RESEARCH BY THE FEDERAL FORESTRY BRANCH IN THE GREEN RIVER PROJECT

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INTRODUCTION

In 1944 a program of research in various aspects of forestry was initiated in the Green River watershed in northwestern New Brunswick (Fig. 1). Although this program, known as the Green River Project, was originated to study an insect problem, the objectives have expanded to include studies in entomology, pathology, small mammals, silviculture, growth and yield, ecology, utilization, logging methods, and management.

While the work of the Forestry Branch is carried on separately from that of other organizations, overall guidance and co-ordination is maintained through the Green River Work Committee consisting of representatives of the Forest Research Division, Department of Northern Affairs and National Resources; the Forest Biology Division, Canada Department of Agriculture; the New Brunswick Department of Lands and Mines; and Fraser Companies Limited.

Close co-operation and collaboration is maintained between these agencies in planning research and applying the results. The Forest Biology Division is responsible for all work on insects and diseases. Fraser Companies Limited manage the area, direct all cutting operations, and are responsible for fire detection and suppression. The Department of Lands and Mines provides additional fire control services and administers Provincial regulations dealing with timber, fish and game. The Forest Research Division is responsible for research in silviculture and management, including work in ecology, site classification and growth.

Annual reports, summarizing progress, are issued by the committee. This report describes the contributions of the Forestry Branch.

THE AREA

Initially, much work was devoted to describing the area and defining the problems. This information is summarized here under physiography, species and associations, and history.

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FIGURE 1. Key map of Green River Project.

Physiography

The Green River watershed contains about 263,000 acres, of which 240,000 acres are in the management area. About one-third of the management area is owned by Fraser Companies Limited; the remainder is New Brunswick Crown land held under license to this company.

The watershed is a strongly rolling upland plateau 1,000 to 1,500 feet above sea level, but with extreme elevations up to 2,050 feet. The bedrock is strongly folded slates and argillites with a free vertical cleavage and local concentrations of lime in the form of calcite veins. The soil mantle is a glacial till largely derived from the bedrock. Considerable variation occurs in the depth, petrography, and stoniness of the till, and in the amount of reworking by water. Podzol soils predominate.

The climate is characterized by abundant precipitation, long cold winters and short cool summers. Weather records have been kept since 1944 at the Green River Laboratory which is at an elevation of 1,350 feet. The data show a frost-free period of 111 days, a mean annual temperature of 36 degrees and an annual average precipitation of 43 inches, of which 18 inches falls between June and September.

Species and Associations

Because the watershed extends from the Great Lakes - St. Lawrence into the Boreal Forest Region (Rowe, 1959) it contains many of the species and associations representative of each of these Regions. The most common species in their approximate order of volumes are: balsam fir, white spruce, black spruce, sugar maple, red maple, white birch, yellow birch, white cedar, beech, aspen, and poplar². There are also minor amounts of white pine, red spruce, black ash, white elm, and tamarack. Pin cherry, striped maple and mountain-ash occur in the small-tree class, while mountain maple, speckled alder and hazel are the common shrubs.

Softwoods predominate on most of the watershed but hardwoods are abundant, particularly in the southern part. There the lower gentle slopes and flats usually support fir and spruce; gentle mid-slope and most moderately steep slopes support mixedwoods of fir, white birch, yellow birch and spruce; the upper slopes support similar mixedwoods with red maple, sugar maple, beech and striped maple as added components; the hilltops are largely hardwood—sugar maple, beech, red maple, yellow birch, with the occasional fir and spruce. Stands of spruce with some fir are common on steep slopes and it is on steep upper slopes that red spruce is most often located. The rare peat flats usually support spruce, fir and cedar; the infrequent rich moist flats have either fir-spruce or mixedwood with black ash and cedar. Eskers occurring in the main valleys support spruce and fir.

