

#### PROCEEDINGS OF THE SIXTH MEETING OF

#### THE COMMITTEE ON FOREST TREE BREEDING

#### IN CANADA

Held at Macdonald College, Ste. Anne de Bellevue, Que., on August 17th, 18th and 19th, 1958.

#### PART II

#### PROGRESS REPORTS, PROGRAMME REVIEWS AND PAPERS

#### PRESENTED AT THE MEETING

Part I of the Proceedings, including Minutes of the Business Meeting and the Discussions of Reports and Papers, received restricted distribution to Committee Members only.

Part II, in addition, is distributed for information to persons and organizations outside of Canada who are actively engaged in forest tree breeding and forest tree improvement.

The Proceedings are prepared and distributed by the

Forest Research Division

Forestry Branch

Canada, Department of Northern Affairs and National Resources

Ottawa

# CONTENTS

|  | Pag                      | e No.        |
|--|--------------------------|--------------|
| List of Active Members of the Committee on<br>Forest Tree Breeding in Canada, August, 19 | 58                       | 4-5          |
| 1. Member Progress Reports   | •                        |              |
| A. J. Carmichael   | <b>A.</b>                | 1-6          |
| W. H. Cram   | B.                       | 1-6          |
| B.W. Dance   | C.                       | 1-7          |
| D. A. Fraser   | E.                       | 1            |
| C. Heimburger  | F.                       | 1-4          |
| M. J. Holst  | G.                       | 1-11         |
| A. H. Hutchinson   | I.                       | 1-3          |
| H. G. MacGillivray   | J.                       | 1 <b>-</b> 3 |
| R. J. Moore  | K.                       | 1-2          |
| A. L. Orr Ewing  | $L_{\bullet}$            | 1-3          |
| R. Pomerleau   | M.                       | 1 <b>-</b> 3 |
| W. A. Porter   | N.                       | 1-3          |
| L. P. Chiasson   | Ρ.                       | 1            |
| 2. Programme Reviews by Visitors   |                          |              |
| K. W. Dorman. Southeastern Forest Experim<br>Asheville, N.C., U.S.A.                     | ent Station, Q.          | 1 <b>-</b> 2 |
| H. B. Kriebel. Ohio Agricultural Experime<br>Wooster, Ohio, U.S.A.                       | ent Station, Q.          | 3- 5         |
| Francois Mergen. Yale University, School<br>New Haven, Conn., U.S.A.                     | of Forestry, Q.          | 7-10         |
| A. de Jamblinne. Centre de Biologie, Bokr<br>Belgium.                                    | ijk-Genk, Q.             | 11-12        |
| Hans Nienstaedt. Northern Institute of Fo<br>Rhinelander, Wis., U.S.A.                   | prest Genetics,<br>Q.    | 13-16        |
| Scott S. Pauley. University of Minnesota<br>Forestry, St. Paul, Minn.,                   | , School of<br>U.S.A. Q. | 17-19        |

3. PAPERS

4.

| Natural Polyploidy in Slash Pine.<br>François N  | 1ergen R, 1-6   |
|--|---|
| Geographic Differentiation in Seed Do<br>and Juvenile Growth Rate of Ontari<br>Maple. H. B. Krie     | ormancy<br>Lo Sugar<br>Sbel R. 7-11                   |
| Interspecific Grafting of Hard Pines.<br>M. J. Hols<br>J. B. Sant                                    | st and R. 13-14<br>ton                                |
| The Taxonomy of Fungi Causing Leaf an<br>Blights of North American Poplars<br>B. W. Danc             | nd Twig<br>ce R. 15-17                                |
| A Tree Crown Isolation Tent.<br>C. W. Yeat   | tman R. 19-20   |
| The Role of Rhubarb in Forest Tree Br<br>C. Heimbur  | reeding.<br>rger R. 21-22                             |
| SEMINAR: TIMBER QUALITY AND GENETICS   |   |
| The Status of Work on Wood Quality in<br>Forest Tree Improvement Research.<br>K. W. Dorn             | n Southern<br>man S. 1-15                             |
| Investigations of Variation in Wood<br>Southern Pines and Its Genetic Sig<br>Thomas O.<br>Wang Chi-W | Quality of<br>gnificance.<br>Perry and S. 17-29<br>Nu |
| Thoughts on Wood Density.<br>M. J. Hols  | st <b>S.</b> 31-32                                    |
|  |   |

List of Active Members of

The Committee on Forest Tree Breeding in Canada.

August, 1958

Mr. A. Beckwith. Dept. of Lands and Forests, Southern Research Station, Maple, Ontario. Dept. of Agriculture, Forest Biology Division, Dr. M.G. Boyer. c/o Laval University, Quebec, P.Q. Dept. of Lands and Forests, Tree Seed Plant, Mr. A.J. Carmichael. Angus, Ontario. Dr. L.P. Chiasson. St. Francis Xavier University, Antigonish, Nova Scotia. Laval University, Faculty of Land Surveying Dr. L. Chouinard. and Forestry, Quebec City, Quebec. Dr. W.H. Cram. Dept. of Agriculture, Forest Nursery Station, Indian Head, Saskatchewan. Dept. of Agriculture, Division of Forest Mr. B.W. Dance. Biology, Southern Research Station, Maple, Ontario. Dr. L.F. Ebell. Dept. of Northern Affairs and National Resources, Forestry Branch, c/o Forest Biology Laboratory, Victoria, British Columbia. Dr. J.L. Farrar. University of Toronto, School of Forestry, Toronto, Ontario. Mr. D.P. Fowler. Dept. of Lands and Forests, Southern Research Station, Maple, Ontario. Dr. D.A. Fraser. Dept. of Northern Affairs and National Resources, Forestry Branch, Petawawa Forest Experiment Station, Chalk River, Ontario. Mr. C. Gagnon. Dept. of Agriculture, Forest Biology Division, c/c Laval University, Quebec City, Quebec. Dept. of Lands and Forests, Southern Research Dr. C. Heimburger. Station, Maple, Ontario. Dept. of Northern Affairs and National Mr. M.J. Holst. Resources, Forestry Branch, Petawawa Forest Experiment Station, Chalk River, Ontario.

| Dr. A.W.S. Hunter.                | Dept. of Agriculture, Horticulture Division,<br>Ottawa, Ontario.   |
|-----------------------------------|--|
| Dr. A.H. Hutchinson.              | University of British Columbia, Dept. of<br>Biology and Botany, Vancouver, B. C.   |
| Mr. H.G. MacGillivray.            | Dept. of Northern Affairs and National<br>Resources, Forestry Branch, Fredericton,<br>New Brunswick.                               |
| Dr. R.J. Moore.                   | Dept. of Agriculture, Division of Botany<br>and Plant Pathology, Ottawa, Ontario.  |
| Dr. A.L. Orr Ewing.<br>(Chairman) | B. C. Forest Service, Research Division,<br>Victoria, British Columbia.  |
| Dr. R. Pomerleau.                 | Dept. of Agriculture, Forest Biology Division,<br>c/o Laval University, Quebec City, P. Q.   |
| Mr. W.A. Porter.                  | Dept. of Agriculture, Forest Biology Division,<br>Victoria, British Columbia.  |
| Mr. J. Salm.                      | Canadian International Paper Company,<br>Harrington Forest Farm, R. R. No. 1,<br>Calumet, Quebec.                                  |
| Dr. E.C. Smith                    | Acadia University, Wolfville, Nova Scotia.   |
| Dr. C.R. Sullivan.                | Dept. of Agriculture, Forest Biology Division,<br>Forest Insect Laboratory, Sault Ste. Marie,<br>Ontario.                          |
| Mr. H.S.D. Swan.                  | Pulp and Paper Research Institute of Canada,<br>Woodlands Research Division, 3420 University<br>Street, Montreal 2, Quebec.        |
| Mr. C.W. Yeatman.<br>(Secretary)  | Dept. of Northern Affairs and National<br>Resources, Forestry Branch, Petawawa Forest<br>Experiment Station, Chalk River, Ontario. |

## 1. MEMBER PROGRESS REPORTS

1

REPORT TO COMMITTEE ON FOREST TREE BREDDING July, 1958

> A. J. Carmichael Ontario Tree Seed Plant, Angus

#### I General

A change in the program for seed production has resulted in the full time employment of A. J. Carmichael and G. B. Withers on a Seed Production and Improvement Project. This project will be concerned with the verification of the seed zone system in use in Ontario and with the development of improved seed collection methods, to include the thinning of selected natural stands and the establishment of seed orchards. The work will be designed not as a research project but as a production unit to improve the quality and quantity of seed available. This will be done by adopting the practices and principles made available by research organizations. Headquarters for this work will remain for the present at Angus, Ontario.

#### II Provenance Tests

Routine maintenance and refill planting was carried out for existing test plantings. No growth measurements were made of test trees.

Red pine and white spruce provenance tests were established for the Dominion Forest Service in three locations. In each case the wedge method of hand planting in furrows was used and trees were placed at a spacing of 4' x 4'.

#### III Seed Orchards and Seed Production Areas

#### A. General

An analysis has been made of the size, number and general location of seed orchards and seed production areas required for each species in each seed zone for an annual production of 100,000,000 trees. This has been used to develop a work program co-ordinating the efforts of five nurseries in the production of grafted seed orchard materials.

The majority of the work will be concerned with the northern part of the province where the emphasis will be on spruce and red pine. The 1959 seed orchard grafting program will include 2500 white spruce, 2000 black spruce, 4000 red pine and 2000 white pine. B. Red Pine Seed Production Area - Lynn Tract

The test area of red pine at Lynn Tract, Simcoe County (13 yr. age, 12' x 12' spacing), has been re-examined for flower production. A detailed description of the 15 sites selected was given in the August 1957 report to the committee.

There were no 2 year old cones present in 1958, but a small crop of 1 year old cones was found. This crop is described in Table 1.

A comparison of the 1957 and 1958 cone counts, indicates that a few trees had a higher production in both years. These trees possibly differ genetically in their flowering pattern. They are found in general on those sites where the red pine have good growth rather than on those sites supporting slower growing trees. The counts would indicate that several cone crops must be examined before individual tree differences became definite.

The great variation in cone production between individual trees on the same site would indicate that there are great differences in the inherent capacity of the trees to produce cones, or that some trees are at their low ebb in the cycle of cone production while others are at their peak, or that the sites as selected are not uniform. When further counts are available, these factors might be resolved. Until then no attempt will be made to increase flower production by means of fertilizer treatments.

Foliar analysis tests were carried out for three trees in site F, a depressed flat with good growth (Table 2) samples were taken in September 1957 from each wherl on the trees, air-dried and analysed for nitrogen, phosphorous and potassium, by Donald Inspection Ltd., Toronto. Plotting of these values singly and in ratio did not show a correlation with the production of 2 year old cones.

Grafts of trees F2 and F9 were made and will be observed to determine whether variations in cone production are genotypic. When tests in the induction of buds in needle fascicles have been completed for red pine, plants might be reared and used on various sites, to explain further the variation in cone production between these trees. This is of interest since the two trees have a similar phenotype.

Table IRed Pine- Lynn Tract- 1958

Average of 1 Year Cones - Trees 1 - 16, Site A - 0

| #   | -                                     |  | **************************************       |                                       |                                  |   | С<br>Х.                                  | Site   |   |   |                                       |   |  | -91-0-1                                 | a ngarat ngamat ngalak sina          | - Andrew State (1997), and a second                 |
|---|---------------------------------------|--|--|---------------------------------------|----------------------------------|---|--|--|---|---|---------------------------------------|---|--|---|--------------------------------------|---|
| Tree  | Ą                                     | В  | C  | D                                     | I.                               | F   | G  | H  | I                                       | J                                       | T7<br>                                | L                                       | 14   | ци<br>ЦИ                                | СЛ                                   | OTAL  |
| 1<br>2<br>3<br>4<br>5<br>6<br>7<br>8        | 12<br>5<br>19<br>40<br>21<br>37<br>31 | 8<br>11<br>29<br>2<br>34<br>3<br>9       | 1<br>20<br>5<br>9<br>38<br>27<br>48<br>17    | 1<br>37<br>28<br>1<br>0<br>8          | 2<br>3<br>1<br>20<br>9<br>1<br>1 | 67<br>25<br>7<br>53<br>13<br>2<br>30<br>0 | ි<br>5<br>17<br>45<br>31<br>95           | 14<br>6<br>34<br>0<br>105<br>40<br>0           | 3<br>14<br>2<br>9<br>5<br>8<br>4        | 0<br>10<br>0<br>2<br>10<br>2<br>0       | 0<br>0<br>4<br>0<br>3<br>1            | 0<br>0<br>33<br>28<br>0<br>13<br>0<br>1 | 0<br>5<br>0<br>6<br>18<br>0<br>0           | 0<br>2<br>4<br>2<br>0<br>11<br>6        | 0<br>1<br>0<br>6<br>0<br>0<br>0<br>0 | 111<br>97<br>168<br>214<br>159<br>291<br>186<br>143 |
| Tc<br>Avg                                   | 166<br>20.7                           | 97<br>12.1                               | 165<br>20.6                                  | 76<br>9.5                             | <b>39</b><br>4.8                 | 197<br>24.6                               | 206<br>25 <b>.</b> 7                     | 205<br>25.6                                    | 49<br>6.1                               | 25<br>3.1                               | 8<br>1.0                              | 75<br>9.6                               | 29<br>3.7                                  | 25<br>3.1                               | 7<br>•8                              | 1369<br>171.1                                       |
| 9<br>10<br>11<br>12<br>13<br>14<br>15<br>16 | 2<br>4<br>2<br>59<br>1<br>0<br>0      | 6<br>8<br>0<br>56<br>15<br>56<br>12<br>3 | 35<br>20<br>17<br>85<br>138<br>138<br>0<br>0 | 5<br>0<br>0<br>0<br>6<br>0<br>5<br>37 | 0<br>0<br>5<br>21<br>0<br>1<br>2 | 15<br>17<br>6<br>35<br>0<br>0<br>0<br>10  | 2<br>14<br>37<br>6<br>5<br>14<br>9<br>24 | 8<br>0<br>2<br>6<br>3<br>215<br>15<br>15<br>13 | 8<br>17<br>0<br>20<br>0<br>10<br>0<br>0 | 16<br>0<br>13<br>25<br>0<br>0<br>5<br>0 | 3<br>2<br>0<br>0<br>1<br>3<br>40<br>0 | 6<br>1<br>8<br>25<br>6<br>5<br>18<br>2  | 3<br>1<br>0<br>3<br>7<br>7<br>7<br>3<br>11 | 7<br>11<br>0<br>24<br>0<br>0<br>11<br>2 | 1<br>0<br>0<br>20<br>29<br>0<br>0    | 117<br>95<br>90<br>256<br>260<br>342<br>119<br>104  |
| Tot<br>Avg                                  | al<br>71<br>8.8                       | 103<br>12.8                              | 296<br>37.0                                  | 53<br>6.6                             | 30<br>3 <b>.</b> 7               | 83<br>10.3                                | 111<br>13.8                              | 262<br>32 <b>.7</b>                            | 55<br>6.8                               | 59<br>7.3                               | 49<br>6.1                             | 71<br>8.8                               | 35<br>4 <b>.</b> 3                         | 55<br>6.8                               | 50<br>6.2                            | 1383<br>172.8                                       |
| Gra<br>Ave                                  | ind to<br>237<br>14.8                 | otal<br>200<br>12.5                      | 461<br>28.8                                  | 129<br>8.0                            | 69<br><b>4.</b> 3                | 280<br>17.5                               | 317<br>19.8                              | 467<br>29.1                                    | 104<br>6.5                              | 84<br>5.2                               | 57<br>3.5                             | 146<br>9.1                              | 64<br>4.0                                  | 80<br>5.0                               | 57<br>3.5                            | 2752<br>172.0                                       |

## **A-4**

### <u>Table II</u>

Foliar Analysis for N. P. K. for Red Pine Trees F2 and F9, Lynn Tract

| Whorl<br>No.*  | No. 2 Yr. Cones                           |  | N<br>Oven D  | •%<br>ry Wt.   | P.<br>Oven D   | グ<br>pry Wt.   | K.<br>Oven 1   | .%<br>Dry Wt.  |
|--|---|--|--|--|--|--|--|--|
|  | F 2                                       | F.9  | F 2  | F 9  | F 2  | F 9  | F 2  | F 9  |
| 0<br>1<br>2<br>3<br>4<br>5<br>6<br>7<br>8<br>9<br>10 | 14<br>31<br>43<br>27<br>15<br>1<br>0<br>0 | -<br>0<br>0<br>2<br>2<br>5<br>2<br>0<br>0<br>0 | 1.67<br>1.56<br>1.59<br>1.67<br>1.78<br>1.43<br>1.55<br>1.50<br>1.55<br>1.40 | 1.67<br>1.55<br>1.73<br>1.62<br>1.67<br>1.67<br>1.40<br>1.51<br>1.67 | 0.17<br>0.14<br>0.15<br>0.16<br>0.15<br>0.15<br>0.16<br>0.15<br>0.14<br>0.14 | 0.18<br>0.16<br>0.15<br>0.15<br>0.15<br>0.15<br>0.14<br>0.16<br>0.14<br>0.15 | 0.62<br>0.43<br>0.48<br>0.59<br>0.44<br>0.50<br>0.37<br>0.18<br>0.40<br>0.52 | 0.62<br>0.56<br>0.72<br>0.37<br>0.46<br>0.51<br>0.68<br>0.41<br>0.41<br>0.37 |
| Total  | 131                                       | 9  |  |  |  |  |  |  |

\* The current seasons growth at the top of the tree is designated as whorl 0.

#### IV Scotch Pine Christmas Tree Test

It is common practice to prune the branches of Scotch Pine to develop a denser and better formed tree. Since the sources of Scotch pine planted in test plantations differ in the number of lateral buds surrounding the terminal bud, it was necessary to determine what number of buds would be produced in the needle fascicles after prining. Trees which had good form, were pruned in each seed source in test plantations near Ottawa and Sault Ste. Marie. The average number of buds is given for the three trees pruned in each seed source. (Table 3)

| Tt | ab | le |                  | 3 |
|----|----|----|------------------|---|
| -  | -  |    | . <del>.</del> . | - |

## Humber of Lateral Buds on Terminal Shoot before and after Fruning Scotch Pine

| Seed Source O<br>Before | Number<br>ttawa Pla<br>Pruning | of Lateral Buds<br>antation<br>After Pruning | on Terminal S<br>Sault Ste.Mar<br>Before Pruning | Shoot<br>rie Plantation<br>g After Pruning |
|-------------------------|--------------------------------|--|--|--|
| France-Haute<br>Loire   | 7.0                            | 34.0   | 5.1  | 17.6                                       |
| -Auvergne               | 8.2                            | 32.2   | 4.0  | 15.0                                       |
| -Cevennes               | 8.1                            | 33.1   | 6.2  | 20.6                                       |
| West Europe             | 8.1                            | 24.2   | 6.2  | 22.6                                       |
| Lower Austria           | 7.1                            | 29.1   | 4.5  | 22.6                                       |
| Lower Austria           | 8.0                            | 24.2   | 5.1  | 22.0                                       |
| West Baltic             | 8.1                            | 42.0   | 5.1  | 24.0                                       |
| East Baltic             | 8.0                            | 26.0   | 6.2  | 16.0                                       |
| Sweden                  | 7.2                            | 34.3   | 6.1  | 15.6                                       |
| Finland                 | 5.2                            | 18.0   | 6.1  | 9.6  |
| S. Finland              | 6.0                            | 20.2   | 3.1  | 11.3                                       |
| Adirondacks             | 8.2                            | 25.2   | 6.1  | 19.0                                       |

A further examination of these trees will be necessary to determine the number of shoots which have developed from the available buds. Northern sources produced in general minute buds, whereas Southern sources produced very large buds.

#### V. Shoot Moth Test

A comparison of Pinus nigra cebennensis from Cevennes, France, and red pine from Douglas, Entario is being made on two areas, to determine any difference in the attack of European Pine Shoot Moth (Rhyacionia buoliana) on these species. Previous measurements have indicated that Pinus nigra cebennensis is not attacked as frequently as red pine and that attacked trees tend to develop a single stemmed form more frequently than red pine.

Specimen trees have been transplanted by the Forest Biology Division of the Department of Agriculture, to their field station at Elmira, Cntario, for detailed examination to determine if any physical factors of tree growth inhibit the development of shoot moth larvae.

An attack of Formes annosus on both species in the Site Region 6 plantation at Mansfield may disrupt the test. If not, further growth measurements will be made.

Snow depth measurements were made at Mansfield during the winter of 1958 to determine whether pockets of heavier infestations were due to snow protection. This data has to be examined as yet.

#### A-5

## VI Rooting Leaf Bundle Cuttings

Mr. H. J. Jeckalejs of the Division of Research, Ontario Department of Lands & Ferests will be extending his earlier studies on rooting leaf bundle cuttings to develop a means for the production of plants by this method.

In order to define the correct time of pruning required to induce buds in needle fascicles, a test was established in which white pine, red pine and Scotch pine were pruned at monthly intervals commencing on March 17 and at weekly intervals commencing on June 16, and extending to July 21. Trees of approximately 3 ft. and 20 ft. heights have been used for each species. One-third of the past seasons growth was removed up to June 9, after which onethird of the current seasons growth has been removed. The terminal, first and second whorls have been pruned on 3 ft. trees and the first, second and third whorls on 20 ft. trees. B - 1

1957 REPORT ON BREEDING AND NURSERY RESEARCH

W. H. Cram

Forest Nursery Station, Indian Head, Sask.

#### Introduction: -

Improved facilities for breeding and nursery research were provided by the new headerhouse, and an adjoining greenhouse in 1957-58. Weather:-

Climatic conditions were favorable for field breeding and nursery operations in 1957. The frost-free period was 120 days from April 26 to August 25, with only 9.8 inches of precipitation. An early and dry spring permitted field operations to start on May 2, when Russian poplar began to bloom. Dry weather, which was ideal for field operations presisted to the end of July. August was a relatively wet month with 3.3 inches of rain. The months of May and July were exceptionally warm as indicated by average mean daily temperature of 55.0 and 70.0°F, respectively. A dry open fall was experienced from September until snowfall on November 25.

### Caragana Breeding: -

Information on the inheritance of two characters of <u>Caragana arborescens</u> was derived from the progenies of three compatibility determinations. Data for an 'albino' character were obtained in 1954 from the greenhouse germination of the 1953 inbred  $[S_1]$  and hybrid  $[F_1]$  seed. Data for the so-called "pendulant" character were recorded in 1957 from the 1954 plantings. Segregation data for the two characters in three  $F_1$  progenies are presented in Table 1. It would appear that the 'albino' and the 'pendulant' characters are both inherited as simple recessive and independent factors. This information confirms the value of N-19 as a tester in the breeding program to determine the genotype of self-incompatible selections for the pendulant and albino characters.

| - | Progeny          |       |        | Segregation | n for albino  |       | ~    |                         |  |
|---|------------------|-------|--------|-------------|---------------|-------|------|-------------------------|--|
|   | çı               | -     | ර්     | green       | yellow        | ratio | X2   | Genotype<br>of 9 Parent |  |
|   |                  |       |        | (No)        | (No)          |       |      |                         |  |
|   | N19              | x     | N19    | 77          | 17            | 3:1   | 2:40 | Aa                      |  |
|   | A-1              | x     | N19    | 88          | 0             | 88:0  | -    | AA                      |  |
|   | <b>V16</b>       | x     | N19    | 131         | 0             | 131:0 |      |                         |  |
| - |                  | •     |        | Segregation | n for pendula | int   |      |                         |  |
|   |                  |       |        | ūpright     | pendulant     |       |      |                         |  |
|   | - <b>N</b> 10    | •<br> | - NTIO |             | 14            | 0:14  | -    | pp                      |  |
|   | N7               | ~     | NIQ    | 21          | 25            | 0:1   | 0:35 | Pp                      |  |
|   | $\overline{v_1}$ | x     | N19    | 75          | ó             | 75:0  | -    | PP °                    |  |
|   |                  |       | /      | 1.4         |               |       |      |                         |  |

| Table 1. | Segregation for Albino and Pendulant Characters in |  |
|----------|--|--|
|          | F <sub>1</sub> Progenies of Caragana arborescens   |  |

1 N19 is a pendulant, A-1 and V16 are upright in habit

Self-compatibility determinations for Caragana accession material was initiated in 1957. Only 90 of the vigorous selections were sexually mature. These selections were found in four accessions, which were field planted in 1953. The original seed came from Botanical Gardens in Europe and the United States. Results of the fertility determinations have been tabulated in Table 2.

Table 3. -Frequency distribution for Self-Compatibility Values<sup>1</sup> of 57 Vigorous Selections from Four Caragana Accessions

|             | C mieror |         | C arborescens |            |         |           |         |
|-------------|----------|---------|---------------|------------|---------|-----------|---------|
| rertillby   | A-109    | Average |               | D-13       | D-14    | D-16      | Average |
|             | (No)     |         | (No)          | (No)       | (No)    | (No)      | (%)     |
| (%)         | (10)     |         | 2             | 5          | 6       | 12        | 50.0    |
| 0-20        | 2        | 18.2    | 2             | - <u>-</u> | 2       | 0         | 15.2    |
| 21-40       | 5        | 45•4    | 4             | 1          | 2       | ĩ         | 19.6    |
| 41-60       | 3        | 27.3    | - 3           | 2          | ん<br>う  | 0         | 13.0    |
| 61-80       | 0        | Q       | 3             | 0          | 2       | Õ         | 2.2     |
| 61-100      | 0        | 0       | 0             | 0          |         | õ         | 0       |
| 101-120     | 0        | 0       | 0             | 0          | 0       | . 0       | 0       |
| 121-140     | 0        | 0       | 0             | 0          | 0       | 0         | 0       |
| 141-160     | 1#       | 9.1     | 0             | 0:         | 0       | 0         |         |
| Selections  | (No.) 11 | ;       | 13            | 6          | 14      | 13        |         |
| Fertility   |          |         |               |            |         |           |         |
| - range (%) | 4 to 145 |         | 0 to 67 12    | 2 to 52    | 0 to 83 | o to $46$ | ~ ~ ~   |
| - mean      | 40       |         | 37.8          | 34.8       | 37.5    | 7.4       |         |

<sup>1</sup> Self-compatibility or fertility as % of tripped flowers

# Autogamous plant exhibits self tripping

Self-fertility of the one accession of <u>C. microphylla</u> was somewhat similar, although greater, than any of the C<u>. arborescens</u> accessions. Seven selections from accessions of C<u>. arborescens</u> demonstrated self-incompatibility. One accession, Dl6, from Cheyenne, Wyoming, contained five of the seven incompatible plants. We hope to incorporate genetic diversity and increased vigor into the caragana breeding program, with these self-incompatible selections.

