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An Embryonic Forestry Program In Coastal British Columbia-Preparation For Management

M Crown

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AN EMBRYONIC FORESTRY PROGRAM IN COASTAL BRITISH COLUMBIA-PREPARATION FOR MANAGEMENT

By

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Forester

PACIFIC LOGGING COMPANY LIMITED

1971-72 CHAMPION INTERNATIONAL CORPORATION LECTURESHIP

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A Note to Readers
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Champion International Corporation made this lectureship possible on a continuing basis, beginning in 1967, by an endowment to the Yale School of Forestry and Environmental Studies.

INTRODUCTION

THE key word in this title is "embryonic". Though we live in the sophisticated, computerized decade of the 70's, true forest management is still struggling to be born. Because forest management is at an embryonic stage of development, the future holds a world full of exciting challenges and change. However sophisticated our planning or discussion may become, forestry is practised in the woods (Figure 1). What we *do* in the woods is what adds up to forest management, be it good, poor, adequate or inadequate. *Time* is of vital importance in forest management. Decisions must be *made* and those decisions must be translated into *action in the woods* with a minimum of delay.

BACKGROUND INFORMATION

Canada has some 615 million acres of commercial forests. Approximately 20% or 118 million acres of these commercial forests occur in British Columbia where they represent approximately 50% of the land surface of the Province. The importance of the forest resource to the economy of B.C. is clearly evident—64% of the Province's natural resource income comes from the forest industry. The forest under discussion lies in the coastal forest region which is characterized by such species as Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco), Hemlock *(Tsuga heterophylla* (Raf.) Sarg.), Cedar *(Thuja plicata* Donn), Cypress or Yellow cedar *(Chamaecyparis nootkatensis* (D. Don) Spach) and the true firs *(Abies grandis* (Dougl.) Lindl.) and *(Abies amabilis* (Dougl.) Forb.) which are usually called balsam.

Pacific Logging Company Limited operates primarily on private forest land on the southeastern tip of Vancouver Island, a mere postage stamp compared to the vast public forest land ownership in British Columbia (Nagle, 1971) and only 3% of the forest land of Vancouver Island (Figure 2). It is important to note two features of this 300,000-acre forest which are unusual for British Columbia. Firstly, it is private forest land and secondly, it is located close to the sea, trade routes and markets. The existence of such a block of private forest ownership is

FIGURE 1. Operational planting of seedlings encased in plastic "bullets" (Walters, 1961). Photo: Alan Vyse — Canadian Forestry Service.

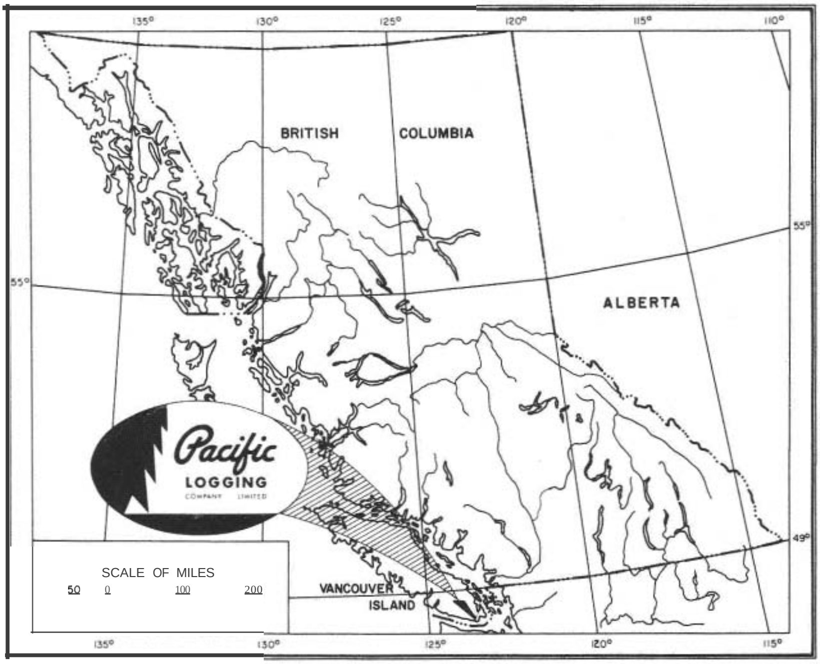

FIGURE 2. Location of Pacific Logging Company's main operations in the southern part of Vancouver Island.

unusual for British Columbia where, as in most other Canadian provinces, virtually all forest land is in Crown, that is, provincial, ownership. On typical Crown lands there is a division of authority and responsibility, sometimes awkward, in which private corporations, in the role of leaseholders, execute responsibility for management while most authority for the setting of management policy resides in the Forest Service of the provincial government. On this privately owned tract, however, responsibility and authority are not fractionated even though certain government regulations must still be met. The making of management decisions and their execution is swifter than it would be on public forests in the province. Good access to markets adds impetus to the need for management.

The Company has only been active since 1962. In 1964 I was hired to manage the reforestation and tree improvement programs. The forestry "arm" is headed by our Timberland Administrator beneath whom we now have a total permanent staff of two foresters, three technicians and two foremen.

EDAPHIC FACTORS

CLIMATE

Our knowledge of the local forest climate is as yet very sketchy as it is based on records from stations of the Department of Transport at low elevations on the perimeter of the forest areas.

Data for Cowichan Lake Forestry Station at 600′ above sea level are as follows:

		1970	Average 1940-1970
Temperature (°F)	– Mean Annual	50	48
	– Extreme Maximum	100	
	– Extreme Minimum	0	
Precipitation (inches)	– Total	74.2	78.6
	– June-August	2.1	4.7
Bright Sunshine (hours)		1,587	1,462
Frost Free Period (days)		174	

The surrounding forests go up to 2,500-3,500′ above sea level and it is common to have 80-100 inches of precipitation there. The climatic extremes of summer drought and open frosty winters are severe enough to hamper reforestation.

GEOLOGY

The land south of Cowichan Lake can be differentiated into three main subdivisions bounded by E-W fault lines (Figure 3). North of the lake, ownership patterns and geological complexity defy simple description.

1. Two main formations are found south of Cowichan Lake:

(a) Volcanics (V) – Mainly Triassic basalts with occasional limestone cappings. Young Douglas-fir plantations grow well on these sites (Figure 4).

(b) Intrusive rocks (JI)—Mainly Jurassic granodiorite and quartz diorite. The rapidly drained, droughty soils derived from these rocks create the worst problems for survival of plantations. .

