DOMINION FOREST SERVICE

MARITIME DISTRICT

INTERIM REPORT ON THE ESTABLISHMENT OF THE GREEN RIVER EXPERIMENTAL CUTTING AREA

Madawaska County

New Brunswick

by

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April 30th, 1940

CONTENTS

CONTENTS (Continued)

THE GREEN RIVER EXPERIMENTAL CUTTING AREA

SUMMARY

Since the expansion of the pulp and paper industry into Eastern Canada, heavy demands have been made on the spruce and balsam fir forests throughout this region, in order to supply the raw material necessary in the manufacture of wood pulp. During the past several years a shortage in the supply of these species has become evident, and cutting operations have had to be extended into more or less marginal forests, containing a relatively higher percentage of species undesirable for pulpwood. The marginal forests, in the majority of cases, are "mixedwood" in character, containing 25 to 75 per cent of the coniferous species desirable as pulpwood, and the balance in mature hardwoods: yellow birch, white birch, maple, and beech.

Aside from the increased costs in operating mixedwood stands for pulpwood, another serious problem has arisen. Briefly, the perpetuation of spruce and balsam fir within those stands appears to be doubtful. Pulp and paper companies, governments, and other agencies owning vast areas of mixedwood forest, from which the chief revenue is pulpwood, have realized the necessity of determing correct methods of silvicultural treatment for the production of adequate regeneration, improved growing conditions, and maximum yield of coniferous species used in the manufacture of pulp.

In 1939 an experimental cutting area was established on the Green River Watershed, by the Dominion Forest Service in co-operation with Fraser Companies, Ltd., of Edmundston, New Brunswick, and the Department of Lands and Mines of the

Province of New Brunswick.

Located about twenty miles northeast of Edmundston, New Brunswick, the "Green River Experimental Cutting Area" is comprised of five separate areas.

Area No. 1 was logged over during the spring of 1939 by the clear cutting method (undersized permit)* now generally in use by Fraser Companies.

Area No. 2 was logged over during the spring of 1939 by the clear cutting method, with the exception that:

(a) Approximately two good white spruce seed trees per acre were selected and retained.

(b) All defective unmerchantable overmature hardwoods were killed by girdling.

Area No. 3 was not treated in any manner, but serves the purpose of a control area.

Area No. 4 was cut over for pulpwood in the spring of 1939 by the clear cutting method with all the skidding and yarding done by tractors.

Area No. 5 was clear cut for pulpwood during the summer of 1937.

From these examples of various methods, or applications of silvicultural treatment, data will be collected over a period of fifteen or twenty years, and the reaction of coniferous reproduction, sapling, and main stands will be measurable.

In the establishment and measurement of these areas several improved methods of procedure were employed, resulting in additional data, greater accuracy, better control

Additional studies within the Experimental Cutting Area are recommended:

(1) Seed dissemination studies by means of strategically placed seed traps.

(2) Additional prepared seed beds, with the mineral soil exposed for the purpose of studying coniferous regeneration.

(3) Hardwood utilization studies for the purpose of making hardwood removal from the stand an economically practicable operation.

The present Green River Experimental Cutting Area should be expanded to include samples of other silvicultural treatments, as it is possible only through trial, to determine the final method, or methods most suited to the needs of the pulpwood industry, and to the perpetuation of a desirable forest.

This report is not intended as conclusive evidence on how to silviculturally manage mixedwood forests for pulp wood production, but merely sets forth the initial method used in establishing and collecting data on an experimental area for the purpose of studying this problem.

Note - An extract from the "Permit to Cut Undersized Lumber," issued to Fraser Companies, Ltd., by the Department of Lands and Mines of the Province of New Brunswick, in accordance with section 16 of the Timber Regulations will clarify the term "clear cutting method (undersized permit)" used throughout this report.

> "All the spruce and balsam fir on the permit areas suitable for pulpwood must be utilized, and every tree must be cut within the areas being cut over which will make at least three four-foot bolts to a top diameter of four inches inside the bark. Stumps must be cut as low as possible and not over twelve inches above the ground."

When the maximum size of spruce and balsam fir on a permit area does not exceed the minimum requirements stated above, even though logging is economically practicable, no cutting is permitted.

INTERIM REPORT ON THE ESTABLISHMENT OF THE GREEN RIVER EXPERIMENTAL CUTTING AREA

INTRODUCTION

In Eastern Canada vast forested areas are located, from which pulp and paper companies obtain their basic raw products for manufacture. A great proportion of these forests are characterized by a type commonly known as "mixedwood", comprised of spruce, balsam fir, and so-called northern hardwoods which include sugar maple, red maple, yellow birch, white birch, and to some extent beech. These mixedwood stands are definitely marginal, in-so-far as spruce and balsam fir pulpwood is concerned.

At present the coniferous species, spruce and balsam fir, are of primary importance in the pulpwood industry, and while the stocking of mature conifers in the mixedwood type is sufficient for operating purposes on a clear cutting basis, doubts are held as to the validity of this silvicultural method in promoting a sustained yield of the important species. These doubts are supported by widely accepted theories:

(a) By clear cutting, the initial source of seed supply is so diminished, in the face of a supposedly inadequate stock of reproduction, that the perpetuation of coniferous species in the stand is extremely doubtful.

(b) Due to the lack of adequate, healthy advanced growth, the removal of all merchantable conifers in one operation will so lengthen the rotation period, as to make it economically impracticable.

(c) If sufficient seedlings and advanced growth are found to be present, there remains the constant suppressing and damaging influence of a relatively dense stand of tolerant hardwoods.

These theories, however, do not prove that the clear cutting of conifers in this type of forest is entirely devoid of silvicultural merit, but in an endeavour to verify, or disprove them, they have led to the actual establishment of an experimental area from which factual data can be collected, and the results of various silvicultural treatments followed.