Toward the northern part of the watershed the fir-spruce stands hold the same valley bottom and lower slope positions, with mixedwoods of balsam fir, white birch, black spruce and white spruce covering the middle slopes, upper slopes and hilltops.

² Common names of trees are those used in Native Trees of Canada, Forestry Branch Bulletin 61.

History

In the last three decades, two widespread natural disturbances have occurred in the forests of the region: the birch dieback which began about 1938, and the spruce budworm infestation of 1952 to 1958. The dieback caused extensive mortality of both white and yellow birch. In terms of volume, the standing dead yellow birch in northwestern New Brunswick has been estimated at 150 per cent of the living; the corresponding figure for white birch is 291 per cent (Anonymous, 1958.)

Mortality of fir and spruce due to the budworm outbreak has not been extensive, mainly because cutting has been concentrated in the most vulnerable areas and because of spraying with DDT. The Kedgwick Control Area, immediately adjoining the Green River watershed, has been neither cut nor sprayed through the course of the outbreak, and depicts the mortality that would have occurred if spraying had not been carried out. There, upward of 95 per cent (by basal area) of the fir is dead in mature stands and 30 to 60 per cent is dead in the immature stands. However, the main effect in the Green River watershed during the period of severe defoliation has been the reduction in growth rate. Also, undesirable vegetation, such as raspberry and mountain maple, has developed in severely defoliated stands.

In a previous budworm outbreak from 1913 to 1919 some softwood stands suffered severely, some moderately, and some very little. Where mortality was light the stands are now overmature and are breaking up because of decadence. Where mortality was moderate, advance growth was released and the stands are now two-storied in appearance. Where mortality was extensive new stands of fir-spruce developed that now contain stems up to 9 inches in diameter at breast height. About 30 per cent of the softwood sites support these dense young stands.

The general history of cutting is known back to about 1880. Scattered operations for large spruce and pine were conducted prior to 1900. Saw-log operations for several species, but mainly for fir, spruce, pine, and birch, continued until about 1937. Pulpwood cutting began in 1933. During the last few years, some of the ridges have been cut over for merchantable maple, birch and beech logs.

Fire has not been a factor in stand succession during the last century. Only about ten fires are recorded in the Green River watershed, of which six occurred between 1880 and 1899. The four fires since 1900 were suppressed before they burned appreciable acreages.

RESEARCH PROJECTS

Discussion of the research is presented below in three parts and when possible in chronological order. Generally, studies in management, mensuration and stand development were initiated first, then attention shifted to silviculture and more recently to site classification and ecology.

MANAGEMENT

Management Plan

The first project initiated by the Forest Research Division was a survey of forest conditions. Stand data collected on temporary and permanent plots, supplemented by inventory data and maps supplied by Fraser Companies

Limited, were the basis of the management plan written in 1950. Briefly this plan provided for: (1) Clear cutting of merchantable fir and spruce in the northern working circles which contained a large percentage of stands highly susceptible to damage from an expected budworm outbreak. (2) Gradual conversion where possible to partial cutting every 20 years in all softwood cover types. (3) Annual allowable cut of 50,000 cunits (59,000 cords) for the first decade, gradually increasing to an annual cut of 75,000 cunits (88,000 cords) by the year 2010, at which time about 150,000 acres would be partially cut under a 20-year cutting cycle.

The amount of pulpwood harvested since 1944 has averaged 43,000 cunits (51,000 cords) per year, and since 1955 the annual cut has averaged 65,000 cunits (76,800 cords). (Anonymous, 1956, 1957 and 1958).

Stand Development

Five sampling areas called research blocks were established, one each year from 1945 to 1949, in five sections of the watershed. Each block contains 4,000 acres in a rectangle 100 chains by 400 chains. Some 640 permanent tenth-acre plots were established in each block at 6-chain intervals along lines ten chains apart, giving a cruising intensity of 1.6 per cent. Information collected on each plot included diameter class tallies of all living and dead trees, amount of cut and blowdown, abundance of lesser vegetation, descriptive records of site conditions, and height, age, diameter and radial increment data.