2. The band south of the first fault is mainly of the Leech River formation (LR)—Slates and quartzites with some volcanics. Soils derived from this material have good moisture-holding capacity and the results of both natural and direct seeding are good. The terrain is even

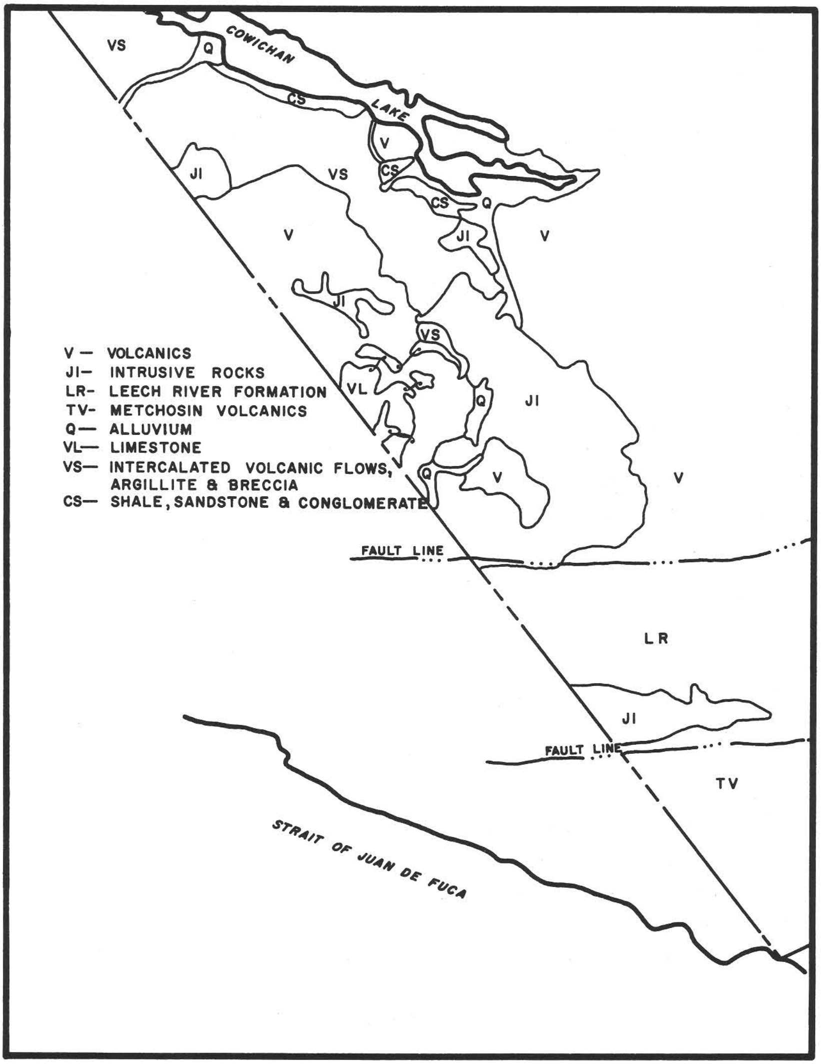

FIGURE 3. Geological map of the part of southeastern Vancouver Island where the Pacific Logging Company holdings lie (Canadian Pacific Oil and Gas Ltd.)

FIGURE 4. Eight-year-old plantation on basalt bedrock - upper Lens Creek. Photo: Pacific Logging Company.

and easily logged but the glacial till associated with this formation is highly erodable.

3. South of the second fault line and extending to the Straits of Juan de Fuca are the Metchosin Volcanics (TV)-Mainly Tertiary basalt. These have produced a very broken, hilly terrain that is difficult to log and so variable in productivity that it is not easy to map for management purposes.

SOILS

We were fortunate in 1967 to be able to map 40,000-50,000 acres of the Cowichan Division on a broad physiographic soil-site basis. This work was done in cooperation with D.S. Lacate and M.J. Romaine, who were interested in the relationship of mean annual increment (M.A.I.) to soils in Vancouver Island forests. In this provisional mapping we used aerial photographs to classify the land, supplemented by adequate growth and yield field data to estimate the productivity rating of the types defined.

Soils derived from glacial till, mainly in the uplands, were separated from glacio-fluvial deposits such as those of outwash gravel terraces and the silt or clay loams of lacustrine deposits. Drainage classes were incorporated. Bedrock geology was shown on the maps. It appears from further examination that we should also have distinguished between each kind of till even though these appear to be closely related to the bedrock geology. This step will be incorporated in future soil-site mapping which we plan to complete as soon as time permits.

Previous agricultural soil mapping of the lowlands stopped at the foot of the hills which were classified as "Undifferentiated Forest Soils." The soils of most forest land in British Columbia have yet to be mapped.

FOREST COVER

Forest-cover differences in the area are few but have far-reaching effects on logging efficiency, fire hazard, and reforestation possibilities.

The main types worthy of mention here are:

1. Overmature climax vegetation types - mainly cedar (C), hemlock (H), balsam (B) with some Douglas fir (F)-abbreviated CHB (F) or BHC (F) if balsam is predominant-500-700 years old.

2. Mature fire climax stands—FH (CB) or HF (C)—200-300 years old.
3. Immature fire climax stands—FH (C) or HF (C)—50-90 years old.
4. Other younger immature stands of natural or artificial origin following fire or logging.
5. Non-commercial decidous (N.C.D.)—Stands of alder *(Alnus rubra* Bong.) and maple *(Acer macrophyllum* Pursh) which occupy good valley-bottom sites.

Unfortunately most of our timberland is covered by overmature, climax vegetation. It is decadent and we do not consider that we have any positive periodic annual increment (P.A.I.) where this type occurs. The following management problems are associated with this type.

(a) A heavy volume of semi-rotten and broken logs is left behind after logging; this creates quite a fire hazard and has to be removed by broadcast slash burning.

(b) The chances of good natural seeding, especially of Douglas fir, from timber fringes of this type are poor. Therefore artificial reforestation is necessary.

(c) The accumulated raw humus, and the inter-twined roots of cedar and hemlock make satisfactory hand planting with bare-root stock and mattocks impossible. This is especially true when the fibrous mat overlies nothing but granodiorite rock rubble.

The younger 200 to 300-year-old fire-climax stands are much less common on our lands. These provide high volumes of clean solid timber which can be logged efficiently leaving much less slash. Such stands are composed of trees with vigorously growing crowns. The

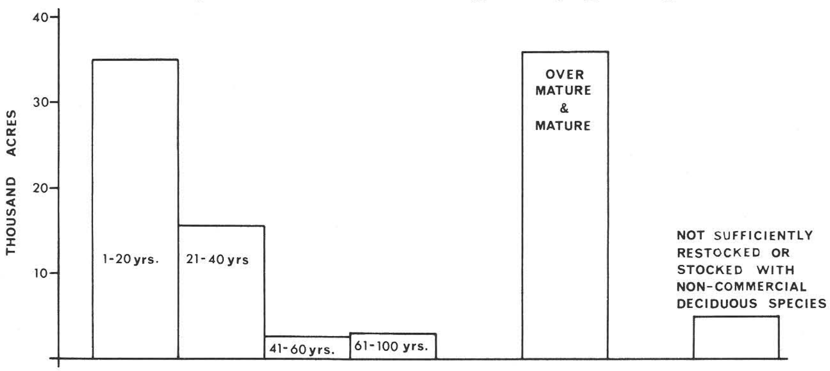

FIGURE 5. Approximate age-class distribution by area, on the Cowichan Division.

natural seeding potential from such stands is good and the ground conditions usually provide no real problems for artificial reforestation, where this is required.