It must be remembered, however, that any method of silvicultural treatment considered is directly dependent on existing conditions such as:

(a) The fact that pulp and paper companies do not utilize deciduous trees to any extent, for the manufacture of pulp.

(b) The relatively small volume of merchantable conifers within the mixedwood type necessitates, in many cases, a clear cutting policy, in order to make the operation economically practicable.

For several years pulpwood operators and government agencies have realized the necessity of determining correct methods of silvicultural treatment in these mixedwood forests for the production of adequate regeneration, improved growing conditions, and maximum yield of softwood species used in the manufacture of pulp.* No doubt this necessity has arisen from the fact that increased exploitation of mixedwood stands has become necessary, due to rapid depletion of coniferous species in softwood stands which had previously provided the bulk of the pulpwood cut.

Many of the pulp and paper companies have, through their logging or forestry departments, conducted studies, and collected data in an endeavour to solve this problem themselves.

*See Appendix - page 1.

A great deal of credit is due these individual organizations for the strides in silvicultural management already accomplished, especially when consideration is given to the unstable economic conditions prevalent throughout the world during the past decade, and upon which business management has crashed many times.

In October of the year 1937, Fraser Companies, Limited, of Edmundston, New Brunswick, requested that the Dominion Forest Service of the Department of Mines and Resources inaugurate an experiment in the mature mixedwood stands found in Northwestern New Brunswick in an endeavour to ascertain the possibilities of solving this problem through proper silvicultural management.

During the summer of 1938 the Dominion Forest Service investigated all aspects of this problem, in order to find an area suitable for study, and to draw up an outline of investigation.* After due consideration of all locations examined, one was chosen as suitable for the establishment of an experimental area; to be referred to hereafter as "The Green River Experimental Cutting Area". This area, located on the Green River watershed at approximately 68° 18' west longitude, and 47° 37' north latitude included the "Demonstration Woodlot" as laid out by Fraser Companies during the spring of 1938,† and additional forest areas in this vicinity.

* See Appendix - page 3.
† See Appendix - page 22.

GENERAL DESCRIPTION OF THE AREA

The Green River Experimental Cutting Area is typical of most of the forest lands in what W. E. D. Halliday[1] calls the "Temiscouata-Restigouche Section of the Great Lakes-St. Lawrence Forest Region", and is characterized by medium slopes, forming a series of low hills, and valleys at the bottom of which a brook, or river is generally to be found. The ridges are more or less flat topped, providing an excellent opportunity for road construction.

Soil Conditions

Twenty soil sample pits were dug for the purpose of obtaining a profile and description of the various ~~ground~~ soil layers. The pits were about two feet in diameter and a clean vertical surface was prepared in order to facilitate accurate measurements of the layers.

The litter is generally thin, having a depth of less than one inch. It is composed of hardwood leaves, softwood needles, and dead ground vegetation, with the former more in evidence throughout.

The humus layer ranges in thickness from one-half inch, to three and one-half inches. Full decomposition has not taken place except on wet sites near the valley bottoms.

The surface soil is characterized by three distinct layers. A leached, light grey soil forms the top layer, in most cases, and ranges from one-fifth, to five inches in depth. Directly below this leached soil a dark brown layer is noticable. Although it occured in only 70 per cent of the soil sample pits established, it cannot be attributed to any particular belt. Its maximum thickness is two inches. The bottom layer of the surface soil is light brown in color

(1) Bibliography

ranging in thickness from one-half inch, to twelve inches.

The surface soil in general is of a clay-loam content, "derived from glacial materials, residuals, and some marine clays."(1) The average depth is approximately eight inches, except, in some cases on the higher ridges where a depth of less than two inches was recorded. Drainage is good except on the flat valley bottoms, where a moist to wet soil condition is found. The sub-soil is made up of loose fragmentary rock, "of Cambrian, Devonian, and Silurian sedimentaries, locally metamorphosed",(1) but is generally well covered by the surface layer. The actual extent of the sub-soil was not obtainable as it was impossible to dig through it.

Climate

Climatic conditions are slightly more severe than in other parts of the Province. Three to four feet of snow is the average depth, while the winter temperatures are somewhat lower than those reached in central New Brunswick. Rainfall is generally heavier in the Temiscouata-Restigouche Section, possibly due to the altitude and the air cooling influence of the wide spread deciduous types of forest.

Forest Types

The Green River Experimental Cutting Area is composed of three distinct, and mature forest types: soft-wood, hardwood, and mixedwood.

The softwood type is found exclusively on the bottom land bordering brooks, or rivers. Balsam fir and white spruce predominate in this type, although scattered hardwoods are present, but do not exceed 25 per cent of the total stand. Numerically, balsam fir exceeds spruce in all stages of growth. Coniferous reproduction is prolific

(1) Bibliography

except where a profusion of alders or underbrush prevents its growth. These softwood areas are fairly well confined as to width, as the valley bottoms are narrow and with the slope upward comes increased hardwood representation. In a pulpwood operation, the conifers in these softwood types would enhance the pulpwood cordage per acre removed from any watershed, if it were not for the fact that many of these softwood stands had been selectively cut for saw logs several years ago. This light logging which occurred in 1926, in the vicinity of the Experimental Cutting Area, seems to be the only disturbing factor in the softwood stand. As the area of this cut was not limited directly to the valley bottom, but extended up the valley slope, in some cases ten or fifteen chains from the brook, a light disturbance was also caused in the lower extremeties of the mixedwood type.

The hardwood type is found on the ridges between valleys. Yellow birch and sugar maple predominate, with white birch becoming more prominant as the ground slopes downward. Beech is found scattered throughout. Some pure stands of sugar maple are to be found on these ridges, but aside from possible value as a source of maple sugar products, they are of little commercial use. In general these hardwoods are overmature and only fit for fuelwood, for which there is little demand in this region, consequently no cutting has been carried on in this type. There are no conifers of any description to be found on the hill tops and they only become noticeable as the slope is descended. When conifers exceed 25 per cent of the total stand the type classification changes to mixedwood.

