuin kotimainen mänty.

Varttuneille kontortametsiköille ruskea mäntypistiäinen muodostaa vakavan uhkan, sillä puut eivät näytä kestävän paljaaksisyöntiä yhtä hyvin kuin kotimainen mänty. Puuyksilöiden välillä saattaa olla kuitenkin huomattavia eroja tuhoalttiudessa, mitä seikkaa voitaisiin mahdollisesti käyttää hyväksi kehitettäessä Suomen oloihin mahdollisimman hyvin soveltuvaa kontortamäntyä. Heikentyneitten puitten runkoihin iskeytyvillä hyönteisillä ei näytä olevan kovinkaan suurta merkitystä puitten kuolemisessa ja kontortamännystä valmistetussa puutavarassakin metsälle vaarallisten hyönteisten lisääntyminen on jokseenkin vähäistä.

Annila, E., Heliövaara, K., Puukko, K. & Rousi, M. 1983. Pests on lodgepole pine (*Pinus contorta*) in Finland. Seloste: Kontortamännyn tuhot Suomessa. Commun. Inst. For. Fenn. 115:1—27.

Appendix 1. Provenances of the young lodgepole pine stands.
Liite 1. Tutkimuksen kohteena olleiden kontortamännyn taimikoiden alkuperät.

No. of provenance, locality, seed code *Alkuperän no, paikkakunta, siementunnus*	Latitude *Leveys-piiri*	Altitude *Korkeus m*	Plantation locality *Viljelypaikkakunta*
Canada, British Columbia *Kanada, Brittil. Columbia*			
1. Falkland T3—71—138	50°40'	1000—1200	Keuruu, Varpaisjärvi
2. Wenthworth Creek Road G—69—017	50°58'	1020—1095	Kuusamo, Rovaniemi, Kolari
3. Prince George T3—71—312	53°40'	500—670	Loppi, Ruotsinpyhtää, Pyhtää Lappeenranta, Keuruu
4. Dog Creek T3—71—314	54°14'	830—1000	Karkkila, Lappeenranta
5. Stuart Lake T3—71—313	54°30'	770—930	Ruotsinpyhtää, Luumäki, Lappeenranta
6. Kalder Lake G—69—016	54°49'	945	Kuusamo, Rovaniemi, Kolari
7. Gwillim Lake T3—71—310	55°20'	830—1000	Rautavaara, Sotkamo, Rovaniemi, Kittilä
8. Nation River T3—71—311	55°31'	800—830	Kiihtelysvaara, Ilomantsi, Kaavi, Pihtipudas, Lieksa, Vieremä, Sotkamo
9. Moberly Lake T3—73—2	55°49'	1110—1390	Lieksa
10. Alaska Highway Mile 81—83 T3—71—308	56°37'	830—900	Rautavaara, Loppi
11. Wonowon	56°43'	—	Vieremä
12. Summit Lake G—69—027	58°39'	1265—1300	Pudasjärvi, Rovaniemi, Salla, Kittilä
13. Testa River G—69—025	58°40'	830	Pudasjärvi, Rovaniemi, Salla, Kittilä
14. Muncho Lake G—69—015	59°03'	930	Pudasjärvi, Kuusamo, Rovaniemi, Salla, Kolari, Kittilä
15. 4—4,5 miles SE Cottonwood River Bridge G—69—014	59°06'	865	Kuusamo, Rovaniemi, Kolari
16. Atlin Magnus-sens Road G—69—013	59°48'	830—890	Kuusamo, Rovaniemi, Kolari
17. Lower Post Mile 624 G—69—012	59°59'	700	Pudasjärvi, Kuusamo, Rovaniemi, Salla, Kolari, Kittilä
Alberta			
18. Cypress Hills G—69—020	49°38'	1450	Kuusamo, Rovaniemi, Kolari
19. Swan Hills G—69—019	54°19'	825	Kuusamo, Rovaniemi, Kolari
20. Mount Watt G—69—018	58°39'	760	Kuusamo, Rovaniemi, Kolari