In 1950 and 1951 two blocks were remeasured. The analyses showed that the 5-year interval did not give a good picture of developments because true changes were enlarged or nullified by small errors in measurement. The re-measurement schedule was then changed to ten years. The third block was remeasured in 1957 and the fourth and fifth blocks in 1958 and 1959 respectively. The data provide information on inventory and stand development, particularly on such aspects as net and gross increment, successional trends by site types, and amount of birch mortality due to dieback. Because they are not reserved from cutting, a block or part of a block may be cutover between measurements. This adds to the difficulties of remeasurement and analysis but the data will provide information about future stand development.

From 1951 to 1955 fir and spruce pulpwood was harvested on about half of Research Block 3, which was remeasured in 1957. Some of the highlights of the analysis are: (1) Gross increment of fir and spruce for the whole block has been 43 cubic feet per acre per year. (2) Blowdown for the ten-year period, 1947 to 1957, amounted to about 0.8 and 0.3 cunits per acre on the cutover and uncut portions of the block, respectively. (3) Cutting from 1951 to 1955 removed about 14,000 cunits of pulpwood. This was obtained from about 1,000 acres. (4) The area classed as heavily cutover softwood was more than 50 per cent stocked to fir and/or spruce reproduction in 1957.

In addition to the research blocks, there are currently four other stand development studies underway. Two were established because of the recent budworm outbreak, one to follow the effect of defoliation on the development of softwood reproduction, and the other to study the development of an immature fir-spruce stand during and following severe repeated defoliation.

Mortality of fir has been high in unsprayed areas for all sizes of advance growth over 1.5 feet in height. However, depending on the structure of the

overstorey that was destroyed, there remains a well distributed young stand of some 4,000 to 20,000 fir per acre below 1.5 feet in height. These small stems suffered relatively less defoliation than the larger trees. Mortality has not been severe on areas sprayed once or twice during the outbreak. Although white spruce, and to a lesser extent black spruce, suffered some defoliation, there has been no mortality of these species.

Preliminary information from a study in a stand of heavily defoliated immature fir-spruce in the Kedgwick Control Area indicates about 42 per cent mortality based on total basal area. Mortality occurred in all size classes but the basal area of trees dominant before the attack began was reduced by 35 per cent, co-dominant by 36 per cent, intermediate by 50 per cent and suppressed by 58 per cent.

The third stand development project also follows mortality and changes in immature fir-spruce stands that originated following the 1913 to 1919 budworm epidemic. These stands are similar to those just described except that they were unaffected by the recent infestation. Because this is a long-term study, little information is as yet available. Permanent plots were established in these immature stands mainly to obtain data on mortality. An earlier project, using temporary plots, indicated that analysis of stand development was weak when mortality data were lacking. The earlier study also indicated that density was one of the most important factors affecting stand development. Although stands 32 to 34 years in age had densities ranging from 1,000 to 5,000 stems per acre, dominant crown classes were least affected by increasing density and nearly all stands had dominant stems. Thus these dense stands are not stagnating as had been supposed.

Results from a study in a mixedwood stand indicate a marked reduction in the hardwood component, particularly of white birch, with evolution towards a predominantly fir stand. The gross merchantable volume growth of softwoods is estimated at 67 cubic feet per acre per year. Softwood mortality during the decade 1947 to 1957 averaged 43 cubic feet per acre per year.

Cull and Logging Waste

Studies of the amount of cull and waste in operations where the wood was cut into 4-foot bolts and piled at the stump were conducted co-operatively with Fraser Companies Limited between 1947 and 1950. These indicated that cull averaged 6.0 per cent of the gross merchantable volume; it varied from 1.3 to 19.4 per cent. Waste averaged 4.7 per cent of gross volume and varied from 0.5 to 16.9 per cent. Although there was a range in the amounts, only 14 of the 38 areas sampled had more than 5 per cent waste and only five showed more than 10 per cent. Most of this was in skids, unused butts, trees knocked down, and large tops.

