FINANCIAL IMPLICATIONS
AND SOME COSTS AND BENEFITS
OF
LOGGING GUIDELINES
IN THE
CHILLIWACK PROVINCIAL FOREST

by

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ABSTRACT

The financial implications and some of the costs and benefits of two sets of logging guidelines were examined in two sample drainages in the Chilliwack Provincial Forest. Time limitations and lack of data on non-timber resource impacts prevented a full quantitative evaluation of all costs and benefits. Instead, an analysis of the financial impact of these guidelines on the timber resource was undertaken, and supported by a qualitative discussion of environmental, social and income distribution effects.

The potential variation in the system was demonstrated by a simulation approach to the financial evaluation. There still is much uncertainty in most of the assumptions and research and improved methods could provide more precise answers.

The financial analysis showed that the alternative patch cutting system, common to both sets of guidelines, was the main contributing factor to increased logging costs. The more extensive basis for harvesting under this system was found to result in as much as a 60% decline in potential economic rent per developed acre, without any consideration of increases in physical harvesting costs.

The size of the increase in physical logging costs per cunit was found to be very sensitive to interest rates and to the length of the leave period between consecutive harvesting passes.

Application of the 1972 Coast Logging Guidelines to harvesting operations in the Chilliwack Provincial Forest was found to result in an

extra annual cost, ranging from between $0.632 million to $6.645 million for the next 24 years. A figure of $1.423 million was considered to be the most realistic estimate of the extra costs resulting from the guidelines.

The alternate patch cutting system with long leave periods may aggravate instability of those small undiversified communities which are highly dependent upon the local timber processing industries for employment.

Analysis of the costs and benefits of the guidelines as they affect other resource values revealed that they may be an inefficient means for attaining multiple use objectives. It appeared likely that problems of erosion, sedimentation and aesthetic impact may even be increased overall, because of the more extensive basis for forest development.

There still is a need for much investigation of the quantitative aspects of harvesting impacts on forest land resources. In addition the analyses should be extended to other units, and guideline effects evaluated by mathematical modelling.

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LIST OF CONVERSION FACTORS

To convert:	Into:	Multiply by:
Inches (in.)	Centimeters (cm.)	2.540
Cubic feet (cu.ft.)	Cubic meters (m^3)	0.0283
Miles (mi.)	Kilometers (km.)	1.609
Acres (ac.)	Hectares (ha.)	0.405

To convert degrees Fahrenheit (^oF) to degrees Celsius (^oC), subtract 32 and multiply by 5/9.

1.0 INTRODUCTION.

In recent years the B.C. Forest Service, other Government agencies and private industry have been showing signs of increased cooperation in managing the forest environment. Although a framework is well on the way to being established, relatively little attention is being devoted to the problem of multiple-resource decision making, and to the use of explicitly defined management objectives and criteria. The main reason for this is a lack of information on resource values and little knowledge of the impact of management of one resource on the values of other resources.

Logging guidelines in Coastal B.C. have tended to be vague and too subjective. Despite these obvious problems, it is essential that guidelines are updated continually in the light of changing circumstances and additional information and research. This thesis attempts to quantitatively evaluate the costs and benefits of two sets of logging guidelines, namely the 'Planning guidelines for Coast Logging Operations' (B.C.F.S., 1972) and the 'Interim Guides - Logging on Severe Sites - Vancouver Forest District' (B.C.F.S., 1973a). The need for such research originated in part from recommendations made by the author of this thesis, to a Task Force appointed by the Chairman of the Reforestation Board of the Tree Farm Forestry Committee. This Task Force was instructed to review comments made by foresters in the Vancouver District on the latter set of guidelines, and to outline any apparent information gaps. A separate report on research needs was forwarded by the Chairman (Devitt, 1974) to various research agencies with a request for assistance and a request for guidance in the type of work that each might be able to undertake. As a result of discussions with Mr. R.L. Schmidt, R.P.F. and Mrs. E.A.F. Wetton, R.P.F.*, the author prepared a research proposal outlining a method for analysing the costs and benefits of logging guidelines. This was accepted, and the author was awarded a contract, dated May 10, 1974 requesting the following project to be undertaken:

> "Socio-economic evaluation of the impact of environmental protection constraints and regulation upon existing timber harvesting practices at high elevations in the Chilliwack Provincial Forest." (Stokes, pers. comm.)

The Chilliwack Provincial Forest was selected as a suitable study area for two main reasons. Firstly, the area provides a good example of conflicting interests in timber production, fish and wildlife values and recreation, and may indicate the sort of problem which is likely to be faced a great deal more in B.C. in the future. Secondly, a realistic analysis in a short period of time requires a sound data base. This is lacking for a great many areas in B.C. but a lot of information has been collected for the Chilliwack Provincial Forest by the Westwater Research Centre at U.B.C. and by the B.C. Forest Service, Vancouver District Staff.

The available information was reviewed and analysed as to its potential usefulness for this study (Benskin, 1974a). The evaluatory procedure adopted was specifically designed to accomodate the basic limitations of the available data. Those costs and benefits which could be quantitatively identified were included in a traditional economic analysis. The remaining intangible components were reviewed in a supporting qualitative discussion, and were related to the results of the quantitative analysis.

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2.0 DESCRIPTION OF THE CHILLIWACK PROVINCIAL FOREST

2.1 Introduction.

The physical and biological attributes of the Chilliwack Provincial Forest have been well documented in the literature. The objective of this section is to provide a fairly concise background review of the resources considered in this study. For more detailed information the reader should refer to the 'Integrated Use Plan for the Chilliwack Provincial Forest: Part 1 Basic Resources', (B.C.F.S., 1974) and to a number of unpublished Westwater Research Centre reports cited in the text.

2.2 Location and extent of the Chilliwack Provincial Forest.

The Chilliwack Forest covers approximately 175,000 acres and is located about 55 miles east of Vancouver, B.C. between the Fraser River and the International Boundary (Figure 1). Unless one hikes in over the mountains or flies in to Chilliwack Lake, entrance to the forest is by road from Vedder Crossing located about four miles south of the town of Chilliwack.

2.3 Physical features.

2.31 Physiography and Geology.

The Chilliwack River flows in an almost due westerly direction through a narrow valley located in the Cascade Mountains (Skagit Range) of British Columbia. The drainage area measures approximately 486 square miles and is bordered by mountains with peaks ranging between 5,000 to 8,500 feet above sea level. The headwaters of the river originate in the North Cascades National Park, Washington, U.S.A., and join to form the Chilliwack River some 1.6 miles north of the Canada-U.S. border. The river then flows

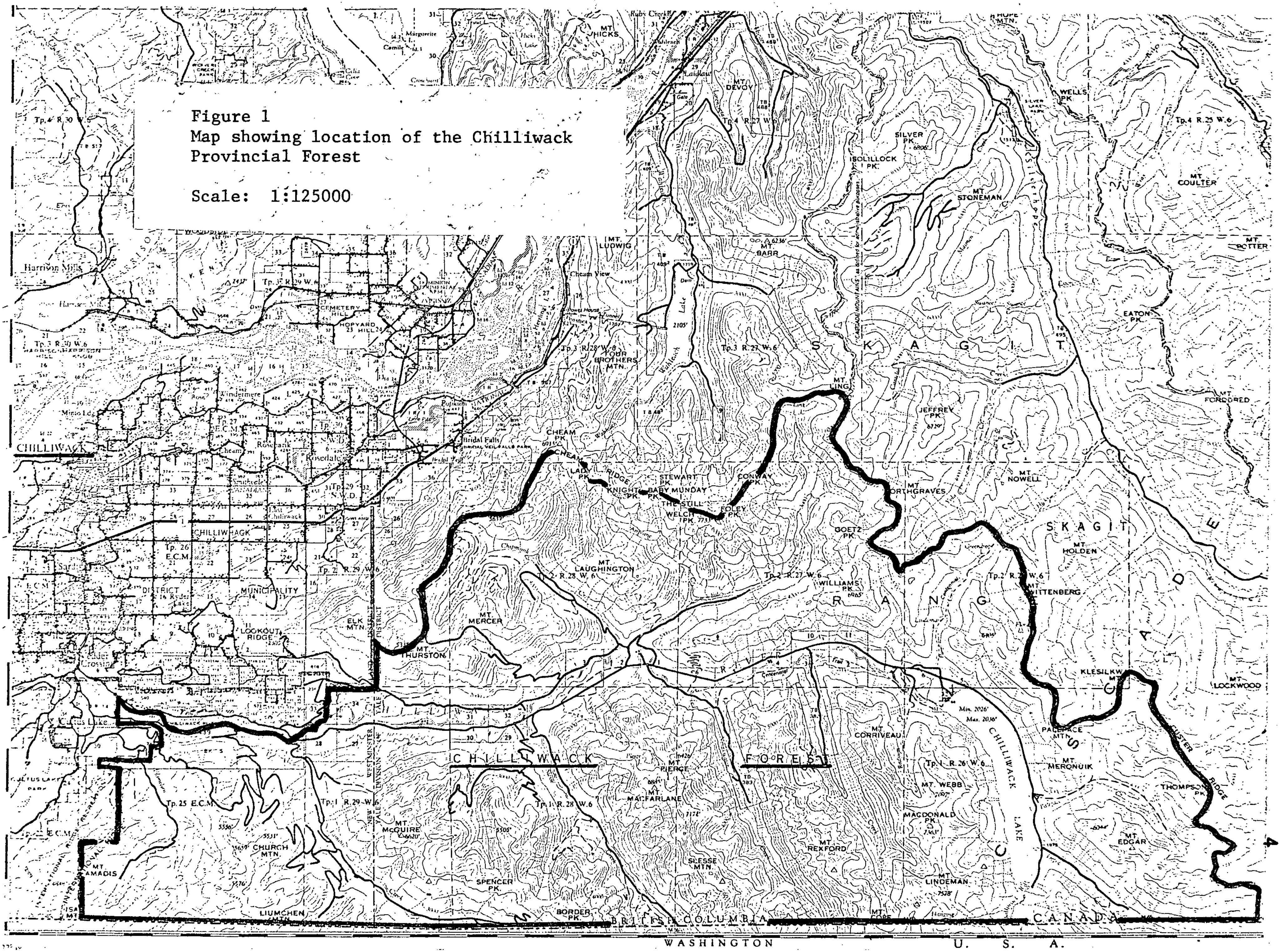


Figure 1
Map showing location of the Chilliwack Provincial Forest

Scale: 1:125000

in a northerly direction into Chilliwack Lake, and from there proceeds in a westerly direction for a distance of 37 miles to the Fraser River. Topographically, the drainage consists of a long U-shaped valley, broad in places, with relatively steep, rugged slopes and a number of narrow tributary drainages entering in from the sides (Figure 2). Monger (1974) described the Chilliwack Forest as lying on the west side of the Cascade Mountain System: an axial core of granite rock and gneiss flanked on the east and west by belts of faulted metamorphic, sedimentary, plutonic and volcanic rocks. The latter accounts for the western two-thirds of the forest, eastwards to a line drawn roughly from Slesse Mountain to Williams and Goetz Peaks, while the remaining eastern portion was described as essentially granitic rock with minor gneiss and sedimentary rock.

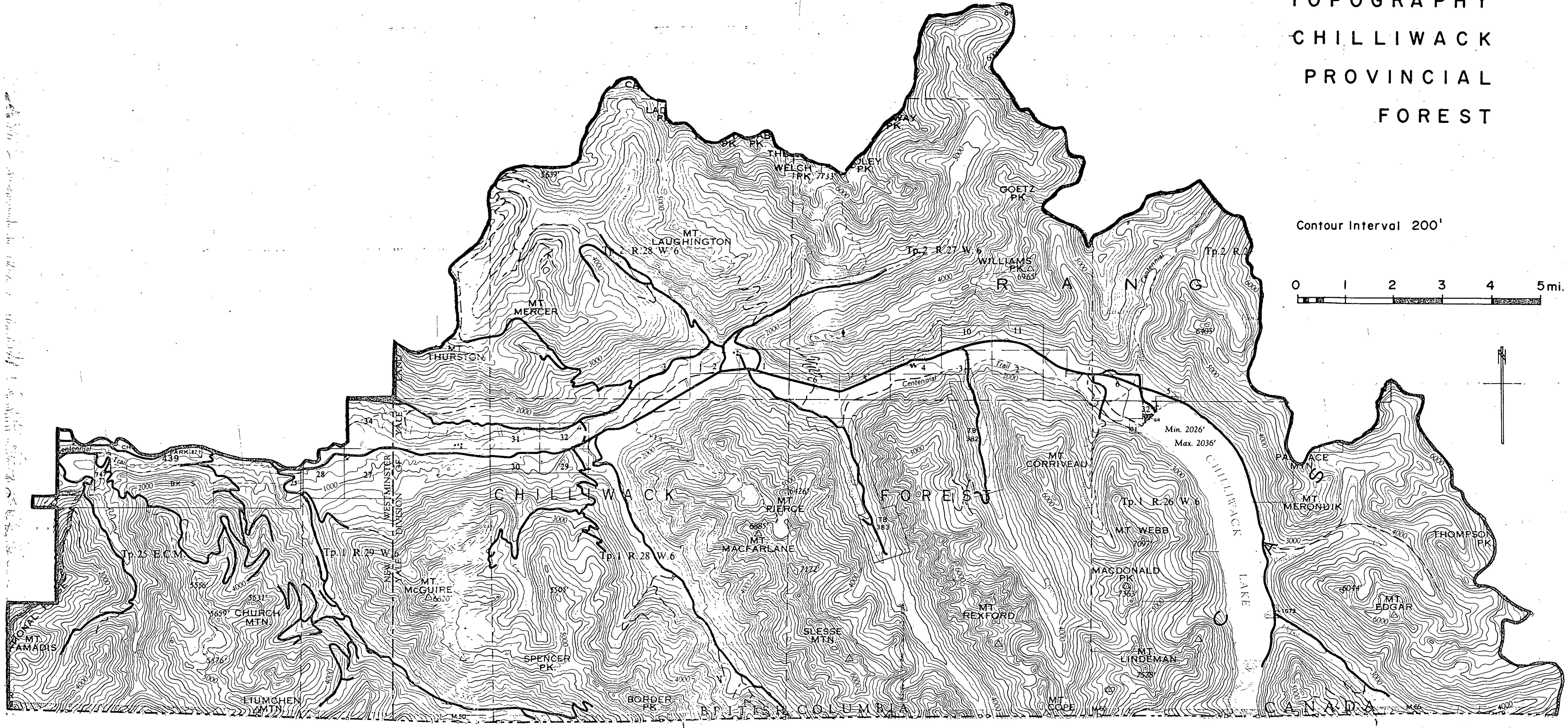
2.32 Climate.

The Forest, which is under the influence of the Coastal Pressure System (Chapman, 1952), has an annual total precipitation of 62.12 inches with only slight variation from station to station. On the other hand, the average snow fall shows a definite increase in an easterly direction, from 28 inches at Cultus Lake to 52 inches at Tamihi Creek and 91 inches at Center Creek (Farley, 1966). The area falls into Koppen's Dfb (Humid Continental-Cool Summer) climatic zone, which is characterized by average temperatures between 50^{o}F and 72^{o}F during the warmest month and less than 27^{o}F during the coldest month. There is no distinct dry season in the Dfb zone; the driest summer month has more than 1.2 inches of rain. (Chapman, 1952). Mean daily temperatures in the Chilliwack Provincial Forest range from 60^{o}F for July to 25^{o}F for January with a mean annual temperature of 49^{o}F (Farley, 1966). It should be noted that

FIGURE 2

TOPOGRAPHY CHILLIWACK PROVINCIAL FOREST

Contour Interval 200'



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several of the climatic stations from which these measurements were taken are located outside the boundaries of the Chilliwack Provincial Forest and almost all stations are situated at elevations of 1600 feet or below. Care has to be exercised, therefore, in forming conclusions based on these figures which do not include high elevation information or take account of local variation due to the immense topographic variability in the area.

2.33 Soils and Landform.

A survey was carried out by Leskiw (1973) in order to provide basic information on soils and landform for the 'Integrated Resource Use Plan for the Chilliwack Provincial Forest' (B.C.F.S., 1974). The area was found to possess a great variety of landforms, from valley bottom to mountain top. Some valleys such as those of the Chilliwack River and Slesse Creek are broad in places with benches and terraces, and were found to consist of deep glacio-fluvial, lacustrine and morainal deposits. In comparison, the narrower and steeper-sided valleys of Foley and Nesakwatch Creeks had colluvial deposits along the sides and patches of moraine and alluvium at their lower ends and entrances. Leskiw (1973) analysed soil types within these landform categories. Shallow ridge soils (approximately 20 inches deep)consisting of lithic alpine brunisols and lithic humo-ferric podsols were common within subalpine and alpine areas (elevation range between 5,000 and 7,000 feet). On the mountain slopes within forested areas (elevation range between 500 and 5,000 feet) there were mainly podsols (orthic, lithic and humo-ferric types) with intermittant colluvial fans which had very little soil development. The valley bottom soils consisted of humo-ferric podsols or complexes of gleysolic, podsolic and regosolic soils developed on alluvium, lacustrine, outwash or colluvial deposits. Reduced copies of Leskiw's soil and landform maps are shown in Figures 3 and 4 respectively.