The mixedwood type as previously pointed out forms the crux of this problem, as it covers the greatest area in this forest region, and although the coniferous content

ranges only between 25 and 75 per cent of the total stand much of the pulpwood supply is harvested from it. This type generally occurs on the valley slopes, between the softwood and hardwood types, although it may extend completely to the valley bottom, or to the height of land if the ridge is low. Balsam fir is the predominant coniferous species, in all age classes, with white spruce being relatively scattered. The large white spruce have less defect and are generally better trees in form and size than balsam fir. Yellow birch is the predominant hardwood species in the mixedwood type. In this species are found most of the very large "wolf" trees with diameters ranging as high as 34 inches at breast height. White birch and maple share second place, the former species having the least defect and best form of all the hardwoods. The maple is mainly the sugar or hard variety, but some red maple is present. Beech is scattered and of poor form.

General Characteristics

The forest incorporated in the Green River Experimental Cutting Area is characteristically climax, having reached maturity without any serious disturbances from logging, blowdown, fire, or insect attack.

The average age of white spruce, and of balsam fir was determined by examining numerous stumps after the 1939 logging on the Experimental Area. A total of 37 spruce, and 71 balsam fir stumps were examined. The average age of white spruce, with stump diameters ranging from twelve inches up, is 138 years, while ages recorded from balsam fir, with stumps seven inches and up in diameter, ranged between 65 and 115 years, with an average of 81 years. The age of the mature large hardwoods is 150 years and over.

The nature of the selection cutting in 1926, as previously described, while reducing the stand per acre to

some extent, had little silvicultural effect on the residual stand.*

Coniferous blowdown is negligible, due to the protection afforded by deciduous trees, and fire has apparently never disturbed this area.

The Spruce Budworm (Cocoecia Fumiferana, Clem.) did some damage during the epidemic of 1915-18. Although the results of this insect attack were noticeable in nearly all main stand conifers by the presence of several suppressed growth rings, relatively few balsam fir stubs were found on the Experimental Area, which would indicate that the attack was not heavy.

During the past two years yellow and white birch have been showing signs of devastation by what is thought to be an attack of the Bronze Birch Borer (Agrilus anxius). Although the damage has not as yet reached a point to result in a serious stand disturbance, there is evidence that it will in the near future.†

*See Table I - Appendix page 53.
†See Appendix - page 32.

METHODS OF ATTACKING PROBLEM*

Establishment of The Green River Experimental Cutting Area

The Green River Experimental Cutting Area embraces five separate areas, four of which represent a different application, or method of silvicultural treatment on mature mixedwood stands, and one which constitutes a control area as an untreated stand of a similar type.

Area No. 1

Area No. 1 was established directly southwest of the "Demonstration Woodlot", earlier referred to in this report, and adjacent to its southwestern boundary. This area was bounded by a closed compass and chain traverse, and contains approximately 45 acres. Living trees were blazed and used as station hubs along the traverse, with the station number being marked on the blazed plaque. The trees along the traverse were spotted with white paint in order to make them more noticeable.

Area No. 1 is representative of a mixedwood stand, logged over for pulpwood during the late spring of 1939, by the clear cutting method (undersized permit) now generally in use by Fraser Companies. The purpose of establishing an experimental area in this type of cutting is to make possible a comparison with other silvicultural methods employed.

Area No. 2

The "Demonstration Woodlot" of 240 acres (40 by 60 chains) was divided by a line run parallel to the south-eastern boundary and approximately fifteen chains from it. The section southeast of this dividing line, and within the "woodlot", was titled Area No. 2, and contains 90 acres, more or less. The trees along the boundaries of this area

* Based on Mr. R. H. Candy's report of 1938; (see appendix-page 3) together with suggestions from the various Dominion Forest Service officers, and others interested.

were spotted with white paint.

Area No. 2 was logged over during the summer of 1939 by the clear cutting method with the exception of that:

(a) Approximately two good white spruce seed trees per acre were selected and retained. These seed trees were banded at breast height (4½ feet above the ground level) by a ring of bright yellow paint two or three inches wide, and an aluminium number tag was placed on each one. The location of all seed trees was determined so that their positions could be marked on a map of the area.

(b) All defective unmerchantable overmature hardwoods were girdled by completely removing, with an axe, a ring of bark about four inches wide from the bole of the tree. This ring was cut three or four feet above the ground level, or high enough to avoid the irregular butt swellings which make difficult the complete removal of bark.

The purpose of this treatment was to create an area, in order to study the possibilities: of releasing coniferous advanced growth, of encouraging the reproduction of spruce following the opening up of the stand, and of releasing the subsequent growth of young conifers from suppression and interference by dominant hardwoods.

Area No. 3

Northwest of the dividing line, and within the "Demonstration Woodlot", Area No. 3, of 24 acres more or less, was established, bounded by Halfway Brook on the northeast, and by the motor road and portage road to Green River on the southwest.

Area No. 3 was not treated in any manner, but serves the purpose of a control area. It was believed

advisable to establish experimental plots in an undisturbed stand condition of a similar forest type to those being treated, as a means of comparing the silvicultural treatments employed on other areas, on the basis of an untreated stand.

Area No. 4

Area No. 4 was established in a mixedwood type near the point where Halfway Brook enters the Green River, and about fifteen chains east of what is known as the "1939 tractor operation camp", located on the Portage from Halfway Brook Depot to Green River, and about 5 miles from the Depot.* A group of ten, one-tenth acre sample plots was laid out in the desired forest condition and type, with no specified area, other than that comprised in the sample plots, being surveyed.

