A CANADIAN-SWEDISH SPECIES GENOTYPE ENVIRONMENT INTERACTION STUDY

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SUMMARY

An experimental series comprising a set of lodgepole and Scots pine improved materials, commercial lodgepole pine samples, Norway spruce and Sibirian larch has been established on five localities in Canada and two localities in Sweden. Height in the nursery and height, health and survival after the first three or four seasons in the field are presented in Figures. The results are presented on a provenance level, although there is a family structure in most provenances.

Keywords: Pinus sylvestris, Pinus contorta, Larix sibirica, Picea abies, Progeny test, Provenance test.

BACKGROUND

There are only two indigenous commercial conifers in Sweden; Scots pine (Pinus sylvestris L.) and the Norway spruce (Picea abies). The imported species lodgepole pine (Pinus contorta Dougl. var. latifolia) has become increasingly important the last decades. By late 1989 around 430 000 hectares have been planted with lodgepole pine. The planting peaked in 1984, when 40 000 hectares were planted. The forcasted annual planting in the next years is 23 000 hectares. Up to now, seeds from wild stands in BC and the Yukon have been used. However, plus trees have been selected, seed orchards established and the first plus tree crosses are being produced. In the autumn of 1987, 8.8 kg of seed was harvested in Swedish seed orchards, and in 1990 it is likely that around 25 kg will be harvested. Lodgepole pine seems superior to the native Scots pine regarding growth, survival and health in most Swedish environments (excluding the northwest). The reasons are poorly understood. Pathogens and pests constitute uncertain factors in introductions. More could be learnt about the mechanisms, benefits and risks of introduction by studying the introduction reciprocally. This paper gives a description of such an experiment and the first results.

Special features of the experiment are:
* Lodgepole pine and Scots pine are compared on areas where either one or the other is planted in its native habitat.
* Two additional species are included, but marginally.
* "Home-coming trees", offspring of Canadian trees which once emigrated to Sweden and set seeds, will now return to their original home in Canada.
* There are many "provenances" of both species. Conclusions on similarities and differences between the two economically significant pine species used in Sweden will thus be safer and more general, than for any other existing experiment.
* The experimental design is extremely flexible with lot of options for answering questions not yet phrased. It is a combined provenance and progeny test. It combines large plots with single tree plots.
* The serie offers possibilities to describe Canadian pathogens and pests on European trees, and thus it is a part of the "early warning system" which Sweden has installed to reduce risks connected with the large-scale introduction of lodgepole pine into Sweden.
* The species comparison is futuristic rather than historic. Improved materials of tomorrow are compared rather than wild populations of yesterday.
* It is the first planting of Swedish seed orchard progeny of lodgepole pine raised under experimental conditions. Thus, these are the first plants of a new type, the naturalised domesticated Pinus contorta (var suecica), which can be predicted to play a considerable role in the future economy and ecology of Sweden.
* The degree of cooperation and involvement in the experiment is large and multi-national. Hopefully, that will result in fruitful interfacing far beyond the experiment itself.

THE EXPERIMENT

Test materials and test localities are described in Tables 1 and 2.

Table 1. **Test Localities**

Name	Lat	Long	Alt	Plants	Inventories
Ft St James	54.45	124.03	855	3564	86, 88HD
Mackenzie	55.50	123.43	680	3582	86, 88H
Ft St John	56.53	122.22	800	4004	86, 88HD
Ft Nelson	59.00	123.20	600	4416	86, 88HD
Whitehorse	60.68	135.22	660	4224	86, 88H
Garsås (Mora)	60.93	14.88	205	4053	87, 89
Renberget(Umeå)	64.25	19.80	225	4373	87, 89HD

Comments and explanations: On the Ft St James site there are intentional activities to introduce Canadian pathogens into the site. Year of inventory is given. H means that height of all plants was measured, D means that diameter of the plants in block 5 was also measured. There is an additional small demonstration trial at Sävar, close to Umeå.