2.34 Natual Vegetation.

Briere (1974) mapped the natural vegetation of the Chilliwack Provincial Forest (Figure 5) according to methods developed by Krajina (1969). Krajina's Zones and Subzones were not only defined on the basis of vegetation but also by the combined effects of vegetation, soils and climatic variation on a local scale. The Chilliwack Provincial Forest was found to contain three of his Biogeoclimatic Zones: the Coastal Douglas-fir zone, the Coastal Western Hemlock Zone, and the Mountain Hemlock Zone. The respective areas of each Zone and Subzone have not yet been calculated. The reader should consult Briere (1974) and Krajina (1969) for a comprehensive list of tree and plant species as well as for the physical characteristics of these mapping units.

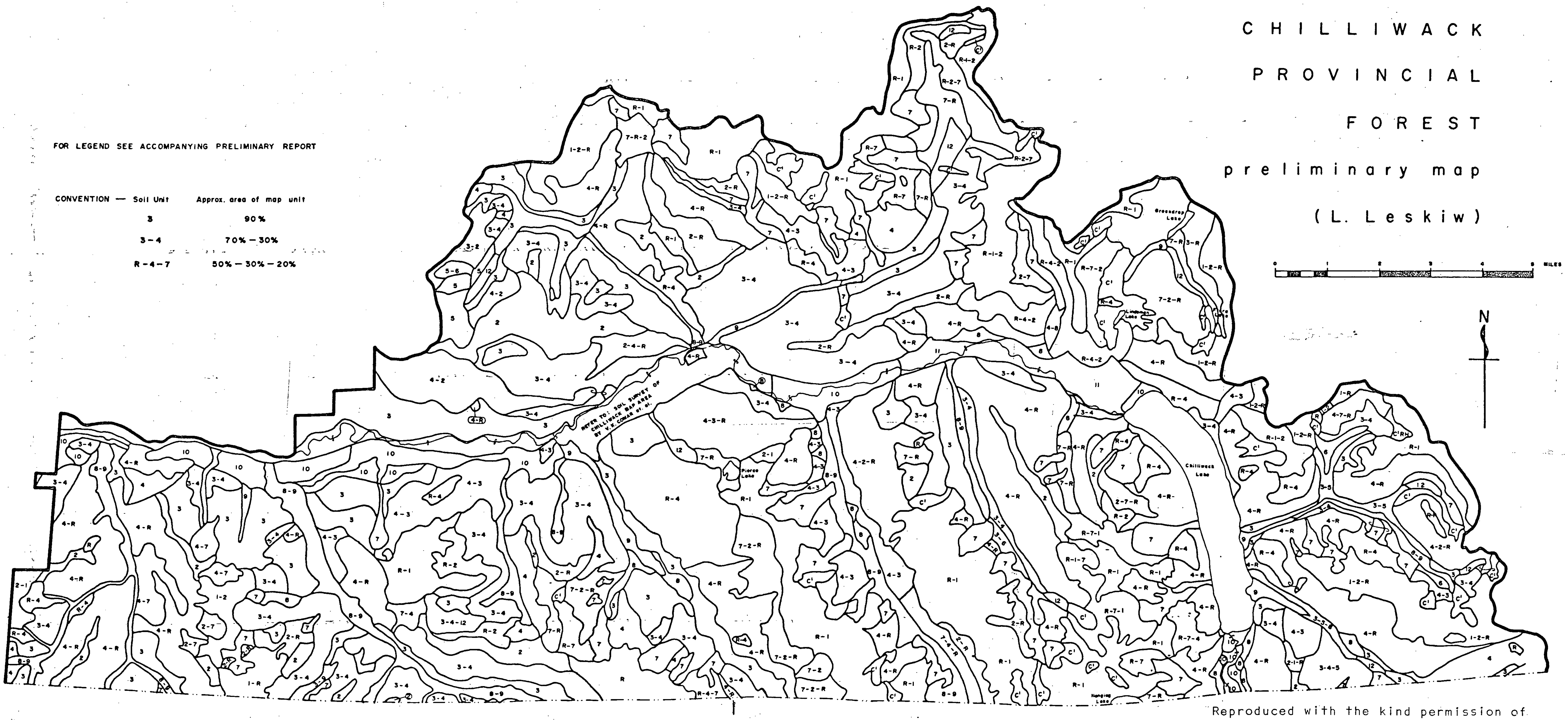
2.4 The history, extent and significance of the timber resource.

2.41 History.

Utilization of the forests in the Lower Fraser Valley has been continuous since the early days of settlement, but logging did not become very significant until about 1900. The first know operations in the Chilliwack Provincial Forest were started in 1910 by Bowman and Sons Logging and Sawmilling, and although the Camel River Logging Company began railroad logging operations soon afterwards, to all intents and purposes the forest was still in a 'virgin' condition (Okonski, 1974). Railroads were usually constructed in the main valley and logging operations were restricted to the most profitable old growth Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), western hemlock (*Tsuga heterophylla* (Raf.)Sarg.), and

SOILS
CHILLIWACK
PROVINCIAL
FOREST
preliminary map

(L. Leskiw)



UNIT LANDFORMS CHILLIWACK PROVINCIAL FOREST

preliminary map

(L. Leskiw)

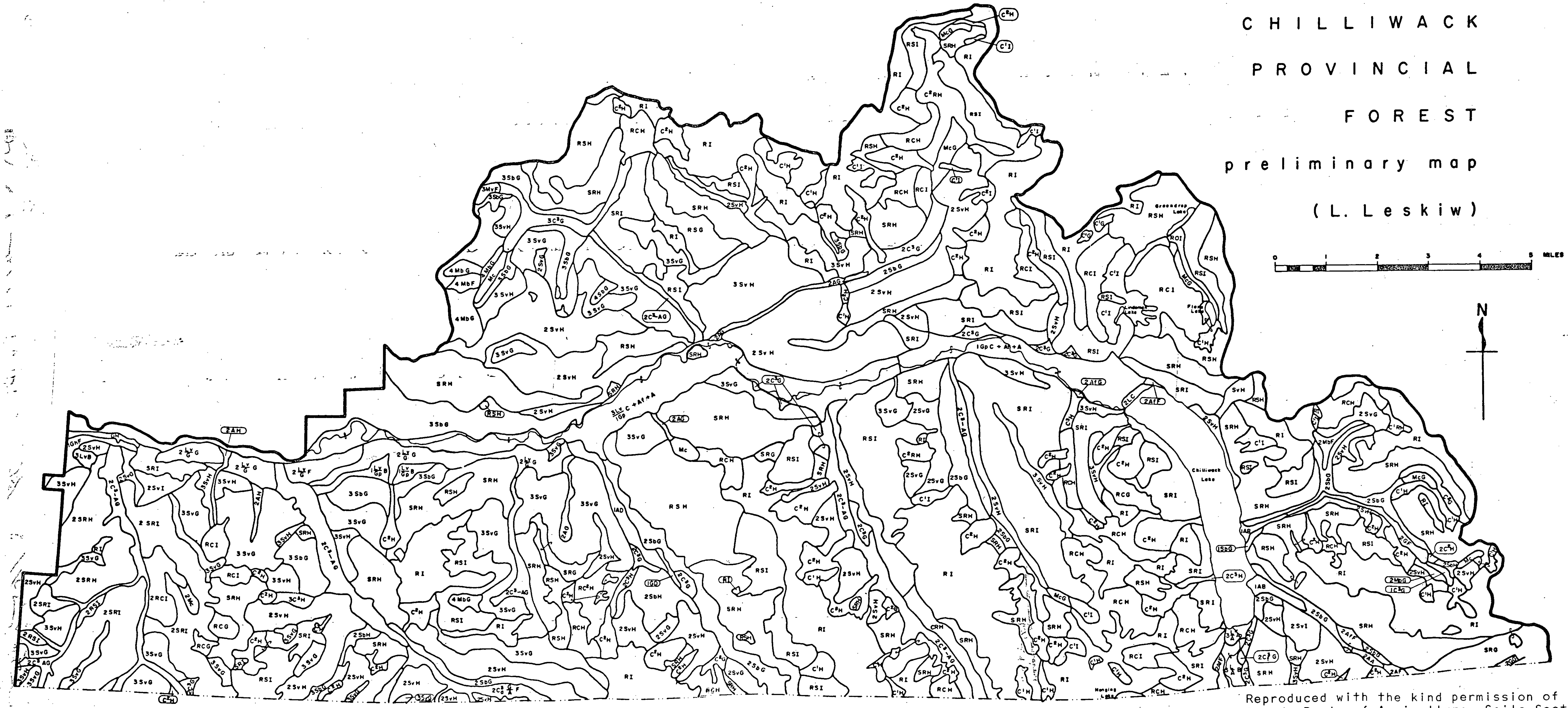
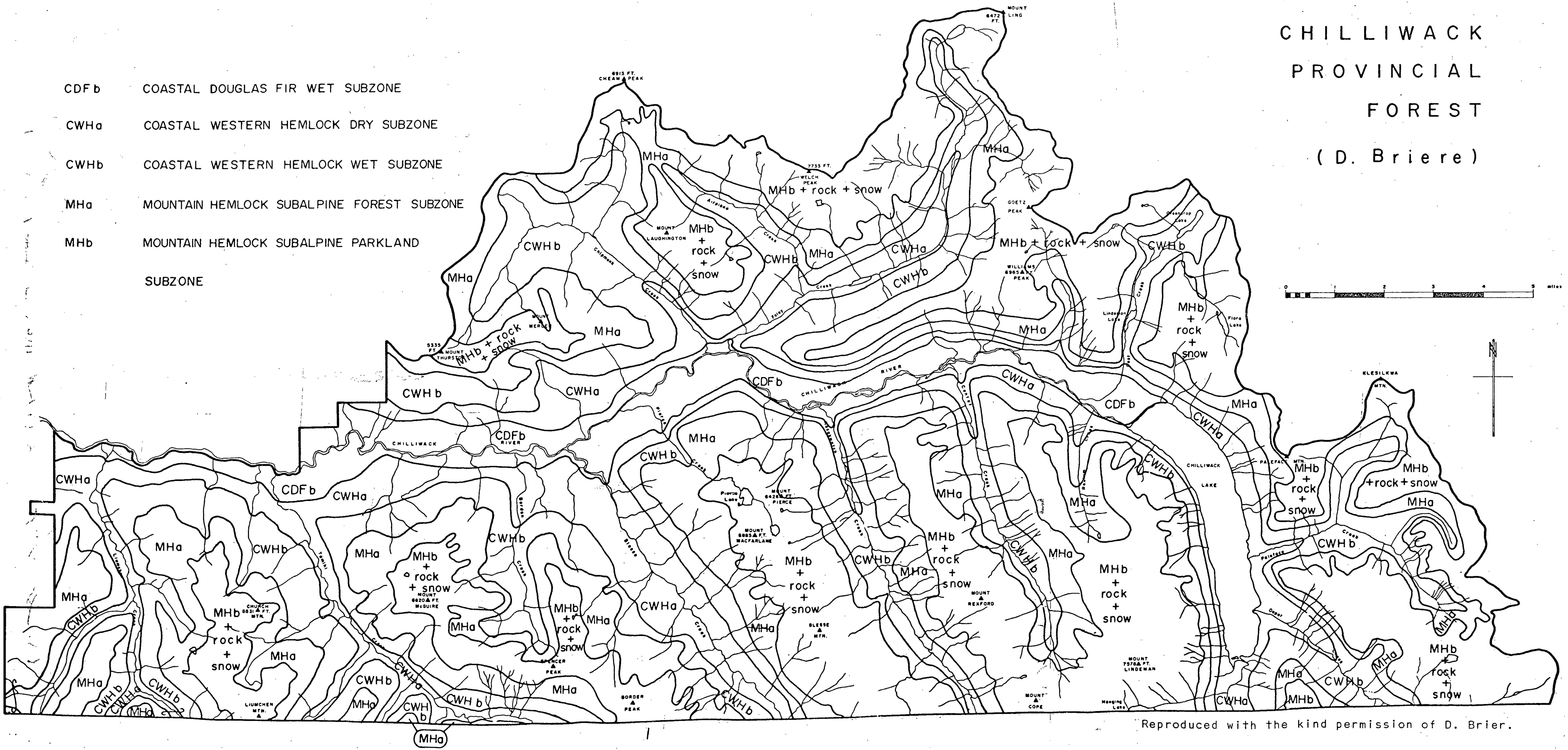


FIGURE 5

BIOGEOCLIMATIC ZONES AND SUBZONES CHILLIWACK PROVINCIAL FOREST

(D. Briere)



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western redcedar (Thuja plicata Donn) stands. The railroad logging era ended after a large forest fire in 1938, and logging technology entered a new phase where truck hauling, gas donkeys and bulldozers made smaller operations possible. In the fifties, portable chainsaws and steel spars were developed and refined, which made practicable the logging of previously inaccessible tributary drainages to the Chilliwack River Valley (Anon., 1973).

In the late thirties and early forties it had become increasingly apparent that the forest, which at that time had been administered as part of the 'Fraser South Area', was being overcut and would have to be placed on a sustained yield basis in order to provide for future supplies of timber. By 1937 the Vancouver Forest District had adopted a general policy of not making any timber sales in second growth stands. In 1949 the Chilliwack Forest Reserve was created by an Order-in-Council which cleared the way for the establishment of the Chilliwack Public Working Circle (P.W.C.) - a sustained yield unit. In 1953 an allowable annual cut in amount of 2.33 million cubic feet (2.33 MM cf) was established for the P.W.C. and in 1958 this was subsequently raised to 3.00 MM cf . It must have been apparent that between 1960 and 1963 the current rate of cut was too high and could not be reduced to comply with the allowable annual cut constraint. In comparison, the adjacent Harrison and Yale P.W.C's were being considerably under-utilized. Consequently in 1963 the Chilliwack Forest was resurveyed to 'Unit Survey' standards and amalgamated with the other P.W.C.'s in 1965 to form the Dewdney Public Sustained Yield Unit (P.S.Y.U.). The unutilized allowable cut in the remote areas of the old Yale and Harrison P.W.C.'s was therefore redistributed to the more profitable areas for logging, such as the Chilliwack

Forest. The average cut in the forest appears to have risen from about 6.75 MM cf in 1963 to a current annual average cut of 7.71 MM cf (roundwood only) calculated over the period 1970-74 (Ingram *pers. comm.*).

The distribution of logging activity has changed considerably in the Chilliwack Provincial Forest over the last decade. Large valley-bottom Douglas-fir and western hemlock stands have mostly been removed and replaced by immature second growth stands. The current harvestable old growth consists mainly of western hemlock, amabilis fir (*Abies amabilis* (Dougl.) Forbes) and yellow cedar (*Chamaecyparis nootkatensis* (D.Don) Spach) in the higher elevation forests, located primarily in the tributary drainages to the Chilliwack River Valley. Harvesting these forests has presented the logging industry with higher production costs and lower quality timber, making it more difficult to operate profitably. For example, higher road construction costs and log hauling costs have been encountered because of increased ruggedness of the terrain and longer hauling distances. Logging costs have also increased because of smaller log sizes and higher stand defect, the latter averaging 30-40% and reaching as high as 70% in some high elevation hemlock-amabilis fir stands (Richardson, *pers. comm.*). Problems have also been encountered in attempting to artificially regenerate these sites with Douglas-fir planting stock. It is not uncommon to encounter sites where reforestation attempts have failed two or three times in succession (Hahn *pers. comm.*).

As a result of the immense scenic beauty which the area possesses as well as the importance of several other resource values (to be mentioned later), the 'Planning Guidelines for Coast Logging Operations' (B.C.F.S., 1972) have been vigorously applied to reduce the undesirable impacts of logging. In addition, several aspects of the unpublished 'Interim Guides - Logging on Severe Sites - Vancouver Forest District' (B.C.F.S., 1973a) have been implemented especially with regard to improving regeneration performance.

2.42 Significance of the Timber Harvest to the Local Economy.

The 1971 Census estimated that there were approximately 23,739 people in the Chilliwack ennumeration area of whom 9,135 resided in the town of Chilliwack itself. Available data on labour force by sector indicate that forestry based employment ranks fourth after employment in the service, agriculture and retail trade sectors (McLean, 1973). The same author made an estimate of the employment and value of production which could be related to the annual cut in the Chilliwack Forest over the years 1970-72. His results have been reproduced in Table 1, with the following modification: the estimate of 34 men in sawmilling was based on the estimate of about one-quarter of the allowable cut being processed locally (1.7 MM cf) multiplied by the Coastal average of 20.27 man years per MM cf of roundwood processed. Since a local allowable cut is no longer in existance and the current cut is higher (about 7.71 MM cf), a figure of 2 MM cf was substituted in the calculation of mill employment. It was apparent from the employment figures that the forest industry in the Chilliwack is of relatively minor importance in relation to other sectors.