Area No. 4 was cut over for pulpwood in the spring of 1939, by the clear cutting method, with all skidding and yarding done by tractors. The disturbing effect, on litter, humus, and surface soil, of a tractor operating in unbroken bush was apparent, consequently the question arose as to whether or not this disturbance would prove beneficial to coniferous regeneration, and if so, to what extent. These plots were established on this area in order to collect data for a comparison with similar operations where the yarding and skidding was done by horses instead of tractors as, for example, on Area No. 1.

Area No. 5

Area No. 5 is adjacent to the motor road, about two and one-half miles from Halfway Brook Depot toward Edmundston.† The method of establishment was similar to that of Area No. 4, with twenty one-tenth acre sample plots comprising the area.

*See Figure 1.
†See Figure 2.

Area No. 5 was established in a mixedwood type, clear cut for pulpwood during the summer of 1937. It was the first sap-peeled, clear cutting operation to be conducted by Fraser Companies on the Green River watershed. On a few earlier operations, where the clear cutting method was used, logging was conducted during the winter months. In order to give a substantial basic comparison with the other silvicultural experiments, this fundamental factor could not be ignored, consequently no stands, clear cut previous to 1937, were suitable for an example of this silvicultural treatment. It will be possible to obtain immediately, advance information from this area, concerning the effects of clear cutting mature mixedwood stands for pulpwood, on coniferous regeneration.

Transect Sample Plots

The sampling was done by establishing transect sample plots. Lines two chains apart were run across the contours within each area, by means of a surveyors compass. The intersection, of the beginning and end of these lines, with the boundary of the Area was marked by a squared post, on which the line number was scribed. As the line was being run, a one-tenth acre plot, two chains long by one-half chain wide, was established along each two chain interval of line, and located on one selected side of the lines throughout each Area, thus a constant interval of one and one-half chains exists between lines of plots.

In laying out the plots, a right angle from the compass line was turned off and the end of the plot measured (33 feet), a squared post being set at each corner. Two chains further along the compass line this operation was repeated, and so on at every two chain interval until complete lines of plots were established across each Area. This type of plot proved very satisfactory, in that it was easily and

quickly established, and gave an added control in stem tally, because of its narrow width. Approximately a 25 per cent coverage resulted on any specific area where this system of sampling was employed. Travelling along the compass line in the direction that it was run, the first plot post encountered bears the scribe number of the plot directly ahead of the post, and so on throughout each line of plots. All the plots were numbered consecutively throughout all Areas, beginning with number one in Area No. 1, and ending with number 355 in Area No. 5.

The boundaries of each plot were marked with bright yellow paint in the following manner:

Along the long sides of the plot, trees immediately outside the boundary were marked with a spot at breast height, on the side of the tree facing the plot. No trees within the boundary of the plots were painted, except in marking the ends of plots, which formed the dividing line between plots along the compass line. In this case trees were spotted at breast height outside the end of the first plot, and facing the first plot, and inside the end of the first plot but facing the second plot, and so on. (See Figure 3).

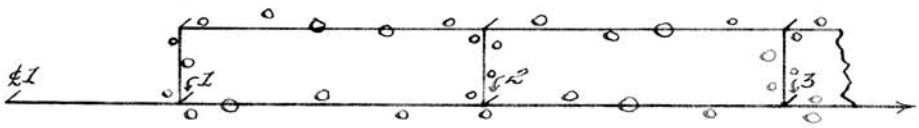

Figure 3.

This method of demarkation insured a permanent, and clear boundary to each plot, thus trees spotted as outside the plot will not be tallied as inside at any succeeding measurement.

Prepared Seedbeds(2)

On Areas No. 1, 2, and 3 several prepared seedbeds were established. Plots 3.3 feet (0.05 chains) wide and

(2) Bibliography

from one to three chains long were laid out in groups; one or two plots at a right angle to the contours, and one or two parallel to them. All seedlings, ground cover, underbrush, small trees, and debris were cleared off the plots, living growth being uprooted when possible. In the process of this operation the litter was well disturbed although the primary purpose in clearing the plots was to free them from all growth, so that possible seed reception would not be impaired and an accurate count of subsequent regeneration could be obtained.

Two prepared seed beds were established on Area No. 1, eight on Area No. 2, two on Area No. 3, and one on Area No. 4. After consulting the plot by plot stand tally, one group of beds was established on each of the first three areas in similar, and representative stand conditions, in an endeavour to ascertain the general stand reproductive capacity, and future species distribution under average conditions found on the three areas. One group located near the southwest corner of Area No. 2 was established to show the reproducing capacity of one isolated spruce seed tree. On Area No. 4 one bed was established on a tractor haul road, for the purpose of determining the probable amount of coniferous reproduction to be expected on bare mineral soil.

Collection and Preparation of Data

Diameter Height

Diameter height measurements were taken in the usual way with an Abney Hand Level (topographic arc). These heights were measured on Areas No. 1, 2, and 3; the following number being recorded for each species:

White Spruce	79	measurements
Balsam Fir	136	"
Yellow Birch	96	"
White Birch	69	"
Maple	56	"
Beech	18	"

The resulting data were summarized and smooth curves plotted for each species, using height over diameter. A height, to the nearest foot, for each one inch diameter class, was recorded from these curves.

Form Class

No form class measurements on white spruce, or balsam fir were necessary as sufficient data were available from a growth study conducted by Fraser Companies in 1937. From this data it was determined that an average form class of 65 was applicable to both white spruce, and balsam fir.