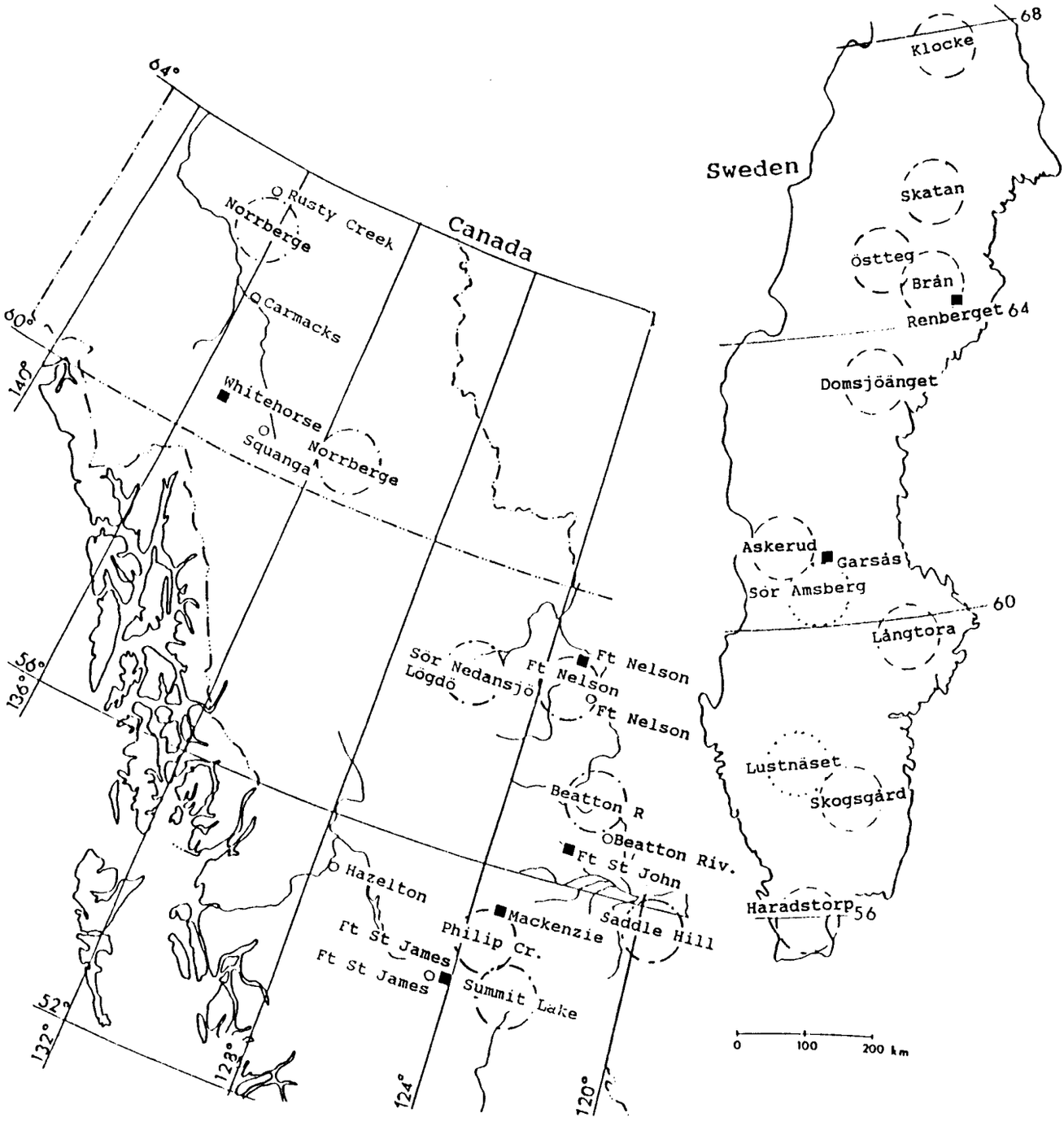
Table 2. **Test Materials**

Number	Description	Name	lat	long	alt
11- 18	Scots Full sibs	Haradstorp	55.95	13.82	52
21- 28	Scots Polycross	Skogsgård	57.57	15.07	208
31	Scots Orchard	Långtora	59.70	17.08	130
32	Scots Orchard	Askerud	61.10		460
33	Scots RTK9		60.04	15.36	212
41- 48	Scots Full sibs	Domsjöänget	63.33	16.86	242
51- 58	Scots Full sibs	Brån	64.54	19.16	219
61- 68	Scots Full sibs	Östteg	64.95	17.64	372
71- 78	Scots Full sibs	Skatan	65.91	19.63	334
81- 88	Scots Polycross	Klocke	67.79	20.74	432
101-104	Cont Open poll	Summit Lake	54.40	122.62	813
105-108	Cont Open poll	Philip Creek	55.05	123.50	1020
111-114	Cont Open poll	Beatton R	57.23	121.87	1010
115-118	Cont Open poll	Saddle Hill	55.73	119.67	825
121-136	Cont Full sibs	Sör Nedansjö	58.45	125.85	831
137-140	Cont Open poll	Ft Nelson	58.65	123.21	562
141-148	Cont Full sibs	Norrberge	60.58	131.23	816
151-158	Cont Full sibs	Norrberge	63.01	136.32	836
159	cont Stand	Ft St James	54.42	124.50	805
160	cont Stand	Hazelton	55.33	127.50	600
161	cont Stand	Beatton R	56.83	121.37	800
162	cont Stand	Ft Nelson	58.63	122.70	495
163	cont Stand	Squanga	60.50	133.75	792
164	cont Stand	Carmacks	62.07	135.70	569
165	cont Stand	Rusty Creek	63.50	136.57	760
166	Norway Orchard	Lustnäset	58		145
167	Norway Orchard	Sör Amsberg	60.6		270
168	Larix Orchard	Imatra	61.2	28.8	70

