# SOME PROBLEMS THAT AFFECT WHITE SPRUCE SILVICULTURE IN WEST-CENTRAL CANADA

by

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A Thesis submitted to the Faculty of Graduate Studies
and Research of the University of Manitoba
in partial fulfillment of the requirements for the
degree of Master of Science

1963

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## ABSTRACT

In West-Central Canada white spruce, one of the most sought-after species, does not regenerate satisfactorily after logging. This is causing much concern amongst industry and government agencies because without adequate regeneration the white spruce logging industry is doomed.

This report reviews the autecology of white spruce and trembling aspen, emphasizing those characteristics that influence reproduction. White spruce is dependent entirely on seed for continued survival. Most habitats in the undisturbed and cut-over forests are not conducive to good seedling establishment, so the species fails to regenerate adequately. On the other hand, trembling aspen can reproduce by vegetative means as well as by seed and as a result this species becomes well established, especially in cut-over areas.

Most of the stands in the forests of West-Central Canada have resulted from some disturbance (usually fire). A great variety of cover types are present and each represents a stage of successional development. Those silvical characteristics of white spruce and trembling aspen that affect regeneration are examined in relation to habitat conditions obtaining in various environments. This is done to explain successional development and to provide the background necessary for the development of silvicultural treatments to favour spruce.

The early work done by the Department of Forestry to develop suitable methods for regenerating white spruce is summarized briefly.

This is followed by an account of the work presently being undertaken. Results to date indicate that mechanical seedbed preparation, costing about $10 per acre, after logging, will ensure regeneration.

Lastly, the research program for the immediate future is outlined briefly in broad terms. This work will investigate seedling performance in specific habitats and the edaphic and climatic factors that limit performance in these habitats. Only through such study can present silvicultural methods be improved and new ones developed.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. J.C. Ritchie, Department of Botany, University of Manitoba, for his guidance and help in the preparation of this manuscript, and Mr. C.C. Thomson, Department of Forestry, for his many helpful suggestions and review.

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The work reported in this thesis has been done while the author was in the employ of the Forest Research Branch, Department of Forestry, Canada, and grateful acknowledgement is made for permission to use the material.

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# INTRODUCTION

Surveys (Phelps 1940, Candy 1951) in the Mixedwood Forest Section (Figure 1) of the Boreal Forest Region (Rowe 1959) in Manitoba and Saskatchewan have shown that white spruce (Picea glauca Moench Voss) does not regenerate satisfactorily after logging. Since white spruce saw timber has been and still is one of the principal forest products in the Prairie Provinces the fact that the species does not regenerate well on cut-over areas is causing much concern among forest industries and various government agencies.

The purpose of this thesis is (1) to give some insight into the problems of regenerating white spruce, and (2) to describe briefly the work being done by the author to develop silvicultural methods that will promote regeneration at moderate costs.[1] To achieve that purpose the report reviews briefly the silvics of white spruce and trembling aspen (Populus tremuloides Michx.) emphasizing those factors that influence regeneration; it discusses ecological relationships obtaining in the Mixedwood Forest Section in Manitoba and Saskatchewan; it summarizes past and present research work dealing with studies of spruce regeneration; and it briefly outlines future research plans.

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[1] The author joined the Forest Research Branch, Department of Forestry, Manitoba-Saskatchewan District, in June 1958 and was assigned the problem of developing silvicultural methods to ensure white spruce regeneration. Much of his work that year and in 1959 was of a reconnaissance nature to familiarize himself with the studies already in progress and to obtain some understanding of the ecology of the forests in this part of Canada. Consequently the author's present research program is in an early stage of development and only preliminary results are available from studies he has initiated.