Volume Tables

Local volume tables were prepared for each species using the average height for each one inch diameter class. Logarithmic charts, based on the Dominion Government "Form Class Volume Tables", were used to compute unit volumes of white spruce and balsam fir, while form class volume tables 168, 167, 169 and 166 were used to compute the unit volumes of yellow birch, white birch, hard maple, and beech, respectively.*

Stand Tables

(a) Stand Tally

In order to prepare stand tables, showing the number of trees, and volume of wood per acre after silvicultural treatment, a tally of the residual living trees on all transect sample plots was necessary. The diameter at breast height (4.5 feet above ground level) of all trees, 0.6" D.B.H.

*See Appendix - page 52A and 52B

and up, was measured in one inch diameter classes with each species being separated in tallying into two classes:

(1) LIVING GOOD - meaning trees which are not defective, or too badly suppressed; that is, merchantable trees, or small trees which have a good chance of becoming merchantable.

(2) LIVING DEFECTIVE - meaning trees that are visibly defective; that is, unmerchantable trees, or small stems that have no chance of ever becoming merchantable.

This stand tally gives a precise picture of the forest cover on each sample plot at the time of measurement and the corresponding conditions under which regeneration takes place. When future stand tallies are made on these same plots, changes in forest cover become apparent and their influence on new and young growth will be discernable.

All standing dead trees were tallied and blazed at breast height so as to prevent them being tallied again, at the next remeasurement, with those dying between the measurement periods. By securing a tally of all trees dying between any two periodic stand measurements on an area, gross and net annual increment in both stems and wood volume may be computed.

As the logging operations were conducted previous to the measurement of the areas, all stumps were tallied in one inch diameter classes by species as follows:

Area No. 1 - Stumps resulting from 1939 logging.
Area No. 2 - " " " " "
" " " 1926 "
Area No. 3 - No stumps
Area No. 4 - Stumps resulting from 1939 logging.
Area No. 5 - " " " 1937 "

The diameter measurement was taken at about 1.5 feet above the average ground level in order to make use of the conversion tables (F.C.V. Tables 176 and 187) to D.B.H. The

stumps were tallied to determine the amount and number of each species cut on the several areas, and with the exception of the 1926 cut on Area No. 2, to formulate stand tables showing the stands previous to cutting. Further effects of the degree of cutting on present and future reproduction will be learned.

On Area No. 2 all the girdled hardwoods occurring on the sample plots were tallied by species in one inch diameter classes, for the purpose of determining the intensity of this treatment on the several hardwood species, and the resultant effects on conifers of various age classes.

(b) Checking Tally

In order to insure a correct tally, complete checks of each sample plot were made. The trees on some plots were remeasured as many as four times, and on all plots laid out, they were measured at least twice.

The following method of checking proved to be the most satisfactory, and consists of four essential points:

(1) The first diameter measurement of all the trees on a sample plot was immediately followed by a second measurement.

(2) A different man was used for each measurement.

(3) The two tallies were kept on separate sheets and compared when the tallies were completed.

(4) Any differences were immediately checked and a correct tally was obtained before leaving the plot.

The necessity for checking tally arises from the fact that these same plots will be measured several times, over a period of fifteen, or twenty years, and in order to compare measurements, and obtain correct increment data, accuracy in tally is essential.

(c) Compilation

Two methods of compiling the stand tallies were used in order to facilitate complete control of each plot, now, and at any future remeasurement. The first method is a simple summary of field tally sheets, by D.B.H. classes, and species for each plot, so that tallies recorded at future remeasurements may be added to the summary sheets, and a quick comparison made of the stand at each period.* The second method is simply a complete stand table for each separate sample plot, showing number of trees, and total cubic foot volumes in each species and diameter class, at each phase of the stand's treatment.† Total softwood, and total hardwood stems and volumes by species, are also shown, together with the total sapling stand (1" to 3" D.B.H. inc.), total main stand (4" D.B.H. and up), and a grand total of the two stands. These stand tables give a complete and understandable picture of the stand on each sample plot. In order to combine any series of plots the simple addition of the desired stand tables is all that is necessary. In that the size of the sample plots is one-tenth acre, it is only necessary to multiply any figure on these stand tables by ten (10) in order to arrive at a per acre basis, as represented by any single plot.

(d) Stand Table Summary

As there is not space in this report to show a detailed stand table for each of the 355 sample plots on the Experimental Area, a summary of the main stand, and sapling stand, on each of the five areas, was prepared. This summary comprises three main divisions according to the general forest type classification, on the basis of the number of coniferous and deciduous trees appearing in the

*See Appendix - page 37 for a copy of this summary sheet
†See Appendix - page 38 for an example of this stand table

main stand:[3]

1. HARDWOOD - 75 per cent and over of hardwoods.
2. SOFTWOOD - 75 per cent and over of conifers.
3. MIXEDWOOD- Types not included in 1. or 2.; in this case between 25 and 75 per cent of either hardwoods or conifers.

No attempt was made to segregate the sample plots into final groups for comparison, but rather to allow for individuality of samples. If at some later date a combination of plots is desired, in order to bring out some specific stand characteristic other than the forest type classification, an addition of the individual stand tables of the plots desired is the only operation necessary.

Table II* shows the "main stand" per acre (Trees 3.6" D.B.H. and up) on each of the five areas, before and after the silvicultural treatment, together with the number of trees, and cubic feet of wood cut and girdled.

Table III† shows a summary of the "sapling stand" per acre (Trees 0.5" to 3.5" D.B.H. inc.) on each of the five areas. The classification is similar to that used in summarizing the main stand. As the silvicultural treatment did not apply to the sapling stand no stem, or volume deductions were necessary.