#### Maple & Ash Seed Maturity

Seed was harvested from four trees of Green Ash and of Boxelder Maple at three tri-weekly intervals in 1956. It was dried in the greenhouse for one week, then stored under room and cellar conditions until sown outdoors October 16. Moisture Content of the seed was determined at time of harvest and at time of sowing 1957 germination records and results are summarized in Tables 4 and 5. Table 4. Moisture Content in 1956 and Germination Capacity in 1957 of Green Ash Seed

| Date of                      | Moisture                       | content of                     | seed <sup>1</sup>        | Seedbed germination <sup>2</sup> |                             |  |  |
|------------------------------|--------------------------------|--------------------------------|--------------------------|----------------------------------|-----------------------------|--|--|
| harvest                      | at<br>harvest                  | whien s<br>cellar              | own<br>room              | cellar                           | room                        |  |  |
| Aug. 22<br>Sept.12<br>Oct. 3 | (%)<br>51.6<br>48.8*<br>12.9** | (%)<br>14.7<br>13.2*<br>10.3** | (%)<br>6.6<br>6.7<br>6.8 | (%)<br>0.1*<br>12.2<br>12.1      | (%)<br>5.0*<br>13.0<br>15.5 |  |  |

<sup>1</sup> Moisture content as % of wet weight after 24 hours of 100°C; <sup>2</sup> Germination in 1957 as % of seed sown for 5 reps of 100 seed; \*, \*\*, Significantly less than for other dates at 5%, and 1% levels.

| Table 5. | Moisture Con | tent in 195 | 6 and | Germination | Capacity | • in 1957 | 7 of | Maple | Seed |
|----------|--------------|-------------|-------|-------------|----------|-----------|------|-------|------|
|----------|--------------|-------------|-------|-------------|----------|-----------|------|-------|------|

| Date of                      | Moisture content of seed <sup>1</sup> |                               |                              | Seedbed ge                   | rmination <sup>2</sup>        |  |
|------------------------------|---------------------------------------|-------------------------------|------------------------------|------------------------------|-------------------------------|--|
| harvest                      | at<br>harvest                         | when so<br>cellar             | room                         | cellar                       | room                          |  |
| Aug. 22<br>Sept.12<br>Oct. 3 | (%)<br>67.2<br>57.1*<br>10.8**        | (%)<br>16.4<br>15.7*<br>9.3** | (%)<br>6.7<br>7.2**<br>7.8** | (%)<br>28.8**<br>4.1<br>40.5 | (%)<br>30.2**<br>38.8<br>40.0 |  |

<sup>1</sup> Moisture content as % of wet weight after 24 hours of 100°C; <sup>2</sup> Germination in 1957 as % of seed sown for 5 reps of 100 seed;

\*, \*\*, Significantly less than for other dates at 5%, and 1% levels.

B - 3

From these tables it is evident that neither Ash nor maple seed should be harvested in August, and that storage conditions from harvest to sowing had little influence on viability of fresh seed.

Ash seed, which was prematurely harvested in August, demonstrated over 50% moisture content and little viability. Seed, as harvested in September and October, exhibited a high degree of dormancy. Apparently some pre-sowing seed treatment is required to ensure adequate germination of ash seed especially if it must be sown in a dry fall.

Viability of Maple seed increased from 30 to 40%, when allowed to mature on the tree from August to September. Maple seed would also appear to require special treatment to increase germination especially if sown in a dry fall. Storage of Poplar Cuttings:

Investigations on the winter storage of dormant poplar cuttings was initiated in 1956 to overcome a serious nursery problem. Cuttings were collected on October 22 from stooling beds of three clones, cut into 10 inch lengths, segregated into diameter size classes and tied into bundles of 25. Five prestorage treatments were applied by dipping the bundles into solutions of fungicides. The five treatments involved Captan, Tersan, check (water), Semesan and Oxyquinolene Sulphate. The cuttings were stored on October 25 under five different conditions (as listed in Table 6). On May 7, 1957, the cuttings were removed from storage and planted in the field to evaluate the results. The design involved three replications of five treatments and five storages with 25 cuttings per plot. Records for field stand were compiled on September 25 with the results listed in Table 6.

Average stands for the five fungicidal treatments as listed above were: 42, 36, 36, 35 and 30%, respectively. The Captan treatment (150 grams per gallon) was evidently beneficial to rooting of poplar cuttings. It significantly increased the stand of one clone and appeared to increase that of another. Toxicity of the Oxyquinolene treatment ( 25 grams per gallon) caused a significant decrease in the stand of two clones.

B - 4

|                            | Storages             |                      |                     | Clones               |                     | Means for            |  |
|----------------------------|----------------------|----------------------|---------------------|----------------------|---------------------|----------------------|--|
| Place                      | Medium               | Temp.1               | N.W.                | Sask.                | 44-52               | Storage              |  |
| <u></u>                    | <u></u>              |                      | (%)                 | (%)                  | (%)                 | (%)                  |  |
| Cellar<br>Cellar<br>Cellar | Sand<br>Poly<br>Poly | 41°F<br>41°F<br>31°F | 9.9<br>23.5<br>40.3 | 16.0<br>14.0<br>31.6 | 13.6<br>9.1<br>29.1 | 13.2<br>15.5<br>33.7 |  |
| Cellar<br>Outdoors         | Sand<br>Soil         | 31°F<br>?            | 52;5<br>89.6*       | 42.8<br>68.4*        | 25.9<br>69.6*       | 40.4<br>75.9*        |  |
| Mea                        | ns for clo           | nes                  | 43.2                | 34.6                 | 29.5                | ·                    |  |

| able 6. | Stand for | Poplar | Cuttings | of | Three | Clones | After | Five | Storages. |
|---------|-----------|--------|----------|----|-------|--------|-------|------|-----------|
|---------|-----------|--------|----------|----|-------|--------|-------|------|-----------|

<sup>1</sup> Cellar temperatures were  $31.8 \pm 11^{\circ}F$  and  $41.2 \pm 7^{\circ}F$ 

Τ

Outdoor or 'heeling-in' storage proved vastly superior to any of the four types of indoor storage as evident from the stands for cuttings listed in Tables 6. Regretably, temperatures of the cellar storages varied greatly  $(31.8 \pm 11^{\circ}F)$  and  $41.2 \pm 7^{\circ}F$ , due to absence of insulation and temperature control facilities. Nevertheless, it would appear that indoor storage of poplar cuttings at low temperatures of approximately 31°F is superior to storage at higher temperatures.

Stand of poplar cuttings was improved when moist sand was placed with the cuttings being stored in polyethylene bags for the following pathogenicity study. This treatment increased the stand from 38 to 77%, when the cuttings were stored at 31°F. and from 8 to 53% when stored at 41°F.

Studies to determine the pathogenicity of isolates from diseased cuttings were initiated in 1956 in cooperation with Dr. O. Vaartaja of the Forest Biology Division. Cuttings of two poplar clones were collected sized and tied in bundles of 25 in 1956 as for the storage study. These bundles of cuttings were inoculated by dipping the basal and upper ends in suspensions of the isolates. Sixteen isolates were supplied by Dr. Vaartaja, for this study. Each inoculum was applied to four bundles of cuttings, which were then sealed in polyethylene bags with sterile and moist sand. The packages were covered with moist sand and stored in the cellar

B - 5

at  $31 \pm 11^{\circ}F$  and  $41 \pm 7^{\circ}F$  for the winter. In the spring of 1957, the cuttings were planted to evaluate pathogenicity of the isolates in terms of the rooting capacity or field stand of the cuttings so inoculated.

Only one of the 16 isolates proved highly pathogenic to poplar cuttings. This was a Pythium spp., isolate (#2058), which had been obtained from diseased willow cuttings. Cuttings of only one clone, 44-52, proved susceptible to this isolate when the cuttings were stored at 41  $\pm$  7°F temperature.

#### Publication in 1957:-

Research papers:-

- 1. Cram, W. H. and O. Vaartaja. 'Rate and timing of Fungicidal Soil treatments'. Phytopath. 47:169-172. 1957.
- 2. Cram, W. H. and H. A. Worden, 'Maturity of white spruce cones and seed'. For. Sci. 3:263-269. 1957.

## REPORT TO COMMITTEE ON FOREST TREE BREEDING July, 1958

#### B. W. Dance Division of Forest Biology Canada Department of Agriculture

#### <u>General</u>

The Laboratory of Forest Pathology, Canada Department of Agriculture, Maple, is participating in a joint programme with the Division of Research, Ontario Department of Lands and Forests for the purpose of evolving diseaseresistant hybrid poplars. In this programme, the writer has been assigned responsibility for assessing the degree of susceptibility of hybrids, both presently available and to be developed, to the fungal flora of <u>Populus</u> in Ontario.

This project entitled "Pathological Considerations in the Development of Hybrid Poplar" (No. SFB 50.06) was reviewed in the spring of 1958 by senior officers of the Division of Forest Biology and the Division of Research. As a result of the review, the responsibilities were re-dofined. This revision became feasible when it was concluded that, of all hybrid poplars evolved to date, <u>Populus alba L.x grandidentata</u> Michx. has the most significant economic potentialities. The assessment was made despite knowledge that this hybrid is seriously and even fatally affected by a leaf and twig blight which has been described (1,2). Justification for the conclusion was founded in observations of apparent high resistance to the disease by a few clones. In view of the potentialities of <u>P</u>. <u>alba</u> x <u>grandidentata</u> it was decided that the main immediate investigative effort should be placed on the biology of the pathogen responsible for the leaf and twig blight condition.

Judged to warrant next priority in attention, was final resolution of the biology of <u>Fusicladium tremulae</u> Frank - a prevalent, destructive, longmisunderstood and hitherto misidentified pathogen of aspen. Specifically, it was intended to relate <u>F. tremulae</u> to an ascomycete, believed to be its ascigerous stage. This ascomycete, identified as <u>Venturia tremulae</u> Aderh., has only rarely been observed in Ontario. It seemed likely that attainment of this goal would yield a fairly complete understanding of the taxonomy of that group of fungi, including <u>Pollaccia elegans</u> Serv., that cause leaf and twig blight of poplar in Canada.

In addition to the foregoing lines of investigation, it was felt that a watch should be maintained for evidence of other pathogenic activity on hybrid poplar. It was concluded that the responsibilities of the Forest Pathology Laboratory in this project should be delimited as follows:

- Studies on the biology of currently and potentially important pathogens of hybrid poplars. At the present time close attention will be paid to pathogens that appear significant in the development of <u>P. alba x grandidentata</u>. The pathogen to receive foremost attention will be <u>Gloeosporium</u> sp. Of lesser interest are <u>Cytospora spp. Hypoxylon pruinatum</u> (Klotzsch) Cooke, <u>Dothichiza</u> <u>populea</u> Sacc. and Briard and <u>Melampsora sp</u>.
- (2) The conduction of periodic surveys and assessments of disease problems in test plantings established by the Tree Breeding Section of the Division of Research.
- (3) The provision of identifications and advice in respect to disease materials submitted by Dr. Heimburger, of the Division of Research, from breeding stock, test garden stock, and other related sources.

In the report to the Committee on Forest Tree Breeding submitted in 1957, the investigations underway on poplar diseases were outlined. Some phases of

C - 2

these investigations have terminated; others are continuing or are being repeated. However, initiation of new investigations will be governed by the established order of priority indicated above.

Developments since the last report appeared are summarized in the following review. In general, these developments consist of an extension of knowledge relating to the biology and taxonomy of fungal pathogens of poplar.

## Leaf and Twig Blight of Hybrid Aspen

Blighted leaves and twigs of <u>P. alba</u> x <u>grandidentata</u> were collected at Chalk River, in September 1957, and set outdoors in a lattice box in the vicinity of the parental trees. They were re-collected in late May 1958. Examination of leaf tissue at that time revealed the presence of an ascomycete. Perithecia of this fungus were prevalent in all leaves and were observed to contain mature-appearing asci and ascospores. The fungus was identified as <u>Plagiostoma populi</u> Cash and Waterman from the recently-published description (2) of that species on <u>Populus tremuloides</u> Michx. x <u>grandidentata</u> Michx. This collection from Ontario probably constitutes the first record of <u>P. populi</u> on <u>P. alba</u> x <u>grandidentata</u>.

Ascospore discharge onto synthetic media and onto leaves was secured but only occasionally and with difficulty. In no instance did the discharged spores germinate. In this respect, ascospores of <u>P. populi</u> are like conidia of the <u>Gloeosporium</u> sp. which is suspected of being its imperfect stage.

Until the factors that inhibit or control spore germination in these stages have been ascertained, it seems improbable that any progress can be made in determining the biologies of these organisms. Additional impeding factors, in this regard, are the small size and colourless character of the

C - 3

spores of both stages.

#### Other Ascomycetes on P. alba x grandidentata

In addition to <u>P</u>. <u>populi</u> two, as yet unidentified, ascomycetes were detected on overwintered leaves of <u>P</u>. <u>alba</u> x <u>grandidentata</u>. One develops on the upper surface of leaves; the other on the lower surface.

These fungi seem likely to be saprophytic since they were collected from non-blighted as well as from blighted leaves. Both were obtained in pure culture by the usual method of shooting ascospores onto the surface of synthetic media.

Spores of both ascomycetes germinated readily and pure cultures were secured. Cultures of the fungus from the upper surface of leaves produce conidia in large numbers. These are being used to inoculate leaves of <u>P</u>. <u>alba</u> x <u>grandidentata</u> for the purpose of establishing the parasitic capability of the fungus.

#### Cladosporium subsessile El. and Ev.

A collection of <u>C</u>. <u>subsessile</u> was made on an unidentified host believed to be <u>P</u>. <u>tremuloides</u>. Severe leaf spotting had occurred which was accompanied by heavy sporulation. Leaves of <u>P</u>. <u>alba</u> x <u>grandidentata</u> are being inoculated with spores of this pathogen.

#### Fusicladium tremulae Frank

<u>Related to ascigerous stage</u>. This prevalent leaf and twig blight pathogen of aspen has been connected with <u>Venturia tremulae</u> Aderh. The connection had been suspected but due to difficulty in finding <u>V. tremulae</u> and to the reluctance of ascospores to germinate it has, until recently, been impossible to prove the connection.

It is now evident that the former complex of fungi causing leaf and twig blight of poplar consists of two pathogens: <u>V. tremulae</u>; imperfect stage <u>F. tremulae</u>, and <u>Venturia populina</u> (Vuill.) Fabric.; imperfect stage <u>Pollaccia</u> <u>elegans</u> Serv.

Spore Release Mechanism and Dissemination. Spore release and dissemination in <u>F</u>. tremulae was studied. Conidia were trapped on glass slides exposed, daily, in a stand of aspen regeneration heavily infested with this pathogen.

It was found that spore release was triggered by rainfall in any degree. At such times, up to several hundred spores per square cm. were deposited on the horizontal glass surfaces. Practically no spores were trapped during dry periods.

From the pattern of distribution of spores on the slides, it was evident that they are disseminated by the impact of fragmenting and splattering raindrops. In view of the high concentration of spores on the traps and from the observed radius of splattering (a minimum of five feet from sporulating leaves) it appears that all leaves in a diseased area are thoroughly inoculated with conidia.

<u>Germination tests</u>. A series of spore germination tests were conducted ranging, at regular intervals, from  $50^{\circ}$  to  $80^{\circ}$ F. The results obtained confirmed previous findings that optimum spore germination in <u>F. tremulae</u> lies in the range  $72^{\circ} - 74^{\circ}$ F. This knowledge should increase the effectiveness of future inoculations with this organism.

C - 5

#### Inoculations

Several poplar species and varieties were inoculated with three pathogens of poplar noted for their destructiveness. The inoculum employed was mycelium grown on artificial media. In all instances the inoculum was introduced between the inner bark and the cambium. Inoculations and controls were wrapped with wet cotton and tin foil. The hosts inoculated were:

> Populus tremuloides Michx. P. tremula L.

P. alba L. x grandidentata Michx.

P. maximowiczii Henry x berolinensis Dipp.

F. angulata Ait. x vernirubens ?

The fungi used as inoculum were:

<u>Hypoxylon pruinatum</u> (Kotzsch) Cooke <u>Dothichiza populea</u> Sacc. and Briard <u>Cytospora chryososperma</u> (Pers.) Fries.

Of all these inoculations, only one yielded what appear to be positive results. This consisted of <u>H</u>. <u>pruinatum</u> on <u>P</u>. <u>tremula</u>. A very extensive canker developed at and below the site of inoculation. The control callused over completely and has remained healthy.

The negative results are attributed to resistance, in the host, induced by the time of year at which the inoculations were made (summer) and by the fact that all trees, with the exception of <u>P. tremula</u>, seem to be growing vigorously.

#### <u>H. pruinatum</u> on <u>P. alba x grandidentata</u>

During a recent visit of Dr. M. Boyer of the Laboratory of Forest Pathology, Quebec, to the Laboratory of Forest Pathology, Chalk River, a sporulating imperfect stage collection of <u>H. pruinatum</u> was obtained from <u>P. alba x grandidentata</u>. A large canker had formed around a branch stub on a five inch stem. Should this hybrid be very susceptible to <u>H</u>. <u>pruinatum</u> as well as to <u>Plagiostoma populi</u>, then its usefulness may be reduced to a very low level.

#### References

- (1) Cash, E. K. and M. Waterman. A new species of <u>Plagiostoma</u> associated with a leaf disease of hybrid aspen. Mycologia; XLIX, No. 5, 756-760. Sept. - Oct. 1957.
  - (2) Dance, B. W. A fungus associated with blight and dieback of hybrid aspen. Canada Dept. of Agr. Bi-monthly Progress Report; 13(6):
    1-2. 1957

#### SUMMARY FOR TREE BREEDING COMMITTEE MEETING

#### August 1958

A Study of Physiological Factors Influencing Flowering in Spruce - P-385

#### D.A. Fraser

#### Petawawa Forest Experiment Station

#### This study is divided into two parts:

- (a) Investigation of environmental factors influencing flowering in mature trees and the biochemical and anatomical changes associated with reproductive and vegetative growth. These data have been used to design experiments for growth chamber investigation of young trees.
- (b) Experiments on the effect of photoperiod, day and night temperatures and the application of auxins and auxin antagonists on growth and flowering of young spruce trees are being continued. A 3-acre Corry Lake Physiology area has been prepared and a planting programme for white and black spruce has been initiated so that material in different age classes will be available for future experiments.

The auxin assay research awaits the completion of the auxin assay room and the replacement for the position made vacant by Dr. L. Ebell's transfer to British Columbia.

Mr. W. Vanden Born has initiated Ph.D. studies on "Histochemical Investigation of Vegetative and Flowering Spruce Trees", under the auspices of Professor D. S. Van Fleet, University of Toronto, and D. A. Fraser, Tree Physiology Section, Petawawa Forest Experiment Station.

#### PUBLICATIONS

Fraser, D.A. 1958. The Relation of Environmental Factors to Flowering in Spruce. In The Physiology of Forest Trees 629-642; Ed. K.V. Thimann, The Ronald Press Co., N.Y.

and Andreas (1997) Andreas an an ang sanan an taon taon katala 

#### C. Heimburger

Breeding work with white pine, aspen poplars and twoneedled pines was continued, and some new work with white cedar was expanded.

#### White Pine

The seeds for an international 5-station provenance test Seeds of 12 provenances were sown at were assembled and sown. St. Williams to raise plants for two provenance test plantations, and at this Station, for a blister rust screening test. In a special study of seed germination in relation to length of stratification, it was found that seeds of the northern origins, as a rule, require less stratification than seeds of southern origins. The collection of scions from selected trees in the plantation at Connaught Ranges near Ottawa was completed. The plantation was then thinned, liberating all selected trees. Scions were also collected from Dr. Haddow's selections at Orono and of the 5 weevil resistant trees in the Lake of Two Rivers plantation in Algonquin Park. A test for weevil resistance was started at Thessalon, utilizing the plantation of Scotch pine established there in 1947 for top grafting of white pine test These comprised 5 clones selected for good growth materials. form and freedom from weeviling at Midhurst, 5 clones of weeviled white pine, and 5 weeviled and 5 seemingly weevil resistant clones of Pinus peuce near Havelock.

e the second a sour site philosophie, aspen poplate and tworespect pirages as well us y and row your with white ocdar the sources.

the standing and shat will present to stand the standard of the second Server and a server of the ് പട്കാലം നിന്നും പ്രവസം പ്രത്യം സംഗ്യം നിന്നും നിന്നും പ്രത്യം പ്രത്യം പ്രത്യം പ്രത്യം and the second process of denter redaktion of the second second second second second second second second second reader of the source and the second second of the second of the second second second second second second second enacian pretion of a second total compose that are the state of the pretion of the second second second second analysis and the second material states in the second second second second second second second second second s and the second of the second and constrained and sandthe second straining to a second straining the constant escap u eesti uuta on alle gilikeesti uutaa ja gadi geera eelitaayua MARST BRE PROVED AND A CONSIDER STOLEN IN SECTION AND AND A DEVICE AND A DEVICE AND A DEVICE AND A DEVICE AND A · 경제적 같이 · 비원이 나는 지역에 이 사람이 있는 것이라. 이 이 문제에 이 가슴에 가지 못했다. 이 가슴에 가지 않았다. an an an the set of the system of the set of the set of the state of the state of the state of the state of the and for the contraction of the contraction of the second state of  $\mathcal{T}$  is the constant of the constant of the constant of the constant of the constant  $\mathcal{T}$ di se esse de l'étais d'un de la company de la plan de la comp Breaktown (Son a construction of the second s ascore there also a reason dipodes of the only other of the transformed at the state . The second second

· . .

It was possible to induce bud formation in needle bundles of young white pine after summer pruning and to propagate these buds by means of plate budding in the greenhouse. A method of summer grafting was worked out, similar to the method developed previously for red pine. A new method of bark grafting was tried but proved inferior to the current method of veneer field grafting. A method of hastening the germination of freshly harvested seeds has been found. It consists of carefully removing the seed coat after soaking the seeds in water. The naked seeds then germinate promptly when mine placed in moist sand. Fifty-six inter-specific crosses out of 89 made in 1956 yielded viable seeds. One hundred and twelve new such crosses were made in 1957. Inoculation with blister rust was very successful, due to favourable weather conditions. The population of Pinus strobus x peuce showing outstanding low frequency of infection in 1956 continued to do so in 1957. A collection of named varieties of black currants was assembled, to find materials retaining their leaves until fall, for white pine inoculation with blister rust. Thus far, some of our own black currant seedlings appear more suitable in this respect.

#### Poplars

The production of aspen-like hybrids for easy propagation and growing in Southern Ontario, continued to be the chief aim of this project. By means of exchange with other poplar breeders, 18 new clones and 2 populations were obtained. A new method for determining rooting ability of cuttings was introduced, consisting of planting the cuttings in protected beds and mulching with leaves over winter. In breeding for good rooting ability, 20 new hybrid populations were produced. In breeding for early flowering,

F-2

gauoy to calculate affeorent cotto and and a set of the set of . Alte site all a cost grandes as it projects there are shote the bude by measu - Perind the Market and the second - Ben Miss - Mane Card Carley and the contract of the second second second second second second second second s (1,2,1) . Alter which is a product of the transformed structure of the transformed structure (1,2,2,2) . The Tharder and the second state of the second structure and been from the second structure. andra a Supera ng Barn Bren Sampang ang kunana ang kunana a sa sa sa sa sa sa sa sa sa Constant in the ADST All water that the second s The second state in the second state of the se ster and dame redenily date council process of the second second second second second second second second second sweepping of secondly paths in sold thous. The population of Pinus stroius graves devine devine outroandance from fragmanay off angeoties in 200 spitting of the solution of the 1957 of the transference of Books large ending to give increase on puddements of the high ending. The one and and billing in the second and a second of production of the

## 

<sup>1</sup> The production of angenerities by the second secon

<u>\_\_\_\_</u>

several hybrid populations produced in 1954, contained plants with flower buds in the fall of 1957. A progeny of two precocious aspens contained the largest proportion of precocious seedlings. It was possible to combine the precocious flowering habit with normal growth rate, at least up to the age of 4 years. Ninetyfour seedlings with outstanding growth rate and good form were selected from 1,552, for further propagation and testing. Two-needled Pines

Resistance to attack by the European pine shoot moth and adaptation to the growing conditions of Southern Ontario continued to be the chief aims of this project, and included the breeding of improved types of red pine. Twenty-six new clones and 4 populations were obtained, mostly of selected red pine and pitch pine, and Asiatic pine species. Five inter-specific crosses out of 38 made in 1956, yielded seemingly viable seeds. Twenty new such crosses were made in 1957. The method of summer grafting developed in 1956, was utilized for the propagation of 11 selected clones. Over a thousand seedlings and grafts of exotic hard pine species were set out in a plantation at Turkey Point, in a warmer climate than at this Station.

#### White Cedar

The production of improved types of this species and of western red cedar hardy in Southern Ontario, is the aim of this project. Seeds of one origin in Ontario and of 41 origins of western red cedar in British Columbia were obtained and sown. In addition, cuttings of 2 clones of Japanese red cedar and of 15 clones of western red cedar from British Columbia were collected and planted in rooting media.

F-3

Chestnut

The aim of this project is the production of hardy dwarf types, suitable as dwarfing stocks for timber-type chestnuts. Two seed lots, one of native chestnut and one of Chinese chestnut, were obtained and placed in boxes with sand in the fall of 1957. A seedling lot of native chestnut was received in the fall and heeled-in for the winter.

#### ANNUAL REPORT 1957 - 158

#### Forest Tree Breeding and Genetics

#### at the

#### Petawawa Forest Experiment Station

#### General

This report is issued for the information of co-operating persons and agencies in the field of tree breeding. It is not a research report, but merely gives an outline of the physical work accomplished in tree breeding at Petawawa during the year ending March 31, 1958.

Progress was disappointing for several reasons. Flowering was poor in 1957 owing to the combination of a heavy 1956 cone crop and cool, wet spring and summer weather in 1956 which discouraged formation of flower primordia. No control pollination work could be done.

#### White Spruce

A large white spruce provenance experiment with about 70 provenances has been in preparation for planting in the Great Lakes-St. Lawrence Forest Region for several years. Most of the seed has been assembled, but poor cone crops in 1957 prevented collection of the missing lets and we only managed to get a few small seedlots from the Lake States. However, we hope to collect the missing provenances in 1958 and to start the first series of experiments that fall.

A mursery provenance experiment in white spruce (Exp. No. 93-A) was measured and scored for several characters in an attempt to obtain data for studies of population genetics. The data have not yet been compiled and analysed.

パンの計画語

Observation plots (Exp. No. 78) including eight races of white spruce and two races of Colorada blue spruce were planted in the Fuel Wood Area (P.A. 114).

One provenance experiment in white spruce (Exp. No. 93-D) including 25 races was field planted during the fall of 1957 at Kapuskasing, Ontario, by the Spruce Falls Power and Paper Company. This experiment will be described in more detail when the complete series is planted during the Spring of 1958.

#### Norway Spruce

A number of Norway spruce experiments were established at the Station. Hybrids and selfings resulting from controlled pollination between weevil susceptible and weevil resistant individuals from Hudson's place were planted in the Fuelwood Area (Exp. No. 6-A, P.A. 114). Single tree progenies of elite slender Norway spruces were planted for later selection of frosthardy and weevil resistant trees (Exp. No. 75, P.A. 114). Slender genotypes may be associated with weevil resistance. Observation plots including 11 provenances of Norway spruce from selected stands in Poland, Germany, and Austria were field planted after being heavily graded in the transplant beds. (Exp. No. 80-A, P.A. 114). These observation plots will be heavily thinned at an early date to rogue out individuals susceptible to frost damage and white pine weevil.

Three experiments established to allow comparison of the progeny of the best Norway spruce stands in Europe and "second generation" Norway spruce in Canada were planted on the Valcartier Forest Experiment Station (Exp. Nos. 57-E, 57-G) and on the Causapscal Forest Research Station (Exp. No. 57-H). Another experiment in the same series had been planted with transplants that were too small, which resulted in a low survival. This experiment was replanted and enlarged (Exp. No. 57-C).

So far we have only worked with Norway spruce types from western Europe. Although these are easy to grow in the nursery, they may well be too tender for the continental climate of eastern Canada. For some years we have tried to obtain hardier types from Russia and Siberia. We finally managed to exchange seed with the Main Botanical Garden in Moscow and now have some very good seedbeds of Russian and Siberian <u>Picea ables</u> and <u>Picea obovata</u>. This material, was collected along the southern border of the species range to get hardy continental types which are also fairly fast growing. These may be used in future breeding and selection of spruces suitable for acid sites.

Eight clones including 506 grafts of selected weevil-resistant Norway spruces were planted in the A.E.C.L. graft plantation (P.A. 117). Grafted population samples of Norway spruce from Romania, Serbia, Slovenia, Denmark and some slender types of German Norway spruce selected in Sweden were planted in the arboretum on the Meridian Road (P.A. 101).