2.43 Significance of Timber Harvest to the Regional Economy.

Roughly three-quarters (or 6 MM cf) of the harvest from the Chilliwack is made into booms on the Fraser River and sold in the Vancouver log market. McLean (1973) estimated that

Table I

EMPLOYMENT AND VALUE OF WOOD PRODUCTS FROM THE CHILLIWACK PROVINCIAL FOREST, 1970-1972.

	1970	1971	1972
Av. no. of men employed (full time):			
a) in logging.	80	93	68
b) in local mills.	40	40	40
c) dead and down salvage.	114	140	75
Total volume of logs produced (C cf.)	92,861	90,727	60,023
Total market value of logs ($)	4,067,358	3,435,491	2,796,576
Total market value of minor products ($)	249,442	410,040	396,330

69% of these logs are processed by sawmills, 22% by pulp and paper plants and remaining 9% by plywood and veneer plants - all located on the Lower Coast. On this basis, the Chilliwack harvest only contributed about 0.7% of the total roundwood consumption on the Lower Coast in 1972 - which is very small indeed when considered on its own.

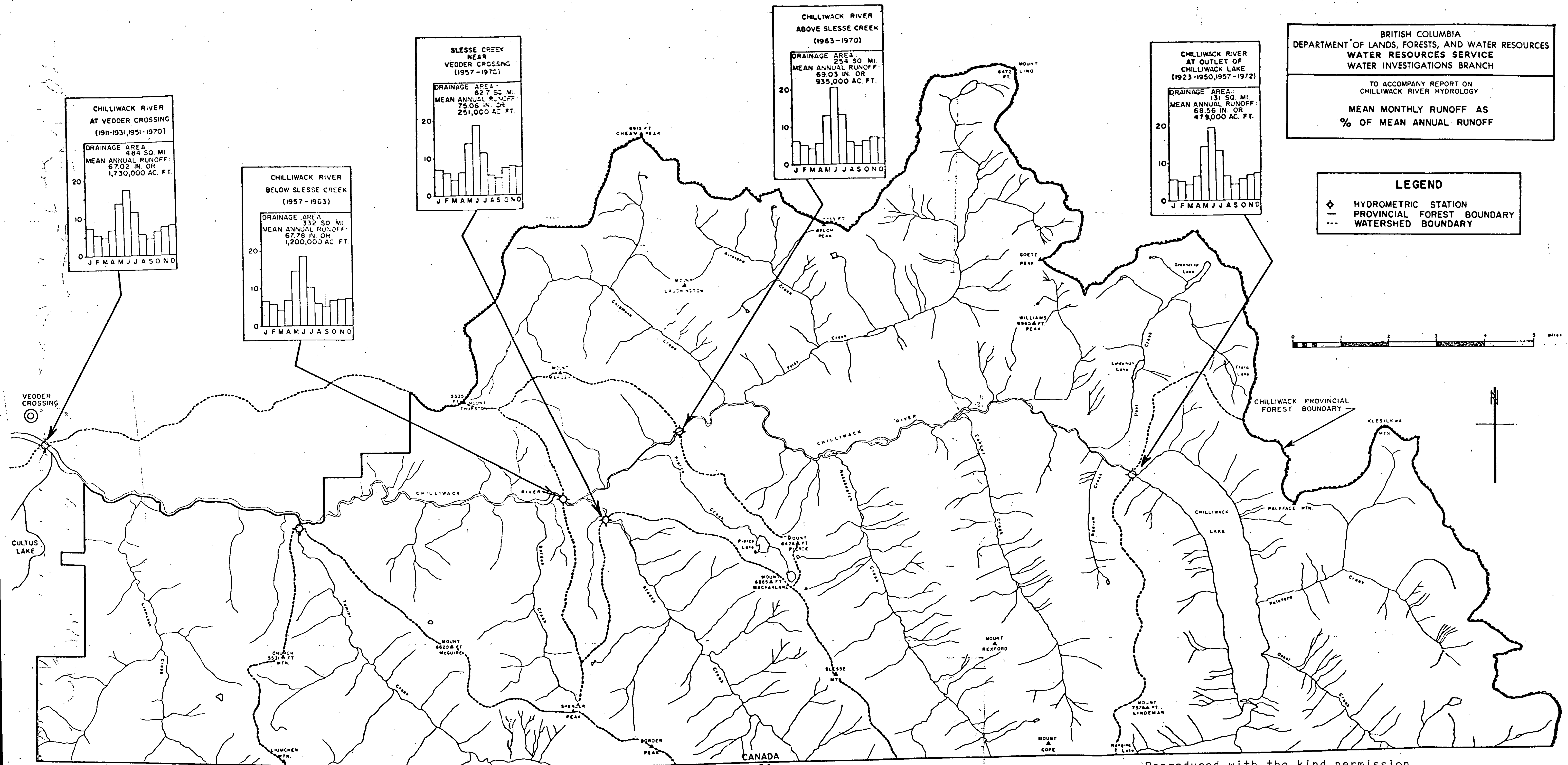
2.44 Returns to the Province.

Estimates of Provincial revenues are difficult to assess because of the great variability in stumpage prices over the past few years. For example, the B.C. Forest Service Annual Reports show that the average stumpage price for all species in the Vancouver District varied between $4.71 and $15.48 per cunit over the period 1970-73 inclusive. Based on the annual variation in the Chilliwack timber harvest, the average weighted stumpage price paid was found to be 7.70 per cunit over the period 1970-74. Provincial receipts would therefore total $593,670 per annum based on an average annual cut of 7.71 MM cf over the same period. Other payments to the Provincial Treasury were estimated by Reed and Assoc. (1973) as being approximately $1.36 for every $1.00 of Forest Service receipts. Such payments included fuel tax, social service tax, the Provincial share of income tax, logging tax and the forest land improvements tax. By multiplying the figure of $1.36 by the average weighted stumpage receipts calculated above, an estimate of $807,391 per annum was obtained. Total Government revenues were therefore in the region of $1,401,081 per annum.

2.5 Other resources.

2.51 Water Resource.

The watershed of the Chilliwack River, which includes the 274 square mile Chilliwack Provincial Forest, comprises an area of 484 square miles, 327 of which lie in Canada and 157 within the United States (Cheng, 1974). The elevation of the watershed ranges between 200 feet above sea level to 8,956 feet with more than 50 percent of the area lying above 4000 feet. Included within the boundaries are many extensive permanent snow fields and glaciers, especially at higher elevations. Slopes of the watershed are generally steep, with between 75 percent and 100 percent not uncommon. Cheng (1974) compiled summaries of annual, monthly and extreme run-off data from a variety of sources. Mean monthly run-off figures expressed as a percentage of mean annual runoff are illustrated in Figure 6. Cheng stated that precipitation falling in the form of snow or rain originated in particular from high elevation areas. Rainstorms alone seldom caused high runoffs from the watersheds, and if snow fields and winter snow accumulation from the previous year started to melt between April and June it was these that



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JULY 1974

caused the river to rise appreciably (See Figure 6). Cheng stated that extreme summer peaks depended on the magnitude of the snow pack and high temperatures between April and July, and that these factors combined with intermittent rainstorms and steep topography gave extreme runoff conditions.

2.52 Mineral Resource.

Wimsby (1974) stated that the Chilliwack Provincial Forest is an area of relatively low overall mineral potential. At present, there are no mines in the area, and activities have been limited to exploratory surveys. Wimsby considered that the ruggedness of the area would diminish the profitability of a mining operation, were a minable deposit discovered. He noted that there was the possibility that a deposit(s) may be found on which to base a small-scale gold operation.

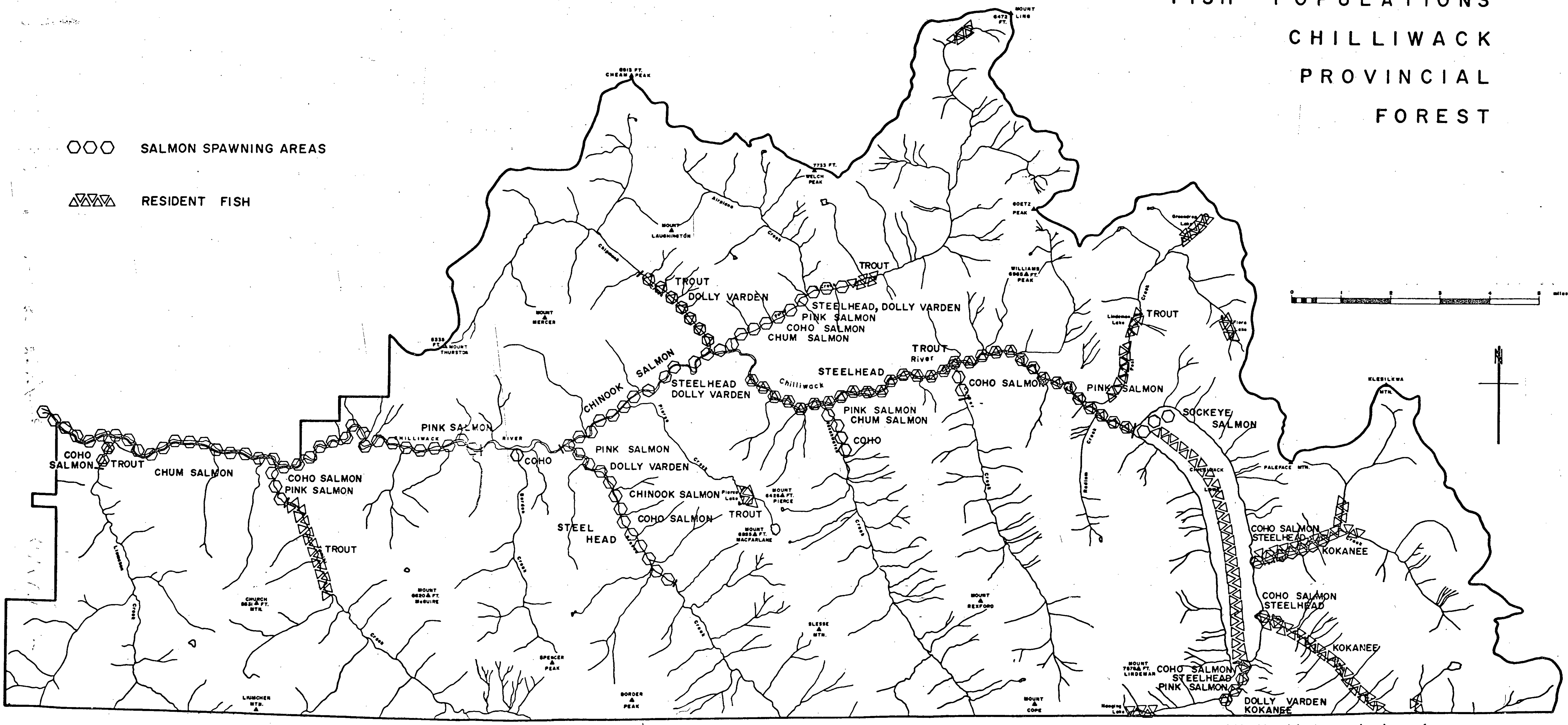
2.53 Fish Resource.

The Chilliwack river has been considered either the best, or one of the best, in the Province for steelhead and trout fishing. In addition, the basin contributes several major runs of commercial salmon to the Fraser River fishery. Swiatkiewiez (1974) stated that from a commercial point of view Chum (Oncorhynchus keta), Coho (Oncorhynchus kisutch) and Pink Salmon (Oncorhynchus gorbuscha) are the main sources of revenue. He estimated that approximate annual landed value, based on a 10 year average catchment as follows:

Chum	$500,000
Coho	$120,000
Pink	$250,000
Total	$870,000

The approximate distribution of fish populations in the Chilliwack Provincial Forest is shown in Figure 7. In general, the watershed upstream

FISH POPULATIONS CHILLIWACK PROVINCIAL FOREST



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JULY 1974

of Slesse Creek represents a prime spawning and rearing area, and is closed to angling with the exception of a two week special opening in July (Rissling *pers. comm.*). The significance of the Chilliwack River to the Lower Mainland recreational anglers is indicated by the intensity of use of the river over the years 1970-71 and 1972-73 (Swiatkiewicz, 1974):

	1970-71	1972-73
Estimated no. of anglers:	5,269	4,341
Angler days:	36,250	32,502
No. of steelhead caught:	4,269	3,157

Swiatkiewicz stated that these figures represented Provincial 'highs' and reflected the significance of the proximity of the river to the Vancouver population centre. The ability of the Chilliwack watershed to sustain high levels of fish production has frequently been attributed to the high quality of the local environment (despite extensive logging activity since 1910). The effects of logging activity on fish production in the Chilliwack have been documented by Vroom and Dunford (1974). These authors contend that historically, the side tributaries appeared capable of sustaining high levels of fish, and that recent logging activities in these areas have severely reduced adult spawning populations. Although the practice of clearcut logging throughout a given drainage may substantially increase the magnitude and frequency of peak water flows and size of silt loads, a number of other factors must be considered before hasty conclusions are drawn. Especially important is the natural variation in fish populations and the influence of climatic extremes. Like so many Coastal rainforest rivers, the Chilliwack River suffers from wide extremes in discharge as was shown in the previous section. Vroom and Dunford (1974) quoted an observed variation of between 280 and 27,000 cubic feet per second (c.f.s.) and compared this with optimum spawning and emergence rates of between 1,000 and 3,000 c.f.s. An example of such a 'natural disaster' occurred during heavy floods in 1948-49 which resulted in the loss of 10,000 to 15,000 yards (or 50%) of the Sweltzer Creek Chum grounds (Vroom and Dunford, 1974). In addition, the relative contribution of individual tributaries to the Chilliwack River fish production is unknown, and therefore the impact of logging activities in these areas cannot be realistically assessed.

Even though the Chilliwack River has provided a high level of recreation experience to the angling fraternity, there appears to be a constant demand by enthusiasts to further improve or enhance present fish stocks. In fact, there are proposed plans for a hatchery near the Slesse Creek confluence and for a steelhead propagation centre at Salverne Creek (outside the Provincial Forest boundaries), respectively Federal and Provincial Government undertakings. The basic benefit - cost ratio of the Federal Fisheries hatchery at Slesse Creek has been calculated to be in the order of 8.5 to 1 (assuming a 50 year life span) (Meyer, 1974) and might add an additional $2.5 million to the annual value of commercial fishery on the Chilliwack River (Swiatkiewcz, 1974).

2.54 Wildlife Resource.

The Chilliwack Forest area contains a great variety of seral stages and biogeocoenoses and these provide suitable habitat for most of the wildlife species known to occur in south-western British Columbia. Some of the more common mammals are: beaver, racoon, skunk, bobcat, black bear, blacktailed deer, mountain goat and cougar. Forbes (1974) stated that the most common big game species in the Chilliwack Valley is the Columbian Blacktail

Deer (Odocoileus hemionus columbianus) and, although no accurate data as to actual deer numbers exist, it is known that a fairly good population does occur. Furthermore:

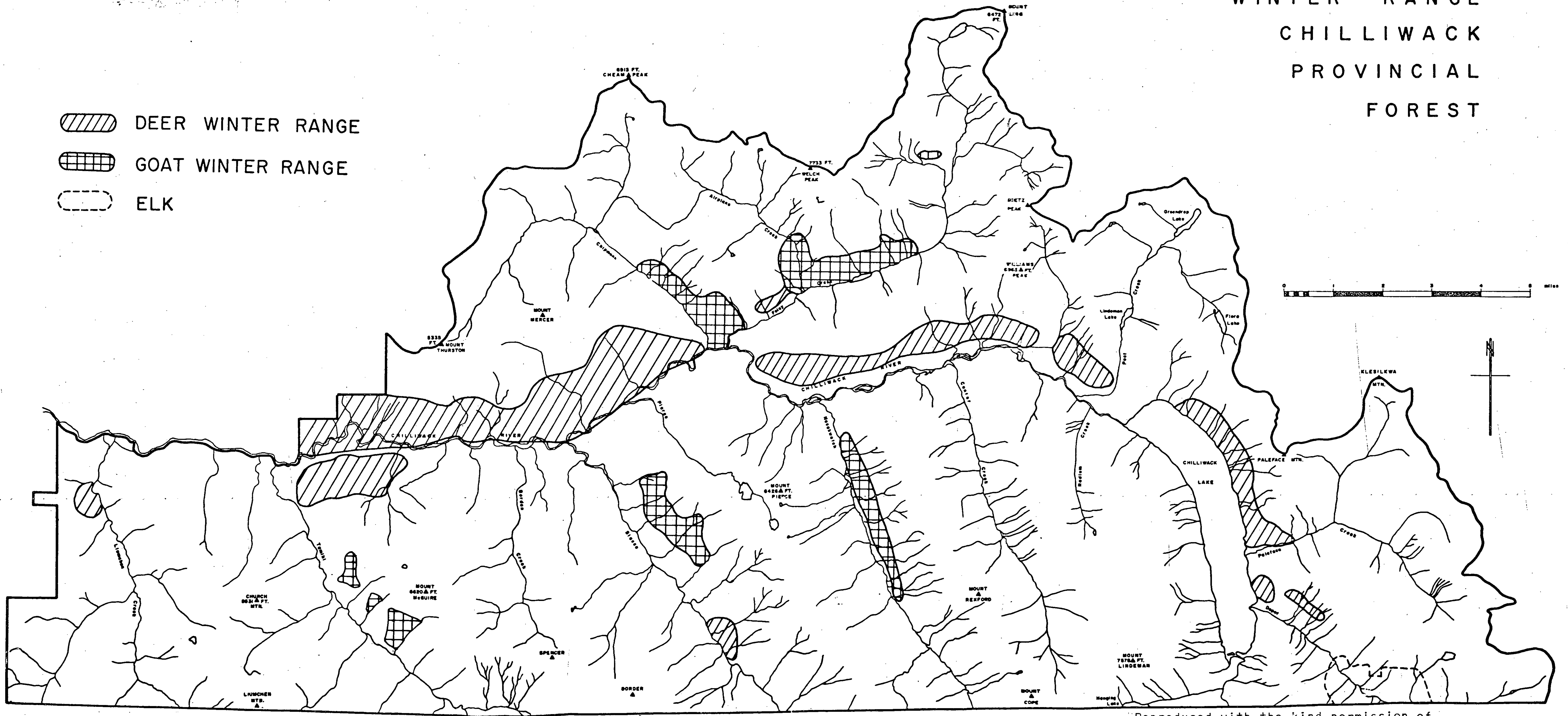
> "These animals are subject to the normal elevational migration patterns influenced by seasonal variations, and the total population size fluctuates appreciably with winter severity. It would appear that climatic factors in conjunction with the availability and condition of range are the most serious limiting factors to deer populations in the Chilliwack Valley." (Forbes, 1974).