Reproduction[2]

Reproduction was classed as all trees below 0.5 inches in D.B.H., including both hardwood and softwood species. It was tallied on a small transect sub-plot within each tenth acre sample plot. The sub-plots were 3.3 feet wide (0.05 chains) by 132 feet long (2 chains) and were laid out along the side of the sample plot tangent to the compass line. The following method of counting seedlings on these sub-plots was used:

(3) Bibliography - (section 39)
*See Appendix - page 55
†See Appendix - page 56
(2) Bibliography

A two chain steel tape was placed along the boundary of the sample plot. Two men were employed, one carrying a light stick 3.3 feet long for measuring the width of the sub-plot, and one tallying. The first man checked the width of the sub-plot, and called the seedlings by species and height class. It was the duty of the second man to follow closely behind the first, tallying all seedlings called, and keeping a sharp lookout for any seedlings missed. This method proved very satisfactory in that a saving of time, and accuracy were combined.

The seedlings were tallied by species in two separate classes: those less than one-half foot in height, and those over one-half foot in height. The reason for dividing the seedling tally into two height classes, was due to the general belief that seedlings under 0.5 feet high should not, in most cases, be classed as established, or permanent growth. The new seedlings appearing in a stand from year to year may represent many thousand per acre, but it is well known that very few of them survive to become full grown trees and the majority never reach a height of over one-half foot. While it cannot be assumed that all seedlings over one-half foot in height will live, a coresponding larger number than can be expected from the smaller height class will survive to enter the sapling class.

Actual counts were made of each species up to a maximum number of 50 seedlings in the first height class and 25 seedlings in the second height class. When more than the maximum counted number occurred in either class on a single sub-plot, a plus sign was affixed to the 50, or 25, which indicates adequate stocking in the species and class referred to.

The purpose of this reproduction tally is to provide actual data regarding the stocking of the stand with young growth. The abundance of all reproduction has a direct influence on the future forest; consequently, sustained yield of the desirable species and crop rotation depend on the quantity and quality of each species present.

Tables IV, VI, VIII, X, and XII were prepared to show the number of seedlings under 0.5 feet in height on each separate sub-plot.* These plots were grouped according to the three forest type classifications, previously described, and the seedlings per acre computed.

Tables V, VII, IX, XI, and XIII show the number of seedlings over 0.5 feet in height on each separate sub-plot and in groups according to forest type classification, with the number per acre for each type.†

Ground Vegetation

On each of the 355 sample plots laid out, all species of plants and shrubs were tallied and classed in order of abundance as follows:

1 -- Abundant
2 -- Moderately Abundant
3 -- Scattered

Compilations were carried out separately for each of the five areas, and lists were made showing the number of plots on which the species were absent, scattered, moderately abundant, or abundant.

From an examination of the species occuring on Areas No. 1, 2, 3, 4 and 5, a list of the more common plants was compiled in order of abundance.

*See Appendix - page 57 etc.
†See Appendix - page 59 etc.

This is shown below:

wood sorrel
clintonia
shining clubmoss
wood ferns (2 species-common, and mountain)
sarsaparilla
bunchberry
false lily of the valley

Of these species, wood sorrel, bunchberry, and false lily of the valley indicate nothing, as they were found under various conditions throughout all areas. Clintonia, shining clubmoss, sarsaparilla, and wood ferns indicate a moist rich soil, typical of the hardwood, or mixedwood type.

On the top of the ridges, where a high percentage of hardwood species occur, wood ferns and shining clubmoss were abundant. Trillium, although rare, was also present. As the slope was descended these species disappear. Wood sorrel was continually present, but appears most vigorous near the bottom of the slope. Twisted stalk was scattered throughout all areas, but was most common on the higher ground. Clintonia, sarsaparilla, bunchberry, white violet, false lily of the valley, and starflower were present every where, with the former three most abundant, and the remainder scattered. Narrow beech fern was found near the valley bottoms in moist stoney soils.

Of the shrubs, mountain maple was most common, being abundant practically every where in all forest types. Throughout the hardwood and mixedwood types this species was followed closely in abundance by hobble bush, which thrives vigorously on these sites. Striped maple was present in limited quantities on a majority of the plots in the hardwood, and mixedwood types. Other shrubs present included: hazel, existing chiefly under hardwood stands, mountain ash, wild currant, juneberry, and nannyberry, which were, for most part, scattered throughout the entire Experimental Area.

RESULTS DERIVED FROM THE ESTABLISHMENT AND MEASUREMENT OF THE GREEN RIVER EXPERIMENTAL CUTTING AREA

Generally speaking, present results can be summed up as follows:

1. Most important is the fact that a start on an Experimental Cutting Area has been undertaken, for the purpose of collecting and analysing data over a period of years, in an endeavour to solve the problems of silvicultural management for pulp wood production of the marginal mixedwood forests covering large areas in Eastern Canada.

2. In the establishment and measurement of this Experimental Cutting Area, several improved methods of procedure were employed, resulting in additional data, greater accuracy, better control in measurement, and more speed throughout.

3. The statistical results, and deductions there from, obtained by the first measurement of the "Green River Experimental Cutting Area" are now available.

Main Stand (trees 4" D.B.H. and up)

Table II,* as previously asserted, gives a complete main stand summary for each forest type, on each of the five areas incorporated in the Green River Experimental Cutting Area. The main stand, as a whole, is important, in that the methods of silvicultural treatment were employed directly to this division of the forest, and it is by means of these treatments that the sapling stand, seedling stand, and even future regeneration is to be controlled. Consequently it is necessary to know the extent of the main stand prior to

* See Appendix - page 55.

treatment, the amount of the main stand removed by treatment, and the residual main stand now present.

Considering the mixedwood type, which covers the greatest area within the Experimental Area, we find that Area No. 1 originally supported 853.6 cubic feet per acre of coniferous trees, 78 per cent of which was balsam fir, the balance being spruce. The clear cutting for pulpwood applied to this area reduced the original softwood stand by 68 per cent (584.0 cu.ft. per acre), 70 per cent of which was balsam fir. The residual coniferous stand contains 17.2 cubic feet of spruce per acre, with 60 per cent representing good trees, while out of the 252.4 cubic feet of balsam fir per acre only 42 per cent are good trees. This leaves a total of 116.2 cubic feet of potentially merchantable softwood per acre, of which only 9 per cent is spruce and the balance balsam fir.

