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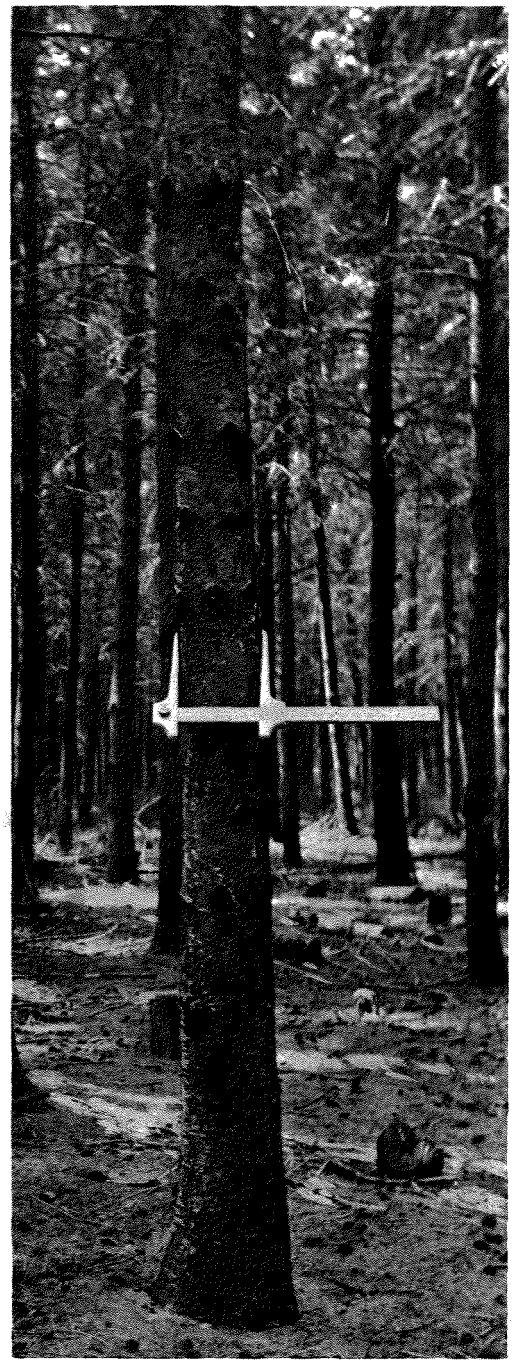
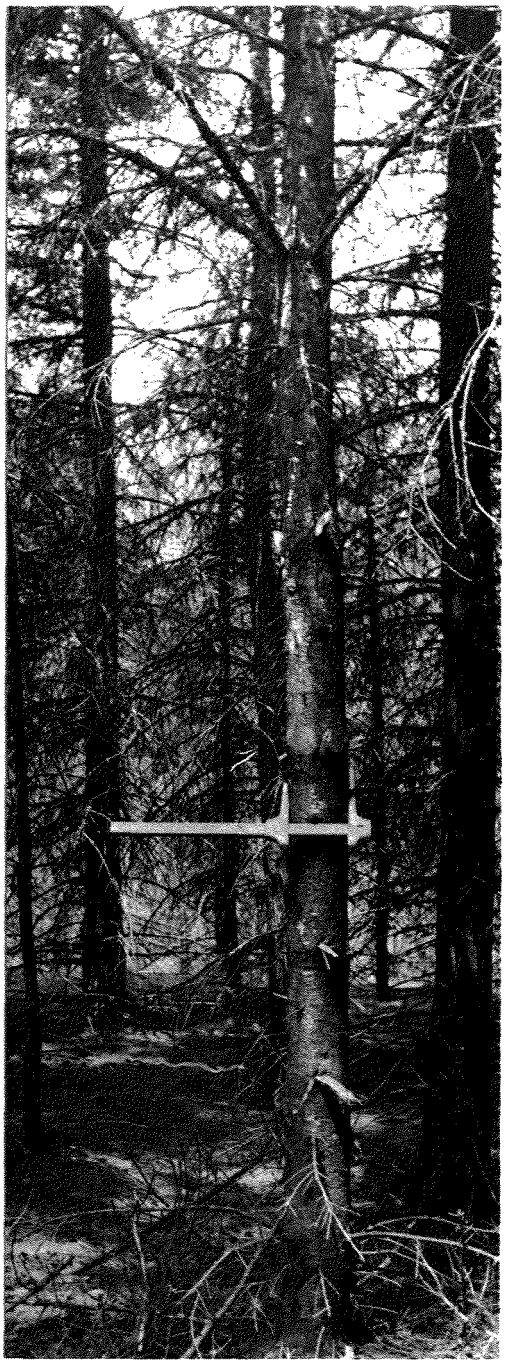
# Review of

# FOREST FERTILIZATION IN CANADA





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# A Review of

# Forest Fertilization in Canada

*COVER PICTURE*

*Left - White spruce manured plot, 30 tons per acre. Marked tree is 6 inches d.b.h. Trees have been pruned and light thinnings of suppressed trees have been made. Total volume in 1956, 2,420 cu. ft.; average height, 40 ft. Planted 1920, photographed 1957.*

*Right - White spruce control plot, untreated. Marked tree is 4 inches d.b.h. Photograph taken in the best part of the plot.*

# CONTENTS

# FOREWORD

In 1965-66 Professor K.A. Armson, University of Toronto, undertook a survey of forest fertilization in Canada on behalf of the Department of Forestry. This report summarizes his findings.

As a first attempt to survey current and recent fertilization work, the record is not complete. However, the intention is to expand it and update it periodically, providing an index which should be of continuing use to forest land managers and research workers.

Grateful acknowledgement is made of the assistance from foresters in the various government departments, industry and the universities who so kindly provided information on forest fertilization studies. Their co-operation made the review possible.

# INTRODUCTION

Problems of soil amelioration by fertilization in tree nursery, plantation and managed wild stand are increasingly attracting the attention of foresters. In recent years many trials and experiments have been established by various agencies to test the effects of forest fertilization, but for the most part such work has not been reported. It was therefore considered useful to attempt a summarization of projects and results, making available information in an important and rapidly developing field.

Questionnaires were sent out to the various agencies and workers known to be studying forest fertilization. Information was requested on all past and present tests and research work in plantations and forest stands in Canada, and on fertility trials in nurseries since 1960. The response was good, and the coverage of the report is extensive though by no means complete.

The information for each reported project has been arranged on one page under headings which give the name of the species, the location, the region, objective of study, the soil, methods of the trial or experiment, the name of the sponsoring organization, and the personnel involved. On the reverse side of the page may be found a summary of results to date, plus publications which provide more detailed reports. Each one-page project summary is numbered in the upper right hand corner for ease of locating by reference to either of the following indices: Project Studies by Species (p. vii), or Project Studies by Provinces and Type of Stand (p. ix).

A short commentary on the results of the survey concludes the report, and a conversion table to facilitate comparison of different fertilizer formulations is appended (p. 175).

# PROJECT STUDIES BY SPECIES

| Species | Study Number |
|---|---|
| Pinus strobus L.<br>eastern white pine | 41,42,65 |
| Pinus monticola Dougl.<br>western white pine | 11 |
| Pinus resinosa Ait.<br>red pine | 40,43,47,49,51,54,58,59,60,63,65,70,<br>71,72,79,80,83 — 17 |
| Pinus banksiana Lamb.<br>jack pine | 13,22,23,26,27,28,47,48,51 — 9 |
| Pinus contorta Dougl. var latifolia Engelm.<br>lodgepole pine | 6,12,31,62,67 — 5 |
| Larix decidua Mill.<br>European larch | 28 |
| Picea glauca (Moench) Voss.<br>white spruce | 22,23,24,25,28,38,39,42,43,45,46,52,<br>53,55,56,57,61,63,64,65,66,70,71,72,<br>73,81,82 — 27 |
| Picea mariana (Mill.) B.S.P.<br>black spruce | 14,15,16,17,18,19,20,21,28,29,30,32,<br>50,51,53,55 — 16 |
| Picea rubens Sarg.<br>red spruce | 28 |
| Picea abies (L.) Karst.<br>Norway spruce | 28,47,66 |
| Tsuga heterophylla (Raf.) Sarg.<br>western hemlock | 11 |
| Pseudotsuga menziesii (Mirb.) Franco<br>Douglas fir | 1,2,3,4,5,7,8,9,10,11,33,34,35,36,37,<br>68,69,75,76,77,78,84,85 — 23 |
| Populus eugenii Simon-Louis<br>Carolina poplar | 74 |
| Populus nigra x P. deltoides<br>Raverdeau poplar | 74 |
| Acer saccharinum L.<br>Silver maple | 70 |
| Tilia americana L.<br>basswood | 70 |
| Fraxinus americana L.<br>white ash | 70 |

Spruce 43
fir
J x L pines 14
hemlock 1
cedar
D fir 23

# PROJECT STUDIES
# BY PROVINCES AND TYPE OF STAND

| Province | Seed and Cone Production | Nursery Seedbeds | Plantations at time of Establishment | Established Stands |
|---|---|---|---|---|
| | 14 | 15 Type of Stand 23 | | 33 |
| British Columbia | 1,4,7,10,33,<br>34,35,36,37,<br>68 | 75,76,77,<br>78,84,85 | 2,3,8,9,28 | 5,6,11,69 |
| Alberta | - | - | 38 | 12,31,67 |
| Saskatchewan | - | 39 | - | - |
| Manitoba | 40 | - | - | - |
| Ontario | 14,71,79 | 43,44,45,<br>72,73,81,<br>83 | 15,16,17,18,<br>19,28,41,46,<br>82 42 | 13,20,21,22,<br>23,24,25,26,<br>30,57,58,59,<br>60,61,80 |
| Quebec | - | 50 | 28,29,51,52,<br>56,63,74 | 24 26 27<br>29,32,47,48,<br>49,53,54,55,<br>62,64,65,66 |
| New Brunswick | - | - | 28 | - |
| | 7 | 4 | 7 | 6 |

# FOREST FERTILIZATION SUMMARIES

Species: Douglas fir, 130-150 year age class. Site Index 140.

Location: Near the mouth of the Gold River at the head of Machalat Inlet on the west side of Vancouver Island, British Columbia.

Region: Insular mountain physiographic division: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine how the application of fertilizers affects cone and subsequent seed production of plus trees, and also its effect on the chemical composition of the foliage.

Soil: The soils apparently belong to the Acid Brown Wooded group; the parent material is a compact coarse-textured till.

Methods: Twenty-six trees were selected for treatment. Ammonium phosphate sulphate was applied by hand to a circular area of ground below each tree. The diameter of the circle was approximately 1-1/2 times the diameter of the crown.

In April 1961, each tree was treated with 80 pounds of 16-20-0 fertilizer; in April 1962, 40 pounds of the same fertilizer were applied and in April 1963, 80 pounds were applied. At the 80 pounds rate of application, each tree received 12.8 pounds of N, 8.7 pounds of P, and 11.2 pounds of S.

In September 1962, five of the fertilized trees and five unfertilized adjacent trees were felled for cone and seed collection.

In April 1963, prior to fertilization, shoots of 1961, 1962, and 1963 growth were sampled from the upper one-third of the crowns of two fertilized and two unfertilized trees. The foliage from each year's growth was dried and weighed; nitrogen, phosphorus, potassium, calcium, magnesium and sulphur determinations were made on samples of the foliage.

Sponsoring Organization(s): Tahsis Company Limited, Gold River Logging, Gold River, British Columbia.
Consolidated Mining and Smelting Company of Canada, Trail, British Columbia.

Personnel: R. Kosick and J.D. Beaton.

Summary: A fertilizer study was begun in 1961 in a stand of 130-150 year old Douglas fir of Site Index 140 to determine the effects of ammonium phosphate sulphate on cone and seed production. A subsidiary study was also made of the effects on foliage nutrient content. Twenty-six selected plus trees were fertilized.

By 1963, measurements from five fertilized and five unfertilized trees indicated that numbers of cones, cone size, numbers of seeds, 1,000 seeds' weight and seed germination rates were all significantly increased by fertilization.

Shoots of 1960, 1961, and 1962, growth were sampled prior to fertilization in April, 1963. Fertilization had increased the length of the 1962 shoots and weight of the 1962 needles. Both concentration and content of nitrogen in the foliage were increased, particularly in the 1962 growth. Phosphorus concentrations were slightly reduced, but content was increased in the 1962 needles of the fertilized trees. N/P ratios were greater in all foliage from the fertilized trees than in the foliage of the unfertilized trees. Potassium concentrations were reduced in foliage from fertilized trees but content was not affected. Concentrations and contents of calcium, magnesium and sulphur were higher in the foliage from fertilized trees.

Publication: 1964 - Beaton, J.D., Kosick, R. and Speer, R.C. Chemical composition of foliage from fertilized plus Douglas-fir trees and adjacent unfertilized check trees. Soil Sci. Soc. Amer. Proc. 28:3, 445-449.

Species: Douglas fir, two-year-old seedlings.

Location: Gold River, Vancouver Island, British Columbia.

Region: Insular mountain physiographic division; Southern Pacific Coast Section, Coastal Forest Region.

Objective of Study: To determine if fertilizers, placed in the planting hole with Douglas fir seedlings, would eliminate "planting check".

Methods: The fertilizer materials used in this study were finely-divided oxamide, 8-24-0 sludge, aqua humus, thiourea, magamp, urea and bark product. All materials, except bark products, were applied at time of planting in 1963 at the rates of 2.5, 5.0 and 10 grams of nitrogen per planting hole. Bark product was supplied at rates equivalent to 2.0, 4.0 and 8.0 grams of $P_2O_5$ per hole.

Observations on rates of growth and survival of seedlings were made in July, 1963.

In 1964, the following materials were placed at rates of 2.5, 5.0 and 10 grams of nitrogen per planting hole, immediately before planting of 2-year seedlings:

(a) Magamp ($MgNH_4PO_4H_2O$) normal particle size range,
(b) Magamp - 6 plus 8 mesh,
(c) Magamp - 8 plus 10 mesh,
(d) 8-24-0 sludge - 8 plus 14 mesh,
(e) Thiourea - 4 plus 6 mesh,
(f) Uramite - normal particle size range.

A further study was conducted in 1965, when three fertilizers - Magamp 6 plus 8 mesh, nitrogen enriched coal, and nitrogen enriched humic acid derivative were applied separately to 2-year seedlings at time of planting. Three rates of application of each fertilizer were used, equivalent to 1.25, 2.5 and 5.0 grams of nitrogen per seedling.

Sponsoring Organizations: Tahsis Company Limited, Gold River Logging, Gold River, British Columbia.
Consolidated Mining and Smelting Company of Canada, Trail, British Columbia.

Personnel: J.D. Beaton and R. Kosick.

Summary: A series of fertilizer studies were begun in 1963 involving the addition of nitrogen and phosphorus to the planting holes at time of planting of 2-year-old Douglas fir seedlings. The object of the additions was to reduce or eliminate "planting check" in these seedlings.

An assessment of the 1963 treatments indicated that by July 1963 all materials significantly reduced the rate of survival. Magamp, at all rates, appeared to have a less deleterious effect than the other materials. It was suggested that a 2- to 3-inch barrier of soil between the seedling roots and the fertilizer would be more successful.

Species: Douglas fir, 2- and 3-year-old seedlings.

Location: University of British Columbia Nursery and University of British Columbia Forest, Haney, British Columbia.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effect of slowly soluble fertilizers placed in the planting hole or mixed with soil at the time of outplanting on the growth of Douglas fir seedlings.

Methods: Seven fertilizers were used - Aqua humus, 8-24-0 sludge, magamp, oxamide, urea, thiourea and bark product. All fertilizers except the bark product were applied randomly at three levels equivalent to 2.5, 5.0 and 10.0 grams of nitrogen in a split plot design. The fertilizers were dumped out of bags into the bottom of the planting hole or mixed into the soil in which the tree was planted. The bark product was applied at two rates, equivalent to 2 and 4 grams of $P_2O_5$ per planting hole.

The basic unit of replication was four seedlings (one 2-year-old seedling from Green Timbers Nursery and one each of small, medium and large classes of 3-year-old seedlings from the U.B.C. campus nursery).

One set of experimental plots was located at the U.B.C. Forest Nursery and one each on TS 3 and TS 32b. At each location two blocks were planted; each block was 10 seedlings wide and 24 seedlings long. The outside rows were planted with the 2-year-old seedlings from Green Timbers. Each row of seedlings contained one level of fertilizer of one kind with one side a mixture of fertilizer and soil in the planting hole and the other side unmixed for a total of eight fertilized and three control seedlings.

The experiment was begun in April 1963. At time of planting the seedlings were partially flushed. A long drought occurred in May. In the fall of 1963, all dead seedlings were replaced by 2-year-old seedlings from Green Timbers in order to test for persistence of the fertilizers.

In 1964, the six fertilizers:

(a) Magamp ($MgNH_4PO_4 \cdot H_2O$) normal particle size range,
(b) Magamp - 6 + 8 mesh particles,
(c) Magamp - 8 + 10 mesh particles,
(d) 8-24-0 - 8 + 14 mesh particles,
(e) Thiourea - 4 + 6 mesh particles,
(f) Uramite - normal particle size range,

were used in a second experiment to determine their effects on the growth of 2-year-old seedlings from the U.B.C. nursery.

The fertilizers at rates of 2.5, 5.0 and 10.0 grams of nitrogen were placed in the planting holes immediately before planting.

Sponsoring Organizations: Faculty of Forestry, University of British Columbia, Vancouver 8, British Columbia.
Consolidated Mining and Smelting Company of Canada, Trail, British Columbia.

Personnel: J.H.G. Smith and J.D. Beaton.

Summary: A fertilizer study was begun in 1963 to investigate the results of applying various nitrogen and phosphorus fertilizers to the planting holes at the time of outplanting Douglas fir seedlings. Two methods of application were used, one in which the fertilizer was placed in the hole and a second in which the fertilizer was mixed with soil in the planting hole.

A survival count in the third week of July (after planting in April) gave the following results (mortality expressed as seedlings dead out of groups of four planted):
Control 0.50, Aqua humus 3.4, sludge 2.9, magamp 2.1, oxamide 2.4, urea 3.6, thiourea 3.7, and bark 1.9. Mortality was similar at all three locations (U.B.C. nursery and two locations on U.B.C. Forest at Haney). Mortality increased significantly with rate of fertilizer application from 2.2 at the low rate to 2.5 at the middle rate to 2.9 at the high rate. Thus, at the high level of application, nearly 75 percent of the seedlings were killed.

Species: Douglas fir, 20-32 years old.

Location: University of British Columbia Forest, Haney, British Columbia.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To increase the cone production on Douglas fir trees by using fertilizer.

Methods: Since 1957, Professor Griffiths has been making phenological observations and studying the cone yield of selected trees at the U.B.C. Forest. In May 1963, a nitrogen fertilizer was applied to five trees, chosen randomly from each of the 10 worst, 10 best, 10 lower quartile, 10 upper quartile, and 10 average cone producers. In addition, 10 average cone bearers were selected for fertilization in 1963 only.

Nitrogen was applied as nitraprills (33.5-0-0) at five levels in the following manner:

(1) 200 pounds per acre of nitrogen on east and west tree quadrants.
(2) 400 pounds per acre of nitrogen on east and west tree quadrants.
(3) 200 pounds per acre of nitrogen on east, west, north and south quadrants.
(4) 200 pounds per acre of nitrogen on the east quadrant and 600 pounds per acre on the west quadrant.
(5) 400 pounds per acre on the east quadrant and 800 pounds per acre on the west quadrant.

Competing shrub vegetation on the area was cut prior to fertilizer applications. The quadrant areas were based on the average crown radius in the quadrant plus an allowance of 2 feet. The fertilizer was broadcast evenly over the quadrant areas. Treatments were applied in the order of bud flushing.

In 1964, all five tree groups were re-fertilized and, in addition, a new group of 10 average cone producers were treated.

Foliage was collected from low, middle and high crown positions of the 10 best and 10 worst cone producers in February and October 1963. This sampling procedure was repeated in February 1964.

Sponsoring Organizations: Faculty of Forestry, University of British Columbia, Vancouver 8, British Columbia.
Consolidated Mining and Smelting Company of Canada Ltd., Trail, British Columbia.

Personnel: B. Griffith, A. Kozak, J.H.G. Smith, and S.D. Beaton.

Summary: In 1963, a fertilizer study, using nitrogen (nitraprills - 33.5-0-0), was begun on Douglas fir trees whose flower and cone producing history had been recorded for the previous 5 years. Five levels of fertilizer were applied, based on amount of nitrogen and proportion of ground area under the tree crown treated.

Foliage samples were taken for analysis from low, mid and high crown positions of the 10 worst and 10 best cone producers. Sampling was done in February and October 1963, and February 1964.

1963 diameter growth was not influenced by fertilization made in May 1963. In October 1963, no influence of fertilization in the production of female cone buds was noticeable.

From the results of the analyses of foliage from the 10 worst and 10 best cone producers, it was concluded that the nitrogen concentrations were significantly higher in the best cone producers than in the worst cone producers, but there was no significant difference in concentrations between fertilized and unfertilized trees.

In the foliage sampled in February 1963, phosphorus concentrations were lower in the best cone producers than in the worst cone producers, whereas the calcium concentrations were higher in the best cone producers. Position, within the crown, had a significant effect on the concentration of phosphorus, potassium, calcium and sulphur.

In the October 1963 foliage, calcium, magnesium and potassium concentrations were again influenced by position within the crown. Foliage of the best cone producers had significantly higher concentrations of calcium and lower concentrations of magnesium than that from the worst cone producers.

Foliage sampled in February 1964, showed higher nitrogen concentrations in the best cone producers than in the worst cone producers, but magnesium concentrations were lower. All nutrients, except nitrogen, showed an influence of crown position on foliage concentrations.

Species: Douglas fir, 13-49 years old.

Locations: Port Alberni, Duncan, Paldi, Lake Cowichan, and Roach Logging, Vancouver Island, British Columbia.

Region : Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To study the effect of aerial application of fertilizers on Douglas fir and the associated soils. More specifically;

a) To determine chemical characteristics of the soils occurring in three of the fertilizer trial areas (Port Alberni, Duncan, and Roach Logging).
b) To determine the extent of movement of nitrogen from a urea fertilizer into the soil.
c) To determine the effect of fertilizer on nitrogen levels in Douglas fir and Salal foliage.
d) To determine the ranges of concentrations of nitrogen, phosphorus, potassium, calcium and magnesium and sulphur in Douglas fir foliage and the influence of fertilization on these ranges.

Soils: Port Alberni - a) Stamp gravelly loam - Concretionary Brown.
b) Sproat gravelly sandy loam - Concretionary Brown.
Duncan - probably related to Shawnigan gravelly sandy loam - Acid Brown Wooded to degraded Acid Brown Wooded.
Roach Logging - probably related to Shawnigan gravelly sandy loam - Acid Brown Wooded.