The immature types are mostly natural unmanaged stands that will be managed in the future. Susceptibility to windthrow and disease following partial cutting are just two of the more obvious problems.

Non-commercial deciduous types originated naturally after fire or logging. They serve to enrich the soil in nature's scheme of things but as they are non-commercial and occupy excellent sites they are destined to be converted back to conifers in a program of bottomland rehabilitation.

We have a maldistribution of age classes which makes life interesting. Based on a quick recent summary, the approximate age-class distribution in the Cowichan Division is given in Figure 5 and includes land which is not sufficiently restocked (N.S.R.).

CURRENT FORESTRY PROGRAM

The Company has carried out an ambitious forestry program since its reactivation in 1962. During these, the early formative years of the Company, our forest management objectives may be simply stated as:

1. To restock all logged or burned acres promptly, efficiently and with the best possible seed or seedlings, with due attention to species requirements.
2. To manage the second growth stands so as to increase the yield and shorten rotations.

In retrospect we might say that we have already made a good start on the first objective while setting the other aside as one of tomorrow's targets.

For planning purposes we group our current activities under the four main headings of reforestation, tree improvement, forest fertilization and general forestry.

Reforestation

Since 1962 we have planted approximately 12.3 million trees on 33,000 acres. It should be noted that we include natural regeneration in our planning wherever the stand condition and timing appear to offer a good prospect for natural seeding. If it were not for the excellent natural restocking that has occurred following the 1966 and 1968 seed years we would not be nearly as close to being up-to-date as we are today.

Four years ago our planting target was 1 1/4 million trees per year, but we never came close due to shortages of planting stock. These shortages, in addition to purchases of N.S.R. land, fires and failures with bare-root planting, left us with an unacceptably large backlog of N.S.R. land.

We set ourselves the objective of eliminating our backlog in five years. Our target was the planting of 2.5-3.0 million trees per year, but this will drop to 1.8 to 2.0 million in 1973 when our objective will be reached. The direct seeding of 2,100 acres is also being done in 1972, and it is anticipated that, with experience, direct seeding will become a permanent part of our reforestation program.

Three alternatives were open to us:

1. Increase manpower and equipment to the level necessary to accomplish the job in the 3-4 months available annually, using the conventional mattock and bare-root planting stock.

2. Try direct seeding techniques, especially on hilltops of low productivity.
3. Investigate planting techniques that give better production rates and enable us to do the bigger job without expanding our facilities.

The first possibility was unacceptable due to the lack of suitable labor and our poor experience with bare-root survival. Several years of such planting in the Cowichan Lake area has given only 60% average survival after two years. Production was 650 trees/man/8-hour-day.

Testing of the second possibility started in 1968 with a five-year hand-seeding study to determine:

(a) What ground conditions gave satisfactory seeding results (Stewart, 1966).
(b) How many years in five could we seed successfully.

This replicated study is still being continued. We were encouraged by the results and made our first 600-acre operational trial in the spring of 1970 using the Cessna Agwagon and the Brohm seeder developed in Ontario. **In** 1971 we seeded another 725 acres. This time we used R.55, a repellant which was tested for us by the Canadian Forestry Service (Radvanyi, 1970; Edwards and Olsen, 1971). Germination from the 1970 seeding looks promising but has yet to be finally confirmed. The total cost per acre in 1971 was $5.66.

The third possibility involved the use of high-production planting techniques.

Mud-packs

By 1968 Pelton Reforestation had developed a commercial "mud-pack" technique. A mud-pack is a conventional 1-0 or 2-0 bare-root nursery seedling that has its roots encased in a cylindrical peat-clay mud-pack after lifting. We tried mud-packs for the first time in the fall of 1968. The crew liked them and so did we. We have now planted 4,534,000 seedlings by this method starting with 130,000 in 1968 (Figure 6). The peak year was 1969 in which 1,700,000 were planted but the use of other new methods caused the number to decrease to 1,467,000 in 1970 and 1,237,000 in 1971.

In general our "mud-pack" survival has been above our bare-root average of 60% for the Cowichan area. For best results nursery stock for mud-packing should be lifted during the dormant period of mid-November to mid-February. A summary of the first- and second-year survival of our spring 1970 planting for the Cowichan area is given in Table 1 as an example of the results obtained during a hot, dry year.

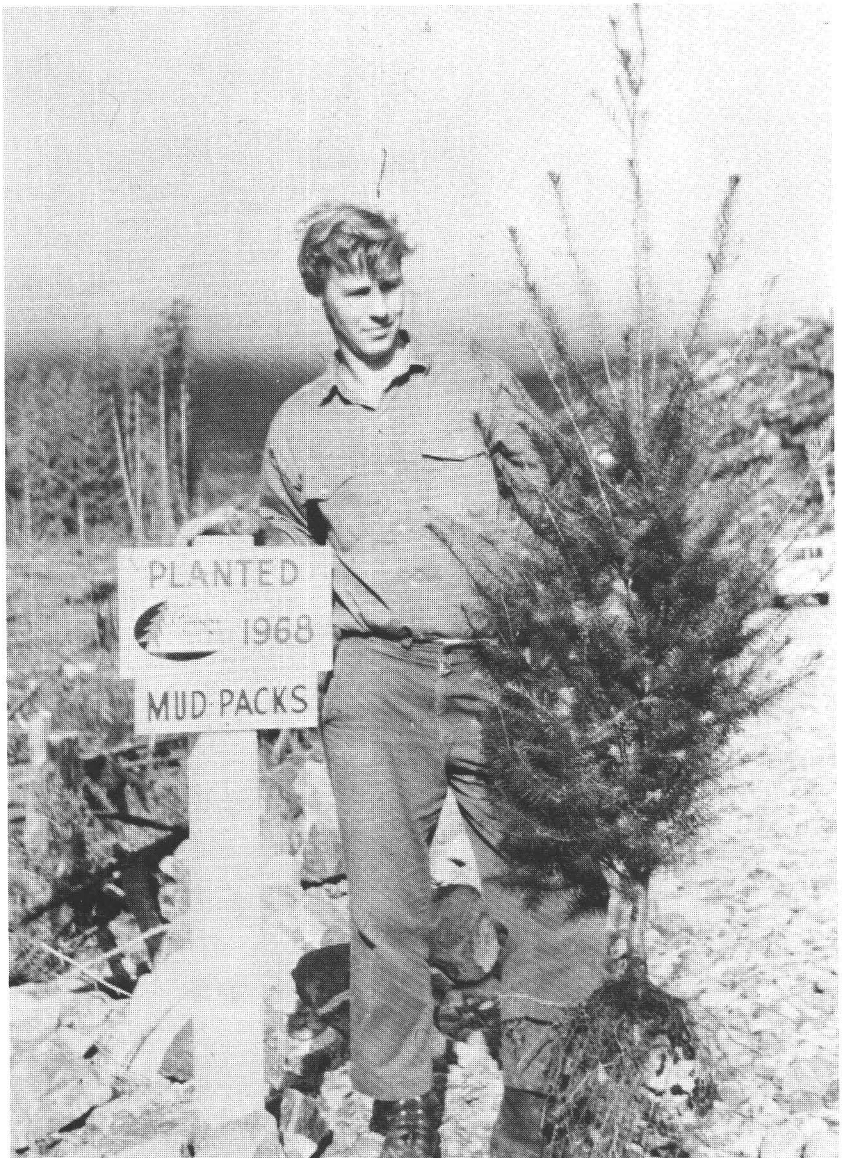

FIGURE 6. "2-0 mud-pack" three growing seasons after planting in the Fall of 1968. Photo: Pacific Logging Company.

