EXPERIMENTAL THINNING OPERATIONS ON A COMMERCIAL SCALE¹

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In dealing with perpetual forestry as an independent paying enterprise it is hardly possible to neglect thinning, it being one of the more beneficial aspects of intensive forest management—and before entering the details of thinning experiments it might serve a useful purpose to emphasize why thinning is so important in utilizing a given forest potential to full advantage.

TECHNICAL AND ECONOMIC POSSIBILITIES

Contrary to common belief, thinning does not increase to any great extent total volume production, as represented by net yields plus mortality in the unthinned stand. Although this statement is not yet a fully-proven fact no contradicting evidence has been produced so far and the evidence in favour is sufficient to make the statement acceptable as a working basis. Thus it appears that thinning has no greater production-increasing effect than that derived from mere salvage or mortality. A minor modification of this conclusion will be dealt with later on but it may be said now that the modification is not great enough to be of any practical importance.

Our knowledge about mortality is rather limited, but there are observations in Douglas Fir which indicate that accumulated mortality constitutes between twenty-five and forty per cent of net yield at 100 years. Why is it then that we hear about thinnings constituting 100-200 per cent of the final crop? In other words, a volume, constituting from one to two times the main crop at rotation age has been removed in thinnings, and there is still a well-stocked stand of all the best trees to be harvested. The answer to this question is complicated but definite—partly technical and partly financial. The technical aspect is readily understood as we realize that the magnitude of forest production depends not only on pure quantity, but also, and possibly to even greater extent, on quality and dimension. Straight, knot-free boles of large diameter produced in a minimum of time are the trade marks of good forestry. Correctly applied thinnings remove the poorer trees and leave the better ones, with the result that each consecutive thinning places future volume production in a higher quality-class than it was before. Not only will the final crop benefit from this effect but also each succeeding thinning. Considering the increased quality in conjunction with the greatly stimulated diameter growth it becomes evident that technically there is nothing hazardous in thinning beyond the mortality stage—as long as maximum total production is maintained. Rapid diameter growth is commonly thought of as a structural disadvantage. It is, however, rather a question of specific gravity, or the proportion between spring-wood and summer-wood in the annual ring. It is proved that a decrease in specific gravity results in a decrease in certain strength properties, particularly of Douglas Fir, and it is possible that increased growth is followed by decreased specific gravity—but even so, it is doubtful whether the detrimental effect would be sufficient to bring thinning into disrepute.

Technically we gain by improved quality and by producing bigger trees

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in a shorter time, but we may lose to some degree by decreased structural strength. The essential value of thinning, however, lies in the financial benefits obtained. The standing volume, or the production accumulated in the forest, constitutes the main part of the forest capital. Any portion of this capital liberated without diminishing mean annual return means lower capital investment and consequently improved rentability. In other words, the earlier and the more frequent a net profit is realized from the immature forest the better the rentability. The consequences of an improved rentability is in turn a prolonged financial rotation, which is a decided advantage seen from silvicultural and technical viewpoints.

Assuming that thinning is carried as far as to constitute 125 per cent of net crop-volume at rotation age and that market conditions and utilization allow thinnings to be early and frequent, then—speaking in terms of revenue discounted at compound interest—it is possible to realize as much as 250 per cent of the final crop value from thinnings—and that without diminishing total production. This example is based on a standard yield table for managed Norway spruce in Denmark (see illustration). At age 70 the particulars are:

Height of average tree.....	75 feet
D.B.H. " " "	13 inches
Number of trees per acre	154 trees
Standing volume per acre	5,400 cubic feet
Volume removed since year 20	
in 19 thinnings	6,700 " " (125%)
Total production in 70 years	12,100 cubic feet
Value of standing volume discounted	
to age 4 at 4.5% (1 Dollar=4 Kroner)	\$41 per acre
Revenue from thinnings discounted	\$106 " " (250%)
Total value discounted	\$147 per acre

THINNING EXPERIMENTS

Any idea or thought pertaining to practical life must be tested and adjusted before it can be brought into full action. Thinning as a common forest practice has passed the idea stage long ago, but in British Columbia it has not yet developed into general practice. There are still tests and adjustments to make before we can answer the questions: "How should it be done, and what are the results to be expected?" It may not be many years before we shall have to answer such questions, and, therefore, we should embark on experimental work on a scale small enough to avoid any excessive risk by mistakes, but large enough to make the experimental results significant for practical application.

There are hardly any serious obstacles in the way of straight engineering problems such as, lay-out of roads; location of landings; felling, bucking, and yarding techniques; transportation; utilization; processing; slash disposal, etc. Although the techniques would be different from those to which we are accustomed, I am convinced that after just one season of operation all the main problems would be solved, or at least we would know how to solve them. The major problems of thinning arise in the forest manager's office. There lies the responsibility of selecting the most beneficial thinning practice.