Appendix 1. Cont.
Liite 1. Jatkoa

Yukon			
21. Takhini River G—69—011	60°41'	816	Pudasjärvi, Kuusamo, Rovaniemi, Salla, Kolari, Kittilä
22. Francess Lake G—69—010	61°10'	885	Kuusamo, Rovaniemi, Kolari
23. Carmacks G—69—008	62°14'	670	Pudasjärvi, Kuusamo, Rovaniemi Salla, Kolari, Kittilä
24. Ethel Lake G—69—007	63°18'	885	Kuusamo, Rovaniemi, Kolari
USA, Alaska			
25. Annette Airfield G—69—006	55°03'	35	Kuusamo, Rovaniemi, Kolari
26. Petersburg G—69—005	56°47'	15—30	Kuusamo, Kolari
27. Sitka G—69—004	57°04'	30	Kuusamo, Rovaniemi, Kolari
28. Skagway G—69—002	59°27'	0—70	Kuusamo, Rovaniemi, Kolari
29. Yakutat G—69—001	59°30'	30—70	Kuusamo, Rovaniemi, Kolari

Appendix 2. Main characteristics of the young lodgepole pine and Scots pine stands surveyed in 1978—80. Numbers of provenances are presented in Appendix 1.
Liite 2. Tietoja vuosina 1978–80 tarkastetuista kontortamännyn ja kotimaisen männyn taimikoista. Alkuperien numerot on esitetty liitteessä 1.

Locality *Paikkakunta*	No.of proven. *Alkuperän n:o*	Year of survey *Tutkim. vuosi*	Year of planting *Istutus-vuosi*	Area *Pinta-ala ha*	No. of trees *Taimia*			Mean height of trees *Taimien keski-pituus*	
					no. kpl	*per ha*	*S.E.*	*cm*	*S.E.*
Karkkila	4	1978	1976	3,5	89	1108	166,6	20	0,8
		1979	"	"	98	1001	80,6	38	2,4
		1980	"	"	125	1379	93,8	53	1,8
	sylv.	1979	—	—	21	1050	169,0	62	3,4
		1980	—	—	42	1576	157,9	98	3,4
Loppi	3	1978	1974	1,7	103	1915	193,6	81	2,7
		1979	"	"	107	2008	156,8	132	3,1
		1980	"	"	149	1839	77,3	156	3,0
	sylv.	1978	1974	5,0	109	1908	126,0	62	1,9
		1979	"	"	41	2052	224,9	111	4,2
		1980	"	"	43	2152	180,3	130	4,9
Loppi	3	1978	1975	2,5	199	2308	103,7	71	2,0
		1979	"	"	125	1973	185,2	105	4,0
		1980	"	"	138	2057	119,9	142	3,6
	sylv.	1978	1975	—	117	1919	136,8	60	1,4
		1979	"	—	31	1826	220,6	102	5,4
		1980	"	—	67	2169	233,5	124	8,1