Methods: Urea, ammonium sulphate and concentrated superphosphate fertilizers were applied aerially, May-June 1963. The urea was applied at two levels, 100 and 200 pounds of nitrogen per acre in strips 330 feet wide and 2640 feet long, strips were 660 feet apart. Ammonium sulphate and superphosphate were applied in strips 264 feet wide and 792 feet apart, at right angles to, and across the urea strips. The rate of application of ammonium sulphate was 100 pounds of nitrogen per acre, and superphosphate, 100 pounds of $P_2O_5$ per acre.

At Port Alberni, a series of 1/5 acre plots were laid out in fertilized and unfertilized areas. At all other locations 1/10 acre plots were used. The total number of plots was 188. At Port Alberni and Roach sites, soil and foliage samples were obtained from three plots in each of the control, 100 lb/acre N-urea, and 200 lb/acre N-urea treatments. Only one plot of each treatment was sampled at Duncan. These samples were taken in October 1963.

Soil samples were air-dried, sieved and the minus 20 fraction analysed for pH, organic matter, total nitrogen, potentially available nitrogen, phosphorus (sodium bicarbonate or Bray No. 1), non-exchangeable potassium, cation exchange capacity and exchangeable cations.

Foliage samples of current and two years' growth were taken from the upper crown of at least one Douglas fir, adjacent to each soil sampling pit. Where Salal was an important part of the ground cover, leaf and stem samples were also taken.

A series of Douglas fir foliage samples taken from trees in the Duncan and Lake Cowichan areas were analysed for minor elements (boron, chlorine, cobalt, copper, iron, manganese, molybdenum and zinc).

Sponsoring Organizations: Consolidated Mining and Smelting Company of Canada, Trail, British Columbia.
Pacific Logging Company, Victoria, British Columbia.

Personnel: J.D. Beaton and R.C. Speer. Employees of Pacific Logging Company.

Summary: In 1963, aerial application of urea, ammonium sulphate and concentrated superphosphate fertilizers was made on stands of Douglas fir, ranging in age from 13 to 49 years. Levels of nitrogen, as urea, were 100 and 200 pounds per acre and as ammonium sulphate, 100 pounds per acre. Superphosphate was applied at a rate of 100 pounds of $P_2O_5$ per acre.

At three locations, soil samples and foliage samples of Douglas fir and salal were taken for analysis. The main purposes of this sampling were to investigate the levels of nutrients in the foliage, the effect of fertilization on these levels and the movement of urea nitrogen in the soil.

It was found that the total nitrogen contents of the organic horizons at Port Alberni, Duncan and Roach areas were higher in the fertilized than the unfertilized plots. At Roach, total nitrogen was increased at both 0 to 6-inch and 6 to 12-inch depth, whereas at Port Alberni and Duncan, most of the applied nitrogen was retained in the organic horizons.

Duncan soils were higher in available phosphorus than those at Port Alberni, but Port Alberni mineral horizons were higher in exchange potassium and magnesium. Non-exchangeable potassium levels were higher at Duncan than at the two other areas.

At Duncan, the nitrogen concentrations in current foliage of Douglas fir were slightly higher in trees treated with urea than in controls.

Nitrogen fertilization significantly increased nitrogen concentrations and decreased sulphur concentrations in Douglas fir at Port Alberni.

At Roach, urea applications resulted in significant increases in foliage concentrations of nitrogen, potassium and sulphur. Calcium concentrations were decreased by fertilization.

STUDY NO. 6

Species: Lodgepole pine - 40 years old.

Location: Bear Lake, Powers Creek.

Region: Montane Forest Region.

Objective of Study: To determine the effect of fertilizer application on thinned stands; in particular, to increase the diameter growth of residual trees in order to increase the merchantable value.

Methods: In November 1963, branches carrying current (1963) 1- and 2-year-old foliage were taken from the crowns of 72 lodgepole pine trees, felled during a stand thinning. The spacing of the residual trees was approximately 12 x 12 feet.

In May 1964, fertilizer treatments were applied as set out below:

| | Rate of Application - pounds per acre | | | | | |
|---|---|---|---|---|---|---|
| Treatments | N | $P_2O_5$ | $K_2O$ | S | B | Minor elements mix |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 100 | 120 | 80 | 0 | 1 | to be added |
| 3 | 50 | 120 | 80 | 0 | 1 | to be added |
| 4 | 100 | 0 | 80 | 0 | 1 | to be added |
| 5 | 100 | 120 | 0 | 0 | 1 | to be added |
| 6 | 100 | 120 | 80 | 0 | 0 | to be added |
| 7 | 0 | 120 | 80 | 0 | 1 | to be added |
| 8 | 100 | 120 | 80 | 0 | 1 | to be omitted |
| 9 | 100 | 120 | 80 | 20 | 1 | to be omitted |

Fertilizer materials used were: urea, ammonium sulphate, triple superphosphate, potassium chloride, solubor, and a minor element mix (magnesium sulphate, calcium sulphate, cobalt sulphate, zinc sulphate, manganese sulphate and sodium molybdate).

In May 1964, foliage from 108 trees in this experiment was sampled prior to fertilization and analysed for nitrogen, potassium, phosphorus, calcium, magnesium and sulphur. In 1965, foliage from the same 108 trees was sampled for analysis again.

Sponsoring Organizations: S.M. Simpson Limited, Kelowna, British Columbia. Consolidated Mining and Smelting Company of Canada Limited, Trail, British Columbia.

Personnel: A. Moss, J.D. Beaton.

Summary: In 1964, a series of fertilizer applications involving additions of nitrogen, phosphorus, potassium, sulphur, calcium, boron, magnesium, cobalt, zinc, manganese, sodium and molybdenum were made to a 40-year-old stand of lodgepole pine which had been thinned in 1963 to a 12 x 12 spacing.

The purpose of the study was to increase diameter growth of the residual trees.

Foliage samples were taken in May 1964, prior to fertilization and again in 1965.

Species: Douglas fir - planted 1953, 1956 and 1959.

Location: University of British Columbia Forest, Haney, British Columbia.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the influence of fertilization on the age at which planted Douglas fir will begin cone production.

Methods: Nitrogen as nitraprills (33.5-0-0) was applied to 100 trees in each of 1956 and 1959 plantations on TS3 and to 50 trees each in 1953 and 1956 plantations north of Spur 17. Fertilizer was applied on quadrants of the projected crown area in the following manner:

Treatment 1 - 200 pounds of nitrogen per acre on east and west quadrants.
Treatment 2 - 400 pounds of nitrogen per acre on east and west quadrants.
Treatment 3 - 200 pounds of nitrogen per acre on east, west, north and south quadrants.
Treatment 4 - 200 pounds of nitrogen per acre on east quadrants and 600 pounds of nitrogen per acre on west quadrants.
Treatment 5 - 400 pounds of nitrogen per acre on east quadrants and 800 pounds of nitrogen per acre on west quadrants.

Controls were established for each plot, data on competitive trees were recorded and complete measurements of all pertinent tree characteristics were made at the time of fertilization in May 1963. Fertilization is to be repeated in 1964, and possibly for three more seasons.

Sponsoring Organization: Faculty of Forestry, University of British Columbia, Vancouver 8, British Columbia.

Personnel: J.H.G. Smith, J. Walters.

Summary: In May 1963, nitrogen fertilizer as nitroprills (33.5-0-0) was applied to Douglas fir planted in 1953, 1956 and 1959. Five different treatments were made involving amount of fertilizer and ground area under the tree crown covered. Fertilizer additions are to be repeated during four subsequent years.

In 1963, leader growth, as measured in September 1963, was not found to be affected by fertilizer applications.

Species: Douglas fir - 2 years old.

Location: Bear Creek, Renfrew, Vancouver Island.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effect of fertilizer at time of planting on the survival and growth of Douglas fir.

Soil: Gravelly and sandy, some rock.

Methods: Ammonium sulphate (21-0-0), ammonium phosphate nitrate (27-14-0) and ammonium nitrate (33.5-0-0) fertilizers were applied at the time of planting to 2-year seedlings of Douglas fir in October 1958.

For the ammonium sulphate and ammonium phosphate nitrate each treatment plot consisted of 49 trees at a 7 x 7 foot spacing. In addition to the control, treatments consisted of 2, 4 and 6 ounces of fertilizer per tree and an additional treatment of 2 ounces applied to the root system.

Using ammonium nitrate, the applications were 2 and 4 ounces per tree with the same number of trees (49) and spacing as for the other fertilizers. All fertilizers were applied dry.

The competing vegetation on the planting site was light and the site had been well-burned, 1951-53.

The height of each seedling was measured at time of planting.

In 1959, a preliminary examination of survival and growth was made, and in 1962 a final assessment of the project was completed.

Sponsoring Organization: British Columbia Forest Products Limited, Vancouver, British Columbia.

Personnel: W.G. Burch.

Summary: In October 1958, a fertilizer trial was set out in 2-year-old Douglas fir at time of planting. Ammonium sulphate and ammonium phosphate nitrate were applied at three rates to each tree, 2, 4 and 6 ounces per tree and at a rate of 2 ounces to the roots. Ammonium nitrate was applied at two rates - 2 and 4 ounces per tree.

A preliminary examination in 1959 showed that direct application of fertilizer to the root system caused mortality, that increased mortality occurred in all fertilizer plots as compared with controls, but growth of surviving trees on fertilizer plots was generally greater than on controls. Generally, plots treated with ammonium phosphate nitrate had slightly lower mortality and greater growth than other treatments. The greatest mortality and least growth occurred on trees treated with 4 ounces of ammonium nitrate.

Measurements made in 1962 confirmed the observations of 1959. No advantage has been realized by the use of these fertilizers. Maximum height growth occurred on trees treated with 4 ounces of ammonium phosphate nitrate and this growth was only 1 inch per year greater than that of the controls.

Species: Douglas fir - 1- and 2-years old, and a 3-year-old plantation; grand fir - 2-year-old.

Location: Nitinat Area, Block 109 and Wilson Creek Area, Cowichan, Vancouver Island.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To study the effect of fertilizers on seedlings of different ages and on different sites with a view to increasing survival and growth.

Methods: "Tree feed pellets" - urea formaldehyde resin and superphosphate (24% nitrogen, 6% phosphorus) were applied to the roots of 1- and 2-year-old Douglas fir and 2-year-old grand fir at the time of planting in May 1959. The areas planted represented different cover conditions, ranging from heavy bracken to heavy slash debris and salmonberry.

At Wilson Creek, ammonium phosphate nitrate was applied to trees 3 years after planting at the rate of 3 ounces per tree.

Sponsoring Organization: British Columbia Forest Products Limited, Vancouver, British Columbia.

Personnel: W.G. Burch.

Summary: In May 1959, "Tree feed pellets" were applied to 1- and 2-year-old Douglas fir, and 2-year-old grand fir at time of planting. In addition, ammonium phosphate nitrate was applied to a 3-year-old Douglas fir plantation at the rate of 3 ounces per tree.

At the end of the first growing season, greater mortality was shown on the fertilized plots, but the experimental plots were also subject to flooding. Growth rate of surviving trees in the fertilized plots was greater than that of the control. Douglas fir showed somewhat greater mortality than the grand fir, particularly the 1-year-old Douglas fir.

The application of ammonium phosphate nitrate gave promising results.

In 1962, it was concluded that growth of fertilized trees was not significantly increased. Fertilizer had increased mortality. It was noted that trees which were shorter than average at time of planting sustained the greatest mortality in the first and second growing seasons.

Species: Douglas fir.

Location: Block 1053, Cowichan Division, Vancouver Island.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To increase cone and seed production in Douglas fir.

Methods: Ammonium nitrate (33.5-0-0) was applied at the rate of 400 pounds per acre to a seed production area in April 1959. In September of the same year, 90 trees were topped 22 feet above ground level.

In May 1960, 400 pounds per acre of ammonium nitrate was applied. The trees were thinned to a 20 x 20 foot spacing. In 1961, a further application of ammonium nitrate was made to half of the seed production area. In May 1962, the area was treated with 800 pounds of ammonium nitrate and an insecticide, Guthion, was applied to control damage by cone midge. In May 1963, at the beginning of flushing, a further 800 pounds of ammonium nitrate was applied. No fertilizer was applied in 1964.

Sponsoring Organization: British Columbia Forest Products Limited, Vancouver, British Columbia.

Personnel: W.G. Burch.

Summary: Beginning in April 1959, ammonium nitrate (33.5-0-0) was applied to Douglas fir in a seed production area to stimulate increased cone and seed production. Further additions of ammonium nitrate were applied in 1960, 1961, 1962 and 1963 at a rate of 400 pounds per acre (1960) and 800 pounds per acre (1962 and 1963).

Although a good cone crop was evident by 1961, few seeds were present due to poor pollination conditions and cone insects. In subsequent years, although good cone crops occurred, little seed was obtained due to loss to insects and squirrels. In 1964, some trees showed die-back and others were dead - this was attributed to fertilizer injury.

I9 on map

STUDY NO. 11

Species: Douglas fir, 55 years old, with some western hemlock and western white pine.

Location: Koksilah Division, Vancouver Island.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effectiveness of a fertilizer application to a stagnated immature stand with a view to increasing growth of dominant trees.

Soils: Porous, fairly deep glacial till. The area has had several fires in the last few hundred years.

Methods: Broadcast application of ammonium nitrate (33.5-0-0) was carried out in May 1961, at a rate of 200 pounds of fertilizer per acre. Plot size was 1/10 acre and a total of four plots were treated; an additional four plots were left as controls. A minimum of 15 dominant trees per plot were measured for dbh and height. The stand averaged 2000 stems per acre, with an average dbh of 4 inches and height of 27 feet. Annual precipitation is approximately 30 inches with only 3 to 5 inches during the growing season.

Sponsoring Organization: British Columbia Forest Products Limited, Vancouver, British Columbia.

Personnel: W.G. Burch.

Summary: In May 1961, ammonium nitrate (33.5-0-0) was applied at the rate of 200 pounds of fertilizer per acre to a 55-year-old stand of stagnating Douglas fir, western hemlock and western white pine. The purpose was to increase the growth of dominant Douglas fir in the stand.

A visual examination in 1962 showed no colour differences or noticeable leader lengths between fertilized and control trees. In October 1963, the trees were remeasured and although there was some variation between plots, the average diameter and height growth over the three growing seasons since treatment was greater for the fertilized than the unfertilized trees.

Species: Lodgepole pine, 90 years old.

Location: McLeod Working Circle, Hinton, Alberta.

Region: East Slope Rockies Section, Subalpine Forest Region.

Objective of Study: To determine the growth response in an older stand of lodgepole pine to nitrogenous and mixed fertilizer additions.

Soil: Well-drained, stony loam till.

Methods: The experiment was set out in June 1964. Two sets of paired plots were established to compensate for differences in topography. In each set of plots, one plot and its surround were treated with fertilizer and the other was left as a control; each plot was 1/5 acre in extent.

One treatment plot received ammonium nitrate (33.5-0-0) at the rates of 150 lb/acre or 50 lb/acre of nitrogen. The other treatment plot received 385 lb/acre of 13-13-13, which contained 50 lb/acre of nitrogen. Fertilizers were spread on the soil surface, using a cyclone seeder, in early June 1964.

Trees on all plots were tagged, dbh recorded, and the total height of every fifth tree measured.

Trees are to be remeasured in 1968.

Sponsoring Organizations: North Western Pulp and Paper Company Limited, Hinton, Alberta.
Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: D.I. Crossley.

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Summary: In June 1964, ammonium nitrate and a mixed fertilizer (13-13-13) were applied to trees in a 90-year-old stand of lodgepole pine to increase the growth of trees nearing merchantable diameter.

The plots receiving ammonium nitrate were treated at the rate of 150 lb/acre of fertilizer. The plots receiving mixed fertilizer were treated at the rate of 385 lb/acre. Both fertilizers were broadcast to the soil surface.

Species: Jack pine, approximately 56 years old.

Location: Sunstrum sand plots, Dryden.

Region: Lower English River Section, Boreal Forest Region.

Objective of Study: To stimulate growth in a slow growing, nutrient deficient stand of jack pine.

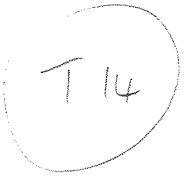
Soil: Medium sand.

Methods: Using jack pine seedlings grown in a pot culture of sand taken from the area, Mr. H.S.D. Swan, P.P.R.I.C., determined that growth was limited by nitrogen, phosphorus and potassium deficiencies.

A preliminary experiment was set out in the older stand in May 1965. One-fifth-acre plots were established and ammonium nitrate (33.5-0-0) at rates of 100 and 300 lb/acre of nitrogen was applied to one series of plots. A second series of plots was treated with urea (44-0-0) at the same rates of nitrogen application.

Sponsoring Organizations: Dryden Paper Company Limited, Dryden, Ontario. Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: R. Bunney, H.S.D. Swan.



Summary: A preliminary bio-assay of a soil was made using jack pine seedlings. The results of this study indicated that nitrogen, phosphorus and potassium were limiting the growth of the seedlings.

In May 1965, ammonium nitrate and urea were each applied at two levels to a 56-year-old stand of jack pine in preliminary field experiments to determine if these additions would stimulate an increase in growth of the trees.

Species: Black spruce - young plantation.

Location: Moonbeam Nursery, Moonbeam, Ontario.

Region: Northern Clay Section, Boreal Forest Region.

Objective of Study: To determine if the growth and cone production of vigorous trees of plantation black spruce can be increased by fertilizer.

Soil: Abandoned farm land.

Methods: The following fertilizers were applied broadcast to the surface of a plantation of black spruce trees, which had been picked out when transplants as vigorous trees.
Ammonium nitrate (33.5-0-0) - 200 lb/acre of nitrogen
Superphosphate (0-20-0) - 200 lb/acre of $P_2O_5$
Potassium sulphate (0-0-50) - 200 lb/acre of $K_2O$
Magnesium sulphate (16% MgO) - 80 lb/acre of MgO.

Sponsoring Organizations: Spruce Falls Power and Paper Company Limited, Kapuskasing, Ontario.
Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: E. Bonner, H.S.D. Swan.

disappeared from plot 1971

Summary: Four fertilizers - ammonium nitrate, superphosphate, potassium sulphate and magnesium sulphate were applied to a plantation of selected vigorous black spruce. The purpose was to determine to what degree growth and cone production of these trees could be increased.

By 1965, the fertilized plots had produced 23% more cones than the unfertilized plots, but differences in production between trees within the same plot were greater than between plots; for example, 10 trees have produced more than 1000 cones each in the last 4 years, whereas 15 trees have produced less than 100 each during the same period.

Species: Black spruce (2 + 2).

Location: Fergus Road, Mile 17, Kapuskasing.

Region: Northern Clay Section, Boreal Forest Region.

Objective of Study: To determine the effects of fertilizer treatment at time of planting on black spruce.

Soil: Clay, top soil removed.

Methods: Black spruce transplants (2 + 2) of Kapuskasing provenance and graded to a minimum 9-inch height and 8-inch root length were planted in early September 1961, on a skidded cutover (1960-61). The topsoil had been removed by a bulldozer.

Twenty-five trees were untreated and twenty-five were fertilized at time of planting with a mixed fertilizer (8-16-16). Two ounces of the fertilizer was spread on the soil surface around each tree. Total height and 1961 leader length were recorded at time of planting. Survival and leader growth were measured in 1962 and 1963.

Sponsoring Organization: Spruce Falls Power and Paper Company Limited, Kapuskasing, Ontario.

Personnel: R.H. Armstrong.

Summary: Graded black spruce transplants (2 + 2) of Kapuskasing provenance were treated with a two-ounce application of a mixed fertilizer (8-16-16) at time of planting in early September 1961. The fertilizer was applied broadcast to the soil surface. The planting site had been logged 1960-61, and the topsoil of the clay had been removed by bulldozing.

In 1962, 1 year after planting, survival of fertilized trees was 56%, compared with 76% for the untreated controls. Mean leader length was 1.7 inches for fertilized trees, compared with 1.5 inches for controls. In 1963, survival was 56% and 72% for the fertilized and controls, respectively. Leader length for the 1963 growing season was 1.6 inches for fertilized and 1.3 inches for controls.

Species: Black spruce (2 + 2).

Location: Parnell Township, Fergus Road, Kapuskasing.

Region: Northern Clay Section, Boreal Forest Region.

Objective of Study: To study the effects of various fertilizers and a transpiration retardant on the survival and growth of planted black spruce.

Methods: Black spruce transplants (2 + 2) graded to a minimum 9-inch height and 8-inch root length were planted during the latter part of May 1961. A total of 19 treatments were employed. Each treatment was applied to form replicates of 25 trees each. Treatments were as follows:

| Treatment Number | Details of Treatment |
|---|---|
| 1. | "Treefeed" pellets (38-0-0) two pellets per planting hole. |
| 2. | "Treefeed" pellets (38-0-0) four pellets per planting hole. |
| 3. | "Treefeed" pellets (24-6-0) two pellets per planting hole. |
| 4. | "Treefeed" pellets (24-6-0) four pellets per planting hole. |
| 5. | Ammonium nitrate (33.5-0-0) 1 oz. per tree, applied to soil surface. |
| 6. | Triple superphosphate (0-46-0) 1 oz. per tree, applied to soil surface. |
| 7. | Turf special (10-6-4) 1 oz. per tree applied to soil surface. |
| 8. | Turf special (10-6-4) 2 oz. per tree applied to soil surface. |
| 9. | Turf special (10-6-4) 4 oz. per tree applied to soil surface. |
| 10. | Turf special (10-6-4) 1 oz. ) agricultural limestone 1/3 oz.) applied, per tree, to soil surface. and magnesium sulphate, 1 oz. ) |
| 11. | Blood and bone meal (7-6-0) 2 oz. per tree applied to soil surface. |
| 12. | Blood and bone meal (7-6-0) 4 oz. per tree applied to soil surface. |
| 13. | "Rapid Gro" (23-21-7) 4 teaspoons per gallon of water, applied to roots. |
| 14. | "Rapid Gro" (23-21-7) 4 teaspoons per gallon of water, applied to foliage. |
| 15. | Wilt Pruf - transpiration retardant - applied as spray to foliage. |
| 16. | Wilt Pruf and Rapid Gro - transpiration retardant applied to foliage and Rapid Gro to roots. |
| 17. | Rapid Gro applied as spray to foliage, followed by Wilt Pruf spray in foliage and Rapid Gro on roots. Soil of planting hole well dug and 4 oz. of blood and bone meal (7-6-0) mixed with soil. |
| 18. | Soil of planting hole dug and mixed before tree planted. |
| 19. | Control. |

Total heights of trees and 1960 leader lengths measured at time of planting.

In June 1961, the general condition of the trees was recorded. At the end of the first and second growing seasons after planting, survival and leader growth were measured.

Sponsoring Organization: Spruce Falls Power and Paper Company Limited, Kapuskasing, Ontario.

Personnel: R.H. Armstrong.

Summary: In May 1961, black spruce transplants (2 + 2) stock were outplanted in an experiment using 19 treatments involving fertilizers and a transpiration retardant in various combinations. In June 1961, a visual inspection indicated that only trees of the following treatments had healthy green foliage and were apparently vigorous: "Treefeed pellets" (24-6-0), both two and four pellets per hole; blood and bone meal - 2 oz.; Rapid Gro on foliage at high rate; all treatments with Rapid Gro. Treatments of ammonium nitrate and soil digging No. 18, showed variable response. In all other treatments, trees had foliage in varying stages of discoloration and were generally of low apparent vigor.