TABLE I. SURVIVAL OF 530,400 TREES PLANTED BY THE MUDPACK METHOD IN THE SPRING OF 1970.

Planting Unit No.	No. of Lines	1st Year Survival %	2nd Year Survival %
IA	4	74	63
* IB	5	89	75
3	3	85	77
4	4	93	85
10	4	73	68
11	10	92	89
12	4	84	77
13	2	84	79
14	6	86	78
15	4	78	74
16	4	67	65
*Operationally different type of mud-pack planting			
Weighted Average		84.5	76.3

TABLE 2. SURVIVAL SUMMARY

Seed Lot #	Stock Description	[1]Ave. Survival Percent 1st Yr.	2nd Yr.	[2]Estimated Operational Expectation
# 1990/1.6 Goldstream (66)	Regular MP	93	93	82
	Regular MP & Jiffy-Gro	97	89	78
	Vermiculite MP	98	96	84
	Vermiculite MP & Jiffy-Gro	98	94	83
	Perlite MP	97	93	82
	Perlite MP & Jiffy-Gro	95	88	77
		Av.96	92	Av.81
	Bare-root	93	88	66
# 1047/2.0 Hill 60 (66)	Bare-root	81	72	54
	Bullets	78	74	?
	Bullets & Jiffy-Gro	79	69	?

In 1970 we established a trial of various kinds of mud-pack stock with bare-root controls, as we believed that the mud-packs could be improved. This trial was set up to determine if vermiculite, perlite or a root-growth hormone ("Jiffy-Gro") increased in survival and growth of "mud-packs" (MP). The results are tabulated in the upper part of Table 2.

In the Spring of 1971 we planted 508,000 mud-packs in the Cowichan Division. The average production was 1,283 trees/man-day and the total direct cost, 6.1 cents per tree. The cost includes all transportation from the nursery to the mud-pack plant, mud-packing, cold storage, shipment to the site, board and lodging, crew overhead and project supervision but not the cost of growing the stock.

Bullets

Having started to divorce ourselves from the bare-root concept, and realizing the potential cost reduction of high-production techniques we next tried the plastic "bullet" developed by Walters (1961, 1968) in early 1969.

We felt that the biological answer to such problems as root egress from the slotted tubes would shortly be answered by the Canadian Forestry Service and British Columbia Forest Service. After inspecting the encouraging results of Walters' planting at University of British Columbia Research Forest, we embarked on pilot bullet projects aimed primarily at testing equipment and gaining experience about the costs, production and survival we could expect on our own lands. Information on survival is tabulated in the lower part of Table 2.

Our bullet-planting program and survival are summarized below:

		Survival	
		1st Year	2nd Year
Fall 1969	45,000	69%	54
Spring 1970	35,000	77	68
Fall 1970	380,000	62	
Fall 1971	1.276.000		

1 Four replicates on two test sites, treatments randomized within each test site.

2 We apply a Planter Foulup Factor (P.F.F.) to all such trial results to obtain the "Estimated Operation Expectation." In our experience this is a 20-30% reduction for bare-root and 10-15% for mud-packs. As yet we have insufficient experience with bullets to make such an estimate.

The planting in the fall of 1970 was our first truly operational program. Only the limited survival data given above are available. It should be noted that the survival figures relate to extremely severe hilltop conditions. We expect to obtain better results as experience is gained in growing seedlings in bullets and planting them.

During the first three weeks of our current program starting September 14, 1971, 446,000 bullets were planted in 198 man-days at an average of 2,252 tree/man-day.

Costs were (a) Growing	1.5 cents
(b) Plastic	1.5 cents
(c) Planting	2.0 cents
Total direct planting costs	5.0 cents

Plugs

Recently the Canadian Forestry Service and B.C. Forest Service developed a styro-block "plug" (Arnot and Vyse, 1971), several thousand of which were planted on our lands in cooperation with the Canadian Forestry Service. Planting productivity data for several reforestation systems is given in Table 3.

TABLE 3. SUMMARY OF PLANTING PRODUCTIVITY DATA FOR SEVERAL REFORESTATION SYSTEMS (ARNOT AND VYSE, 1971)

Refor. System	Planting tool	Avg. Plant. speed trees/min	Delays % of day	Avg. Daily Production trees/ 8-hr day	Operational conditions
Bare-root (2+0)	Mattock	1.86	25.0	670	day wage, mod- difficult site, 9' x 9' spacing, avg. quality crew.
Bare-root (2+0)	Mattock	3.19	41.2	900	day wage, mod- difficult site, 9' x 9' spacing, high quality crew.
Mudpack (2+0)	Dibble	3.19	32.7	1031	day wage, easy-mod site, 9' x 9', poor quality crew.
Styro-block (package)	Dibble	4.38	37.3	1373	Incentive wage, mod site, 8' x 12', high quality crew.
Mudpack (1+0)	Tool	4.50	23.2	1658	incentive wage, easy-mod site, 9' x 9', avg. quality crew.
Styro-block	Dibble	5.91	36.0	1816	day wage, easy site, 8' x 12', high quality crew.
Bullet (4½")	Dibble	5.60	27.9	1936	incentive wage, easy-mod site, 8' x 12', avg. quality crew.
Bullet (4½")	Walters' Gun	6.37	28.8	2175	incentive wage, easy site, 8' x 8', avg. quality crew.
Tubeling	Dibble	7.09	34.3	2238[1]	day wage, easy site, 10' x 10', high quality crew (2 planters, 1 packer).

[1] 1492 trees/day when packer included

It is our intention to carryon with our work using mud-packs and bullets and to assess the styro-block "plug" system when additional data become available on operational production, cost and survival.

Reforestation conclusion

The effect of an incentive bonus system on planting crew production and psychology has been an important factor with these new techniques. We can now look back and begin to analyze cost figures and see where we are heading. Of course it will probably be another 3 to 5 years before we can properly compare the new techniques but it is particularly important to note that they have enabled us to get the job done.

Table 4 clearly demonstrates:

1. The value of switching to new techniques as early as possible and conversely the cost of indecision or unnecessary delay.

2. In terms of costs and logistics, Walters' Bullet and direct seeding have to be considered the most promising techniques. If the plastic bullet does hinder root development and growth, then we must make sure that this defect is corrected without delay!