Appendix 2. Cont.
Liite 2. Jatkoa

Ruotsin-	3	1978	1975	2,5	86	1291	95,2	50	1,9
pyhtää		1979	”	”	57	1089	144,8	79	3,1
		1980	”	”	56	1277	138,9	106	5,8
Ruotsin-	5	1978	1978	4,5	118	1688	67,1	17	2,8
pyhtää		1979	”	”	117	1079	118,0	36	6,7
		1980	”	”	72	1151	77,8	63	1,8
Pyhtää	3	1978	1974	3,0	115	1587	88,3	88	3,0
		1979	”	”	104	1487	70,2	130	3,8
		1980	”	”	126	1346	54,1	152	4,6
Luumäki[1)]	5	1978	1977	3,0	90	1226	142,3	36	1,1
		1979	”	”	140	1637	102,2	50	1,5
		1980	”	”	85	1561	138,1	81	2,7
	sylv.	1978	1977	3,0	72	—	—	27	1,3
		1979	”	”	91	—	—	38	2,2
		1980	”	”	32	—	—	70	4,8
Lappeen-[1)]	3	1978	1974	2,0	142	1583	102,1	98	6,6
ranta		1979	”	”	138	1707	134,7	151	3,3
		1980	”	”	76	1408	112,1	203	6,2
	sylv.	1978	”	”	78	—	—	74	4,1
		1979	”	”	63	—	—	132	7,4
		1980	”	”	33	—	—	207	7,5
Lappeen-	5	1978	1977	1,5	79	1542	151,9	34	1,0
ranta		1979	”	”	89	1519	101,3	58	1,7
		1980	”	”	90	1407	160,8	91	3,9
	sylv.	1978	1977	11,0	100	1942	157,4	28	1,0
		1979	”	”	78	1609	97,6	50	1,5
		1980	”	”	25	1252	163,0	69	4,4
Lappeen-	4	1978	1978	2,0	132	1580	128,3	15	0,4
ranta		1979	”	”	86	1233	124,6	18	0,9
		1980	”	”	58	1223	145,9	37	1,9
	sylv.	1978	1978	5,0	104	1668	159,6	18	0,5
		1979	”	”	89	1652	161,4	35	1,0
		1980	”	”	36	1802	219,3	42	2,0
Keuruu	1	1978	1973	3,5	55	934	96,8	101	4,6
		1979	”	”	93	1035	56,3	136	4,4
		1980	”	”	109	1285	68,3	161	4,2
	1	1978	1973	6,0	52	976	107,9	162	6,6
		1979	”	”	97	1005	94,6	178	4,6
		1980	”	”	93	1117	91,0	234	5,1
	1	1978	1974	5,0	85	1418	79,8	117	3,4
		1979	”	”	141	1387	116,0	161	3,3
		1980	”	”	131	1574	67,8	205	4,3
Keuruu	3	1978	1976	6,5	53	1014	125,3	10	0,8
		1979	”	”	66	781	101,1	16	2,1
		1980	”	”	125	1490	130,3	31	1,1
Kiihte-[1)]	8	1978	1972	2,2	112	1770	157,2	88	2,5
lysvaara		1979	”	”	134	1750	156,4	117	3,1
		1980	”	”	73	1422	123,6	145	2,9
	sylv.	1978	”	”	51	—	—	96	4,7
		1979	”	”	185	—	—	91	2,5
		1980	”	”	24	—	—	117	6,1
Ilomantsi	8	1978	1973	2,0	59	1363	178,6	101	3,1
		1979	”	”	98	1397	90,3	99	3,6
		1980	”	”	75	1482	115,3	136	5,3
	sylv.	1978	1973	1,0	28	649	264,8	79	3,2
		1979	”	”	71	1333	139,7	89	3,5
Ilomantsi	8	1978	1974	3,0	66	1239	195,6	92	3,5
		1979	”	”	113	1786	93,2	107	3,9
		1980	”	”	116	1393	77,3	137	4,8
Ilomantsi	8	1978	1977	3,0	39	1067	113,1	12	0,9
		1979	”	”	60	819	74,4	21	0,9
		1980	”	”	47	680	77,6	35	1,6
Ilomantsi	8	1978	1972	5,5	97	1468	116,2	159	3,9
		1979	”	”	150	1762	142,2	174	3,9
		1980	”	”	106	1872	132,6	238	6,0