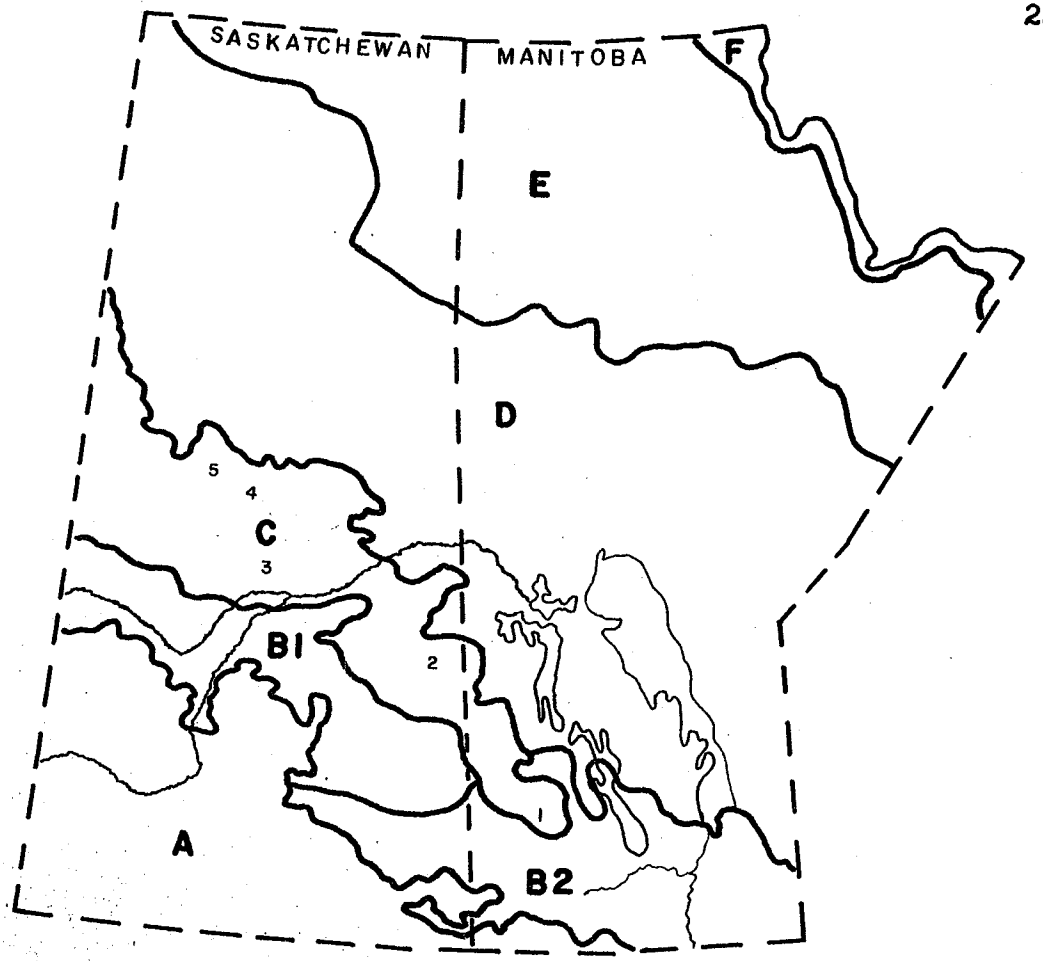


Figure 1. Map of Manitoba and Saskatchewan showing vegetative regions (A to F) and location of areas (1 to 5) in the Mixedwood Forest Section where studies are being undertaken presently by the author.

A - Grassland
B1 - Aspen Grove Woodland
B2 - Aspen-Oak Woodland
C - Southern Boreal Forest (Mixedwood Forest Section)
1 - Riding Mountain
2 - Hudson Bay
3 - Prince Albert
4 - Lac La Ronge
5 - Doré Lake
D - Northern Boreal Forest
E - Taiga
F - Tundra

The prominence given to trembling aspen (Chapter 2) in a thesis dealing with white spruce might seem unwarranted. However, the regeneration and development of white spruce is so closely associated with, and influenced by, trembling aspen that a discussion of its silvical characteristics is considered necessary.