#### Red Spruce and Black Spruce

Observation plots including eight provenances of black spruce (Exp. No. 79) were planted in an area with a high water table in Young's Creek Road Area (P.A. 106). We lost a rather extensive black spruce provenance experiment due to pregermination in the autumn so we will have to wait with further black spruce provenance experiments until our white spruce experiments are completed.

About 42,000 2-0 red spruce seedlings of various provenances (Exp. No. 95) were transplanted in the nursery. The plants were obtained from Acadia Forest Experiment Station, and were not too thrifty.
Grafted population samples of red spruce from the Appalachian Mountains were planted in our Spruce Graft Arboretum and also at the Southern Research Station, Maple, Ontario.

## Other Spruces

Grafted samples of various exotics, such as <u>Picea schrenkiana</u>, <u>P. pungens</u>, <u>P. orientalis</u>, <u>P. omorica</u> and <u>P. asperata</u> were planted in the arboretum on the Meridian Road (P.A. 101).

Fifty-seven seed lots of various spruce hybrids were sown in the mursery and some of these were transplanted to the greenhouse in the fall and given a 20-hour photoperiod. This technique produced seedlings in one year which are the size of normal 3-year-old seedlings. Only the <u>P. glauca × pungens</u> hybrids show variation in growth response; some plants have developed slowly in comparison with the remainder.

## Red Pine

An experiment including two Ontario and three Quebec provenances (Exp. No. 81) was planted in the Young's Creek Road area, (P.A. 106). This experiment is intermediate between our established series of provenance experiments with Ontario red pine and the provenance experiment with samples from the entire range of red pine. The latter experiment is to be established across Canada in 1958.

A single tree progeny test (Exp. No. 38), a provenance experiment (Exp. No. 39), and a nursery provenance experiment (Exp. No. 74-A) were remeasured.

We also initiated a study of all known red pine provenance experiments in Canada and the United States to investigate the relationship between the climate in the place of origin and the growth in plantations of each provenance recorded. These data will be compared with our local phenological observations on red pine provenances. The compilation of data is nearly complete and we hope to publish the results soon.

We obtained seed for another red pine provenance study and a single tree progeny test to be conducted in co-operation with R. G. Hitt of the University of Wisconsin. (Exp. No. 215 and Exp. No. 216). The experiments are to be planted at Petawawa and in Wisconsin.

#### Jack Pine

An experiment with nine provenances of Ontario and Quebec jack pine (Exp. No. 82) was planted in the Young Creek Road Area (P.A. 106). In the same location a number of jack  $\times$  lodgepole pine hybrids were planted with the true species for comparison; these will be investigated at a later date and the undoubted hybrids will be selected. Another provenance experiment including twelve lots of Ontario jack pine (Exp. No. 40) was remeasured. When plotted on graph paper, the heights of the various provenances appeared to be related to the mean summer temperature and the length of growing season of the respective places of origin.

Collection of cones was continued for a jack pine provenance experiment covering the range of the species. Twenty-five collections were made by a number of co-operators.

#### Scots Pine

Seed of Russian and Siberian Scots pine provenances were sown in the nursery. Scots pine has a very poor reputation in Canada mainly because the seed originally imported came from stands of notoricusly malformed trees near Darmstadt in southwestern Germany. However, well adapted Scots pine of good form may have some merit on jack pine sites, and may produce more timber of a better quality than jack pine.

Scots pine provenances noted for a high production of resin in certain areas of Russia also may be of value for breeding of shoot moth resistant types.

An attempt was made to rate Scots pine Christmas tree selections grafted at an earlier date. This proved difficult. Future rating should be done five years after the grafts have been planted in the field.

Progenies of Scots pine selected for early flowering (Exp. No. 85) were planted. In due course these will be rated for their value as Christmas trees.

### Other Tree Species.

Observation plots for the comparison of Austrian and Polish larch and Ontario tamarack were planted in the Fuel Wood Area (Exp. No. 90-A, P.A. 114). In the same area a number of <u>Larix eurolepis</u> × <u>laricina</u> hybrids were also planted. (Exp. No. 100, P.A. 114).

Various <u>Betula verrucosa</u> lots which originated from plus trees in Sweden were planted in the Arboretum, (P.A. 101), and in the Young Creek Read Area, (Exp. No. 101-A and Exp. No. 101-B, P.A. 106).

Four provenances of high altitude Douglas fir from Montana, Utah and Wyoming were established in the Arboretum, (Exp. No. 84, P.A. 101).

#### Vegetative Propogation

Eight hundred grafts were made for an interspecific grafting

G-4

experiment in which white, Norway, red and black spruce were grafted in all combinations (Exp. No. 212). There were no apparent differences in the per cent take and all scients look normal. In time we shall see whether black spruce rootstocks have a flower inducing effect.

## Nursery Work

A study of damping-off in relation to soil types and various soil treatments (Exp. No. 191) indicated that a combination of forest litter and steam sterilization gave the best protection against dampingoff.

About 68,000 seedlings were transplanted.

## Plantation Work

Sixteen experiments including 39,500 plants and covering an area of 21 acres were established on the Petawawa Forest Experiment Station. Three Norway spruce experiments including 26,400 plants and covering an area of 17.9 acres were planted in the Province of Quebec.

REPORTS

Establishment Report for Experiment No. 57-E, Project P-136. Provenance experiment planted fall 1956 including six races of Norway spruce planted in Compartment B of the Valcartier Forest Experiment Station.

M. J. Holst.

Establishment report for Experiment No. 57-G, Project P-136. Provenance experiment planted spring and fall 1957 including eight races of Norway spruce planted in the Hart Hill Block of the Valcartier Forest Experiment Station.

M. J. Holst.

Establishment Report for Experiment No. 57-H, Project P-136. Provenance experiment planted fall 1957 including seven races of Norway spruce planted on the Causapscal Forest Research Station of the New Brunswick International Paper Company.

M. J. Holst.

How are our white spruce provenance experiments progressing? Paper presented at the Annual Meeting of the Woodlands Section of the C.P.P.A. in Montreal, March 27, 1958.

M. J. Holst.

¢7

Planting plans for Spring, 1958.

C. W. Yeatman.

| Experiment<br>Number | Description   |                                  | No. of<br>Plants | Area<br>(acres) | Plantation<br>Area |
|----------------------|---|----------------------------------|------------------|-----------------|--------------------|
|                      | Weeyil resistant Norway Spruce  | Gratis                           | 500              | 1.64            | P.A. 117           |
|                      | Benanical spruce grafts   | Grafts                           | 200              | 2,30            | 1.<br>1.           |
| 6- <b>A</b>          | Controlled hybrids between weevil resistant<br>and weevil susceptible Norway spruces on<br>Hudgon's Place |                                  | 490              | 1.80            | P.A. 114           |
| 75                   | Single tree progeny test with 15 Norwegian<br>elite Norway spruces  |                                  | 3,000            | 1.14            | P.A. 114           |
| <b>78</b>            | Observation plots including eight races of<br>white spruce and two races of Colorado blue<br>spruce       |                                  | 5,000            | 1,18            | P.A. JLL           |
| 42                   | Observation plots including nine provenances of whack spruce  | ē.                               | 3,000            | 1,10            | P.A. 106           |
| 80 <b>-A</b>         | Observation plots of eleven provenances of<br>Nerway spruce   |                                  | 11,000           | 3°25            | P.A. 114           |
| 5                    | Frovenance experiment in red pine including<br>two Ontario races and three Quebec races                   | Experiment<br>Div. &<br>Surround | 2,500<br>3,352   | 1,22            | P.A. 106           |
|                      |   |                                  | ·                |                 | C2<br>•<br>•       |
|                      |   |                                  |                  |                 |                    |

•

TABLE 1

1

G-7

| <br> -<br> -<br> -<br> - |   |                        | ,                     |                 |                        |
|--------------------------|---|------------------------|-----------------------|-----------------|------------------------|
| Experiment<br>Number     | Description   | 24                     | Ne. of<br>Plants      | Area<br>(acres) | Plantatio<br>Area      |
| 82                       | Provenance experiment with nine Expe<br>races of jack pine Dive<br>Surr | rîment<br>, &<br>found | 2,700<br>964<br>2,664 | 1°35            | P.A. 106               |
| 83                       | Mixed jack pine lodgepole pine wherids                                  |                        | 3,000                 | 1.10            | P.A. 106               |
| 84                       | Provenance experiment with four races<br>of Douglas fir                 |                        | 200                   | 0°07            | P.A. 101               |
| 85                       | Selection of early flowering Scots<br>pine for root stock purposes      |                        | 240                   | 0°09            | P.A. 106               |
| 4.8                      | Lodgepole pine test   |                        | 1,000                 | 0°.37           | P.A. 106               |
| <b>A−0</b> €             | Observation of Austrian, Polish, Finnish<br>and Ontarie larch           |                        | 3,000                 | 3.94            | P.A. 114               |
| 100                      | Interspecific hybridization in Larix                                    |                        | 400                   | 0°25            | P.A. 114               |
| 101 A+B                  | Trial of Scandinavian elite birch                                       |                        | 1,000                 | 0°.37           | P.A. 101 &<br>P.A. 106 |
|                          |   | 1                      | 39,546                | 21.17 ac.       |                        |

TABLE 1 (Cont'd)

**G-**8

à.

|                      | PLANTATIONS ESTABLISHED IN 1957 OUTSIDE   | PETAWAWA FORI    | ST EXPERIM      | ENT STATION   |
|----------------------|---|------------------|-----------------|---|
| Experiment<br>Number |   | Ne. of<br>Plants | Area<br>(Acres) | Agent   |
| 57 <b>-</b> E        | Provenance experiment planted<br>fall 1956 including six races of<br>Norway spruce                      | 18,940           | 13.0            | Compartment B<br>Valcartier F.E.S.<br>Loretteville, P.Q.                              |
| 57-G                 | Provenance experiment planted<br>spring and fall of 1957 in-<br>cluding eight races of Norway<br>spruce | 4,160            | 2.4             | Hart Hill Block<br>Valcartier F.E.S.,<br>Loretteville, P.Q.                           |
| H≂LS                 | Provenance experiment planted<br>fall 1957 including seven races<br>of Norway spruce                    | 3,300            | 2°2             | Causapscal Forest<br>Research Station,<br>New Brunswick<br>International<br>Paper Co. |
|                      | TOTALS  | 26,400           | 17.9            |   |

TABLE 2

# TABLE 3

# SUMMARY OF GRAFTING DURING SPRING AND FALL 1957

| Lake States red pine plus trees  | 150  |
|----------------------------------|------|
| Early flowering red pine         | 52   |
| Fastigiate red pine              | 60   |
| <u>Pinus sinensis</u>            | 86   |
| <u>Pimis nigra</u>               | 77   |
| <u>Pinus sylvestris</u>          | 105  |
| Interspecific grafting in spruce | 800  |
| One plus tree                    | 20   |
| Total                            | 1350 |

# TABLE 4

# TRANSPLANTING SPRING 1957

| Experiment<br>Number | Material  | Ne. of Plants |
|----------------------|---|---------------|
| 140                  | Slender Norway spruce types to<br>be selected for weevil resistance | 12,335        |
| 139                  | Danish white × sitka spruce hybrids<br>and comparison material      | 5,485         |
| 95                   | Red spruce provenances (obtained from Acadia F.E.S.)                | 42,000        |
| 98                   | High resin yield Austrian pine<br>for shoot moth resistance work    | <b>1,</b> 260 |
| -                    | Russian Scots pine  | 850           |
| -                    | Pine and spruce reststecks  | 6,000         |
|                      | Total   | 67,930        |

T:

G-11

÷

# PROJECT INVENTORY OF FOREST GENETICS RESEARCH UNIVERSITY OF BRITISH COLUMBIA

Under a Grant from the National Research Council by

A.H. Hutchinson, Ph.D., Professor Emeritus Abstracts of Research in Progress, 1958

# 1. <u>An Analysis of Growth Variation in Douglas Fir with a View</u> <u>toward Seed Selection</u> A. H. Hutchinson.

Thirty localized seed collections from areas west of the Rocky and Sierra Nevada Mountains have been utilized in coastal British Columbia nurseries, under comparable conditions, during the period 1953-58. The total number of readings exceeds 90,000. Particular attention has been given to stem and branch length and diameter; leaf size and colour; bud activity cycles and frost sensitivity. Evidences of disease and insect resistance are noted.

During the five year period, climatic extremes have been recorded. For instance, the November frost of 1955 resulted in complete annihilation of seedlings from California seed, 70 to 90 percent killing of lower level coastal British Columbia seedlings and distortion of 40 to 60 percent of the survivors; conversely, seed from higher levels, including coastal and interior areas show increased tolerance, to the extent of completeness.

There is evidence that variation is greatest under optimal conditions and that adaptive standardization results from selection under rigorous conditions and that these characters are hereditarily retained in the new environment.

It is concluded that multiple factors are operative in the inheritance of these physiological characters. The moder of operation of polygenes is formulated in the second project reported here and a basis of controlled selection is presented.

2. <u>The Cyto-operative System Basic to the Binary Frequency</u> <u>Distribution of Multiple Factors - Polygenic Alleles</u>. A.H. Hutchinson.

The inheritance of many quantitative characters, as colour and size of wheat was attributed by Nilsson-Ehle (1911) to the action of multiple factors or polymeric genes. Mather (1943-53) uses 'polygenes' to designate the components of any group contributing to a common phenotypic product. Nilsson-Ehle, Lang (1911) and Sirks stipulated Mendelian segregation as a requisite and Lang stipulated equality of the factors. A paper presented to the Tenth International Congress of Genetics by A. H. Hutchinson emphasized the quantisized concept; that the phenotypes may include overlapping phenotypic ranges of the classes without loss of identity.

Characteristics of the population may be expressed in terms which are in accord with Pascal's binomial triangle and the binary notation: specifically let the number of polygenic alleles = 'N', the heterozygocity of genotypes = 'H', and the combined heterozygocity of biparental genotypes = 'H', then the number of polygenes = 2N; the number of phenotypes (2N+1); the number primary genotypes is  $3^N$ ; the base of phenotypic and genotypic frequency is  $4^N$ ; the number of effective genotypes is factorial (N+1); the number of filiotypes = factorial (2N+1); the frequency of the phenotypes in a filiotypic series = (1+1)H × 22N-H. The class frequencies of filiotypes are characterized by polygon curves.

The limitations of gamete or spore dispersal results in localized establishment of filiotypes. Further the operation of adaptive natural selection increases the completion of adapted ecotypes, races or subspecies.

3. <u>Cytological Studies of Sensitivity to Nutritional Deficiencies</u> <u>in Conifers</u>. A. H. Hutchinson.

Leaves of Douglas fir, sitka spruce, western hemlock and western red cedar have been sectioned and stained by special methods. There is a notable variation of sensitivity to nutritional deficiencies, which is not only inter-generic and interspecial, but also applies to individuals within species and is evident in particular tissues and cellular structures. The cytological changes finally become externally evident as characteristic markings or deformities.

The leaves were obtained from experiments conducted by Prof. V. Krajina of the University of British Columbia.

<u>Cytological studies of Chromosomes and Plastids in</u>
<u>Douglas fir</u>,
A. H. Hutchinson and H. Sweet.

Studies of leaf buds of Douglas fir show definite individuality of chromosomes and under varying cultural conditions aberrations occur in a number of chromosomal structures suggesting translocations and polysomaty.

Special methods of preparation and staining have been utilized.

5. <u>Aberrations in the Chromosome Complement of Douglas fir</u>. A. H. Hutchinson.

There is much evidence of the nuclear origin of plastids and other "cytoplasmic" bodies in the leaf cells of Douglas fir. In some cases the nuclear orifices, from which the protoplastids emerge, have specific loci. Further investigation is necessary.

# Publication:

Hutchinson, A. H.

<u>The Principles Involved in Polygenic</u> <u>Selection from a Polyzygous Population of</u> <u>Douglas Fir</u>. Proc. X Int. Gen. Congress., McGill University, Montreal, Aug., 1958.

## Abstract

A genotypic evaluation of wind pollinated Douglas fir populations is premised on polygenic segregation involving various growth rates, frost sensitivity and cyclic bud activity. In each case three or four allelic factors are required to satisfy the polyzygous states, which are evident from more than 80,000 readings. Simple equations in terms of 'N', the number of polygenic alleles and 'n', the degree of parental heterozygocity, relate the phenotypes and genotypes of the progenitors to the class frequency distribution coefficients of the progenies, (1+1)<sup>n</sup> × 2<sup>2N-n</sup>. All population curves are reduced to the common base, 2<sup>2N</sup>.

Each controlled biparental class frequency polygon of a specific polyzygous population is balanced and includes (n + 1)phenotypic classes from a possible (2N + 1) classes each of which belongs to one of (factorial (N + 1)) effective genotypic classes. These genotypes may combine to produce factorial 2N + 1 class frequency series, as progenies. Wind pollinated, multiparental stocks are characterized by class frequency polygons which show predictable skewness, multiple peaks and extended plateaus.

Selection may be controlled genotypically on these bases. Examples of natural selection are presented.

## REPORT ON TREE IMPROVEMENT WORK AT THE ACADIA FOREST EXPERIMENT STATION, 1957-58

## H. G. MacGillivray

This report deals with the tree improvement work that was done at the Acadia Forest Experiment Station from the summer, 1957 to the spring, 1958. This work was chiefly concerned with red pine, <u>Pinus resinosa</u>, red spruce, <u>Picea rubens</u> and balsam fir, <u>Abies balsamea</u>.

### Red Pine Provenance Experiment

A red pine provenance experiment was established at the Chignecto Game Sanctuary, in Nova Scotia in May, 1958. This is part of a larger provenance study being conducted by Mark Holst. The planting stock for the Chignecto experiment was supplied from the Petawawa Forest Experiment Station.

The pre-planting treatment of the planting site was completed in August, 1957. This consisted of clear cutting a light hardwood overstory and spraying the root collars of the stumps with 2,4,5-T in diesel oil with a concentration of 2.5 ounces of 2,4,5-T acid equivalent per gallon of spray.

The planting material consisted of 16 provenances from the United States and Canada. A lattice square design, with five replications of each provenance, was used. Each plot or replication consisted of 49 trees--seven rows of seven trees each. The spacing was 4 feet x 4 feet. One division row was planted between the plots and two surround rows were planted around the outer edge of the plantation. Planting was done with Saguenay tools.

#### Red Spruce

### Selection

The selection of red spruce, as described in the report to this Committee last year, was continued during the fall of 1957. Selections were made of the two best and one of the poorest trees in each of five stands. Scions from these trees were grafted during the late fall, 1957. A side line experiment to check the effects of red spruce, black spruce, <u>P. mariana</u> and white spruce, <u>P. glauca</u>, rootstocks on the growth of the red spruce scions was initiated using this material. Thirty-three scions from each tree were grafted to each species of rootstock. Unfortunately a needle-cast disease attacked the rootstocks in February. It did not appear to harm the scions. Conditions in the greenhouse, temperatures of  $50^{\circ}$ -  $55^{\circ}$ F and relative humidity 80 - 95 per cent, may have favoured the development of the disease. The temperature was raised to  $60^{\circ}$ F and the relative humidity was lowered but mortality of the rootstocks was heavy.

# Provenance Experiments

Sites for three red spruce provenance experiments were selected and are being prepared in New Brunswick near the Bay of Fundy, at Acadia Forest Experiment Station and in the northwestern part of the Province.

#### Balsam Fir

#### Breeding

Attempts to produce a hybrid fir, suitable for Maritime conditions, were made in May, using balsam fir as the female and pollen from <u>A</u>. <u>nobilis</u>, <u>A</u>. <u>cephalonica</u>, <u>A</u>. <u>grandis</u>, and <u>A</u>. <u>nordmanniana</u>. This pollen had been in cold storage since it was collected in 1957.

Ten special tents were made with the cooperation of Mr. B. Douglass, Superintendent, Acadia Forest Experiment Station, for isolating the cone producing sections of the crowns of balsam fir trees. The use of these tents greatly reduced (1) the amount of work, and (2) the danger involved in bagging and pollinating.

Each tent is cone shaped and about 4 feet high and 4 feet in diameter at the bottom. The top of the tent is a cone-shaped cap of galvanized iron, about 1 foot in diameter. The cloth (pillow ticking) part of the tent is lashed to the cap. A hoop of light iron, 4 feet in diameter, is fastened inside the lower part of the tent to keep it flared and away from the branches. A flap or skirt, 3- to 4-feet long, extends below the iron hoop.

In placing the tent in position a 20-foot pole was first tied to the top part of the stem of the tree to support the tent. The top of this tent pole extended just beyond the leader of the tree. The tent was raised on an aluminum rod and set down over the tent pole. The tent pole supported the metal cap which in turn supported the tent. The lower flap was puckered and bound around the stem and tent pole. Cotton wool was wrapped around the tent pole and stem, under the tent flap to ensure a pollen tight joint. Four guy ropes from the iron hoop to the tree stem secured the tent in position.

To make pollination less dangerous an 8-foot piece of copper tubing was attached to the tent pole. The top of the tube came within a foot of the upper end of the pole. A car tire hand pump was used to force the pollen up through the tube into the flowering part of the crown. This made it unnecessary to climb into the weak section of the crown during the pollination. The tent poles will be left in position until the fall. The tents will be replaced at the end of August to catch the seeds should cone collecting be delayed. Nicotine or DDT will be applied to the cone bearing section of the crowns when the tents are replaced to discourage squirrel damage.

#### Miscellaneous

Material is growing in the nursery which will be suitable for provenance experiments in balsam fir and Norway spruce, <u>P</u>. <u>abies</u> and observation plots of exotic fir.

The following were published during the past year.

MacGILLIVRAY, H. G. 1957. Rooting balsam fir cuttings under intermittent mist. For. Chron. 33: 353-354.

MALCOLM, D.J., C.F. EVERETT, and H.G. MacGILLIVRAY. 1957. Preplanting treatments for control of weeds in conifer seedling beds. <u>In</u>. Res. Rep. Nat. Weed Comm., East Sect. 1957, pp. 60. Canada Dept. Agriculture.

1957. Pre-emergence treatments for weed control in conifer seedling beds. A. Early pre-emergence (residual). B. Late pre-emergence (contact). <u>In</u>. Res. Rep. Nat. Weed Comm., East Sect. 1957, pp. 60-61. Canada Dept. Agriculture.

1957. Post-emergence treatments for weed control in conifer seedling beds. <u>In</u>. Res. Rep. Nat. Weed Comm., East Sect. 1957, pp. 61-62. Canada Dept. Agriculture.

1957. Post-emergence treatments for control of weeds in conifer liners. <u>In</u>. Res. Rep. Nat. Weed Comm., East Sect. 1957, pp. 62-63. Canada Dept. Agriculture.

The work on weed control is mentioned here because of the importance of nursery management in tree breeding. This was started when it became apparent that weeds were going to be a serious nursery problem in 1957. It was done in cooperation with members of the Field Husbandry Branch, New Brunswick Department of Agriculture, and the Experimental Farm, Canada Department of Agriculture. This work is being continued in 1958. In 1957 only chemicals recommended for use in forest nurseries were tried. None of these proved to be entirely satisfactory when both weed control and damage to seedlings and liners were considered.

## CYTOGENETIC STUDIES IN CARAGANA 1958

R.J. Moore

Botany & Plant Pathology Division, Science Service, Department of Agriculture, Ottawa

### Caragana arborescens Tetraploid

The selfed seed obtained in 1957 from a colchicinetreated branch of a bush of G. arboressens germinated and produced seedlings with the tetraploid (2n=32) chromosome number. The seedlings were grown from time of emergence (Nov. 22, 1967) under daylight supplemented by artificial incandescent light to produce a 16 hour day. Seedlings from self and open-pollinated diploid seed of the same bush were grown for comparison. All tetraploid seed germinated and grew at about the same rate as the diploids, all seedlings having 4-6 leaves one month after emergence. At this time the more variable open-pollinated seedlings ranged in height from 2.5 to 9 cm, whereas the selfed seedlings (diploid and tetraploid) were more uniformly 5-6 cm. About 2 months after germination the tetraploids seased growth at a height of ( em. (10 leaves) and remained thus for 3 months, eventually losing their leaves. The diploid seedlings continued growth for 4 months from germination and easily surpassed the tetraploid in height (to 30 cm.). The tetraploids were planted outdoors in early May but not until early July did the terminal bad begin to open to resume growth. One tetraploid seedling was placed at emergence (late April) under continuous light (daylight plus 1000 fe artificial). Growth was apparently normal for 2 wooks but then ceased (ht. 2 on.). The seedling began to deteriorate and although it was returned to natural daylight, soon died. Under these conditions of continuous illumination Dr. Senn has found that diploid Q. arboressens makes continuous growth and some plants will flower in 9 months.

# Caregana arborescens Lam, f. lorbergii Kochne

Observation of this narrow-leaved, narrow-flowered, usually seed-sterile form and of the progeny of crosses with typical arborescens and with lorbergii have led to the hypothesis that the form is a periclinal chimera. It is believed that mutation of the wild gene (1) to an incompletely dominant condition (L)has produced lorbergii from the species. The peripheral tissue (tunica) of the form lorbergii is of the genotype L1, the core (corpus) being 11-- as in normal arborescens. Oscasionally bushes of lorbergii are seen where a branch arising from ground level is typical arborescens. Presumably such a branch is composed of sorpus tissue only.

It is believed that gametes are formed from the heterozygous tissue. When crossed with <u>arborescens</u>. 8 types of progeny result: typical <u>arborescens</u> (II) and plants with foliage intermediate between <u>lorbergii</u> and <u>arborescens</u> and variable on the one bush (L1). The occasional fertile flowers of <u>lortergii</u> are self-sterile but when open-pellinated, presumably by other adjacent <u>lorbergii</u> bushes, produce the above 2 classes of progeny and, in addition, a third class -- super-lorbergii--foliage lorbergii-type, bush dwarf and non-flowering (L1). Seedlings wholly of tissue L1 are unlike the parental chimers composed of L1 tissue on the l1 core.

(Assistance of Dr. W.H. Cram, Indian Heed, Sask., in providing seedlings of crosses made by him, is acknowledged).

#### ANNUAL REPORT ON FOREST GENETICS 1957

by

## A. L. Orr Ewing, Research Division, B.C. Forest Service.

## 1. General

No changes in personnel have taken place and the shortage of trained assistance with a rapidly expanding program remains a constant problem.

General interest in forest genetics has increased considerably and talks to both professional and public groups were given during the year. The annual field meeting of the Western Forest Genetics Association was held at the Duncan Nursery and the Forest Experiment Station of the B. C. Forest Service. This Association draws members from the western states of the U.S.A. in addition to those from B. C.

There were again a large number of requests for seed and **consignment** form has been introduced for the purpose of recording the source of all seed sent out of the province. During the year seed was sent to India, South Korea, Iceland, Denmark, Argentina, U.S.A. and other provinces of Canada. A seed receipt form has also been introduced in order to record all seed brought in to the province, special seed lots were received from California, Formosa, Japan and the Soviet Union.

## 2. Seed Classification and Registration

The new system of seed classification and registration was used for the first time in 1957 and all seed lots collected by or for the B. C. Forest Service were duly registered. The research nurseryman now supervises the reception of all cone collections at the seed extraction plant at Duncan nursery. He is also responsible for keeping all records concerned with registration and for the seed while it is in storage. Some amendments and improvements to the system have been made, it will now include all those seed lots stored and sown in the Forest Service nurseries which are the property of the Forest Industry and other agencies. In future lots of either cones nor seed will not be received for extraction or storage at Duncan unless they are accompanied by the necessary information.