Similarly, with direct seeding, research is needed to develop a "seeding concept" for the '70's that is as far removed from present seeding techniques as the Walters' Bullet is from the mattock of the '30's.

TREE IMPROVEMENT

Tree improvement goes hand in hand with reforestation and the aim, of course, is to plant the best possible trees. The importance of seed origin and seed quality cannot be over-emphasized when the severity of the planting sites is considered. A classic example of what can happen to low-elevation strains planted high above the source of origin is clearly demonstrated by a 57-year-old study in the Pacific Northwest (R.R. Silen and F.e. Sorensen / personal communication). Seedlings from many sources were planted at several locations. Of the 13 tested sources at the high-elevation Mt. Hood plot, only those from high elevations have survived to make an acceptable stand. Trees from some low-elevation sources were killed outright by early fall frost in 1955 at the middle-elevation Mt. Hebo plot.

TABLE 4. TOTAL COST PER MILLION TREES PLANTED IN 1971

		Expected 2nd Yr. Survival	Cost per Million Surviving Trees	Cost per Acre to Achieve 450 Surviving Trees
(a) 2-0 Bare-root — (650 trees/man-day)		60%	$133,000	$59.80
(a) Growing	$11,000			
(b) Planting[1]	69,000			
	$80,000			
(b) 2-0 Mud-packs — (1,300 trees/man-day)				
(a) Growing & Mud-packing	$41,000			
(b) Planting	35,000	80%	$95,000	$42.75
	$76,000			
(c) 1-0 Mud-packs — (1,500 trees/man-day)				
(a) Growing & Mud-packing	$35,000			
(b) Planting	30,000	80%	$81,000	$36.45
	$65,000			
(d) 1-0 Walters' Bullet — (2,250 trees/man-day)				
(a) Growing & Plastic	$30,000[2]			
(b) Planting	20,000	(80%)	$(62,000)	$(27.90)
	$50,000			
(e) Direct Seeding — ($6.00/acre)		(50% Failure)		$ 9.00[3]

[1] Assuming $45.00/man-day.
[2] Likely to be reduced with volume and experience.
[3] Variable stocking may have to be corrected in the future.

The objectives of the Company's Douglas-fir tree improvement program are:

Short-Term—To produce quality controlled seed for operational use, especially to obtain enough high-elevation seed for stock planted at those elevations.

Long-Term—To maximize genetic gain through controlled crossing and progeny testing.

The "time-clock" for tree improvement (Figure 7) shows the sequence of activities accomplished and planned.

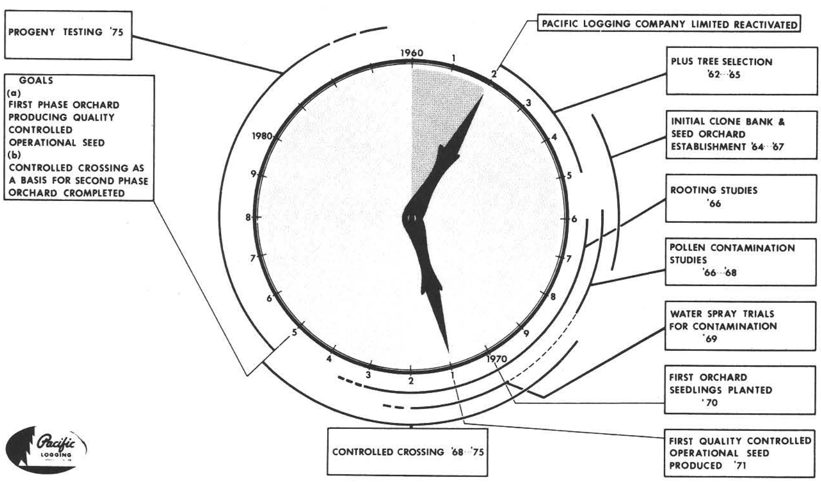

FIGURE 7. Tree improvement activities completed before 1971 and those planned thereafter.

Plus tree selection

The Company has participated in "plus tree" cruising with the B.C. Forest Service and other companies in an effort to locate the best trees in the woods. "Plus trees" are good phenotypes selected in 40 to 100-year-old stands of Douglas-fir, that are superior in underbark volume and form to their three largest dominant neighbours of the same age. They should be straight, with little taper, and light crowned having light branches that are as near to horizontal as possible. Over 3,000 acres of young Douglas-fir stands were cruised for "plus trees" by the Company between 1963 and 1965.

Initial establishment of clone banks and seed orchards

Scion material or branch tips from the tops of the "plus trees" was collected, using a 0.22 rifle with a telescopic sight. This was done during the winter or early spring. The scion material was grafted to seedling root stocks in the clone banks and seed orchards. In the spring of 1964 and 1965 clone bank grafting was carried out at Cowichan in the vicinity of Nineteen Mile Creek. Grafting in the Saanichton Seed Orchard (Figure 8) was carried out from 1965 to 1967. Some grafting was done on potted 2-0 root stocks just three weeks after potting, with an 80% take.

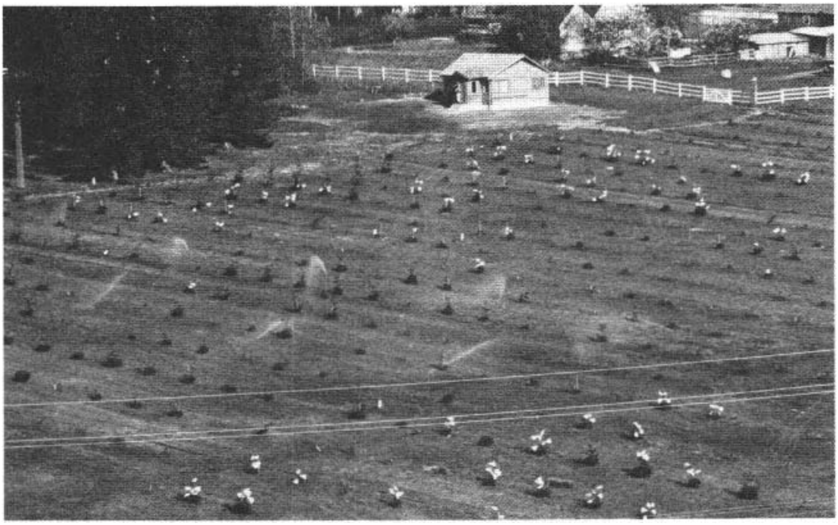

FIGURE 8. Saanichton Seed Orchard - 1971.

By 1965 two major seed-orchard management problems were clearly evident—*graft incompatibility* and *pollen contamination.*

Incompatibility problems are well known to fruit orchardists. In the case of Douglas-fir the scion outgrows the root stock and finally dies (Copes, 1967). Two steps were taken to alleviate this problem. Firstly, cones were collected from "plus trees" and the seedlings from these were used in the seed orchard, and secondly, rooting studies were commenced in 1966 so that Douglas-fir could be propagated without grafting.