# CHAPTER I

## SILVICS OF WHITE SPRUCE

### (a) Distribution

White spruce occurs throughout Canada. Its boundaries extend from Newfoundland and Labrador westward along the northern limit of trees to the Northwest Territories, Yukon, and northwestern Alaska, south to southern Alaska (not southeastern Alaska) and that part of British Columbia east of the main range of the Rocky Mountains, east in Alberta, Saskatchewan and Manitoba at a latitude of about 52°N, southeast through northern Minnesota and Wisconsin to central Michigan, northeastern New York, northwestern Massachusetts and Maine (Anon. 1956a). Outliers are to be found in Wyoming, Montana, and the Black Hills of South Dakota (Little 1953).

### (b) Habitats

#### (1) Climatic relationships

White spruce is a hardy species and can grow under a variety of climatic conditions. Average January temperatures within its range vary from about -20°F to 25°F and average July temperatures from about 55°F to 70°F. Extreme minima and maxima temperatures recorded are about -75°F and 110°F.

Annual precipitation within the range of white spruce varies from about 7 inches in the Yukon to over 50 inches in Nova Scotia. Average snowfall varies from about 30 to 150 inches. Moisture conditions are most critical along the southern boundary in Alberta, Saskatchewan and Manitoba where mean annual precipitation is about 15 to 20 inches and where mean daily maxima temperatures in July are 75°F or more.

The growing season varies from about 160 days in Maine to as little as about 20 in the most northern areas of its distribution.[2] Generally, however, white spruce occurs only on favourable local habitats north of a line indicating a growing season of about 60 days (Anon. n.d.[3], 1954, and 1956b).

(2) Edaphic relationships

White spruce occurs over a wide range of soil moisture classes, but optimum growth is recorded from trees on soils with intermediate moisture levels. For example, the author has observed white spruce up to 110 feet tall on well drained habitats at the Riding Mountain but on wet or dry habitats trees of similar age are seldom over 70 feet in height.[4]

White spruce is more exacting than many other conifers in its nutrient requirements. Heiberg and White (1951) studying nutrient deficiencies on depleted soils in the Adirondacks noted that, of all the species observed, white spruce was the most affected by a shortage of nutrients.

White spruce will tolerate a wide range in pH. Spurway (1941) reported the optimum range as 5.0 to 6.0 with a maximum upper limit of 7.0. However, the author has observed white spruce growing well in Ontario on siliceous podsols with a pH of 4.5, and in Manitoba and Saskatchewan on calcareous grey-wooded soils with a pH of more than 7.4.

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[2] Growing season is taken to mean the number of days between the occurrence of a temperature of 32°F in the spring and fall.

[3] n.d. = no date.

[4] throughout this report the English rather than the Metric system has been used for recording measurements as this is the system of measurement regularly used by the Forest Research Branch.

(c) Life history

(1) Flowering and fruiting

Flowers are unisexual with both male and female flowers occurring on the same tree. Time of flowering varies with latitude, occurring from about the middle of May to early June. Cones ripen in August or September and most of the seed is disseminated shortly afterwards. At the Riding Mountain Forest Experimental Area, Waldron (1962a) has found that the period of maximum seedfall is generally in mid-September. His records also show that seedfall commenced some years as early as the first of August and in others not until October. Early seedfall is associated with below normal precipitation and above normal temperatures whereas late seedfall is associated with opposite conditions. Rowe (1955) also working at the Riding Mountain has shown that on occasion some seed is held in the cones into the following summer. In the Lake States, studies have shown (Roe 1946) that about 80 per cent of the seed is shed within 5 weeks after cone ripening and 93.5 per cent within 9 weeks.

(2) Seed production and dissemination

Excellent seed crops have been reported in some 20-year-old plantations in the United States (Nienstaedt 1957). However commercial seed production does not start usually until trees are at least 30 years of age, with optimum production after 60 (Anon. 1948). In Manitoba and Saskatchewan seed production begins usually between the ages of 45 and 60 (Rowe 1955).