At the end of the first growing season, survival of controls was 100 percent. Considerable mortality (<80 percent survival) occurred in the two treatment plots, Turf special (10-6-4) at a rate of 4 oz. per tree, and ammonium nitrate at 1 oz. per tree. Improved height growth (20 percent increase over controls) was shown by trees receiving the following treatments - blood and bone meal - 2 and 4 oz., soil worked, tree feed pellets (24-6-0) - two and four pellets, triple superphosphate, Turf special (10-6-4) 1 oz., Turf special with limestone and magnesium sulphate, and lastly ammonium nitrate.

At the end of the second growing season, relative survival rates remained unchanged from the previous year. All treatments showed increased height, compared with controls and except for treatments Nos. 2, 13, 15, 16 and 18, the increases were all greater than 20% over the controls. Tree feed pellets (24-6-0) at the rate of four pellets per hole showed the greatest height increase.

Species: Black spruce (2 + 2).

Location: Fergus Road, Kapuskasing, Ontario.

Region: Northern Clay Section, Boreal Forest Region.

Objective of Study: To determine the effects of three levels of magnesium ammonium phosphate, applied to black spruce at time of planting.

Soil: Clay with 2-3 inches of humus and moss.

Methods: Magnesium ammonium phosphate (8-40-0 and MgO 24%) coarse granules, was applied at the rates of 1, 2 and 4 oz. per tree at the time of planting. The fertilizer was spread uniformly at the bottom of the planting slit. The black spruce transplants (2 + 2) were graded to a minimum 9-inch height and 8-inch root length and the fertilization and planting was carried out in early September 1961. Each treatment plot consisted of 10 trees and there were five replications. Total heights and current leader lengths (1961) were measured at time of planting.

Survival and leader lengths were measured in September 1962 and 1963, and November 1964.

Sponsoring Organization: Spruce Falls Power and Paper Company Limited, Kapuskasing, Ontario.

Personnel: R.H. Armstrong.

Summary: Magnesium ammonium phosphate (8-40-0 and MgO 24%) was applied at rates of 1, 2 and 4 oz. per tree in the bottom of the planting slit at the time of planting black spruce in September 1961. Total heights and current leader lengths were measured at time of planting.

In September 1962, one growing season after treatment, survival rates were: control, 100%; fertilizer 1 oz., 98%; 2 oz., 94%; and 4 oz., 92%. Leader growth as a percent of the control was 124%, 108%, and 112% for the 1, 2 and 4 oz. treatments respectively.

At the 1963 and 1964 remeasurements, little change in survival rates had occurred. After two seasons, leader growth of fertilized trees ranged from 43 to 57% greater than that of the controls; during the third growing season, leader length of fertilized trees was 25 to 28% greater than that of controls.

Species: Black Spruce (2 + 2).

Location: Moonbeam Nursery, Moonbeam, Ontario.

Region: Northern Clay Section, Boreal Forest Region.

Objective of Study: To determine what nutrient or combination of nutrients (N, P, and K) when applied to black spruce at time of planting, will result in greatest growth.

Soil: Clay loam.

Methods: The experiment was set out as a factorial with two levels of nitrogen, one of phosphorus and two of potassium, excluding the controls. Nitrogen was applied as ammonium sulphate (20-0-0) at rates of 1-1/4 and 2-1/2 oz. per tree, phosphorus as superphosphate (0-25-0) at 4 oz. per tree and potassium as potassium sulphate (0-0-48) at 1/2 and 1 oz. per tree. All fertilizers were applied broadcast to the soil surface in a circle of 1-foot diameter around the stem of each tree.

The black spruce transplants used were graded to a minimum 9 inches height and 9 inches root length and showed no visible defects. "Hole" method of planting was used. Time of planting and fertilizing were late May 1961.

Survival and leader growth was measured in the fall 1962.

Sponsoring Organization: Spruce Falls Power and Paper Company Limited, Kapuskasing, Ontario.

Personnel: R.H. Armstrong.

Summary: A factorial experiment using two levels of nitrogen (ammonium sulphate, 20-0-0), one level of phosphorus (superphosphate 0-25-0) and two levels of potassium (potassium sulphate, 0-0-48) plus controls was set out at time of planting black spruce in May 1961. Rates of application were - ammonium sulphate 1-1/4 and 2-1/2 oz. per tree, triple superphosphate, 4 oz. per tree and potassium sulphate 1/2 and 1 oz. per tree. All fertilizers were applied to soil surface (9 inches diameter circle) around each tree.

In the fall 1961, survival and leader lengths were measured. Survival of controls, most treatments, was 100%. Lowest survival was 92% ($N_0P_1K_1$). Treatments $N_2P_0K_0$, $N_0P_1K_2$ and $N_1P_1K_1$ had survival of 96%. Leader length (1962) as compared with controls was reduced in trees receiving potassium at the high rate of application. Only treatments $N_1P_1K_0$, $N_2P_1K_0$, and $N_1P_0K_1$, gave growth responses 20% or more than trees in control plots. Greatest growth response occurred in trees at low nitrogen and potassium rates ($N_1P_0K_1$).

Species: Black Spruce (2 + 2).

Location: Seaton Township, Kapuskasing, Ontario.

Region: Northern Clay Section, Boreal Forest Region.

Objective of Study: To study the effects of various fertilizers and soil treatments at time of planting on the survival and growth of black spruce.

Methods: The following seven treatments were applied to a planting of 2+2 black spruce, in late May 1964.

1. Soil well worked up before planting.
2. Soil in planting hole replaced with peat.
3. Ammonium sulphate (20-0-0) applied at rate of 1-1/4 oz. and potassium sulphate (0-0-48) at rate of 1/2 oz. per tree on the soil surface.
4. Magnesium ammonium phosphate (8-40-0, MgO 24%) applied at rate of 2 oz. per tree in bottom of planting slit.
5. Lower third of foliage on tree removed after planting.
6. Control.
7. Magnesium potassium phosphate applied at rate of 2 oz. per tree on soil surface.

A treatment plot consisted of 10 trees and there were five replications of each treatment. Flushing of buds had commenced before trees were planted. Total heights of trees and leader lengths (1963) were measured at time of planting. Survival and height measurements were made in September 1964, one growing season after treatment.

Sponsoring Organization: Spruce Falls Power and Paper Company Limited, Kapuskasing, Ontario.

Personnel: R.H. Armstrong.

Summary: Seven treatments were applied: soil working, peat application, ammonium sulphate (20-0-0) at 1-1/4 oz. per tree with potassium sulphate (0-0-48) at the rate of 1/2 oz. per tree; magnesium ammonium phosphate (8-40-0) at the rate of 2 oz. per tree; and a treatment involving the removal of the lower third of the foliage from the tree, immediately after planting.

The treatments were applied to black spruce (2 + 2) at time of planting in late May 1964. The buds had flushed prior to planting.

Survival and leader lengths were measured in September 1964. Survival of trees receiving ammonium and potassium sulphate was 32% and for those receiving magnesium ammonium phosphate was 56%. For trees in all other treatments, survival was greater than 95%. Leader growth was less in the peat and magnesium ammonium phosphate treatments than in the control trees. Leader length was somewhat greater than that in controls, in all other treatments. Largest height increment (2.2 inches) occurred in trees receiving mixed ammonium and potassium sulphate.

Species: Black spruce.

Location: Camp 511, Fort William, Ontario.

Region: Lower English River Section, Boreal Forest Region.

Objective of Study: To determine the most suitable form of nitrogen to use for the fertilization of a stand of 75-85-year-old black spruce.

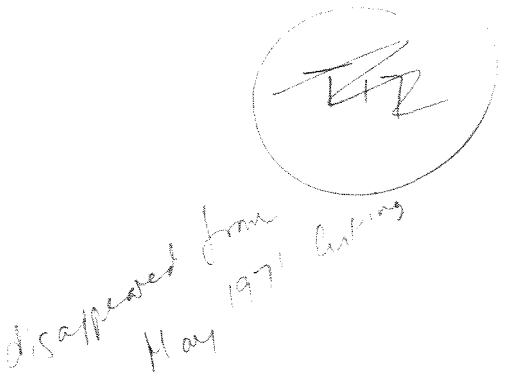
Soil: Moist boulder pavement, moss covered.

Methods: Nitrogen in the form of calcium nitrate (15-0-0, 43% Ca), ammonium nitrate (33.5-0-0) and urea (45-0-0) was applied at rates of 100 and 400 pounds per acre to the soil surface of a 75-85-year-old stand of black spruce. The fertilizers were applied during the last week of May and the first week of June 1964, and broadcast uniformly over the soil surface. A total of 12 plots comprised the experiment.

In the spring 1964, before fertilizer application, diameters of trees in all plots were measured. In October 1964, diameters were re-measured and, in addition, foliage samples from trees in treatment plots were taken for nitrogen analysis.

Sponsoring Organizations: The Great Lakes Paper Company Limited, Fort William, Ontario.
Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: D.G. MacKinnon, H.S.D. Swan.



Summary: In late May-early June 1964, three nitrogen fertilizers, calcium nitrate, ammonium nitrate and urea, were applied each at two rates of 100 and 400 pounds of nitrogen per acre to the soil surface of a 75-85-year-old black spruce stand. Applications were broadcast by hand. The purpose of the trial was to determine the most effective form of nitrogen fertilizer to use in a subsequent trial.

Diameter growth measurements, one growing season after treatment, indicated greatest diameter growth occurred on trees receiving ammonium nitrate at the 400-pound (N) rate. Growth response of trees receiving ammonium nitrate at the 100-pound (N) rate and 400-pound (N) rate were similar. Trees receiving calcium nitrate showed no growth response.

Foliage analyses indicated that in terms of nitrogen concentrations urea, at both levels of application, was more effective than either calcium nitrate or ammonium nitrate in increasing the level of nitrogen in the foliage.

Species: Black spruce, 75-85 years old.

Location: Camp 511, Fort William, Ontario.

Region: Lower English River Section, Boreal Forest Region.

Objective of Study: To determine the response of a black spruce stand to applications of nitrogen, phosphorus and potassium fertilizers.

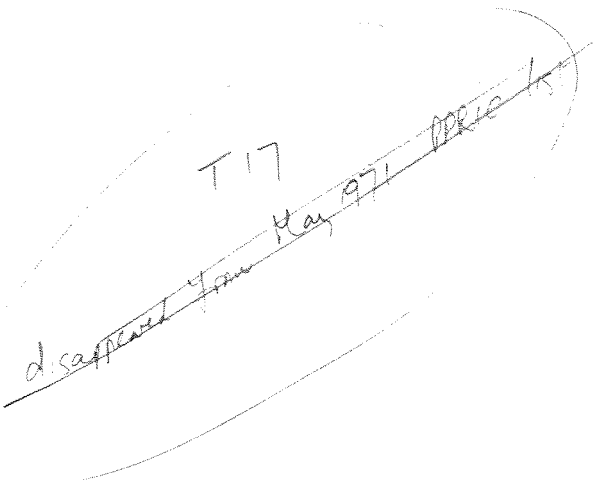
Soil: Moist boulder pavement, moss covered.

Methods: Nitrogen as urea (45-0-0) was applied at rates of 100 and 200 pounds per acre, phosphorus as triple superphosphate (0-46-0) at a rate of 50 pounds per acre of $P_2O_5$ and potassium chloride (0-0-48) at a rate of 100 pounds per acre of $K_2O$. The fertilizers were applied broadcast to the soil surface in May 1965.

Trees on plots are to be remeasured annually for 5 years after treatment.

Sponsoring Organizations: The Great Lakes Paper Company Limited, Fort William, Ontario.
Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: D.G. MacKinnon, H.S.D. Swan.



Summary: Nitrogen, phosphorus and potassium fertilizers were applied in May 1965, to the soil surface of 75-85-year-old stand of black spruce.

The nitrogen was applied as urea (45-0-0) at rates of 100 and 200 pounds of nitrogen per acre. Phosphorus was applied as triple superphosphate (0-46-0) at a rate of 50 pounds per acre of $P_2O_5$. Potassium was applied as potassium chloride at a rate of 100 pounds per acre of $K_2O$.

Species: White spruce - 12 years, jack pine - 11 years.

Location: O'Connor Township, Fort William, Ontario.

Region: Lower English River Section, Boreal Forest Region.

Objective of Study: To determine the effect of magnesium ammonium phosphate applied to white spruce and jack pine plantations.

Soil: Clay to clay loam.

Methods: Magnesium ammonium phosphate (8-40-0, 24% MgO) was applied at the rate of 4-1/2 oz. per tree in white spruce and jack pine plantations, in October 1961. Both species were planted in October 1953. The fertilizer was applied in each of two holes opened one on each side of a tree, at a distance of 1 to 2 feet from the stem.

In the white spruce plantation, two plots 92.0 and 0.22 acres respectively were treated and in the jack pine plantation, one plot of 2.5 acres was treated.

No measurements were made at the time of fertilization. In September 1962, the plots were visually assessed and in June 1964, leader lengths were measured on 50 fertilized and 50 unfertilized white spruce.

Sponsoring Organization: The Great Lakes Paper Company Limited, Fort William, Ontario.

Personnel: D.G. MacKinnon.

Summary: Magnesium ammonium phosphate was applied at the rate of approximately 4-1/2 oz. of fertilizer per tree, to a 12-year-old plantation of white spruce and an 11-year-old plantation of jack pine. The fertilizer was placed in holes on either side of the tree, 1 to 2 feet away from the stem. The fertilizer was applied in October 1961.

In September 1962, no noticeable difference in needle length, color or tree vigor existed between fertilized and unfertilized trees.

A measurement of leader lengths of the white spruce plantation indicated no significant difference in height between fertilized and unfertilized trees.

Species: Jack pine, planted, 10 years old and a natural stand 14 years old. White spruce, planted, 11 and 12 years old.

Location: O'Connor and Paipoonge Townships, Fort William, Ontario.

Region: Lower English River Section, Boreal Forest Region, and Quetico Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the effect of a nitrogen, phosphorus and potassium fertilizer on the growth of natural and planted jack pine and planted white spruce.

Methods: A series of 18 plots each of 1/10 acre was established in planted jack pine (10 years old), and natural jack pine (14 years old) and planted white spruce (11 and 12 years old). In mid-July 1960, a mixed fertilizer (10-5-5, with nitrogen in urea formaldehyde form) was applied at the rate of 235 pounds of fertilizer per acre. On nine plots, the fertilizer was broadcast uniformly to the soil surface and on six of these plots, the fertilizer was rototilled into the soil to a depth of approximately 2 inches after application. On three plots, the fertilizer was spread evenly around each tree in an area with a radius of 2 feet. The remaining six plots were controls.

Heights and diameters of 10 trees in each plot were recorded at time of treatment. Remeasurements were made in August 1961 and October 1962.

Sponsoring Organizations: The Great Lakes Paper Company Limited, Fort William, Ontario.
Canadian Industries Limited, Montreal, P.Q.

Personnel: D.G. MacKinnon.

Summary: A mixed fertilizer (10-5-5) containing nitrogen as urea formaldehyde was applied at the rate of 235 pounds per acre to young stands of jack pine and white spruce. In one set of plots, the fertilizer was distributed uniformly over the soil surface. In a second set, after uniform distribution, the fertilizer was rototilled into the soil. In a third series, the fertilizer was applied to the soil surface in an area of a 2-foot radius about each tree.

At a remeasurement in October 1961, the fertilizer showed little effect in height growth, with the exception of one plot of white spruce. Diameter growth of fertilized trees was greater than that of controls. Rototilling did not appear to increase the growth rate.

Species: White spruce, approximately 45-year-old plantation.

Location: Grand'Mère, P.Q.

Region: Laurentian Section, Great Lakes-St. Lawrence Forest Region.

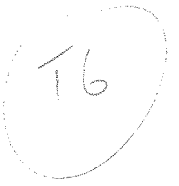
Objective of Study: To determine if low growth rates are due to nutrient deficiencies.

Soil: Loamy sand over massive lacustrine clay.

Methods: Sixty 1/10 acre plots were established in May 1963. Nitrogen as urea (45-0-0) was applied at rates of 114 and 228 pounds of urea per acre. Potassium was applied as potassium sulphate (0-0-50) at rates of 100 and 200 pounds per acre of the fertilizer. The experiment was set out as a factorial so that all combinations and levels of N and K were represented. On one-half of each block magnesium as magnesium sulphate (16% MgO) was applied at a rate of 200 pounds of fertilizer per acre. All fertilizers were applied broadcast to the soil surface.

Sponsoring Organizations: Consolidated Paper Corporation Limited, Grand'Mère, P.Q.
Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: J.M. Conway and H.S.D. Swan.



Summary: In May 1963, urea and potassium sulphate were applied in a factorial experiment to a 45-year-old plantation of white spruce. Two rates of both fertilizers were used: urea, 114 and 228 pounds per acre, and potassium sulphate, 100 and 200 pounds per acre. In addition, one-half of each plot was treated with 200 pounds of magnesium sulphate.

By July 1965, nitrogen and potassium levels in foliage of treated trees had increased. Diameter measurements indicated that fertilized trees were beginning to grow more rapidly than control trees.

Species: White spruce, 9-year-old plantation.

Location: Cockburn Island, near Manitoulin Island, Ontario.

Region: Huron-Ontario Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine if the growth rate of a slow-growing plantation could be increased by the application of fertilizers.

Soil: Medium sand. Analyses indicated that it was low in organic matter and very low in available phosphorus, potassium and magnesium, pH 4.8 - 5.1.

Methods: In early June 1960, nitrogen, phosphorus, potassium and magnesium fertilizers were applied to the trees. All possible combinations, as well as single fertilizer additions were made. Nitrogen was applied as urea (45-0-0) at the rate of 4 oz. of fertilizer per tree. Phosphorus was applied as superphosphate (0-20-0) at the rate of 4 oz. of fertilizer per tree, potassium was applied as potassium chloride (0-0-60) at the rate of 3 oz. of fertilizer per tree and magnesium was applied as magnesium sulphate (16% MgO) at the rate of 4 oz. of fertilizer per tree.

On half of the replicates, the fertilizers were broadcast on the surface of the ground beneath each tree. On the other half of the replicates, the fertilizers were placed in holes around the "drip line" of the tree's crown.

Sponsoring Organizations: Ontario Paper Company Limited, Thorold, Ontario. Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: J. Walker, H.S.D. Swan.

Summary: Nitrogen, phosphorus, potassium and magnesium fertilizers were added singly and in all combinations to white spruce in a 9-year-old plantation. Urea, superphosphate and magnesium sulphate were applied at rates of 4 oz. per tree, and potassium sulphate at 3 oz. per tree.

On a half of the plots, the fertilizers were broadcast on the soil surface underneath the trees; on the other half the fertilizers were placed in holes around the tree crown's "drip line".

In 1965, height growth of trees was measured. Only in one treatment (phosphorus plus magnesium) did trees show a greater than 20% increase as compared with control trees (5-year-height growth was expressed as a percentage of initial height prior to fertilization). Two treatments, NPMg and NPKMg showed height increases of 18 and 19% as compared with controls.

Species: Jack pine - natural stand.

Location: Blue Lake, Oriskany, P.Q.

Region: Missinaibi-Cabonga Section, Boreal Forest Region.

Objective of Study: To determine if the growth rate of a slow growing stand of jack pine can be increased by fertilizer application.

Soil: Deep, medium sand.

Methods: Nitrogen, phosphorus, potassium, magnesium and calcium fertilizers were applied in a 15-plot factorial experiment. Nitrogen was applied as ammonium sulphate (20-0-0) at the rate of 100 lb/acre of nitrogen, phosphorus was applied as superphosphate (0-20-0) at the rate of 100 lb/acre. $P_2O_5$, potassium as potassium sulphate (0-0-50) at the rate of 110 lb/acre $K_2O$, magnesium as magnesium sulphate (16% MgO) at the rate of 25 lb/acre MgO and calcium as agricultural limestone (50% CaO) at the rate of 500 lb/acre CaO.

All fertilizers were applied broadcast to the soil surface in May 1960.

Sponsoring Organizations: Canadian International Paper Company Limited, Montreal, P.Q.
Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: H.S.D. Swan.

Summary: In May 1960, a factorial experiment was established in an attempt to increase growth in a natural stand of jack pine. Nitrogen was applied at the rate of 100 lb/acre as ammonium sulphate, phosphorus at the rate of 100 lb/acre $P_2O_5$ as superphosphate, potassium at the rate of 110 lb/acre $K_2O$ as potassium sulphate, magnesium at the rate of 25 lb/acre MgO as magnesium sulphate and calcium at the rate of 500 lb/acre CaO as agricultural limestone.

In October 1964, increment borings and discs cut from three trees indicated that there had been an appreciable response to some of the treatments. Trees on all plots are to be remeasured in October 1965.

Species: Jack pine - natural stand.

Location: Silver Lake, Oriskany, P.Q.

Region: Missinaibi-Cabonga Section, Boreal Forest Region.

Objective of Study: To determine the effects of fertilizers and water on the growth rate of slow-growing jack pine.

Methods: In June 1962, eight plots were established and treatments consisting of a mixed fertilizer, nitrogen, phosphorus, potassium and magnesium, irrigation and mixed trace elements (B, Cu, Zn, Mo, and Fe) were applied singly and in combination.

Sponsoring Organizations: Canadian International Paper Company Limited, Montreal, P.Q.
Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Personnel: H.S.D. Swan.

Summary: Three treatments were applied to a natural, slow-growing, stand of jack pine in June 1962. Treatments consisted of a mixed fertilizer (NPKMg), irrigation water and trace elements (B, Cu, Zn, Mo, Mn and Fe) singly and in combination.

Preliminary indications are that mixed fertilizer plus trace elements has increased diameter growth by 140% as compared with controls.

Species: European larch, hybrid larch, Norway spruce, white spruce, black spruce, red spruce, Douglas fir and jack pine.

Location: British Columbia, Ontario, Quebec and New Brunswick.

Regions: Various.

Objective of Study: To determine the effects of using a urea formadehyde phosphorus pellet fertilizer on the growth, survival and foliage nutrient levels of trees of various species after planting.

Soils: Various - sands to clays. History of use was burns, old fields, recent and older cutovers.

Methods: Twenty-two, 1,000-tree field-trials were established in 1959. Each plot contained only one species. In each trial, 500 trees were treated and 500 untreated as controls. In 1960, two trials were discontinued and six additional trials were established.

The fertilizer used was a urea-formaldehyde-phosphorus (28-5-0). At the rate of one pellet per tree, the application rate was 6.7 pounds of nitrogen and 0.5 pounds of phosphorus per acre.

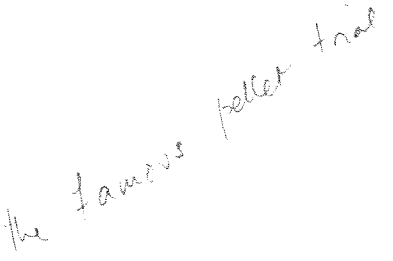
In nine of the plots, two methods of placement were used: (1) bottom placement - pellet placed at bottom of planting hole, (2) side placement - pellet placed close to soil surface and to one side of the tree. In the remaining plots, bottom placement only was used.

