

### A PROBLEM

The demand for wood products is increasing and resources of mature Douglas-fir and western hemlock forests are diminishing in many regions of coastal British Columbia. Timber must, therefore, be transported over longer distances to the mill sites. Moreover, forest land is being taken out of production for other purposes, such as recreation, roads, dam sites and power-line rights-of-way.

To meet the demand for wood, it becomes more attractive and necessary to invest in intensive forest management for higher wood production.

## A POSSIBLE SOLUTION

Forest fertilization and thinning of stands are two promising management practices for increasing tree growth in young stands.

Studies have shown that many forest soils in coastal British Columbia are deficient in nitrogen, whereas other soil nutrients have not been shown to limit tree growth. To increase growth, nitrogen fertilizer has been successfully applied to forests, although on a minor scale, by small aircraft (Fig. 1).

Thinning the forest reduces competition among trees, resulting in increased growth of the remaining crop trees. By concentrating growth on fewer trees, more usable products can be obtained and at an earlier age.

Fig. 1. A small aircraft applying fertilizer to a managed forest. (Photo - Pacific Logging Co. Ltd.)

# Appendix I

## Stand and Site Characteristics

Site index (tree height at 50 years): 21 m

Tree age: 24 years in 1970

Soil type: well-drained, shallow, coarse textured glacial till with thin organic layer and underlain by impermeable basal till; classified as Orthic Dystric Brunisol.

Climate: transitional between the Cool Summer Mediterranean Climate and the Marine West Coast Climate. Mean annual precipitation 1090 mm; mean annual temperature 8.9 C.

Vegetation: site situated in the wetter subzone of the Coastal Douglas-fir Biogeoclimatic zone. Douglas-fir is prevalent with a small proportion of western hemlock, western white pine, lodgepole pine, and western red cedar and a few arbutus and red alder. Understorey is dominated by salal, Oregon grape and bracken fern.

## THE NEED FOR RESEARCH

Although fertilization and thinning are promising silvicultural treatments, their application in British Columbia is new and many technical and basic questions must be answered before they can be applied efficiently.

Research must show how and why various fertilization and thinning regimes affect tree growth, wood quality, the economics of wood production and the quality of the environment, so that specific questions by the forest manager can be answered. For example, where should we fertilize; what kind of fertilizer should be used, and how much; how





Fig. 2. Experimental plots at the Shawnigan Lake installation (a) unthinned control (b) heavy thinned.

frequent and at what time of the year should fertilizer be applied? Where should thinning be applied; how often, and how many trees should be left after each thinning?

The Canadian Forestry Service, the British Columbia Forest Service, the University of British Columbia and the forest industry are engaged in continuing research to study the effect of fertilization and thinning on the growth and yield of the forest, and to clarify the practical and operational aspects of these practices. In 1970, the Pacific Forest Research Centre of the Canadian Forestry Service expanded their previous involvement to include studies of basic ecological effects of fertilization and thinning in a 24-year-old Douglas-fir forest near Shawnigan Lake, B.C.

## THE SHAWNIGAN LAKE INSTALLATION

Some stand and site characteristics are given in Appendix I and further details can be found in the Shawnigan Lake Establishment Report (BC-X-110). The basic design of the field installation consists of three levels of nitrogen fertilization, as

urea, and three levels of thinning. The resulting nine treatment combinations were applied to experimental plots in the spring of 1971 and 1972 (Fig. 2 and back cover, Appendices II, III). Subsidiary plots were treated in 1973 with another source of nitrogen, ammonium nitrate, and others received heavier applications of urea than in earlier trials.

# MANIPULATING THE ECOSYSTEM

In using fertilization and thinning, we are attempting to manipulate a complex forest ecosystem to favor tree growth. To do this successfully under different stand and ecological conditions, we should know:

- (1) how the natural ecosystem functions,
- (2) how treatments change the environment, and
- (3) how these changes affect tree growth.

These aspects are studied in the field at Shawnigan, as well as in the laboratory in Victoria, by a team of researchers specializing in soil chemistry, hydrology, soil fauna, soil flora, tree physiology, tree mensuration and silviculture.

# Appendix II

## **Treatments**

### Basic:

3 levels of nitrogen fertilization with urea; i.e.,

 ${\sf F}_0$  - control (no fertilizer);  ${\sf F}_1$  - 224 kg N/ha;  ${\sf F}_2$  - 448 kgN/ha.