Appendix 2. Cont.
Liite 2. Jatkoa

Ilomantsi	8	1978	1972	1,8	65	1330	171,6	146	5,0
		1979	”	”	88	1555	141,6	161	4,5
		1980	”	”	59	1652	128,5	196	6,9
Ilomantsi	8	1978	1972	1,8	65	1202	109,7	131	8,9
		1979	”	”	82	1351	155,9	145	5,1
		1980	”	”	59	1652	128,5	196	6,9
Kaavi	8	1978	1972	6,0	109	1559	121,9	78	5,3
		1979	”	”	99	1093	106,7	120	3,8
		1980	”	”	113	1571	138,3	145	7,1
Pihtipudas	8	1978	1972	13,0	58	954	134,4	125	6,1
		1979	”	”	150	1298	100,9	186	5,8
		1980	”	”	102	1514	68,2	231	6,4
	sylv.	1978	1972	—	84	1385	146,0	147	5,1
		1979	”	—	57	1711	110,1	182	5,6
		1980	”	—	55	1652	111,9	233	7,1
Varpais-	1	1978	1972	3,9	89	1040	166,4	77	5,3
järvi	sylv.	1978	—	—	118	1394	145,0	123	3,1
Lieksa	9	1978	1977	15,5	176	1257	89,8	24	0,9
		1979	”	”	211	1481	115,4	50	2,1
		1980	”	”	127	1514	125,6	76	2,5
Lieksa[1)]	8	1978	1977	5,0	85	1081	148,4	29	2,3
		1979	”	”	93	1162	98,7	44	2,5
		1980	”	”	46	1427	92,1	74	4,1
	sylv.	1979	”	”	52	—	—	58	2,4
		1980	”	”	50	—	—	85	3,2
Rauta-[1)]	10	1978	1975	2,5	65	1627	100,9	71	2,3
vaara		1979	”	”	102	1801	158,7	113	2,9
		1980	”	”	61	1832	113,6	162	4,6
	sylv.	1979	”	”	23	—	—	97	6,1
		1980	”	”	53	—	—	134	3,9
Rauta-	7	1978	1975	4,4	132	1976	92,7	69	2,0
vaara		1979	”	”	140	1976	124,3	71	6,1
		1980	”	”	115	1996	92,6	103	3,1
Rauta-	7	1978	1975	5,0	92	1318	128,8	73	2,8
vaara		1979	—	”	101	1801	175,5	92	2,9
		1980	”	”	67	1638	199,8	119	3,2
Rauta-	7	1978	1975	7,5	144	1468	149,8	69	6,0
vaara		1979	”	”	178	1502	124,0	84	2,0
		1980	”	”	160	1814	104,7	108	2,2
Rauta-	7	1978	1974	3,5	116	1652	118,3	89	2,5
vaara		1979	”	”	129	1976	106,0	103	2,9
		1980	”	”	92	1652	106,1	146	4,7
Vieremä	8	1978	1976	2,0	91	1537	154,2	10	0,5
		1979	”	”	91	1689	232,4	13	0,8
		1980	”	”	63	1241	130,6	21	1,4
Vieremä	8	1978	1976	3,0	87	1577	141,1	21	1,1
		1979	”	”	129	1817	184,2	29	1,2
		1980	”	”	76	1482	118,2	43	2,4
Vieremä	8	1978	1976	8,0	30	693	98,5	12	1,2
		1979	”	”	179	1572	167,7	22	0,6
		1980	”	”	162	1922	118,8	36	1,3
Vieremä	8	1978	1976	7,5	76	1141	98,9	18	1,5
		1979	”	”	79	818	112,4	28	2,0
		1980	”	”	109	1297	132,8	48	2,6
Vieremä	8	1978	1976	3,0	49	1073	124,8	11	1,1
		1979	”	”	67	1118	118,5	19	1,7
		1980	”	”	66	1302	112,2	34	1,9
Vieremä	8	1978	1977	9,5	71	889	96,5	8	0,3
		1979	”	”	145	1325	106,2	14	0,5
		1980	”	”	103	1237	103,0	25	1,5
Sotkamo	8	1978	1974	17,0	141	1114	94,7	86	2,3
		1979	”	”	223	1284	70,9	116	2,6
		1980	”	”	129	1418	103,3	172	4,1
Sotkamo	7	1978	1976	8,5	99	1090	101,5	12	0,6
		1979	”	”	117	1171	89,2	23	0,8
		1980	”	”	101	1201	60,1	43	1,5