The total height of each tree was measured immediately after planting and again at the end of the experiment in fall 1963.

In 1961 and 1963, foliage samples were collected from 25 pelleted and 25 unpelleted trees in each plot.

Sponsoring Organizations: Pulp and Paper Research Institute of Canada, Montreal, P.Q. and 18 industries and institutions.

Personnel: H.S.D. Swan and company cooperators.



Summary: A large trial involving eight species and locations in New Brunswick, Quebec, Ontario and British Columbia was established, using urea-formaldehyde-phosphorus pellets at time of planting in 1959 and 1960. One pellet was used per planting hole; two methods of placement - bottom and side placement - were used. Rates of application were nitrogen, 67 pounds per acre and phosphorus 0.5 pounds per acre.

Final assessments were made in 1963. The following conclusions were made:

(1) Small but significant (P = 0.01) increases in 5-year height growth were found for twenty spruce plots. In no instance did the increase in 5-year growth exceed 4.25 inches and in most cases was less than 1 inch.
(2) Side placement of pellets gave slightly better results than bottom placement.
(3) Survival for pelleted and control trees averaged just over 80%.
(4) Height growth in plantations showed a wide range between plots.
(5) Height growth in old field plots was significantly less than in the other plots.
(6) Foliage analyses in 1963, showed no appreciable differences in nitrogen and phosphorus concentrations between pelleted and control trees.

Publication: Swan, H.S.D., 1965. Studies of the mineral nutrition of Canadian Pulpwood Species Phase II, Fertilizer pellet field trials, 1959-1963, Final Report.
Woodlands Research Index No. 163. Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Species: Black spruce - 65 years old.

Location: Pistuakanis River, Baie Comeau, P.Q.

Region: Chibougamau-Natashguan Section, Boreal Forest Region.

Objective of Study: To study the effects of clear cutting, thinning and urea and superphosphate applications on the humus decomposition, nitrogen availability and productivity of a calliergon black spruce stand.

Soil: 3 to 5 inches of mor humus over a podzol profile in a deep coarse textured till.

Methods: (a) In order to test the effects of thinning and urea applications, two levels of thinning (25 and 50% of crown removed) and two levels of urea (2.5-0-0; 100 and 400 pounds of nitrogen per acre) were applied singly and in combination plus controls. Plots were circular and 1 acre in extent; thinning cuts were made in July and August 1961. Urea was applied by hand to the soil surface in September and October 1961. The urea was applied to 1/3 acre pie-shaped segments of the plots and these were always on the downhill side of the plot. Within each split plot, a 1/40 acre permanent sample plot was established.

(b) To assess the effects of clear cutting and urea and superphosphate treatments on planted spruce, a rectangular area was clear cut and 18 randomized blocks, 20 x 20 feet, were established. In October 1961, 4-5-year-old black spruce wildlings were planted, six trees in each 8 x 8-foot plot. Planting treatments consisted of (i) trees planted in humus layer, (ii) trees planted in 50-50 mixture of humus and soil, (iii) trees planted in humus but 490 lb/acre of nitrogen as urea applied to soil surface broadcast and 3 oz. of superphosphate (0-20-0) placed around each tree 3 to 4 inches from the stem, and (iv) the same fertilizer treatments as in (iii) but trees planted in a 50-50 mixture of humus and mineral soil.

Sponsoring Organizations: Pulp and Paper Research Institute of Canada, Montreal, P.Q.
Quebec North Shore Paper Company Limited, Baie Comeau, P.Q.

Personnel: G.F. Weetman, C.E. Lafond.

Summary: In July-August 1961, a series of thinning cuttings (25 and 50 percent of crown removed) were made in a 65-year-old black spruce stand, north of Baie Comeau. Urea was applied at two rates, 100 and 400 lb/acre of nitrogen singly and in combination with the thinning treatments. All urea treatments were made to 1/3 of the thinned plots, and were on the downhill side of the plot.

In a second study two methods of planting and a fertilizer treatment were applied to wildling black spruce planted in a clear cut portion of the stand. Planting methods were (a) planting in humus, and (b) planting in a 50-50 mixture of humus and mineral soil. Fertilizer treatments consisted of a combination of urea (45-0-0) applied broadcast at a rate of 490 lb/acre of nitrogen and superphosphate (0-20-0) applied at a rate of 3 oz. per tree.

Based on 2 years' measurements and observations during three growing seasons it appears that:
(1) Clear cutting increases the dry weight of the partially decomposed organic matter on the forest floor by about 10%.
(2) The black spruce trees are nitrogen deficient, although plots which were thinned but not fertilized, showed no growth response.
(3) Survival of trees planted in humus-soil mixture was greater than for trees planted in humus. Additions of fertilizer resulted in lower survival rates in all plots so treated.
(4) Planted trees, treated with urea and superphosphate, had greater leader growth than unfertilized trees.

Publications: Weetman, G.F., 1962. Mor Humus Studies (Project 59-3). Establishment Report on a humus decomposition experiment. Research Note No. 33, Woodlands Research Index No. 134. Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Weetman, G.F., 1964. Clear cutting, planting, thinning and nitrogen fertilization of a black spruce-feather moss site. Research Note No. 44, Woodlands Research Index No. 156, Pulp and Paper Research Institute of Canada, Montreal, P.Q.

Species: Black spruce - 50-year-old stand.

Location: Iroquois Falls, Ontario.

Region: Northern Clay Section, Boreal Forest Region.

Objective of Study: A study of the inter-relationships between growth, nitrogen nutrition and humus decomposition in a black spruce stand.

Soil: Fibrous mor 3 to 8 inches - pH 3.5-4.5; grey wooded soil profile - pH of C horizon 8.0.

Methods: Six treatments to the stand were applied: (i) control - no treatment, (ii) soil mixed with Pulaski, to disturb moss and humus layer, (iii) calcium applied at 1,000 lb/acre as hydrated lime, (iv) nitrogen added at a rate of 100 lb/acre as ammonium nitrate (33.5-0-0), (v) combined applications of nitrogen at 400 lb/acre and calcium at 1,000 lb/acre. Treatments were applied to soil surface in June 1959. One-fifth-acre circular plots, each replicated three times were used.

In September 1959 and 1960, two trees were selected from each plot for weighing and analyses.

Sponsoring Organizations: Pulp and Paper Research Institute of Canada, Montreal, P.Q.
Abitibi Power and Paper Company Limited, Toronto, Ontario.

Personnel: G.F. Weetman.

Summary and Results: In June 1959, a stand of 50-year-old black spruce was treated in the following ways: (i) control, (ii) soil mixed to disturb moss and humus layer, (iii) calcium applied at rate of 1,000 lb/acre as hydrated lime, (iv) nitrogen applied at a rate of 100 lb/acre as ammonium nitrate (33.5-0-0), (v) nitrogen applied at a rate of 400 lb/acre as ammonium nitrate, (vi) combined applications of calcium at 1,000 lb/acre and nitrogen at a rate of 400 lb/acre.

Leader lengths in 1959 and 1960 were greater for trees treated with nitrogen - these increased lengths were correlated with higher foliar nitrogen concentrations. Average foliar nitrogen concentrations of nitrogen fertilized trees were higher in the third growing season than in trees in other treatments. Soil mixing and calcium treatments did not increase nitrogen availability.

Nitrogen treatments of 400 lb/acre resulted in total tree nitrogen contents approximately 200 lbs greater than the non-nitrogen treatments. Litter from trees on nitrogen treated plots had higher nitrogen contents than that from trees in non-nitrogen plots. Effect of nitrogen in increasing growth was greater, relatively, in suppressed trees than dominant trees. In addition, multiple leaders were more frequent in nitrogen treated plots, possibly related to earlier flushing and then killing by late spring frosts.

Studies using $N^{15}$ indicated large leaching losses of nitrogen, a large gaseous loss of nitrate nitrogen and a lack of preferential uptake by black spruce of ammonium or nitrate nitrogen.

Publications: Weetman, G.F. 1962. Nitrogen relations in a black spruce stand (*Picea mariana* Mill.) subject to various fertilizer and soil treatments.
Woodl. Res. Index, Pulp and Paper Res. Inst. Can. 129.

Species: Lodgepole pine, 15 years old.

Location: Embarras Working Circle, Hinton, Alberta.

Region: East Slope Rockies Section, Subalpine Forest Region.

Objective of Study: To attempt to develop differential vigor by fertilization of selected crop trees in a stand of stagnating lodgepole pine.

Methods: The stocking of the pine stand varied from 7,200 to 15,300 stems per acre. In 1958, five 1/5-acre plots were established and crop trees were selected on a 6 x 6-foot spacing, each tree was logged and its total height measured. In 1959, another 1/5-acre plot was established. On each plot a total of 225 trees were selected.

In the spring of 1958, selected trees in plots No. 1 and 4 were treated at the rate of 4.25 oz. per tree (300 lb/acre) with a mixed fertilizer (10-32-10). In the spring of 1959, plot No. 1 received a second application at the same rate.

Selected trees in plots No. 2, 4, and 5 were treated at the rate of 4.25 oz. per tree (300 lb/acre) with ammonium nitrate (33.5-0-0) in the spring of 1958. Plot No. 2 received a second application of ammonium nitrate at the same rate in the spring of 1959.

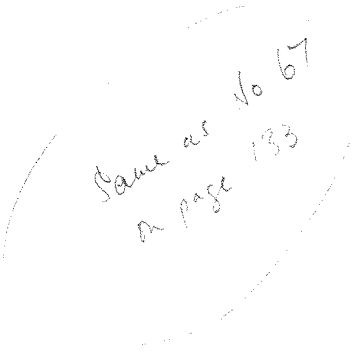
Plot No. 3 was a control.

Plot No. 6 established in the spring of 1959 received urea at the rate of 4.25 oz. per tree.

In all applications, the fertilizer was applied broadcast to the soil surface adjacent to the crop tree.

Sponsoring Organization: North Western Pulp and Power Limited, Hinton, Alberta.

Personnel: D.I. Crossley.



Summary: The project was established in a 15-year-old stand of stagnating lodgepole pine. In the spring, 1958, a mixed fertilizer (10-32-10), and a nitrogen fertilizer, ammonium nitrate (33.5-0-0), were applied to selected crop trees (1000 per acre) at the rate of 4.25 oz. of fertilizer per tree (300 lb/acre). Two plots each received a second application of the respective fertilizer in the spring, 1959. An additional plot was set out in 1959, and to selected crop trees 4.25 oz. of urea was applied.

The purpose of these treatments was to increase the vigor of the selected trees in the stagnating stand.

In the fall, 1960, the trees in the treated and control plots were remeasured. Although a small increase in height growth, when compared with untreated control trees, was apparent, there was no indication that the condition of stagnation had been overcome.

Species: Black spruce - 65 years old.

Location: Pistuakanis River, Baie Comeau, P.Q.

Region: Chibougamau-Natashguan Section, Boreal Forest Region.

Objective of Study: To study the effects of nitrogen, calcium, magnesium and potassium fertilizers on the growth and humus conditions of a black spruce stand.

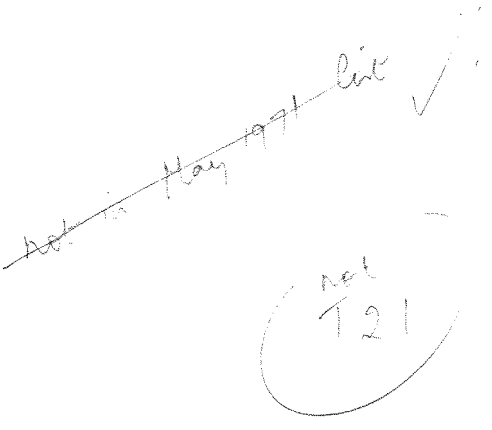
Soils: Three to five inches of mor humus over a podzol profile in a deep coarse textured till.

Methods: A series of 1/40-acre plots were established in September 1964. Treatments were: (i) control, (ii) calcium at 31 lb/acre plus magnesium at 23 lb/acre plus potassium at 50 lb/acre plus nitrogen at 100 lb/acre as urea, (iii) 62 lb/acre of calcium plus 46 lb/acre of magnesium plus 100 lb/acre of potassium plus 200 lb/acre of nitrogen as urea.

The calcium, magnesium and potassium fertilizers were applied in September 1964. The nitrogen was applied in June 1965.

Sponsoring Organizations: Pulp and Paper Research Institute of Canada, Montreal, P.Q.
Quebec North Shore Paper Company Limited, Baie Comeau, P.Q.

Personnel: G.F. Weetman, C.E. Lafond.



Summary: An experiment was established in September 1964, in which nitrogen, calcium, magnesium and potassium were applied in combination at two rates to a stand of 65-year-old black spruce. Rates were Ca, 31 and 62 lb/acre; Mg, 23 and 46 lb/acre; K, 50 and 100 lb/acre and N, 100 and 200 lb/acre as urea.

All fertilizers except nitrogen were applied in September 1964. The nitrogen was applied in June 1965.

Species: Douglas fir (i) Robertson River Valley, 13-year-old plantation.
(ii) Mt. Prevost - a natural stand, 20 to 25 years old.

Location: Robertson River Valley and Mt. Prevost, South Vancouver Island.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine growth and cone response to fertilization.

Soils: Acid brown wooded.

Methods: In July 1957, a fertilizer experiment was established on a single tree basis. The following fertilizers were used: ammonium nitrate (33.5-0-0), ammonium sulphate (20-0-0, 24% S), calcium nitrate (15.5-0-0, 20% Ca), urea (46-0-0), calcium cyanamide (21-0-0, 30% Ca), triple superphosphate (0-46-0), potassium chloride (0-0-60), equal amounts of N and P using ammonium sulphate and triple superphosphate, equal amounts of NPK using ammonium sulphate, triple superphosphate and potassium chloride. At Mt. Prevost, equal amounts of NPK using calcium nitrate, triple superphosphate and potassium chloride; at Robertson Valley, equal amounts of N and K using calcium nitrate and potassium chloride. Agricultural lime and a control. Schedule of rates and times of applications are as follows:

| | Robertson Valley | Mt. Prevost |
|---|---|---|
| 1957 | July 3, 200 lb/acre<br>Sept. 3, 2 tons/acre (limestone only) | July 23-31, 400 lb/acre<br>Sept. 4, 2 tons/acre (limestone only) |
| 1958 | Oct. 16, 2 tons/acre (limestone only) | June 9, 200 lb/acre (to one half of replicates)<br>Oct. 15, 2 tons/acre (limestone only) |
| 1959 | 200 lb/acre<br>May 11, to odd numbered replicates<br>June 1, to even numbered replicates | May 12<br>200 lb/acre to odd numbered replicates<br>400 lb/acre to even numbered replicates |

Above rates for N, $P_2O_5$ and $K_2O$.

All treatments were applied broadcast to the soil surface at Robertson Valley, to a circular area with 8 feet radius and at Mt. Prevost to an area with 10 feet radius. Bud dendrometers were used to measure diameter growth.

Sponsoring Organization: Forest Research Laboratory, Canada Department of Forestry, Victoria, B.C.

Personnel: L.F. Ebell.

Summary: In July 1957, a series of nitrogen, phosphorus, potassium and calcium fertilizers were added to two stands of Douglas fir on a single tree basis with the objective of determining diameter and cone production responses.

Final assessment was made in 1962. The following conclusions are based on the results.

(i) All nitrogen fertilizers except calcium cyanamide, enhanced foliage color and increased diameter growth.

(ii) Additions of phosphorus, potassium and calcium did not increase growth or cone production.

(iii) Cone induction requirements are more specific as to type of fertilizer and time of application than diameter growth. Cone production was increased by rates of 200 and 400 lb/acre of nitrogen except for calcium cyanamide.

(iv) Nitrate nitrogen promoted ovulate bud formation immediately after treatment. Cone induction responses from ammonium nitrogen sources were delayed usually until the second year after treatment. Higher cone yields from both forms of nitrogen continued into the third year.

(v) Cone production was weakly correlated with growth and vigor. There was a suggestion that ammonia nitrogen in excess, inhibited reproductive bud initiation, but excess nitrate nitrogen stimulated reproduction bud initiation.

(vi) Ammonium nitrate and urea appeared to be the most effective fertilizers for sustained cone production.

Species: Douglas fir - 20-year-old stand.

Location: Greater Victoria Water District Lands, Victoria, B.C.

Region: Strait of Georgia Section, Coast Forest Region.

Objective of Study: To determine a chemical index for the optimum production of Douglas fir reproductive buds and cones.

Soil: Well-drained sandy loam colluvium overlying till, acid brown wooded.

Methods: Fourteen plots, with ten trees on each, were established in early 1964. Calcium nitrate (16-0-0, 43% Ca) and ammonium sulphate (20-0-0) were each applied separately at a rate of 400 lb/acre. Three times of application were used: (i) mid-April, (ii) at time of vegetative bud break, and (iii) late June.

After fertilizer application, sampling of current twigs and foliage from the upper third of the crown was carried out at weekly intervals. The samples were freezer-dried for laboratory analyses.

Sponsoring Organizations: Forest Research Laboratory, Canada Department of Forestry, Victoria, B.C.
Greater Victoria Water District, Victoria, B.C.

Personnel: L.F. Ebell.

Summary: In early 1964, an experiment was established in a 20-year-old stand of Douglas fir to determine a chemical index of the optimum production of Douglas fir reproductive cones and buds.

Calcium nitrate and ammonium sulphate were each applied at a rate of 400 lb/acre. Three times of application were used: (i) mid-April, (ii) time of vegetative bud break, and (iii) late June. After application, samples of the current twigs and foliage from the upper third of the crowns were taken at weekly intervals for analyses.

Species: Douglas fir.

Location: Greater Victoria Water District Lands, Victoria, B.C.

Region : Strait of Georgia Section, Coast Forest Region.

Objective of Study: To determine the influence of nitrogen fertilizer on foliar nitrogen levels as related to cone production of Douglas fir.

Soil: Well-drained sandy loam colluvium overlying till, acid brown wooded.

Methods: In 1964, twenty-eight plots, each with five trees, were established. Six rates of nitrogen were applied - 50, 100, 200, 400, 800, and 1600 lb/acre. The plots are to be refertilized annually until 1968. Current twigs and foliage are to be sampled from the upper third of the crown at regular intervals. The number of buds, their development or abortion are to be recorded.

Sponsoring Organizations: Forest Research Laboratory, Canada Department of Forestry, Victoria, B.C.
Greater Victoria Water District, Victoria, B.C.
British Columbia Forest Service, Victoria, B.C.

Personnel: L.F. Ebell.

Summary: In 1964, six rates of nitrogen, 50, 100, 200, 400, 800, and 1600 lb/acre were applied to plots of Douglas fir in order to determine the influence of nitrogen fertilizer on foliar nitrogen levels as related to cone production. Refertilization is planned annually until 1968.

Current twigs and foliage are to be sampled regularly for analyses and the number of buds, their development or abortion will be recorded.

Species: Douglas fir - 2- and 5-year-old rootstock, grafted 2 years.

Location: Quinsam Seed Orchard (B.C.F.S.) Campbell River, Vancouver Island B.C.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effects of fertilizer on cone induction in grafted Douglas fir.

Soil: Well cultivated clay loam with shallow hardpan.

Methods: In early May 1965, at time of vegetative bud break, two rates of calcium nitrate were applied to a 3-foot radius plot area around each tree. The two rates were equivalent to 200 and 400 lb/acre of nitrogen.

Each treatment was replicated on two ramets of each of 10 clones.

Sponsoring Organizations: Forest Research Laboratory, Canada Department of Forestry, Victoria, B.C.
British Columbia Forest Service, Victoria, B.C.

Personnel: L.F. Ebell.

Summary: In early May 1965, calcium nitrate was applied at two rates - 200 and 400 lb/acre of nitrogen to grafted Douglas fir 2- and 5-year-old rootstock. The time of application coincided with vegetative bud break.

Species: Douglas fir - 11-year-old plantation.

Location: Campbell River, Vancouver Island, B.C.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effects of fertilizer application on cone induction in juvenile Douglas fir.

Soil: Brown wooded soil low nitrogen availability to Douglas fir due to loss of organic material following severe fire after logging. Two sites:
SI. 80 - poor site and
SI. 120 - medium site.

Methods: Four levels of nitrogen - 200, 400, 800 and 1600 lb/acre were applied as calcium nitrate (16-0-0, 43% Ca) and ammonium sulphate (20-0-0). Each fertilizer was applied broadcast to the soil surface in a plot area with a radius of 5 feet around each tree. Treatments were replicated 10 times on each of the two sites (S.I. 80 and S.I. 120). Time of treatment was the latter part of May 1965, when the vegetative buds were breaking.

Sponsoring Organizations: Forest Research Laboratory, Canada Department of Forestry, Victoria, B.C.
British Columbia Forest Service, Victoria, B.C.

Personnel: L.F. Ebell.

Summary: In late May 1965, four levels of nitrogen - 200, 400, 800, and 1600 lb/acre - were applied as calcium nitrate and ammonium sulphate to an 11-year-old stand of Douglas fir. The object of the applications was to induce cone production. Two sites (S.I. 80 and S.I. 120) were represented. Fertilizers were applied broadcast to a 5-foot radius plot about each tree.

Species: White spruce (2 + 1).

Location: Lusk Creek, Kananaskis Forest Experiment Station, Alberta.

Region: East Slope Rockies Section, Subalpine Forest Region.

Objective of Study: To increase survival and growth of white spruce by applying fertilizers at time of planting.

Soil: Medium textured loamy podzol with highly calcareous parent material.

Methods: The area was logged in 1940-41 for spruce and during the summer of 1948, the soil surface was scarified. In early June 1961, the present experiment was established. Four fertilizers each at three rates of application were used:

(1) Ammonium phosphate (11-48-0) at 339, 509 and 847 lb/acre.
(2) Ammonium nitrate phosphate (23-23-0) at 435, 652 and 1087 lb/acre.
(3) Ammonium nitrate (33.5-0-0) at 600, 900 and 1500 lb/acre.
(4) Mixed (14-14-7) at 571, 857 and 1429 lb/acre.

Rates of application were equivalent to 200, 300 and 500 lb/acre of nitrogen, nitrogen plus phosphorus and nitrogen plus phosphorus plus potassium depending on the fertilizer used.

Each plot contained 36 trees at a 3 x 3-foot spacing. Fertilizers were applied broadcast to the plot two days prior to planting the 2+1 stock on June 7 and 8, 1961. The planting stock was ungraded and of low vigor.

Survival and loader length was measured in September 1961.

Sponsoring Organization: Forest Research Laboratory, Canada Department of Forestry, Calgary, Alberta.

Personnel: J.R.B. Holmes (deceased).

Summary: In early June 1961, four fertilizers - ammonium phosphate (11-48-0), ammonium nitrate phosphate (23-23-0), ammonium nitrate (33.5-0-0), and a mixed fertilizer (14-14-7) were each applied at three rates of application broadcast to the soil surface. Two days after fertilizer application, 2+1 white spruce stock, ungraded and of low vigor, were planted in plots of 36 trees. Spacing of trees in plots was 3 x 3 feet.