3 levels of thinning; i.e.,

 $T_0$  - control (no thinning);  $T_1$  - approx 1/3 and  $T_2$  - approx. 2/3 of total stem basal area removed.

# Subsidiary:

fertilization with 672, 896 and 1344 kg N/ha using urea;

fertilization with 224 and 448 kg N/ha using ammonium nitrate.

# Plot Establishment

Basic 9 treatment combinations applied to 2 replicated plots in the spring of 1971 and in 1972 using 0.08 ha plots surrounded by 10-m-wide buffer zones. Subsidiary treatments applied in 1973 to 2 replicated plots 0.04 ha in size with 10-m-wide buffer zones.

# Appendix III

# Some Average Plot Characteristics Immediately Before and After Thinning

Treatment	Trees per ha	Average tree diameter, cm	Stem basal area m <sup>2</sup> /ha
No thinning (T <sub>0</sub> )	4250	7.8	23.1
Intermediate thinning $(T_1)$			
before after	3911 1923	8.2 9.4	14.5
Heavy thinning (T <sub>2</sub> )			
before after	3854 914	8.1 10.5	8.3

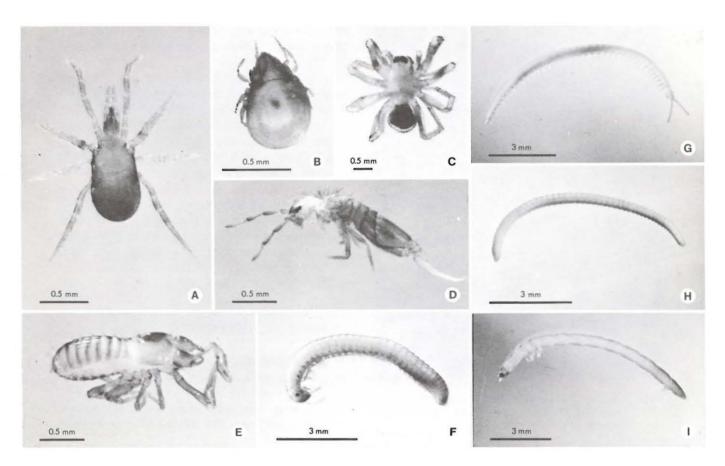


Fig. 3. Representative of some common, medium-sized, soil fauna aiding in organic matter decomposition: (A) Mesostigmatid mite, (B) Cryptostigmatid mite, (C) Spider, (D) Entomobryid collembolan, (E) Pseudoscorpion, (F) Millipede, (G) Centipede, (H) Enchytraeid worm, (I) Insect larva.

## GROWTH OF A FOREST

Productivity of a forest is closely linked to the process of photosynthesis since this is the source of organic carbon and energy for tree growth. Some 90% of the dry matter of trees is derived from this process. Light absorbed by the green chlorophyll of leaves is the driving force and, with the use of water from the soil, the carbon dioxide taken up from the air is reduced to carbohydrates. Some of the stored chemical energy is released in respiration for use in manufacturing other compounds needed in tree growth. Nitrogen and other minerals taken up from the soil are essential for synthesis of these compounds. Normally, the availability of nitrogen in the forest soil depends to a large extent on the breakdown of nitrogen containing organic matter shed by trees and understorey vegetation (forest litter). This breakdown and recycling of nitrogen is made possible by the action of the flora (bacteria, fungi) and fauna of the soil (Fig. 3).

## STUDIES IN PROGRESS

To explain tree growth, the major emphasis of the project is placed on studying how changes in the environment brought about by fertilization and thinning will affect the availability of nitrogen to the trees and their rates of photosynthesis and respiration. Many important changes can be expected. Fertilization will, obviously, improve the nitrogen status of the soil, but it may cause drastic changes in soil acidity and in population dynamics of the soil flora and fauna and thereby influence the availability of nitrogen. Also, some nitrogen may be leached away from the rooting zone with the soil water and some may be lost in gaseous form to the atmosphere. Thinning opens up the forest and increases the amount of light in tree crowns. Furthermore, with less trees, those remaining will have a better share of soil water and nutrients. Soil nutrition will also be improved by the initial increase in organic matter returning to the forest floor as litter.



Fig. 4. Detailed measurements of weekly stem diameter growth of selected trees, using specially constructed dendrometer bands.

The understorey vegetation also benefits from these changes and provides more competition for the trees.