FIGURE 9. Rooted Douglas-fir cutting from clone-bank material. "Plus Tree" parent was 90 years old. Photo: Pacific Logging Company.

Rooting studies

These studies were undertaken in cooperation with the Saanichton Research Station, Canadian Department of Agriculture, and several trials were carried out before positive results were obtained (Figure 9). Ever-improving results have now been obtained for the last three attempts and it is hoped a usable technique will result from the many experiments. Once we have learned to root cuttings, then the next step is to grow them successfully and establish rooted orchards.

Pollen contamination

The high elevation orchard at Saanichton contains grafts from "plus trees" that originated 1,700-3,500 feet above sea level. Because of the importance of seed origin, as already explained, pollen from local Saanich trees just 200 feet above sea level would therefore contaminate the selected high-elevation orchard stock. In 1966 the first pollen study was carried out to determine the nature of the enemy. With assistance from the Canadian Forestry Service and the B.C. Forest Service, pollen collection equipment and meteorological instruments were set out so that pollen flight could be related to local climate. In 1968 a similar study was conducted, but in addition, the phenology of the trees in the orchard was studied in relation to the local pollen flight. Pollen counts were usually made over a 20-day period. Maximum counts recorded for a 24-hour period were 22,000 pollen grains per square inch of sample tape. The problem was, therefore, serious enough to commence trials with water sprays to combat contamination.

Water spray trials for contamination

Limited water spray trials (Silen and Kene, 1969) were carried out in 1970. The object of the study was to see if the development of the orchard trees could be held back until the local pollen peak had passed. Unwatered flowers developed normally. Watered buds remained closed and were successfully held back for 10 to 14 days to develop after the local pollen had shed. In 1971 a more elaborate automated system was installed on a two-acre test area and cones from this area have provided our first "quality controlled" operational seed. By September 1972 seedlings produced from this seed will be planted on the hills as 1-0 mud-packs.

Controlled crossing

Steady progress has been made in the controlled crossing that represents the intricate and interesting long-range aspect of tree improvement. Two hundred crosses were made in 1971, producing some 87,000 filled seeds. Female buds are identified and isolated in pollination bags. All male buds on the same branch are removed to assure that no outside pollen lands on the female strobili to be cross-pollinated. Pollen is collected from the male cones of each parent tree when it begins to be shed and is kept separate from pollen from other parents at all times. The ripe pollen cones are picked into paper cups, washed and placed in the pollen extraction equipment. Six dozen pollen lots can be extracted simultaneously in the same apparatus without fear of mixing (Figure 10).

The extraction equipment passes a warm flow of air through the buds to dry and release the pollen. The air is switched off after 24 to 48 hours and the cans are tapped to release the heavy pollen into the bottles ready to use or refrigerated storage.

When the female strobili reach the upright, receptive stage in mid-April, the pollen is transferred to the pollination equipment which is kept cool and shaded. The records are checked very carefully before each pollination to avoid mistakes. Controlled pollinations are then carried out by squirting the appropriate pollen onto the female strobili and sealing the pollination bag. The female strobili close shortly after pollination and become pendant prior to rapid growth of the conelets. The pollination bags are replaced by insect bags to protect the developing cones from insect attack until the seed matures in mid-September.

The cones are collected, opened in a drying kiln and tumbled to shake out the winged seed. The seed is dewinged, and then cleaned and separated in a Dakota blower until only filled seed is left. This seed is stored or sown to produce the first generation of improved seedlings which will become the basis for a second phase seed orchard and also progeny trials to determine if they can withstand the rigor of the environment.

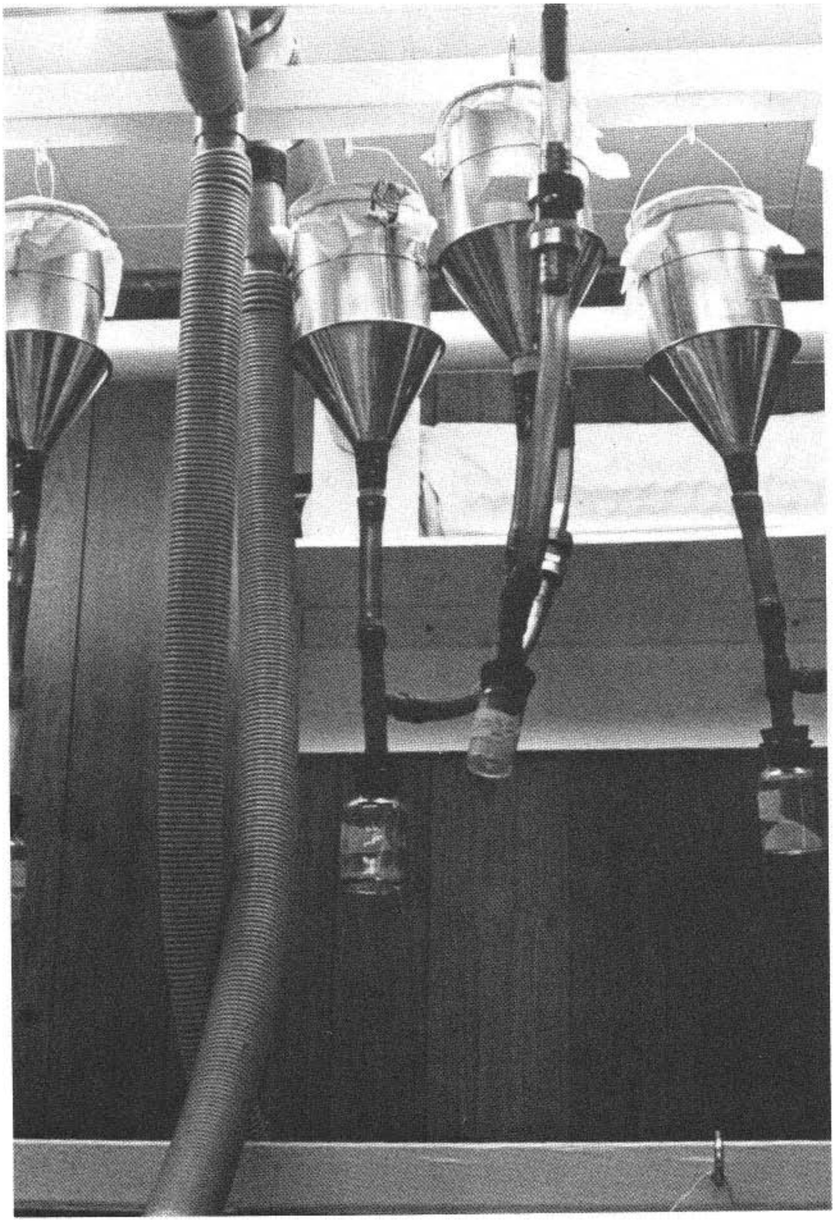

FIGURE 10. Pollen extraction equipment. Photo: Pacific Logging Company.