The area is certainly very popular for hunting in the Fall months. Over 1300 hunters were recorded at intermittent game checks manned by Fish and Wildlife Branch personnel during the 1973 hunting season, but it is not known what component this reflects of the total contingent of hunters visiting the area. Forbes (1974) stated that deer hunting success was fairly low for this area in 1973 with 0.03 deer being taken for each hunter day of effort. Vroom and Dunford (1974) stated that over the period 1961 to 1972, 7818 hunters shot 332 deer. Over the past two years the B.C. Forest Service Vancouver District staff have been making considerable efforts to protect or enhance wildlife values in the Chilliwack Forest. In cooperation with the Fish and Wildlife Branch, a number of important winter range areas have been deliniated (Figure 8). For example in Depot Creek, considerable amounts of timber have been deleted from logging plans for this purpose (B.C.F.S., 1973b).

2.55 Recreation.

The Chilliwack valley and its predominantly forest environment provide a wide variety of recreation features and opportunities. Turner (1974) and Vickerson et al. (1973) provided good reviews of the recreational resources of the area. The visitor entering the Chilliwack valley on the only easy access road soon

WINTER RANGE CHILLIWACK PROVINCIAL FOREST



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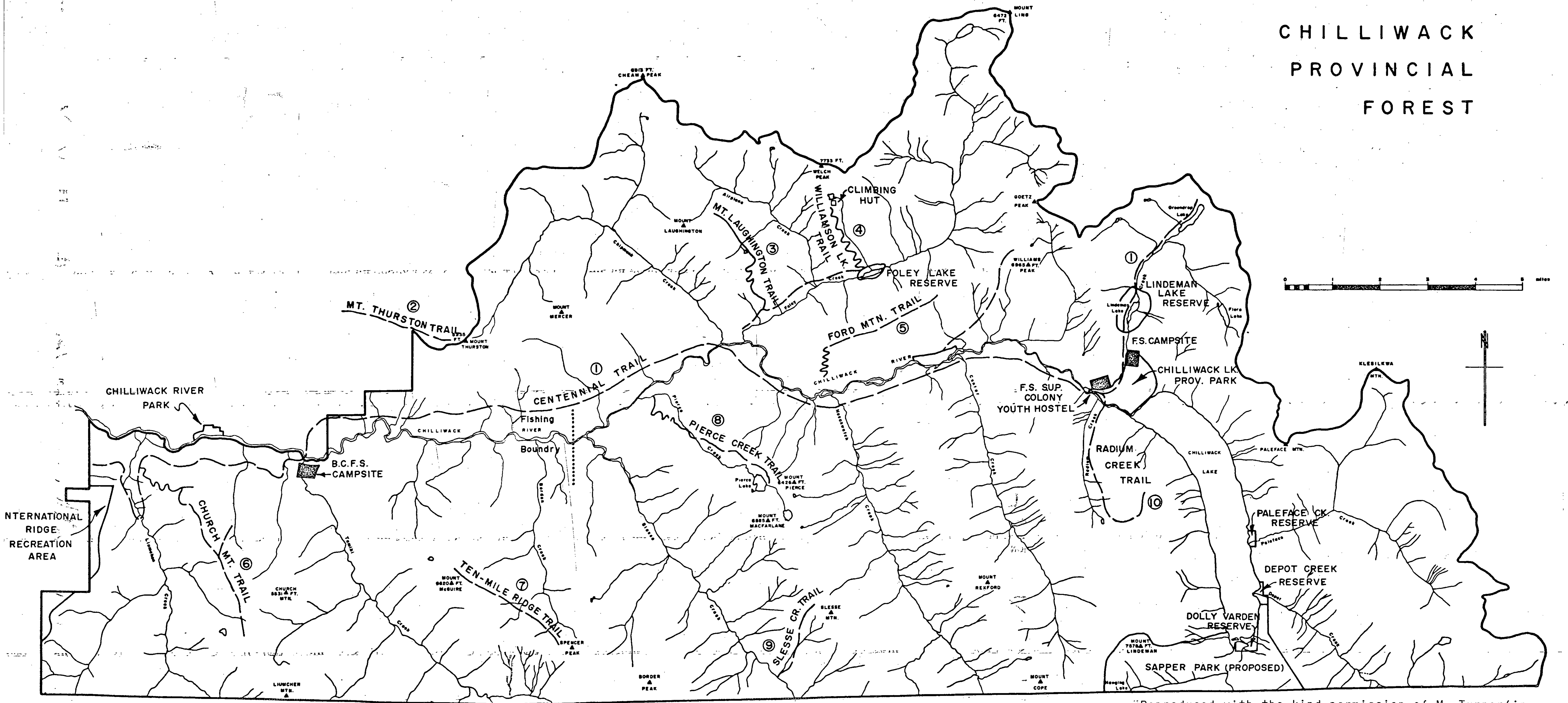
JUNE 1974

finds himself in a mountain-enclosed valley supporting luxuriant growth, spectacular scenery and a broad spectrum of features for public enjoyment. Besides hunting and fishing, other popular activities include camping and hiking. The Parks Branch and B.C. Forest Service provide separate facilities in the valley. The 400 acre Chilliwack Lake Park (Class A) at its north end is being expanded to 100 campsites, with boat launching facilities, picnic sites, nature trails and a group campground also planned. In conjunction with current policy in the Vancouver District, the Forest Service tends to provide more 'bare-bones' or minimum facilities. Three of their recognized campsites are located at Tamihi Creek, Post Creek and at Paleface Creek (Figure 9). In addition there are 24 rough camp clearings and picnic sites along main access roads (Drage _pers. comm._). Turner (1974) noted ten major hiking trails, including the famous Centennial Trail which traverses the full length of the forest as it winds its way from Simon Fraser University in Burnaby to Manning Park. Available data concerning the number of visitor days in the Chilliwack Forest are poor, although the Forest Service intends to use the 'visitor questionaire' approach in the near future to improve its information. Besides the few statistics pertaining to hunting and fishing already mentioned, the only other estimates are made by Forest Service maintenance crews (Muller _pers. comm._). Approximately 43,475 users days were recorded for the Chilliwack Forest between May 1st and October 31st, 1973 (Drage _pers. comm._). An additional 4 percent was suggested as a good estimate for the whole year, 1973-74: i.e. 45,214 user days.

RECREATIONAL OPPORTUNITIES
CHILLIWACK PROVINCIAL FOREST



"Reproduced with the kind permission of M. Turner (in corporation with the Parks ... Branch)" JULY 1974

3.0 ENVIRONMENTAL PROTECTION CONSTRAINTS AND REGULATIONS.

3.1 Philosophy behind government regulation in the forest industry in B.C.

The Province of British Columbia is richly endowed with a great variety of resources, the major resource of course being its forests. Out of a total Provincial area of 234 million acres, approximately 134 million acres or 57% are classified as productive forest land with most of the balance being in barren land, non-productive forest land or water. The allocation of constitutional powers in Canada provides the Provinces with jurisdiction over land and other resources, and therefore Government policy determines the landlord decisions that are left to private parties elsewhere. The influence of public policies on the development of the forestry sector was effectively discussed by Haley (1971), who stated that:

> "...public forest policies are regarded as important elements for directing the economy towards socially desirable objectives. Nowhere is this more apparent than in the Province of British Columbia where economists can recognize that resource pricing, industrial structure, industrial investment policies, regional economic development and even the product mix are all influenced by public forest resource allocation."

In contrast to the situation in the United States, the decision to maintain forests in public ownership was made at an early stage in the Province's history, and no substantial alienations of forest land to the private sector have taken place this century. The idea of maintaining forest land in public ownership stemmed from the Land Ordinance of 1865. This introduced the principle of granting rights to harvest timber on Crown lands without alienation of the land and resources themselves. Alienation of lands and timber by sale, pre-emption and homesteading continued, however, for several decades

(Pearse et al. 1974). Stricter measures were later introduced by the Government of 1905, action subsequently described in the Fulton Report of 1910. Timber licence holders were anxious to renew their agreements with the Provincial Government in view of the apparent rapid decline in supplies from the United States and Eastern Canada. Because of the lack of revenues generated under this system in the past, the Government decided to issue long term (21 year) transferable licenses to cut timber and stipulated that annual payments for the timber would be fixed by them on a year by year basis. Consequently, the public was guaranteed a reserved share in the incremental value of the standing timber as it should accrue, and money would become available to open up the Province and re-invigorate the stagnating industries.

Current forest policy was essentially derived from the Sloan Report of 1945 which recommended a system of perpetual sustained yield management for all Crown forest lands. The principal objective was to bring these areas under a system of planned forest management following sustained yield principles, and so provide operators with long-term supplies of wood. It was felt that this would encourage them to undertake the heavy investments associated with capital intensive utilization plants.

The necessity of Government ownership of the forest resource, and regulation by sustained yield principles has been a point of contention for a considerable period of time. Dowdle (1975) stated that:

> "Sustained yield is appropriate for a society in which timber is a common property resource. This was the case in the feudal system where the concept originated. Sustained yield allowable cuts, which are effectively a bag limit on trees, are not appropriate for the management of resources in which exclusive and transferable rights

exist."

He added that the reason why the model is not appropriate in the U.S. today is that publicly owned timber in the U.S. is not common property, but is owned and exchanged in the market. Dowdle's argument may also be applied to B.C. Sirkin (1968) added another interesting perspective:

> "The popular notion that regulations are needed to conserve resources for some future date is incorrect. The threat of increasing scarcity of a resource in the future is reflected in a rise in the current price. The price thus regulates the rate of consumption and distributes its use as optimally through time as human knowledge permits. Unless the cost of the resource is external to the user, the price system regulates its use at least as well as a conservation commission can."

The last qualifying phrase is especially important in the context of forestry in British Columbia, and is largely the basis for the current distrust of private ownership and management. Costs become external to the user when some costs or gains occur outside of a perfectly functioning market; in other words, market prices may not correctly measure the true costs or gains to society. Consequently there is a divergence between private and social costs and benefits. This well-known defect of the market system can be overcome by supplementing the market with direct government intervention. Mead and McKillop (1974) stated:

> "Where externalities are present and are significant, they may be compensated for by one of four policies: a) Where net external benefits are present, subsidies may be granted equal to the net external benefit. b) Where net external costs are present, a tax may be levied equal to this net externality. c) An activity producing a net external cost may be restricted by government regulation. d) Government enterprise may be substituted for private enterprise."

In summary, it appears that there are two major reasons for government intervention in the forest industry in B.C. Firstly, there is the feeling that it takes a long time to grow a tree, and because private enterprise is solely concerned with maximizing short run profits they cannot be entrusted with providing future timber supplies. Secondly, it appears that the externalities involved in harvesting the timber crop are so significant that not only Government intervention is required, but also Government ownership.

3.2 The framework within which guidelines operate.

Guidelines are essentially a set of flexible means which, if correctly applied, lead to the attainment of certain specified objectives. Stated another way, guidelines represent practical interpretations of results when the appropriate criteria are applied to specified management alternatives. The efficiency and practicability of guidelines depend on how clearly the objectives, criteria and constraints are stated. If criteria are improperly derived, then only by chance will the enterprise achieve its stated objective(s) (Johnston et al., 1967).

The private entrepreneur uses price signals derived in the market place as his 'guideline' to achieve an objective of profit maximization. Investment decisions are based on estimated rates of return from various management alternatives derived from estimates of future costs and revenues. Investments should therefore flow into their highest yielding alternatives, and if externalities are not significant, both short-term profit and long run social welfare will be maximized.

Guidelines necessary to manage a publicly owned resource, such as forests in B.C., are not so easily conceived. Not only problems of resource allocation, but also questions of income distribution (equity) must be solved. However, as soon as more than one objective is specified, problems arise as to which one is primary and which one is secondary and also the appropriate criteria to use. Lewis (1974) outlined the problem rather well:

> "Public policy is basically a political matter in which various interests and objectives must be subjectively balanced against each other in a constantly changing economic and social environment. But the responsible politicians who mould and direct government policy seldom provide us with comprehensive and clear statements of what policy is at any given time. Thus we are often forced to infer the objectives of policy from government actions, fragmentary political statements, legislation, and regulations and procedures that govern public administrations."

The policy of the B.C. Government is no different in this respect. Although the objective of public forest management in this Province is to practice maximum sustained yield, a number of modifications have been added in recent years. The concept of 'balanced use' was briefly outlined (B.C.F.S., 1973c), and illustrates the fact that although much wealth for development can still be taken from the forest, management for recreation, water and other benefits should be given equal consideration Smith (1970) noted that:

> "...there is also recognition from a wide variety of concerned citizens of the need for a greatly improved quality of environment and a growing willingness to forgo some material wealth to achieve it."

The terms of reference for the Task Force on Crown Timber Disposal (Pearse et al., 1974) shed even more light on current timber resource management goals. Mead and McKillop (1974) summarized these as follows:

> "Management of timber resource should protect the public interest in such a way that (a) multiple uses will be served, (b) payments made for Crown timber capture the full value of the resource, (c) the health and vigor of the forest industry is maintained, and (d) good forest management practices are advanced."

Points (a) and (b) are of particular concern in this thesis. Although there are clear statements of objectives, the criteria for selecting between management alternatives are lacking. Biologically based criteria, such as harvesting a crop of trees at the age of maximum mean annual increment are of little use when making decisions in a multiple resource context. However, given the problems of inadequate inventories of resources, inadequate knowledge of the monetary and other social values of these resources, and inadequate knowledge of the impacts of management of one resource on the values of other resources, it becomes very difficult to specify definite, all-embracing criteria for decision making (Kimmins, 1974b). It is therefore not surprising that guidelines for forest management in B.C. have necessarily been vague, and relied heavily on the subjective element. Despite this obvious dilemma, it is essential that decision making is constantly reviewed and updated in the light of changing circumstances and additional information and research. Tysdal (1973) pointed out:

> "In order to make rational decisions concerning the balance of uses, it will be essential to develop quantitative information concerning supplementary and complimentary relationships, plus competitive relationships and their rates of substitution. This information which is derived from the natural sciences and the field of economics, when combined with political and cultural factors, will enable us to make wiser decisions in multiple resource management."

3.3. Background of logging guidelines in the Vancouver Forest District.

The first official logging guidelines to be issued in the Vancouver Forest District related to fire control planning. The intention behind Circular VR65-10 (B.C.F.S., 1965a) was to improve the coordination of protection planning on Vancouver Island, involving Crown lands, private holdings and Tree Farm Licenses.