The hardwood stand was untouched by the cutting, and its comparative volume equals 2,023.3 cubic feet per acre, 69 per cent of which is yellow birch, the balance composed of white birch and maple in about equal quantities.

Area No. 2, clear cut for pulpwood with the exception that about two good spruce seed trees per acre were retained, shows an original coniferous stand in the mixedwood type of 745.6 cubic feet per acre (17 per cent spruce - 83 per cent balsam fir). Cutting reduced the stand by 51 per cent, or 382.4 cubic feet per acre, of which 85 per cent was balsam fir. The residual coniferous stand contains a volume of 73.2 cubic feet of spruce per acre, and 290.0 cubic feet of balsam fir per acre. Of these amounts 94 per cent of the former species, and 67 per cent of the latter species are good trees, making a total of 263.8 cubic feet of softwood per acre potentially available.

This figure is over twice the residual volume of the mixedwood type on Area No. 1.

The original hardwood main stand on Area No. 2, in all of the three forest types combined, was composed of 48 yellow birch per acre, 15 white birch per acre, 23 maple per acre, and 9 beech per acre, with a total volume of about 2,290 cubic feet per acre. Of this original stand 90 per cent of the yellow birch was girdled, 80 per cent of the white birch, 83 per cent of the maple, and 89 per cent of the beech, or a total of 82 hardwoods per acre, representing a volume of approximately 2,230 cubic feet per acre.

Fraser Companies, Ltd., supplied the labour for girdling at a cost of $223.39 which included wages, and board at the rate of 60¢ per man per day. The girdling operation was completed by a crew of men in 12 days, which amounted to 112½ man days in all. Approximately 90 acres were treated, bringing the cost to about $2.48 per acre.

The residual hardwood stand, after girdling comprises five yellow birch, three white birch, four maple, and one beech per acre, representing a total hardwood volume of about 64 cubic feet per acre throughout the whole area.

Area No. 3, untreated in any manner, contains 845.0 cubic feet of softwood per acre, in the mixedwood type, of which 625.0 cubic feet per acre is balsam fir and 220.0 cubic feet per acre spruce. Of the former species, 34 per cent is defective, while 26 per cent of the latter species is also defective. This results in a present pulpwood stand of 163.0 cubic feet of spruce, and 411.0 cubic feet of balsam fir per acre.

The hardwood volume in the mixedwood type on this area is 2,325.0 cubic feet per acre, of which 78 per per cent is yellow birch, 8 per cent white birch, 11 per cent maple, and 3 per cent beech.

Area No. 4 is all mixedwood type containing originally 1,263.4 cubic feet of softwood per acre. Cldar cutting for pulpwood in 1939 removed 150.9, and 971.6 cubic feet per acre of spruce, and balsam fir respectively. The residual softwood stand contains 3.5 cubic feet per acre of good spruce, 53.7 cubic feet per acre of good balsam fir and 83.6 cubic feet per acre of defective unmerchantable balsam fir, or a total merchantable coniferous stand of 57.2 cubic feet per acre. In comparison with this the hardwood stand is equivalent to 2,360.5 cubic feet per acre, of which 87 per cent is yellow birch, and the balance maple and white birch.

Area No. 5, clear cut for pulpwood in 1937 originally contained about 1,580.0 cubic feet per acre of softwood in the mixedwood type. The cut removed 219.0, and 1,190.0 cubic feet per acre of spruce, and balsam fir respectively. The residual stand in 1939 contains 1.0, 23.0, and 87.0 cubic feet per acre of good spruce, good balsam fir, and defective balsam fir respectively. Hardwood volume is 1,770.0 cubic feet per acre, of which 61 per cent is yellow birch and 39 per cent white birch.

Sapling Stand (trees 1" to 3" D.B.H. inc.)

The coniferous sapling stand (0.5" to 3.5" D.B.H. inc.) is an important division of this forest. Coniferous trees in this class are too small for cutting, consequently if the residual stands are sufficiently stocked with saplings to produce a new stand, then a short rotation is conceded.

From the factual data resulting from an actual tally, the abundance and condition of the sapling stand becomes an accurately known quantity. As the mixedwood type is the most important, in view of the problem under study, and is found on all five of the areas involved, the hardwood and softwood types will be disregarded for the time being, and only the former type dealt with.

In dealing with the sapling stand the most important figures to note are the number of trees present. On the 306 plots, or 30.6 acres of mixedwood sampled, throughout all five areas, eight per cent of the softwood is spruce (nine trees per acre) of which eighty-three per cent are good trees free from visible defect (seven trees per acre). Ninety-two per cent of the softwood is balsam fir (one hundred and three trees per acre) and of this, eighty-four per cent are good trees (eighty-seven trees per acre). From this it is obvious that only ninety-four coniferous saplings per acre at the most, can be relied upon for a future harvest in this type. In comparison with this figure there are approximately forty-four hardwood saplings per acre throughout. This condition, in that there are twice as many coniferous saplings present as there are hardwoods, is encouraging to some extent, but the fact that there are only ninety-four softwoods per acre present is unfavorable to say the least. In so far as the mixedwood type on each individual area is concerned, Area No. 2 supports the most softwood, (one hundred and forty trees per acre) and the most hardwood (forty-nine trees per acre), while Area No. 4 supports the least softwood, (twenty-six trees per acre) and also the least hardwood (fifteen trees per acre).

As would be expected, the softwood type found on Areas No. 1, 2, 3, and 5 supports more coniferous saplings

(two hundred and seventy-three stems per acre) with comparatively few hardwood stems present (thirty-two stems per acre). The area involving this type is so small, that very little weight can be given to any coniferous stand expected on it.