Appendix 2. Cont.
Liite 2. Jatkoa

Pudas-[2]		1978	1971	8,3	288	—	—	157	2,9
järvi 12,13,		1979	”	”	258	—	—	175	3,3
14,17,21,23		1980	”	”	210	—	—	188	4,8
Kuusamo[2]		1978	1971	2,9	173	—	—	134	3,4
2,6,14—29		1979	”	”	157	—	—	166	3,5
		1980	”	”	148	—	—	170	4,2
	sylv.	1978	”	”	60	—	—	123	4,4
		1979	”	”	121	—	—	151	3,5
Rovaniemi[2]		1978	1971	5,0	127	—	—	151	3,4
2,6,12—25,27—29		1979	”	”	248	—	—	175	2,6
		1980	”	”	237	—	—	192	2,1
	sylv.	1980	”	”	18	—	—	171	2,9
Rovaniemi[2]		1978	1971	2,9	135	—	—	97	2,9
2,6,14—25,		1979	”	”	150	—	—	122	3,5
27—29		1980	”	”	123	—	—	145	3,5
Rovaniemi	7	1978	1975	7,0	68	1095	133,6	35	2,0
		1979	”	”	176	1220	62,8	50	9,3
		1980	”	”	164	1249	92,4	79	2,6
	sylv.	1979	1975	—	133	1313	66,5	37	3,3
		1980	”	—	179	1468	89,4	51	2,0
Rovaniemi	11	1978	1969	2,4	71	869	109,9	188	8,0
		1979	”	”	130	940	79,7	208	4,6
		1980	”	”	148	950	78,5	274	7,0
Salla[2]		1978	1971	4,6	173	—	—	145	2,9
12—14,17,		1979	”	”	365	—	—	165	2,1
21,23		1980	”	”	284	—	—	171	3,9
	sylv.	1978	”	”	96	—	—	107	3,0
		1979	”	”	135	—	—	145	3,7
		1980	”	”	9	—	—	150	3,2
Kolari[2]		1978	1971	2,9	310	—	—	146	5,1
2,6,14—29		1979	”	”	330	—	—	167	2,3
		1980	”	”	337	—	—	187	2,4
Kittilä[2]		1978	1971	4,2	182	—	—	99	2,5
12—14,17		1979	”	”	325	—	—	116	2,2
21,23		1980	”	”	385	—	—	145	2,3
	sylv.	1978	”	”	121	—	—	103	2,6
		1979	”	”	156	—	—	134	8,9
		1980	”	”	60	—	—	157	2,8
Kittilä	7	1978	1975	20,0	155	1147	74,5	37	5,8
		1979	”	”	180	535	51,7	37	1,2
		1980	”	”	165	425	70,6	35	2,2
	sylv.	1979	1975	—	95	1057	90,3	19	1,0
		1980	”	—	198	1377	77,1	32	1,0

1) mixed stand
sekataimisto

2) Provenance trial
Alkuperäkoe

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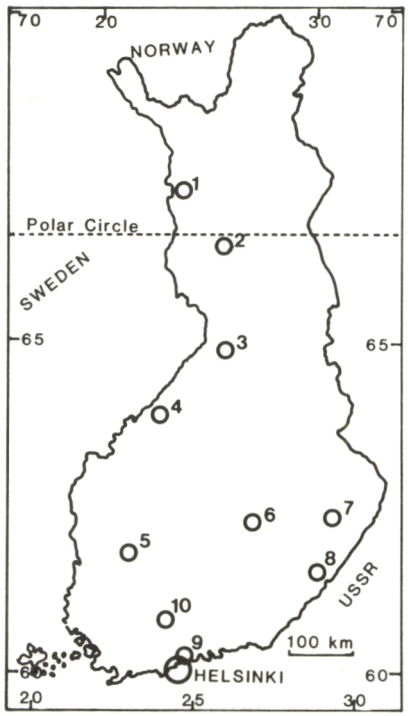