SILVICULTURE

Cutting in Merchantable Stands

Some experimental fellings in mixedwood stands, conducted in 1939 by Fraser Companies Limited and the Forest Research Division predate the Green River Project. The treatments were: (1) clear cut of fir and spruce, (2) clearcut of fir and spruce with the large hardwoods girdled and two white spruce seed trees left per acre, and (3) clearcut of fir and spruce with the skidding and

yarding done by tractor in the spring. An uncut area was sampled for a control. Girdling the hardwoods and leaving spruce seed trees did not favour the regeneration and development of either spruce or fir. However, the scarification which resulted from the tractor skidding did lead to the establishment of abundant yellow birch.

Several partial cuttings in mature fir-spruce-birch stands were the first silvicultural experiments conducted under the Green River Project. The first study covers an area of 90 acres containing three structure types; mature fir-spruce with good advance growth, mature spruce-fir with a dense understorey of 30- to 40-year-old fir, and a mature mixedwood. Management is by the periodic selection system and two fellings have been made on a 10-year cycle. A total of 15.3 cunits per acre has been removed, leaving a merchantable growing stock of 8.6 cunits per acre at the last felling in 1956. Net merchantable volume growth over the first cycle was 27 cubic feet per acre per year. Mortality amounted to an additional 39 cubic feet per acre per year. Reproduction is not a problem and the stand structure is rapidly approaching the theoretical form of a selection forest. Another two or three cycles will be necessary, however, before developments in balanced selection stands can be assessed. Because of the decadent condition of the stands at the time of the initial felling, the residual trees have been susceptible to wind damage, which accounts for the heavy mortality.

In a second study an area of 500 acres was cut to a diameter limit of nine inches. The area supported uniform, mature fir-spruce stands but lacked the fir understorey present in the first study. As a result, the felling left a residual stand of low volume which was destroyed by wind-fall within five years. Mortality was 101 cubic feet per acre per year leaving a net annual loss of 27 cubic feet of merchantable volume per acre.

In a third study, all-aged management under a 20-year felling cycle was initiated on a softwood area of 50 acres. The first operation removed 33 per cent of the merchantable volume leaving a stand of 15.2 cunits per acre. The large size and extreme age of the stems in the residual stand, coupled with its position in a narrow valley bottom, led to extensive wind damage.

Two- and three-cut shelterwood systems are also being tested. In one experiment, the removal of 30 and 60 per cent of the softwood volume was tested against an uncut control (on nine 1-acre plots). A second study on nine 10-acre compartments is designed to leave 60 and 80 per cent of the average basal area before cutting. These experiments are located in stands that are just maturing, and are much less prone to wind damage than those discussed above. While none of the shelterwood studies has gone through a 10-year period, it is already evident that good regeneration will be established before the final felling is made.

Although it now appears possible to initiate all-aged management in mature and overmature stands, this is neither wise nor necessary, except on an experimental basis. The technique will work in younger stands where fir can be harvested as it matures.

Thinning

Although development studies have shown that the dense young fir stands

are not stagnating, there are usually far more stems present than are required for the final crop. Two experimental thinnings have been made in this condition.

The first consists of six one-acre blocks, two of which were uncut controls, one was marked for a thinning from below, and the other three were treated to give uniform spacings of 6 x 6, 8 x 8, and 10 x 10 feet. That the extreme density was retarding diameter growth of the better trees was evidenced by much wider growth rings on the residual stems on the thinned plots in the first years after treatment. Unfortunately, this area was subjected to prolonged and severe defoliation by the budworm. In most instances the resultant mortality has left a basal area in 1958 which was less than the residual basal area in 1948.

