SILVICULTURAL INVESTIGATION IN BRITISH COLUMBIA.

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Prior to 1922 silvicultural research in British Columbia was carried on spasmodically by various technical officers of the Forest Branch as time from executive duties permitted. In 1922 there began the first organized attempt to secure the basic knowledge so essential in the art of growing timber, and a special officer was assigned to research work. Later in 1924 the field of study was divided between the Northern Interior and the Coast, each in charge of a permanent officer working independently under the Management Office at Victoria. A permanent assistant was appointed in the Coast district.

In the Northern Interior there are two main forest types, spruce and lodgepole pine. The work has been confined to the spruce type so far. In this type there is abundant reproduction on unburned areas, but unfortunately most of it is balsam, at present a worthless species, so defective from rot that it is doubtful if it can ever be of commercial value. A survey of unburned cut-over areas seven years after logging gave an average of 120 spruce and 800 balsam per acre. On the burned areas very few seedlings of any kind had established. The problem is to develop a practical silvicultural method, which will increase the proportion of spruce in the reproduction after logging, preferably by natural means.

The work thus far has been confined mainly to finding out conditions as they exist through the examination of the composition and density of the natural reproduction in the logged and burned areas, as well as in the natural stands of green timber, and a study of the ecological factors producing these conditions. The present knowledge would indicate that the condition of the seed-bed is the factor controlling the proportions of spruce in the natural reproduction, and experiments in the control of soil, moisture, and surface conditions have been started this year to determine the effect on the establishment and survival of spruce by natural means. As these studies progress the results will be applied in the first series of experimental cuttings.

The necessity of sound knowledge of practical silvicultural methods in this type is emphasized by the rapid development of the lumber industry in the Upper Fraser and the prospect of the establishment of pulp mills in the near future.

While much of the investigation will be carried on throughout the region, intensive studies and experimental cuttings will be centered at Aleza Lake, about 35 miles east of Prince George, where a block of 6,300 acres has been reserved for research purposes and is being developed as an experiment station. The first experimental logging is being done this winter.

The studies on the Coast, started in 1923, have been confined to the Douglas fir and hemlock-cedar types. The field of study has been subdivided into the following main projects:

Natural Reproduction:

- (1) Empirical studies from survey of cut-over areas.
- (2) History maps.
- (3) Seed production.
- (4) Seed dissemination.
- (5) Seed survival.
- (6) Seed germination.
- (7) Seedling survival.
- (8) Seedling growth.
- (9) Yield.

Artificial Reproduction,

- (10) Nursery practice.
- (11) Planting.
- (12) Seeding.

In the time allotted it will be possible to give only the briefest outline by projects under the above headings:

(1) Empirical studies from survey of cut-over areas.

The main use of this study consists of the determination of conditions as they exist after logging. Since the work began some 231 cut-over areas have been examined in the Douglas fir type. 66 per cent of these areas had over 500 seedlings per acre; 79 per cent of the areas which had been logged for four years and the slash left has over 500 seedlings per acre, as against 64 per cent on the burned. On the burned-over areas seedlings after 4 years increased at the average rate of 240 per acre until such time as the cover was complete. The theory that satisfactory stocking takes place the year following a spring burn is not substantiated by our studies, but restocking appears to be a gradual process, the rate largely depending on the distance from seed-trees and the occurrence of abundant seed crops. Burning in the Douglas fir type, except around spar trees or at the foot of slopes where the ground may be so densely covered with debris as to prevent seedlings coming in, is not necessary for the natural regeneration of Douglas fir, but appears to delay the establishment of a forest cover from three to five years.

In the hemlock-cedar type 176 areas have been examined. 71 per cent of the total cut-over areas has at present more than 500 seedlings per acre. 97 per cent of the areas logged for more than four years and the slash either left or not burned had over 500 seedlings per acre, and 91 per cent had more than 1,000. On unburned areas an average of 686 young trees averaging two feet in height and capable of recovery survive logging. This advance reproduction, which is 90 per cent hemlock, shows remarkable growth on being released and, combined with a scattering of larger trees, forms

a valuable nucleus for the future crop. In this type an average of 1803 young trees were found one year after logging, of which 1117 had established since the timber was removed. The increase in subsequent years was at the average rate of 400 per acre on the unburned areas until the crown cover was complete. Where the slash is burned in this type an average of 124 seedlings were found one year after logging. These had established mostly on the unburned patches within the burned area.. It is considered that broadcast burning in this type has delayed the establishment of a forest cover an average of eight years.