In September 1961, survival and leader length was measured. In general, survival in all plots, including controls, was low - maximum survival was 56%. Survival of trees in plots treated with ammonium phosphate increased somewhat with rate of application - 48 to 56%. With ammonium nitrate phosphate, survival rates increased with rate of application to a maximum at the intermediate level and then was reduced at the highest rate of fertilizer treatment. Survival rates declined with increasing rates of ammonium nitrate application. Survival rates of trees treated with mixed fertilizer were not related to rates of application. Leader lengths were unrelated to treatments.

Reduced survival in certain fertilizer treatment was apparently related to the increased growth of competing grass which responded to the fertilizer.

Species: White spruce (2 + 1) - Nursery study.

Location: Big River Nursery, Saskatchewan.

Region: Mixedwood Section, Boreal Forest Region.

Objective of Study: To investigate whether growth response of white spruce seedlings to ammonium sulphate was due to nitrogen addition or acidification with resultant greater availability of iron and manganese.

Soil: Grey podzolic soils (Sylvania association) developed in alluvial lacustrine deposits.

Methods: During the 1961 growing season chlorosis of 2 + 1 white spruce was corrected to a degree by application of solutions of ammonium sulphate (21-0-0). In June 1962, a detailed experiment was set out in beds of chlorotic white spruce seedlings. The following treatments were used:
(1) Ammonium sulphate (21-0-0) at rates of 182 and 364 lb/acre.
(2) Urea (45-0-0) at rates of 82 and 164 lb/acre.
(3) Iron chelate (Sequestrene 330 DTPA 10% metallic iron) at 48 and 57 lb/acre.
(4) Manganese chelate ($Na_2$ Mn EDTA - 12% metallic manganese) at 40 and 48 lb/acre.
(5) Combined iron and manganese chelates at low rates only.
(6) Ammonium sulphate and iron chelate at low rates only.
(7) Urea and manganese chelate at low rates only.
(8) Control.
All chemicals were applied in aqueous solutions to plots on June 15. Color and height of seedlings were measured in early October 1962.

Sponsoring Organization: Forest Research Laboratory, Canada Department of Forestry, Winnipeg, Manitoba.

Personnel: M.I. Timonin.

Summary: In June 1962, ammonium sulphate (21-0-0), urea (45-0-0), iron chelate (10% Fe) and manganese chelate (12% Mn) were applied each at two levels and in various combinations to chlorotic seedbeds of white spruce. The object of the study was to determine if color and growth response which had been obtained previously with treatments of ammonium sulphate was due to nitrogen or to increased availability of iron and/or manganese.

In October 1962, high rates of nitrogen fertilizers (364 lb/acre of ammonium sulphate or 164 lb/acre of urea) had corrected chlorosis. Lower rates of nitrogen fertilizer were without effect. Applications of iron and manganese chelates separately or in combination did not remove chlorosis. High rates of iron and manganese chelates were slightly toxic to current foliage. Heights of seedlings at high rates of nitrogen application were 12 to 18 cm as compared with heights of 3 to 8 cm for the control seedlings.

Publication: Timonin, M.I. 1963. Chlorosis of white spruce seedlings in Saskatchewan nursery.
Department of Forestry, For. Ent. & Path. Br. Bi-Mon. Prog. Rept. 19:2.

Species: Red pine - 45 to 75 years old.

Location: 70 miles southeast of Winnipeg, Manitoba.

Region: Rainy River Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the effectiveness of ammonium nitrate for increasing red pine seed production.

Soil: Well drained sand.

Methods: Originally the study area supported a mixed stand of jack pine and red pine, but in the early 1950's all merchantable jack pine was removed. In 1962, the residual open spaced red pine varied in diameter from 4 to 15 inches and averaged 55 feet in height.

In late May 1962, prior to buds breaking, ten pairs of trees ranging in diameter from 6 to 15 inches, were chosen and one tree from each pair was chosen randomly for fertilizing, the other was untreated. Ammonium nitrate (33.5-0-0) fertilizer was applied at the rate of 15 pounds of fertilizer per tree and spread broadcast in a circular area with a radius of 25 feet about the base of the tree. This rate of application was equivalent to 300 lb/acre of fertilizer.

In early September 1964, all trees were felled and a count was made of all old and immature cones. Mature cones were picked for subsequent measurements of seed and cones.

Sponsoring Organization: Forest Research Laboratory, Canada Department of Forestry, Winnipeg, Manitoba.

Personnel: J.H. Cayford and J.M. Jarvis.

Summary: In late May 1962, prior to buds breaking, 10 red pine trees in an open-spaced stand 45 to 75 years old, with an average height of 55 feet, were fertilized with ammonium nitrate (33.5-0-0) at the rate of 15 pounds of fertilizer per tree, spread broadcast on the soil surface. Ten other trees were left as controls.

In September 1964, all trees were felled; old and immature cones counted, and mature cones collected for subsequent measurement.

Fertilization resulted in a significant increase in the total number of mature cones produced in 1964. Cone production for both unfertilized and fertilized trees was not related to diameter. A smaller percentage of cones were damaged in fertilized trees than control trees. Damage was caused primarily by insects and the overall damaged was 43%. Although greater numbers of large and small cones occurred in the fertilized than the control trees, the percentage of large cones was significantly greater on the unfertilized trees.

Fertilization had no effect on the seed production of small cones, but significantly increased the seed numbers in large cones. Seed soundness and viability did not differ significantly between treatments, nor did fertilization affect mean seed weight.

Species: White pine (2 + 2).

Location: Saddler Tract, Ausable River Conservation Authority, Middlesex County, Ontario.

Region: Niagara Section, Deciduous Forest Region.

Objective of Study: To investigate the possibility of reducing the period of competition between planted white pine and herbaceous vegetation by increasing height growth of pine by fertilization, and reducing growth of herbaceous species by herbicide application.

Soil: Clay loam cleared and pastured for many years.

Methods: In mid-April and early May 1964, two areas were planted with 2+2 white pine. Ammonium nitrate (33.5-0-0), potassium sulphate (0-0-48), and granular simazine (50w) were applied at different rates in combination.

Fertilizers and herbicides were premixed and applied broadcast, around the base of each tree. The following is a list of the treatments.

| Treatment No. | N lb/acre | K lb/acre | Simazine lb/acre |
|---|---|---|---|
| 1 | 75 | 20 | 4 |
| 2 | 75 | 20 | 8 |
| 3 | 150 | 40 | 4 |
| 4 | 150 | 40 | 8 |
| 5 | 300 | 80 | 4 |
| 6 | 300 | 80 | 8 |
| 7 | 0 | 0 | 4 |
| 8 | 0 | 0 | 8 |
| 9 | control | | |
| 10 | control | | |

Sponsoring Organizations: Ontario Region Office, Canada Department of Forestry, Richmond Hill, Ontario.
Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: F.W. von Althen.

Summary: In mid-April and early May 1964, two areas were planted with white pine. After planting, nitrogen as ammonium nitrate (33.5-0-0) and potassium as potassium sulphate (0-0-48) were applied in combination at three rates together with two rates of application of simazine herbicide. All treatments were made to the surface soil around the stem of each tree.

At the end of the first growing season, survival of trees was 100%. Weed control in Area A, planted in mid-April was very good, but in Area B, planted in early May, little control of weeds was evident.

Species: White pine and white spruce (2 + 2).

Location: Camp 83, Bailey Tract, Saugeen Authority Forest, Grey County, Ontario.

Region: Huron-Ontario Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To investigate the effects of fertilizers and herbicides on survival and height growth of conifer transplants machine planted in furrows on abandoned pasture-land of low fertility.

Soil: Pike Lake loam, cleared and pastured for many years.

Methods of Study: In May 1965, white pine and white spruce were machine planted in furrows, 10 days after planting, fertilizers and simazine were premixed and applied to the soil surface around each tree. Ammonium nitrate (33.5-0-0) was applied at rates of 50, 100, 200, and 400 lb/acre of nitrogen, singly and in combination with 200 lb/acre of phosphorus as triple superphosphate (0-45-0) and 50 lb/acre of potassium as potassium sulphate (0-0-48). All treatments included 3 lb/acre of simazine (50w).

Sponsoring Organizations: Ontario Region Office, Canada Department of Forestry, Richmond Hill, Ontario.
Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: F.W. von Althen.

Summary: White pine and white spruce transplants were machine planted in May 1965. Ten days after planting, ammonium nitrate (33.5-0-0) was applied, singly at rates of 50, 100, 200 and 400 lb/acre of nitrogen and in combination at the same rates with 200 lb/acre phosphorus as triple superphosphate (0-45-0) and 50 lb/acre of potassium as potassium sulphate (0-0-48). All treatments included 3 lb/acre simazine (50w).

Species: White spruce (1+0, 2+0) - red pine (1+0, 2+0).

Location: Provincial Forest Nursery, Midhurst, Ontario.

Region: Huron-Ontario Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the long term effect of repeated applications of mineral fertilizers and different organic amendments on soil fertility factors, the quality of consecutive crops of conifer seedlings and the incidence of nursery diseases.

Soil: Tioga fine sand.

Methods: In the summer of 1962, the experiment was established using four main treatments, (1) control, (2) nitrogen, phosphorus and potassium fertilizers, (3) nitrogen, phosphorus and potassium fertilizers plus peat, and (4) green manure plus nitrogen, phosphorus and potassium fertilizers. Details of treatments are as follows:

(2) Nitrogen - 144 lb/acre per 2+0 seedling crop as:
- (i) 14 lb/acre as ammonium phosphate (11-48-0) in soil preparation for fall seeding.
- (ii) 30 lb/acre as ammonium nitrate (33.5-0-0) in top dressing of rising 1+0 seedlings.
- (iii) 100 lb/acre as ammonium nitrate and ammonium phosphate in top dressings of 2+0 seedlings.

Phosphorus - 50 lb/acre per 2+0 seedling crop as:
- (i) 30 lb/acre as ammonium phosphate in soil preparations for fall seeding.
- (ii) 20 lb/acre as ammonium phosphate in top dressings of rising 2+0 seedlings.

Potassium - 150 lb/acre per 2+0 seedling crop as:
- (i) 100 lb/acre as potassium sulphate (0-0-48) in soil preparation for fall seeding.
- (ii) 50 lb/acre as potassium sulphate in top dressings of rising 2+0 seedlings.

(3) Peat plus fertilizers - Acid sphagnum peat applied at a rate of 60 $yd^3$/acre at time of soil preparation for fall seeding, together with fertilizer applications as listed in (2) with the exception of the nitrogen where 30 lb/acre of nitrogen was applied at the time of soil preparation instead of the 30 lb/acre applied as a top dressing of ammonium nitrate during the first growing season.

(4) Green manuring plus fertilizers - A mixed grass-legume green crop was grown during the summer and plowed down several weeks before fall seeding. The following fertilizer additions were made:

Nitrogen - 100 lb/acre as ammonium nitrate and ammonium phosphate as top dressings during the second growing season.

Phosphorus - 50 lb/acre per 2+0 seedling crop as:
30 lb/acre as calcium phosphate in soil preparation for green crop.
20 lb/acre as ammonium phosphate in top dressings of rising 2+0 seedlings.

Potassium - 150 lb/acre per 2+0 seedling crop as:
100 lb/acre as potassium sulphate in soil preparation for green crop.
50 lb/acre as potassium sulphate top dressing of 2+0 seedlings.

Summary: In 1964, an experiment was set out in nursery seedbeds in which 2-year-old seedlings of white spruce and red pine were to be grown. Treatments consisted of (1) control, (2) NPK fertilizers, (3) acid peat plus NPK fertilizers, and (4) green crop plus NPK fertilizers.

Sampling of seedlings and soil for measurements and analyses to be made in the spring of 1965.

Location: Provincial Forest Nursery, Midhurst, Ontario.

Region: Huron-Ontario Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine losses and leaching patterns of potassium added to nursery soils of different pH.

Soil: Tioga fine sand - fallow.

Methods: In 1963, potassium as potassium sulphate (0-0-48) was applied at rates of 75, 150 and 300 lb/acre to three soils which were treated with either sulphuric acid or lime to give soil reactions of pH 4,3, 5.1 and 6.4. Tension plate lysimeters were used to study the leaching patterns when the soils were exposed to rainfall and irrigation water.

Sponsoring Organizations: Forest Research Laboratory, Canada Department of Forestry, Maple, Ontario.
Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: H.H. Krause.

Summary: During the summer of 1963, the losses and leaching patterns of potassium were studied in three soils using tension lysimeters. The soil reactions were adjusted to pH 4.3, 5.1 and 6.4. Potassium as potassium sulphate was applied at the beginning of the experiment at rates of 75, 150 and 300 lb/acre in addition to a control.

During a period of one year, potassium losses from the most acid soil (pH 4.3) were 1.7 to 2.4 times higher than losses from moderately acid (pH 5.1) and weakly acid (pH 6.4) soils.

Seasons of greatest loss were late fall, early spring and wet periods during the summer.

Publications: Krause, H.H. 1965. Effect of pH on leaching losses of potassium applied to forest nursery soils.
Soil Sci. Soc. Amer. Proc. 29: 5, 613-615.

Species: White spruce - (seedlings).

Location: Provincial Forest Nursery, Midhurst, Ontario.

Region: Huron-Ontario Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine to what extent levels of available nutrients are affected by partial sterilization of the soil with methyl bromide.

Soil: Tioga fine sand.

Methods: In the fall of 1964, an experiment was established involving a control and fumigation with methyl bromide at the rate of 1 pound per 100 square feet. In addition, four fertilizer treatments were superimposed in the fumigation treatments. They were (1) NPK, (2) NP, (3) NK, (4) PK. The rates and times of application were as follows:
Nitrogen - 60 lb/acre as ammonium nitrate in top dressings of rising 1+0 seedlings.
Phosphorus - 100 lb/acre as calcium phosphate in soil preparation for fall seeding.
Potassium - 100 lb/acre as potassium sulphate in soil preparation for fall seeding.

Sponsoring Organizations: Forest Research Laboratory, Canada Department of Forestry, Maple, Ontario.
Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: H.H. Krause.

Summary: In the fall 1964, a treatment of methyl bromide was set out in a nursery soil, to be seeded with white spruce. Rate of application was 1 pound per 100 square feet. Four fertilizer treatments were superimposed on the methyl bromide area. They were (1) NPK, (2) NP, (3) NK, and (4) PK. Nitrogen was applied at the rate of 60 lb/acre as ammonium nitrate in top dressings to the rising 1+0 seedlings. Phosphorus was applied at a rate of 100 lb/acre as calcium phosphate in soil preparation for fall seeding as was potassium at a rate of 100 lb/acre as potassium sulphate.

Preliminary results show a marked difference between levels of mineral nitrogen in fumigated and non-fumigated soils. There were also indications that the level of weak acid extractable phosphorus was affected by methyl bromide treatment.

Species: White spruce (2+2) and (1-1/2 + 1-1/2).

Location: Bell's Corners, Ottawa.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the causes and relief of white spruce check.

Soils: Rideau clay, uplands sand and a loam.

Methods: White spruce transplants (2+2) were planted out on abandoned farmland in 1962. Three major treatment combinations were used:

(i) Nitrogen at rates of 100 and 200 lb/acre as ammonium nitrate (33.5-0-0) was applied to the soil surface with and without supplementary water and with and without weed control in all combinations. Fertilizer was applied early in the growing season.

(ii) As in (i) but with additional fertilizers - 100 lb/acre of potassium as potassium chloride (0-0-60) and 100 lb/acre of phosphorus as superphosphate (0-25-0).

(iii) Slow-release perforated polyethelene sachets of ammonium nitrate, potassium chloride and superphosphate were placed with the roots of 2+2, and 1-1/2 + 1-1/2 white spruce at time of planting in the spring.

Growth measurements are being made and will be related to foliar and soil analyses.

Sponsoring Organization: Ontario Region Office, Canada Department of Forestry, Richmond Hill, Ontario.

Personnel: R.F. Sutton.

Summary: In 1962, a large experiment using 2+2 transplants was set out in soil of three textures - clay, sand and loam. Nitrogen as ammonium nitrate, potassium as potassium chloride and phosphorus as superphosphate were broadcast to the soil surface in the spring after planting.

Fertilizer treatments, with and without supplementary water and with and without weed control, were used. In addition, slow release perforated polyethelene sachets containing nitrogen, potassium and phosphorus fertilizers were placed with the roots of 2+2 and 1-1/2 + 1-1/2 spruce at time of planting.

Species: Red pine, Norway spruce, jack pine.

Location: Ste. Christine, Portneuf County, P.Q.

Region: Middle St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To increase growth of plantations on abandoned farm lands by fertilizer additions and soil scarification.

Soils: Marine sands (90% sand, 10% silt plus clay). Land previously used for potato and tobacco crops, abandoned 1952.

Methods: The experiment was set out in the spring of 1964 and consisted of three rates of potassium, two of magnesium and two soil treatments (scarified and unscarified). The plots were randomized and the experiment had four replications. Potassium was applied at rates of 100 and 200 lb/acre as potassium sulphate (0-0-48). Magnesium was applied at a rate of 100 lb/acre as magnesium oxide. The fertilizers were applied to an area, 1-foot square around the base of each tree, 1 day after planting.

Sponsoring Organization: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.

Personnel: J.D. Gagnon.

at time of planting

Summary: In the spring of 1964, three rates of application of potassium (0,100 and 200 lb/acre as potassium sulphate and two rates of magnesium (0 and 100 lb/acre) as magnesium oxide were applied to the soil surface in an area 1-foot square around red pine, Norway spruce and jack pine 1 day after planting. In addition, two soil treatments (scarified and unscarified) were combined with the fertilizer.

After the first growing season, 3% mortality was recorded for trees on scarified soil and 5% on trees in unscarified plots.

Species: Jack pine.

Location: Ste. Christine, Portneuf County, P.Q.

Region: Middle St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To increase growth and survival of plantations on abandoned farmland using a combination of fertilizers and soil scarification.

Soil: Marine sand of low fertility, particularly potassium.

Methods: In the spring 1965, four rates of potassium (0, 100, 200 and 300 lb/acre) were applied broadcast to the soil surface as potassium sulphate (0-0-48). These applications were combined with two soil treatments - scarified and unscarified.

Sponsoring Organization: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.

Personnel: J.D. Gagnon.

Seedlings

Summary: In the spring 1965, four rates of potassium (0, 100, 200 and 300 lb/acre) as potassium sulphate were combined with two soil treatments (scarified and unscarified) in a jack pine plantation.

Species: Red pine - 20-year-old plantation.

Location: Valcartier Forest Experiment Station, Valcartier, P.Q.

Region: Middle St. Lawrence Section - Great Lakes-St. Lawrence Forest Region.

Objective of Study: To stimulate growth in a slow growing plantation of red pine.

Soil: River terrace in marine sand.

Methods: In the spring of 1956, 30 trees were selected at random and paired according to their diameters, heights, and competing crowns. Magnesium at the rate of 100 lb/acre and potassium at the rate of 200 lb/acre were broadcast on the soil surface covering an area with a radius of 30 feet around one of each of the 15 pairs of trees.

Diameter and height growth was measured for 7 years after treatment.

Sponsoring Organization: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.

Personnel: J.D. Gagnon.

Summary: The study was carried out in a 20-year-old red pine plantation. In the spring 1956, potassium at the rate of 200 lb/acre and magnesium at the rate of 100 lb/acre were applied on a single tree basis to 15 trees of a selected set of 30 which had been paired for similar height and diameter and competing crown competition.

Diameter and height measurements were made for 7 years following treatment.

Diameter growth responded significantly after the second growing season, and height after the third growing season. Stimulation of height and diameter growth was progressive and persisted over the 7 years of observation.

Publication: Gagnon, J.D. 1965. Effect of magnesium and potassium fertilization on a 20-year-old red pine plantation. For. Chem. 41.3: 290-294.

Species: Black spruce - seedlings.

Location: Valcartier Forest Experiment Station, Valcartier, P.Q.

Region: Middle St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the optimum nutritional conditions for growing black spruce to ensure survival and optimum growth after planting.

Soil: Sandy loam.

Methods: Nitrogen as ammonium sulphate (20-0-0) was applied at rates of 100, 200 and 300 lb/acre to seedbeds of black spruce. Times of application were May, June, and July 1964. Phosphorus as triple superphosphate was applied at rates of 200 and 400 lb/acre and potassium as potassium sulphate at rates of 150 and 300 lb/acre in the spring, 1964.

Sponsoring Organization: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.

Personnel: J.D. Gagnon.

Summary: In 1964, nitrogen, phosphorus and potassium were applied in a factorial experiment to seedbeds of black spruce.

Nitrogen as ammonium sulphate was applied in May, June, and July at rates of 100, 200 and 300 lb/acre. Phosphorus as triple superphosphate was applied at rates of 200 and 400 lb/acre and potassium as potassium sulphate at rates of 150 and 300 lb/acre were applied in the spring, 1964.

The effect of the fertilizers in growth and root development will be studied in 1965, and then the stock will be outplanted.

Species: Black spruce, jack pine, red pine.

Location: York River, Gaspé, P.Q.

Region: Gaspé Section, Boreal Forest Region.

Objective of Study: To determine the effects of soil treatments on growth of conifer plantations.

Soil: Deep sandy loam, derived from calcareous schists.

Methods: In June 1964, three treatments, (i) untreated, (ii) nitrogen as ammonium sulphate (20-0-0) at the rate of 200 lb/acre, and (iii) mixing of lichen crust (Lecidea granulosa), were applied in an outplanting experiment using three species - black spruce, jack pine and red pine.

The fertilizer was applied broadcast. Each treatment and each species were replicated twice in each block. A total of 72 plots were set out.

The site had supported a stand of black spruce which was burnt in 1941. At the time of the experiment there was only a sparse ground vegetation of Vaccinium canadense, Kalmia angustifolia and Polytrichum commune together with a surface crust of lichen.

Sponsoring Organization: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.

Personnel: J.D. Gagnon.

Summary: In June 1964, three treatments, (i) control, (ii) nitrogen at the rate of 200 lb/acre as ammonium sulphate, and (iii) mixing of lichen crust with soil, were used at the time of outplanting black spruce, jack pine and red pine. The fertilizer was applied broadcast.

Frost damage and growth response will be determined in the fall 1965.

Species: White spruce.

Location: Grand'Mère, P.Q.

Region: Middle St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To increase the fertility and organic matter in a soil for planting white spruce.

Soil: Marine sand.

Methods: The study was carried out in an area which supported a 29-year-old white spruce stand in deteriorated condition; previously the area had been farmed. In 1958, the existing stand was cleared, stumps were removed and the soil scarified. In the spring 1958, buckwheat was sown and a mixed (nitrogen, phosphorus and potassium) fertilizer (5-10-13) was applied at rates of 40 to 200 lb/acre. In addition, a bacterial compost was applied at 10 lb/acre. In August 1958, the buckwheat was plowed down. White spruce were planted. In 1962, fertilizer and bacterial compost were added to a part of the experimental area.

Sponsoring Organizations: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.
Consolidated Paper Corporation, Grand'Mère, P.Q.