## 3. Plus tree selection for Douglas fir seed orchards

Selected high elevation stands of Douglas fir were intensively cruised in 1957 and ten plus trees were finally selected, the criteria of selection being based on quality rather than on volume. The stands were from forty to ninety years of age as it was considered that selection in these age classes would be preferable to selection in mature stands of Douglas fir where the ages commonly range from 250 to 600 years. In these latter stands, the effects of the environment are even more difficult to dissociate from those that may be genetic. Scions were shot down from all ten trees and successfully tip grafted on to root stock in the spring of 1958. These will serve to initiate a clone bank as the plus trees are not readily accessible. Some cones were also collected from three of the trees and progeny tests will be instigated as early as possible. The root stock for a small seed orchard has been planted at Duncan nursery and grafting of the plus tree scions will begin in 1959. Other suitable high elevation stands are being cruised at the present time and a further ten plus trees remain to be selected. The seed orchard will be represented by sixteen clones from each of the twenty plus trees with a final spacing of twentyone by twenty-one feet. A four by five rectangular lattice design replicated five times has been used in establishing the orchard.

It was felt that an early start should also be made on evaluating the inherent factors related to wood quality and a co-operative study with the Vancouver Forest Products Laboratory of the Dominion government is accordingly being initiated. It is planned that the important wood characters of all selected plus trees will be analysed and that later parent progeny relationships will be made.

## 4. Inbreeding experiments with Douglas fir

Eight inbred lines have been planted out on experimental area for later outcrossing and it is hoped that this work can be extended to the selected plus trees.

## 5. A study of phenotypes in Douglas fir

This study was initiated to compare the development of the progeny from poor and good phenotypes growing at high elevations in order to determine the significance of unfavourable aspects of environment. Stock from both seed sources was fall planted in 1957 in three replicated blocks at an elevation of 3,000 feet.

# 6. Phenotypic selection in open grown Douglas fir

This study was initiated to demonstrate the need for careful selection of parent trees for cone collections. Both scions and wind pollinated cones were collected from both good and poor phenotypes in an open grown stand, the parent tree being selected on the basis of form, growth and branching characteristics. The scions were veneer grafted on to root stock and planted out in replicated blocks in 1957. The seedlings resulting from the wind pollination of each of the parent trees were planted out in the same blocks in 1958. Both the seedlings and grafts from one of the poorer phenotypes already provide an excellent demonstration of the risks attached to uncontrolled cone collections. There was encouraging evidence of early cone production from the grafted scions. One of these which was grafted in March 1956 and planted in 1957 produced one fully developed female cone and several male cones that same year, the female cone, moreover, produced seven viable seeds. A detailed analysis of this study will be made at an early date. 7. A co-operative seed provenance study of Douglas fir

Seed from sixteen sources in British Columbia, Washington and Oregon has been collected and sown at the Oregon State nursery. The seedlings from all sixteen seed sources will be outplanted in replicated blocks at each of the sources and will be available for planting in either the fall of 1958 or in the spring of 1959. Each outplanting area is over eleven acres in size and considerable clearing has been necessary on the one selected by the B.C. Forest Service, who are also responsible for coordinating the project for the other four co-operating agencies in B.C.

# 8. <u>Experimental plantings of exotic conifers for future</u> <u>hybridization studies with related coastal species</u>

It was felt that a start should be made towards the establishment of a small arboretum which could be used for later hybridization studies. Seed from the following species of Douglas fir were obtained in 1957 and sown in the spring of 1958, <u>Pseudotsuga macrocarpa</u>, <u>Mayr</u>, from California, U.S.A., <u>Pseudotsuga japonica</u>, <u>Beissner</u> from Japan, <u>Pseudotsuga Wilsoniana</u> (Hay) from Formosa, <u>Pseudotsuga forestii</u>, <u>Craib</u> and <u>Pseudotsuga sinensis</u>, <u>Dode</u> from China, and <u>Pseudotsuga menzeseii var glauca</u> from Arizona, U.S.A. One species of Hemlock, Tsuga siebaldii, Carr was obtained from Japan.

## 9. Seed. Production Areas

In order to improve both the quality and quantity of Douglas fir seed, the Reforestation division have recently established two high elevation seed production areas of from 4.4 and 7.4 acres respectively. The better phenotypes in the stand have been retained at an arbitrary spacing of twenty feet, the remaining trees have been removed and the underbrush sprayed in order to eliminate competition. The two stands are from 28 to 30 and from 31 to 38 years old and average 34 feet in height. Seed coming from such areas in the future will be in the B2 category. Several replicated fertilizer treatments were applied in May and June of this year in attempts to stimulate cone production.

### PUBLICATIONS IN 1957

Orr Ewing, A. L.

Possible Occurrence of Viable Unfertilized Seeds in Douglas Fir. Technical Publication T. 47, 6 pp. Reprinted from Forest Science, Vol. 3, No. 3, September 1957.

A Cytological Study of the Effects of Self-Pollination on <u>Pseudotsuga</u> <u>Menziesii</u> (Mirb.) Franco. Technical Publication T. 48, 7 pp. Reprinted from Silvae Genetica. Vol. 6, No. 6. December, 1957.

Further Inbreeding Studies with Douglas Fir. Technical Publication T. 50. 15 pp. Reprinted from Forestry Chronicle. Vol: 33. No. 4. 1957.

Better Timber for B. C. Depends on a Good Seed Programme. B. C. Lumberman. 4 pp. Vol. 41. No. 5. 1957.

## August 1958

## Rene Pomerleau

## Forest Biology Laboratory

## Canada Department of Agriculture

Quebec City, Que.

#### Dutch Elm Disease

The breeding program for elm strains resistant to this desease was initiated in 1949 in co-operation with the L'Assomption Experiment Station. The main purpose of this project was the finding of resistant or tolerant strains of the American elm to the attack of <u>Ceratocystis ulmi</u>. From a number of trees, which have escaped infection in the central zone of the outbreak in Quebec, seeds and cuttings are collected every year and propagated in the greenhouse and the field of the experiment station. To test their resistance, oneyear-old seedlings and cuttings are inoculated with the fungus the following year and trees showing symptoms of the infection are discarded the same year. Those that have not shown wilting of leaves are left another year and reinoculated. An increasing number of seedlings have been inoculated since 1952 and now more than 30,000 new seedlings are grown for this purpose every year at L'Assomption.

After a consultation with Dr. Swingle in Columbus, Ohio the writer and Dr. Hunter of the Horticultural Division in Ottawa in 1953, it had been agreed to treat a number of seeds with x-rays in view of obtaining mutations which may prove resistant to the infection. In 1956, a seed lot was also treated with Thermal neutrons for the same reason. The result of these tests for resistance up to 1957 is summarized in the following table:

|                        | in 1                               | L'Assomption s | ince 1952                   |                           |                       |
|------------------------|------------------------------------|----------------|-----------------------------|---------------------------|-----------------------|
| Year of<br>inoculation | Year of<br>sowing                  | Treatment      | No. of<br>inocu-<br>lations | Number of s<br>Inoculated | seedlings<br>Infected |
| 1952                   | 1949-51                            | None           | 0                           | 288                       | 33                    |
| 1953                   | 1949-51<br>1949-52                 | 88<br>36       | 1 .<br>0                    | 33<br>1,341               | 15<br>144             |
| 1954                   | 1949<br>1949-51<br>1952<br>1952-53 | 98<br>98<br>69 | 2<br>1<br>1<br>0            | 15<br>47<br>97<br>4,576   | 1<br>0<br>6<br>701    |

# Inoculation Tests of Elm Seedlings

| Year of     | Year of |             | No. of            | Number of  | seedlings |
|-------------|---------|-------------|-------------------|------------|-----------|
| inoculation | sowing  | Treatment   | inocu-<br>lations | Inoculated | Infected  |
|             |         |             |                   | · · · ·    |           |
| 1955        | 1949    | None        | 3                 | 1          | 0         |
|             | 1952    | Ħ           | 2                 | 6          | 3         |
|             | 1952-53 | . <b>19</b> | 1                 | 701        | 21        |
|             | 1954    | 11          | ō                 | 14.092     | 2.584     |
|             | 1954    | X-rayed     | Ō                 | 2,698      | 416       |
| 1956        | 1952    | None        | 3                 | 3          | 1         |
|             | 1952-53 | 11          | 2                 | 21         | ī         |
|             | 1954    |             | 1                 | 2,584      | 19        |
|             | 1955    | <b>H</b> is | 0                 | 1,000      | 53        |
|             | 1954    | X-rayed     | 1                 | 416        | 6         |
|             | 1955    | ູສັ         | 0                 | 19,000     | 1,265     |
| 1957        | 1952    | None        | 4                 | 1          | 1         |
|             | 1952-53 | Ħ           | 3                 | 1          | ō         |
|             | 1954    | , tt        | 2                 | 19         | 2         |
|             | 1955    | 11          | 1                 | 53         | •         |
|             | 1954    | X-rayed     | 2                 | 6          | 0         |
|             | 1955    | n           | l                 | 1,265      | 185       |
|             | 1956    | None        | 0                 | 3.050      | 846       |
|             | 1956    | X-rayed     | 0                 | 19.490     | 4.574     |
|             | 1956    | T.N. *      | 0                 | 12.481     | 3.441     |

T.N. = Thermal-neutrons

Total number of inoculated plants in 1957 = 36,366

During the six years more than 70,000 seedlings have been inoculated once and sometimes twice, thrice and even four times. Results of this work indicated that a large number of seedlings have succumbed from one inoculation, and those which were not symptomatic the first year and have apparently resisted to the attack were infected after two and three inoculations. One tree from the 1950 seed crop was not killed by the fungus after five inoculations, but was thoroughly infected and finally died in 1957. Another one planted in 1952 is still living after six inoculations. However, both trees are stunted individuals which hardly grow every year. This cannot be considered as a resistant material since the fungus development is limited in the small wood vessels.

In view of surveying for possible existence of resistant elm strains, collections of seeds have been made in 1957 and 1958 in the Quebec city area and further north at the border of the American elm range. The result of the first test carried out this year is not yet compiled.

Since the American elm had not yet shown definite signs of tolerance to the disease, a number of hybrids of European elm species with low susceptibility to the fungus attack were obtained in Holland. In order to initiate a series of tests on the potentiality of such trees in Eastern Canada, scions from height clones, produced at the Willie Commelin Scholten laboratory in Baarn, Holland, were imported last winter and grafted in the Quebec laboratory greenhouse. As many as five and sometimes ten grafts were successful and are now growing in the laboratory nursery. This material will be used for propagation and for testing their hardiness and susceptibility to native diseases.

## Poplar Hybrid Disease Resistance

This project, initiated in 1956, was undertaken in co-operation with the Harrington Forest Farm and the Maple Experiment Station in view of determining the hardiness of poplar hybrids and their resistance to diseases under the conditions of Quebec. A number of clones provided by the Harrington Farm and Dr. Heimburger were planted on the laboratory nursery for future observations.

The first significant observation on the condition of health of these hybrids in Quebec was made in the Harrington Farm, during August 1957, where many poplars of a few years of age are severely sunscalded and show heavy top dying. As reported by Mr. Jaap Salm, the clones which could not withstand winter and spring conditions of 1957 at Harrington were the following ones:

- P. angulata x Simonii no. L611
- P. berolinensis x Simonii no. L885
- P. candicans x berolinensis no. L978
- P. nigra x laurifolia Strathgloss no. L1060

Since May 1958 this project has been assigned to Dr. M. G. Boyer, who is now surveying diseases occurring on poplars in Quebec. The main aspects of this problem to be investigated in this laboratory will be determined at the earliest possible date when enough information on poplar diseases will be gathered. Report to Committee on Forest Tree Breeding July, 1958

W. A. Porter - Forest Biology Laboratory - Victoria, B.C.

General.

One wing of the permanent Departmental greenhouse and headerhouse was completed this spring in Victoria. A research greenhouseman has been added to the staff. These new facilities will be of great assistance in the grafting and preliminary artificial inoculation work on the blister rust project.

In co-operation with the British Columbia Forest Service, a two-acre outplanting area for long-term observation of some selected white pine crosses and grafting scions is being cleared. In the disease garden, which is located on a forest service mursery, routine maintenance and inoculations were continued.

Active membership is maintained in the Western Genetics Association. White pine seed is being collected in the coast and interior regions of British Columbia for a provenance study of the Northeastern Forest Experiment Station.

# Testing white pines for resistance to blister rust.

In British Columbia this Department is responsible for testing for blister rust resistance in western white pine from coast and interior white pine regions.

Five hundred grafts for this year's outplanting were made from 10 coastal selections which show varying degrees of resistance in the disease garden. These grafts include 4 selections previously reported as canker free, and still free, from the 1952-7 inoculations; and the best 6 of the ll selections previously reported having 1 to 2 cankers. Replicated selections from the interior white pine region remain canker free in the disease garden. In one field outplanting area most selections received from Ontario, Wisconsin, and Idaho remain canker free under conditions of heavy natural inoculation. Scions from additional clones previously selected from the field and awaiting resistance testing in the disease garden, will be grafted this winter. Planting space is now available for resistance testing of pines from other pine areas. Approximately 40 man days were spent on this project during the past year. An interim report is being prepared on the detailed progress to date.

# Frost damage to coastal Douglas fir saplings.

Following the November, 1955, sudden freezing period, damage to needles, buds, twigs, and trunk was noted on some sapling Douglas firs in both planted and natural regeneration on the coast. The damage varied greatly between adjacent trees on the apparently same micro-climatic and soil regimes. Secondary fungi quickly entered the damaged trees through frost cracks or killed portions of trunk or leader, and these fungi are still active in many trees causing a continued dieback and canker. Two years of observations on the damaged trees show clearly that such trees flush out earlier in the spring and have a higher bark moisture content later in the fall than do the undamaged trees. Thus the difference in susceptibility to this extreme natural environmental condition differs greatly between individual trees. It is definitely related to differing durations of the growing period of individual trees. All of the damaged trees showed varying amounts of a characteristic frost ring in the 1955-56 annual ring juncture. Many of the damaged trees from Socke on Vancouver Island showed additional frost rings in the 1948-49 and 1949-50 annual

N-2

rings, indicating that in some individuals there is a definite frost history. No such frost rings were observed in the sectioned healthy trees. Weather records show that sudden freezing conditions terminated moist-mild extended growth periods during these years.

Many of the frost-damaged, susceptible trees are showing distress cone crops and could be attractive to cone collectors. Such seed, however, might produce a higher number of frost-susceptible seedlings than those from non-damaged trees. Thus, seed collected from local frost-free areas or over periods when there was no frost to give a natural selection, would likely contain a high number of frost-susceptible individuals.

The original objectives of this study have been completed and are being prepared for publication.

## Reference:

Porter, W. A. Dieback of Douglas fir. <u>In</u> Can. Dept. Agr. For. Biol. Div. Bi-Monthly Prog. Rept. 13(5): 3. 1957.

# BREEDING OF FIRS AND ASSOCIATED STUDIES

AT

## ST. FRANCIS LAVIER UNIVERSITY

A programme of breeding involving different species of fir (Abies) has been initiated in the spring of 1958. Abies balanmen has been used as the female parent, and the following species have been used as putative male parents; A. koreans, A. homolepis, A. homolopis var, umbellats, and A. cophalonics.

It is hoped to make comparative studies of the sytology of these species and of their hybrids if obtained.

The purpose of these crosses is to obtain a fir type that would be fast-growing possibly through heterosis, and resistant to some of the common entenelogical posts of  $A_{*}$  balance.

It is intended to use solchisine and gibberellis acid on native fir, and on hybrids to determine their effects on growth.

Some study is presently being done on the details of fertilization and seed developments

A constant watch is being maintained for native trees of superior quality that would involve particularly resistance to parasites, good seed production, seed production at an early age, and rapid growth with symmetry.

L.P. Chiasson

# 2. PROGRAMME REVIEWS BY VISITORS

C

-----

# FOREST GENETICS AND THEF TOPHOVEMENT RESEARCH AT THE

## SOUTHEASTERN FOREST EXPERIMENT STATION

by

# Keith W. Dorman USDA, Forest Service Southeastern Forest Experiment Station Asheville, N.C., U.S.A.

# I. Objective

To determine the principles of tree-to-tree and racial variations and inheritance of characters in important southern forest trees, evaluate their importance in silvicultural practices, and apply them in the selective breeding of improved strains,

## II. Racial Variation

- A. Cooperation in Southwide Pine Seed Source study with the four major species of southern pine. Test plantings are distributed over a 5-State area.
- B. Local (State-wide) studies of loblolly pine in Georgia and slash pine in Florida.
- C. Cooperation in interregional study of variation in yellow-poplar and white pine (Southern Appalachian Mountains).
- D. Cooperation in a study with red oak and hemlock (Southern Appalachian Mountains).
- E. Variation in resistance to littleleaf in shortleaf in South Carolina and Georgia (Forest Disease Research Division).

# III. Tree-to-Tree, Variation

- A. For slash pine variation in resin yield, specific gravity and tracheid length of the wood, vigor, form, and resistance to southern fusiform rust.
- B. For loblolly pine, variation in wood quality and tree form in Georgia and Virginia.
- C. For shortleaf pine, variation in resistance to littleleaf disease (Forest Disease Research Division).
- IV. Inheritance of Traits (with clonal, one-parent, and two-parent tests)
  - A. Resin yield, form, wood quality, resistance to pests in slash pine.
  - B. In loblolly pine, form, wood quality, and resistance to pests.
  - C. In shortleaf pine, resistance to lfttleleaf (Forest Disease Research Division).

- V. Introduced Species
  - A. Pines and a few other species that may be useful in tree breeding in the naval stores region in Georgia and Florida.
  - B. Pines and other softwoods in Southern Appalachian Mountain area.
  - C. Hardwoods that may be useful in the Piedmont for production of forest products and soil rehabilitation.

# VI. <u>Cooperative Projects</u>

- A. Technical guidance to the tree improvement project of the Ida Cason Callaway Foundation.
- B. Technical guidance to the Georgia Forestry Commission's seed orchard project.
- C. Assistance in the development of seed certification programs in Georgia and South Carolina.
- D. Supplying of study material to colleges and universities, Southern Institute of Forest Genetics, and the Forest Products Laboratory.
- E. Participation in the work of the Committee on Southern Forest Tree Improvement and the Regional Technical Committee for Project S-23, Forest Tree Genetics.

## CURRENT RESEARCH IN FOREST THE IMPROVEMENT AT THE

#### OHIC AGRICULTURAL EXPERIMENT STATION

by

## H. B. Kriebel

### 1. Tree Breeding.

At the present time, tree breeding is being concentrated in Section Cembra of the soft pine. Two objectives are the improvement of <u>Pinus strebus</u> with particular attention to growth rate and the production of as many hybrids as possible within the section for tests of adaptability, form and vigor. Species crosses attempted to date have included strobus, <u>flexilis</u>, <u>griffithii</u> and <u>parviflora</u> as female, and pollen species have included strobus, <u>flexilis</u>, <u>griffithii</u>, <u>parviflora</u>, <u>monticole</u>, <u>albicaulis</u>, and <u>lambertiana</u>. Selfs, unpollinated and wind-pollinated strobili are included in the breeding which began in 1957. Studies of time and duration of strobilus receptivity in relation to seed yield are being made in <u>Pinus strobus</u>. In 1958 about 2800 flowers were pollinated, the large majority on <u>strobus</u>.

## 2. Progeny testing.

Several hundred seedlings resulting from earlier intraspecific crosses in <u>Acer saccharum</u> are lined out in the nursery and will be planted out next year. These trees will be used to test inheritance of sugar content of the sap, and include putative crosses of high x high, high x intermediate, low x intermediate, and low x low. There are quite a few seedlings resulting from selfing.

# 3. Vegetative propagation and establishment of seed orchards.

About 25 clones of sugar maple have been propagated by grafting and budding. Greenhouse grafting included a multi-factor study of factors affecting survival and growth of grafts. An electrically-heated hotbed and a lath house are used in conjuction with the greenhouse. Budding has been fairly successful, but less so than grafting. Outdoor grafting in the nursery has been quite successful, when high-quality scion material was available. Unfortunately, this is frequently not the case with sugar maple.

A seed orchard of sugar maple was planted in 1958, consisting of twenty selected clones, some of ortets averaging 4% to 7% sugar content. Ramets from trees in Vermont, New Hampshire, Massachusetts, New York, and Ohid are included. The orchard is planted on a 30' x 30' spacing, using the triangular layout described by Langner (Zeitschn. für Forstgen. 4: 81-88).

Grafting of soft pines on <u>Pinus strobus</u> has included the following species and cultivars: <u>koraiensis</u>, <u>parviflora</u>, <u>parviflora</u> <u>pentaphylla</u>, <u>flexilis</u>, <u>griffithii</u>, <u>peuce</u>, <u>strobus</u>, <u>strobus</u> <u>fastigiata</u>, <u>cembra</u>, <u>monticola</u>, <u>armandi</u>, <u>and</u> <u>ayacahuite</u>. Several clones of each species are being propagated. A breeding arboretum will be started in 1959. In addition, other subspecies and cultivars of hard maple were grafted on <u>Acer saccharum</u> in 1958.

#### 4. Race studies

A comprehensive race study of <u>Acer saccharum</u> includes about 45 seed sources. Two permanent experimental plots have been established, one in northern Ohio in 1957 and one in southern Ohio in 1958. A "seedlingsource" plot was also planted in 1954 at Wooster, including trees from 18 sources. A small plot was established in Florida in January, 1958 to compare response under a radically-different daylength-temperature regime.

A series of oak genotype plots has been established at Wooster in cooperation with the Morris Arboretum in Philadelphia, which furnished the material. Twenty-two American species and from one to sixteen seed sources per species are included, a total of 101 collections, with three **trees** per collection.

Provenance tests of shortleaf pine from six northern sources from New Jersey to Missouri have been initiated. The first phase is in teooperation with stripmine reclamation research and is a greenhouse test of first-year seedlings on two types of spoil material, one with a pH of 3.6 and the other with a pH of 6.8. Highly significant differences in growth rate have been identified; the differences are related to seed origin and not type of spoil material in which the trees are growing. Phosphorus and nitrogen deficiencies are common to all sources. A similar test is being conducted of <u>Pinus strobus</u> from two geographic origins, with no differences as yet evident. The origins are eastern Tennessee and central Ohio.

Racial tests of <u>Pinus strobus</u> are planned, as a part of the largescale inter-regional study, in cooperation with the Central States Station and the Northeastern Station of the Forest Service.

# 5. Clonal tests and selection tests.

A series of field tests is being initiated of ten clones of black locust, in cooperation with the Soil Conservation Service. Five selections of <u>Castanea mollissima</u> are also under test in a plot now in its fifth year in southern Ohio.

# 6. Techniques for dwarfing and flower induction.

An experiment was established in 1958 on six-year-old trees of <u>Pinus strobus</u>, using various modifications of the phloem inversion technique to evaluate the effects on vegetative and reproductive behaviour. Six treatments are included in the experiment.

# 7. Special studies of morphological and physiological variation.

A study of geographic variation in root systems of <u>Acer saccharum</u> was completed in 1958, and is being prepared for publication. Results show relationships between root and stem morphology of four-year-old trees and drought resistance of first-year seedlings. Ecotype differences are very pronounced. Two factorially-designed studies of chilling requirement in relation to provenance were made in 1957-58. A study of <u>Acer saccharum</u> included trees from four sources at 500-mile north-south intervals, and eight lengths of chilling period. Phenological observations, made at weekly intervals, showed systematic differentiation between genotypes. A similar analysis of <u>Pinus</u> strobus of two origins was evaluated in terms of stem elongation. In both species the minimum chilling requirement for normal bud-breaking was only a few weeks, even for the northern trees, although northern maples with the shortest chilling period, ending October 16, were just breaking bud on August 1. Analysis of these studies is not yet completed.

#### ANNUAL REPORT 1957 - '58

#### FOREST TREE BREEDING AND GENETICS

## AT

#### YALE UNIVERSITY

ЪУ

## François Mergen

#### Assistant Professor of Forest Genetics

### Graduate Students Working on their Ph. D. Dissertation.

Mr. J.R. McWilliam completed his research work on the various phases of incompatibility in <u>Pinus</u> and has presented his dissertation to the Graduate School. The title of the dissertation is, "pollination, pollen germination, and interspecific incompatibility in <u>Pinus</u>." He found significant results, as set forth in the Digest of his dissertation:-

"The objective of this study was to investigate the problem of interspecific incompatibility in <u>Pinus</u>. For this purpose certain aspects of pollination and pollen germination were studied to provide the necessary background for a proper understanding of this problem.

"An investigation of the pollination mechanism revealed that the reception of pollen on the micropyle is a chance phenomenon, and no evidence was found to suggest that bioelectrical forces are involved in this process. Once on the micropyle, the pollen is conveyed to the nucellus by the micropylar fluid, which is produced during the period of pollination. The production of this fluid is a constant feature of the genus, and resembles the phenomenon of guttation. No stage during pollination imposed any restriction on the success of interspecific pollination, and in all the crosses studied, pollen grains reaheed the nucellus.

"The influence of certain environmental factors on pollen germination in <u>vitro</u> has been studied to obtain a better understanding of the physiology of pollen growth <u>in vivo</u>. The important feature of the growth of pine pollen is the long interval between pollination and fertilization. This provides favourable conditions for selection to operate, and makes the nucellus effective as an incompatibility sieve against the pollen of another species. Pollen germination <u>in vitro</u> responded to changes in the environment, and was most sensitive to changes in the chemical nature of the germination medium. The effect of temperature was more limiting at high than at low values, except when the pollen was subjected to low temperature during imbibition. During hot weather, temperatures inside pollination bags used for control-pollination can reach a level that is lethal to germinating pollen. This problem can be overcome by protecting the strought from direct insolation.

"Incompatibility between certain pine species appears to be incomplete, indicating that reproductive isolating mechanisms are still evolving in this genus. This process has been accelerated by geographic separation. Interspecific incompatibility is genetically determined, and acts to prevent the formation or survival of hybrid zygotes. In one cross (Austrian pine x red pine) which was studied in detail, chemical differences between the ovules of the two species may be one of the primary causes of incompatibility. This appears to affect the ability of the pollen of one species to either germinate or function effectively in the nucellus of the other. This functional failure of the pollen tubes caused the breakdown of the gametophyte, and the ultimate collapse of the ovule. Differences in the pattern and timing of the incompatibility may reflect the extent of the genetic diversity between the species."

Mr. Henry Gerhold is still working in <u>absentia</u> on his dissertation entitled, "Genetic variation in needle coloration of Scotch pine." Mr. Gerhold has completed all his field and laboratory analyses and is presently working on the statistical analysis of his results.

# Research Work Completed:

1. <u>Distribution of reaction wood in eastern hemlock as a function of its terminal</u> <u>growth</u>. A relationship was sought between the shape of the terminal shoot of eastern hemlock trees and the type of wood produced. As a result of its peculiar height growth, irregular zones of compression wood were formed. It was postulated that these zones might be involved in the initiation of ring shakes.

The growth pattern of the terminal shoot was traced during one growing season and there was a strong correlation between the curvature and orientation of the leader and the reaction wood which was produced. By preventing the leaders from drooping during the growing season, no compression wood was formed. By subjecting green sections of hemlock stems to freezing and thawing cycles, and bending these sections gently during the frozen state, ruptures between normal wood and reaction wood cells were produced. These minute failures which are brought about by differential internal stresses might be comparable to shearing failures which eventually enlarge to the size of the common ring shakes in the boles of living hemlock trees.

The results of this study appeared in the June 1958 issue of Forest Science.

2. <u>Male flowers on one-year-old Mugo pine seedlings</u>. Staminate flowers were observed on Mugo pine seedlings that were growing in our nursery and were less than one year old. The catkins were of normal size and the pollen was fully developed at the time of shedding. Both percentage germination and tube growth were normal when the pollen was cultured in double distilled water.

The results of these observations appeared as a short article in Forest Science, with Steve Cutting as co-author.

3. <u>Natural polyploidy in slash pine</u>. Abnormal slash pine seedlings were collected in a Florida State Nursery for a cytological study. The frequency of these abnormal seedlings in the nursery beds was about 0.0002 per cent, and their subsequent survival and growth was greatly hindered because both their roots and shopts were depressed. Some of the seedlings were verified to be polyploids (mixoploids), having chromosome complements of 2n, 3n, and 4n.