White spruce is a prolific seed producer with good crops every 2 to 6 years and medium to no crops in the intervening years (Anon. 1948).

In a good seed year a tree may produce as many as 15,000 cones with about 50 seeds per cone. In a particular study in northern Minnesota Roe (1952) reported that an open-grown 75-year-old white spruce produced 11,900 cones in a good year with a total of 271,000 viable seeds.

Seed is disseminated by wind. The greatest distance of seed dispersal which has been accurately determined in the field is 330 feet (Crossley 1955a). However, with strong winds dispersal of more than 1,000 feet might be expected. Turbulence and convection currents might increase the distance even more. Rowe (1955) stated that late falling seed may scud over the snow for more than a mile providing conditions are right. However not many seeds travel in that manner since most are shed before the snow arrives.

(3) Vegetative reproduction

Under suitable environmental conditions white spruce cuttings can be rooted (Farrar and Grace 1940). Also cuttings may be grafted on other white and Norway Spruce (Picea abies (L.) Karst) root stock (Holst 1956a and Holst et al 1956b). There are no available records which suggest that white spruce will reproduce by layering or suckering.

(4) Establishment

The viability of white spruce seed is affected considerably by field conditions. For instance Place (1955) obtained from 0 to 89 per cent germination depending upon seedbeds and weather conditions. Natural germination usually takes place in June and July of the year following dispersal, as soon as seedbeds reach favourable temperatures. In Alberta, Crossley (1949) found that on mountain podsols germination was completed by June 19 whereas Rowe (1955) in Manitoba and Saskatchewan found little germination until the warm weather of early July.

If seedbeds are dry seed may remain in a state of dormancy until the second year (Rowe 1958). Optimum temperatures for white spruce germination are between 68°F and 86°F (Anon. 1948). Temperatures over 92°F after imbibition of water damages the embryo and may prevent germination entirely. The rather narrow range of optimum temperatures may preclude germination on some of the cool moist seedbeds that exist under forest canopies, and on burned surfaces and dry sites where temperatures are often very high.

Moisture is perhaps the most important single factor affecting germination and early survival of spruce seedlings. An adequate but not excessive supply is required. White spruce seed is very small and consequently the first-year seedlings are small with root systems which rarely penetrate to a depth of more than 3 inches (Long 1945a, Place 1952 and 1955). Any seedbed which dries out easily to a depth of 2 or 3 inches or more will therefore be detrimental to spruce during the first season. Litter, humus, and moss are generally poor seedbeds but mineral soil is good. However, where modifying circumstances assure a continued supply of moisture, humus and moss may support good spruce reproduction (Long 1945b and Place 1955). Heavy mineral soils are often too wet and too cold, at least under shade, resulting in poor or late germination. Also on heavy soils frost heaving is often a serious problem. Coarse soils have a tendency to dry out before the germinating seedlings become established; on such soils a mulch of needles or leaves aids both germination and growth.

The tolerance of seedlings to shade varies with edaphic and climatic conditions; generally seedlings are more tolerant than the parent trees. Spruce seedlings will grow in very shady areas but in such habitats they are spindly and weak. This is an important consideration in seedling

survival, since leaves from trees and shrubs crush and smother them (Koroleff 1953). On the other hand, seedlings in more open conditions are sturdy and are much less susceptible to crushing by leaves.

In the undisturbed forest most seedlings are found on decayed wood. This medium has the following advantages over other natural seedbeds: better moisture conditions, less opportunity for leaves to collect and smother seedlings, better temperature and light conditions, freedom from damping-off, and perhaps better mycorrhizal development (Bedell 1948, Phelps 1948, Westveld 1949 and Baldwin 1927). Of all the seedbeds observed by the author in Manitoba and Saskatchewan, in both disturbed and undisturbed forests, mineral soil and mineral soil mixed with organic material appear to be the best for both germination and survival.