Personnel: J.D. Gagnon.

Summary: A 29-year-old white spruce stand established on old farmland was felled in 1958 because of its deteriorated condition. The area was then stumped and scarified.

In the spring 1958, a mixed fertilizer (5-10-13) was applied at rates varying from 40 to 200 lb/acre, bacterial compost was applied at a rate of 10 lb/acre, and buckwheat was sown. In August 1958, the buckwheat was plowed down. White spruce was planted. In the spring 1962, additional fertilizer (NPK) and bacterial compost was applied to a part of the experimental area.

Soil scarification was found to be more beneficial to the planted spruce than fertilizer additions.

Species: White spruce and black spruce.

Location: Reservé St. Clet et St. Lazare, Vaudreuil-Soulanges County, P.Q.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the effects of adding fertilizers to nutrient deficient plantations of white and black spruce.

Methods: In the spring 1955, three permanent plots, each of 1 acre, were established in a plantation of white and black spruce. On one plot, 200 lb/acre of a mixed fertilizer (10-10-10) and 50 lb/acre of magnesium sulphate were applied. On the second plot, 200 lb/acre of potassium chloride (0-0-50) and 50 lb/acre of magnesium sulphate were applied. The third plot was a control. All fertilizers were broadcast in an area around the stems.

Sponsoring Organization: Bureau de Sylviculture et de Botanique, Quebec Department of Lands and Forests, Quebec, P.Q.

Summary: In the spring 1955, 200 lb/acre of a mixed fertilizer (10-10-10) and 50 lb/acre of magnesium sulphate were applied to a 1-acre plot of plantation white and black spruce. A second plot of one acre received 200 lb/acre of potassium chloride and 50 lb/acre of magnesium sulphate. A third plot was untreated. All fertilizers were applied around the base of each stem.

After several years, no diameter or height growth response was noted for the black spruce. White spruce, particularly trees in the 4-inch diameter class, responded in terms of diameter growth to the treatment of potassium chloride and magnesium sulphate. A number of white spruce also increased height growth in relation to this treatment.

Species: Red pine.

Location: Reservé St. Clet et St. Lazare, Vaudreuil-Soulanges County, P.Q.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study the effects of fertilizing a red pine plantation with magnesium sulphate.

Methods: Magnesium sulphate was applied broadcast at the rate of 200 lb/acre to a plantation of red pine.

Sponsoring Organization: Bureau de Sylviculture et de Botanique, Quebec Department of Lands and Forests, Quebec, P.Q.

Summary: Magnesium sulphate was applied broadcast at the rate of 200 lb/acre to a plantation of red pine.

After several weeks the majority of the fertilized trees had brown colored foliage and many of them subsequently died. The experiment has been discontinued.

Species: White and black spruce, 35-year-old plantation.

Location: Reservé St. Clet et St. Lazare, Vaudreuil-Soulanges County, P.Q.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study the effects of additions of composted hardwood leaves and farmyard manure on a plantation of white and black spruce.

Methods: In 1959, composted hardwood leaves at the rate of 5,000 lb/acre and farmyard manure at the rate of 5,000 lb/acre were added to a 35-year-old plantation of white and black spruce. The trees were very chlorotic and mortality was high.

In 1964, a second experiment was established using composted hardwood leaves at the rate of 10,000 lb/acre and farmyard manure at the same rate.

Both materials were applied broadcast around the base of each tree.

Sponsoring Organization: Bureau de Sylviculture et de Botanique, Quebec Department of Lands and Forests, Quebec, P.Q.

Summary: In 1959, composted hardwood leaves and farmyard manure were applied separately each at the rate of 5,000 lb/acre around the base of chlorotic 35-year-old white and black spruce.

At the end of the first growing season, the foliage of the treated trees had become green-blue. Measurements made yearly from 1959-1964 indicated that both species responded in both diameter and height to treatments.

In 1964, a second experiment was established using similar treatments, but the rates of application were increased to 10,000 lb/acre.

Species: White spruce (2 + 2).

Location: Reservé St. Clet et St. Lazare, Vaudreuil-Soulanges County, P.Q.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study the effects of additions of hardwood leaf litter and farmyard manure on white spruce.

Method: In May 1965, hardwood leaf litter was applied at rates of 5,000 and 10,000 lb/acre and farmyard manure at rates of 10,000 and 20,000 lb/acre to white spruce (2 +2) after planting.

Sponsoring Organization: Bureau de Sylviculture et de Botanique, Quebec Department of Lands and Forests, Quebec, P.Q.

Summary: In May 1965, hardwood leaf litter at rates of 5,000 and 10,000 lb/acre and farmyard manure at rates of 10,000 and 20,000 lb/acre were added to white spruce (2 + 2) after planting.

Species: White spruce - planted 1958.

Location: Zealand Township, Kenora District, Ontario.

Region: Quetico Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the effects of various fertilizers on the growth of white spruce.

Soil: Well-drained silt loam, previously farmed.

Method: In mid-August 1959, 150 trees were selected at random and five treatments were applied to 30 trees. The treatments were ammonium nitrate (33.5-0-0), potassium sulphate (0-0-48), single superphosphate (0-20-0), mixed fertilizer (10-10-10) and a control. Rates of application were given as 3/4 cup per tree. The fertilizers were applied in a circle around each tree at a radius of 8 inches from the stem.

Foliage color and height growth were assessed in August 1960, 1961, and 1962.

Sponsoring Organization: Ontario Department of Lands and Forests, Kenora, Ontario.

Personnel: R.B. Hall, J.R.M. Williams.

Summary: In mid-August 1959, ammonium nitrate, potassium sulphate, single superphosphate and a mixed fertilizer were applied each to 30 trees in a 1-year-old white spruce plantation.

Height growth measurements made in 1960, 1961, and 1962 indicated a definite response to the mixed fertilizer and single superphosphate and a slight response to potassium.

During the first 2 years, growth of competing grass was greatly stimulated by the fertilizer treatment.

Species: Red pine - 7-year-old plantation.

Location: Huntsville, Ontario.

Region: Georgian Bay Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: The diagnosis of a nutrient deficiency in a red pine plantation.

Soil: Medium sand, weak podzol profile in which the organic and $A_e$ layers had been plowed. A complete profile description was made and soil analyses (pH, OM, C.E.C., exchange Ca and K, and phosphorus) made.

Methods: The red pine were planted at a 6 x 6-foot spacing in 1950, on gently rolling land which had been cultivated and used as pasture for many years. In June 1957, heights of trees varied from 2 to 9 feet. One-year-old needles of many trees were chlorotic and 2-year-old needles were dead or distal halves of needles were necrotic. Both foliar discoloration and soil analyses indicated that the trees were probably deficient in potassium.

On June 19, 1957, at time of flushing of terminal buds, six plots, each containing 12 trees, were established. Six treatments were as follows: (1) control, (2) K - 75 lb/acre, (3) K - 150 lb/acre,(4) K - 300 lb/acre, (5) N - 99 lb/acre and K - 150 lb/acre, (6) N - 99 lb/acre, P - 59 lb/acre and K - 150 lb/acre.

Potassium was applied as potassium chloride (0-0-60), nitrogen as ammonium nitrate (33.5-0-0) and phosphorus as triple superphosphate (0-45-0) in circular area of 2 feet diameter about the base of each tree. Heights of all trees at time of plot establishment were measured. In October 1958, current height growth was measured and samples of current foliage from the terminal leader of each tree were collected for chemical analysis. In June 1960, the 1959 height increment was measured.

Sponsoring Organizations: Ontario Department of Lands and Forests, Toronto, Ontario.
Faculty of Forestry, University of Toronto.

Personnel: K.A. Armson.

Summary: In June 1957, three levels of potassium as potassium chloride (0-0-60) and two combinations - potassium plus nitrogen and potassium plus nitrogen plus phosphorus (nitrogen as ammonium nitrate, 33.5-0-0), and phosphorus as triple superphosphate (0-45-0) - were applied on a tree basis to a 7-year-old plantation of red pine with visual symptoms of a potassium deficiency. Rates of potassium applied were 75, 150, and 300 lb/acre. Rate of potassium, applied with nitrogen, and nitrogen and phosphorus was 150 lb/acre. Nitrogen applied at a rate of 99 lb/acre and phosphorus at 59 lb/acre.

At time of treatment, mean heights of trees in all plots were similar. In terms of 1958 and 1959 height growth, all potassium treatments resulted in significant increase compared with the controls. Maximum and similar heights were obtained in treatments with 150 and 300 lb/acre potassium. Current foliage analysed in 1958, indicated that levels of potassium were 0.3% (o.d.w.) for the control trees and 0.57 to 0.63% for plots receiving potassium. Nitrogen and phosphorus concentrations were similar for foliage from trees in all plots. By June 1960, trees receiving 150 and 300 lb/acre of potassium showed no foliage chlorosis and live, green 3-year-old needles were abundant. Control trees had foliage which remained chlorotic, with few 3-year-old needles.

Species: Red pine - 5-year-old plantation.

Location: Williams Farm, Simcoe County, Ontario.

Region: Huron-Ontario Section, Great Lakes-St. Lawrence Forest Region.

Methods: In mid-July 1956, 62 trees were treated with a mixed fertilizer (0-12-20) at the rate of 1 oz. $P_2O_5$ and 2 oz. $K_2O$ per tree. The fertilizer was applied broadcast to an area with a 3- to 4-foot diameter around each tree. A comparative number of untreated trees were measured as controls. At time of treatment the foliage was chlorotic, 3-year-old foliage was lacking, and growth was poor.

Sponsoring Organization: Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: J.R.M. Williams.

Summary: In mid-July 1956, a mixed fertilizer (0-12-20) was applied to the soil surface around the base of chlorotic slow-growing red pine in a 5-year-old plantation. Rate of application was equivalent to 1 oz. of $P_2O_5$ and 2 oz. of $K_2O$ per tree.

Height growth measurements in 1957 and 1961 indicated a significant growth response to fertilizer treatment compared with height growth of untreated controls.

Species: Red pine - plantation.

Location: Cambridge Township, Prescott and Russell Counties, Ontario.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To increase height growth of red pine using fertilizers.

Soil: Deep medium to fine sand, with plow layer; weathered profile 18 to 24 inches deep.

Methods: Small sample plots consisting of approximately 10 trees, each set out in 3- to 4-year-old plantation of red pine at a 7 x 7-foot spacing. The following fertilizer treatments were applied: potassium chloride (0-0-60) at 1, 2, 4 and 8 oz. per tree, ammonium nitrate (33.5-0-0) at 3 oz. plus potassium chloride at 4 oz. per tree, single superphosphate (0-20-0) at 4 oz. plus potassium chloride at 4 oz. per tree and ammonium nitrate at 3 oz. plus superphosphate at 4 oz. and potassium chloride at 4 oz. per tree.

All fertilizers were applied broadcast to an area with 1-foot radius around the base of each tree in early July 1957.

Heights of all trees were measured in 1957, and again in May 1961.

Sponsoring Organization: Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: J.R.M. Williams, K.A. Armson.

Summary: Potassium, nitrogen and phosphorus fertilizers were applied to a young red pine plantation in early July 1957. Potassium chloride was applied at rates of 1, 2 and 4 and 8 oz. per tree. Ammonium nitrate at rates of 3 oz. per tree in combination with 4 oz. of potassium chloride and in a second combination with 4 oz. of superphosphate and 4 oz. of potassium chloride.

Total tree heights were measured in 1957 and in May 1961. Maximum height growth response (1958-61) occurred on the NK plot - 5.0 feet compared with the control 3.5 feet. Treatment with 4 oz. of potassium chloride resulted in a height growth of 4.7 feet over the same period.

Species: White spruce - 12-year-old plantation.

Location: Cambridge Township, Prescott and Russell Counties, Ontario.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine if addition of nitrogen fertilizer will increase height growth of white spruce.

Soil: Loamy sand, plow layer over a gleyed medium sand with a water table at 10 inches.

Methods: In mid-June 1956, a series of 1/10- and 1/20-acre plots were set out in chlorotic slow-growing white spruce. Spacing of trees was 7 x 7 feet. One series of plots was treated with ammonium sulphate (20-0-0) at a rate of 150 lb/acre and a second series was treated at a rate of 300 lb/acre. A third set of plots were controls. Fertilizer was applied broadcast to the soil surface. Total heights of trees (1955), 1956 and 1957 height growth, and total tree heights in 1961, were measured.

Sponsoring Organization: Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: J.R.M. Williams, K.A. Armson.

Summary: In June 1956, ammonium sulphate at rates of 150 and 300 lb/acre was applied broadcast to slow-growing white spruce planted in 1944. The soil was poorly drained with a water table at 10 inches.

Height measurements indicated no response to treatments in 1956; in 1957, a small height response occurred in trees treated at a rate of 300 lb/acre. Total height of trees in 1961 showed no significant difference.

Species: Lodgepole pine - 4-year-old plantation.

Location: Valcartier, P.Q.

Region: Middle St. Lawrence Section, St. Lawrence Forest Region.

Objective of Study: To study the effects of potassium and magnesium fertilizers on the growth of lodgepole pine.

Methods: In 1956, a 4-year-old plantation of lodgepole pine was fertilized with potassium chloride and magnesium oxide. Rates of application for both fertilizers were 50 and 100 lb/acre, applied singly and in combination. Each plot was 1/40-acre and there were six replications.

Annual height measurements were recorded from 1955 to 1960.

Sponsoring Organization: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.

Personnel: A. Linteau.

Summary: Potassium chloride and magnesium oxide were applied at rates of 50 and 100 lb/acre, both singly and in combination to a 4-year-old plantation of lodgepole pine at Valcartier, P.Q., in 1956.

At the end of the first growing season, after treatment, no appreciable differences in height growth were recorded. After the second growing season, 1957, differences in height were significant with rates of 100 lb/acre producing greater response than the remainder; also, Mg treated plots were better than K treated and K treated showed greater height than controls. At the conclusion of the 1960 growing season, the high rate of application increased height growth more than the other treatments and magnesium treatments were more effective than those with potassium.

Species: White spruce and red pine - plantations.

Location: Valcartier, P.Q.

Region: Middle St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study the effects of potassium and magnesium fertilizers on the growth of white spruce and red pine.

Soil: Sand - river terrace.

Methods: A series of plots, each approximately 500 $ft^2$, in extent were set out in 1952. In September 1952, white spruce were planted, 20 trees per plot in one-half of the plots. In September 1953, the remaining plots were planted with red pine at 20 trees per plot. In the spring 1954, potassium chloride (0-0-60) and magnesium oxide in granular form were applied to the soil surface at rates of 100 and 200 lb/acre both singly and in combination.

Survival and heights were recorded during the period 1954-1958.

Sponsoring Organization: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.

Personnel: A. Linteau.

Summary: Potassium chloride and magnesium oxide were applied at rates of 100 and 200 lb/acre, both singly and in combination to the soil surface in the spring 1954. The plots had been planted previously with white spruce in September 1952, and red pine in September 1953.

Survival and height growth were recorded for the period 1954-1958. In 1954, 33% of the spruce died in the growing season following treatment, whereas mortality of the pine was only 3%. Regardless of treatment, mortality of pine during the period 1955-1958 was high (38%) in the plots located in a depression. Mortality in both pine and spruce was relatively lower for treatments where magnesium or magnesium plus potassium was applied on slope positions.

Treatments of potassium plus magnesium were most effective in reducing foliage chlorosis, treatments of potassium alone brought no response. Frost damage during the period 1956-1958 was significantly lower for both spruce and pine receiving potassium plus magnesium treatments.

Height growth of pine was affected significantly by treatments. Combined treatments were more effective than magnesium alone.

Species: White spruce - 33-year-old plantation.

Location: Grand'Mère, P.Q.

Region: Laurentian Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study the effects of potassium and magnesium fertilizers on the growth of white spruce.

Soil: Loamy sands and sandy loams over deep coarse sand.

Methods: In May 1956, potassium and magnesium fertilizers were applied to three sites - Calliergon-Polytrichum, Cladonia-Polytrichum and Kalmia-Spiraea supporting 33-year-old white spruce. Treatments were: 200, 100, and 50 lb/acre of potassium chloride (0-0-60) and 100 lb/acre of potassium chloride plus 50 lb/acre of magnesium oxide and 50 lb/acre of potassium chloride plus 25 lb/acre of magnesium oxide. Each treatment was applied to two 1/5-acre plots on each of the three sites. Heights and diameters of the ten largest trees in each of the plots were measured.

Sponsoring Organization: Quebec District Office, Canada Department of Forestry, Sillery, P.Q.

Personnel: A. Linteau.

Summary: Potassium chloride at rates of 50, 100 and 200 lb/acre, potassium chloride at 100 lb/acre plus 50 lb/acre of magnesium oxide and potassium chloride at 50 lb/acre plus 25 lb/acre of magnesium oxide were added to the soil beneath a 33-year-old plantation of white spruce in May 1956. Treatments were applied to two 1/5-acre plots in each of three site types.

In the spring 1958, coloration of foliage had become a normal green. Three years after treatment some response in heights was observed, but only a part could be attributed to the treatments. Annual height growth was 50% greater than before treatment on the Cladonia-Polytrichum site but no difference with respect to treatments was apparent. On the Kalmia-Spiraea site, height response only occurred in the treatment of 200 lb/acre of potassium chloride. No height response occurred on the Calliergon-Polytrichum site. In terms of diameter growth, all treatments gave significant increases compared with controls. Response was greatest for trees in the Cladonia-Polytrichum site.

Publication: Linteau, A. 1962. Some experiments in forest soil fertilization. In: Forest Fertilization in Canada. Bull. No. 5. Fonds. de Rech. For. de Univ. Laval. 1962.

Species: White pine, red pine and white spruce - plantations.

Location: Valcartier, Proulx and Cap-Tourmente, P.Q.

Region: Middle St. Lawrence Section, St. Lawrence Forest Region.

Objective of Study: A study of potassium and magnesium deficiencies in white pine, red pine and white spruce plantations.

Soils: Coarse sands of alluvial or glacio-fluvial origin. Prior to planting they were farmed for many years.

Methods: From 1948-1952, soil analyses were made on samples taken from three plantation locations. Analyses were made of foliage taken from plantation trees and these suggested potassium and/or magnesium deficiencies in white and red pine and potassium deficiency in white spruce.

Trial applications of potassium chloride (0-0-60) at a rate of 200 lb/acre and magnesium sulphate at 50 lb/acre were made.

Sponsoring Organization: Faculté de Genie Forestier, Université Laval, Quebec, P.Q.

Personnel: A. Lafond.

Summary: Trial applications of potassium chloride (0-0-60) at 200 lb/acre and magnesium sulphate at 50 lb/acre were made in plantations of white pine, red pine and white spruce. Soil analyses had previously indicated low fertility levels and foliage analyses suggested that there were potassium and/or magnesium deficiencies in the pines and potassium deficiency in the white spruce.

After treatment, height growth increased and chlorosis of foliage disappeared.

Publication: Lafond, A. 1958. Les deficiencies en potassium et magnesium de quelques plantations de Pinus strobus, Pinus resinosa, et Picea glauca dans la province de Quebec. Bull. No. 1. Fonds. Rech. For. Univ. Laval, Quebec. pp.24.

Species: White spruce and Norway spruce - plantations.

Location: Radnor Twp., Grand'Mère, P.Q.

Region: Laurentian Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study the effects of manure on a white spruce and Norway spruce plantation at Grand'Mère, Quebec.

Soil: Deep sand, well-drained.

Methods: White and Norway spruce, 2 + 2 transplants, were planted at a 5 x 5 foot-spacing in June 1920. On separate plots approximately 1/2-acre in area, 15 and 30 tons of manure was spread on the ground and plowed in before planting. A 1-acre control plot was established for the white spruce.

At the time of establishment in 1920, heights of all trees were recorded and their locations mapped. In September 1922, and May 1925, plots were remeasured to compare mortality and height growth. In 1946, and 1956, diameter and height measurements were taken and height diameter curves and local volume tables prepared for each species.

During this 36-year period the manured plots were thinned in 1939 and a few suppressed trees removed. In 1950, pruning was undertaken and in 1953, suppressed trees were removed. In 1957, suppressed trees from the Norway spruce plots only, were removed.

The provenance of the Norway spruce used was Norrland, Sweden, and that of the white spruce, Black Hills, South Dakota.

Sponsoring Organizations: Canada Department of Forestry, Valcartier, P.Q. Consolidated Paper Corporation, Grand'Mère, P.Q.

Personnel: J.D. MacArthur, W.L. Bubie.

Summary: Manure at rates of 15 and 30 tons per acre was spread and then plowed in before planting Norway and white spruce, 2 + 2 transplants at a 5 x 5 foot-spacing in June 1920. One thinning was carried out in 1939.

Norway spruce greatly exceeded white spruce in volume on manured plots over the 37-year-period (5,100 and 5,460 as compared with 2,960 and 2,700 cubic feet for each species at 15 and 30 tons rates respectively). As indicated, these were only small differences in volume between two rates of manure. In contrast the volume of white spruce in the control plot was only 956 cubic feet after 37 years.

Publication: MacArthur, J.D. 1957. The effects of manure on a white and Norway spruce plantation at Grand'Mère, Quebec. Tech. Note No. 64. Forest Res. Div., Forestry Branch, Dept. North. Affairs National Resources, Ottawa.

Species: Lodgepole pine, 15 years old.

Location: Embarras Working Circle, Hinton, Alberta.

Region: East Slope Rockies Section, Subalpine Forest Region.

Objective of Study: To attempt to develop differential vigor by fertilization of selected crop trees in a stand of stagnating lodgepole pine.

Soils: Well-drained stony loam till, pH 5.0; nitrate N, trace; phosphorus, 4 lb/acre; potassium 70 lb/acre; calcium 40 ppm.

Methods: The stocking of the pine stand varied from 7,200 to 15,300 stems per acre. In 1958, five 1/5-acre plots were established and crop trees were selected on a 6 x 6-foot spacing, each tree was logged and its total height measured. In 1959, another 1/5-acre plot was established. On each plot a total of 225 trees were selected.

In the spring of 1958, selected trees in plots No. 1 and 4 were treated at the rate of 4.25 oz. per tree (300 lb/acre) with a mixed fertilizer (10-32-10). In the spring of 1959, plot No. 1 received a second application at the same rate.

Selected trees in Plots No. 2 and 5 were treated at the rate of 4.25 oz. per tree (300 lb/acre) with ammonium nitrate (33.5-0-0) in the spring 1958. Plot No. 2 received a second application of ammonium nitrate at the same rate in the spring 1959.

Plot No. 3 was a control.

Plot No. 6 established in the spring, 1959, received urea at the rate of 4.25 oz. per tree.

In all applications the fertilizer was applied broadcast to the soil surface adjacent to the crop tree.

Sponsoring Organization: North Western Pulp and Power Limited, Hinton, Alberta.

Personnel: D.I. Crossley.