The objective was to establish a grid network of long-term firebreaks to cover the area from Kelsey Bay south to Victoria by cooperation between private owners and the Government. Prior to that date, no policy had been established as to what did or did not constitute a satisfactory firebreak, or what was considered the most suitable terrain from a location standpoint. This Circular, together with notes on 'Fire Break Guidelines' (B.C.F.S., 1965b), were subsequently issued to all Forest Rangers and quota holders for future Timber Sale Harvesting License (T.S.H.L.) firebreak planning. Primary firebreaks were defined as timbered strips 40 chains in width with closed canopy and having fire retardant qualities, and were divided into two categories - either cross-valley firebreaks or ridge-top firebreaks. A distinction was made between firebreaks and natural fuelbreaks, the latter constituting high elevation alpine areas, lakes, swamps, slides and so on. In terms of firebreak duration it was intended that primary firebreaks were to remain intact until the adjacent hazard had been satisfactorily abated and the natural regeneration or plantation had reached the stage of closed canopy, ie. condition of second-growth firebreaks. Secondary firebreaks on the other hand were only of short-term duration, and useful in areas of active development as a protection measure and safeguard during the disposal of logging slash by burning. As the hazard was abated on both sides, so they could be removed. In other words, they were the last areas to be logged in a development area.

These guidelines appeared to be quite reasonable from the forest protection standpoint, but there was a total lack of consideration for the protection of other forest resources. In view of the growing concern for environmental protection, Mr. I.T. Cameron, then Chief Forester of the B.C. Forest Service, set out in a five page document the 'Planning Guidelines for Coast Logging Operations' (hereinafter called '1972 Coast Logging Guidelines'). A copy of these guidelines is located in Appendix I. They included suggested utilization standards, fire control constraints and guidelines for the "...maintenance of a managed environment suitable for the preservation, protection, and regulation of other users of the forest habitat." The contents of these guidelines will be briefly outlined in the next section, but in general they were designed to accomodate conditions encountered at low elevations in Coastal B.C. However, a seemingly large proportion of all logging operations were being undertaken in high elevation areas where different problems were being encountered. Early in 1972, as a result of increasing concern over achieving satisfactory regeneration on high elevation logged-over lands on the Coast, the Forest Service employed Mr. Franz Reuter to investigate the problem in the Vancouver Forest District. The management practice had been to clearcut and then plant the preferred species (Douglas-fir) - a system that had proven successful at lower elevations. Reuter (1973) undertook a problem analysis, concentrating on Douglas-fir plantations at elevations above 2000 feet. Based on an average survival of planted trees at the time of final survival survey (with failure arbitrarily defined as any plantation with an average survival of 50 per cent or less), it was established that the failure rate of high elevation Douglas-fir plantations ranged from 33 per cent between 2000 and 2500 feet to 90 per cent at elevations above 3500 feet. Foresters in Government and industry identified the factors contributing to seedling mortality in order of decreasing importance as:

1. Environmental limitations.
2. Planting stock condition.
3. Deficiencies in planting operations.

In response to the problems outlined in Reuter's report, the Forest Service drafted a five page set of 'Interim Guides - Logging on Severe Sites - Vancouver Forest District' (B.C.F.S., 1973). A copy of these guidelines is located in Appendix I. The primary objective of these guidelines hereinafter called 'Severe Site Guidelines' was:

> "To sustain productivity levels of severe forest sites by adjusting present management practices and allowing greater flexibility of silvicultural choice. Natural seeding and the utilization of good quality advance regeneration to restock logged areas is to be encouraged..."

It was emphasized that these guidelines represented an interim measure only:

> "It is apparent that information to fully substantiate guidelines for logging extreme sites does not exist. Research must fill information gaps and provide knowledge for guideline modification, on a rational basis."

A considerable amount of research is currently being undertaken in order to improve the data basis for decision making in high elevation forests in Coastal B.C. A summary of the interim results of research projects currently being undertaken by the B.C. Forest Service and the Canadian Forestry Service in the Vancouver Forest District have recently been published (B.C.F.S./C.F.S., 1975). A report emphasizing problems of soil stability and stand regeneration in high elevations in B.C. was also completed by Utzig and Herring (1974).

3.4 Review of the main aspects of the 1972 Coast Logging Guidelines.

The general objective of these guidelines is to maintain a suitable environment for the preservation, protection and regulation of other users of the forest habitat, commensurate with maintaining good timber utilization standards and minimizing fire hazard.

This is to be achieved as follows:

1. Forest land within a watershed will be harvested under a multiple-use concept. Timber will be harvested on an alternate '50 per cent' cut programme for watershed protection, held pending hazard abatement and development of new forest growth on cutover areas. Additional areas will be deferred depending on wildlife species requirements, fisheries values, forest protection, recreational values and presence of unique features.
2. Utilization of all resources and compatible integrated use of all resources will dictate the size, shape and orientation of individual proposed clearcut openings. Openings will be kept as small as possible and should not exceed 200 acres in size.
3. Cutting within approved openings adjacent to streams or lakes will be carefully regulated to prevent undesirable environmental impacts. Setting boundaries and yarding plans will coincide with watercourses so there is no yarding damage. In certain circumstances filter strips will be left until the last logging sequence within the opening. Harvesting of this timber may entail special measures in falling, bucking and yarding to prevent damage to advance regeneration and

undergrowth. In addition, allowances for tree growth on unstable erodible cutbanks and leaning trees must be deliberately incorporated into logging plans.

4. All roads (main, secondary, spur and skid trails) must be planned, located, designed, constructed, used and maintained in such a manner that their impact on the total managed unit will be an acceptable minimum. Roads should be located away from difficult terrain, and should have design specifications that are best adapted to given slopes, topography and soil materials. Culverts should be large enough to cope with a 25-year frequency storm, and roads should be constructed in dry weather conditions.
5. Operating plans and proposals are subject to approval prior to implementation, and the Forest Service will consult with other resource managers to ensure that all interests have been served.
6. The guidelines must not be construed as being absolute. Particular forest units, special circumstances, or needed objectives and policies will also dictate the resultant planning and treatment required for development and cutting plans.

3.5 Review of the main aspects of the Severe Site Guidelines.

The general objective of these interim guidelines is to sustain productivity levels of severe forest sites by adjusting present management practices and allowing greater flexibility of silvicultural choice, especially the use of good quality advance regeneration and natural seeding. For most practical purposes, the guidelines refer to land over 2,500 feet, but full recognition of the individuality of severe site habitats is specified. This objective is to be achieved as follows:

1. The proposed logging area must be thoroughly examined and a regeneration plan prepared before logging commences. Clearcutting must be confined to those forest habitats with relatively deep soil phases, reasonably well-drained soils with stable geomorphic characteristics.

2. The effective seed dispersal distance of adjacent stands must be considered when designing opening size. If the clearcut is a square, it should not exceed 40 acres in size. If the clearcut is larger than 40 acres, the width should not exceed 20 chains, (the '40-20 rule'). The shape and size will also vary according to aspect, slope, location and density of advance regeneration, protection requirements, wind resistance, economics and environmental factors affecting germination and survival.

3. In order to further enhance site protection, slash burning should be drastically reduced and no tractor and skidder logging will take place on slopes exceeding 30 per cent.

4. Stands whose major tree elements have site indices less than 65 (base 100) or soil mantles of less than one foot over bedrock should not be logged. Such forests (mainly in the Mountain Hemlock Zone), even if marginally economic at the time, may be excluded from logging and held over as environmental or protection forest.

5. Cutting must comply with other published guidelines for Coast logging operations.

3.6 Response from Government agencies, private industry and University to the logging guidelines.

The intention of this section is to analyse a broad body of response to the guidelines, with a view to determining their primary limitations and in particular, to get an idea of the main sources of financial impact resulting from their implementation. In general, there have been very few published critiques, and so the author has had to rely on comments made in newspaper articles and from personal communication in order to form a broad body of opinion. Problem areas have been itemized for each set of guidelines for purposes of clarity:

1972 Coast Logging Guidelines

1. Objectives

In general there has been no question of forest managers' acceptance of the objectives of the guidelines towards balanced use of forest lands for greatest overall benefits. In fact: "A large segment of industry has already taken significant steps to plan and conduct forest operations to minimize deleterious effects on the environment." (C.O.F.I., 1973a)

2. Difficulties with present guidelines

A. HARVESTING PROBLEMS.

In their present form and as they are currently being interpreted and applied by the B.C. Forest Service field staff, the guidelines appear to be posing many critical and immediate problems:

Deferment - This appears to be the most crucial factor from the timber harvesting viewpoint. The guidelines are not specific as to the time period during which the cutting of adjacent timber (on an alternate cut and leave programme) must be deferred:

> "...where interpretations can be obtained from your (B.C. Forest Service) field officers, overly long greening-up periods are being specified (i.e. ten or more years). Also, the 50 per cent rule and the 200 acre maximum are being applied rigidly even in areas where they are obviously not justified by the other values to be protected. There are many cases where this view has been supported by fish and wildlife biologists." (C.O.F.I., 1973a)

The basic deferment policy appears to have several serious impacts:

a) Road construction requirements are often being increased to completely impracticable levels. "Costs of building roads have risen from $32,000 per mile in 1971 to an estimated $51,000 per mile next year" (McMurray, 1974a). Not only have the costs been substantially increased, but the sheer logistics of the problem are also giving cause for concern:

> "In order to sustain production, a high level of construction will be necessitated in all seasons because the additional capital, skilled labour, engineering staff and equipment required are simply not available to accomplish this construction in a shorter period." (C.O.F.I., 1973)

b) The dispersal of logging based on a 50 per cent alternate cut policy is also a major problem in its own right. Write-off costs in road amortization calculations have had to be substantially increased as can be deduced from the following statement by D.W. Timmis (President and Chief Executive Officer of MacMillan Bloedel Ltd.):

> "Availability of timber from MB developed roads has dropped from 74 per cent in 1971 to an expected 42 per cent in 1975 and 35 per cent in 1977..." (McMurray, 1974a)

The guidelines not only attempt to solve old problems, but in many cases they appear to create new ones, as evidenced by G. Ainscough (Chief Forester of MacMillan Bloedel Ltd.):

> "Intended to disperse logging and reduce the impact on fish, wildlife and aesthetics, they force the industry to build vastly-increased mileages of roads with attendant increase in sedimentation and greater impact on the whole watershed..." (Taylor, 1975a)

c) Substantial increases in windthrow and slashburning damage have also been observed:

> "Timmis described the rules and regulations as ludicrous. Because more openings were being made in the forests, for instance, the area that was vulnerable to windthrow has been increased. Damage from windthrow has increased very considerably." (Lyon, 1974)

Although susceptibility to blowdown is very variable in Coastal B.C., significant increases have been attributed to the effects of the guidelines in local areas. Parker (1975) said, "...in one area on the West coast, blowdown accounted for approximately 3% total production. Now, with the guidelines, blowdown has ballooned to 10%."

Increased blowdown results in additional fibre loss, more chance of personal injury, increased salvage costs as well as rendering adjacent immature stands more susceptible to insect attack.

d) A 50 percent cut and leave program means that operators have to develop twice as much forest area in order to harvest a given timber volume. Difficulties have already been encountered in trying to find future supplies of timber, and in particular 'winter shows' (Lyon, 1974). The latter are essential to ensure continuity of employment and full utilization of equipment.

Planning - A very important impact of guidelines has been apparent in the field of development planning. As a result of these guidelines, twice as much area is being developed and more resource values are being considered in these areas. Consequently the onus is upon Government agencies to speed up the review procedures for cutting permit applications in order to ensure continuity of wood supplies. This does not appear to have been the case. McMurray (1974b) quoted Mckenzie who said the Truck Loggers Association (T.L.A.) had complained about the lack of coordination between Government departments in dealing with applications for timber cutting permits, particularly with the Fish and Wildlife Branch. Fisher, when interviewed by McMurray (1975a) had much the same to say:

> "...qualified foresters charged with administering them (the guidelines) have been placed in a position where every decision can be challenged, or even vetoed by other departments who have no interest or knowledge of forestry or economics."

Taylor (1975b), commenting about the T.L.A. Convention in Vancouver stated:

> "The loggers have been complaining of coast cutting guidelines, stumpage assessments; left-hand, right-hand situations in which government departments come into conflict

> and issue conflicting orders; political interference; undue environmental influence; delay and lack of official action; and a myriad of other things that have put them in a financial straitjacket."

A useful suggestion for improving the situation was offered by Young, in an interview with McMurray (1975a). As a personal view, he suggested that B.C. set up a department of natural resources handling all resources in a given area. Furthermore, departments should be structured vertically instead of horizontally as at present, to expedite handling and improve efficiency.

Costs - There have been numerous comments made by private industry as to the cost increases brought about by the guidelines. It appears that these grievances are primarily centred around incorrect appraisal calculations rather than questioning the basis for the increased costs. McMurray (1974a) quoted Timmis as follows:

> "We are not asking for handouts or subsidies or anything like that. All we are asking for in the calculation of stumpage is proper allowance for costs based on actual figures not historic estimates, plus some relief from the guidelines and close utilization rules."

In a later editorial, McMurray (1974b) stated:

> "In its presentation on forest guidelines, the T.L.A. showed Barrett and Williams comparative figures for a Fraser Valley logging operation. Under the new rules the T.L.A. said, the logger would have a loss of $11.50 per 100 cubic feet of timber cut as apposed to an operating profit of $7 under the old rules. The T.L.A. argued that the $18.50 "swing" between the two examples was not unique and said that the situation could apply in varying degrees in all logging operations."

In a brief to Mr. I.T. Cameron, the Council of Forest Industries (C.O.F.I., 1973a) gave a summary of their estimate of the cost per cunit increase for a 'typical Coast logging operation'. This calculation showed an increase from $32.72 per cunit to $38.42 per cunit. In their supporting discussion, the Council expressed concern that industry may have to bear some of this cost increase on Crown lands, and that no mechanism existed to defray these costs on private tenures.

B. FAILURE TO MEET OBJECTIVES.

The Council of Forest Industries (C.O.F.I., 1973a) considered that the guidelines were developed without adequate consultation with the industry or, apparently, with other resource departments:

> "There have been serious reservations expressed by knowledgeable people as to the efficiency of the Guidelines to meet the objective to preserve these other values. These Guidelines ignore many of the workable procedures which have been established in cooperation with other resource agencies."

Probably the most important way in which the guidelines have departed from their original objectives is in their apparent inflexibility. Timmis stated in an interview with Lyon (1974):

> "...guidelines are supposed to be lines by which you are guided. The Forest Service, however, is imposing them as inflexible rules..."

The basis of the problem lies essentially in the chronic understaffing and lack of finances for the Forest Service and other resource agencies, although this situation is improving. Because of their lack of definitive information on values other than those of the timber resource, it appears that the Forest Service has taken the attitude of accepting the demands of other resource agencies and special interest groups without regard to trade-offs. The situation is not improved when representatives from various other agencies are not aware of their overall role in multiple resource decision making. Ainscough provided the following example of potential conflicts in goals:

> "I am told by wildlife biologists that their objective is

> the maintenance of a maximum deer population - this is simply not compatible with intensive forest management." (Taylor, 1975a)

Severe Site Guidelines.

Devitt (1974) prepared a summary of comments made by a Task Force, appointed by the Reforestation Board of the Tree Farm Forestry Committee to examine the contents of the Severe Site Guidelines. Critiques were received by the Task Force from foresters in Government agencies, private industry and university, however, the author is not at liberty to quote individuals' submissions (Devitt, pers. comm.). The following is a brief review of the findings of the Task Force:

In general, foresters were agreed upon the intent of the guidelines, in particular the necessity for regeneration planning prior to harvesting. However, it was felt that the guidelines were formulated in the narrow silvicultural or ecological sense rather than from an in-depth understanding of the problem. Clear statements of objectives, criteria and standards were found to be lacking, as well as a realistic appreciation of the financial implications and practical limitations of the guidelines. Concern was expressed that these guidelines would be treated as rules and regulations at a non-professional level, and the need for flexible and dynamic local interpretation was stressed. Factors such as elevation, site index or the presence of mountain hemlock and thin soils were not considered reliable indicators of severe sites. The question was raised as to whether or not it would be expedient to practice more intensive forest management on good sites at low elevations, than to engage in expensive harvesting and silvicultural practices at high elevations. Foresters in companies holding private tenures felt that the current insecurity of tenure made private initiative for improved forest management very difficult. They wondered if land assessment or other Crown revenue producing procedures would allow for the additional costs of environmental protection. In general, foresters felt that workable guidelines could not be based solely on the 'Reuter report' which had such a limited scope, and that more supporting studies and site specific information were needed.

The Association of B.C. Professional Foresters also expressed their views on several important points developed in the guidelines to the Chief Forester (Anderson, 1974). In reply, Young (1974) stated that the guides were intended to apply to a range of sites regardless of elevation, and that imposition of the '40-20 rule' depended largely on the regeneration plan submitted. He noted that the Forest Service had subsequently reworded the section restricting logging on soils with 'one foot mantles', to permit some flexibility of choice not previously available. Young added that the guidelines would undergo further discussion and possible adjustment at their upcoming management meeting. The results of this meeting have not yet been made available.

3.7 Discussion of the main financial impacts of the logging guidelines.

In the light of the previous statements, it would appear that there are substantial cost increases associated with both sets of guidelines. For the purposes of this discussion, the major sources of cost increase will be examined, but the question as to how these costs are likely to be distributed will be outlined later on in the thesis.