At what age should thinnings begin, how frequent should they be, and how heavy, all in relation to species, site, market conditions, management policy, and many other factors—and last but not least, what are the technical and economic results to be expected?

Let us assume that the time has arrived for action and a decision has to be made. By collecting all available data and knowledge about the subject we may be able to narrow the field of possibilities to within certain limits, both with regard to procedure and results. Beyond these limits assumptions would have to be substituted, which is little better than pure guess-work and hardly an incentive to capital investment.

In defining existing knowledge, we also define the foundation upon which to base our experiments and, further, we define the information wanted.

THINNING FREQUENCY

As previously stated, the earlier thinnings are started the better—according to both the silviculturist and the economist. The economist, however, is not yet prepared to accept a present loss in exchange for a future gain. There is our first objective—to determine the earliest age, under various conditions, at which thinnings will produce a clear net return. However small the margin may be, it must be a profit. Such information will be available immediately after the first experimental thinning has been completed.

It was also stated that thinning should be frequent—but how frequent? Should it be every year, every five, ten, or maybe twenty years? This problem is closely related to the choice of thinning intensity, but some guidance may be obtained by simple reasoning. Even the most intensive management systems do not apply to less than two to three year intervals, despite the fact that the forests are criss-crossed by roads, the areas small, and yarding and transport distances short. A certain volume has to be available in order to compensate for such fixed costs as administration, marking, transport of equipment and crew, etc. A less intensive management system which we may anticipate here would almost certainly not justify intervals of less than five years on the better sites and probably fifteen or twenty years on the poorest sites and less accessible areas. It is not possible to lay down a definite rule concerning this point. Thinnings become less frequent with advancing age, and variations from the standard are bound to occur, which can only be settled in the field by observing the progress of crown closure and thereby the need for another thinning.

THINNING INTENSITY

There is one factor which influences just about every aspect of thinning, namely, thinning intensity. It is the most controversial factor; firstly, because so little is known about it and, secondly, because it is so important in its effect upon the forest economy.

Regardless of how little we know about the subject, there is still valuable information available, definite enough to prevent serious mistakes. Thinning intensity incorporates two definitions: heaviness of the single cut — and accumulated thinnings in proportion to crop-volume. The two definitions are closely related to each other, and the first one, in particular, to thinning frequency. Generally speaking, thinnings should be frequent and light as possible, technically and financially, rather than few and heavy. This generally

may be qualified further by stating that any single thinning should be heavy enough to yield a volume sufficient to make the operation pay, and heavy enough to provide ample growing space for the residuals through the main part of the thinning interval. On the other hand, the cut should not be so heavy as to endanger the residual stand through excessive blow-down or damaging biological influences derived from suddenly created openings in the canopy. Moreover, it must be borne in mind that openings in the canopy mean unutilized growth potential and consequently loss of production. The greater the openings the greater the loss. The stand must be animated or brought up gradually to grow faster, rather than be given the chance to do so suddenly.

To give an exact answer on what should be the combination of thinning interval and magnitude of the single cut is impossible. So many factors are involved—such as site, age, health, aim of management, market conditions, etc.—and we are handicapped by an almost complete lack of local information on the subject. One may get a working basis, however, by turning to the intensive management systems once again. There it is common and sound practice to remove about fifteen per cent of standing volume every three years. Extending the thinning interval to say ten years would not mean a proportionately heavy periodic cut of fifty per cent of standing volume but somewhat less, possibly in the neighbourhood of thirty-five per cent (less on the poor sites, at younger age, and in the first thinning—and more on good sites, at older age, and in repeated thinnings.)

Cutting at the rates exemplified will bring the gross thinning intensity well above the mortality level, and that focuses attention on the second definition: volume removed throughout the rotation in terms of net volume at rotation age. It was mentioned before that the meagre information available supports the statement that thinning and any moderate change in gross thinning intensity do not influence total volume production to any great extent. The modification is introduced because thinning can in some cases increase total production, indirectly by site improvement, and directly by removal of trees with an unfavourable balance between assimilated and consumed energy—in other words trees whose crowns are under-proportioned to stem and branches. By placing their growing space at disposal of trees with a better energy-balance a small gain is obtained in total production. Thus, advancing thinning from the passive stage, where only trees dying from suppression are removed, into the active stage, where trees that would keep alive are also removed, appears to have a production-increasing effect. That has also been observed in field experiments but to such a minute degree that the gain is negligible in comparison to the gain obtained from salvaging mortality only, and the increase is found only at the transition from passive to active thinning. Further intensified thinning does not result in increased production. The growth increase on the individual trees is compensated for by a collective decrease in production by the stand, due to incomplete use of growing space. This balance between loss and gain is maintained well into the active thinning category up to a certain limit where the stand loses more in production per acre than the residuals are able to compensate for by

accelerated growth. From this point total production begins to decrease rapidly.