Comments and explanations:
* The material numbers are the same as used on field tags.
* Some provenances are composed of several materials, each material being a family. Then there is an array of material numbers in the Table.
* Origin refers to initial origin, thus not location of seed orchard. For material with parents of different origin, the average is calculated (using decimals for lat and long). For polycross it is the maternal average. Thus, to a varying extent there is a geographic variation around the mean for all materials except collections in Canadian stands.
* "Name" is the name of the seed orchard except for collections in Canadian stands.
* Norrberge and Sör Nedansjö are Swedish lodgepole pine seed orchards, there most parents of full sib groups are represented.
* Full sib and Polycross families are made by controlled crosses between grafts of selected plus trees.
* RTK refers to Full sib families used as standard checks in Sweden.
* Open pollination refers to seeds collected in Canadian stands from selected trees. At the Canadian sites, one of these samples can be regarded as "local" and is better represented.
* Stand refers to samples from commercial seed lots collected in Canadian stands.

* Orchard refers to commercial seed orchard harvests.
* All families are represented in other experiments in Sweden, which increases the number of potential future comparisons.
* Norway spruce did not germinate well in Canada. Therefore there were plants available only for a few plots in Canada and for use in block 5.
* Material 166. The Norway spruce seed orchard at Lustnäset is composed of 27 Swedish clones (average: lat 59.6, alt 145) and 23 continental clones (lat $<54^0$).
* Sibirian larch (no. 168 Larix sibirica) is represented in Canada only. It is a harvest from a Finnish second generation seed orchard. The origin refers to that of the seed orchard.

The locations of experimental sites (■) and origins of tested materials are shown in the map below. Most origins are composite which is demonstrated by circles.



Plant Production

In Canada the plants were raised 1985 in a nursery situated in Kamloops (lat 50.6) at Balco Reforestation Centre. In Sweden the seeding was done on May 23-24, 1985 at the nursery of the Faculty of Forestry, Umeå (lat 64.1, alt 15). The plants were propagated indoors until early July, when they were moved outdoors. The materials of southern origin was treated with prolonged nights after July 22, as the natural night length at Umeå is too short to get good hardening of southern material. Both Canadian and Swedish nursery stock were measured before planting (see Figure).

Experimental Design

The spacing is 2 x 2 m. The planting was done in spring and early summer 1986. There are five blocks on each locality. In blocks 1-4, origins (provenances) are typically represented by 8 x 8 square plots (4 replications of 64 plant plots). If an origin could be represented by individual families, there are (when possible) 8 different families within each origin. Each plot will then be composed of 8 seedlings from each of 8 families. However, because of the low number of seeds per cross, sometimes a higher number of families and a lower number of seedlings per family may occur. Within the 8*8 plot the families are planted at random. In addition, 64 plants of each origin are planted in single tree plots in block 5 (all entries are mixed at random). Some materials are more sparsely represented (e. g. origins which are evidently too southern or too northern for the site). Not fully represented origins may still have some representation in block 5. There are usually 3 border rows surrounding the experiment. These rows are less carefully managed.

RESULTS

Inventories made are listed in Table 1. The design of the experiment offers plenty of options for more complex analyses, but because of the low age of the experiment and space restrictions on this presentation, we will only make a rough presentation as if the experiments were nothing more than a multi-species provenance experiment. Percentage of living plants (ALIVE), percentage of healthy undamaged plants (GOOD) (based on all planted plants including dead) and average height of GOOD plants (HEIGHT) have been calculated. Plants were pooled over "provenance groups" of Table 2 for each locality. Results are shown in Figures. There is a varying number of plants behind different values; many values are based on more than 300 plants distributed over five blocks, and no value is based on less than 18 planted plants.

Some comments on the results are given:

* In comparison with lodgepole, Scots pine plants in nurseries are smaller at Kamloops than at Umeå.

* Southern origins of Scots pine are not well-adapted on northern sites.
* Slower growth of Scots pine seems to be a consequence of latitudinal transfer rather than an inherent species difference.
* Northern pine provenances seem to be able to live everywhere, but grow slowly at southern sites.
* Southern lodgepole pine suffers at Whitehorse, but nowhere else.
* Plant survival is higher in Canada than in Sweden.
* Where plant mortality and health is a problem (Sweden and Whitehorse), it seems that the problem is bigger for Scots pine than for lodgepole pine.