The most significant source of cost increase was considered to be the increased interest costs resulting from higher unamortized investments being carried over the longer period of time needed to develop the total volume of timber in a given area. For example, the unamortized investment at the end of the first 'pass' would be charged interest until some of the accumulated deficit could be written off in the second or subsequent passes. Substantial cost increases would also be apparent in road maintenance. Fire access roads would have to be maintained each year until the total volume of timber in an area had been removed. The 50 per cent 'cut and leave' policy also implies that developable areas of mature timber will be cut over twice as fast, because only half of the volume in a given area can be removed. This would appear to have several financial implications:

1. Moving-in costs and the cost of site improvements would increase for two main reasons. Firstly because of the lower volumes available with which to write off these costs, and secondly because operations would become more remote a lot faster, necessitating more complete camp and shop facilities.

2. Assuming that prior to the guidelines the best quality and most accessible stands were developed first, the effect would now be that the poorer quality, more inaccessible stands become available faster. This implies not only increased harvesting and road construction costs, but also lower quality timber and higher transportation costs than otherwise would have been the case.

3. This basic policy may also be in conflict with one of the objectives of sustained yield. For example, shortages may develop in local areas where the leave period in between passes is too long to maintain continuity of supply. In fact, major operators and the

often closely associated dead and down salvage operators may find it worth their while to transfer their processing activities elsewhere to cut down transportation costs. Consequently, community instability may result in those settlements heavily dependent on the benefits of the local timber industry.

4. A speedier cut-over of developable areas will require a great deal more effort on behalf of other resource agencies in gathering the necessay information for multiple resource planning and decision making. If review procedures for cutting permit applications are not made more efficient, operators will be faced with the prospect of layoffs and idle machinery.

The other major category of cost increases can be attributed to the special stream protection measures; improved harvesting standards; road, bridge and culvert construction standards; and to modified silvicultural systems required under the Severe Site Guidelines. Without detailed analyses, it is not possible to estimate the magnitude of these additional costs. However, it is felt that they would not be so substantial as those discussed under the first category. It is not clear whether or not the creation of Environmental Protection Forests would necessarily be a cost. In many cases it would appear that these forests are sub-marginal in economic terms, but have been harvested under the instructions of the Forest Service for purposes of 'good timber utilization'. If these areas were deleted and allowable cuts not reduced, it would appear that net social benefits may be increased. In view of the fact that price increases and technological innovation may render these stands economically viable in the future (with environmental protection costs taken into account), it does not appear justifiable to reduce annual allowable cuts at the present moment. Instead, this action may be considered as a mere redistribution of cut based on current notions of economic accessibility and environmental protection.

4.0 EVALUATION OF THE COSTS AND BENEFITS OF LOGGING GUIDELINES.

4.1 Introduction.

The central assumption implicit in any evaluation of public policy alternatives is that the overall objective is to allocate resources into those activities which maximize net social benefits. Objective decision making in the field of multiple natural resources becomes very difficult by virtue of the fact that there are so many intangible aspects to the problem. Consequently, instead of using any single criterion for evaluating the best course of action, attention must necessarily be given to the use of several 'indicators'. These may include economic efficiency effects, and income distribution effects as well as environmental and social effects. Information gathered under each of these four categories is intended to delineate the best that can be made available to the policy maker, which he, in turn, can apply to a value framework which he perceives as representative of the views of the public.

When evaluating the economic efficiency effects of logging guidelines, it must be remembered that these function within the basic policy framework of sustained yield which is not based on economics. Consequently, certain management alternatives which may be deemed 'efficient' in an analysis of logging guidelines may turn out to be 'inefficient' when viewed in an overall economic perspective. Annual allowable cut constraints and the felling decisions which are based on biological criteria may be cases in point. These basic constraints will be accepted, however, in the following quantitative analyses, although reference may be made to their inadequacy in subsequent discussions.

The following description of evaluation procedures is intended to be as concise as possible. It should be remembered that this topic has an immense scope and a major thesis could be written on almost every aspect of tangible and intangible, direct and indirect, costs and benefits. A supporting literature review has been omitted, although important references have been cited where necessary.

4.2 Evaluation of quantifiable costs and benefits.

4.21 Review of Available Data.

Data on the resources of the Chilliwack and especially non-timber resources were found to be very scanty and frequently not up-to-date (Benskin, 1974a). Because results of the 1974-75 inventory for the Dewdney P.S.Y.U. had not yet been published, the author had to rely on data from the 1962-63 Inventory Report (B.C.F.S., 1968). However, up-to-date topographic and forest cover maps with cruise data were available for local areas that had been recently harvested or were destined for cutting in the near future. The Westwater Research Centre studies, mentioned in the Introduction, were reviewed to see if they would be of some value in this quantitative analysis (Benskin, 1974a). Although they contained useful background information on the resources of the Chilliwack, the few quantitative data cited were considered to be of little use. The B.C. Forest Service Vancouver District made available its Dewdney P.S.Y.U. Working Plan which was found to consist of a booklet enclosing 2 mile to the inch base maps with overlays depicting forestry projects and proposals, alienations, areas of particular importance for wildlife and recreation, and forest management tenures. No quantitative information was available. The most comprehensive review of basic resources in the Chilliwack was found to be the recently completed Phase I of the 'Integrated Resource Management Plan for the Chilliwack Provincial Forest' (B.C.F.S., 1974). Altogether, 16 agencies were involved in compiling information for this plan, and a number of their contributing studies have already been cited in this thesis. Although a few more statistics concerning other resources were outlined in the plan, it became increasingly evident that a quantitative evaluation of those resources was impossible on the basis of the available data. The conclusion was drawn that any meaningful analysis of the guidelines would necessarily have to be based on a quantitative assessment of forestry costs and benefits with a supporting discussion of other resource values.

4.22 Methodology for Evaluating Forestry Costs and Benefits.

The major constraint affecting choice of method was the lack of data for evaluating the benefits of guidelines. In terms of forestry, the major benefits may be improved artificial and natural regeneration performance resulting from reduced clearcut sizes and improved logging.

This would be reflected in possible improvements in successor crop volume as well as in an earlier date of maturation. However, because these guidelines have only been in effect for two years, there are no data to substantiate these possibilities. Data from a number of relevant research projects in the United States were examined, but for a variety of reasons they were not considered suitable. The author had little alternative but to make the necessary assumptions in order to fill this obvious information gap. These will be discussed later. On the basis of the discussion in Section 3.6 the evaluation of quantifiable costs and benefits associated with the forest resource, was divided into two parts. The first analysis was designed to evaluate the redistribution of timber harvest over time. A compound-interest model was used to calculate the value of opportunities forgone by changing the sequence of road construction and volumes harvested over time, in return for expected benefits of faster and improved artificial and natural regeneration. In other words with the aid of an interest rate, the discounted costs and revenues from harvesting the existing <u>and</u> successor crop had to be compared, for conditions existing prior to, and after, the guidelines. The discounting procedure can be expressed as follows:

$$P.N.W. = \frac{R_o - C_o}{(1+p)^o} + \frac{R_1 - C_1}{(1+p)^1} + \ldots\ldots\ldots\ldots\ldots\ldots \frac{r_n - c_n}{(1+p)^n}$$

where:

P.N.W. = Present Net Worth, in dollars.

R_1 = Revenue derived from selling logs harvested from the existing forest during year 1, in dollars.

C_1 = Total logging costs incurred during year 1, in dollars.

r_n = Revenue derived from selling logs harvested from the successor crop during year n, in dollars.

c_n = Total logging cost incurred during year n, in dollars.

p = Interest rate (in this case, the social rate of discount), in decimals.

This approach accounts for the flow of costs and benefits over time and facilitates their comparison at any particular period of concern. Some may prefer to use end-value analyses to justify investments, and problems can arise if large changes result because of uncertainty. A second analysis was needed to evaluate specific increases in harvesting and road construction costs attributable to the guideline recommendations. In view of the considerable technical expertise behind the method developed by the Council of Forest Industries (C.O.F.I., 1973b), the author considered it worthwhile to modify and update their procedure and apply it to conditions in the Chilliwack Provincial Forest.

Time constraints as well as a lack of detailed information for the whole of the Chilliwack Provincial Forest, required that a detailed study be made only in representative sample drainages. Paleface and Depot Creeks, located side by side at the south eastern end of Chilliwack Lake (See Figure 9) were selected for the following reasons:

1. Both drainages were fairly characteristic of the general conditions encountered in the forest.
2. They had both been logged recently, and up to date development plans were available for the entire area of both drainages. This is in contrast to several other drainages which had been logged intermittently over a longer period of time.
3. Only one major operator had been harvesting the timber in both areas. Cattermole Timber Ltd. was found to be very helpful in providing the necessary cruise maps and cutting plans, as well as discussing the operations and costs involved. Another advantage was that because only one operator was involved, work had been completed with the same standards, machinery and method of costing.

4. Both drainages were in the process of being logged when the 1972 Coast Logging Guidelines were introduced. Future cutting plans had to be altered to comply with the new regulations. The way in which they were, and any cost increases involved, were considered to be of particular importance to this study.

The following two sub-sections will show the basic assumptions, the methods of computation, and will discuss the results of the two categories of analysis mentioned above. For purposes of simplicity they will be described as 'Net Present Value Method' and 'C.O.F.I. Method'.

4.23 Net Present Value Method.

4.231 Logging plan preparation.

In order that the changes in cash flow over time could be evaluated, it was necessary to have comparative figures of wood volume and road construction flows over time. The first task was to prepare four 'logging plans' showing cutting block layout, firebreaks, road, bridge and culvert locations for both Paleface and Depot Creeks as follows:

1. Pre-1972 Guideline operation.
2. Actual operation.
3. 1972 Guideline operation.
4. Severe Site Guideline operation.

Copies of the development plans for the first two 'operations' were already available. These were supplied by J. Livland and Assoc., the consulting firm employed by Cattermole Timber Ltd. to prepare its cutting permit applications. These maps consisted of combined topographic, forest cover and cruise information at scales of either

20 chains to the inch or 800 feet to the inch. Development proposals were superimposed on some of these maps, and the remaining copies without this information were intended for planning the other two operations. Hypothetical plans were prepared to conform to the 1972 Coast Logging Guidelines and to the Severe Site Guidelines for Depot Creek only. A '1972 Guideline Operation' was prepared for Paleface Creek; however, the physical characteristics of this drainage prevented a different interpretation for the Severe Site Guidelines from being made. After consultation and considerable revision, tentative approval for these hypothetical operations was obtained from Cattermole Timber Ltd., J. Livland and Assoc., the B.C. Forest Service Vancouver District staff, the Fish and Wildlife Branch in Burnaby, as well as local technical staff in Chilliwack. A visual comparison of these plans showed that although there were significant differences in location and extent of cutting blocks between operations, road locations were not very different because of the lack of reasonable alternative sites. Copies of these maps are available on request from the author.

4.232 Evaluation of cost and revenue flows over time.

The first step in estimating the magnitude of cost and revenue flows over time involved planning the hypothetical rate of harvest of the existing crop and the required road construction. Cutting plan maps showed the average C.U. volumes per acre (less decay) and extent of each forest type within the limits of 'accessible' timber as defined and agreed upon by the Forest Service and Cattermole Timber Ltd.

The extent of individual forest types within cutting blocks had to be determined in order to obtain the total volume for each block. J. Livland and Assoc. (pers. comm.) provided a species breakdown for each forest type, and so the volume by species could be determined for individual cutting blocks. A considerable problem arose in trying to decide how much timber should be 'cut' in these drainages each year for the four operations under consideration. In order to have a basis for comparison and yet maintain some realism in the evaluation, the actual volume scaled per year over the period 1969-74 in each of the two drainages was obtained from the B.C. Forest Service Vancouver District office. Although these figures applied in part to the 'pre-1972 Guideline Operation' and the 'Actual Operation', the problem arose as to how the remaining timber in the drainages should be harvested (i.e. that actually deleted from cutting under the guidelines). Furthermore, what rate of cutting should be adopted for the hypothetical operations? It was decided to apply two sets of volume-flow-over-time assumptions to each drainage. The first would be an 'actual cut per year' based on how fast the timber destined to be harvested sometime in the future. With respect to any of the guideline operations, this would mean that the first pass would be based on an 'actual cut per year', and subsequent passes on an 'average cut per year'. The other alternative was that all operations except the 'Actual Operation' would be harvested on an 'average cut per year' basis, which would improve the basis for comparison. As a result of these assumptions, the volumes harvested each year for all four operations in both drainages could be determined. By applying the average 1974 market prices per cunit for each species, the revenue flows over time could be estimated.

Once the location, acreage and volume cut per year were determined, the next stage of the analysis involved calculating how many roads, bridges and culverts needed to be constructed in order to realize this volume. It was assumed that all roads, bridges and culverts required for a given year's timber harvest had to be constructed in the previous year if this was at all possible. Furthermore, the average road would have to be maintained for at least three years, including the year of construction. In contrast, fire access roads would require maintenance each year, until the last remaining tract of timber (including wildlife corridors and primary firebreaks) had been removed. The latter assumption appeared to be fairly realistic, not only from the fire control standpoint, but also that public access could be maintained in developed areas. It was also assumed that main roads under the guidelines would require decked bridges and 72 inch steel culverts, as opposed to branch and spur roads which would only have dirt-filled bridges and wooden culverts. The latter would require replacement at the start of each subsequent logging 'pass' in the future.

For the purposes of this analysis it was assumed that logging costs, other than the improvements in road, bridge, culvert and maintenance costs specified above, did not significantly differ as a result of guidelines. This particular aspect will be analysed in greater detail in the C.O.F.I. method. On the other hand, it was considered interesting to compare different notions of current logging costs as expressed by the Council of Forest Industries, Cattermole Timber Ltd. and the B.C. Forest Service Appraisals Section. A summary of these cost assumptions will be presented in a later section.

4.233 Planting and planting cost assumptions.

The problem faced in evaluating the impact of guidelines on planting success was lack of definitive data. Evidence was needed to answer such questions as: 'How much will percentage success be improved by reducing clear cut size?' and 'What effect do elevation and aspect have on this relationship?' The following description outlines the development of the basic assumptions made in order to fill this information gap.

The Reforestation Section of the B.C. Forest Service Vancouver District was consulted as to the nature and extent of their artificial regeneration records for the Chilliwack Provincial Forest. Individual data cards were available for each plantation showing the number of trees planted, year of planting, species, stock type and nursery of origin. Because of the time limitations for this study these data could not be aggregated and analysed. However, a summary table of 57 observations of Douglas-fir plantations established over the period 1958-71 between the elevations of 800 and 4300 feet in the Cultus Lake Ranger District, were obtained from Hahn (pers. comm.). These data were to be analysed with the main objective of finding out the main factors influencing percentage planting success. The following variables were available:

No. of naturals per acre.

No. of planted trees surviving per acre at final survey.

No. of years after planting.

No. of years after burning.

Spring or Fall planting.

Average elevation of Plantation.

Aspect.

No. of acres planted.

Percentage survival figures were also shown in the data provided for 41 of the 57 plantations. Altogether 14 of the missing values were related to plantations established below 2000 feet. Because these data were rather difficult to obtain from other sources, it was assumed that the initial number of trees planted was 650 per acre. The mean number of trees planted per acre for the other plantations below 2000 feet was 699, so the previous assumption would tend to over-estimate percentage planting success.

Multiple regression analyses and analyses of variance and covariance were carried out and the results reported (Benskin, 1974b). Several interesting conclusions were drawn from these data. Firstly, there was found to be no correlation between the number of naturals per acre and elevation (or any of the other possible variables). This observation will be discussed in greater detail in the next section. Secondly, the results showed that although there were significant differences in percentage planting success between the five elevation ranges considered, once the variation due to Spring or Fall planting had been removed, no significant differences were apparent. This was due to the fact that a greater amount of Fall planting in the higher elevation ranges resulted in the observed poorer survival, and not the higher altitude. The following multiple regression equation illustrates the calculated relationship between percentage survival, elevation and Spring or Fall planting:

$$Y = 89.203 - 7.346\ x_1 - 7.817\ x_2^{\ 2}$$

where

Y = % survival of Douglas-fir.

x_1= Elevation Range (Numbered from 1 to 5).

x_2= Spring (1) or Fall (2) planting.

Standard error of estimate = 24.862

F (variance ratio) = 14.609** (with 2 and 54 degrees of freedom).

Although Reuter (1973) showed an apparent decrease in plantation success with increasing elevation, he failed to statistically verify that there was such a relationship and that other factors (such as Spring or Fall planting) were not partially responsible. However, because the above mentioned data represented only a small sample for a limited area and because the results were contrary to the basis for the Severe Site Guidelines, it was decided to ignore the effects of Spring or Fall planting differences. The following figures therefore only represent the mean planting success with 95 per cent confidence limits for each of the five elevation range classes considered:

Elevation Range (ft.)	No. obs.	Mean percent success	95% Conf. limits
< 2000	17	63	±13
2000-2500	16	59	±13
2501-3000	7	47	±20
3001-3500	10	39	±17
> 3500	7	15	±20
	57		

The 95 per cent confidence limit values will be used in the next section as optimistic and pessimistic alternatives to the mean planting success figures. (The former figure may represent the results of future improvements in planting technique, stock type and so on.)