Thus it appears that we may be relatively free in choice of thinning intensity, seen from the production angle, as long as we stay within the limits of mere passive thinning at the lowest, and undiminished total production at the highest. Under certain conditions, different from those predominating here at present it is financially sound to increase thinning intensity even beyond the top limit, but how far we eventually may do so here, if at all, is another objective of local experimentation—technical in character at first, but the ultimate answer will not be available until the financial effects are analysed.

THINNING METHOD

Another controversial ingredient of a general thinning policy, the thinning method, has remained unmentioned so far because it cannot be analysed separately until a conclusion has been reached as to the objectives of thinning, thinning intensity and frequency.

Concurrent with the evolution of forest management a number of thinning systems have developed, such as cutting to a lower diameter limit—later modified into the high grading system, which was and still is used quite extensively in Sweden—thinning from above or the crown thinning method which concentrates on dominants and codominants only—and thinning from below, where only suppressed trees are removed. None of these methods are flexible enough to fill the joint technical and financial requirements of present-day intensive forest management. It is imperative to maintain a high degree of flexibility in order not to restrict the manager in his choice of trees to be removed. The tree community is a living organism, highly flexible in itself in its relation to the physical environment, and situations are bound to arise where a set rule or system is short of an answer. It may appear from this that the manager cannot be given much to go by. He should be guided only by his own understanding of the biological and economic consequences of his decisions. However, there are certain generalities to apply. Thinnings in young stands should concentrate primarily on the lower crown classes in order not to interrupt natural pruning. When a satisfactory bole is obtained more and more dominants and codominants are removed in order to speed up growth on the remaining trees and retard volume accumulation. The first early thinning is mainly stand-improving, cutting suppressed trees, potential whips and wolf trees, the latter ones only if there are better trees available for replacement.

Within these limits, marking procedure is nothing but common sense paired with a little experience—still aiming at speeding up growth on better and better trees combined with earliest and highest possible capital realization.

The basis upon which to establish experimental thinning operations can now be summarized in general form:

The area selected for each operation must be large enough to make results practically significant, say from twenty-five to fifty acres.

Permanent sample plots must be established within the area and they should constitute at least one-half acre each. It is desirable to have a few unthinned control plots near the area.

Volume removed and volume remaining after each thinning must be

Illustration of merchantable volumes and corresponding discounted net values on the stump on one acre of Norway Spruce (site index 90), thinned at 2-4 year intervals. All values are discounted at 4.5 per cent from the age when realized to age 4. Prices are converted from Danish Kroner (1 dollar = 4 Kroner). Price level 1942/43.

recorded, as well as net value on stump of the material to be removed.

Thinning intervals may vary from five to twenty years according to local conditions, but must be as short as possible.

First thinning should be carried out as soon as a net profit may be expected and should primarily aim at stand-improvement.

Thinning intensity must increase gradually as the stand grows older, varying roughly between twenty and forty per cent every ten years according to age, site and market; and gross intensity should be as high as technically possible without reducing total production. Accumulated thinning constituting 100 per cent of final net yield may be suggested as a suitable working basis.

INFORMATION EXPECTED

For each species and site such experiments should answer relatively soon the question of the earliest age at which thinning is a paying operation. The essential items of information are:

1. Stand data before and after each thinning;
2. Distribution of each cut to various products;
3. Specified costs of producing each product at the place of delivery;
4. Felling and yarding damage to residuals
5. Overrun in processing saw materials.

} for a limited number
of experiments only.

Continuous records of stand data before and after each thinning supply the material for constructing standard yield tables for thinned stands, and it is hardly necessary to emphasize how vitally important such tables are in forest management. Growing trees is a long term process and mistakes are usually beyond correction within the rotation. The forester planning the details of managing the individual stands and the entire forest is working in the dark without standard information on expected yield. He may happen to be right in his judgment but often he will be wrong. A wrong estimate may turn the entire forest estate into an economic failure, not visible until many years have elapsed.

Being in possession of a yield table picturing the progression of residual volume as well as thinned volume at advancing age is the first step towards a close financial control of the forestry enterprise. The net value on the stump per unit volume increases with advancing age or rather with increasing diameter as the thinning material grows into more and more valuable product classes (fuel wood, pulpwood, sawlogs, poles, piling, veneer logs, etc.) Each cut will constitute several products but, as the stand grows older, the relative amount of valuable products will increase at the same time as the relative amount of the less valuable products decreases. The information collected from the thinning experiments on relative distribution of products derived from thinned stands of varying average diameter enable us to predict yield in terms of products. The link between expected product yield and expected money yield is the net value on the stump of each product. This information is extracted from the thinning experiments. Prices, however, are of momentary validity only and, therefore, it is desirable to carry financial calculations as far as possible on the basis of volume alone and then convert volume to value by means of current prices as the last step.