A second experiment in releasing 30- to 40-year-old fir was designed as a crop tree thinning. Four levels of crown release were assigned randomly to 120 selected trees. Data collected for each tree were used to analyze the response. Although the area suffered only moderate budworm defoliation for two years, the damage caused unusual variations in height growth. The response to release (basal area increment) depended primarily on the diameter at the time of release. Other factors were crown size, and competition.

A third thinning study was begun in 1959. This includes four levels of cleaning and thinning in dense young stands mostly less than ten feet in height which have developed from the advance growth following clear cutting. The study will contain some 120 acres and data will be collected on both an area and a single tree basis. The objective is maximum yield. Treatments, based on the best current silvicultural knowledge, will be made throughout the rotation.

Reproduction and Regeneration

A number of surveys have been made to assess the amount and quality of reproduction. The findings show that softwood stands have adequate advance growth by the time they are mature. Softwood advance growth is also present in mixed-wood stands, although fewer in number and patchy in distribution. Data from some 15,000 quadrats on the research blocks show that there is about 50 to 60 per cent stocking to fir and spruce in softwood, and 30 to 40 per cent stocking in mixed-wood stands. Spruce comprises between 5 and 25 per cent of the softwood reproduction.

Up to 1955 most pulpwood was stump-cut; more recently the method has been horse yarding in tree lengths to a bulldozed truck road. Old sleigh roads and bulldozed truck roads do not reproduce to softwoods readily because of the rapid invasion of shrubs and herbs. The areas between the roads, however, often support a dense growth of fir and spruce. Thus, when considering the following data it should be noted that probably two-thirds of the softwood cut-over is overstocked and one-third is either normally stocked or understocked.

Sampling in various parts of the watershed has shown that five years after cutting in softwood stands there is 71 per cent stocking to softwood seedlings and 81 per cent stocking to seedlings and saplings. Fifteen years after cutting the corresponding figures are 91 and 92 per cent respectively. Approximately 80 per cent of the fir and 90 per cent of the spruce is advance growth; thus while some regeneration does occur after cutting, it forms a relatively small part of the new stand.

Studies of the amount of advance growth destroyed by logging have been carried out separately and with some of the experiments described above. The results show that the number destroyed is not related to the intensity of cutting or to the method of logging and that the greatest losses are in seedlings one to six feet in height. As would be expected, damage is greatest where the reproduction is densest and reduces the stocking by 5 to 30 per cent, averaging about 15 per cent.

A study of the effect of slash piles on regeneration indicates that few softwoods are killed by the smothering effects of the slash, and that most of the mortality results from breakage. Slash has no apparent effect on trees over three feet in height, but slow decomposition at slash pile centres does not render conditions suitable for softwood regeneration for at least 15 years.

The factors contributing most to the variation in reproduction are: (1) site, particularly as it affects shrub competition, (2) density, age and composition of the former stand, (3) slash piles, (4) extremes of radiation in openings and hollows, and (5) destruction of advance growth during cutting.

Shrub Control

The suppressing effect of shrubs on fir and spruce reproduction is evident both from observation and experiment. Mountain maple quickly occupies most mixedwood cut-overs and by virtue of its rapid growth soon overtakes the reproduction, which may then be suppressed for periods up to 40 years. In addition to suppressing the seedlings, the maple casts a dense shade and deposits a thick leaf litter, thus inhibiting the establishment of additional softwoods.

Raspberry is also common on mixedwood cut-overs, but it is not as damaging as in softwood areas where it can reach four feet in height and 100,000 canes per acre. Spruce and fir above the raspberry are unaffected. However, practically no light passes through the growth and the slow rate of litter decomposition results in a seedbed which prohibits further regeneration of softwoods. Established spruce and fir below the raspberry are in danger of suffocation in summer or breakage in winter when the snow carries the canes to the ground.