FOREST FERTILIZATION

In 1963, Pacific Logging Company Limited and Cominco Limited began a series of cooperative fertilization trials in second-growth Douglas-fir stands (Figure **II).**

The objectives were:

1. to learn how to handle and apply fertilizer to the forest, to obtain good operational cost data and
2. to establish growth and yield plots and carry out other allied studies to determine the response of the stands to fertilizer.

FIGURE II. Cessna Agwagon applying fertilizer. Photo: D. Flintoft-Pacific Logging Company.

To date, some 13,446 acres have been fertilized with 2,035 tons of urea (46% nitrogen), and 500 growth yield plots have been established.

From 1966 to 1968 we regressed from hand loading with bags to attempts at bulk loading using cement tankers. During this period Steerman aircraft were operated from expensive conventional airstrips and the operation was far from efficient. By the fall of 1968 it was obvious that the economic application of fertilizer using fixed-wing aircraft required improved ground procedures.

The idea of constructing inclined airstrips as used for quick take-offs in New Zealand was proposed by James Evans, Agricultural Manager for Conair Aviation (Figure 12).

FIGURE 12. Cessna Agwagon poised for take-off from "Kiwi" strip. Photo: Alan Vyse, Canadian Forestry Service.

The first "Kiwi" strip to be built for forestry purposes was roughed out at Nineteen Mile Creek in the winter of 1968 and graded in June 1969. The site selected was at 1,000 feet above sea level and 500 feet above the valley floor. The strip was 840 feet long, including the loading area at the top of the slope, and inclined at 10%.

In the fall of 1969 314 tons of urea were applied to second growth stands in 4 1/2 days. Maximum flight distance for this operation was 3 1/2 miles from the strip. The strip was used in the spring of 1970, for seeding by fixed-wing aircraft and again in 1971 for fertilization. Advantages of this kind of strip are:

1. The low construction costs of six such strips built to date in coastal terrain, range from $160-$1,700.
2. Sites suitable for building such strips can be located in close proximity to operating areas.
3. Pilot fatigue factor is lower than for conventional level strips.
4. Down-time due to adverse winds is much less than for conventional strips.
5. The technique is safe-some 1,730 landings and take-offs have been made from inclined strips without mishap.
6. At 1,000 Ibs. per load an experienced pilot will spread 10 tons of fertilizer an hour.
7. Landing, loading and take-off are accomplished in 45-50 seconds.

Cost offertilization (1971)

(a)	Urea at $75.00 per ton (varies with location)	3.75¢/lb.
(b)	Handling costs - rail cars to airstrip (approximately 4 mile haul)	.28¢/lb.
(c)	Cost of aerial application (fixed wing) up to 3 1/2 miles from the airstrip	1.00¢fib.
		5.03¢/lb.

Urea is 46% available nitrogen (N); therefore, the application of 100 Ibs. of N/acre requires 2.17 times as much urea, at a cost of 2.17 x 5.03 = $10.92/acre/100 Ibs. of available nitrogen.

Response to fertilization

This is our last year of cooperative financing of trials with Cominco so the question of the value of the response is the crucial one for us. Anyone who has worked with forest fertilization will appreciate that it will be several years before any good answers will be obtained. Our soil mapping has helped us in the selection of growth and yield plot locations. Some interim guides should emerge as we remeasure growth and yield plots although we may only discover that we have to develop new techniques to measure response.

One new technique involves the use of low-level stereo-photographs to measure dynamic changes in the crowns of trees, and a computer simulation model to determine volume changes. This work was carried out in cooperation with Professor K.J. Mitchell of the Yale School of Forestry and Environmental Studies. The photographic system twas developed by the British Columbia Forest Service (Lyon, 1964, Figure 13).

GENERAL FORESTRY

This category includes our first steps towards second-growth management, namely thinning and bottomland rehabilitation.

Bottomland rehabilitation

This is the conversion of non-commercial deciduous (N.C.O.) areas on good sites to coniferous forests. We carried out detailed mapping of several hundred acres of N.C.O. in the Robertson Valley just south of Lake Cowichan in 1969 and found that maple, alder and -some cottonwood *(Populus trichocarpa* Torr. and Gray) were the main deciduous

FIGURE 13. Helicopter photographing stands. Photo: G. Buffett - British Columbia Forest Service.

species. We decided that commercial working of this material was not a practical answer to our problem because most stands have relatively small irregular shapes, and the alder tends to have poor form and multiple stems. The study showed that about one-third of the area was already stocked with conifers and chemical release was probably all that was required. Another third was partially stocked and would require supplementary planting and release. Most of the remaining third of the acreage was pure N.C.D. and would require planting and release. A small acreage was N.C.D.+, *i.e.,* non-commercial deciduous plus a scattered coniferous volume, mostly Douglas-fir of piling size. Thus we had the bottomland problem categorized.

The conifers are currently being released by killing alder with 2,4-D amine and maple with MSMA (monosolium-methane arsenate). These chemicals are injected into individual trees and spectacular release of the conifers is already evident.

The plan for the partially stocked and pure N.C.D. areas is as follows:

1. Underplant with 500 large Douglas-fir seedlings per acre using a shovel- survival to date has been excellent. This is usually done during the winter.
2. Carry out a partial chemical thinning in the deciduous stand the summer before planting or very early in the summer following planting. The objective here is to allow sufficient light into the stand to encourage vigorous growth of the planted trees, without encouraging detrimental quantities of grasses, bracken, brambles, salmonberry and other undergrowth species. We try to remove about 50% of the canopy. A rapid invasion of the planted area by undergrowth species is clearly evident in some of our early trials where we removed more than 50% of the canopy. It is doubtful whether the Douglas-fir will be able to compete, but this remains to be seen. One other problem that we probably have to live with is deer browsing, but we do not know just how serious this is at the present time.
3. Wait until the planted stock has been released and is beyond deer browsing and brush competition problems and then complete the chemical treatment of the deciduous overstory.

This program has not been in progress long enough to assess the effectiveness of the prescriptions.

Just this fall, with a Douglas-fir cone crop evident, we have finally been able to tackle the smaller acreages of N.C.D.+. Our plan here is to attempt coniferous restocking by a natural shelterwood system.

I. The deciduous overstory has been given a partial chemical treatment.
2. Approximately 50% of the area under the stand has been scarified.
3. Once the seed has fallen and the natural regeneration is established, the remaining deciduous trees will be removed chemically.
4. We also plan to remove the large piling-sized Douglas-fir seed-trees in the winter, just as the final fellings of prime oak veneer timber is removed in France leaving little or no trace of damage to the regeneration. Am I dreaming? I don't think so. If we are

going to *do* second growth management one of our first jobs will be to train good loggers with the special attitudes needed for second-growth work. Care and cooperation are probably the keys to such problems.

Thinning and general management

When we think about operational thinning or general management of second-growth stands, as opposed to research or trial plot work, a whole series of pertinent questions comes to mind. The first of these might be:

Where to thin first?

How to provide maps suitable for management purposes?

How to prescribe thinning?

How to control thinning?