Same as No 31 on page 61

Summary: The project was established in a 15-year-old stand of stagnating lodgepole pine. In the spring 1958, a mixed fertilizer (10-32-10) and a nitrogen fertilizer ammonium nitrate (33.5-0-0) were applied to selected crop trees (1000 per acre) at the rate of 4.25 oz. of fertilizer per tree (300 lb/acre). Two plots each received a second application of the respective fertilizer in the spring 1959. An additional plot was set out in 1959, and 4.25 oz. of urea was applied to selected crop trees. The purpose of these treatments was to increase the vigor of the selected trees in the stagnating stand.

In the fall of 1960, the trees in the treated and control plots were remeasured. Although a small increase in height growth, when compared with untreated control trees, was apparent, there was no indication that the condition of stagnation had been overcome.

Species: Douglas fir.

Location: Vancouver Island, B.C.

Region: Southern Pacific Coastal Section, Coast Forest Region.

Objective of Study: To investigate the possibility of increasing cone production in Douglas fir.

Methods: An exploratory trial using (a) ammonium nitrate (33.5-0-0), (b) ammonium sulphate (20-0-0), (c) ammonium phosphate (11-48-0), (d) a mixed fertilizer (nitrogen, phosphorus and potassium), (e) superphosphate, and (f) control plot, was established in mature Douglas fir in October 1954. The trial was repeated in the spring, 1955, the fall of 1955, and the spring of 1956.

In 1956 and 1957, the trial was repeated in young Douglas fir stands and two further treatments of sodium nitrate and calcium nitrate were added.

In 1958, ammonium nitrate (33.5-0-0) was added at the rate of 400 lb/acre to younger trees in each of five months, February, March, April, May and June. In the spring 1960, a trial using ammonium nitrate was set out, applying the fertilizer prior to, at the time of, and after the time of opening of vegetative buds.

Cone yields were measured from trees in all trials.

Sponsoring Organization: MacMillan, Bloedel and Powell River Ltd., Vancouver, B.C.

Personnel: T.N. Stoate, I. Mahood, E.C. Crossin.

Summary: During the period 1954-1960, a series of fertilizer trials were set out in both mature and younger stands of Douglas fir to determine if cone yields could be increased. The main fertilizer used was ammonium nitrate, but ammonium sulphate, ammonium phosphate, mixed fertilizer (NPK), superphosphate, sodium and calcium nitrate were also employed.

From the preliminary trial it was found that all treatments of ammonium sulphate, ammonium phosphate and NPK mixture, increased both the quantity and size of cones. But ammonium nitrate and the mixed fertilizer increased the numbers of flower buds produced. The mixed fertilizer contained nitrogen as ammonium nitrate.

It was found that, using nitrate nitrogen, the time of application is important in increasing female cone production. Application at time of flushing of the vegetative buds was found to result in increased female cone production.

Publication: Stoate, T.N., Mahood, I., and Crossin, E.C. 1960. Cone production in Douglas fir. Emp. For. Rev. 40:2, 105-110.

Species: Douglas fir - 7-year-old plantation.

Location: Robertson River Valley, Cowichan Lake, B.C.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To study the effects of various nitrogen fertilizers on the height growth of young Douglas fir.

Soil: Stony coarse sand.

Methods: In late March 1958, ammonium sulphate (20-0-0) at rates of 1, 2, 4, and 16 oz. per tree, uramite (38-0-0) at a rate of 2.1 oz. per tree, calcium cyanamide (21-0-0) at 3.81 oz. per tree, calcium nitrate (15-0-0, -43% Ca) at 5.33 oz. per tree, ammonium phosphate (16-20-0) at 5 oz. per tree and milorganite (5-3-0) at 16 oz. per tree were applied broadcast to the soil surface under the crowns of each tree and lightly cultivated. All treatments, except ammonium sulphate, received nitrogen at the rate of approximately 400 lb/acre. This rate was equivalent to the 4 oz. per tree rate of ammonium sulphate.

Annual height growth was measured for the years 1958, 1959 and 1960.

A total of 275 trees were treated, 25 trees were in each treatment plot, and the control.

Sponsoring Organization: Research Division, British Columbia Forest Service, Victoria, B.C.

Personnel: H. Knight.

Summary: In late March 1958, five nitrogen fertilizers - uramite, calcium cyanamide, calcium nitrate, ammonium phosphate and milorganite - were applied to individual trees in a 7-year-old plantation of Douglas fir at a rate of 400 lb/acre of nitrogen. In addition, ammonium sulphate was applied at rates of 100, 200, 400, 800, and 1600 lb/acre of nitrogen on a per tree basis.

Fertilizers giving the greatest height growth response were milorganite, ammonium phosphate and ammonium sulphate at the 4 oz. per tree (400 lb/acre N) rate. Generally, larger trees showed a greater response.

All fertilizers induced a deeper green coloration in the 1958 foliage. Calcium cyanamide caused some mortality and partial defoliation. Defoliation also occurred with the 4 and 16 oz. treatments of ammonium sulphate.

Species: White spruce, red pine, basswood, white ash, and silver maple plantations.

Location: Morgan Arboretum, Macdonald College, P.Q.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study the uptake of nitrogen, phosphorus and potassium and the growth response of fertilized seedlings over a 5-year period.

Methods: Nitrogen, phosphorus and potassium singly and in all combinations were applied in June 1958, to plantations of white spruce, red pine, basswood, white ash and silver maple.

Foliage analyses and leader measurements were made at yearly intervals.

Sponsoring Organization: Macdonald College, P.Q.

Personnel: A.R.C. Jones.

Summary: In June 1958, nitrogen, phosphorus and potassium were added singly and in all combinations to plantations of white spruce, red pine, basswood, white ash and silver maple.

No significant increase in uptake or concentration of the applied nutrient elements was shown by the foliage. Only for the broad-leaved species was there an increase in height growth and this was where NPK were applied together.

Species: White spruce - 10 years old; red pine - 8, 14, and 80 years old.

Location: Chalk River, and Simcoe County, Ontario.

Region: Huron-Ontario and Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To induce flower production in white spruce and red pine.

Methods: In a 10-year-old stand of white spruce, ammonium nitrate (33.5-0-0) at four rates - 0, 50, 100 and 200 g per plant - was applied on May 30. In addition, certain trees were root-pruned at different intervals (April 30, June 7, June 27 and August 1) during the growing season. A similar experiment was established in 8-year-old red pine.

A third experiment established in 14-year-old red pine involved treatments of a mixed fertilizer (4-24-12) at a rate of 50 $g/m^2$, hydrated lime at 300 $g/m^2$ and ammonium nitrate at rates of 50, 100 and 200 $g/m^2$. All fertilizers were applied on June 6. Another experiment in the 14-year-old pine involved strangulation, ringing and treatments of superphosphate, ammonium nitrate and two mixed fertilizers, 4-12-6 and 10-6-4.

Finally, treatments of a mixed fertilizer (4-12-6) and ammonium nitrate were applied at rates of 50 $g/m^2$ of each fertilizer to an 80-year-old stand of red pine in a deep infertile sand.

Sponsoring Organization: Canada Department of Forestry, Ottawa, Ontario.

Personnel: M.J. Holst.

Summary: A series of experiments were established in white spruce and red pine plantations and in natural, mature red pine stand. These trials used ammonium nitrate, superphosphate, hydrated lime and mixed fertilizers at different levels. Other treatments such as root pruning, strangulation and ringing were also used.

Numbers of female flowers in the 10-year-old white spruce tended to increase with rates of ammonium nitrate application, the treatments were less effective if root pruning was delayed after June 27. The same treatments applied to 8-year-old pine, failed to induce flowering.

Treatments of a 14-year-old stand of red pine indicated the ammonium nitrate was most effective in inducing flowering. Ammonium nitrate was also effective over a 2-year-period in inducing greater flower development.

Publication: Holst, M.J. 1959. Experiments with flower promotion in *Picea glauca* (Moench) Voss. and *Pinus resinosa* Ait. In: Recent Advances in Botany, Univ. Tor. pp.1654-8.

Species: White spruce and red pine.

Location: Orono, Ontario.

Region: Niagara Section, Deciduous Forest Region.

Objective of Study: To determine the effects of different levels of soil fertility and seedling spacing on the growth of white spruce and red pine.

Soil: A nursery soil - sandy loam.

Methods: In November 1962, a factorial experiment was set out using white spruce and red pine, three fertility levels and four spacings (10, 20, 40 and 60 seedlings per square foot). Plot size was 1.22 $yd^2$ and each treatment was replicated three times.

Fertility levels were established by adding nitrogen as ammonium sulphate (20-0-0), phosphorus as triple superphosphate (0-45-0) and potassium as potassium sulphate (0-0-45). Rates of addition were as follows:

| Fertility level | Nitrogen lb/acre | | Phosphorus lb/acre | Potassium lb/acre |
|---|---|---|---|---|
| | 1963 | 1964 | | |
| 1 | 30 | 60 | 100 | 60 |
| 2 | 60 | 120 | 200 | 130 |
| 3 | 120 | 240 | 400 | 240 |

The triple superphosphate and potassium sulphate were worked into the soil prior to seeding in November 1962. Nitrogen was applied as a top dressing during the 1963 and 1964 growing seasons. In 1963, five equal applications were made during June to September, and in 1964, four equal applications were made during June to September. The seedbeds were thinned to the appropriate densities in mid-June 1963.

In mid-October 1964, twenty spruce seedlings were sampled from each plot for measurement, and in late November, a similar number of pine seedlings were sampled. Total heights, diameters, and dry weights of component organs - foliage stems and roots - were determined. Nitrogen, phosphorus and potassium analyses were made in samples from the tissues of each organ.

Sponsoring Organizations: Ontario Department of Lands and Forests, Toronto, Ontario.
Faculty of Forestry, University of Toronto, Toronto 5, Ontario.

Personnel: K.A. Armson, W.R. Bunting, K.N. Reese.

Summary: Seedlings of white spruce and red pine were grown for 2 years, 1963 and 1964, at three fertility levels and four different spacings. The fertility levels were created by adding ammonium sulphate, triple superphosphate, and potassium sulphate to the soil. The ammonium sulphate was applied periodically during the two growing seasons, but the phosphorus and potassium fertilizers were mixed into the soil prior to sowing the seed in November 1962. Seedling spacings used were 10, 20, 40 and 80 per square foot.

Measurement of seedlings after sampling in the fall, 1964, showed the following results:

1. For white spruce both increase in fertility and decrease in seedbed density resulted in heavier and taller seedlings.

2. For red pine, decrease in seedbed density but not an increase in fertility resulted in heavier seedlings. Seedling heights were unaffected by changes in fertility and density.

3. Measurements of foliage concentrations and total nitrogen contents of seedlings indicated that growth of white spruce seedlings was limited by nitrogen supply. White spruce, especially at the lower fertility levels, was much less efficient than red pine in absorbing nitrogen from the soil.

4. Over the ranges of fertility and density used, total seedling dry matter production per unit area increased with increase in seedbed density. This contradicts a belief held by many foresters that such a production is usually constant.

Species: White spruce - seedlings.

Location: St. Williams, Ontario.

Region: Niagara Section, Deciduous Forest Region.

Objective of Study: To study the effects of levels and times of fertilizer application on the growth of white spruce seedlings.

Methods: In April 1961, an experiment was set out in 1-year-old seedbeds of white spruce. Four levels of nitrogen and phosphorus were applied as ammonium sulphate and triple superphosphate respectively. Fertilizer levels were: 0 - no fertilizer; 1/2 - 30 lb/acre of N and 20 lb/acre of P; 1 - 60 lb/acre of N and 40 lb/acre of P; 2 - 120 lb/acre of N and 50 lb/acre of P. Each level of fertilizer was applied on three time schedules termed "Periodic", "Normal", and "Summer and Fall". All treatments were replicated four times. The seedlings were thinned to a uniform spacing of 30 per square foot at the beginning of the experiment. All fertilizers were applied as a broadcast top dressing and watered into the soil. The seedlings were unshaded and irrigated from May to November. Thirty seedlings were selected randomly in early December 1961, and heights, total dry weights, and foliage weights were measured. Nitrogen, phosphorus and potassium analyses were determined for the foliage.

Sponsoring Organizations: Ontario Department of Lands and Forests, Toronto, Ontario.
Faculty of Forestry, University of Toronto, Toronto, Ontario.

Personnel: K.A. Armson.

Summary: Four levels of nitrogen and phosphorus were added in combination on three different time schedules to white spruce seedlings during their second growing season at St. Williams nursery in 1961. The three time schedules were (i) "Periodic", in which fertilizer was applied in fine dressings from May to September; (ii) "Normal", in which fertilizer was applied in May, June and July; and (iii) "Summer and Fall", in which fertilizer was applied in May, June and September.

Seedling dry weight increased with increasing level of fertilizer application, but was not significantly affected by time of application. Seedling height showed a general increase with increase in fertilizer supply. Shoot-root ratios increased with increase in level of fertilizer; however, by using a "Periodic" time schedule, the increase was minimized. Nitrogen concentrations and contents in the foliage increased with increase in fertilizer level and "Periodic" and "Summer and Fall" applications resulted in lower concentrations than did those under the "Normal" time schedule. Foliage concentrations of phosphorus were unaffected by any of the treatments.

Publication: Armson, K.A. 1963. The effects of levels and times of fertilizer application on the growth of white spruce seedlings. Soil Sci. Soc. Am. Proc. 27:5:596-597.

Species: Populus nigra x P. deltoides (Raverdeau); Populus eugenei (Carolina).

Location: Harrington Farm, Grenville, P.Q.

Region: Upper St. Lawrence Section, Boreal Forest Region.

Objective of Study: To study the effects of tillage, fertilizer and herbicide on the growth of Raverdeau poplar.

Soil: Well-drained, brown podsolic, Brebeuf fine sandy loam.

Methods: In 1955, Raverdeau poplar were set out, nine to a plot. Three treatments were used: tillage, mixed fertilizer (10-10-10), two placements - 1 oz. deep, and 1/2 oz. broadcast - and treatment of herbaceous vegetation with maleic hydrazide. In 1956, the nine trees per plot were thinned to five and tillage was continued by hand-hoeing in mid-July and mid-August. The length of the longest shoot for each tree was recorded in early September 1956.

In 1956, a second experiment was established using cuttings of Carolina poplar, graded and cut to 36 inches. There was a randomized factorial arrangement with treatments of: tillage (rototilling prior to planting and land hoeing in mid-July and early August); nitrogen fertilization - 1 oz. of urea (45-0-0) applied 1 inch below the roots at time of planting; herbicide - 1 lb. acid equivalent of 24-D and 10 lb. acid equivalent of Radapon (2, 2-dichloro propionic acid) per acre with water and sprayed to "run off", prior to planting. Each plot was 16 x 16 feet and contained nine trees at 4 x 4 feet spacing. Trees were planted at least 5 days after herbicide treatment. In early September 1956, the trees were measured and the roots of some were excavated and examined. Foliage samples of the lower five leaves and the upper nine of the stem were taken and analyzed for nitrogen, phosphorus, potassium, calcium and magnesium.

Sponsoring Organization: Canadian International Paper Company Limited, Montreal, P.Q.

Personnel: P.L. Aird.

Summary: In 1955 and 1956, experiments were set out, using poplar cuttings and involving treatments of tillage (prior to planting) nitrogen fertilization (urea (45-0-0) applied in planting hole below roots at time of planting) and herbicide applications. In 1955, the poplar used was Raverdeau (P. nigra x P. deltoides) and the herbicide was maleic hydrazide. In 1956, the poplar used was P. eugenei and the herbicide was a mixture of 24-D and Radapon. The soil on which the study was carried out was Brebeuf fine sandy loam which had previously been farmed but was abandoned some years before the experiment.

In both experiments, tillage increased height, volume and leaf weight significantly. The maleic hydrazide effectively reduced growth of the herbaceous vegetation, but did not affect significantly tree height; it had no effect on the herbaceous vegetation the second year after application. The maleic hydrazide application on the tilled plots resulted in a significant increase in tree volume in the first year.

The 24-D Radapon treatment resulted in very significant increases in first year leader length, volume and leaf weight. At the end of the first growing season, herbicide treatments were significantly more effective in increasing height than tillage. The herbicide controlled the herbaceous vegetation more effectively than tillage during the early part of the growing season. However, in the second growing season, tilled plots gave significantly better height growth than the herbicide treatments and over both years, tillage was superior.

Fertilizer treatments (10-10-10) significantly increased height and volume of trees; this was only where deep placement was used. There were no significant differences in height between broadcast fertilized trees and of the control. Response to deep fertilizer was greater on the tilled than non-tilled plots. In the second year, no response to fertilizer was noted.

In the 1956 experiment, using urea, there was no height response to fertilizer in the first year. Foliar analyses indicated low levels of phosphorus and potassium. However, leaf weight and content ration and content of nitrogen was increased as a result of the urea application.

Publications: Aird, P.L. 1956. Fertilizers in forestry and their use in hardwood plantation establishment. Pulp and Paper Mag. Can. 57:376, 379-381, 384.

Aird, P.L. 1962. Fertilization, weed control and the growth of poplar. For. Sci. 8:413-428.

Species: Douglas fir - seedlings.

Location: Duncan and Quinsam (Nurseries), B.C.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effects of calcium, magnesium, boron and nitrogen, phosphorus and potassium fertilizers on the growth of Douglas fir seedlings.

Methods: In 1960, powdered calcium carbonate and magnesium carbonate were each applied at 1000 and 3000 lb/acre and borax at 10 lb/acre to 40 square-foot plots. A split plot design was employed and half of each plot received ammonium nitrate (33.5-0-0) superphosphate (0-21-0) and potassium sulphate (0-0-48) supplying elemental nitrogen, phosphorus and potassium each at 20 lb/acre. Seed was sown at Quinsam on May 17, and at Duncan on May 24. Only nitrogen was applied after sowing on June 10. There were three replicates at each nursery.

Seedlings were sampled for measurement in October 1961, but in addition, seedbed densities were measured in October 1960.

Sponsoring Organization: British Columbia Forest Service, Victoria, B.C.

Personnel: R. van den Driessche.

Summary: In May 1960, fertilizer trials were set out at Quinsam and Duncan nurseries. Calcium and magnesium were applied at two levels and boron at one level; one-half of each plot received an application of nitrogen, phosphorus and potassium, each (NPK) element at the rate of 20 lb/acre.

At both nurseries, applications of calcium, magnesium and boron reduced seedbed densities. At Duncan, treatments of NPK reduced densities.

Increase in height and weight was associated with application of NPK fertilizers. Although high rates of magnesium and calcium increased seedling height and weights, analysis showed that at Quinsam, increase in weight was associated with reduction in seedbed density.

Publication: van den Driessche, R. 1963. Nursery experiments with Douglas fir. Comm. For. Rev. 42:3:242-254.

Species: Douglas fir - seedlings.

Location: Duncan (nursery), B.C.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effects of nitrogen fertilizer on 1+0 seedlings of different size, obtained by sowing at different times.

Methods: Douglas fir seed was sown on four dates - March 10, April 10, May 10 and June 12 in 1961. Fertilizer treatments were made on July 18, 1961, and consisted of 20, 40 and 80 lb/acre of nitrogen in one series supplied as ammonium nitrate (33.5-0-0) and in another as ammonium sulphate (20-0-0). There were three replications. Fifteen seedlings were lifted for measurement on July 6, and again on October 15, 1961.

Sponsoring Organization: British Columbia Forest Service, Victoria, B.C.

Personnel: R. van den Driessche.

Summary: In 1961, Douglas fir was sown at Duncan Nursery in March, April, May and June. Nitrogen fertilizer was applied in early July at rates of 20, 40 and 80 lb/acre of nitrogen as ammonium nitrate and ammonium sulphate in separate plots.

The largest 1+0 seedlings gave the greatest response to nitrogen. Seedlings smaller than those sown in March gave little or no response. Ammonium sulphate resulted in greater seedling mortality, but per unit of nitrogen applied resulted in greater growth than ammonium nitrate. Maximum response was obtained at a rate of 40 lb/acre of nitrogen. Increased mortality at higher nitrogen levels was related to increased nitrogen concentrations and more severe damping off.

Publication: van den Driessche, R. 1963. Nursery experiments with Douglas fir. Comm. For. Res. 42:3:242-254.

Species: Douglas fir - seedlings.

Location: Quinsam Nursery, B.C.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To study the effects of adding different forms of calcium and magnesium to Douglas fir seedlings.

Methods: On November 8, 1960, 1 month before sowing seed, carbonate, sulphate, chloride and hydroxide of calcium and the carbonate, sulphate and chloride of magnesium were applied at rates of 1,000 and 3,000 lb/acre to 20 square-foot plots. A control was included and a split plot design employed. Half of each plot received the routine nursery application of ammonium nitrate, superphosphate and potassium sulphate supplying nitrogen at 40 lb/acre, phosphorus at 22 lb/acre and potassium at 143 lb/acre. Nitrogen was applied on July 12, 1961. All others on November 8, 1960.

Sponsoring Organization: British Columbia Forest Service, Victoria, B.C.

Personnel: R. van den Driessche.

Summary: In November 1960, the carbonates, sulphates, and chlorides of calcium and magnesium and the hydroxide of calcium were applied at rates of 1,000 and 3,000 lb/acre to nursery soil prior to seed sowing. Half of each plot also received the routine nursery application of ammonium nitrate, superphosphate and potassium sulphate. Only the nitrogen was applied in July 1961.

Response of the seedlings to NPK during their first growing season was considerable with shoot and root dry weight increases of about 20%. No effect of calcium or magnesium on growth was detected.

Publication: van den Driessche, R. 1963. Nursery experiments with Douglas fir. Comm. For. Res. 42:3:242-254.

Species: Douglas fir - seedlings.

Location: Duncan, Quinsam and Great Timbers (nurseries), B.C.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the most desirable levels to apply nitrogen, phosphorus and potassium to Douglas fir seedlings.

Methods: Three levels of nitrogen, phosphorus and potassium were employed in eight combinations at each of three nurseries. Six replications were set out and used during the first growing season, but only three replications during the second year.

Applications of phosphorus and potassium and seed sowing were made in May, 1960. Nitrogen was applied in mid-June 1960. In the second year, phosphorus and potassium were applied as top dressings in April 1961, and nitrogen at the end of May.

Nitrogen was supplied as ammonium nitrate (33.5-0-0), phosphorus as superphosphate (0-20-0) and potassium as potassium sulphate (0-0-50). The rates of application in lb/acre are given below:

| Treatment | Amount in 1st year lb/acre | Amount in 2nd year lb/acre |
|---|---|---|
| 0 | 0 | 0 |
| 1N | 19 | 40 |
| 2N | 58 | 120 |
| 1P | 19 | 33 |
| 2P | 58 | 112 |
| 1K | 20 | 40 |
| 2K | 60 | 120 |

Seedlings were lifted in October of both 1960 and 1961 for measurement.

Sponsoring Organization: British Columbia Forest Service, Victoria, B.C.

Personnel: R. van den Driessche.

Summary: In 1960 and 1961, nitrogen, phosphorus and potassium fertilizers were applied singly and in all combinations at two levels to Douglas fir seedlings. Nitrogen was applied as ammonium nitrate, phosphorus as superphosphate and potassium as potassium sulphate.