Pin cherry, and to a lesser extent mountain-ash, are often prolific invaders of softwood sites after cutting. Although their shade is not as dense as that of mountain maple, they are able to suppress softwoods for lengthy periods. The seedbed under pin cherry is more amenable to further softwood reproduction than that under mountain maple or raspberry, and the period of suppression is usually much shorter than under mountain maple.

Because the problem of shrub control is primarily one of releasing established reproduction, the first study consisted of the release of individual softwood stems. Each softwood on a one-acre plot was given a crown release of three feet. Average height growth for the succeeding nine years on the treated plot was four times greater than on the untreated control. Height growth increased for all classes but trees taller than six feet at the time of release showed relatively less response. Within three years the mountain maple and raspberry had closed in on the reproduction.

For this reason it appeared that some form of chemical control might be useful even if it held back the shrubs only temporarily. Two experiments with chemicals have been carried out. The first employed a fog generator on the

ground, to drift atomized 2,4,5-T downslope through the mountain maple crowns during the temperature inversion period in the evening. The results were good in terms of killed maple, but the response of the softwoods will not be known until 1960. Because of physical limitations, the technique has application only on small areas.

In a second study, five 20-acre blocks were sprayed from the air, four with 2,4,5-T and one with Silvex, at a rate of one pound of acid equivalent per acre. This has resulted in a 45 per cent decrease in the average height of the shrub stand and an 80 per cent increase in the number of stems.

Planting

Because of the abundance of natural reproduction, studies of planting have been limited.

The first planting was made with natural seedlings of red and black spruce taken from a bog at the Acadia Forest Experiment Station. These were set out on a cut-over mixedwood hilltop. About 50 per cent of the planted stock has survived and growth has been excellent for both species.

Approximately 12,000 white spruce transplants (2-0 to 2-3 stock) of various provenances have been set out in 21 small plantations. The trees were planted along sleigh and truck roads using a 6 x 6 foot spacing and the hole method of planting. Both spring and autumn plantings have been made. Poor survival on sleigh roads was due largely to the crushing effects of the dense raspberry and bracken fern. Survival is good on bulldozed roads, but the transplants require two years to adjust to conditions before they achieve any growth. Frost damage has been noted on the more exposed seedlings. Exceptionally good survival and growth has occurred in one plantation set out on a recent burn.

A third series of plantings is designed to convert a partially logged sugar maple - beech hilltop into a stand with a much higher spruce content. In this project three 1-acre areas on a hilltop have been scarified with a tractor and planted with 200 2-2 white spruce. Survival has been good and growth exceptional to date.

ECOLOGY AND SITE

Succession and Species Ecology

Early in the Project some 150 acres of overmature softwood and mixed-wood stands near Summit Depot were reserved from cutting. A study was established within this area to follow the break-up and eventual replacement of an essentially even-aged stand of fir-spruce-birch. Detailed measurements obtained on each tree on two 0.6-acre plots provide stand tallies, and stem and crown projection maps. A one-foot interval contour map has been prepared and additional information has been obtained on regeneration and lesser vegetation. The plots are remeasured at regular intervals.

The rapid changes in the vegetation immediately after burning are under observation by a photographic technique. In 1952 photo-points were established in two burns which occurred in 1948 and 1949 to obtain graphic records of the distribution of the ground cover and regeneration. Stereo-photography was then used to take both vertical (from a 10-foot tower) and oblique photographs.

Depending on the site and intensity of burning, a variety of responses may be distinguished in the first rephotographing, made in 1958.

The vigorous development of mountain maple following felling on many softwood and mixedwood sites prompted an investigation of the ecology of this species. Several age classes of mountain maple on cut-over and uncut stands were studied using stem analysis and root exposure techniques. It was found that, depending on shading, this species grew up to a foot a year for ten years, after which growth was irregular. Most reproduction was vegetative as several stems often shared a widespread root system. Within ten years of release the maple usually forms a dense canopy at a height of about 10 feet. This species dies from the top downwards when about 40 to 50 years old and may suppress fir and spruce reproduction for periods in excess of 30 years.