COOPERATORS AND ACKNOWLEDGEMENTS

Because of the extremely cooperative nature of this experiment, this acknowledgements is extremely long, yet incomplete. In Sweden there is a project group: Margareta Karlman, Dag Lindgren and Per Persson. Oscar Sziklai is coordinating the project from the Canadian side. Christian Walli was responsible for plant production and field establishment in general. C Cartright lead the preparation of the sites, the planting, the documentation and the first inventory in Canada. Staff from the Pacific Forestry Centre, Canadian Forestry Service, have examined the plots. Among others the following have assisted in getting seeds: Ola Rosvall, Martin Werner, Anders Fries, Enso-Gutzeit Oy. The initiative of the experiment originates from Stig Hagner. Trevor Jeans was important in the early phases. B van der Kamp has cooperated on the pathological side (especially on the Ft St James site). Advice from M Carlson was valuable. The organisations involved in different aspects of this project are:
Canada: Balco Industries Ltd, B C Forest Products Ltd, Canfor Corporation Ltd, University of B C (Department of Forest Sciences), Northern Affairs - Forest Resources, B C Ministry of Forests, Canadian Forestry Service.
Sweden: Swedish University of Agricultural Sciences (Department of Forest Genetics and Plant Physiology; Silviculture; and Forest Yield Research, respectively). Institute for Forest Improvement, Swedish National Board of Forestry (Grants for seeds), SCA Skog AB (Swedish Cellulose - Forest Division) and Bo Rydins Research Foundation, which supplied the basic funding for the project.

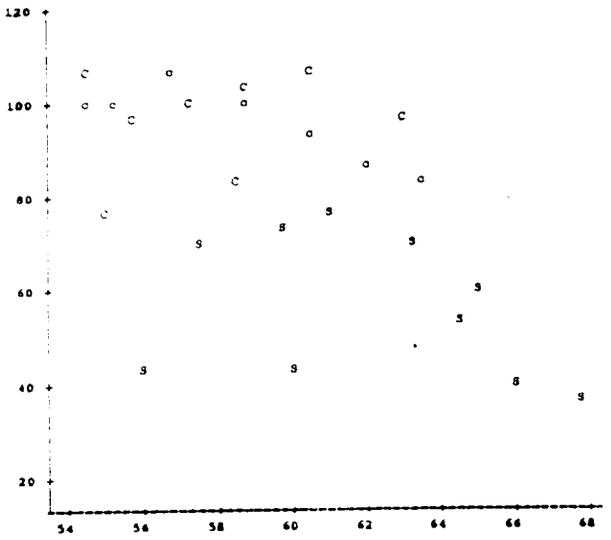
The persons locally involved with the different sites are: R W Baker, B Zak (assisted by F Gundersen), B Clarke, S Lindsay (earlier M Pedersen), W McJanett (assisted by D White), E G Ståhl (assisted by N Ganered), D Lindgren (assisted by A Fries, K Lindgren and S Löfmark) and O Rosvall.

We are grateful to our kids (Anna and Jan Lindgren) for assistance in field work in 1988. Nigel Rollison, Adalsteinn Sigurgeirsson and Margareta Karlman have suggested verbal changes.

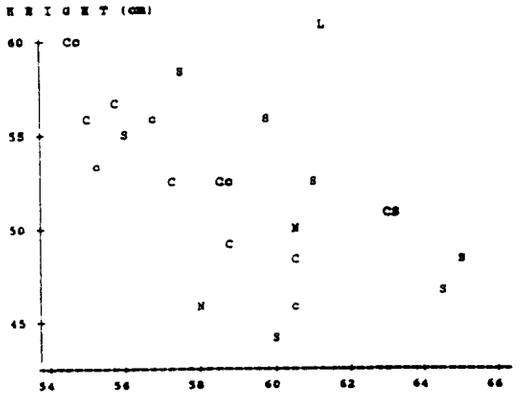
Prepared June 1990, modified October 1990.

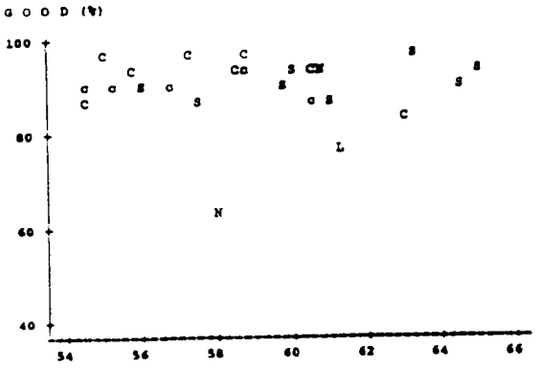
Plant height (mm)

in Canadian nursery (lat 51)