The next problem was to decide on how clearcut size influences natural recruitment, and how many trees have to be planted in order to achieve a 'desirable' future crop. In view of the uncertainty of future successor crop volumes, Smith (<u>pers. comm.</u>) suggested the use of variable density yield table data which he had recently compiled for the B.C. Forest Service Productivity Committee. The objective would be to plant as many trees as are necessary to achieve the maximum possible number of trees per acre for each site class. By using values for both Douglas-fir and western hemlock it was possible to accomodate the possibility that an initial Douglas-fir plantation might revert to an essentially hemlock stand because of natural recruitment. Certain additional assumptions were made as to mortality and net recruitment per acre over the rotations, depending on four clearcut width classes. The above assumptions, combined with the mean percentage planting success values with confidence limits determined above, enabled the determination of the number of trees to be planted on an optimistic, average and pessimistic basis. An example of the resulting values for Douglas-fir Site Class I is shown in Table II. Altogether, 360 values were calculated for the two species, three site classes, four clearcut width classes, five elevation ranges, as well as for the optimistic, average and pessimistic alternatives. Values ranged from 175 to 4551. The latter figure would normally represent several planting operations required to get a site satisfactorily regenerated. For purposes of simplicity it was assumed that this number would be planted at a given point in time. In order to relate these data to the cutting plan maps, it was necessary to calculate the extent of good, medium and poor sites in each cutting block, as well as specifying the clearcut width class. The latter criterion turned out to be more subjective than was first anticipated, and other factors such as the influence of local topography, prevailing wind direction and the potential of adjacent stands as seed sources were also taken into account be-

TABLE II

BASIC ASSUMPTIONS AND NUMBER OF TREES TO PLANT IN ORDER TO ACHIEVE THE MAXIMUM NUMBER OF SUCCESSOR CROP TREES PER ACRE

MAX NT/AC.	AGE MAX NT.	MORTALITY NT/AC.	MIN CLEARCUT WIDTH (CHAINS)	NET RECRUIT-MENT PER AC.	NEED TO ESTABLISH NT/AC.	ELEVATION RANGE (ft.)	NUMBERS OF TREES TO PLANT TO ACHIEVE MAX NT PER ACRE.		
							OPTIMISTIC	AVERAGE	PESSIMISTIC
208	50	75	20	150	133	< 2000	175	210	263
208	50	75	20	150	133	2000-2500	184	224	288
208	50	75	20	150	133	2501-3000	198	280	482
208	50	75	20	150	133	3001-3500	237	337	581
208	50	75	20	150	133	> 3500	379	870	1361
208	50	75	40	100	183	< 2000	241	287	362
208	50	75	40	100	183	2000-2500	253	309	396
208	50	75	40	100	183	2501-3000	272	386	664
208	50	75	40	100	183	3001-3500	326	463	799
208	50	75	40	100	183	> 3500	521	1197	1873
208	50	75	60	50	233	< 2000	306	367	460
208	50	75	60	50	233	2000-2500	322	393	505
208	50	75	60	50	233	2501-2500	346	491	845
208	50	75	60	50	233	3001-3500	415	590	1018
208	50	75	60	50	233	> 3500	663	1524	2385
208	50	75	60+	0	283	< 2000	372	446	758
208	50	75	60+	0	283	2000-2500	392	477	614
208	50	75	60+	0	283	2501-3000	422	597	1025
208	50	75	60+	0	283	3001-3500	504	716	1236
208	50	75	60+	0	283	> 3500	806	1851	2888

fore ratings were finalized.

The total cost per planted seedling was estimated from basic principles using 1974 data supplied by the Council of Forest Industries (Ross, pers. comm.). Values for Douglas-fir and western hemlock were derived as follows:

Basic assumptions:

Contract planting cost (per 1000 plants).....................$110.00

Cost of seed collection and extraction per lb. (Douglas-fir)..$ 20.00

Cost of seed collection and extraction per lb. (western hemlock).......$ 50.00

Cost of 1000 viable seeds (Douglas-fir)......................$ 1.25

Cost of 1000 viable seeds (western hemlock)..................$ 0.50

The above figures were applied to production costs for four types of planting stock as follows:

Type of planting stock.	Production cost (per 1000)	Total Cost (per 1000) Douglas - fir	western hemlock
Bareroot 2 + 1	$50	$161.25	$160.50
Bareroot 2 + 0	$25	$131.25	$130.50
Mudpack 2 + 1	$80	$191.25	$190.50
Mudpack 2 + 0	$50	$166.25	$165.50

Discussions with the Council of Forest Industries suggested that 2 + 0 mudpacks were most suitable for planting at high elevations. For the purpose of simplicity it was assumed that this planting stock would be used, and that the approximate total cost per 1000 plants planted for either species would be $170 i.e. $0.17 per plant.

4.234 Natural Regeneration.

The influence of environmental factors on the performance of natural regeneration is a very complex subject, and there are a great many schools of thought as to the important contributing influences. Implicit in the Severe Site Guidelines is the assumption that clearcut size, shape and orientation, logging impacts, aspect and elevation are among the most significant factors, and that past harvesting practices have to be radically improved to improve natural regeneration in high elevations. The above statistical analysis showed however, that there was no apparent relationship between elevation and the number of naturals per acre between 1958 and 1971 for the Cultus Lake Ranger District. Furthermore, it appeared that despite the 'disastrous' harvesting practices of past years, the mean number of naturals per acre for all elevations was still 200 (range: 0-2000). On the basis of an open to normal growth regime this appears to be a perfectly reasonable initial stocking (Smith pers. comm.). In view of the fact that more analyses are necessary before definite conclusions can be drawn, it will be assumed that aspect (northerly or southerly), clearcut size and periodicity of seed supply are the most important factors influencing natural regeneration. The clearcut size ratings derived in the previous section were also used here for naturally regenerated stands. It should be remembered that ratings were based on a number of factors other than purely the magnitude of the clearcut area. Hetherington (1965) stated that even moderate crops of hemlock, cedar and amabilis fir seeds could not be expected more than once in 4 or 5 years. On the basis of his observations, it was assumed that sites with the smallest clearcut size ratings would, on average, be regenerated in 5 years. Furthermore that the more favourable northerly aspected sites would be regenerated 2 years earlier and southerly sites 2 years later. The 5 year average figure was increased to 10 for the next size rating and so on, with the same time differential for aspect incorporated, as above. The resulting values shown in Table III represent 'regeneration lag' times, and must be added on to the normal rotation age in order to approximate the year of maturation of naturally regenerated stands.

4.235 Successor crop.

Variable density yield tables were used to simulate the range of possible density conditions associated with the successor crop. Smith (pers. comm.) provided a summary table which showed for each species and site class, the rotation age and yield for five density classes (expressed in terms of percentage of average basal area 9.1" and + per acre). These data are shown in Table IV. This approach was considerably better than using the only local volume over age curve for the Dewdney P.S.Y.U. ($C + C_{MIX}$ and $H + H_{MIX}$), which indicated a rotation age of 107 years and a yield of 7250 cubic feet per acre. Only one successor crop possibility could have been evaluated using this method, as opposed to the 30 possibilities available in the variable density yield table approach.

TABLE III

NATURAL REGENERATION LAG TIMES

Clearcut rating	Minimum clearcut width (chains)	Regeneration Lag (Years) North	South
1	< 20	3	7
2	$\leq 20 \leq 40$	8	12
3	$\leq 40 \leq 60$	13	17
4	> 60	18	22

TABLE IV

VARIABLE DENSITY YIELD TABLE SUMMARY FOR DOUGLAS FIR AND WESTERN HEMLOCK*

SPECIES	SITE CLASS	STAND DENSITY CLASSES (% of average B.A., 9.1" & + per acre)				
		1-50% (OPEN)	51-80% (SPARSE)	81-120% (NORMAL)	121-150% (DENSE)	151 + % (VERY DENSE)
		YIELD IN CUBIC FEET AND ROTATION AGE IN BRACKETS				
HEMLOCK	1	2160 (60)	6017 (70)	10023 (74)	15411 (77)	18631 (86)
	2	4067 (120)	6024 (110)	8844 (110)	13328 (114)	19069 (120)
	3	1815 (110)	1809 (80)	3081 (85)	5453 (85)	7178 (104)
DOUGLAS-FIR	1	4844 (78)	5355 (64)	10511 (75)	13393 (71)	13271 (70)
	2	2398 (70)	5219 (80)	8046 (79)	11283 (83)	12054 (72)
	3	2033 (114)	2632 (100)	3108 (82)	4303 (80)	6661 (80)

* For each species, values have not been harmonized for all site and stand density classes. The values given are those from sorted data summaries only.

4.236 Summary of cost and revenue data.

Cost and revenue data tend to be very variable depending on their source and method of estimation. A considerable discrepancy was observed between B.C. Forest Service appraised costs for logging in Paleface and Depot Creeks (April 1974 appraisal sheet) and those quoted by Cattermole Timber Ltd. (Richardson pers. comm.) who actually logged these drainages. In this regard, the Council of Forest Industries (Ross pers. comm.) felt that Forest Service appraisals were about 10 per cent too low on average. For purposes of comparison, all three cost alternatives were included in the analysis (Table V). Average market prices for April 1974, for the major species under consideration were obtained from the B.C. Forest Service Vancouver District office. In order to have three alternative revenue assumptions, arbitrary 'high' or 'low' estimates were also included (Table V). These costs and revenues were assumed for the estimation of cash flow from harvesting the existing timber crop in both drainages. In view of the uncertainty of cash flows from the future crop, it was decided to use current stumpage prices for Douglas-fir and western hemlock instead of calculating revenues and costs separately. Arbitrary high and low alternatives were also used (Table V). The fundamental assumption was made that relative costs and prices would remain constant over time. The evaluatory procedure would have been far more complex had changes in demand, technological improvements and different rates of cost and price increases been taken into account. Three rates of interest were used to discount the costs and revenues from harvesting the existing and successor crops. A 6 per cent rate was considered to be a realistic value for the long run social rate of return for Government invest-

TABLE V

SUMMARY OF COST AND REVENUE DATA

Cost or Revenue item.	Alternatives ($)*		
	A	B	C
Costs			
Yarding and skidding costs/cunit	10.35	11.38	11.44
Log Transportation costs/cunit	12.90	14.19	12.23
Contractual costs/cunit	0.15	0.16	0.15
Administrative costs/cunit	2.45	2.69	- **
Forestry costs/cunit	0.20	0.22	0.50
Log making costs/cunit	3.05	3.35	3.00
Operational overhead cost/cunit	7.70	8.47	12.19
Main road cost per mile	24,091	26,500	37,500
Branch road cost per mile	24,091	26,500	55,000
Spur road cost per mile	24,091	26,500	55,000
Reopened road cost per mile	5,000	5,500	10,000
Road maintenance cost per mile	600	660	2,000
Cost of decked bridge (50' span, 100 ton max.)	4,000	4,400	8,000
Cost of dirt filled bridge (50'span, 100 ton max.)	1,300	1,430	4,500
Cost of 72" steel culvert	1,000	1,100	1,500
Cost of wooden culvert	150	165	300
Total cost for one planted tree	0.17	0.19	0.20
Revenues			
Douglas-fir selling price per cunit	60	73	80
Western Hemlock selling price per cunit	60	60	66
Amabilis fir selling price per cunit	58	60	64
Western red-cedar selling price per cunit	60	60	66
Yellow cedar selling price per cunit	255	255	280
Douglas-fir stumpage price per cunit	19	13	21
Western hemlock stumpage price per cunit	8	13	9

*Cost alternatives A B C; respectively B.C.F.S., C.O.F.I., Cattermole Timber Ltd. (Only one B.C.F.S. road cost figure was given in the appraisal for all roads.)

**Cattermole Timber Ltd. estimate of administration costs is combined with Operational Overheads.

ments. Other values of 8 per cent and 10 per cent were used to evaluate sensitivity to interest rates.

4.237 Description of the computer model used to evaluate net present worth.

A computer program was prepared in order to calculate the above mentioned cash flows over time, and to discount them to the present for comparison (Appendix II). The adopted procedure was as follows: Each data card read by the program represented a certain year of a given harvesting operation, where either roads were being constructed and/or timber was harvested. Altogether 30 items of information were coded on each card, as shown in Table VI. These data enabled the computer to calculate all costs and revenues for that particular year, as well as estimating any planting costs and the net value of the successor crop on any areas that had been harvested. These present and future costs and revenues were then discounted to the present by one of the three alternative rates of interest and stored. The same procedure was adopted for each year of a given operation, and repeated for each rate of cut assumption, drainage and rate of interest and stored. A summary flow chart outlining this form of sensitivity analysis is shown in Figure 10.

A number of additional assumptions had to be made with regard to the leave periods required in guidelines:

1. A total of 10 years must elapse between consecutive harvest-ing passes [illegible] operations:

2. Transverse valley firebreaks, wildlife reserved areas and stream protection belts are harvested 20 years after the [illegible]

[illegible]

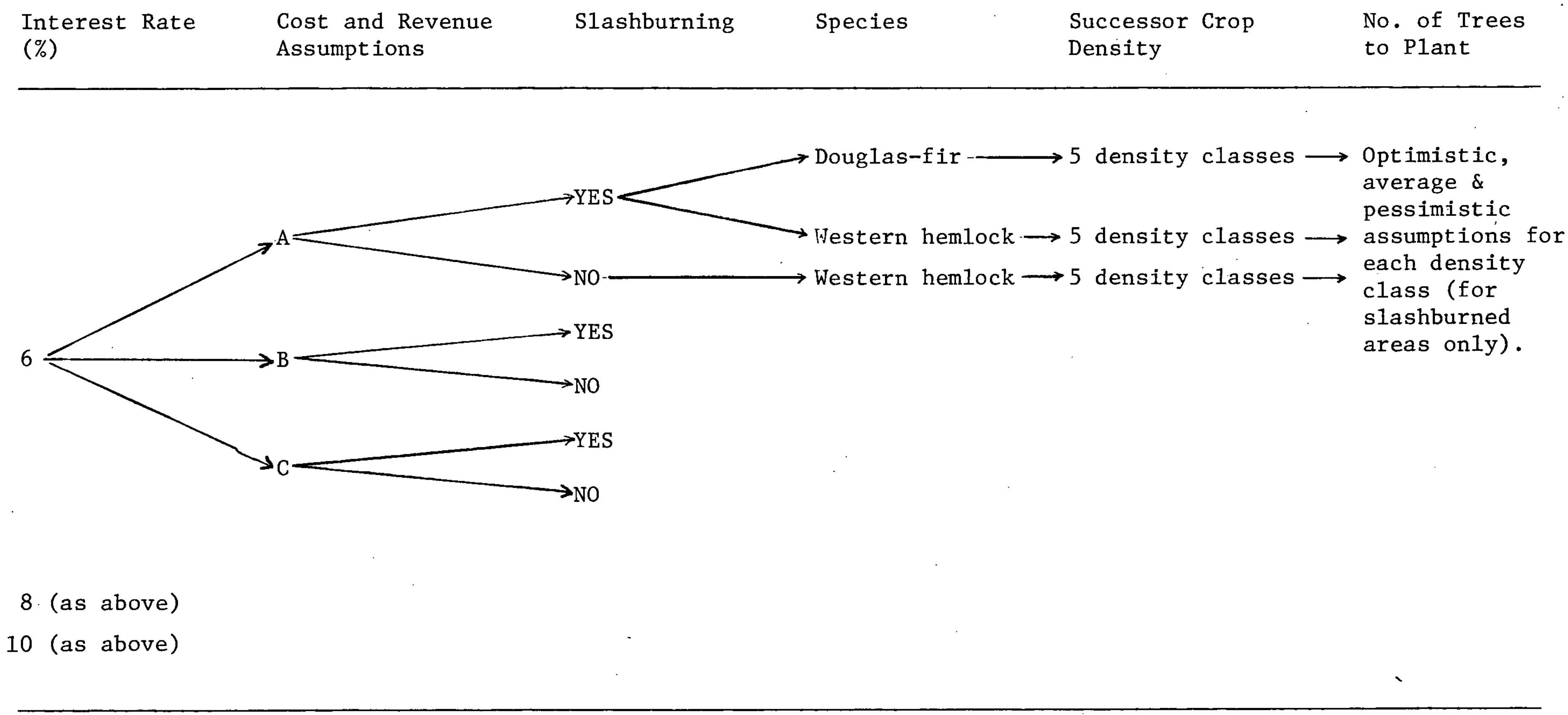
TABLE VI

LIST OF DATA CARD PARAMETERS

Computer Code	Description
CREEK	Drainage number.
CA	Rate of cut assumption number.
OPERAT	Operation number.
YR	Year.
GNAC	No. of acres of good site harvested (N. aspect).
MNAC	No. of acres of medium site harvested (N. aspect).
PNAC	No. of acres of poor site harvested (N. aspect).
GSAC	No. of acres of good site harvested (S. aspect).
MSAC	No. of acres of medium site harvested (S. aspect).
PSAC	No. of acres of poor site harvested (S. aspect).
TA	Total no. of acres harvested.
CCRATN	Av. clearcut size rating for N. aspected sites.
CCRATS	Av. clearcut size rating for S. aspected sites.
NER	Av. elevation range for N. aspected clearcut sites.
SER	Av. elevation range for S. aspected clearcut sites.
TVOL	Total volume harvested for all species (M cf.)
FVOL	Douglas-fir volume (M cf.)
HVOL	Western hemlock volume (M cf.)
BVOL	Western red-cedar volume (M cf.)
BVOL	Amabilis fir volume (M cf.)
CYVOL	Yellow cedar volume (M cf.)
MAIN	Main roads constructed (Miles)
BRANCH	Branch roads constructed (Miles)
SPUR	Spur roads constructed (Miles)
REOPEN	Roads reopened (Miles)
MTCE	Roads maintained (Miles)
BRIG 1	No. of decked bridges constructed.
BRIG 2	No. of dirt-filled bridges constructed.
BGCULV	No. of steel culverts constructed.
SMCULV	No. of wooden culverts constructed.