Response to fertilizers were only detected in seedlings that had been fertilized in both years at Duncan and Quinsam. Treatment $N_1P_1K_1$ resulted in significantly greater shoot length at both nurseries and in greater shoot dry weight at Quinsam. There was no response to treatment at Green Timbers nursery; a negative relationship between soil potassium level and shoot dry weight was revealed.

Publication: van den Driessche, R. 1963. Nursery experiments with Douglas fir. Comm. For. Res. 42:3:242-254.

Species: Red pine - plantation.

Location: Lynn Tract, Simcoe County, Ontario.

Region: Huron-Ontario Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the effects of various combinations of nitrogen and potassium and different levels of phosphorus on the seed production of red pine during the second year of cone maturation.

Soils: A bronisolic grey-brown podsolic profile, well-drained, moderately stoney, sandy loam (physical and chemical analyses were made on three profiles).

Methods: The red pine was planted in 1945. In 1954, the northern half was thinned to an 18-foot spacing, and in 1961 the southern half was similarly thinned. From 1957 to 1962, excluding 1958, annual cone counts were made on 89 trees in the plantation. The mean annual production of cones was 180 cones per tree over a 5-year-period. Thirty-six trees with greater than average cone production were selected for the main nitrogen-potassium treatments. A second sample of 12 trees were chosen for the phosphorus trial. During 1962, analyses for N, P, and K were made on the current foliage of selected trees in the plantation throughout the growing season. Foliage concentrations of all three elements were low compared with similar analyses for other vigorous red pine stands.

In the main experiment, three levels of ammonium nitrate (33.5-0-0) containing 0, 64, and 128 lb/acre of nitrogen and three of potassium sulphate (0-0-48) containing 0, 43, and 86 lb/acre of potassium were used. Fertilizers were used singly and in all combinations and were applied broadcast to the soil on May 17, 1963, by spreading over an area with 1.2 m diameter about the bole of each tree. For the phosphorus experiment, triple superphosphate (0-45-0) was poured into 12 holes drilled 45-60 cm deep around the bole of each tree. The pattern of drilling was based on previous studies of the root system of red pine. Four levels of phosphorus were used - 0, 60, 120, and 240 lb/acre. These trees were fertilized on June 14, 1963. There were four replications of the first experiment and three of the second.

In late September, 1956, all ripe cones were picked from each tree. Measurements were made of total number of cones, number of seed per cone, total seed weight and average seed weight. X-rays were made of representative seed samples.

Sponsoring Organizations: Faculty of Forestry, University of Toronto, Toronto, Ontario.
Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: R.E. Chopowick, K.A. Armson.

Summary: In early 1963, two fertilizer trials were set out in an 18-year-old plantation of red pine spaced at 18 x 18 ft in order to determine their effect on seed production. The first trial consisted of three levels of nitrogen as ammonium nitrate and three levels of potassium as potassium sulphate, applied singly and in all combinations. The second trial consisted of four levels of phosphorus as triple superphosphate. The superphosphate was drilled in holes 45-60 cm deep in the soil under the tree crown.

Results of the nitrogen-potassium trial showed that 50% of the trees produced 81% of the total cone crop. Although large differences existed in terms of seed production between treatments, large differences existed between trees within treatments. The number of seeds per cone, total weight of seed or average seed weight were not affected by treatments.

Magnitude of damage by insects and squirrels was such that 56% of the cones counted in June were lost by September.

For the phosphorus experiment, total seed production increased over a 100% from the zero phosphorus to the high rate of application, total weight of seed also increased. The phosphorus concentrations in the seed showed no differences between treatments.

A technique was established for the x-ray examination of seed.

Thesis: Chopowick, R.E. 1964. A study of seed production in relation to the nutrition of red pine (*Pinus resinosa* Ait.). M.Sc.F. Thesis, Fac. For. Univ. Toronto.

Species: Red pine - 30-year-old plantation.

Location: Orr Lake and Hendrie Forests, Simcoe County, Ontario.

Region: Georgian Bay Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To determine the effects of various fertilizers on the growth of red pine.

Soil: Tioga loamy sands, bisequa podsol.

Methods: Preliminary soil and foliage analyses indicated that:
1. nitrogen levels in the soil and terminal foliage were low;
2. potassium levels were low in the soil and critically low in the foliage;
3. calcium levels were high at 30 inches depth in the soil and excessively high in the foliage;
4. phosphorus levels were high in the soil, but low in the terminal foliage;
5. phosphorus and potassium uptake was inhibited by droughtiness of the soil due to coarse texture and slope.

In May 1959, a mixed fertilizer (10-5-10) was applied broadcast to the surface soil at rates of 348 and 1044 lb/acre. In June 1960, urea (45-0-0) was applied at the rate of 160 lb/acre and in July 1962, potassium chloride (0-0-60) was applied at rates of 348, 696, 1044 and 1392 lb/acre. There were five replications of each treatment except the potassium chloride.

Three months after the last fertilizer application, composite soil samples to a depth of 6 inches were taken in each plot, and in addition, samples to a depth of 12 inches were taken around the base of the largest dominant tree in each plot.

Diameters of all trees were measured before fertilization and 5 years after treatment. The diameter at the center of each internode and the length of each internode of the largest dominant tree in each plot was recorded. Fifteen trees in each plot were fitted with dendrometer tapes to record the response by trees of different size classes. The length of the terminal shoots of these 15 trees was also recorded.

Sponsoring Organization: Ontario Department of Lands and Forests, Toronto, Ontario.

Personnel: R.H. Leach.

Summary: After comprehensive soil and foliage analyses were made in a 30-year-old plantation of red pine, a fertilizer experiment was begun in 1959, in which a mixed fertilizer (10-5-10) was applied at two rates, urea (45-0-0) was applied at one rate, and potassium chloride was applied at four rates. The urea was applied in 1960 and the potassium chloride in 1962.

Five years after the initial treatment, the following results were obtained:

1. Fertilization with 1044 lb/acre of (10-5-10) and 160 lb/acre of urea resulted in significant increases in diameter growth compared with the control trees. Increase in timber volume after 5 years indicated that 14-1/2% compound interest was earned on the investment of fertilizer and application costs.
2. Addition of potassium chloride at 348 lb/acre increased diameter growth but not height growth in plots which had already been treated with 1044 lb/acre of the mixed fertilizer and 160 lb/acre of urea.
3. Crown development of trees treated with urea in addition to the mixed fertilizer was greater than for trees treated with a mixed fertilizer or untreated.
4. The response of trees of larger diameters was proportionately greater to fertilizer than that of trees of smaller diameters.
5. Foliage nutrient levels from leading shoots and from composite soil samples taken under dominant trees correlated well with growth rates.

Species: White spruce (1+0, and 2+0).

Location: Nurseries at Midhurst, Orono and Kemptville. Planting in Kemptville and Parry Sound Districts.

Region: Upper St. Lawrence Section, Great Lakes-St. Lawrence Forest Region. Georgian Bay Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study the effects of different levels of soil fertility and seedling spacing on size of nursery stock, and on performance after outplanting on different sites.

Soil: Nursery soils for nursery phase.
Kemptville - sandy-loam, silt layers, poorly drained.
Parry Sound - sandy-loam, rocky, well drained.

Methods: In 1964, 1+0 and 2+0 beds of white spruce at three nurseries were fertilized at three levels: control (no further fertilizing), normal (as required by nursery soil-management plan), and double (twice normal quantities).

In spring 1965, lifted 3-0 seedlings were sampled, measured, and planted out as graded and ungraded stock.

More plots were established in 1965 in nurseries, using additional feature of density, split-plot design at 15 and 30 seedlings per square foot.

Plantings to continue.

Sponsoring Organization: Ontario Department of Lands and Forests, Maple, Ontario.

Personnel: R.E. Mullin.

Summary: Beginning in 1964, white spruce seedlings (1+0 and 2+0) were fertilized at three levels: control, normal nursery fertilization and twice normal nursery fertilization.

In the spring 1965, the 3-year-old seedlings were lifted, sampled and measured and graded and ungraded seedlings were outplanted.

Beginning in 1965, seedbed densities were controlled at 15 and 30 seedlings per square foot.

Species: White spruce (2+0 and 2+2 at planting).

Location: Midhurst Nursery, Simcoe County, Ontario.

Region: Huron-Ontario Section, Great Lakes-St. Lawrence Forest Region.

Objective of Study: Study of site preparation, fertilizing and watering to reduce planting check.

Soil: Former nursery soil, moist sandy loam.

Methods: The experiment was established in 1962 with the following treatments:
Four methods of site preparation included control (planted in sod), plowed and cultivated, scraped (sod removed by bulldozer) and scraped and cultivated; and sub-plots with four treatments of control, fertilized (lime at 2,000 lb/acre; ammonium nitrate at 200 lb/acre), watered (irrigated to 1 inch per week first growing season), and fertilized and watered; 160 sub-plots of 25 trees each.

There were five replications. Counts of surviving trees and measurements of leaders have been made each year since planting.

Sponsoring Organization: Ontario Department of Lands and Forests, Maple, Ontario.

Personnel: R.E. Mullin.

Summary: In 1962, an outplanting experiment using seedling (2+0) and transplant (2+2) white spruce was established in Simcoe County, Ontario. Four main methods of site preparation were used and four treatments involving fertilizer (lime and ammonium nitrate) and water applications during the first planting season were applied.

Survival counts and measurements of height growth have been made each year since planting.

Species: Red pine - nursery to planting as 3+0.

Location: Orono Nursery, plus outplantings in Pembroke District and at Midhurst and in Oro Township near Barrie.

Region: Middle Ottawa Section of Great Lakes-St. Lawrence Forest Region, and Huron-Ontario Section of Great Lakes-St. Lawrence Forest Region.

Objective of Study: To study methods and effects of artificial acidification of nursery seedbeds.

Soil: A nursery soil-sandy loam, in the nursery. Old-field site for planting.

Methods: Treatments were applied in the nursery as follows:
Acid peat was incorporated in the soil at 60 $yd^3$/acre. Sulphur was incorporated at 750, 1500 and 2250 lb/acre; and combinations of peat and sulphur. Treatments were applied before beds were sown. Trees were grown to 3+0. Irrigation water was acidified during growth.

Samples were taken for laboratory measurement and for planting at two locations. Measurements of survival and growth were taken after outplanting.

Experiment was repeated each year for 3 years.

Sponsoring Organization: Ontario Department of Lands and Forests, Maple, Ontario.

Personnel: R.E. Mullin.

Summary: In 1959, treatments of sulphur, acid peat and acidified irrigation water were applied to red pine to be grown for three years. Acidification of water to pH 6.0 gave no measurable effect on soil pH or seedlings. Addition of acid peat at a rate of 60 $yd^3$/acre gave some reduction in soil pH but had no effect in seedling development. Powdered sulphur applied at rates of 750, 1500 and 2250 lb/acre was most effective in reducing the soil pH values. The heaviest treatment of sulphur caused mortality in the seedbeds whereas lesser treatments resulted in increased survival. Sulphur additions also resulted in taller, heavier seedlings.

Publication: Mullin, R.E. 1964. Acidification of a forest tree nursery soil. Soil Sci. Soc. Am. Proc. 28(3): 441-444.

Species: Douglas fir (1+0 and 2+0).

Location: University of British Columbia Campus Nursery.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effects of various organic and inorganic amendments on the growth of Douglas fir seedlings.

Methods: In 1960, the upper 6 inches of forest floor from a stand of hemlock, cedar, Douglas fir and maple was screened through a 1-inch mesh. Two seedbed sowing densities (high and low) were used. Treatments consisted of:

1. sandy loam nursery soil untreated (control);
2. soil with 40% by volume of organic amendment;
3. 1/2 tablespoon of mixed fertilizer (7-8-6) and 1/4 teaspoon of uramite (38-0-0);
4. a combination of treatments 2 and 3;
5. double the treatment No. 4.

Sponsoring Organization: Faculty of Forestry, University of British Columbia, Vancouver 8, B.C.

Personnel: J.H.G. Smith and G.S. Allen.

Summary: In 1960, nursery seedbed treatments of additions of organic soil from the forest floor of a natural stand of hemlock, Douglas fir, cedar and maple were made at rates of 40 and 80% of the nursery soil by volume. In addition, combined applications of a mixed fertilizer (7-8-6) and uramite (38-0-0) were made with and without the organic amendments.

Germination was reduced significantly by the inorganic fertilizers and reduction was proportional to the degree of fertilization. Height growth of seedlings increased significantly with fertilizer treatment.

In 1961, height growth increased with level of fertilization, and was highest for the plots receiving high organic plus inorganic treatments. The difference between heights of seedlings receiving either high inorganic or high organic amendments was not significant.

Publication: Smith, J.H.G. and G.S. Allen. 1962. Improvement of Douglas fir planting stock. Res. Pap. Fac. For. U.B.C. No. 55. pp.9-10.

Species: Douglas fir (1+0 and 2+0).

Location: University of British Columbia Campus Nursery, B.C.

Region: Southern Pacific Coast Section, Coast Forest Region.

Objective of Study: To determine the effects of fertilizer on the growth of nursery-grown Douglas fir seedlings.

Methods: In 1956, low and high levels of fertilizer were used involving nitrogen, phosphorus and potassium. Nitrogen was supplied as ammonium nitrate (33.5-0-0), phosphorus as phosphoric acid ($H_3PO_4$) and potassium as potassium chloride (0-0-60). One gram of each compound was used for a low level series giving a total of 3 g for the N+P+K treatment. The high levels were provided by use of all three compounds at the low level plus 3 g of each chemical for the high level of treatment alone or in combination.

Fertilizers were placed in late May at a depth of 3 inches and covered with earth. Seeds were sown 1 inch apart.

Sponsoring Organization: Faculty of Forestry, University of British Columbia, Vancouver 8, B.C.

Personnel: J.H.G. Smith and G.S. Allen.

Summary: In 1956, high and low levels of nitrogen as ammonium nitrate, phosphorus as phosphoric acid and potassium as potassium chloride were applied at a 3-inch depth to seedbed soils prior to sowing Douglas fir.

At the end of the first growing season, there was no significant influence of any of the kinds of fertilizers tested, although response to increased amounts of fertilizers was significant. Average height of seedlings increased from 5.8 cm for the control to 7.3 cm for the 6 to 12 g of fertilizer.

By the end of the second growing season, seedlings treated with three or more grams of fertilizer were 4 cm taller than the controls which averaged 14 cm in height.

Publication: Smith, J.H.G. and G.S. Allen. 1962. Improvement of Douglas fir planting stock. Res. Pap. Fac. For. U.B.C. No. 55. pp.8-9.

# COMMENTS

## COMMENTS

The first forest fertilization study in Canada for which there is published information was established at Grand'Mère, P.Q., in 1920 using Norway and white spruce. Applications of 15 and 30 tons per acre of manure were applied and plowed into the soil before planting the trees. The provenance of the Norway spruce was Norrland, Sweden, that of the white spruce, Black Hills, South Dakota. A control plot was established for the white spruce only. There were no replications. In 1956, yield of the white spruce was 2,700 and 2,960 cubic feet per acre on the manured plots and 956 cubic feet on the control plot.

This trial illustrates some of the pitfalls of fertilizer experiments. The growth response has been marked, but because the material applied was manure it is not possible to state whether the growth response was due to the nutrient elements added or whether it was due to an amelioation of the soil's physical properties such as the water-holding capacity, or pore distribution. If the response was due to nutrient elements, which one or ones were responsible? It is impossible to tell. The experiment was not replicated, so that there is no way of knowing if the difference in yield of 260 cubic feet per acre between two rates of application is significantly different or not. At the time this experiment was established, the investigators were not armed with either the knowledge or understanding of fertilization techniques or the importance of experimental design and replication.

With the exception of the 1920 trial at Grand'Mère, forest fertilization studies have been initiated almost exclusively since 1950. Within the past 5 years (1960-65) there has been an acceleration in the number of projects begun and there is every reason to assume that the numbers of such studies will increase dramatically in the next few years. The interest in fertilization in the 1950's was for the most part related to an increase in forest regeneration by planting. Many planted trees either failed to survive or grew slowly after planting and it seemed logical to determine whether or not soil fertility was a contributing factor. In general, it may be said that the majority of such experiments have indicated that fertilizer additions at time of planting decreased survival, but the residual trees have often shown increased height growth. It seems reasonable to infer that much of the mortality associated with fertilizer addition was due to stimulation of growth of adjacent competing vegetation. It is surprising that few experiments at time of planting have also incorporated associated herbicide treatments to control competing vegetation. As might be anticipated, application of fertilizers to roots or in the planting hole have almost always resulted in heavy mortality. The use of slow-release fertilizers has to-date not proven to be as advantageous as was originally hoped.

In many experiments involving fertilizer treatments at time of planting, little or no information has been given concerning the size or condition of the stock. Only in one series of experiments, undertaken by

industry, was an attempt made to use graded nursery stock which was consistent in terms of size and morphological characteristics. It might be expected that relative uniformity of stock on a physical, if not genetic basis, would be obligatory before beginning an experiment. In a small number of experiments there is, in fact, no indication that the original tree size was measured. Much of the individual variation within treatment plots is most likely due to physical and physiological differences between trees. This fact would suggest that much greater attention should be paid to these characteristics.

A number of studies have been conducted with a view to increasing flower, cone and seed production. Some of these studies have emphasized the relative lack of knowledge concerning the physiological processes of trees and the fact that the effects of specific nutrient ions such as nitrate and ammonium ions may be quite different on such physiological processes as flower and cone production. Without exception, trials related to cone and seed production have demonstrated the great losses of developing cones and fruits due to insects and rodents. The results of more than one study have been rendered virtually useless because of such losses. The responsibilities involved in conducting a fertilizer trial often extend far beyond just the application of a fertilizer.

In recent years, interest has developed in the fertilization of natural or planted stands which are immature or approaching maturity. Some of the trials have involved adding fertilizer to dense immature stands with the objective of obtaining greater differentiation between individual trees so that subsequent suppression of many trees and greater expression of dominance by the remainder will result in more vigorous development of the stand. Other trials have been concerned with increasing the diameter growth of trees as they approach maturity so that the financial yield during this period will improve considerably. Such trials appear to have greater application where lumber production is predominant, but similar trials, where pulpwood utilization is concerned, would seem warranted - there are at present only one or two of these.

There are several general criticisms which might be made of current forest fertilization studies. There is a dearth of meaningful specific data concerning the soils which have been treated; in some instances the fertilizer materials used, the characteristics of the trees treated, and the nature of the conditions under which they grew have been frequently overlooked. The presentation of information on the fertilizers is such that comparisons between studies cannot readily be made without the use of conversion factors. In this review no attempt has been made to put fertilizer data on a comparable basis; instead a table of conversion factors is presented as Appendix 1. It is regrettable that the fertilizer producers have not seen fit to present fertilizer analyses in terms of units of weight of nutrient elements rather than the present archaic system of presenting nitrogen in elemental terms and all other elements in terms of an oxide form. Further, nutrient elements are often included in a fertilizer but not recorded; for example, ammonium sulphate $(NH_4)_2SO_4$ is commonly treated as a nitrogen fertilizer when it should be considered as a nitrogen and sulphur fertilizer.

A number of the studies have employed chemical analyses of the foliage either as a diagnostic technique or after fertilization to indicate if increased absorption of an applied element has occurred. In some of these studies confusion arises because of improper use of certain terms. Thus, concentration, content and uptake are often used interchangeably, when in fact they are different. Concentrations are ratios; contents refer to absolute amounts, thus one cannot refer to a nitrogen content of 1.5%, which is a concentration. Uptake refers to the amount of a nutrient within a plant at any given time and in this sense may be synonymous with content. It is often used with reference to changes in content over a stated period of time. Thus analyses of samples of foliage alone cannot in fact result in data which give a measure of uptake.

With the exception of a few studies on the effects of fertilizer on cone production, especially in Douglas fir, little attention has been directed towards the importance of time of fertilizer application. Most studies have applied the fertilizer in the spring or early summer, but in fact differences in time of application may give different responses not only of degree but of kind. Thus, for one species, whose height growth is normally terminated in early summer, an early application just prior to or coincident with height growth may give a response. However, for a species whose period of height growth may extend into mid- or late summer, a mid-summer fertilizer treatment may result in a greater growth than the same amount applied in the early spring. Similarly, where a diameter growth response is desired early spring applications may be much less effective than treatments made later in the growing season. It appears that as yet very little consideration has been given to the use of fertilizers in achieving defined types of growth response.

In addition to the time of fertilizer application, the manner of placement offers possible methods for achieving greater response for a given amount of applied fertilizer. Although techniques for fertilizer placement have been well developed in agriculture, it might at first appear that in forest fertilization few opportunities for variation in placement would occur. However, with the increasing development of soil scarification, following clear cutting, a number of situations may occur when various types of placement will be worth trying on an experimental basis. Fertilization involving phosphorus merits consideration of placement other than that of surface application. It can be conjectured that the lack of growth response to applications of phosphatic fertilizers in many instances is because, almost without exception, the fertilizer was applied to the soil surface.

Fertilization practices in forest nurseries have for obvious reasons followed very closely the patterns of use of fertilizers in agriculture. Nursery crop values are high, often higher than in agriculture and, because coarse textured soils are usually chosen for nursery development and every 2 or 3 years the entire crop including roots is removed, the depletion of nutrients is very great.

Although nurseries occur in nearly all the provinces, the majority of trees are produced in British Columbia and Ontario. As might be expected, most of the studies of fertilizers have been made in these two provinces. Although prior to 1955 a large number of pathological and entomological studies had been undertaken on nurseries, surprisingly few formal fertilizer studies had been made. Nursery and management practices often involved fertilizer additions and nursery superintendents often indulged in temporary trials - usually assessed visually rather than quantitatively - but organized experimentation was largely lacking. Since 1955 many formal, and in some instances very sophisticated experiments, have been conducted. Initially most of the trials were aimed at establishing what nutrients should be applied and in what quantities to obtain a desired seedling size. Attention has been directed to time of application to best achieve a desired result and to type of placement. Interaction with soil moisture supply has also been studied. The movement of fertilizers in the soil and loss in the drainage water has been studied in relation to type and amount of fertilizer and various soil characteristics. The use of fertilizers to control growth - height, diameter and roots - has received attention and, in conjunction with watering, the concept of a relatively rigid control of seedling growth in nurseries is accepted.

Effects of various fertilizer treatments in the nursery on outplanting performance have unfortunately been neglected to a large degree. Again, as with forest fertilization, not enough attention has been paid to the physical and genetic characteristics of the seedling stock. The importance of spacing or density has been recognized but studies of the variations within a species in response to a given fertilizer treatment have seldom been undertaken.

# APPENDIX

## Fertilizer Conversion Table

For mixed fertilizers, a designation such as 10-20-16 refers to the corresponding proportions of nitrogen, $P_2O_5$ and $K_2O$, i.e., 10%N, 20%$P_2O_5$ and 16%$K_2O$

| Amount expressed as: | | Factor | | |
|---|---|---|---|---|
| $P_2O_5$ | x | 0.437 | = | Phosphorus |
| $K_2O$ | x | 0.830 | = | Potassium |
| CaO | x | 0.714 | = | Calcium |
| MgO | x | 0.60 | = | Magnesium |