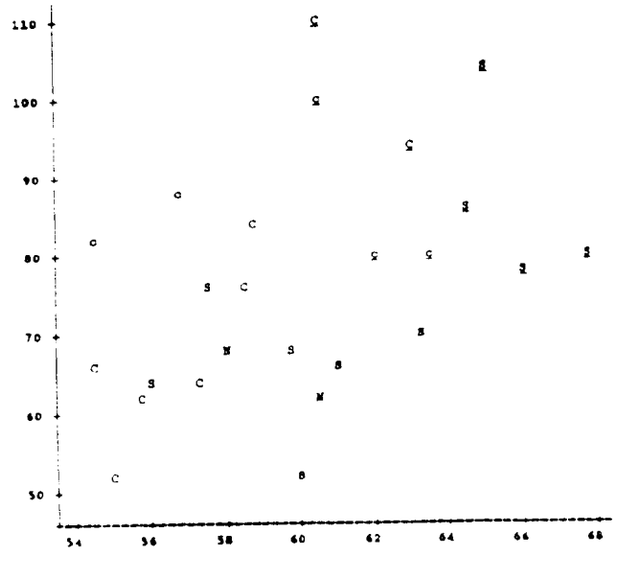


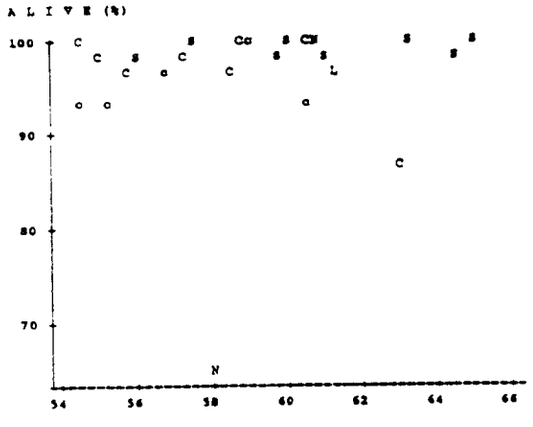
Ft St James (lat 54)





in Swedish nursery (lat 64)





LATITUDE OF ORIGIN

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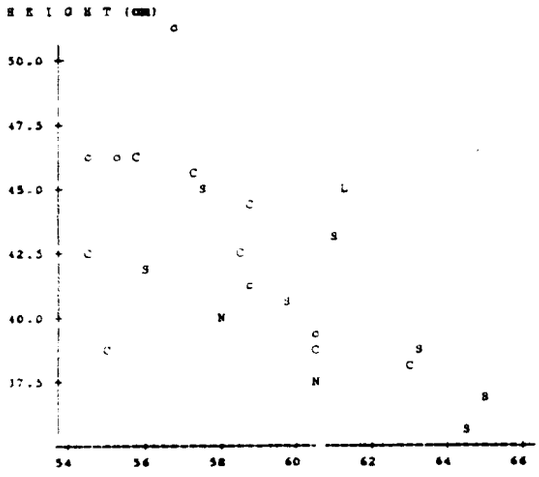
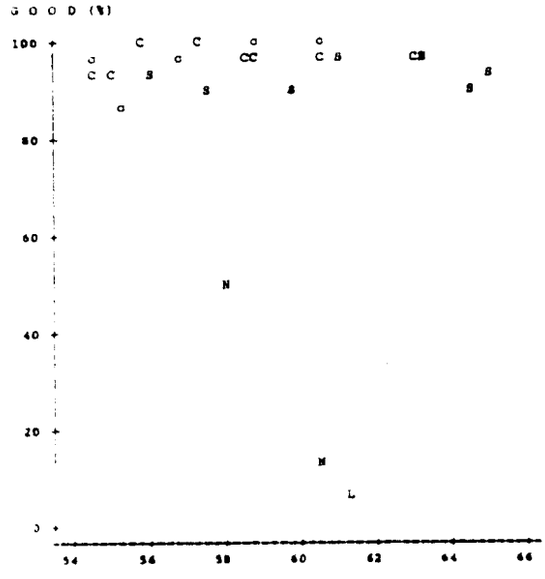
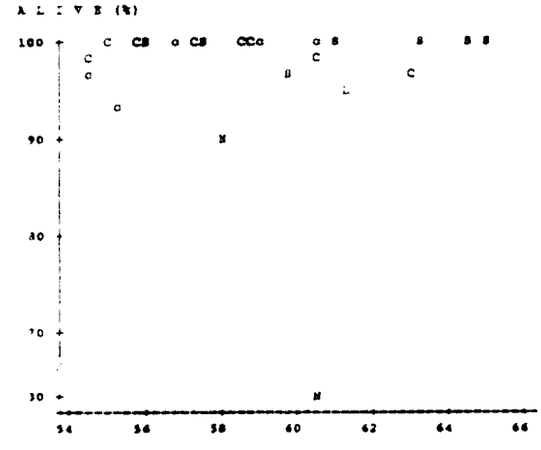
Prolonged nights Natural nights

On the following four pages experimental results are presented in Figures. The symbols used are as follows:
C = plus tree progenies of Pinus contorta (lodgepole pine)
c = stand progenies of Pinus contorta
S = plus tree progenies of Pinus sylvestris (Scots pine)
L = Larix sibirica (Sibirean larch)
N = Picea abies (Norway spruce)
The left Figures on this page are nursery results. They were measured and documented by R E Thomsen (Canada) and E Sundström (Sweden). The other figures are based on field inventories 1988, three vegetation periods after planting (Renberget four seasons).