We may now summarize in general the scope of commercial thinning experiments.

The experiments solve the question of how early a thinning is profitable and how profitable it is. At the same time we gain experience as to the most practical logging methods and equipment, most advantageous utilization, damage to residuals and overrun in processing.

In the future, the stands with their sample plots being thinned and re-measured regularly will form the very foundation upon which to base our future yield tables constructed in the conventional manner. These future aggregate volume yield tables can be broken down into products and then by interest calculations converted into tables of balance volume numbers by product classes—in other words, tables whose figures are the present equivalents of the expected yields, in units of volume, of the various products. From then on it is but a small matter to multiply the balance volume number for each product with corresponding current net value on the stump and thereby arrive at the present value equivalents of future product yields. Adding these values results in the total present value of future product yields per unit area, or the so called balance number. The balance number (dollars per acre) varies with site, rotation and rate of interest and it represents the revenue (from thinning and harvest cutting) against which we must balance our costs and investments (planting, stand improvements, general expenses and land value) if the enterprise of growing trees is to rest on a financially sound foundation.

THE COWICHAN LAKE EXPERIMENT

The rather general and abstract treatment given the subject so far has been crystallized into a concrete example at Cowichan Lake, Vancouver Island.

Fifty-five acres of fifty-year old Douglas Fir, site index 160, have been marked for thinning. Eight half-acre sample plots are laid out and measured as to trees marked and trees to be left after thinning. The experiment has not passed the preparatory stage of marking, mensuration, planning roads and landings and drafting a contract for the operator, and only in these respects is information available at the moment.

The aim is to establish a pilot study that may serve as a model for a multitude of similar experiments. Therefore, it is simple in design and easy to repeat without going into complicated technical details.

The sample plot data indicate a reduction of 40 per cent of number of trees, 40 per cent of basal area and 39 per cent of volume, leaving respectively 254 trees, 143 square feet basal area, and 5,250 cubic feet per acre. Diameter of the average Douglas Fir tree is 11 inches which will yield a log of about 65 lineal feet to a six-inch top.

A 39 per cent volume reduction in the first thinning will undoubtedly be characterized as a heavy thinning, and so it is. On the other hand the area is overstocked even according to standards for unthinned stands, the site is good, and growing power is high. On this background an endeavour has been made to mark a sufficient cut to make the operation attractive to contractors, and also to go as far as silviculturally possible towards

making the operation pay. Another thinning is not anticipated for the next ten to fifteen years, which is expected to leave sufficient time for restoration of the canopy.

The primary purpose of the experiment is to compare costs and revenue derived from thinning material of this age and site. In other words, how much is it possible to realize in net profit as an aggregate of various products, such as piling, poles, boom sticks, sawlogs, and eventually, pulpwood, and what is the percentage contribution of each product? Further, the experiment will yield such information as allowable felling and yarding damage to residuals, and overrun in processing sawlogs; also it will give most valuable experience in handling the practical aspects of a thinning operation.

CO-OPERATION BETWEEN INTERESTED AGENCIES

Considering the multitude of plots needed to cover just a limited range of the most important species and sites, and counting necessary replications under various market and logging conditions, it becomes clear that such a project is too enormous for any single agency to tackle. The only way to get the project started is a united effort by those needing the information; supposedly private industry, woodlot owners, the Forest Service and the University of British Columbia.

There are already a number of experimental thinning operations established in British Columbia. However, they are difficult to co-ordinate because they are not all conducted on the same basis. That is another reason why co-operation is needed. New experiments could easily be established on a uniform basis, thereby filling a collective need without sacrificing any individual purpose.

Therefore, my personal suggestion is that a working group be formed, constituting one representative from each interested category. The primary function of this group should be to draft a working plan for the project, stating purpose, general procedure of establishing the experiments, standard method of collecting and compiling data, and results to be expected. In other words, each individual should know why he should participate in the project, how he should do it in order to serve a mutually beneficial purpose, and what results he may expect in return, immediately and in the course of time. The working group would arrange that technical assistance be given if required, it would ensure continuity and homogeneity of data and prevent unnecessary repetitions.

If it is at all possible to visualize the pattern of forest management just a few decades from now it can hardly be questioned that any lack of production data from thinned stands will be a very serious drawback. Further it can hardly be questioned that those suffering this disadvantage can rightfully blame us, their predecessors, if we neglect to make preparations to meet a situation which is more than likely to occur. It is our, the present-day foresters', responsibility to posterity to counterbalance the most serious obstacle to forest investigative work—"Time"—by initiating experiments from which we ourselves may not benefit directly and fully.