The results of this study, along with photomicrographs of the chromosomes, have been accepted for publication in Forest Science.

4. <u>Chromosome number of Pseudolarix amabilis</u>. A chromosome count of 22 in haploid tissue of <u>Pseudolarix amabilis</u> has been reported, but the actual number in somatic tissue has never been verified. By forcing several golden larch trees it was possible to obtain tissue suitable for a chromosome count. A total of 44 chromosomes was observed in all of the cells undergoing mitotic division.

A note on this, along with idiograms of the chromosomes, will be prepared for <u>Tropical</u> <u>Woods</u>.

Q\_8.

5. The cytology of fertilization in Pinus. With the cooperation of Mr. McWilliam, an attempt was made to follow the movement of individual chromosomes during the actual fertilization process in Austrian pine. A report on this work will appear in the <u>Botanical Gazette</u>. Along with the description of syngamy in Austrian pine, a photographic record is presented of the sequence from the time when the two sperm nuclei enter the egg until the first two free nuclei of the zygote are formed.

6. <u>Colchicine-induced polyploidy in pines</u>. Polyploidy was induced in pines by treating seed, seedlings, and male strobili with colchicine. The results have been summarized in a report, and will be published either in the <u>Journal of Forestry</u> or in <u>Silvae Genetica</u>. The manuscript was divided into three main parts:-

a. Treatment of seed and seedlings of slash pine, Pinus elliottii Engelm. with colchicine.

b. Culture of slash pine embryos on colchicine-enriched agar.

c. Treatment of male strobili of three species of pine with colchicine during meiotic and post-meiotic divisions (Loblolly pine, <u>Pinus taeda</u> L., Austrian pine, <u>Pinus nigra</u> Arnold, and Mugo pine, <u>Pinus mugo Turra</u>).

7. Photosynthetic efficiency of polyploid slash pine. In cooperation with Mr. Bourdeau the respiration and photosynthetic rates of diploid and polyploid slash pines were determined. It was found that polyploid shoots had a lower rate of photosynthesis than diploid ones, while their respiration rates were about equal. This might account for part of the reduced rate of growth of polyploid slash pine trees.

The manuscript on this phase of the polyploidy study will be submitted for publication along with the article mentioned under (6).

Research Work in Progress:

1. Effect of photoperiod and temperature on height growth of Norway spruce and Scotch pine seedlings from different geographical sources.

2. Analysis of needles from pine hybrids.

3. Effect of fertility level of soil on seed and seedling characteristics of slash pine.

4. Factors determining needle coloration of Scotch pine from different geographic sources.

5. <u>Cytological study of abnormal Pinus radiata seedlings</u>. It is anticipated that one of the abnormal <u>P. radiata seedlings located in our nursery might be polyploid</u>, caused by a spontaneous mutation.

6. <u>Rooting of needle fascicles of slash pine</u>. Using modified tissue culture techniques, attempts are made to initiate adventitious roots on excised needles fascicles. Preliminary attempts have been successful.

7. <u>Air-layering of several species of pines.</u> In cooperation with Mr. Cutting, red pine and Scotch pine trees are induced to form roots by manipulating the environment and varying the chemical treatments.
9. <u>Studies on flower induction</u>. There are several studies in progress on the induction of flowers in Mugo pine, red pine, sand pine, loblolly pine, etc.

10. <u>Breeding plantations</u>. All of the breeding plantations had to be lifted and the main and important plants (pines and hardwoods) have been moved to the Great Mountain Forest.

The spruce hybrids and other species from our nursery have been moved to the Yale nursery in New Haven. These trees will be moved to the Great Mountain Forest during the spring of 1959.

# TREE BREEDING IN THE CAMPINE, BELGIUM

Q-11.

by

#### A. de Jamblinne

#### General

The Centre de biologie forestiere de Bokrijk is located in the Campine of north-eastern Belgium. The Campine is an area of sandy soils and heathlands.

The Centre was established in 1949 by private and public wood owners in two Provinces, mainly Limburg. The work is supported by the IRSIA (Institute pour l'Encouragement de la Recherche Scientifique dangl'Industrie et l'Agriculture), an organization comparable to the Canadian Research Council. The research is supervised by and in close co-operation with the University of Louvain, while the Province of Limburg provides the establishment and maintenance of the Centre.

The aim of the Centre is to promote silviculture in its broadest aspect. The increase and improvement of wood production on the poor soils in the Campine is especially important. The Centre has the following sections: Forest Pedology, Microbiology and Soilchemistry, Zoology, (entomology and soil fauna), and Forest Genetics.

Each section has its own program but all co-operate on problems such as erosion, and new techniques in silviculture. For instance, the Genetics section co-operates with the Pedelogy section to produce growth curves as related to soil quality for different tree species.

#### Genetic Section

The genus <u>Pinus</u> is important in the Campine Woodlands, because of the poor soils there. Two lines of study are parsued: provenance and population genetics of various pine species, and inter- and intra-specific hybridization.

# Provenance and Population Genetics

The main purpose is to study the phenotypic and genotypic variability within the species and within the population. The procedure of clearcutting and replanting with plants of unknown origin which is common in the Campine makes the genetic value of the stands a mystery. For instance, I do not know whether poor form and growth is due to heavy podsols or poor genotype of the trees.

We attempt to solve this problem by planting provenance trials on different soil types, and also by studying the growth potentials of different soil types and drainage classes.

The provenance experiments include both exotic and local provenances. The exotic provenances are chosen according to a latitude gradient, while both good and poor types of the local provenances are tested. Each of the local provenances is represented by 30 trees selected at random. The progenies of these single trees are kept separate for further study. This technique is used for both Pinus nigra and Pinus sylvestris. The variability of local provenances (which may be second or third generation in the Campine) are compared with original exotic provenances. The Campine provenances of Scots pine are very variable which indicate their mixed origin. Controlled pollination of a number of selected mother trees will yield further information about the variability of the Campine provenances.

## Hybridization Program

This program includes inter- and intra-specific hybridization. Interspecific crosses have been performed with Pinus sylvestris and Pinus nigra. Provenance hybridization in Pinus sylvestris was done with ten provenances (Brandenburg, Scotland, Pin d'Augrerne, Sweden, Bulgary, Campine, East Prussia, Bavaria, Riga (Latvia)

Different varieties of Pinus nigra (caramanica, calabrica, and Austriaca), and a number of local phenotypical types of Pinus nigra found in the Campine have been crossed. These crosses have been made as test crosses, using one mother and many fathers. The crosses Pinus sylvestris <sup>I</sup> pinaster and Pinus nigra <sup>I</sup> pinaster have been successful. These hybrids may eventually display high resin yield and shoot moth resistance. The hybrid between jack pine and lodgepole pine display no heterosis in the Campine.

Two single trees of Pinus nigra calabric were crossed with one tree of P. sylvestris and three different trees of Pinus nigra. The Pinus nigra pollen parents produced differences in seed weight and seed set which were superior to open pollinated seed. The P.sylvestris parent showed no such relation. It was found that there is an optimum number of seed per cones where the seed reaches the best development.

#### FOREST TREE IMPROVEMENT

#### AT THE NORTHERN INSTITUTE OF FOREST GENETICS

# Hans Nienstaedt Lake States Forest Experiment Station 1/ Northern Institute of Forest Genetics Rhinelander, Wisconsin

#### INTRODUCTION

The Northern Institute of Forest Genetics is one of three such institutes maintained in the United States by the Forest Service. The two others are at Gulfport, Miss., and Placerville, Calif. The facilities at Rhinelander were opened about a year ago and what is there now is only the beginning. We are at present in the planning stages of another building and additional greenhouse space for which funds are available. After completion, the new building should accommodate seven professional men plus subprofessional aides. At present we are staffed and equipped for work in genetics and physiology, but eventually we shall also conduct studies in cytology, pathology, and entomology.

Being new, we have very few results as yet. In the following, I shall describe some results very briefly and outline our more important current work:

#### TREE IMPROVEMENT

Spruce, specifically white spruce, is the species on which we are concentrating our work at present. This choice is based on the growing interest in spruce management, on planting stock demand, and on the fact that most non-Federal efforts in tree breeding in the Lake States emphasize the pines and broadleaf species.

The work so far has centered around the development of research techniques and the studies of variation in white spruce. It has included studies of (1) racial and ecotype variation, (2) individual tree variation, (3) grafting techniques, (4) pollination techniques, and (5) selection of plus trees.

# Racial Variation

In one study 28 seed sources of white spruce, covering the entire range of the species from Alaska to Maine, were seeded in our nursery this spring. We owe our thanks to many of you here in Canada for help with the seed collections for this study.

Another study involves 19 sources of white spruce from the Upper Peninsula of Michigan. In it, we are trying to determine whether or not distinct ecotypes have evolved as a result of the very drastic climatic differences we have in this otherwise fairly uniform area. Based on the development during the first growth period in the greenhouse, all we can say at this time is that distinct differences between sources

1/ A field unit of the Forest Service, U. S. Department of Agriculture. are evident. To a large extent they appear to be independent of seed weight; however, we have not yet compiled all the climatic data necessary for the complete analysis.

# Individual Tree Variation

Preliminary studies of individual tree variation in white spruce gotunder way this summer. Our objectives are to determine the range of variation of the more important characteristics, such as: (1) Growth and vigor, (2) wood quality, and (3) branch characteristics--for example, diameter and length. For the present, we are trying to develop sampling techniques, and have limited ourselves to wood quality in terms of specific gravity. The relationship between ring width, age, percent summerwood, and specific gravity is being studied on samples from 120 plantation-grown white spruce 37 years of age.

Ultimately, we hope to develop indices for the selection of superior trees and for evaluating progeny.

#### Grafting

Like Mark Holst, we have concentrated our efforts on fall grafting. In one study we have tried to determine the effect of rootstock activity at the time of grafting in September on the percent "take." The growth of the rootstock was controlled by a combination of temperature and daylength treatments. However, they had little effect on graft survival.

Treatment after grafting, on the other hand, had marked effects on survival and growth. Treatments which drastically changed the physiology of the stock plant at the time of grafting lowered percent "take." The best treatment combination is long-days (20 hours) for 4 weeks, followed by short-days (13 hours) for 2 weeks, and then 8 weeks of chilling at 36° to 40° F. before the plants are returned to the greenhouse. By repeating this schedule beginning in the middle of March the following year, the plants will be ready for the second flush of growth in late May or early June.

#### Pollinations

Work in pollination so far has been limited to the testing of bagging techniques, studying the period of receptivity, and testing the crossability within the genus <u>Picea</u>. As expected from Mark Holst's experience, a combination of a viscose casing bag and a kraft bag was the best. Female strobili are receptive over a period of 3 to 5 days beginning at the time of the first pollen flight, and this receptivity is well synchronized throughout an individual tree. These results substantiate earlier reports by Jonathan W. Wright.

# The Selection of Plus Trees

The number of plus trees reported has so far been below expectations and we have, therefore, held several training sessions with field personnel this summer. The results remain to be seen.

#### TREE PHYSIOLOGY

Dr. Philip R. Larson is carrying out our research in tree physiology. At present his work emphasizes the auxins in (1) the formation of springwood and summerwood, (2) flower induction, and (3) rooting of cuttings. In addition, he has worked on the effect of gibberellic acid on bud dormancy of a number of hardwood species and conifers.

#### The Formation of Springwood and Summerwood

The formation of springwood and summerwood is studied in seedling and physiologically mature red pine. Dr. Larson is working on the assumption that the change from springwood to summer wood is associated with the termination of elongation and that the control is hormonal in nature.

Treatments of seedlings have attempted to (1) induce summerwood formation on the one hand, and to maintain springwood formation through hormone applications in spite of this induction on the other hand, (2) induce the formation of false rings, and (3) determine the effect of debudding on annual ring formation in seedlings grown under various photoperiods. The course of growth and wood formation has been recorded at intervals after treatment. The treatment effects on wood formation have not been determined as yet.

In the mature trees, the auxin concentration in terminal shoots has been determined at intervals during the growing season, using a combination of paper chromatography and <u>Avena</u> coleoptile bio-assays. At the same time, samples have been collected for the determination of the developmental stage in xylem formation. A change in the auxin concentration apparently takes place during the season, but whether it corresponds to any change in the wood being laid down has yet to be determined.

One of the early problems in this study was the interference from resinous compounds in the quantitative assay. Dr. Larson has been able to overcome this partly, so he now can use the bio-assay method. He still has not been able to prevent streaking on the chromatograms so completely that he can use the densitometer for his auxin determinations.

# Flower Induction and the Rooting of Cuttings

For the studies of flower induction and of the rooting of cuttings we propose to use the tissue culture techniques, or more particularly organ culture. When looking for two particular types of tissue, roots and flowers, we believe it would be simpler to start with an already differentiated organ rather than with a mass of undifferentiated cells. At present Dr. Larson and Karl E. Wolter--one of our summer students--are working on methods of sterilizing detached buds and stem pieces with buds attached. It is a difficult problem, but some progress has been made and we are confident that a method can be developed. Thereafter the problem of flower induction and root formation can be attacked in any number of ways: from the standpoint of chemical or physical environment or a combination of both.

## Smaller Studies

A number of smaller studies in physiology have been made. Gibberellic acid may perhaps be useful in shortening the forcing period of male flowers collected as early as January 10. Best results were obtained with <u>Acer</u> and <u>Prunus</u>. Pollen yields with <u>Betula</u> and <u>Populus</u> were low, but can probably be increased by improving the forcing environment. The effects of the gibberellic acid on pollen viability have yet to be determined.

The chilling requirements of white spruce 2-year-old seedlings have been determined to be 4 to 6 weeks for fully developed buds; partially developed buds apparently require more chilling, 6 to 8 weeks, and their growth does not compare with that of the fully developed buds. Long photoperiods partially compensate for lack of chilling. Incidental observation on older seedlings and grafts from physiologically mature trees indicate that the chilling requirements may change as the trees grow older. The studies are being repeated, using several seed sources of white spruce and a number of exotic spruce species.

# PLANS FOR THE FUTURE

These, then are our results and endeavors up to the present. With our expanding staff and facilities, our plans for the future are far from definite. The emphasis will continue to be on spruce, but we will undoubtedly take up other genera fairly soon, starting with <u>Betula</u> and adding other species including those used in Plains shelterbelt planting as we go along.

#### A SUMMARY

#### FOREST-TREE IMPROVEMENT AT THE UNIVERSITY OF MINNESOTA (1958)

#### Scott S. Pauley

Tree improvement research at the University of Minnesota was initiated in the period 1939-43. During this time Dr. T. Schantz-Hansen established a seed source study of jack pine designed to assess the degree of genetic diversity that exists within the species throughout its natural range.

Later, in 1947, Dr. D. P. Duncan initiated selection and testing studies of poplar, elm and blue spruce. The primary objective of this work has been to isolate hardy, disease-resistant, and vigorous materials adapted for windbreak and ornamental planting.

In 1955 the University's research in the tree genetics field was expanded and a graduate training program was established. In addition to increased University support, vital contributions to the program have been made by the Charles K. Blandin Foundation of Grand Rapids, Minnesota and Resources for the Future, Inc., Washington, D. C.

Most of the briefly summarized projects below are being carried on through the assistance of graduate students.

<u>Mode of Inheritance in Populus</u>. Several  $F_2$  and backcross progenies involving European and American aspen have been produced and outplanted for study. A cross of two  $F_1$ hybrids of the eastern black cottonwood was made during the current season. The  $F_2$  population derived should yield data on the mode of inheritance of the photoperiodic response in this species,

Hermaphroditism in Trembling Aspen. Studies of bisexuality in apsen are being continued by S. C. Hong, a Korean student. Two selfed and two cross pollinated progenies from each of two hermaphroditic trees were produced from controlled pollinations by Mr. Hong during the current season. Particular interest is centered on growth rate and other developmental characters of the selfed and crossed progenies.

Field Budding of Aspen. In cooperation with the Diamond Match Co. of Cloquet, Minnesota, field budding tests of genetically elite aspen clones on native 2-year suckers were initiated this summer.

<u>Birch Studies</u>. Seed collections from phenotypically elite paper birch stands in northeastern Minnesota were made in 1957 and are currently being propagated for tests in cooperation with the Diamond Match Co. Portions of the seed were also used during the past spring in a series of direct seeding experiments designed to determine the influence of different soil preparations on seedling establishment and survival.

Studies of the natural hybrid <u>Betula X Sandbergii</u> Britt. (<u>B. papyrifera</u> Marsh. x <u>B. pumila</u> L. var. <u>glandulifera</u> Regel) are being carried on by Knud E. Clausen. The hybrid is relatively common throughout those parts of Minnesota where the two parents occur. Jack Pine Variation. The phenomenon of "lammas" or late season shoot growth in jack pine is being investigated by Thomas O. Rudolph. Observations of seed source plantings suggest that diversity in this character varies geographically. The influence of long day on lammas shoot formation is currently being investigated.

A study of geographical variation in jack pine has been undertaken by Roland E. Schoenike. Extensive field studies throughout the range of the species are currently underway.

Toxin Tests for Dutch Elm Disease. Tests of a toxin screening method for the isolation of American elm seedlings resistant to the Dutch elm disease were undertaken by Frank S. Santamour. Results of these tests did not support the feasibility of such a screening method nor support the hypothesis that a toxin, produced by the causal fungus, is the prime disease-causing factor in infected trees. (A report on this study was published as <u>Minnesota Forestry Notes</u> No. 65, April 15, 1958.)

<u>Pollen Storage</u>. A study of the vacuum storage of white spruce, Norway spruce and jack pine pollen was conducted recently by John C. Barber. The trials indicated that vacuum storage is feasible and opens up the possibility of long term storage of pollen samples by this method. (See <u>Minnesota Forestry Notes</u> No. 62, October 15, 1957.)

<u>Grafting and Hybridization of Elm</u>. Grafting and hybridization studies in elm initiated by Paul E. Collins while in residence as a graduate student are being continued at South Dakota State College.

Progeny Test Analysis. A 6-year evaluation of several slash pine progeny tests growing in the state of Georgia is being carried on by John C. Barber.

Basswood Propagation. Studies of basswood propagation from seed and from stem and root cuttings are being conducted by William J. Peters.

Growing Northern Planting Stock in the South. This problem, under investigation by Richard F. Watt, is designed to assess the feasibility of growing certain native northern conifers in nurseries of the deep South. Through the use of artificially lengthened photoperiods, transplantable nursery stock may be grown in the long frost-free seasons of the South in a shorter time.

<u>Plot Size for Progeny Tests</u>. Determination of the minimum plot size requirement for short and long-term progeny tests of red and jack pine is being conducted by George M. Blake.

Early Selection for Heterosis. Studies concerned with the problems of early selection for heterosis in poplars, particularly as they relate to the anatomy of hybrids, are being conducted by Frank S. Santamour.

<u>Tulip Poplar Hardiness</u>. Winter hardiness tests of several tulip poplar seed sources in the St. Paul area of Minnesota have thus far been uniformly lacking in promise.

<u>Air-layering Studies</u>. The use of air-layers as a practical means of vegetatively propagating selected jack pine trees is under investigation by Thomas O. Rudolph and William E. Cromell. Results thus far have not been promising.

<u>Stimulation of Early Flowering in Spruce</u>. Although work in this area is just getting under way, Mr. Cromell has had excellent survival of white spruce seedlings grafted into the terminal shoots of cone-producing black spruce.

<u>White Spruce Seed Source Plantation</u>. Through cooperation of Mr. Mark Holst a white spruce seed source plantation was established in the Grand Rapids area this year. Nineteen Quebec and Ontario sources and six from the Lake States are represented.

Tree Improvement Arboretum. Initial plantings in a tree improvement arboretum near Grand Rapids, Minnesota were made in 1956. <u>Betula</u> and <u>Populus</u> are now chiefly represented. We plan to include selected specimens of all potentially useful natives and exotics.

# NATURAL POLYPLOIDY IN SLASH PINE\*

## by

## François Mergen\*\*

### Introduction

In some orders, or families of plants, the chromosome number is quite variable among the different species; in others the numberis quite constant. The coniferales belong in the latter group, in which polyploidy and other major chromosomal changes are rare. In the Pinaceae, particularly, all of the species studied so far occur normally as diploid plants, with the exception of <u>Pseudolarix amabalis</u> (Nehls.) Rehd. which occurs as a tetraploid. There have been several reports on the occurrence within the Pinaceae of freak plants whose chromosome number varied from that of their normal diploid ancestors. These abnormal plants were identified through their external appearance; namely, by their stunted growth, by thick fleshy needles, or by the unusual color of their foliage. There has been only one report so far of a study which verified the chromosome number of an abnormal seedling in the genus Pinus. The presence of polyploids, however, has been postulated by many foresters. A search was made in a forest tree nursery to locate abnormal slash pine, Pinus elliottii Engelm., seedlings. The following comments refer to these plants.

# Materials and Methods

The abnormal seedlings were collected in the Florida State Nursery at Olustee, Florida, where some 40 million slash pine seedlings are grown annually. The nursery beds were surveyed for abnormal seedlings at various times during seven growing seasons; the first collection being made during September of 1951 and the last during February, 1957. The greatest number of abnormal seedlings was located when they were about 3 months old. At this stage their needles had a bluish hue, and the neighboring normal seedlings had not yet had time to crowd out the slower growing abnormal types. At this age, the frequency of abnormal seedlings as about 0.0002 per cent, and they occurred singly and at random throughout the beds. As the season progressed, the apparent percentage of abnormal seedlings decreased, presumably because they were unable to survive, or were crowded out by the larger, more vigorous seedlings. Over 50 abnormal seedlings were dug up and potted in fertile soil and moved to a greenhouse. All of the abnormal seedlings had under-developed root-systems, and many lacked lateral roots. In those instances when lateral roots were present they were short and club-shaped.

\*Note: Figures referred to in the text are photographs which it is not possible to include in this publication.

\*\*Assistant Professor of Forest Genetics, Yale University School of Forestry, New Haven, Connecticut. To obtain vigorous growth for the chromosome counts, soluble fertilizer was added to the soil and the plants were kept under a 17-hour photoperiod for several weeks before material was collected for analysis. Normal seedlings (controls) were treated in the same manner.

To obtain chromosome configuration in the metaphase stage the treating schedule of Mergen and Novotny (1957) was followed. Actively growing buds, and root tips, 3-8 mm. long, were used. The vegetative needle buds supplied sufficient meristematic tissue with mitotic divisions to make chromosome counts possible. On the other hand, chromosome counts could be made from only a few squashes of root tips. The chromosomes were counted by drawing idiograms at an approximate enlargement of 2000X with the aid of a camera lucida, or a projection mirror.

Tangential and transverse sections were prepared from several of the terminal buds to determine the location of the polyploid or abnormal cells.

Cross-sections were made from segments of fully-grown secondary needles, with the exception of those from one seedling which had not developed secondary needles. In this instance primary needles were examined.

The arrangement and size of the stomates was determined on the outer face of the needles. The needle segments were macerated at room temperature for 1-1/2 to 2 hours in a 1:1 mixture of 20% hydrochloric acid and 35% nitric acid. After this treatment the epidermis, along with some cells of the hypodermis, could be separated from the subjacent cell layers.

# Results

<u>Normal diploid seedlings</u>. The characteristic features of an average diploid slash pine seedling are illustrated in Figure 1. When the seedling was photographed it was 2 years old, and bore only secondary needles. The anatomy of the needles was similar to that described for slash pine by Sutherland (1954); the stomates appeared in straight rows and were uniform in appearance. The chromosome number of mitotic figures in somatic tissue was verified to be 24, as had been reported previously by Sax and Sax (1933), and by Mehra and Khoshoo (1956).

Abnormal seedling #1. Seedling number 1 grew very slowly, being 20 cm. tall after three years (Figure 2). The branches, to the extent that they were present, had not elongated more than about 1 cm. Most of the needles were primary, but there were a few short and exception-ally thick secondary needles.

About 65% of the secondary needle buds dried and fell off before they were 5 mm. long. The needles, as well as the growing shoot, were dark green with a bluish hue. Their surfaces were rough with many ridges and expanded teeth. The thickness of the hypodermis was not uniform but was greater under the ridges, and the roughness of the outer surfaces was also reflected in the irregularity of the endodermis. There was a well-developed mesophyll but the number of resin ducts was lower than in the normal seedlings. The stomates appeared in uneven rows; both the spacing within the rows and between the rows was irregular.

Chromosome counts indicated that the majority of cells were tetraploid (4n=48). Normal diploid cells were also present and these occurred in the needle bases in a approximate ratio of 1:4 tetraploid cells, whereas in the root tips the ratio of diploid to polyploid cells was about 1:2.

Abnormal seedling #2. Seedling number 2 was slow-growing and after three years it had a height of 15.5 cm. (Figure 3). The secondary needles appeared singly, and in some instances there was a partial split through the middle, indicating that two needles from one fascicle had fused together. In addition to being very short, the needles started to curve and had the appearance of claws. The root system was poorly developed, and consisted of an enlarged growing knob with several short laterals above it. The cross-sections through the needles showed a very distorted arrangement of the anatomy; the resin ducts were present in only one-half of the needle, and the cells of the plicate mesophyll were arranged and oriented differently in the two halves. Teeth were present on the various ridges, and their arrangement did not appear to follow a definite pattern. The stomates occurred in irregular partial rows, and were slightly smaller than those in the normal seedlings.

The chromosome count showed that the seedling was a mixoploid and was made up of diploid, triploid and tetraploid cells, with the majority of cells having 48 chromosomes. The ratio of diploid cells to tetraploid cells was 1:4.5; the frequency of triploid cells was about 1:10.

Abnormal seedling #4. While in the seedbed, seedling number 4 had dark bluish needles that were quite thick and long. The height growth was somewhat slower than that of the surrounding seedlings and the hypocotyl and the growing points were thick and succulent. After the early seedling stage, its morphology did not differ appreciably from that of normal seedlings, with exception of the secondary needles which were much thicker. The anatomy of the needle appeared normal, with the exception of the stomates which were arranged in uneven rows and were much larger, their diameter on the outer surface being the largest (51.8/4) in any of the seedlings examined.

Chromosome counts showed seedling number 4 to be a mixoploid. It differed from the other plants by its relatively high frequency of polyploid cells in the bases of the needles--13 polyploid cells to one diploid cell. Of the polyploid cells, about three quarters were tetraploid and the remainder were triploid. The number of triploid cells was higher in the other trees studied, and the ratio of diploid to polyploid cells in the root tips was 1:2. Several stages of mitosis could be observed in the dividing cells. There appeared to be no tendency for the chromosomes to move toward the equatorial plate during metaphase, and during anaphase the daughter chomatids remained in an apparently random location within the cell. This partial mitosis doubled the number of chromosomes within the cell because no cell wall formed to separate the daughter chromosomes. <u>Abnormal seedling #5.</u> Seedling Number 5 was 18 months old when the photograph in Figure 5 was taken. At that time it was 4 cm. tall, and when it was 30 months old it had not formed any secondary needles. Periodically, the seedling developed a large, succulent terminal bud but it took considerable time for the bud to enlarge. The root system was almost non-existent, and the growing point died back from time to time.

From the slides that were prepared it was possible to establish that the plant was heteroploid. Idiograms were drawn from several diploid and some tetraploid cells, but no triploid cells were located. There were, however, several aneuploid cells which had a chromosome count of 54. The ratio of diploid to heteroploid cells was approximately 1:7.

<u>Abnormal seedling #6</u>. When seedling number 6 was two years old, it was 19 cm. tall and had one lateral shoot that was about 1 cm. long (Figure 6). It had formed secondary needles that were of normal length, but they were much thicker than those of the control seedlings, and they were irregularly distributed. The root system was comparatively well developed, but all the root tips were swollen and were club-like in appearance. The needles had a tendency to twist, and their surfaces were uneven.