The hardwood stands, occurring on Areas No. 1, 2, and 3 only, are conspicuous by the absence of coniferous saplings (twenty-five stems per acre on the three areas). This figure is definitely the result of including a few plots with less than twenty-five per cent conifers, on the border between the hardwood and mixedwood stands. No conifers what ever were found on the pure hardwood ridges.

Obviously the coniferous sapling stand, now present in the mixedwood types, cannot be counted on to produce a pulpwood crop worth harvesting. One solution of the problem seems to rest on the ability to increase and maintain the sapling stand by silvicultural management. The increases in saplings must depend, to a large extent, on the coniferous seedlings now present, and the possibility of adequate future regeneration, while the maintenance of a healthy, vigorous and adequate sapling stand depends chiefly upon growing conditions free from the suppressing influence of dominant hardwoods.

Seedling Stand (Trees less than 0.5" D.B.H.)

A recapitulation of Tables IV to XIII inclusive shows the following seedlings per acre present in the mixedwood type on all five areas:

	Under 0.5 Ft. in Ht.		Over 0.5 Ft. in Ht.	
	Softwood	Hardwood	Softwood	Hardwood
AREA 1	137 - 6% spruce	1726	969 - 8% spruce	531
AREA 2	194 - 6% "	706	1517 - 8% "	734
AREA 3	313 - 8% "	1045	1230 - 11% "	508
AREA 4	670 - No "	520	930 - 13% "	440
AREA 5	1145 - 2% "	2017	2960 - 20% "	1276

The condition of the coniferous seedlings found on all areas is generally poor with the exception of those found on Area No. 5. By "poor" is meant, that the seedlings have been continually suppressed by the dense hardwood overstory, and probably by the dense under growth, present throughout the forests of this region. The damage caused by suppression is noticable in the appearance of the seedlings, and was verified by an examination of the growth rings on numerous samples. The age of conifers under 0.5 feet in height ranged from one year to seventeen, while those over 0.5 feet in height ranged from ten to forty years old. In general those seedlings under 0.5 feet in height did not show the effects of suppression as much as did the larger class, due no doubt to the relatively younger age of the former.

On Area No. 5 the seedlings were released by a pulpwood cut in 1937. The benefit of this cut is not only evident from the quantity present, but the general quality is much improved over seedlings found under dense canopies. Photographs No. 23 and No. 24 show the type of seedlings to be found on this area.

It is possible that there are at present enough coniferous seedlings throughout the mixedwood types to perpetuate the species. In order to give as many seedlings as possible a chance to survive, the stand must be opened up. It will be of interest to compare, through periodic measurements, the changes in quantity and quality of coniferous seedlings on the areas opened up by the cutting and girdling in 1939.

Ground Vegetation

Since all the areas were located on identical sites the vegetation on all was similar. The plants found were the ones common to mature tolerant hardwood, and mixedwood stands.

The abundant shrub vegetation might well have a very pronounced effect upon the successful survival and growth of the small spruce seedlings, in that it limits the amount of light required by this species. In addition, the shade provided by these shrubs retards the decomposition of the humus, as sufficient light and heat is essential for this process to be carried out. The fallen leaves of the shrubs help build up the layer of humus, until this material reaches a depth which is detrimental to the development of spruce seedlings.

RECOMMENDATIONS

The following recommendations are important to a furtherance of the study undertaken:

1. Seed dissemination studies should be conducted by means of strategically placed seed traps throughout Areas No. 1, 2, and 3. It was not thought advisable to set out seed traps in 1939, due the scarcity of cones on spruce, and balsam fir trees. Traps should be set out during the summer of 1940 so as to co-ordinate the study of seed dissemination with the study of the treated areas.

An interesting letter was received from Mr. A. P. MacBean, Assistant Forester, British Columbia Forest Service in which he describes seed dissemination studies being carried on in that Province.*

A method of study, somewhat along the lines described by Mr. MacBean, is recommended on the Green River Experimental Cutting Area.

2. Additional prepared seed beds should be established on Areas No. 1, 2, and 3 during the summer of 1940. The new beds should be cleared down to the mineral soil.

Possibly it would be advantageous to extend the lengths of the present beds in some cases.

3. The possibility of utilizing more hardwood, throughout regions where extensive mixedwood forest are found, should be studied. It is felt that great benefits to these forests would result, if at least part of the hardwood stands could be removed. Girdling hardwoods is one means of destroying them, and in some cases, the added increment on conifers more than compensates the cost of

*See Appendix - page 39.

girdling. If, on the other hand, enough revenue could be obtained from hardwood logs to justify the cost of logging and transportation the increased increment on conifers as a result of removing the hardwood would be pure profit.

4. The present Green River Experimental Cutting Area should be expanded to include samples of other silvicultural treatments, as it is possible only through trial, to determine the final method, or methods most suited to the needs of the pulpwood industry, and to the perpetuation of a desirable forest.

CONCLUSION

In conclusion, the writer, on behalf of the Dominion Forest Service, wishes to thank Fraser Companies, Ltd., for their whole hearted co-operation in arranging for this study, in supplying the New Brunswick Survey Party with board and lodging at a nominal fee, in supplying their own men to aid in the establishment of the Experimental Area and the collection of data, in undertaking all logging on the areas involved, and the girdling of hardwood trees on Area No. 2, and in providing essential information concerning their own studies of the problem.

This report is not intended as conclusive evidence on how to silviculturally manage mixedwood forests for pulpwood production, but merely sets forth the initial method used in establishing and collecting data on an experimental area for the purpose of studying this problem. There are, no doubt, other ways of attacking the problem, but it is felt that with the information now available, and providing similar data are collected at future measurements, valuable conclusions regarding any silvicultural treatments used may be formed.