MacKenzie (lat 56)

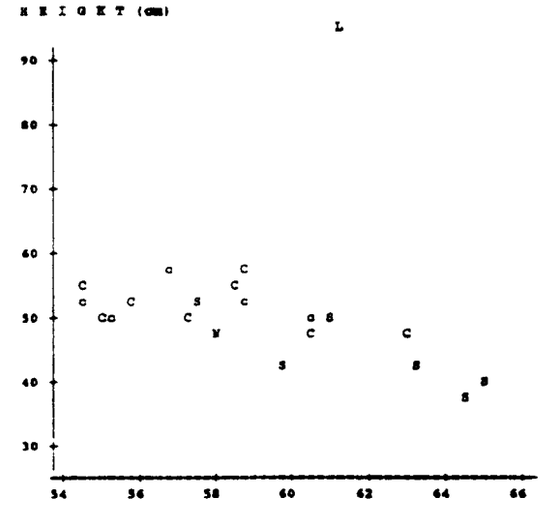


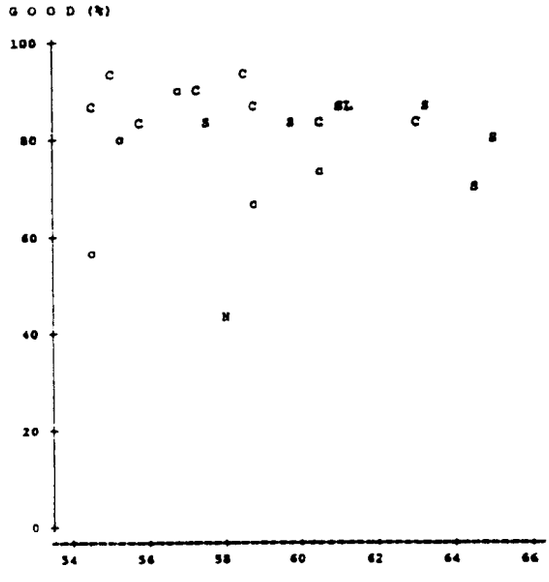


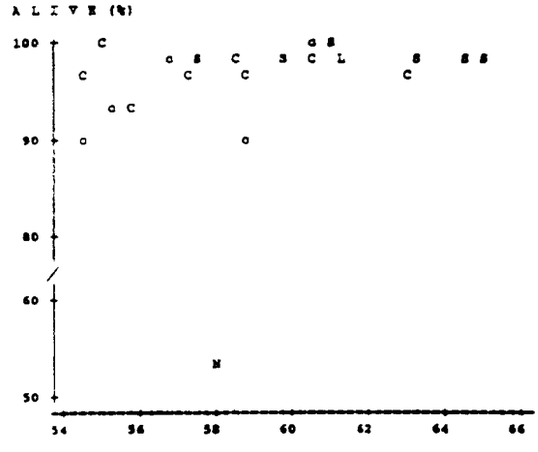


LATITUDE OF ORIGIN

Ft St John (lat 57)