Chromosome counts showed that seedling number 6 was also a mixoploid, the meristematic tissue of the buds being composed of cells with diploid and tetrapolid chromosome complements. The ratio of tetraploid cells to diplcid cells was 6: 1. The ratio of tetraploid cells to diploid cells in the root tips was 1: 2. No triploid cells were found. The number of chromosomes in several of the cells could not be established with certainty, especially in those cells which were in the anaphase stage. Figures 6E and 6F illustrate two polyploid cells in the anaphase stage. Although the precise number of the chromosomes in these cells could not be established, it was estimated that there were about 96 chromosomes in each of these cells, indicating a tetraploid condition in the somatic cell before mitosis.

# Location of the Polyploid Cells

It was difficult to determine the exact location of the polyploid cells because once cell division had ceased, ft was not possible to estimate its chromosome number by its size alone. However, in several of the serial sections there were several dividing nuclei and almost all of the polyploid cells were found along the periphery; in some instances they cocurred for a limited distance inside. They extended toward the center of the growing tip in only a few of the sections.

## <u>Discussion</u>

Abnormal slash pine seedlings in nature are not rare, yet there are no reports in the forestry literature. The frequency of 0.0002 per cent that was observed in the Olustee, Florida nursery was undoubtedly lower than that of the actual number which occurs in nature. These polyploid seedlings have a low capacity for survival because they lack the structures for adequate competition;

the growth of both roots and shoots is depressed. The observed value of 0.0002 per cent is somewhat lower than the frequency of polyploid seedlings that has been observed in the other members of the Pinaceae: 0.1% for <u>Pinus densiflora</u> (Zinnai, 1952), and 0.009% for <u>Picea</u> abies (Kiellander, 1950.) Polyploid individuals are easiest located in the nursery beds where several million even-aged seedlings can be examined within a relatively short period of time. In addition, the selection is made from seedlings in a uniform and favorable environment, growing from seed which came from thousands of trees, scattered over millions of acres of forest land. In a natural forest it is much more difficult to isolate polyploid individuals because most of them have succombed to the environment. Nevertheless, some abnormal slash pine trees have been located in and around the Olustee, Florida area. Some of these have produced male and female flowers. An analysis of the size of the pollen was made from one of these "Mutant Pines", as they are called locally. When compared to normal slash pine pollen, the pollen from the "Mutant Pine" was smaller (49.54 versus 52.54 for the small diameter and 58.14 versus 70.74 for the large diameter). The germination count showed that almost all of the pollen grains from the abnormal slash pines were abortive and all of the seed obtained from these mutants was empty. No chromosome counts have been made on these larger trees.

In general appearance some of these mixoploids are very similar to slash pine trees that were treated with colchicine. Since none of the seedlings had polyploid cells throughout, these seedlings did not originate as the result of chromosome duplication after fertilization. They were not genetically uniform throughout the plant and therefore can be termed chimera (Chittenden, 1927). Crosssections through some of the developing buds indicated the chimeras to be of the periclinal or mericlinal type. There were some indications that one of these mixoploid slash pine seedlings was the result of endomitiotic divisions. In these endomitiotic divisions there is a duplication of the chromosomes with a subsequent separation, but without the formation of a spindle or metaphase plate, and without cell division (Geither, 1951). Endopolyploid individuals have been described before in both the animal and plant kingdoms (Mickey, 1946); Berger, 1941; and Witkins, 1945). There was a certain degree of differentiation in the shape and size of the chromosomes between the different trees, but, due to the drastic chemical pretreatment during the maceration process, no attempt was made to evaluate these differences. Several cells were characterized by incomplete genomes but in these instances it was very difficult to verify the number present in the cells before maceration, as the long, thin chromosomes were crowded and tangled at the metaphase plate and in addition, the cell wall had ruptured in many instances allowing chromosomes to slip out and swim about in the mounting medium.

From a practical forestry viewpoint these mixoploid seedlings have little value because of their low survival rate, and their low fertility. Perhaps some use might be made of some of these shortneedled, slow-growing pines in ornamental work and in foundation plantings. These mixoploids are of little evolutionary value, because they are probably unable to form sexual tissues with balanced higher chromosome numbers.

# Literature Cited

- Berger, C.A. 1941. Multiple chromosome complexes in animals and polysomaty in plants. Cold Spring Harbor Symp, Quant. Biol. 9:19-21.
- Chiva, S. and M. Watanabe. 1952. Tetraploids of <u>Larix Kaempferi</u> appeared in the nurseries. Jour. Jap. Forest Soc. 34(9): 276-279.
- Chittenden, R.J. 1927. Vegetative segregation, Biblio. Genetica 3:355-439.
- Christiansen, H. 1950. A tetraploid <u>Larix decidua</u> Miller. Det. Kgl. Danske Videnskabernes Selskab. Biol. Meddel. XVIII(9): 9 pp., + 2 plates.
- Geitler, L. 1941. Das Wachstum des Zellkerns in tierischen und pflanzlichen Geweben. Ergebn. Biol. 18:1-54.
- Kanezawa, R. 1949. Polyploids appeared in twin seedlings of forest trees. (Japanese with English summary). Jour. Jap. Forestry Soc. 31:22-24.
- Kiellander, C.L. 1950. Polyploidy in <u>Picea abies</u>. Hereditas 36: 513-516.
- Larsen, C.S. and M. Westergaard. 1948. Contributions to the cytogenetics of forest trees. I. A triploid hybrid between <u>Larix decidua Miller and Larix occidentalis</u> Nutt. Journal of Genetics XXXVI(3): 523-530, + 1 plate.
- Mehra, P.N. and T.N. Khoshoo. 1956. Cytology of conifers. I. Journal of Genetics 54(1): 165-180.
- Mergen, F. and H.N. Novotny. 1957. Squash technique for chromosome studies in pine needles and root-tips of slash pine. Forest Science 3:56-60.
- Mickey, G.H. 1946. The presence of multiple strands in chromosomes of Romalea (Orthoptera). Amer. Nat. 80: 446-452.
- Sax, K and H.J. Sax. 1933. Chromosome number and morphology in the conifers. Jour. Arnold Arboretum 14: 356-375.
- Stebbins, G.L., Jr. 1938. Cytological characteristics associated with the different growth habits in the dicotyledons. Amer. Jour. Bot. 25: 189-198.
- Sutherland, M. 1934. A microscopical study of the structure of the leaves of the genus Pinus. Trans. New Zealand Inst. 63: 517-568.
- Witkins, E.R. 1945. Endomitotic tapetal cell divisions in Spinacia. Amer. Jour. Bot. 32: 326-330.
- Zinnai, I. 1952. Tetraploid plants of Japanese red pine (<u>Pinus</u> <u>densiflora</u> Sieb. et Zucc.) discovered in transplant beds. Jour. Jap. For. Soc. 34(6): 185-187.

Ĉ.

# GEOGRAPHIC DIFFERENTIATION IN SEED DORMANCY AND

# JUVENILE GROWTH RATE OF ONTABIO SUGAR MAPLE

by

# H. B. Kriebel\*

During the handling of sugar maple seed accessions from three widely-separated Ontario provenaces, differences associated with provenance were observed in time and rate of seed germination under uniform treatment. Source differences in growth pattern were also noticed and recorded among the seedlings during the first and second growing seasons.

Sugar maple seed will sprout after 60 to 100 days if stratified in moist sphagnum moss at temperatures slightly above freezing. In the work described in this report, each seed lot was divided into two parts, one of which was stratified in mid-November and the other sowed directly outdoors in the seedbed in late fall. It was planned to sow the stratified seed in the greenhouse during late January. At this time, sprouting seeds were visible through the polyethylene bags and sowing was begun. Only seeds of the five collections from the southern-most source (Angus) were sprouting, however, and the decision was made to sow the seed as it sprouted at intervals of a few days, and to keep a continuous record of germination time and rate for each collection. The results of these observations and of growth measurements are presented in this report.

The accessions included collections from several trees from each of the three sources listed below:

| Location      | County or<br><u>District</u> | Lat., N. | Long. W. | Number of<br><u>Collections</u> |
|---------------|------------------------------|----------|----------|---------------------------------|
| Sylvan Valley | Algoma                       | 46°281   | 83°531   | 5                               |
| Powassan      | Parry Sound                  | 46°041   | 79°271   | 年                               |
| Angus         | Simcoe                       | 44°171   | 79°521   | 5                               |

The seed not stratified was kept in cold dry storage (G. 38°F.) and sowed in the nursery in early December. Occasional observations were made during the first growing season of comparative rate of growth.

At the end of the first growing season stem height measurements were recorded in centimeters for approximately fifty trees of each collection, half from the greenhouse seedlings and half from the nursery seedlings. Similar records have just been taken at the end of the second growing season.

\*Ohio Agricultural Experiment Station, Wooster, Ohio

The results are of interest from a genetic viewpoint. There was variation in time and rate of seed germination indicative of geographic variation in chilling requirement of the seed. Seed from Angus germinated in stratification at a considerably earlier date than seed from either of two northern sources, most of it in fact before observations were begun. Seed from Powassan was next to germinate; rate of germination began to increase rapidly in early February, and leveled off about the third week in March. In the case of Sylvan Valley seed, rate of germination was highest in early March, and as with Powassan seed, leveled off at about the third week in March.

Apparent total germination expressed as percentage of all seed, was highest in Angus seed and lowest in Sylvan Valley seed. The theoretical maximum germinative capacity should be 50%, because of the fact that one-half of the samara is almost invariably empty. Higher values found in some of these collections are therefore to be attributed to atypical samples, and between-source comparisons of germinative capacity are probably not valid.

The results of the germination counts are illustrated graphically in Figures 1 to 3. Characteristics of the germination curves of Sylvan Valley seed, which with one exception are almost identical, could be associated with the close proximity of the seed trees. It is probable that the seed parents of the different progenies are either full sibs or half sibs. The Powassan seed trees, on the other hand, were scattered over a total distance of one and a half miles along a road, and it is unlikely that progenies are closely related. The germination curves in this case show considerable variation. The germination curves for Angus progenies are quite similar to each other, disregarding the unreliable total germination percentages. Trees sampled from this locality were fairly close together and could represent very similar biotypes.

Some inter-source contrasts were found in phenology and rate of stem growth of the seedling progenies. The slide shown of progenies in the nursery seedbed illustrates a phenological difference. In the picture, taken on July 10, 1957, nearly all seedlings of Sylvan Valley seed origin (right) are still in the primary leaf stage of development. Trees on the left, from Angus seed, have mostly put out one or more pairs of secondary leaves. These contrasts are reflected by the data on height growth taken after the first growing season, and illustrated in Figure 4. ï



.....

. \_\_\_\_\_\_ In this chart, "G" indicates trees grown in the greenhouse and "N" indicates trees grown in the nursery. Bar height represents mean of a sample of about 100 trees. A factorial analysis of the data is presented in Table 1, in which the effects of mother tree, seedling environment, seed source, and interactions are separated. In the graphs the mean height growth is slightly greater in each case among greenhouse trees, but the differences are not statistically significant, nor are differences between different progenies from the same origin. On the other hand, there are highly significant differences between sources, and further analysis, not illustrated, shows a difference between trees of Sylvan Valley origin and trees of Powassan origin at the end of the first year, as well as a distinctly higher growth rate of Angus trees.

#### ANALYSIS OF FIRST-YEAR HEIGHT GROWTH

| Effect of                                | D. F. | S. S.  | M. S.               |
|--|-------|--------|---------------------|
| Seed tree (replicate)                    | 4     | 1098   | 275                 |
| Greenhouse vs. nursery, A                | 1     | 347    | 3 <sup>1</sup> +7   |
| Seed source, linear, Bl                  | 1     | 8282   | 8282 <del>***</del> |
| q <b>u</b> adratic, B <sub>2</sub>       | l     | 728    | 728                 |
| A x B <sub>1</sub>                       | l     | 2      | 2                   |
| A x B <sub>2</sub>                       | 1     | 34     | 34                  |
| Seed tree x B <sub>2</sub> (replic. erro | r) 4  | 1220   | 305                 |
| Residual interactions                    | 14    | 2719   | - 194               |
| Total                                    | 27    | 14430  |                     |
| Correction                               | l     | 460288 |                     |
| Missing values                           | 2     |        |                     |

Measurements of two-year growth were taken recently (July 28, 1958) which have not been analyzed statistically. Relationships found the previous year appear to continue, with the possible exception of an increased differentiation among progenies from the same seed source.

There is no noticeable effect of parental relationship on degree of intrasource variation; i.e. there seems to be as great a variability between means of progenies of apparent sibs as between progenies of unrelated trees.

Records of the seed parent of each progeny include estimated height. There are indications of a linear relationship between height of one-year-old progeny and height of seed parent, in spite of the rough approximation of the estimate of the height of the seed parent. This relationship will be evaluated at a later date for the full geographic range of the species, on the basis of records of about 250 seed trees and their progenies. If suggested relationship holds, it may open the way for the systematic selection of sugar maple for high growth rate.

# R-13.

# INTERSPECIFIC GRAFTING OF HARD PINES

## by

# M. J. Holst and J. B. Santon

During the winter of 1954-55 we established a series of reciprocal scion-rootstock combinations of jack, red and Scots pine. None of the rootstocks were pruned back during the first year which is contrary to normal grafting practice. The non-pruned grafts were planted in the nursery in June 1955. The rootstocks were pruned back on half the surviving grafts in May, 1956. The remaining grafts were left to grow with the slightly trimmed branches of the rootstock intact.

Scion survival was followed during the first growing season (1955), and was recorded in the autumn of 1956 and 1957. Current year's leader growth was recorded in the autumn of 1955, 1956 and 1957. Needle length was measured in the autumn of 1956 and 1957 on the middle of the current year's leader. Needle colour of both scions and root-stocks was recorded in the autumn of 1956.

The initial survival of the reciprocal jack-red pine combinations was very low, and dropped further during the two-year observation period. Red pine scion survival was nearly three times greater on jack pine rootstocks than that of jack pine scions on red pine rootstocks (45 per cent and 18 per cent respectively), as long as the rootstocks were left non-pruned. When the rootstocks were pruned both jack pine and red pine scions perished within a year.

The survival of the jack-Scots pine combinations was quite high (86 per cent and 96 per cent). The initial superiority of about 10 per cent of the non-proceed Scots-Jack pine combination over the jack-Scots pine combination was maintained during the observation period. When the rootstocks were pruned this difference doubled to about 25 per cent. Compared with controls, the growth of the jack pine scions was retarded about 5 per cent, while the growth of the Scots pine scions was stimulated about 10 per cent. This stimulation was also apparent in the needle length of the Scots pine scions and amounted to about 12 per cent.

There was no difference in scion survival for the non-pruned rootstocks in the reciprocal red-Scots pine combinations. However, when the rootstocks were pruned, the scion survival of the Scots-red pine combination remained at the 96 per cent level while that of the red-Scots pine combination dropped to 82 per cent. Scion growth in both combinations was stimulated considerably. The stimulation was most pronounced for the scions grafted on non-pruned rootstocks. The stimulation diminished during the observation period.

Heimburger (1956) suggested that the success or failure of interspecific grafting is related to the position on the evolutionary scale of the species involved. He based his argument on the results of reciprocal grafting of the primitive five-needle white pine and the more advanced two-needle Scots pine. A scion of the advanced species survived when grafted on a rootstock of the primitive species, but the rootstock died when a scion of the primitive species was grafted on the rootstock of the advanced species. Apparently the primitive scion was unable to provide the complex metabolites required by the advanced rootstock, whereas the primitive rootstock was able to utilize the more complex metabolites of the advanced scion.

Heimburger's concept of graftability of primitive and advanced species, according to the evolutionary scale, is borne out by the reciprocal red-Scots pine and jack-Scots pine combinations. However, as the jack-red pine combinations all perish when the rootstocks are pruned, we must modify Heimburger's theory for the scion survival of non-pruned rootstocks. Here, we find that the primitive scions thrive better on the diet supplied by the living branches of the advanced non-pruned rootstock. The fact that survival of red pine scions was about three times greater on non-pruned jack pine rootstocks than jack pine scions on non-pruned red pine rootstocks, should then indicate that red pine is less advanced than jack pine.

Red pine and Scots pine both belong to the group <u>Lariciones</u> while jack pine belongs to the group <u>Virginiana</u>. That red pine scions do poorly and Scots pine scions do well when grafted on jack pine rootstocks may be an indication of the rigidity of red pine and the plasticity of Scots pine.

References

Heimburger, C. 1956. Blister rust resistance in white pine. Proceedings 3rd Northeastern Forest Tree Improvement Conference. Cornell University, Ithaca, New York, August 30-31, 1955. pp. 6-13. Î

# R-15.

# THE TAXONOMY OF FUNGI CAUSING LEAF AND TWIG BLIGHTS

# OF NORTH AMERICAN POPLARS

by

## B. W. Dance\*

The identity of the fungi that caused leaf and twig blights of poplar puzzled European taxonomists from 1842, when Libert described <u>Oidium radiosum</u>, until 1938 when Servazzi concluded that the condition was caused by two species of <u>Pollaccia</u> which he described.

That almost a full century elapsed before the taxonomy of the causal organisms was unravelled can now be attributed to striking similarities between the pathogens and their affects on the host, to inadequate research by most of the workers involved, and to the apparent tendency of those people to create new names on slight provocation.

The influence of these factors, particularly of the latter, in preventing clarification of the taxonomy of the poplar pathogens, increased continuously from the beginning until later workers, with the exception of Servazzi, became so thoroughly confused that they were unable to clarify the complex.

Inevitably, the confusion that evolved in Europe reached North America where it plagued taxonomists in their efforts to understand the North American blight fungi on poplar. Unfortunately, taxonomists here have discovered, since 1938, that Servazzi's resolution of the European complex did not bring about automatic clarification of the North American complex. Why it failed to do so has only recently become clear.

By 1951, it was evident that leaf and twig blight of poplar was a disease of some silvicultural significance in Ontario. For this reason and because the taxonomy of the fungi was urgently in need of clarification a study of the problem was initiated at the Petawawa Forest Experiment Station.

In North America, the fungus that seemed chiefly responsible for leaf and twig blight of poplar was generally known as <u>Napicladium</u> <u>tremulae</u>. It was considered to be the parasitic stage of the ascomycete <u>Venturia populina</u> which, in Europe, was quite prevalent. However, the validity of the alleged connection was unsubstantiated and appeared doubtful for two reasons: (1) Reported collections of <u>V</u>. <u>populina</u> from North America were very few and of doubtful accuracy, and (2) the host range of <u>V</u>. <u>populina</u> in Duby's classification of poplars, as indicated by Servazzi, disagreed with that of <u>N</u>. <u>tremulae</u>. Therefore, the immediate goal of the investigation was to determine the validity of the reputed connection between <u>N</u>. <u>tremulae</u> and <u>V</u>. <u>populina</u>.

An intensive search for  $\underline{V}$ . <u>populina</u> was concentrated on trembling and largetooth aspens, both of which are in the Section <u>Leuce</u> Duby, because they were obviously the preferred if not sole hosts of

\*Dept. of Agriculture, Forest Biology Laboratory, Maple, Ontario.

<u>N. tremulae</u>. Eventually, perithecia of <u>V. populina</u> were found but, surprisingly, they were on balsam poplar in the Section <u>Aigeiros</u> Duby. As indicated by Servazzi, this agreed with the host range of <u>V. populina</u> in Europe.

Imperfect stage cultures of <u>V</u>. <u>populina</u> were secured from ascospores. When these were compared with cultures of <u>N</u>. <u>tremulae</u> significant differences were noted which proved that the latter was not the imperfect stage of <u>V</u>. <u>populina</u>.

Subsequent examination of diseased leaves from the trees that had furnished <u>V</u>. <u>populina</u> disclosed the imperfect stage of <u>V</u>. <u>populina</u>, and infection studies indicated that this stage caused the leaf and twig blight condition. The imperfect stage was identified as <u>Pollaccia elegans</u>.

In 1922, Davis described a variety of <u>Fusicladium radiosum</u> on balsam poplar from Wisconsin. Since his description fits that of <u>P. elegans</u>, and because subsequent collections identified by his varietal name seem identical with <u>P. elegans</u>, it has been concluded that the varietal name is synonymous with <u>P. elegans</u>.

With refutation of <u>N. tremulae</u> as the imperfect stage of <u>V. populina</u>, this imperfect stage was reidentified as <u>Fusicladium</u> <u>tremulae</u>. Hence, according to Aderhold's revision of the species of <u>Venturia</u>, it should have <u>Venturia</u> tremulae as its perfect stage. To confirm this relationship, it again became necessary to try to connect this fungus with an ascomycetous stage.

During the search for <u>Venturia populina</u>, <u>V. tremulae</u> was found occasionally on aspens which, according to Servazzi, were the hosts for this fungus. For a long time, attempts made to derive <u>F. tremulae</u>, culturally, from ascospores of <u>V. tremulae</u> were unsuccessful but recently this goal was achieved.

It can now be concluded that two similar fungi are principally, if not entirely, responsible for leaf and twig blight of poplar in North America. Perfect and imperfect stages of both fungi occur here but, in both instances, the ascomycetous stages are sporadic and can only be located with difficulty.

With elucidation of the fungi responsible for leaf and twig blight of poplar, here, the reasons that Servazzi's conclusions failed to clarify the North American complex as they did the European, seem to become evident: The original misidentification of <u>Fusicladium tremulae</u> as <u>N. tremulae</u> initiated a misconception which became firmly established. It was difficult to eradicate because of a very effective screen that was formed by striking similarities between the two imperfect stages in morphology in symptomatology and in host ranges, by the great prevalence of <u>F. tremulae</u> in contrast to the rarity of <u>P. elegans</u>, by the infrequency with which the perfect stage of both fungi occurred, by the development of new names in addition to those introduced from Europe, and by the indiscriminate inter-application of the numerous synonyms and names of doubtful status. In retrospect, the taxonomy of the North American blight fungi of poplar seems quite simple now that the previously missing components have been identified.

# A TREE CROWN ISOLATION TENT

#### by

# C. W. Yeatman\*

A problem which faces every tree breeder is how to increase the yield of cones from controlled pollinations. Time and labour available are always limited, and in most species years of abundant flowering are infrequent. At the Petawawa Forest Experiment Station the standard technique of isolating flowering branchlets with small bags has been employed, and in years of abundant flowering this has resulted in acceptable cone yields, at least in spruce. However, in a poor flowering year, each branchlet bears only one to a few female flowers, so that even a great number of isolation bags yields a small harvest. Frequently, more flowers must be left out of the isolation bags than can be included within them because of the difficulty and inefficiency of tying bags onto small branchlets of the third and fourth order. Also, flowers at the tops of tall trees are usually inaccessible.

The success of a breeding project often depends on the amount of control-pollinated seed that can be produced from . individual trees. For example, inter-specific crosses may be difficult owing to a partial incompatibility between the species, and the percentage of viable seed to be expected is very low. Intraspecific crosses, selfings, back crosses, and second and third generation crosses must result in a large number of viable seeds if a significant fraction of the combinations and recombinations of genetic factors which may be possible is to be obtained. From the array of genotypes observed in the progeny, only a few may be worth selecting for further breeding.

Some years ago the possibility of isolating a tree crown with a tent was discussed. It was recalled that Dr. Syrach Larsen, the famous Danish geneticist, had used a tent many years ago to isolate small trees. In this case, the tent covered the tree to the ground. However, the present task was to effect self-pollinations on mature white spruce which range from 75 to 95 feet high. At Petawawa there were few trees of interest which could be reached from the ground or from ladders, and none of the grafted material is available for breeding yet.

The idea gestated for a year or two until the spring of 1956, when it was evident that there would be a bumper flower crop in white spruce. Twenty-five yards of down-proof pillow ticking were used to make a special tent 6 feet in diameter, 6 feet deep, and enclosed by a skirt that was drawn in about the tree trunk and central tent pole. The shape of the tent was maintained by a 2-foot

<sup>\*</sup>Forestry Officer, Department of Northern Affairs and National Resources, Forestry Branch, Petawawa Forest Experiment Station, Chalk River, Ontario.

disk of plywood at the top, and two willow hoops, 6 feet in diameter, one each at the mid-point and bottom of the side of the tent. Guy ropes, extending from the lower hoop to the tree trunk 12 feet below, held the tent in position. The tent was erected on top of an 85foot white spruce and, by removing a few male flowers from the lowest branches within the tent, a 6-foot section of crown was isolated. Pollination was conducted twice with Colorado spruce pollen, and the tent was removed when the cone scales had closed. The same tent was used to cover a small Scots pine, but the flowers and foliage were badly burned because the tree was too well protected from cooling breezes in the heat of the day.

Almost 3,000 cones were collected from the white spruce in the fall, which yielded 80 grams of seed. Poor germination and seedling survival followed, but that is another story.

Following this success, eight tents were ordered to certain specifications. In preference to the heavier pillow ticking, 4-1/2oz. white "Webster cloth" (the fine cotton material used in light sails and 'pup' tents) was used. The material was tested for proof against pollen, but none could be forced through the fine weave. The tents were made in three sizes; five were 6 feet in diameter by 9 feet deep; two were 8 feet by 12 feet; and one was 10 feet by 16 feet, These were used with apparent success in the spring of 1958 for self-pollination, cross-pollination, and control-isolation in mature white spruce, and for self- and cross-pollination in two F1. red x black spruce saplings.

A maximum-minimum thermometer was placed in each tent. Records of maximum and minimum temperature were taken daily within and without one of the 8- by 12-foot tents erected on a tall white spruce. The maximum recorded within this tent was 91°F on May 17 when the air temperature outside was 83°, the sky clear, and there was little wind. The minimum recorded was 34°F following light frosts. The maximum in the tents near the ground on the F1 hybrids was 92°F, but the minimum was 24°F. However, in no case did the flowers or foliage appear to have suffered any damage.

Very high winds were experienced this spring, but no serious damage occurred. The largest tent was ripped on the stub of a branch broken off when the tent was erected, but this could have been avoided by cutting back the stub.

Shrinkage of the tent material when wet presented some problems. The hoops must fit loosely when the tent is dry, and stiff rubber or steel springs will be incorporated in the guy ropes next year.

This year the hoops were made from 14 mm (1/2-inch) cane or reed, except in the largest tent where 1-inch cane was used. The 14 mm cane was too light and bent easily when wet, and 1-inch cane will be used in future.

Colour slides were shown to illustrate the tents, their locations, and the dismantling of one of them.

# R-21.

# SUMMARY

#### THE ROLE OF RHUBARB IN FOREST TREE BREEDING

by

# C. Heimburger\*

Rhubarb is used as an idiom designating irrelevant matter in English and razzing in American, in some cases in both senses. The present tendency to engage in peripheral rather than in central activities in forest tree breeding is a phase characteristic of new fields of research. It is desirable, even at the present stage, to stress the importance of central rather than peripheral activities in this field, be they concerned with basic or various phases of applied research. The aim of forest tree breeding, as pointed out by Matthews in England, is the production of cultivars, in a similar manner as this is done in other fields of plant breeding. High priority is given to ecological adaptation of the tree materials worked with to the various man-made environments where they are to be used. Examples of fall-wheat breeding in Alberta and of Triticum-Agropyron work in Siberia are given. The present preoccupation with wood quality has low priority in species where nursery survival and transplantability leave much to be desired. Future pulpwood requirements (Swan, 1955) also stress present need in wood quantity before quality. A stand of forest trees is assumed usually to be an outbreeding polygenic population. From a statistical standpoint it can be visualized as a fried egg. A cross section through such a population in any direction will represent a somewhat flattened normal frequency distribution curve. A tangential section will not change the population structure or the essential part of its composition to a marked degree. This happens in most silvicultural provenance tests for direct use-value determinations, with small population samples. Samofal (U.S.S.R.) made a statement that provenance tests should be carried out on a more sound genetic basis and be of greater value for forest tree breeding purposes, but failed to follow this in his own work. With our present knowledge of population genetics we can so organize our work in provenance tests that the considerable effort expended in assembling population samples of a tree species from a wide range of natural habitats can be used most effectively in (1) forest tree breeding, (2) determination of the silvicultural use-value at the place of testing and (3) evaluation of the racial composition, in that order of importance. An outline of how this could be done with some of our native forest tree species was then presented. In some cases it is easier to obtain superior populations from other areas than to screen local populations for superior types. Spruce in southern Sweden and southern Nova Scotia were given as examples. The genetic basis for this is an assumption that desirable, largely dominant genes are

\*Forest Geneticist, Ontario Department of Lands and Forests, Southern Research Station, R. R. No. 2, Maple, Ontario. R-22.

extent independently in spatially isolated polygenic systems. In this event great benefit may be derived from complementary genes in future interracial hybridization with the aim of producing more efficient populations than any presently available. The application of this idea to the layout of seed orchards was then outlined.