Four years ago we started to devote some thought to such questions as where to thin in a 2,000-3,000 acre tract. Second-growth mapping and inventory maps provide detailed stand data as the basis for the calculation of allowable cuts. When one considers second-growth management, the complexity of such mapping becomes a problem and its value is questionable for general management purposes.

The opening paragraph of a very timely article by Ray (1964) hits right at the heart of this dilemma:

"Forest classification has received a great deal of attention in Canada. The vast area of our forest, comparatively low timber yields and wide variations in growth rate make it imperative for the purpose of study to group or classify like forest conditions. Studies have been conducted by foresters and specialists in the last 30 years on cover types, age classes, height, density, site, vegetation and other classifications to the point where still another system would appear to be what we need least. Seely's (1929) method of measuring tree heights on air photographs added a third dimension to mapping and still more detail, but in the eagerness to show all these refinements the forest manager seems to have been the forgotten man."

He then goes on to describe the system of "cutting classes" that is used in Norway and is well adapted for forest management.

In 1966 we carried out some theoretical exercises using second-growth cruise data and air photos to describe the following broad groupings of stand or "management" classes:

I Regeneration
(a) Developing plantations or natural regeneration.
(b) Immature at the precommercial thinning stage.
II Developing immature not recommended for commercial thinning.
III Immature, pulpwood thinning stage
IV Immature-pulp and piling stage
(a) Thinnable
(b) Unthinnable due to low stocking
V High volume stands

The foregoing classes were arbitrarily defined in terms of stems per acre larger than 7.1 in D.B.H. and basal area (B.A.) per acre in trees larger than the minimum diameters stated for each class, as follows:

	Stems/acre, 7.1+" *D.B.H.*	*B.A./acre, in trees* ≥:
II	150 stems or less	Less than 100 sq. ft., 7.1" D.B.H.
III	100 stems or more	Less than 100 sq. ft., 11.1" D.B.H.
IV	(a) 100 stems or more	Less than 100 sq. ft., 17.1" D.B.H.
	(b) 100 stems or less	Less than 100 sq. ft., 17" D.B.H.
V	Stands with 100 sq. ft. or more in trees 17.1+" D.B.H.	

Management maps prepared by this approach would have only a few mapped categories rather than the complicated distinctions that proliferate when forest-type mapping becomes an end in itself. Once such classification has been tested in actual thinning operations, it should be possible to proceed with appropriate mapping.

Since basal area, stems/acre and D.B.H. are the basis of classification it is tempting to contemplate some specially adapted form of cruising with prisms and point-sampling techniques to prepare the maps. However, when one is typically short of personnel, thoughts turn to the possibilities of developing techniques of aerial photogrammetry that might do the work with nearly equal effectiveness and greater efficiency.

We are presently working with Professor K.J. Mitchell of Yale on the use of low-level stereo-photography as a means of doing such mappings and also predicting growth and yield. The studies (Mitchell, 1971) that he has made of the description and growth simulation of Douglas-fir fits this kind of approach well.

In 1970 we flew transects across the 30-year-old stands in the Robertson Valley to obtain stereo-photo-samples from a flying height of 400 feet. The objectives were to obtain stem number and information on crown competition from the 70 mm. photographs, plot the data on 20-ehain maps, and then delineate three broad classes of thinning requirements on the latest 20- or lO-chain aerial photographs. We hope to complete the map work in the winter of 1972.

As far as the determination of thinning priorities is concerned, it is not difficult to distinguish between the extreme categories that clearly do or do not require thinning. The problems arise with the large grey category between these extremes. This is where growth simulation should help the most. Once representative samples from various parts of this range of conditions have been defined and incorporated into simulation models it should be possible to assess the relative economic merits of all sorts of stand treatments in each category.

We have found that precise prescription for the marking of thinnings is very difficult due to the variability in stocking and stand condition. Free-growing clumps of three to six trees are especially difficult to assess. Some guidelines or rules of thumb could probably be developed by growth-simulation techniques.

We have not yet carried out any commercial thinning. We have finished a few hundred acres of pre-commercial chemical thinning mostly to test chemicals and develop operational techniques. We should be able to forge ahead with this aspect of forest management once we have our thinning priority map.

As with the use of 20-chain photographs, low-level stereo-photography offers more data than we can afford to measure at the present time. The development of relatively simple and inexpensive ways of estimating or measuring D.B.H., height, basal area and stocking are required if the technique is to be put on an operational basis.

Other facets of management

The use of chemicals calls forth all manner of concern. We find it necessary that all chemical work carried out by our company be carefully supervised. The foresters are registered pesticide applicators which means that they must be fully aware of all precautions that must be taken against any human or environmental hazards. All projects are thoroughly screened within the company. They are also approved by a four-party Provincial Pesticide Control Committee and the Canada Department of the Environmen.t before any work is done in the woods. Most foresters are conservationists at heart because their training is founded on ecology and everything they do is concerned with environment.

Recreation and public use of these private forest lands is not discouraged. Presently we have an open-gate policy that allows hunters and tourists to use our private logging roads during non-operational and non-hazard periods. More sophisticated policies in this regard have yet to be put into effect.

Forest protection is primarily the responsibility of the logging department which is also responsible for slash burning on operational areas. The company is a member of the Forest Industries Flying Tankers that owns the Martin Mars water bombers. We also use the Avenger fire bomber in times of need to assist ground crews. One project we have carried out under second-growth protection is that of falling fire killed snags in second-growth areas to reduce the risk from lightning strikes.

CONCLUDING COMMENTS

This description of our program shows clearly that we are still in the phase of preparation for management. We have been accumulating data and experience as the basis for tomorrow's management decisions. We must think, not in terms of forestry by the acre, but of forestry by the fifty or one hundred acres.

We are well aware of the limitations of our present program. For example, it is obvious that we have reached the point where it is necessary to start using techniques of operations research and economic analysis to evaluate the relative merits of each operation. However, we must never underestimate the value of good judgment based on experience. We must develop a good technical staff "who see what they are looking at" and know their forest, for these are the men who must *do* forest management work in the woods. They must also have a natural aptitude for managing people.

I offer the following advice to potential and practicing foresters. Cooperation and good communications are the key to forest management progress. There is a wide gap between the universities and the practicing field forester. The fact that I have been invited to prepare this paper about "grass roots" forestry is very encouraging. Extension courses now frequently offered by universities also help considerably in this regard.

It is a good idea to get into the forest and practice forestry in your early years. Get your administrative work well organized, delegate routine matters and get out into the woods. Avoid paper empires, remember that unless something is done in the woods as a final result of your deliberations, you have not contributed positively to forest management. Don't regulate forestry to death or try to put forestry operations into the straight jacket of a "how to do it" manual that will probably be obsolete the day it is written.

It is important for researchers to keep in touch with good practical foresters so as to keep abreast of their ideas and future needs, and also to test new ideas with them.

Universities can assist forest management by apportioning more graduate study time to the solution of practical management problems that require scientific hardware and analysis that is seldom available to the field forester.

The resources are vast and the talent unlimited; let's use them to improve the practice of forestry and speed the birth of *true* forest management.

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