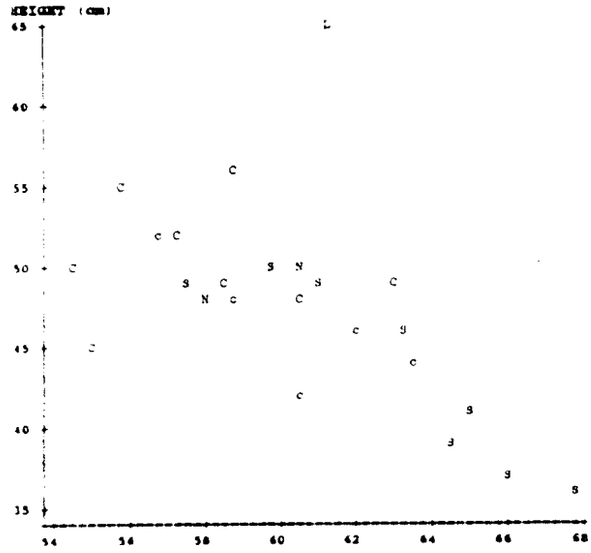


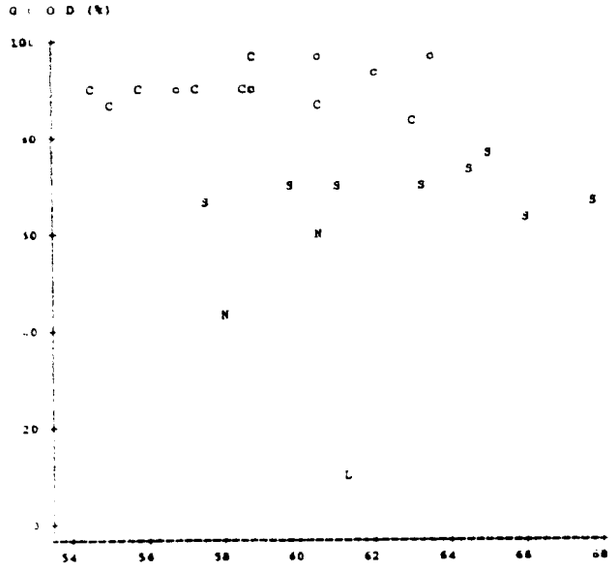


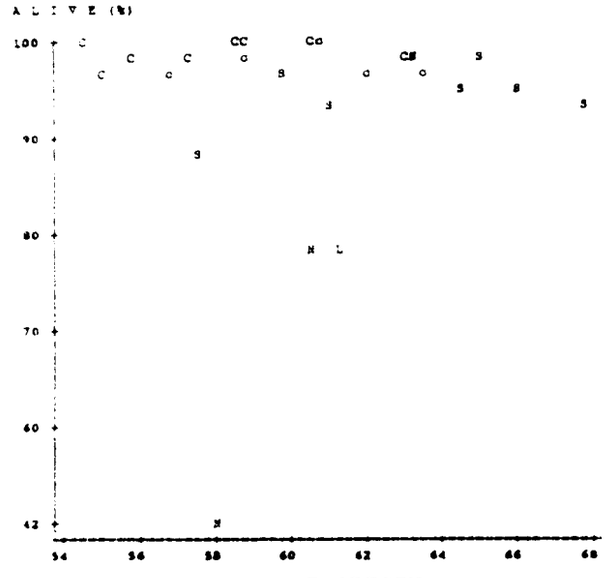


LATITUDE OF ORIGIN

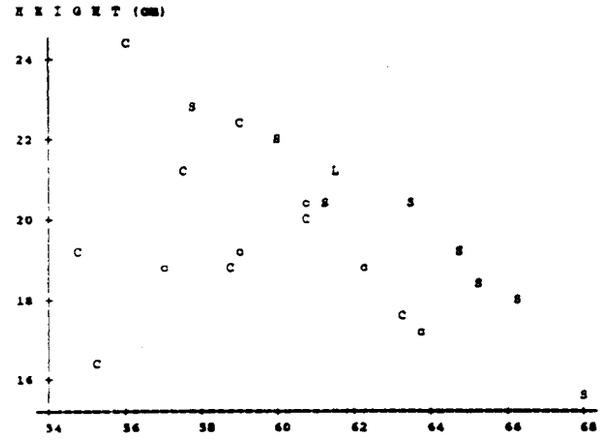
Ft Nelson (lat 59)

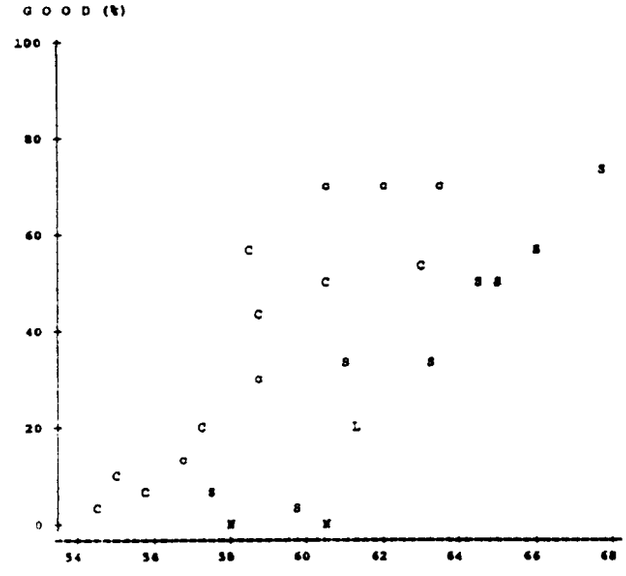


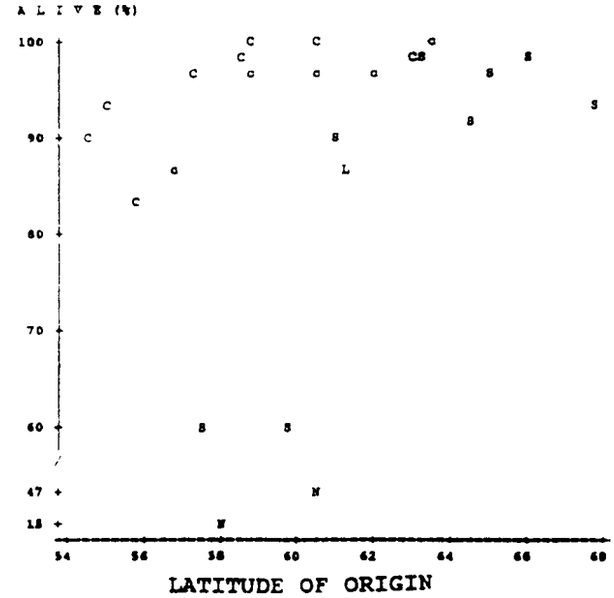




Whitehorse (lat 61)