# REFERENCES

- MATTHEWS, J. D. and C. McLEAN. 1957. Improvement of Scots pine in Britain by selection and breeding. 7th British Commonwealth Conference, 1957, Australia and New Zealand, Forestry Commission, London.
- SAMOFAL, S. 1929. Kizucheniu klimaticheskikh ras sibirskoi listvennitzy (To the study of climatic races of Siberian larch) Trudy po lesnomu opytnomu delu 75(1): 93-115.
- SWAN, H.S.D. 1955. Tree breeding what prospects does this science hold for the Canadian pulp and paper industry? Pulp and Paper Magazine of Canada 5: 154-166.

# 4. SEMINAR: TIMBER QUALITY AND GENETICS

# THE STATUS OF WORK ON WOOD QUALITY IN SOUTHERN FOREST TREE IMPROVEMENT RESEARCH

by

Keith W. Dorman\*

### INTRODUCTION

From the very start in 1951, the Committee on Southern Forest Tree Improvement included representatives of the wood-using industries, and was strongly interested in wood quality. A booklet, "Suggested Projects in the Genetic Improvement of Southern Forest Trees," prepared in 1952, emphasized study of variation and inheritance of traits important in wood quality. In 1956, Drs. Kramer and Zobel prepared a memorandum to the Technical Association of the Pulp and Paper Industry, asking the industry to define optimum fiber characteristics for various products in various localities from various species. This led to the development of the TAPPI Forest Biology Committee described by Nethercut (1958). At the Fourth Southern Conference on Forest Tree Improvement, a paper, "The Pulp and Paper Industry Looks at Future Wood Requirements", was read by Spiers (1957) of the Southern Pulpwood Conservation Association, and one on "The Lumber Industry Looks at Future Wood Requirements", by Cothren (1957) of the Southern Pine Association.

Paul and Smith (1950), of the Forest Products Laboratory, prepared a paper entitled "Summary on Growth in Relation to Quality of Southern Yellow Pine". This paper reviewed work done before 1950.

It is not possible to discuss fully all the work under way and the data available, but the scope can be indicated and the direction in which it is going.

# IMPORTANCE OF WOOD QUALITY IN TREE BREEDING

It is easier to figure the value of specific gravity in tree breeding work than tracheid length and some other traits. This is true because specific gravity can be expressed in terms of pounds of pulp--a common unit of measurement. A difference of 0.01 in specific gravity means 90 pounds of wood per standard cord, 100 percent moisture content (Taras, 1956). Variation between trees is as much as 0.25, so this is real money. Some slash, longleaf, and shortleaf in Mississippi have specific gravities of nearly 0.80 compared with an average of about 0.55 (Mitchell, 1958). A difference in weight of this magnitude, 2,250 to 3,600 pounds per cord, may mean important differences in fiber quality, and this also can mean real money.

\*Southeastern Forest Experiment Station, U.S.D.A. Forest Service, Asheville, N. C., U. S. A. Many pulp and paper companies are establishing seed orchards and contributing financially to tree improvement research programs. Progress or annual reports for Florida by Perry and Wang (1957), Texas by Texas Forest Service (1957), and North Carolina by North Carolina State College School of Forestry (1958) describe these programs. The Florida cooperative program has helped 10 pulp and paper companies establish 15 seed orchards. Ten of the 12 companies in the North Carolina cooperative program are actively engaged in seed-orchard establishment.

Information about environmental and hereditary effect on wood quality is important to silvicultural work as well as to tree breeding. Seedling production this year in the South should be close to 1 billion seedlings. Progressive State forestry organizations want to keep the quality high. It is becoming possible now in some states to control inherent qualities of seed through the seed orchard and seed certification programs. Since much regeneration is by seed trees, good wood quality could also be considered in seed-tree selection. Also, silviculture is increasing in intensity and wood quality may be an important consideration when marking for improvement cuts.

# SOME AGENCIES ENGAGED IN RESEARCH ON WOOD QUALITY

The following colleges, universities, Federal agencies, and State agencies have published results of work on wood quality, or are known to have research under way:

> Texas Agricultural and Mechanical College Louisiana State University Southern Institute of Forest Genetics University of Florida University of Georgia Institute of Paper Chemistry Forest Products Laboratory Southeastern Forest Experiment Station North Carolina State College

In addition to the above list, the research departments of several pulp, paper, and other wood-using industries have active programs.

# IMPROVEMENT OF TECHNIQUES FOR STUDYING WOOD QUALITY

Methods for determining wood-quality factors have been developed or modified for use with southern pines because of the interest by tree breeders. A method for measuring tracheids was reported by Jackson and Greene (1957a). A method used for a study in Texas of variation in tracheids length is described by Kramer (1957). Smith (1954), of the Forest Products Laboratory, published on the maximum moisture-content method for determining specific gravity of small wood samples. The method requires only determination of the weight of the completely water-saturated sample and of the weight of the ovendry sample. Several methods for wood-quality evaluation from increment cores were described and compared by Mitchell (1958). Large increment borers of 8 mm., 3/8 inch, or 1/2 inch, and core cutters are being used to obtain samples from which specific gravity, tracheid length, and percent cellulose can be obtained (Mitchell, 1958; N. C. State College School of Forestry, 1957). The North Carolina State College project used a Little Beaver attachment to obtain chips for a study of variation in pulp yields (N. C. State College, 1957).

The relationship between the weighted specific gravity of merchantable volume of a tree and an increment core at breast height has been determined for loblolly, shortleaf, slash, and longleaf pines in Mississippi. Mitchell (1958) quotes unpublished work of Wahlgren and Fassnacht citing the coefficient of correlation for loblolly pine as 0.7209. Although the figures were not given for slash, longleaf, and shortleaf pines, the slope of the regression lines were similar for slash and longleaf and slightly less steep for shortleaf. With this information and the curve for yield of kraft pulp in relation to wood density (Mitchell, 1958), it is possible to estimate the yield of pulp per tree from increment cores. Another aid in this same type of relationship is the alignment chart presented by Perry and Wang (1958) for determining dry pulp yield of slash pine when wood volume and specific gravity are known.

#### CORRELATION OF MATURE WITH JUVENILE TRAITS

Because the time element is very important in tree improvement work, tree breeders should take every opportunity to shorten the time for evaluating progeny tests. This is being done in studies of wood quality by working out the correlation between certain traits of the mature tree with those in seedlings or young trees. If these correlations are high, geneticists can save a considerable amount of time by not having to wait until trees mature before examining the wood.

Zobel (1956) states that highly significant correlations were found between the specific gravity of the wood of young trees (the first 8 rings) and the over-all specific gravity of the wood of the same trees when mature. He also reports that the relationship may vary from area to area and site to site and thus the exact figures must be used with caution; but he does feel that a study of young or juvenile wood will give a good estimate of the wood of a mature tree. In his study, which was conducted in east Texas, a correlation coefficient of 0.805 was found for 92 trees in a seed production area. These were dominant and codominant trees 42 years old. The correlation coefficient for a second group of trees representing extremes in specific gravity and ages 25 to 70 years was 0.856. Both values were significant at the 1 percent level. In the first group, specific gravity of the juvenile wood in different trees was 0.41 to 0.68. in the second 0.38 to 0.73. Although the specific gravity of the first eight rings is generally lower than that in the entire radius, it exceeded the specific gravity of the entire core for trees with the highest radial specific gravity (above 0.60). The relationship between juvenile and total specific gravity thus tends to be curvilinear rather than linear. There were only a few trees with specific gravity of juvenile wood above 0.60.

For slash pine, Larson (1957) found that summerwood percentage increased rapidly from 6 to 11 years, more gradually from 11 to 21 years, and remained constant from 21 to 26 years. Average summerwood percent for 650 trees at age 6 was 40 percent and at age 21 about 60 percent.

In a study of tracheid-length relationships in 12 trees in Texas, Kramer (1957) found that the initial rate of tracheid-length increase was very rapid, but it was not so rapid in the outer rings. Curves of tracheid length over ring number for eight trees were very similar and flattened out after about the 20th ring. However, curves for four trees were similar to each other but did not flatten out. Tracheid lengths of the fifth and tenth growth rings from the pith were correlated with tracheid length in succeeding growth rings.

Jackson and Greene (1957, 1958) reported that for two slash pine trees 45 and 60 years old, tracheid-length measurements at 5-ring intervals from the pith showed that length increased rapidly to peaks between rings 15 and 25, and then increased very slowly to the last ring. Tracheid length in the first rings was about 1.5 mm. and 2.1 mm. for the two trees and about 4.3 mm. in the outermost rings. They also found that tracheids in the first ring were of nearly constant length throughout the height of the tree. This is very important because it means that the wood of the leader or first ring in topmost branches of trees of different sizes can be compared.

AInformation on the volume and quality of juvenile wood has been obtained in studies of variation in wood quality within and between trees. Information of this type is important because juvenile wood has many undesirable characteristics, including short fibers, low specific gravity, and apparently low cellulose content. Zobel and McElwee (1958a), working in North Carolina, found that in a group of 14 loblolly pines the core of juvenile wood varied from 3.8 inches at breast height to 3.4 inches at 45 feet. For 50 slash pine trees in a South Carolina plantation the average shape of the cores was exactly cylindrical, with a diameter of 2.5 inches, and contained approximately 6 annual rings. They presented a generalized curve showing juvenile wood is produced by the first 6 to 8 annual rings from the pith, followed by a transition period until about the 10th annual ring. Specific gravity of juvenile wood was within the range of 0.41 to 0.49 for loblolly pine in plantations and natural stands sampled from Virginia to Texas.

Larson (1957) found that juvenile wood was formed in slash pine for 6 to 8 years in rings examined at 3.5 feet above ground.

#### CORRELATION OF BRANCHWOOD WITH STEMWOOD CHARACTERS

Correlations between branchwood and stemwood are very important because if they exist it is possible to estimate characteristics of the stemwood of seedlings without sacrificing the plant. For loblolly pine in east Texas, Zobel and Rhodes (1956) found a correlation of 0.772 between the specific gravity of the stem and the adjacent limb section for 30 trees 3 feet in height. Specific gravity of the limb sections was between 0.33 and 0.52. Zobel and Rhodes (1957) state that the use of limbs to estimate the bole specific gravity of trees up to 11 years of age, the oldest group used in their study, is feasible; highly significant correlations were found between specific gravity of the bole and the limb sections.

From their study of tracheid length in slash pine, Jackson and Greene (1957, 1958) found that tracheid length was generally constant in the first ring regardless of distance from the ground. Also, in two 9-year-old trees the first-ring tracheids of the branches were significantly shorter than those in the stem at all the height levels sampled. The first-ring tracheids in the 1955 branches were significantly shorter than those in the stem of 3 loblolly and 5 slash pine parent trees used in a study of tracheid-length inheritance. For 39 slash pine trees the correlation coefficient was 0.7313. They recommend the use of stem-branch relationship in studies of inheritance of tracheid length.

# VARIATION AND INHERITANCE OF TRACHEID LENGTH

Tracheid length variation in loblolly pine in Texas was studied by Kramer (1957). Zobel (1957a) summarized Kramer's results as follows:

- (1) "The longest tracheids in each growth ring were found in the latter part of the summerwood. This result is similar to those published by several other workers.
- (2) "The commonly reported decrease in fiber length with increased growth rate within an individual tree was not found. Outside the core of juvenile wood (with the curve tending to break at 8 to 12 years) wide rings and narrow rings within the same tree had about the same tracheid length.
- (3) "No correlation could be found between growth rate from tree to tree and tracheid length of the tree, i.e., slowgrowth trees did not always have the longest tracheids and vice versa.
- (4) "Trees grown under nearly identical environments, of the same age, and of similar phenotypes had very different tracheid lengths." (Within a group of 12 trees, Kramer (1957) found the average tracheid length was 3.76 to 4.72 mm., or tracheid length in one tree was 25 percent longer than that of another tree.)

Jackson and Greene (1958) found no difference in tracheid length of earlywood and latewood in 2 trees.

Pillow (undated) at the Forest Products Laboratory summarized some of the Laboratory's work on variation in tracheid length and fibril angle as follows: "Fiber length and fibril angles were found to be different at the same height and age in different trees grown in approximately the same environments, thus indicating possible effects of inherited factors on these characteristics of fibers." Working with slash pine in Georgia, Jackson and Greene (1957, 1958) found that tracheid length in the first ring was fairly constant, but in other rings, length increased from the base of the tree to a certain height and then decreased toward the top. In the outermost ring, tracheid length increased to a maximum of 4.97 mm. at the 26-foot level and then decreased to 1.70 mm. in the 1-year-old leader at 51 feet.

Variation and inheritance of tracheid length in 7 slash pine trees was studied by Echols (1955). Among 3 of the trees which were in the same natural stand, tracheid length of one tree was 64 percent longer than that of another. In another stand tracheids of one tree averaged 28 percent longer than those of the tree nearby. Tracheid length of control-pollinated offspring was intermediate with that of the parent and was under strict genetic control. Open pollination resulted in an equalizing effect which tended to produce progeny with average tracheid length.

Greene (1956) found tracheids in loblolly pine branches of some trees in a natural stand to be 41 percent longer than in others (1.10 mm. as compared with 1.55) and in slash pine trees in a plantation 44 percent longer (1.09 mm. as compared with 1.57). Tracheid length in the current shoot and branch were highly correlated. Tracheid length in control-pollinated progeny of two crosses between loblolly pine trees, one between slash pine trees, and four hybrid progenies of slash x loblolly was intermediate with that of the parents. Tracheid length data of open-pollinated progeny was about the same for all groups and demonstrate the equalizing effect reported by Echols (1955).

# VARIATION AND INHERITANCE OF SPECIFIC GRAVITY

Specific gravity is one of the most important characteristics of wood with which tree breeders have to work because it influences many strength factors in wood and the yield of pulp. Specific gravity is influenced strongly by the proportions of earlywood and latewood which contain fibers of different cell-wall thickness. Thus wood of high specific gravity usually contains a high proportion of thickwalled tracheids. The nature of the cell walls influences many qualities of paper.

# Variation Between Species

Small differences in the average specific gravity of southern pine species were reported by Mitchell (1958). Wood samples obtained during the forest survey of Mississippi show average slash pine specific gravity as 0.557, longleaf pine 0.551, loblolly pine 0.487, shortleaf pine 0.513, and spruce pine 0.475. Thus, there is apparently little opportunity to increase specific gravity on one species very much by transferring genes for this trait from another major species of southern pines. On the other hand, a hybrid developed for some other purpose, such as resistance to pests, probably would have desirable wood quality as far as specific gravity is concerned. Spruce pine is a minor species volume-wise, and its crossability with other southern pines is not known.
## Variation Between Stands

Difference in summerwood percentage was found between plots after sources of variation, such as geographic location, age, number of trees per acre, site index, and growing season had been accounted for in a study of slash pine by Larson (1957).

Clinal variation, where indicated, has been small. For # slash pine, Larson (1957) reported a decrease in specific gravity from east to west and from south to north, as did Perry and Wang (1957). In Larson's study, the mean summerwood percentages for the two regions were 62.03 and 54.14 for the South-East and North-West, respectively, and low specific gravities were 0.52 to 0.54, high 0.60 to 0.63. In the Carolinas and northern half of Georgia, Zobel and McElwee (1958a) found a tendency for specific gravity to be lower westward from the Atlantic coast. In the work reported, maximum difference between locations in the three-State area was 0.05. Perry and Wang (1958) state that variation in slash pine within regions is over twice as great as variation between regions.

Large-scale racial variation studies have not yet produced information, because most of them were started only recently. Wood quality has not been examined in the older plantings. Racial variation studies generally consist of plantings of the four major southern pine species from different geographic locations, either Southwide, statewide, or between different areas within a state. These plantings will provide us with information about wood quality of races grown outside the area of origin.

## Variation Between Trees

Variation in specific gravity of the wood between trees has been found to be much larger than between areas. In loblolly pine, specific gravity of individual trees may range from about 0.42 to 0.65. This range has been reported for Texas by Zobel and Rhodes (1955) and the coastal area of North and South Carolina and Georgia by Zobel and McElwee (1958a). The east-west distance involved is about 1500 miles. Since differences in elevation are only a few hundred feet, this is not an important factor. About the same range in variation occurred in slash pine, sampled by Perry and Wang (1957) in connection with seedorchard projects.

Slash pine trees with 75 to 85 percent summerwood and specific gravity above 0.70 were reported by Larson (1957). Minimum and maximum specific gravity from frequency distribution curves for southern pine sampled in connection with the Mississippi forest survey as given by Mitchell (1958) are as follows: slash pine, 0.35 to 0.80; loblolly, 0.25 to 0.75; longleaf, 0.37 to 0.80; shortleaf, 0.30 to 0.80; spruce pine, 0.35 to 0.70. The extreme values may be due in some instances to causes other than inherent variation because a good sample of the population was desired regardless of source of variation. However, the figures do indicate wide variation in this character.

Larson (1957), from his work with slash pine, states that, "considerable differences in adjusted summerwood percentages were found to exist between individual trees. Total age, total height, crown-height ratio, tree spacing (stand density index), and tree radius were not correlated with summerwood percentage, and none of the betweentree variation could be accounted for by these factors." Zobel and Rhodes (1955) could account for little of the wide variation between trees by studying environmental factors.

## Variation Within Trees

In southern pines, specific gravity of the summerwood is about twice that of the springwood (Paul and Smith, 1950).

Summerwood percent in low-density slash pine trees may be 30 to 40 percent, in high density trees 75 to 85 percent (Larson, 1957).

Variation in specific gravity in slash pine trees was studied by Larson (1957). A brief review of some of his findings is as follows:

"It was found that within the range of ring widths normally encountered in slash pine stands, rate of growth exerted a negligible influence on both specific gravity and percentage of summerwood and for all practical purposes its effect may be ignored. The percentage of summerwood was strongly correlated with specific gravity, accounting for 60 percent of the total variation, whereas the effect of age predominated in controlling the percentage of summerwood gradient on the cross section. Mean summerwood percentage increased from about 40 percent at age 6 years to about 60 percent at age 21 years and tended toward uniformity thereafter."

Little relationship between ring width and specific gravity was found in loblolly pine in Texas by Zobel and Rhodes (1955).

Compression wood occurs commonly in southern pines and has many undesirable qualities. The actual amount of compression wood in loblolly trees of various types has been studied at North Carolina State College. The School of Forestry Report (1958) states: "Reasonably straight trees contained, on the average, 6.0 percent compression wood based on total merchantable volume of the tree. Trees that were somewhat more crooked had 9.1 percent of the volume as compression wood. One very crooked tree had 67.1 percent of its total merchantable volume made up of compression wood.

"Indications are that the amount of compression wood associated with knots occupies about the same volume as the actual knots in the bole, i.e., if a knot system occupies 10 percent of the bole volume, the compression wood will also be about 10 percent of the volume; or if the tree has slender limbs and small knots occupying only about 5 percent of the bole volume, the compression wood associated with those knots also takes up about 5 percent of the volume."

### Inheritance of Specific Gravity

In 1957 Zobel and Rhodes reported preliminary data supporting the hypothesis that high and low specific gravity are inherited. Open-pollinated seed was collected from two trees, one with a specific gravity of 0.647, and the other 0.452. In the third growing season 36 progeny of the high-specific-gravity tree and 19 of the low-specific-gravity tree were analyzed. The progeny of the highspecific-gravity parent had higher wood specific gravity than that of the low-specific-gravity parent, both as indicated by limb section and bole measurements. Progeny of three isolated and supposedly selfed parents were also analyzed. The progeny of the higher specific-gravity parent had significantly higher specific gravity than the progeny of the lower specific-gravity parents.

### VARIATION IN CELLULOSE

Variation in cellulose is being studied by the North Carolina State College in cooperation with industry (Zobel and McElwee, 1958). In this work, wood samples are analyzed by a method developed by Yundt and Bradway of Union Bag-Camp Paper Corporation called water-resistant carbohydrate and alpha cellulose Thirty cellulose determinations can be made at one time, of wood. using only 0.75 grams of wood per sample. The results are not intended to be used directly as an estimate of pulp yield but as an index to yield, from which various companies can determine the relationship to its own pulping method. In mature wood, total alphacellulose variation among loblolly pine trees throughout the area studied was found to be more than 10 percent, and water-resistant carbohydrate as large as 7 percent. In juvenile wood, the variabil-ity was even greater, being about 13 percent for alpha-cellulose and over 10 percent for water-resistant carbohydrates. For all trees sampled, water-resistant carbohydrate in mature wood averaged 3.5 percent higher than in juvenile wood, while alpha-cellulose averaged 7.5 percent higher in mature wood than in juvenile wood. Yields of water-resistant carbohydrate and alpha-cellulose are highly correlated. Approximately 65 percent of the variation in yield of alphacellulose can be accounted for by variation in water-resistant carbohydrate. To date, there has been found only a slight relationship between specific gravity of the wood and water-resistant carbohydrates both in juvenile and in mature wood. It is obvious, however, that cellulose yields are greatly affected by specific gravity if computed on a volume basis. Since in normal loblolly pine wood, a change of 0.01 in specific gravity means a change of about 90 pounds per cord (Taras, 1956). Zobel and McElwee conclude that tree-to-tree variability is much larger than differences between the sites studied. If enough of the variability is inherent, it will enable the geneticist to breed up strains of high producers.

### WOOD QUALITY IN HARDWOODS

In hardwoods, the development of techniques for studying variation and inheritance in wood quality has not kept pace with the work in softwoods. Recently, however, there has been increased interest in this field of work, and some pressure from industry for a tree-improvement program. Studies in quality would be a part of a tree-improvement program.

There are a few reports of work with hardwoods. Bailey (1948) described the work of the Tennessee Valley Authority in methods to produce figured wood. Putnam (1928) wrote on the

occurrence of heartwood and figure in red gum. Wright (1944) found chromosome number varied in ash and maple in Alabama and suggested that this condition might result in difference in wood between trees. Paul and Norton (1936) studied the wood of yellow-poplar and concluded it is about twice as variable as that of hard maple. This year Louisiana State College is starting work on the cytology of bottomland hardwood species and this work may throw light on the subject of polyploidy in those species. Yellow-poplar selections thought to have figured grain have been made by the Southeastern Forest Experiment Station and the Tennessee Valley Authority Division of Forestry Relations. Grafts or cuttings of some trees have been established in Tennessee and Georgia.

## WORK NEEDED ON THE GENERAL PROBLEM OF WOOD QUALITY

Tree breeders should have the following information about wood quality for each species: (1) variation between trees under uniform environment; (2) variation between local stands and different geographic areas throughout the natural range; (3) variation within the tree in relation to number of rings from the pith, and height above the ground for various rings; (4) variation between trees in the pattern of within-tree variation; (5) inheritance of traits, including the pattern of variation within trees; (6) characteristics of wood products made from material representing the range of variation in each species; (7) effect of environmental factors, especially those related to fast growth of individual trees, on various wood characteristics.

Some of the subjects listed have been studied in southern pines but not all for all species. In the immediate future, information on the following specific subjects would be useful:

- (1) Characteristics of the wood of geographic races grown in different places. This is particularly important in races selected for characteristics other than wood quality.
- (2) Effects of fiber characteristics other than weight, such as length, stiffness, cell-wall thickness, etc., obtainable through selection within a species, on quality of various papers; and the effect of mixing fibers of different types on the quality of various types of paper. Also, the effects on paper of mixing various types and amounts of softwood tracheids with hardwood fibers.
- (3) Seasonal growth patterns of individual trees with different earlywood-latewood ratios to see if trees with high percent latewood grow faster than others during the summer months or merely form wood of this type for a longer period of time; also information on inheritance of earlywood-latewood ratios and the cause of change from early to latewood production.
- (4) Morphological and chemical characteristics of the wood of strains developed for high gum yield, resistance to disease, drought resistance, and others, to insure that they have no important undesirable traits.

- (5) Variation and inheritance of bark-thickness. Bark is generally a waste product, and the it is worth while to select against thick bark we should do so.
- (6) Specific gravity, tracheid length, cellulose content, and other characteristics of the wood for trees grown at a very rapid rate. These traits are not generally correlated with growth rate, but we are not sure we have been working on the highest limits of the range in growth rate for all species in various geographic regions. Tree quality, such as taper, crook, and limb diameter, should be considered. Since tree size and quality are more important in determining net returns for certain products than are number of trees per acre or total volume, it is desirable to grow trees at as fast a rate as is consistent with the particular characteristics needed for the particular product.
- (7) Results of progeny tests for combinations of good characters. Some geneticists feel it is most efficient to select for one or at least a very few traits at one time. The real problem needs defining. Is it the difficulty of finding trees with a good combination of traits, is it in the mechanism of inheritance, or what? Obviously we can't have high and low specific gravity or long and short tracheid in the same tree, but combinations of desirable traits for pulp, lumber, and poles would be desirable.
- (8) Combining abilities of selected trees. This must be determined so tree breeders will know how much, if any, weight should be given to combining ability when selected trees are rated. At present we do not know if trees vary in combining ability.

#### SUMMARY

Considerable emphasis is being placed on wood quality in forest tree breeding in the South, particularly in projects supported by pulp and paper and other wood-using industries. The major southern yellow pines have been studied most frequently.

Objectives of the work on wood quality in southern pines are: to distinguish the effect of each environmental factor; to know what and how much variation exists within trees, between trees, and between races; to develop techniques for estimating wood quality; to determine inheritance of characters associated with wood quality; to conduct selective breeding programs for the development of strains with special wood characteristics; and to establish seed orchards for mass production of seed.

Objectives of work with hardwoods are to select strains with figured grain, and to determine heritability of figure and variation in wood.

Techniques for obtaining samples for use in wood-quality determinations and the analysis of samples have been largely perfected for pine, but additional work will probably be needed for certain chemical analyses and to determine yield of pulp.

Specific gravity varies widely between trees and appears to be under strong genetic control.

Small clinal variations in the specific gravity of the wood of loblolly pine is indicated. In Mississippi specific gravity decreased with increasing distance to the north from the coastal area. In the Carolinas specific gravity decreased with distance westward from the coast. Also, specific gravity varied slightly between areas in the eastern sections of North and South Carolina.

Clinal variation is indicated in slash pine in Florida, with specific gravity lowering from east to west and south to north. In both mature slash and loblolly pine specific gravity is always greater from tree to tree than between regions or sites.

Specific gravity of the older wood is correlated with that of the wood near the pith.

Tracheid length varies widely between individual slash and loblolly pine trees and is under strong genetic control.

Tracheid length in the first ring of branches in the uppermost whorl can be used as an indication of the tracheid length in the first ring of the stem. Tracheid length in the first ring from the pith in slash and loblolly pine is constant throughout the entire height of the tree. Tracheid length of mature wood is correlated with that near the central core of the tree.

Variation between trees in tracheid length and specific gravity is sufficiently large so that these traits should be considered in tree breeding projects. Apparently an opportunity exists to select within species strains that have wood well suited for special products or which will produce a greater than average yield of pulp.