(5) Early growth

Early growth of white spruce is usually slow. For instance, Rowe (1955) found that on mineral soil seedbeds white spruce took from 10 to 15 years to reach a height of 4.5 feet and on rotten wood as much as 30 years. In a study at the Riding Mountain, Waldron (1961) found that the tallest 10-year-old seedlings on natural seedbeds were less than 15 inches high. Under optimum plantation conditions, however, (good soil and full sunlight) white spruce will grow rapidly. For instance in northern Wisconsin, on a sandy clay loam, dominant white spruce trees in a 13-year-old plantation ranged in height from 18 to 21 feet and in diameter from 2.8 to 4.2 inches.

(6) Longevity and growth

White spruce is considered a long-lived tree and commonly reaches ages of more than 200 years. In fact trees as old as 500 years have been

found in the Mackenzie River Delta (Nienstaedt 1957). Maximum height and diameter vary with site and location, and in favourable situations it is not uncommon for white spruce to reach a height of 120 feet and a diameter of 48 inches. At the Riding Mountain, Jameson (MS in press) found that dominant trees on good sites averaged about 30 inches in diameter and 90 feet in height at 120 years of age. In the Algoma District of Ontario dominant white spruce in stands ranging in age from 90 to 150 years had an average diameter in excess of 20 inches and an average height of close to 110 feet (Wilde et al 1954).

(d) Biotic and other limiting agencies

White spruce seed is consumed by a number of insects (Trip and Hedlin 1956). The spruce seedworm (Laspeyresia youngana) and the spruce cone maggot (Pegohylemyia anthracina) are perhaps the two most serious pests and in light seed years because of their attacks little if any seed may be produced.

One cone rust (Chrysomyxa pyrolae) attacks white spruce but the extent of its damage is not known. In 1962 it occurred quite extensively at the Riding Mountain. Nearly every tree was infected to some degree; on some trees almost all cones were infected but on others the rust occurred sporadically. However, all seed in every infected cone examined had been destroyed.

White spruce seed is sought by several birds including the chickadee (Parus spp.), pine grosbeak (Pinicola enucleator), rose-breasted grosbeak (Pheucticus ludovicianus) and crossbills (Loxia spp.). Red and gray squirrels (Tamiasciurus hudsonicus and Sciurus carolinensis), chipmunks (Tamias spp. and Eutamias spp.) and voles and mice (Clethrionomys spp. and Microtus spp.) also feed on the seed (Rowe 1952 and Nienstaedt 1957).

The snowshoe hare (Lepus americanus) may cause considerable damage to white spruce, especially during population peaks (Aldous 1944). On several occasions the author has noted severe browsing by rabbits, especially on seedlings set out close to brush, which affords some cover for the rabbits. Near Bertwell, Saskatchewan, repeated browsing of trees up to 3 feet tall resulted in their death.

Deer (Odocoileus virginianus), moose (Alces alus) and elk (Cervus canadensis) do considerable damage to white spruce by rubbing their antlers against the stem and in times of food shortage by browsing.

Procupines (Erethizon dorsatum) cause much damage by eating the bark and in Alaska it has been reported (Lutz 1951) that black bears Euarctos americanus) sometimes strip bark from the lower parts of the trunk.

Squirrels often cut off the leaders and ends of the upper branches, especially during years of light seed crops. Usually the leader is replaced by a lateral and damage is slight unless two laterals compete to form a fork.

White spruce is surprisingly free of serious fungal diseases. However, snow blight (Phacidium infestans) causes some damage to small seedlings. Needle rusts (including Chrysomyxa ledicola, C. chiogenis, C. empetri, and Pucciniastrum americanum) attack white spruce but infestations rarely become serious. Witches'-broom caused by Peridermium coloradense and Arceuthobium pusillum may be observed on white spruce but is relatively unimportant (Boyce 1948).

A number of insects attack white spruce foliage. The most important are the spruce budworm (Cacoecia fumiferana), the European saw-fly (Diprion polytomum) and the eastern spruce beetle (Dendroctonus