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RESEARCH STATIONS

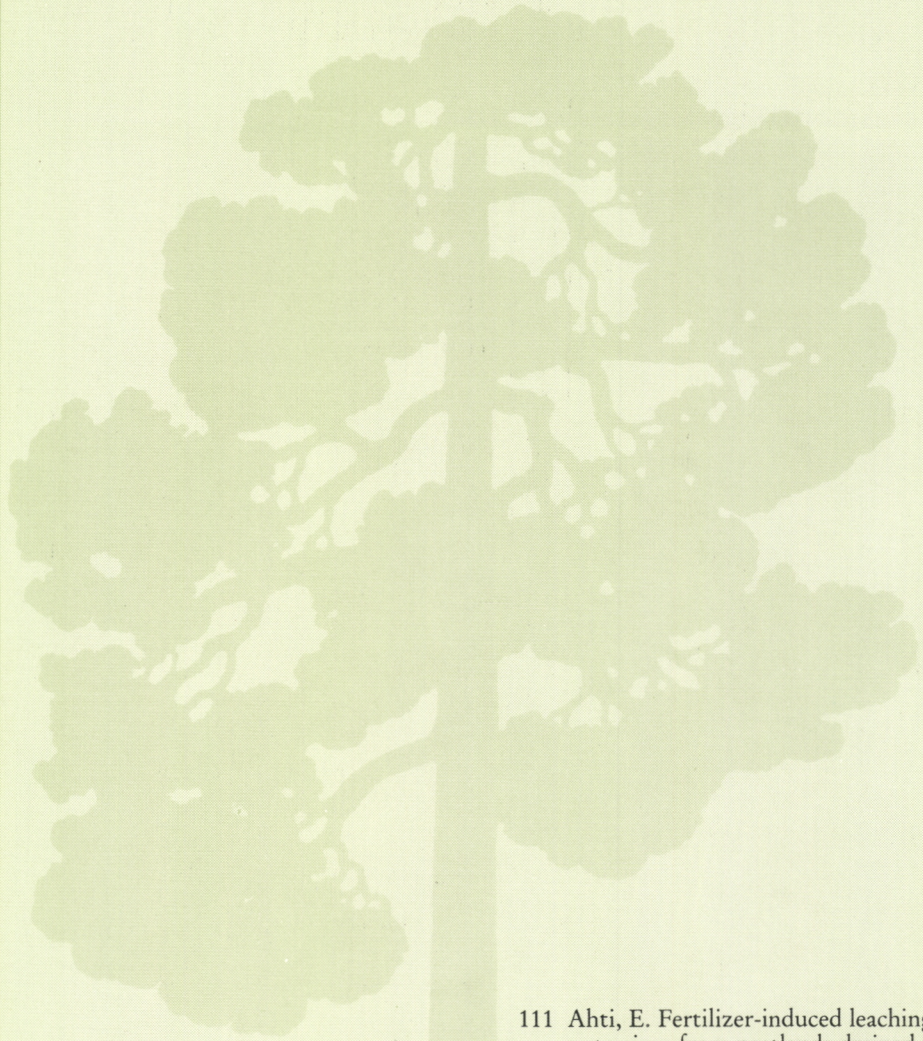
1 Kolari
2 Rovaniemi
3 Muhos
4 Kannus
5 Parkano
6 Suonenjoki
7 Joensuu
8 Punkaharju
9 Ruotsinkylä
10 Ojajoki

FACTS ABOUT FINLAND

Total land area: 304 642 km^2 of which 60—70 per cent is forest land

Mean temperature, °C:	Helsinki	Joensuu	Rovaniemi
January	-6,8	-10,2	-11,0
July	17,1	17,1	15,3
annual	4,4	2,9	0,8
Thermal winter (mean temp. <0°C):	20.11.—4.4.	5.11.—10.4.	18.10.—21.4.

Most common tree species: Pinus sylvestris, Picea abies, Betula pendula, Betula pubescens



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