The surveys of our cut-over areas are very encouraging, but conditions are rapidly changing and our problem is becoming more acute as the cut-over areas become larger and more remote from a source of seed. Owing to the multitudinous factors which influence the forest vegetation, and the difficulty of isolating the influence of each one, the data gathered from these empirical studies must be considered as very general, with the main value in showing conditions which actually exist, rather than supplying knowledge as a basis of scientific management.

(2) History Maps.

Through the mapping in of specific areas a more systematic study of the effects of logging and slash disposal is being made. Detailed maps of 10 representative areas have been prepared and are being kept up to date. A complete record of the time of logging for each setting and subsequent history is being kept.

(3) Seed Production.

This is one of the most important factors in the regeneration of cut-over areas. On a typical area under observation at three-quarters of a mile from green timber 51 seedlings per acre established in 1924 after the heavy seed crop of 1923. The seed crop in 1924 was a failure for fir and light in 1925. This has resulted in very few new seedlings establishing during the last two years. Quantitative data is being gathered on the seed crop through experiments in catching the seed in trays. The variance in the seed crops, to a great extent, is responsible for the great diversity in the reproduction found on areas subject to the same treatment in different years, and in order to isolate this factor of seed supply we have in the experiments with the coast species used a known quantity of viable seed.

(4) Seed Dissemination.

Plans had been prepared for seed dissemination studies in 1924, but owing to the failure of the seed crop could not be carried out. In 1925, 11 seed traps 6 feet by 12 feet and two 6 feet by 36 feet were built at intervals with a maximum distance of 60 chains from green timber. Although the 1925 seed crop was light, Douglas fir, cedar and hemlock averaging in all 2420 per acre were caught at 60 chains from the seed trees. This year we have stationed an additional 100 portable seedtraps, 4 feet by 6 feet, and 11 permanent 6 feet by

12 feet and one trap 6 feet by 36 feet, at distances up to 80 chains from green timber. Up to date we have caught one hemlock seed at one mile from timber, but few of any species have been disseminated more than 20 chains. Owing to the poor seed crops since these experiments have been started definite data are not available on the distances which windblown seed will efficiently seed areas, but the experiments do show that the windblown seed is an important factor, and I believe the most important factor in restocking logged-over lands.

(5) Seed Survival.

The seed dissemination studies show that the emergence of the seed from the cones may extend over a long period. In examining samples of duff in July fresh seeds have been found, but these were bright with the wings still attached and had apparently only recently fallen from the cones. In the spring of 1924, following the heavy seed crop, thousands of fir with only primary leaves were found within the virgin forests. These all died during the summer. Through the seeds which fall to the forest floor germinating and the loss from insects, fungi, and rodents it does not seem probable that much seed from the virgin forests remains stored for more than one summer. However, where logging takes place in the fall and winter immediately following a heavy seed crop, some seed may become buried too deeply for germination and the covering may be removed through erosion, and germination may extend over several years. But, our studies so far indicate very strongly that stored seed cannot be depended on to restock our cut-over areas. Two controlled experiments are being conducted to determine how long seeds remain viable and to determine if viable seed survives on areas logged during the summer and burned the fall immediately after logging. In 1925 two hundred samples of 100 each of fir, hemlock, and cedar were stored in duff and mineral soil within porous earthen containers and buried at various depths in the same class of material, but I have been unable to obtain results of the year's germination tests from the field in time for this paper. Ten plots, four feet by twelve feet, were screened this fall immediately following a broadcast burn so that all wind-blown seed would be excluded, and any seedlings which germinate on these areas must come from stored seed which survived the fire.

(6) Seed Germination.

In order to determine the effect of different kinds of seed beds on germination, known quantities of viable fir, hemlock, and cedar seed were sown this spring on twenty 4' by 12' plots representing the following conditions; bare mineral soil, spring burn, light bracken cover, northern aspect, southern aspect, 25 per cent shade, 50 per cent shade, and 75 per cent shade. The amount of seeds which germinated increased with the amount of protection afforded, probably due to an increase in the surface moisture of the seed bed. The percentage of germination was greater among bracken than on the bare mineral soil or the burned-over area. On the burned areas most of the seeds which germinated had worked down between the crevices in the partly burned debris where they found more favourable

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conditions than on the pure carbon surface. Where the shading experiments were conducted following a spring burn even 25 per cent shade increased the germination over that of the exposed areas. The germination for fir did not seem to vary between those areas with 50 per cent and 75 per cent shade. On the total exposed areas very few cedar or hemlock started, but the greatest germination in these experiments was found to take place under the maximum shade of 75 per cent used in these tests. On the southern slopes even in light bracken cover little germination took place, while on the northern slopes a large number of seedlings germinated.