Site Classification

Two studies were made to assess site quality using growth data. Both compared height/age relationships for different sites. In one project the comparisons were made with data for fir and spruce collected in reconnaissance cruises and on the research blocks. Because the measurements included many trees that had either been suppressed early in life or had been severely defoliated during the 1913 to 1919 budworm epidemic, this attempt to relate height/age to site features was unsuccessful.

In the second project, height/age data were collected on selected dominant trees. Even though each stem was carefully selected, few could be classed as free-growing throughout their life and many had been damaged by defoliation from 1913 to 1919. Although the data showed that height growth (for a free-growth period of 40 years) varied for different sites, which had been independently classified by topography, drainage and soil materials, the differences were not significant. The best height growth recorded was in a stand that originated after a fire in 1880. These trees had not suffered early suppression and were not severely defoliated from 1913 to 1919. Height growth of dominant balsam fir averaged 56 feet in 40 years.

Currently, height/age data are being collected on dominant stems in the young even-aged stands on each research block. Attempts will then be made to establish height/age curves for the different sites.

In conjunction with the site classification work, a site demonstration area and a site trail were established near project headquarters. The trail crosses from one valley, through a moist depression, over a hardwood hilltop into a deeper, V-shaped valley and across another hill to provide a cross-section of site conditions in the area. A map was prepared and the site boundaries marked on the ground.

Site description and site-type comparisons have had a turbulent but generally progressive history within the Green River Project. The initial plan was to investigate the correlation between the variations in the plant community and site quality, including under the latter both wood production and silvicultural problems. Later the system of grouping physiographic sites adopted by Bedell, MacLean and Brown for the Nipigon area in Ontario was introduced, but with additional divisions depending on whether the sites supported softwood, mixedwood or hardwood stands. Correlation between these groupings and the height/age relationship of spruce and balsam fir was the first test applied to

this approach to site description. The difficulties encountered in obtaining suitable data and in interpreting the results have been discussed. The second approach was to investigate the relationship of site to stand composition, density, and yield. The plots on Research Block 1 were located and site-typed on aerial photographs. Analysis of the data from those plots with comparable history indicates satisfactory differentiation among sites for such features as (1) frequency and abundance of lesser vegetation, (2) development of shrubs following disturbance, (3) the high proportion of balsam fir thicket on site types which lack shrubby competition, and (4) numbers and composition of the reproduction following clear cutting. For a few sites, height/diameter curves were sufficiently different from the average curve used for the block to introduce errors in volume of up to 15 per cent.

Although the results were encouraging, efforts are being made to obtain equally good results by evaluating the physiographic features of site alone. Accordingly, modifications have been introduced to permit site identification by means of either physiographic features or vegetation. A detailed analysis of the correspondence between site types recognized by these alternative bases is under way, and will constitute the most critical examination of the site description techniques to date. This study combines investigation of the plant communities with investigation of other site features in addition to site quality class, and will serve to give direction for modifications beyond our present field requirements. It is hoped that a practical but reliable basis for silviculture, management, and further studies in forest ecology will result.

SUMMARY

This report presents a summary of the research work of the Forest Research Division conducted within the framework of the Green River Project.

The studies concerned with stand development have provided voluminous descriptive material and background information for a management plan, and have outlined the most important management and silvicultural problems. The results also indicate average growth rates for prevailing management practices.

The studies in silviculture and growth are aimed at solving some of the problems of how to increase yield. This work is particularly important because of the generally excellent site conditions that prevail throughout the watershed.

The studies in site classification and ecology provide the framework for the analysis of experimental results and for more intensive silviculture.

Finally, all of the work of the Forest Research Division is designed to complement the larger program dealing with the management of a fir-spruce-birch forest that has been devastated periodically by the spruce budworm. The accomplishments to date augur well for the future.

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