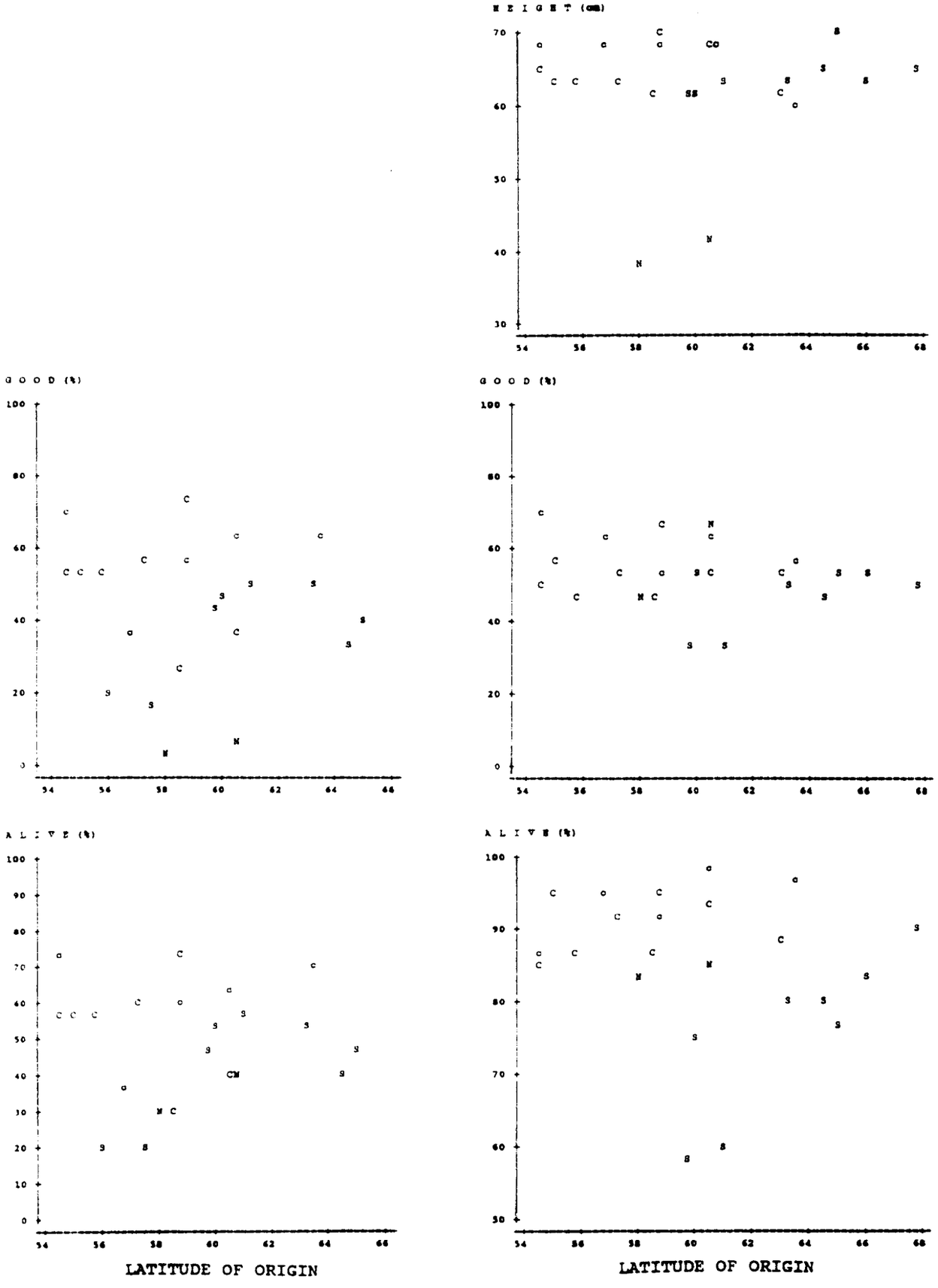


LATITUDE OF ORIGIN

LATITUDE OF ORIGIN

Garsås (lat 61)

Renberget (lat 64)



contorta: C=improved, c=stand; S=Scots pine; N=Norway spruce