(7) Seedling Survival.

Intensive studies were conducted using the plots established for the germination experiments. As the seedlings showed above the surface they were staked and numbered, and location plotted on a plan. Record was kept of the date of germination and the cause and date of mortality. Thermometers were used to determine the surface soil temperature. These were coated with varnish and sprinkled with the same substance as composed the surface of the plots. They were placed parallel with the surface with half the bulb just above the ground level. On level ground the highest temperature usually occurred between noon and one o'clock. The following temperatures were recorded at the same time when the air temperature was 83 degrees F:

Level spring burn	145 degrees F
Level bare mineral soil.....	128 degrees F.
Level light bracken.....	98 degrees F.
30 per cent slope southern aspect	
bare mineral soil.....	143 degrees F.
30 per cent slope northern aspect	
bare mineral soil.....	128 degrees F.

The maximum soil temperature registered during the summer was 160 degrees F. In light bracken 83 per cent of the fir which germinated survived the summer compared with 58 per cent on level bare mineral soil and 51 per cent on a spring burn. 86 per cent of the Douglas fir which died showed lesions on the stem indicating they were killed by the excessive heat at the surface of the soil. These studies indicate that conditions which exist immediately following burns are not favourable to the successful establishment of seedlings, particularly on dry, hot years. They also show the desirability, where planting is being carried out, to set the seedlings where they will receive the greatest protection from the sun. They also indicate that it is not practical to determine if areas will or will not restock naturally after burns until a vegetative cover has established to protect the seedlings after germination.

(8) Seedling Growth.

One thousand trees approximately of fir, hemlock, and cedar, and a few white pine were tagged, mapped and bench marks established so that all measurements could be made from the same point. The studies show that the height growth ceases the latter part of June,

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but early in September when the wet season commenced the buds opened, and additional growth was made. This was particularly apparent where the spruce bud worm had destroyed the summer buds. In most cases new buds were formed which will assist the tree in surviving the attack. All species showed a more than average height growth this year, probably due to the wet spring.

(9) Yield.

During 1924 and 1925 data was gathered for the preparation of normal yield tables, and tentative tables have been prepared for hemlock and Douglas fir. In the tables for fir the average maximum height at 100 years has been used as an index for site-classification. In this way overcoming the confusion which existed when a region was divided into three or more site classes which did not correspond to the site-classification in some other region within the range of the species, as the best site in one region might be equivalent to the average site in another region in productive capacity. On the coast on an average site it will take 50 years for Douglas fir to produce a tie-stand, and 120 years to produce saw material which would be now considered low grade. A comparison on similar sites indicates that the wood production at 120 years of a pure hemlock stand is 10 per cent greater than that of Douglas fir, due to a greater number of trees per acre, although the average diameter and height is less. The studies brought out the great variation in the potential value of the Coast area for pulp and saw timber production. On the Coast the areas of the greatest productive capacity now carrying the heaviest stands of timber are held under Crown Grant or timber license or lease. Outside of these areas the percentage of land which carries merchantable saw timber is comparatively small. The intensity of forest management depends largely on the returns from the soil and it will be on the best lands that crude forestry will first be practical. In order to determine the desirable number of trees for the production of different classes of materials and the yield on areas of various site qualities, twelve permanent plots were established during the past summer. These will be supplemented by further plots and examined at five year intervals.

ARTIFICIAL REPRODUCTION.

(10) Nursery Practice.

Ten nursery beds were prepared this year and sown with Monterey pine, Sitka spruce, Douglas fir, cedar, hemlock, and some Japanese species. This stock is intended for experimental purposes. We wish to try out Sitka spruce on some of the moister areas which originally carried Douglas fir, so as to increase the amount of spruce available for use with hemlock in the manufacture of pulp. The Monterey pine has shown remarkable growth, this year's seedlings attaining an average height of about 8 inches. An additional area is being prepared so that tests may be made with other species, particularly Big Tree (*Sequoia Washingtoniana*). We have used about one-third the amount of seed which is usually sown in seed beds where the trees are set out in transplant lines before being

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finally planted under field conditions as we propose planting the seedlings directly from the seed bed.