Availability of soil nitrogen is investigated in studies of nitrogen amounts, transformations and movement in soil, nitrogen losses to ground water and atmosphere, and soil acidity. Cycling of nitrogen in the forest ecosystem is recorded by measuring organic matter additions to the forest floor, its nitrogen content and breakdown in relation to population dynamics of soil flora and fauna, and the amount of nitrogen contained in trees and understorey. Rates of photosynthesis and respiration are studied in relation to changes in soil and tree water stress, nitrogen concentration of foliage, light intensity and temperature in tree crowns, and production of the photosynthesizing organs; i.e., the foliage.

## **GROWTH RESPONSE**

The preceding studies are designed to explain the growth response to the stand treatments and this response is measured from the most detailed level on individual trees (Fig. 4) to the overall volume production per plot. The volume of stem wood in

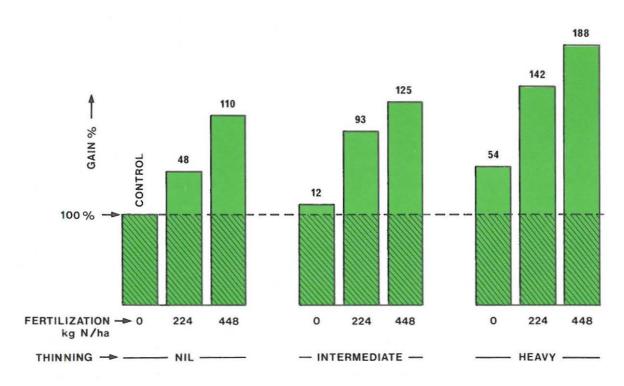


Fig. 5. Three-year volume growth response of the future crop trees to fertilization and thinning treatments expressed as percent gain over growth of untreated, control, trees.

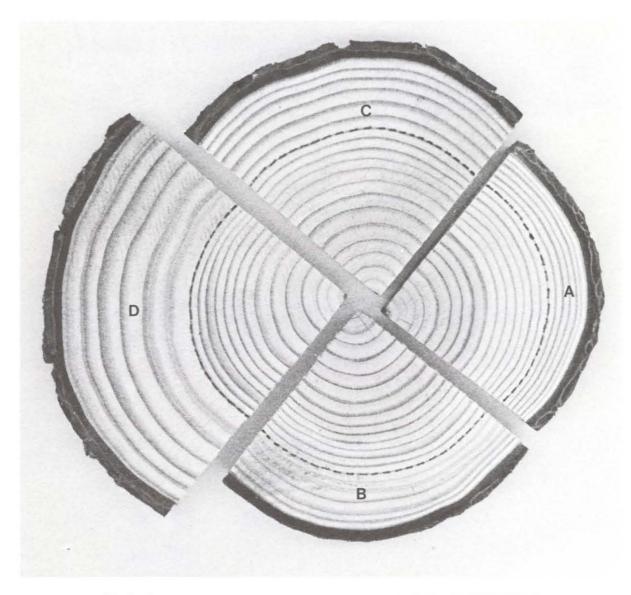


Fig. 6. Stem sections showing six-year growth response to treatments. Trees were all approximately 12.5 cm in diameter at time of treatment (broken line). (A) untreated control, (B) heavy thinning, (C) heavy fertilization, (D) combination of heavy thinning and fertilization.

each tree is calculated from measurements of tree diameter, tree form and height, and is repeated every 3 years. In addition to finding volume production for all trees in the plots, we are interested in examining volume growth of the future crop trees only; i.e., the trees likely to remain till the end of stand rotation (Fig. 5).

Preliminary results for the first 3 years following treatment are encouraging. Application of 448 kg N/ha of urea, plus a heavy thinning, gave a volume

growth response of crop trees 188% greater than that for the untreated trees (Fig. 5). Treatment effects are still evident after 6 years (Fig. 6). However, responses must be evaluated over a longer period and in conjunction with an economic analysis. Furthermore, we must consider treatment effects on the quality of the environment and, for example, make sure that streams are not polluted in the process. This aspect is emphasized in the Shawnigan Lake project.



# RESEARCH ON TARGET

The project described is long-term in nature, and data will have to be collected for many years before a good understanding of the tree response and environmental impact can be obtained. In the learning process, new procedures and methods of study will be developed which will make evaluation of treatment response more efficient.

Data from the Shawnigan site and other stands will be needed as input for growth prediction in computer models from which appropriate treatment schedules can be developed for particular soil and forest conditions. Foresters will then be better equipped to manage for HIGH YIELD FORESTS in a QUALITY ENVIRONMENT.

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