Environmental effects on characteristics of the wood are small. It is very difficult to adjust for environmental effects so that genotypes of trees growing in different stands can be accurately determined.

I hope this summary will be helpful to others and that they can profit by the experience of men in the South. Southern tree breeders feel they are a long way from having the last word, and there is much to be done. We probably didn't know how much we didn't know about the subject until we started work, However, conditions in the South are nearly ideal for applied tree breeding, and it is a real opportunity for the tree breeder to prove he can produce something valuable to forestry.

### LITERATURE CITED

Bailey, Lowell F. 1948. Figured wood: a study of methods of production. Jour. Forestry 46: 119-125.

Cothren, V. W.

The lumber industry looks at future wood requirements. 1957. Fourth Southern Conference on Forest Tree Improvement Proc.: 14-19.

Echols, R. M. 1955. Lin

Linear relation of fibrillar angle to tracheid length, and genetic control of tracheid length in slash pine. Trop. Woods 102: 11-22.

Greene, James T. 1956. Variation in tracheid length of slash pine parents and Thesis. Univ. of Ga. School Forestry. progeny.

Jackson, L.W.R., and Greene, James T.

1957. Hereditary variations in slash pine tracheids. Fourth Southern Conference on Forest Tree Improvement Proc.: 23-26.

1957a. Method for fiber measurements. Jour. Forestry 55: 300.

Slash pine tracheid length as related to position in 1958. stem and branch. Naval Stores Rev. 68(4): 6,8.

Kramer, Paul R.

- 1957. Tracheid length variation in loblolly pine. Tex. Forest Serv. Tech. Rpt. 10, 22 pp., illus.
- Larson, Philip R.
  - 1957. Effect of environment on the percentage of summerwood and specific gravity of slash pine. Yale Univ. School Forestry Bul. 63, 77 pp., illus.

Mitchell, Harold L.

1958. Wood quality evaluation from increment cores. TAPPI 41(4): 150-156.

Nethercut, P. E. 1958. The development and organization of the TAPPI Forest Biology Committee, TAPPI 41(4): 145.

North Carolina State College, School of Forestry

1958. North Carolina State--industry cooperative forest tree improvement program. Second Annual Report, N. C. State Col. 18 pp., illus.

Paul, B. H. and Smith, D. M.

Summary on growth in relation to quality of southern yellow 1950. pine. U. S. Forest Serv. Forest Prod. Lab. Rpt. D1751. 19 pp., illus.

- Paul, B. H., and Norton, Newell, A. 1936. Variations in the wood of yellow-poplar. Jour. Forestry 39: 936-942.
- Paul, B. H.
- Variation in the specific gravity of the springwood and 1939. summerwood of four species of southern pines. Jour. Forestry 37: 478-482.
- Perry, Thomas 0., and Wang, Chi Wu 1957. Second progress report. c Second progress report, cooperative forest genetics research program. Fla. Univ. School Forestry Res. Rpt. 4, 27 pp., illus.
  - Variation in the specific gravity of slash pine wood and 1958. its genetic and silvicultural implications. TAPPI 41(4): 178-180.

- Pillow, M. Y. 1953. Patterns of variation in fibril angles in loblolly pine. U. S. Forest Serv. Forest Prod. Lab. Rpt. D1935.
- (no date) Variability in anatomical features and their effects on properties of second-growth yellow pine. U. S. Forest Serv. Forest Prod. Lab. Rpt. SR-21, 4 pp.
  - Specific gravity relative to characteristics of annual 1954. rings in loblolly pine. U. S. Forest Serv. Forest Prod. Lah. Rpt. 1989, 21 pp.

### Putnam, J. A.

The occurrence of heartwood and figure in red gum. South. 1928. Lumberman 133(1734): 204-206.

Smith, Diana M. 1954. Maxim Maximum moisture content method for determining specific gravity of small wood samples. U. S. Forest Serv. Forest Prod. Lab. Rpt. 2014, 8 pp.

Spiers, James F.

The pulp and paper industry looks at future wood require-1957. ments. Fourth Southern Conference on Forest Tree Improvement Proc.: 11-13.

Taras, M. A.

Buying pulpwood by weight -- as compared with volume measure. 1956. U.S. Forest Serv. Southeast. Forest Expt. Sta. Paper 74, ll pp., illus.

Texas Forest Service

Fifth Progress Report, Forest Tree Improvement Program of 1957. the Texas Forest Service. Tex. Forest Serv. Cir. 58, 14 pp., illus.

- Wright, Jonathan W. 1944. Genotypic
  - Genotypic variation in white ash. Jour. Forestry 42: 489-495

- Zobel, Bruce 1957. Forest genetics and the pulp industry. TAPPI 40(3): 42A-44A

1957a. Inheritance of wood properties in pine. Fourth Southern Conference on Forest Tree Improvement Proc.: 27-29.

Zobel, Bruce J., and McElwee, Robert L.

1958. Variation of cellulose in loblolly pine. TAPPI 41(4): 167-170.

1958a. A natural variation in wood specific gravity of loblolly pine and an analysis of contributing factors. TAPPI 41(4): 158-161.

Zobel, Bruce J., and Rhodes, R. R.

1955. Relationship of wood specific gravity in loblolly pine to growth and environmental factors. Tex. Forest Serv. Tech. Rpt. 11, 32 pp., illus.

1956. Specific gravity estimations of mature loblolly pine from juvenile wood and seedling limb sections. Forest Sci. 2(2): 107-112.

1957. Specific gravity indices for use in breeding loblolly pine. Forest Sci. 3(3): 281-285.

# INVESTIGATIONS OF VARIATION IN WOOD QUALITY OF SOUTHERN PINES AND ITS GENETIC SIGNIFICANCE

Thomas O. Perry and Wang Chi-Wu\*

### Introduction

A strain of trees which is inherently healthy, fast-growing and straight-boled is of little value if the quality of the wood produced is inferior. Therefore, the possibilities of improving wood quality have received considerable attention by forest geneticists. Most of the research has been of an exploratory nature. How much and what kind of variation is there in the wood properties of a tree species? How much influence does variation in the environment exert on the development of a given wood property? Is there a considerable degree of variation in wood quality that is under genetic control? Geneticists have been forced to become wood technologists in investigating these problems. Since most American research is financed by the pulp and paper industry, much of the research is centered on examining characteristics of wood that influence pulp yields and pulp quality.

The results of these exploratory studies have been sufficiently startling as to cause TAPPI, the Technical Association of the Pulp and Paper Industry, to form a special committee on forest biology in 1957. The forest biology committee held its first symposium in New York last winter. Proceedings of this symposium were published in the April issue of TAPPI, volume 41, number 4, pp. 145-180. By referring to the papers of this symposium, plus the literature they cite, one can obtain a comprehensive bibliography of American research work on the control of wood quality through inheritance.

The research on wood quality of pine species has fallen into two general categories: (1) actual progeny tests of trees with contrasting wood characteristics, (2) field investigations of the kinds and patterns of variation in wood properties for tree species.

This paper presents a brief resume of the progeny test findings plus a more comprehensive discussion of the field findings.

### Progeny Test Results

There are only three basic progeny tests on which American publications on the inheritance of wood properties are based. The oldest progeny test was initially intended to investigate the inheritance of gum yield capacity at the Naval Stores Research Center at Lake City, Florida, of the U.S. Forest Service. This progeny test was examined by Mergen, Hoekstra, and Echols in 1955. These authors found that there was a definite genetic control of gum yield capacity for the trees in this study and that this gum yield capacity was correlated with genetically controlled variations in the viscosity of the oleo-resin produced. The number and size of the radial-resin ducts in the wood varied with the age of the tree, and under the conditions studied no correlation of these characters was found

\*University of Florida, Gainesville, Fla., U.S.A.

between the parents and their progeny. Schopmeyer subsequently has been able to show a correlation between resin flow and pressure and that the pressure of the oleo-resin exudate is genetically determined.

Echols, in 1955, re-examined the wood samples taken from this same study. He found that the fibrilar angle of tracheids was highly correlated with tracheid length and that ninety-one percent of the variation in fibrilar angle could be attributed to variations in tracheid length. Examining this same material, Echols found that the inheritance of tracheid length was rigidly controlled by a multiple series of genes. Open-pollinated progeny from mother trees with long tracheids tended to have tracheids of average length while control-pollinated progeny had tracheid lengths intermediate between those of the two parents.

Jackson and Greene, in 1957, reported on the results of studies on open-pollinated progenies and a few control-pollinated progenies of slash and loblolly pine at the Ida Cason Calloway Foundation in central Georgia. These workers found a strong correlation between the tracheid length of the parents and the tracheid length of the progeny. The tracheid lengths of controlpollinated progenies were intermediate between those of their parents in agreement with the findings of Echols.

Zobel and Rhodes, 1957, reported on the results of examining progeny of isolated loblolly pines in the western extreme of the range of this species. They found that there was a high correlation between the specific gravities of the wood of the progeny and the specific gravities of the parents. Zobel and Rhodes, 1956, found that specific gravity varied with age of the tree, from juvenile wood to mature wood, and were able to correlate the specific gravity of juvenile wood with the specific gravity of the mature tree. They demonstrated further that it was possible, by correlation analysis, to assess the inheritance of specific gravity using limb sections of the progeny, thus avoiding the necessity of destroying the tree.

Although it was not American work, one should not leave the topic of progeny tests investigating wood characteristics in pines without mentioning Fielding, 1953, who investigated variations in the wood characteristics of Monterey pine by using grafts of six clones. In sampling the grafts of these clones, he found evidence of inherent variations in specific gravity of twenty percent or more between clones. Spiral grain was found to vary widely from clone to clone; in some clones it was hardly noticeable, while in others the angle of spiral was severe and continued to produce a twisted grain throughout the life of the tree. He found that there was a great deal of variation between clones in their tendency to produce knots and cone holes. One of Fielding's most interesting findings was that spiral grain varied markedly with age between clones, in some instances a clonal spiral would increase with age and in others it would decrease.

# Field Test Results

Far more interesting than the scanty results of current progeny tests are the results from samplings of natural stands of

trees in order to discover the kinds and types of variation in wood characteristics and the factors influencing them. Zobel and Rhodes, 1955, have made a very thorough study of the influence of environmental factors on the growth and development of wood in Texas. They reported finding no correlation between either wood specific gravity and density of the stocking of the stand, site index, or the moisture content of the soil. There was also no correlation between the length of free bole in the stem of the tree and the development of wood density. Larsen (1957) sampled trees from a number of stands of slash pine scattered through the southeastern United States. He found that there was no correlation between specific gravity and the various site factors that he investigated. Larsen reported that there was an in-crease in specific gravity of slash pine from west to east and from north to south, such that the specific gravities in the southern part of the region reached magnitudes of .6 or higher. He attributed this variation in specific gravity to variation in the amount of rainfall occurring in the months of July and August. Actually, there are a number of factors that vary in parallel with the rainfall for this region and his correlation of rainfall pattern may be spurious. Van Buijtenen, 1958, raised loblolly pine seedlings under controlled environmental conditions where temperature, irrigation and the photoperiod were varied frequently throughout the season. He was able to increase the thickness of the tracheid wall but not the diameter, by increasing the temperature. High soil moisture increased the tracheid diameter but not the thickness of the tracheid wall. There appeared to be no influence of photoperiod on the tracheid wall formation of the loblolly pine seedlings with which he was experimenting. In field test with irrigation and photoperiod plots, Van Buijtenen was unable to influence the properties of the wood of mature loblolly pine trees. The samples of Zobel and Larsen were large, involving thousands of trees and months of arduous work and there can be no doubt that there is little significant correlation between the classically cited factors of environment and the development of wood characteristics for southern pine.

Most textbooks and modern references in American forestry cite a distinct correlation between the growth rate and specific gravity of conifer wood. They also report that tracheid length and fibril angle decrease with growth rate. The results of field examinations of trees, however, reveal that there appears to be absolutely no correlation between growth rate and these other characters for southern pine. Spurr and Hsuing, in 1954, showed that there was no apparent correlation between growth rate and the specific gravity for red pine. Zobel, in his Texas study, examined the effect of growth rate on specific gravity and tracheid length. He found no correlation between either growth rate and wood density, tracheid length or fibril angle. Zobel, and Perry and Wang, have been selecting trees of outstanding growth rate for a number of years in the southern United States. One of the first things done in this selection work was to make a comparison between growth rates and the specific gravities of the selected trees and of random trees of average growth rate. The frequency distribution diagram in Figure 1 (see page S-23) illustrates the variation in the specific gravity of the wood of slash pine. The specific gravity for ninety-seven slash pine trees of average growth rate is represented by the solid line while the specific gravity of the ninety-seven selected trees growing

2.6 times as fast as the surrounding dominant and co-dominant trees of the same age is shown by the dashed line. The selected trees averaged four to six growth rings per inch of wood radius. The average specific gravity of the average trees was 0.532. The .003 difference in specific gravity is non-significant. With the wood sampling method used, there was no correlation between wood specific gravity and growth rate in slash pine. Zobel has made a similar finding in his selection program with loblolly pine. Figure 2 (see page S-23) illustrates the variation in specific gravities of selected trees of the International Paper Company for North and South Carolina regions. It should be noted that the average specific gravity falls in the region of 0.54 to 0.55. In another study, Zobel plotted the specific gravity distribution for over a thousand loblolly pine trees and here again the average specific gravity of the trees fell between 0.54 and 0.55.

There is a distinct correlation between wood properties and the age of the tree. As Fielding has reported, there is a correlation between the angle of the spiral of the grain of wood and the age of the tree. Mergen, et al, have observed the variation in the number and size of resin ducts with age. Jackson and Greene observed the variation in tracheid length and fibril angle with age. Zobel (1957) has investigated the variation in specific gravity with age for a large number of trees chosen from many stands and found that the core wood of loblolly pine trees had an average specific gravity of 0.45 while the specific gravity of mature wood averaged 0.54. Figure 3 (see page S-23) illustrates the variation in specific gravity between juvenile wood and mature wood for a single stand as observed by Zobel.

The current literature regarding the effect of the environment on various wood characteristics can be attributed to failure to recognize individual variation and the variation in the wood characteristics with age. The specific gravity of individual trees commonly varies as much as plus or minus 0.10 from the mean of trees from the same stand, growth rate and age class (Figure 3). Hence, wood samples from only one or a few trees of a given category are not adequate for drawing conclusions regarding a given hypothesis. Many workers have failed to account for the correlation of specific gravity with age. It is not valid to characterize wide-ringed wood samples from the center of a tree as representative of fast growth rate and then to characterize narrow-ringed wood samples from the exterior of the tree as representative of slow growth rate. Indeed, in terms of basal area and volume increment, the juvenile and adult growth rates may be the same. On the basis of these findings, the whole matter of the influence of the environment on wood characteristics should be re-examined by wood technologists. It may even be possible that standards of specifications for structural timbers can be modified in some degree as a result of re-investigation of sampling procedures in ascertaining the effect of the environment on wood properties.

Field sampling of wood density over the range of the various southern pine species has revealed variation of wood specific gravity with species and with location in the geographic range of the species. Larsen, 1957, observed that the percent of summer wood and specific gravity increases from north to south and from west to east for slash pine. Mitchell, 1958, reporting on the results of specific gravity determinations taken in the course of forest survey in Mississippi noted a north to south gradient of increasing specific gravity for all of the pine species growing in Mississippi (slash pine, longleaf pine, shortleaf pine, loblolly pine, and spruce pine). Perry and Wang, 1958, found a gradient in slash pine specific gravity similar to that observed by Larsen. Specific gravities in the western part of the slash pine range averaged between .50 and .52, while in the region of south and central Florida the specific gravities reached as high as .62 or more. It is to be emphasized that in all of these studies, variation within regions is far greater than variation between regions. This was illustrated by the data of Zobel showing the variation in specific gravity for fifty trees growing on the same site. He also observed an increase in specific gravity from 0.52 to 0.56 for samples taken along a transect from inland areas of northwest Georgia to coastal regions of South Carolina (Figure 4 - see page S-23).

Such variations in specific gravity are of extreme importance to current forest management. This is not only because of the variation in dry pulp yields obtained with variation in specific gravity but also because of the variation in the amount of cooking required to digest pulp of high specific gravity compared with pulp of low specific gravity. One company in the southeast, for example, had an opportunity to purchase pulpwood from crown lands in the The wood in this region is of extremely high specific Bahamas. The wood in the bulk of the lands of the paper company in gravity. question, however, is of considerably lower specific gravity. The company did not purchase the wood in the Bahamas since it would have required adjusting the cook in the pulp mill for the relatively small amount of wood obtained from the Bahamas. It behoves forest management to prepare at an early date a complete map showing the variation in specific gravity over the ranges of the species they utilize. With this information they can predict the yields to be obtained per cord of wood purchased and the amount of cooking required when wood is being utilized from a given region.

## <u>Discussion</u>

The variation in specific gravity for slash and loblolly pine is between 0.65 and 0.45, with the average specific gravity falling in the neighborhood of 0.54. The dry pulp yield from the slash or loblolly pine tree with a specific gravity of 0.65 would be twenty-two percent above average. Observations by Zobel, Perry and Wang, and other workers selecting superior slash and loblolly pine trees, has indicated that only one tree in every three hundred will have a specific gravity resulting in a dry pulp yield increase of twenty-two percent. Twenty-two percent is, therefore, the theoretical maximum increase in pulp yield that can be obtained through selection and breeding for high specific gravity slash pine wood. It is unlikely that the first generation of breeding of slash pine will yield even eleven percent, or half of this amount. This eleven percent improvement contrasts sharply with the fifty percent increase anticipated by some foresters. Figure 5 (see page S-27) shows an alignment chart for the determination of the total dry pulp yield of a tree when the specific gravity and the volume of the tree are known. By using this chart, the potential pulp production



S-23

per acre for selected tree progenies can be estimated. The study of this alignment chart reveals the dangers involved in selecting tree phenotypes for high specific gravity at the sacrifice of volume superiority. Taken in the same age class, a tree twenty-two percent superior in volume and of average specific gravity will produce much more wood than a tree of average volume, twenty-two percent superior in specific gravity. Most pulp companies participating in the University of Florida and North Carolina State Cooperative Forestry Improvement programs are selecting trees of average or better characteristics and of fast growth rate. Seedlings for the next twenty to fifty years of planting will come from these selections. Further improvements in specific gravity and wood properties will attend the second cycle of selection and breeding that will begin about ten to fifteen years hence.

Zobel has demonstrated that the specific gravity of the juvenile wood of loblolly pine is 0.45 while the specific gravity for mature wood averages 0.54. Loblolly pine produces more juvenile wood than slash pine in the order of seven to eight rings as contrasted to four to five growth rings. Foresters have proposed to reduce the amount of juvenile wood by growing trees slowly for a number of years and then releasing them while another proposal for reducing the volume of core wood is to plant slash pine instead of loblolly pine. This proposal has been made in spite of the fact that loblolly pine will produce more wood than slash pine on many sites. What are the potential results of these ingenious proposals to eliminate the evils of juvenile wood?

The alignment chart indicates that 0.20 cords of core wood with a specific gravity of 0.45 will yield 195 pounds of dry pulp, while 0.20 cords of outer wood will yield 240 pounds of dry pulp. Let us assume an attempt to grow trees slowly in their juvenile stages in order to reduce the diameter of the core wood (an impossible task, as explained in a later paragraph). Let us also suppose that it was possible to reduce the diameter of the core wood by one-half (from three to one-and-a-half inches, for example), then the hypothetical volume of 0.20 cords of core wood would be reduced from 195 pounds to 49 pounds. The same number of years would be required to produce the smaller amount of wood, 146 pounds less pulp would be produced in the process. Can 146 pounds of dry pulp be thrown away?

The term "juvenile wood" is a misnomer. Core wood of low specific gravity is found at the top as well as at the base of the tree. Each layer of annual increment contains core or juvenile wood and outer wood. Hence, it is impossible to reduce the diameter of the core by one-half without making a reduction in the exterior wood by The volume of the tree would be reduced by three-fourths one-half. in the process. Core wood volumes can be significantly reduced only by growing trees slowly throughout their life cycle. The specific gravity of a slow-growing tree would not be altered because the core wood with low specific gravity and outer wood with high specific gravity would be altered proportionately. It is impossible to alter the specific gravity of slash pine wood by slowing growth rate and as a correlary, it is impossible to alter the volume of the core wood without correspondingly altering the volume of the tree! The terms "juvenile wood" and "mature wood" are unfortunate and will lead to confused thinking in the future.

The authors suggest the term "core wood" or "pith wood" be used in preference to the term "juvenile wood" and that the term "outer wood" or "exterior wood" be used in preference to the term "mature wood".

# Variation in Cellulose Content

This seminar discussion on variation in wood characteristics of southern pine would not be complete without some discussion of Zobel and McElwee's pioneering work on the variation in cellulose content of loblolly pine trees.

Using large size increment bores and special microanalytical techniques, Zobel has been able to determine the waterresistant carbohydraté (holo-cellulose) and alpha-cellulose contents of a large number of loblolly pine trees. This study is still in its exploratory stages but Zobel has already discovered some striking information. There is a strong correlation between the waterresistant carbohydrate content and the alpha-cellulose content in the tree, as shown by Figure 6 (see page S-27). The alpha-cellulose content increases with the age of the wood laid down in a given tree and, on the average, the alpha-cellulose content in outer wood is seven-and-a-half percent higher than it is in core wood. The next two figures show the variation in alpha-cellulose content for trees on a single site (Figure 7 - see page S-27) and for trees on several sites (Figure 8 - see page S-27). In each case seven percent difference was found in the alpha-cellulose content of outer versus core wood. Zobel was unable to find any correlation between specific gravity and cellulose content for four out of the five plots he examined. In one plot, however, there was an apparent correlation between specific gravity and cellulose content. Cellulose content of the outer wood seemed to vary between fiftytwo and sixty-three percent for loblolly pine and from this data it would appear possible genetic control of this characteristic can be established. Further cellulose determinations will reveal whether there is a pattern of geographic variation in cellulose content as there is with specific gravity. Progeny tests will be conducted by Dr. Zobel to determine the degree of genetic control over the variation in cellulose content.

In closing this paper, I should wish to acknowledge the generosity of Dr. Zobel in providing me with material for illustration.



\$-27

Literature Cited

- van Buijtenen, J.P. Experimental control of environmental factors and their effect upon some aspects of wood anatomy in loblolly pine. Tappi, Vol. 41, No. 4, pp. 175-177. 1958.
- Echols, R.N. Linear relation of fibrilla angle to tracheal length and genetic control of tracheal length in slash pine. Tropical Woods, No. 102, 11-22. 1955.
- Fielding, J.M. Variations in Monterey pine. Forestry and Timber Bureau Bulletin 31, Canberra, Australia, 1953.
- Jackson, L.W.R., Greene, J.T. Hereditary variations in slash pine tracheids. Proceeding of the Fourth Southern Conference on Forest Tree Improvement, pp. 23-26. 1957.
- Larsen, P.R. Effect of the environment on the percentage of summer wood and specific gravity of slash pine. 1957.
- Mergen, F., Hoekstra, P.E., and Echols, R.M. Genetic control of oleoresin yield and viscosity in slash pine. Forest Science, Vol. 1, No. 1, pp. 19-30. 1955.
- Mitchell, H.L. Wood quality evaluation from increment cores. Tappi, Vol. 41(4), pp. 150-155.
- Perry, T.O. and Wang, C.W. Variation in the specific gravity of slash pine wood and its genetic and silvicultural implications. Tappi, Vol. 41(4), pp. 178-180.
- Spurr, S.H. and Hsuing, W.Y. Growth rate and specific gravity in conifers. Jour. Forestry, Vol. 52: 191-199. 1954.
- Zobel, B.J. and Rhodes, R.R. Relationship of wood specific gravity in loblolly pine to growth and environmental factors. Technical Report No. 11, Texas Forest Service. 1955.
- mature loblolly pine from juvenile wood and seedling limb sections. Forest Science, Vol. 2, No. 2, pp. 107-112. 1956.
- breeding loblolly pine. Forest Science, Vol. 3, No. 3, pp. 281-285. Sept., 1957.
- Zobel, B.J. Inheritance of wood properties in pine. Proceeding of 4th Southern Forest Tree Improvement Conference, pp. 27-29, 1957.
- Zobel, B.J. and McElwee, R.L. Variation of cellulose in loblolly pine. Tappi, Vol. 41(4), pp. 167-170. 1958.

## THOUGHTS ON WOOD DENSITY

### by

## M. J. Holst

I have followed with great interest the intensive wood density studies of the southern pines, notably the pioneering work reported by Zobel and Mitchell. Mitchell has often emphasized the fact that a 50 per cent change in the specific gravity of a stand of timber has essentially the same effect on fibre yields as an equivalent change in growth rate. And what tree breeder would not like to produce a 50 per cent increase in yield?

It is likely that an increase can be produced by selection, but I believe that a 50 per cent increase is too high a target. Combination of high volume growth with high wood densities is possible in single trees, but this does not necessarily imply equivalent increases in production of the whole stand. Factors of production soil, water and heat - may be limiting. A particular forest site can probably yield only a fixed amount of solid matter of a specific species. The limits of variation in total production per unit area might be as low as ±10 per cent of the mean. If this is so, it must be decided whether to produce a high volume of low density wood, or a lower volume of high density wood.

Klem's investigation of Norwegian and German Norway spruce both grown in Norway give us some indication of the target possible in spruce. For the same ring width, the German spruce has a higher specific gravity than Norwegian spruce. This results in higher yield of cellulose. The difference is about 8 per cent. As the German Norway spruce is growing faster than the Norwegian Norway spruce, the German provenances in terms of tons of cellulose per hectare can produce 20 to 25 per cent more than the Norwegian Norway spruce.

This example illustrates that both increased volume production and wood density may be achieved.

Undoubtedly the selection of trees of high wood density would be of great importance to our wood-using industries which are mainly pulp mills. The reasons why a greater effort has not been made in this direction are the following:

- 1) Selection has been for growth and good form only. As the high density trees occur at random in the population, some of the selected trees will also be high density trees. This can be tested under uniform growing conditions at the tree breeding stations.
- 2) Neither facilities nor staff are available to carry out special selections for high wood density.
- 3) A good, fool-proof technique has not been found for estimating wood density in the virgin forest where differences in growth rhythm, age, growth rate, and site make highly specialized preliminary studies necessary before direct comparison of the selections can be made.

- 4) Practically nothing is known about the variation of wood density of individual trees in the wild populations.
- 5) I think that wood density studies should be confined to the plantations of our single tree progeny tests.

It will be some years before these are old enough to provide suitable material for study. However, a small start has been made. With the help of Norman Jones of the University of New Brunswick, I am investigating the wood density of thirteen 18-year-old white spruce provenances grown in the Petawawa and Acadian Forest Experiment Stations. The study also includes comparison of stem wood and branch wood.

The study is not yet completed. However, preliminary results indicate that the Kananaskis provenance has a consistently high wood density while the Lake Edward provenance a consistently low wood density. The Petawawa provenance showed the greatest variability.

The range in wood density found for stem wood of the eighth internode is as follows:

# Wood Density

| Mean<br>High<br>Low | 0.376<br>0.538<br>0.310 | (Kananaskis, Alberta)<br>(Lake Edward, P. O.) |
|---------------------|-------------------------|---|
| Range               | 0.228                   | (Lake Edward, F. W.)                          |

The difference in wood density between the mean and the highest is about 43 per cent. This does not mean that wood density and solid matter production can be increased by 43 per cent. Unfortunately the growth rate of the Kananaskis provenance is only about 60 per cent of that of the local white spruce. It is therefore impossible at present to make an intelligent guess of how much of an improvement in dry matter production can be made by selection for high wood density because both growth rate and wood density must be considered.

The values above for wood density in white spruce are for the central core of low density juvenile wood. The period in which low density juvenile wood is formed is about 10 years for southern pine and about 30 years for plantation grown Douglas fir (in England). What this period may be for plantation grown white spruce has not yet been determined.