(11) Planting.

Five hundred redwood were set out in an experimental plantation this spring. On account of the dry summer they showed little growth, but 87 per cent have survived. Last year a project was started in experimenting with different species for hardwood fire-breaks. A total of 7,500 alder, black cottonwood, ash, Manitoba maple, and caragana were used with the object of determining their possibilities in various sites in rapidly forming a forest cover which will assist in fire-control. On the moist sites 81 per cent of the alder and cottonwood and about 90 per cent of the other species survived. An additional 6,000 alder were planted this year to complete the project.

(12) Seeding.

Only a small amount of experimental seeding has been done, as other agencies have done considerable work in the past, which has indicated that seeding on the Coast is less practical than planting nursery stock. One-half pound of Douglas fir seed sown after a fall burn last year resulted in only 112 young plants this spring, and of these 30 per cent died during the summer. When the cost of seed is considered this indicates that planting would be more economical.

GENERAL.

The fire hazard is closely related to our silvicultural problem, and I believe the best and certainly the final means of reducing the hazard on cut-over areas is to establish a forest cover of young trees, and until such time as the cover is formed cut-over areas whether not burned, burned once, or repeatedly burned several times, will present an enormous hazard. The increase in the area of cut-over lands, the increase in area of fire-killed timber, and of joining up of logging operations is responsible in a large part for the enormous losses which occur annually, and the natural barriers of green timber which once separated operations must again be established. The hemlock-cedar type is one of high precipitation and high humidity, and the fire hazard is not as great as in the Douglas fir type. In the hemlock-cedar type it is not desirable to broadcast burn except where the debris covers the ground too completely for the seedlings to come in. Clearing up along railways, bridges, and around camps where the risk is greatest should be effective in protecting equipment and camps. The cut-over areas in this type are seldom extensive without blocks of unmerchantable timber within seeding distance of the logged-off land. Our seed dissemination studies indicate that the effective distance of seeding is greater for hemlock and cedar than fir, and that these species are more prolific seed-bearers. So long as fires are controlled in this type natural reproduction will be probable in most areas.

In the Douglas fir type, which is one of low

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precipitation and comparatively low humidity, the problem is more critical. The cut-over areas in this type are beginning to be very extensive, and on many areas the logging is progressing rapidly inland from a face without provision for a seed supply. Our studies indicate that stored seed cannot be considered sufficient to restock cut-over areas, and seed must come from living trees if natural reproduction is to be attained. Some provision must be made to supply the areas with seed. Our dissemination studies indicate that although some Douglas fir seed may be carried a long distance the effective range is about 20 chains. The practice of forestry where mature timber is found with the exception of protection should begin with the logging operations. In the logging of the timber there are three alternatives which will guarantee a seed supply, namely: 1st, the reservation of groups of seed trees; 2nd, the reservation of individual seed trees; 3rd, logging by compartments with the cut-over areas not more than 20 chains from a block of green timber. Where blocks of seed trees are being retained advantage could be taken of topography so that they would be least subject to wind-throw, would be of least merchantable value, and would least interfere with the yarding of the remaining stand. Where individual seed trees are reserved they should be at least 30 inches in diameter so as to stand up under logging, and survive fires. An average of two trees per acre would be desirable. Even where individual seed trees are reserved our dissemination studies would indicate that they need not be uniformly distributed. Instead of broadcast burning large areas I believe better results would be attained by making the slash disposal more intensive, and concentrating it along railway grades, bridges, around camps, and along common routes of travel where the greatest risk occurs. Where slash disposal is carried out an attempt should be made to clean up everything which will burn and a line should be cleared to mineral soil so that in the event of a fire it may be fought from a vantage point. Where further protection is necessary fire-lines dividing the areas into compartments should be used. Logging by compartments and the leaving of belts of green timber as fire-breaks should be encouraged. This would also assist in natural restocking. It would be advisable in hazardous valleys to begin the operation on the upper reaches and work towards the lower levels retaining blocks of unlogged timber as fire-breaks. It is apparent that each area presents a problem requiring individual treatment. This necessitates that we in our studies determine the effect of the individual factors on the forest vegetation so that areas presenting any particular set of conditions may be managed to yield the greatest returns economically possible.