FIGURE 10

FLOW CHART SHOWING ALTERNATIVE ASSUMPTIONS FOR NET PRESENT WORTH MODEL.



main body of timber has been removed. Furthermore, these have to be harvested in two passes to comply with the guidelines.

3. The problem of the duration of Environmental Protection Forests in Depot Creek (under the Severe Site Guidelines) was approached in two ways. The first alternative was that this forest would 'never' be harvested, and secondly that it could be harvested 40 years after the main body of timber had been removed - together with other temporarily deferred areas.

The computer program was designed to print out a matrix of 134 net present worth values for each of the assumptions illustrated in Figure 10. One of these matrices was calculated for each rate of cut assumption, operation, drainage and rate of interest. A list of the titles of these matrices is shown in Table VII.

4.238 Results of the analysis.

A number of features were immediately apparent when examining these results. The range of net present worth values for any given matrix was found to be comparatively small. This implied that the effect of species differences, cost assumptions, number of trees to plant (in the case of artificial regeneration) and the density of the successor crop were not very significant. This observation may be contrasted with the considerable differences observed between operations, interest rates and rate of cut assumptions in that order of importance. In order that the latter effects could be illustrated more effectively, the range and mean value were calculated for each matrix and these are presented in Table VIII. In view of the small differences observed for other factors, it was

TABLE VII

LIST OF TITLES OF NET PRESENT WORTH MATRICES.

DRAINAGE	OPERATION	RATE OF CUT ASSUMPTION
PALEFACE CREEK	PRE-1972 GUIDELINES	Actual + Average cut per year
PALEFACE CREEK	PRE-1972 GUIDELINES	Average cut per year
PALEFACE CREEK	ACTUAL OPERATION	Actual + average cut per year
PALEFACE CREEK	1972 GUIDELINES	Actual + average cut per year
PALEFACE CREEK	1972 GUIDELINES	Average cut per year
DEPOT CREEK	PRE-1972 GUIDELINES	Actual + average cut per year
DEPOT CREEK	PRE-1972 GUIDELINES	Average cut per year
DEPOT CREEK	ACTUAL OPERATION	Actual + average cut per year
DEPOT CREEK	1972 GUIDELINES	Actual + average cut per year
DEPOT CREEK	1972 GUIDELINES	Average cut per year
DEPOT CREEK	SEVERE SITE GUIDELINES (E.P.F. PERMANENT)	Actual + average cut per year
DEPOT CREEK	SEVERE SITE GUIDELINES (E.P.F. PERMANENT)	Average cut per year
DEPOT CREEK	SEVERE SITE GUIDELINES (E.P.F. SEMI-PERMANENT)	Actual + average cut per year
DEPOT CREEK	SEVERE SITE GUIDELINES (E.P.F. SEMI-PERMANENT)	Average cut per year

not considered worthwhile to undertake any sophisticated analysis of those results. Table IX shows the observed reductions in net present worth when 'pre - 1972 Guideline Operations' are compared with other operations. In view of the apparent importance attributed to the successor crop in the guidelines, it was considered interesting to calculate the percentage of the total net present value that was attributable to the successor crop. This required only a slight modification to the computer program, and a summary of the results for the 8 per cent rate of interest alternative is shown in Table X. Although these values frequently differed by a factor of 10 within any given matrix, their absolute magnitude suggested that further analyses were unnecessary.

TABLE VIII

RANGE AND MEAN VALUES OF NET PRESENT WORTH MATRICES FOR PALEFACE AND DEPOT CREEKS*

Drainage	Interest Rate	Cutting Rate (Actual and/or average)	Range and Mean Values of Net Present Worth Matrices (in $00)									
			Pre-1972 Guideline Operation		Actual Operation		1972 Guideline Operation		Severe Site Guidelines (E.P.F. Permanent)		Severe Site Guidelines (E.P.F. Semi-permanent)	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Paleface Creek	6%	Act + Av	9144-15864	12504	9713-12437	11075	5661-10041	7851	-	-	-	-
	8%	"	8089-13991	11040	8337-10711	9524	4657-8337	6497	-	-	-	-
	10%	"	7181-12392	9782	7263-9364	8314	3910-7075	5493	-	-	-	-
	6%	Av	9903-16966	13435	-	-	6500-11168	8834	-	-	-	-
	8%	"	8958-15295	12127	-	-	5562-9588	7575	-	-	-	-
	10%	"	8133-13847	10990	-	-	4853-8400	6627	-	-	-	-
Depot Creek	6%	Act + Av	13614-22976	18295	11105-19927	15516	8913-16246	12580	6632-11430	9031	6499-11252	8876
	8%	"	13054-22002	17528	10469 18776	14623	8144-14927	11536	5844-10123	7884	5742-9973	7858
	10%	"	12558-21127	16843	9968-17858	13913	7575-13940	10758	5264-9160	7212	5198-9060	7129
	6%	Av	12447-20403	16425	-	-	8222-14474	11348	5396-9937	7667	5278-9778	7528
	8%	"	11384-18782	15083	-	-	7214-12823	10019	4524-8484	6504	4437-8356	6397
	10%	"	10438-17342	13890	-	-	6441-11556	8999	3883-7413	5648	3829-7330	5580

* Paleface Creek: Total available mature volume = 108610 C cf.; total area = 1304 acres.
Depot Creek: Total available mature volume = 113260 C cf.; total area = 1057 acres.

TABLE IX

PERCENT REDUCTION IN PRESENT NET WORTH OF OTHER OPERATIONS COMPARED TO THE PRE-1972 GUIDELINE OPERATION

Drainage	Interest Rate	Cutting Rate	Percent Reduction in Net Present Worth				
			Pre-1972 Guideline Operation	Actual Operation	1972 Guideline Operation	Severe Site Guidelines (E.P.F. Permanent)	Severe Site Guidelines (E.P.F. Semi Permanent)
Paleface Creek	6%	Act + Av	0	-11%	-37%	-	-
	8%		0	-14%	-41%	-	-
	10%		0	-15%	-44%	-	-
	6%		0	-	-34%	-	-
	8%	Av	0	-	-38%	-	-
	10%		0	-	-40%	-	-
Depot Creek	6%	Act + Av	0	-15%	-31%	-51%	-51%
	8%		0	-16%	-34%	-55%	-55%
	10%		0	-17%	-36%	-57%	-58%
	6%		0	-	-31%	-53%	-54%
	8%	Av.	0	-	-34%	-57%	-58%
	10%		0	-	-35%	-59%	-60%

TABLE X

RANGE AND MEAN VALUES OF THE PERCENTAGE OF TOTAL NET PRESENT WORTH CONTRIBUTED BY THE SUCCESSOR CROP*

Drainage	Interest Rate	Cutting Rate (Actual and/or average)	Range and Mean Values of Percentage of Total Net Present Worth Contributed by the Successor Crop.									
			Pre-1972 Guideline Operation		Actual Operation		1972 Guideline Operation		Severe Site Guideline Operation (E.P.F. Permanent)		Severe Site Guideline Operation (E.P.F. Semi-Permanent)	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Paleface Creek	8%	Act + Av	.00493-.31308	0.15900	.00847-.50241	0.25544	.01337-.66763	0.34050	-	-	-	-
		Av	.00497-.30704	0.15600	-	-	.01409-.67614	0.34512	-	-	-	-
Depot Creek	8%	Act + Av	.01386-.18238	0.09812	.01415-.20896	0.11155	.01821-.31257	0.16539	.02635-.39409	0.21022	.02595-.39294	0.20944
		Av	.01466-.19885	0.10675	-	-	.01850-.28835	0.15343	.02809-.44569	0.23689	.02771 .44527	0.23649

* In general, slashburning and planting of Douglas-fir resulting in a 'very dense" successor crop gave the highest percentage contribution. The lowest values under the assumptions made were associated with no slashburning and an open successor crop of western hemlock.

4.239 Discussion of Results.

The results of this analysis showed a considerable decline in net present worth of guideline operations when compared to pre-1972 guideline operations. This reduction was not offset to any appreciable extent by improvements in successor crop status e.g. by reduced regeneration lag, less trees to plant, reduced rotation age or higher successor crop volumes. In fact, the percentage of total net present worth attributed to the successor crop was found to range from .005% to .313% before the guidelines to between .013% and .676% after the guidelines. The apparent improvement in its significance after the guidelines however, was due to the overall decline in net present worth rather than an improved absolute value per se. The conclusion may be drawn, that in financial terms very little emphasis should be placed on costly measures designed to improve successor crop performance. Even with fairly generous assumptions, the expected returns appear to be very low.

Assessing the significance of the observed decline in net present value proved to be an interesting problem. The question may be asked, 'Does this actually constitute a cost, and if so, how will it be borne?' It should be remembered that the stream of costs and revenues used in this model were related to a fixed area i.e. either Paleface or Depot Creek. In other words the implementation of guidelines resulted in a reduction in net present worth within a fixed area. However, the Dewdney P.S.Y.U. currently has a supply of mature timber which could, by itself, last for at least 90 years without consideration of the growth of immature stands or improvements in utilization standards. Stated differently, there may be no cost associated with deferring timber harvest within a given area because there are alternatives available. Economic theory suggests that net present worth must be maximized with respect to the most limiting factor. The question is, 'What is the limiting factor?' It appears that the limiting factor is the extent of the area developed in order to obtain a given allowable annual cut. Thus, the most appropriate criterion would be to maximize net present worth (or economic rent) per developed acre. Other criteria, such as maximizing net present worth per $100 invested would not be appropriate here, because under the concept of sustained yield each acre is given equal priority regardless of differential rent functions. The fact that very costly reforestation activities are being undertaken at high elevations, in contrast to more intensive management of good sites at low elevations is a case in point. The criterion of maximizing net present worth per developed acre was applied to the results shown in Table VIII. Each value was divided by the total acreage of the appropriate drainage, because the 'developed' area remains constant in each case (the area physically harvested at a given point in time will of course differ). Results of these calculations are given in Table XI.

The following conclusions may be drawn from this analysis: The objective of sustained yield management within the Dewdney P.S.Y.U. is the perpetuation of long term timber supplies, at a constant or increasing level. This is achieved by harvesting a fixed volume over a certain area every year, as determined by the Hanzlik formula plus an area/volume allotment check. Logging guidelines have been introduced in order to enhance environmental values and possibly forestry values over these limited developed areas. The previous analysis showed that by operating over a more extensive area, the potential

TABLE XI

NET PRESENT WORTH VALUES PER DEVELOPED ACRE AND PER CUNIT*.

Drainage	Interest Rate	Cutting Rate (Actual and/or average)	Pre-1972 Guideline Operation	Actual Operation	1972 Guideline Operation	Severe Site Guideline Operation (E.P.F. Permanent)	Severe Site Guideline Operation (E.P.F. Semi-Permanent)
			Net present worth values ($) per developed acre (and per cunit).				
Paleface Creek	6%	Act + Av	959 (11.51)	849 (10.20)	602 (7.23)	-	-
	8%	"	847 (10.16)	730 (8.77)	498 (5.98)	-	-
	10%	"	750 (9.01)	638 (7.65)	421 (5.06)	-	-
	6%	Av	1030 (12.37)	-	677 (8.13)	-	-
	8%	"	930 (11.17)	-	581 (6.97)	-	-
	10%	"	843 (10.12)	-	508 (6.10)	-	-
Depot Creek	6%	Act + Av	1731 (16.15)	1470 (13.70)	1190 (11.11)	856 (7.97)	840 (7.84)
	8%	"	1658 (15.48)	1383 (12.91)	1091 (10.19)	746 (6.96)	743 (6.94)
	10%	"	1593 (14.87)	1316 (12.28)	1018 (9.50)	682 (6.37)	674 (6.29)
	6%	Av	1554 (14.50)	-	1076 (10.02)	725 (6.77)	712 (6.64)
	8%	"	1427 (13.32)	-	948 (8.85)	615 (5.74)	605 (5.65)
	10%	"	1314 (12.26)	-	851 (7.95)	534 (4.99)	528 (4.93)

* Paleface Creek: total available mature volume = 108610 C cf.; total area = 1304 acres.
Depot Creek: total available mature volume = 113260 C cf.; total area = 1057 acres.

economic rent (expressed in terms of net present worth) of each developed acre was drastically reduced even when harvesting and road construction cost increases were ignored. We can assume that the implicit objective of forest management in B.C. is to maximize the potential returns from timber and other resources in those limited areas which are developed each year; it is doubtful however, that the 1972 Coast Logging Guidelines are capable of achieving this. It is unlikely that the potential loss in economic rent from the timber resource can be justified in terms of improvements in other resource values in all areas on the Coast where these guidelines are being applied.

4.24 C.O.F.I method.

4.241 Introduction and basic assumptions.

In contrast to the previous analysis, the C.O.F.I. model was designed to analyse specific cost increases (on a per cunit basis) attributable to improving road, bridge and culvert construction requirements and harvesting practices under the 1972 Coast Logging Guidelines. The results of this analysis were summarized in a brief to Mr. I.T. Cameron (then, Chief Forester of the B.C. Forest Service), outlining the Council's main objections to these guidelines. The basic assumptions made in this analysis were outlined in discussions with Shebbeare (pers. comm.) and these were then applied to the data obtained for both Paleface and Depot Creeks. A similar undertaking was not considered for the Severe Site Guidelines: any cost increases demonstrated by this model would also be incurred if these guidelines were adopted. In order to improve on the original C.O.F.I. model, costs were updated and alternative leave periods and interest rates also incorporated. March

1974 rental rates for T.L.A. operations (Wellburn _pers. comm._) were increased by 10 per cent to approximate machinery costs for January 1975. The use of rental rates avoided consideration of overhead costs which would have made calculations unnecessarily complex. Other costs cited in the text were also obtained from Wellburn. The basic assumptions used in this model are as follows:

1. The average C.U. volume per acre on the Coast is 75 cunits.
2. The average C.U. production per shift for a steel spar on the Coast is 75 cunits.
3. The average Coast operation gets 175 shifts per year, i.e. logs 175 acres per year.
4. At 550 ft. yarding (800 ft. on long corners), a full setting is 25 to 30 acres, and roads are 17 chains apart.
5. All costs and cost increases of roads, bridges and reopened roads due to the guidelines are allowed for in stumpage appraisal calculations.
6. Profit and risk before and after the guidelines are constant, and may therefore be ignored in this evaluation.

4.242 Road costs.

1. Before Guidelines.

An average Coast road is built by grade shovel at approximately 1½ stations of subgrade per shift i.e. 5 miles per year at 175 shifts per year. Rock work (cat and drill) requires approximately 100 shifts. Ballast (loader, two trucks and spreader cat) takes 50 shifts. Roughly 7 culverts per mile are required with bridges extra.

COSTS (for 5 miles of road per year)

			$
Shovel 175 shifts	@	$387	67725
Drill 100 shifts	@	$374	37400
D8 cat 100 shifts	@	$409	40900
Loader (Cat 966C) 50 shifts	@	$290	14520
Trucks (35 ton) 2 x 50 shifts	@	$238	23800
Spreader (Cat 16) 50 shifts	@	$284	14200
Culverts 7 per mile x 5 miles	@	$150 ea.	5250
Foreman			17000
			220795

∴ One mile of road costs $44,159 (say $44,000).

2. After Guidelines.

It was assumed that the 'favourable' soil moisture conditions specified for road construction under the guidelines, would reduce the season to 5 months requiring double shifting. Productivity falls off on the night shift, supervision and maintenance are poorer and wage premiums are required. Poorer quality labour is available for a short year. It was assumed that half the number of culverts per mile need to be upgraded to 72" steel @ $1500 installed, to allow for the 25 year storm. Tightening location requirements was assumed to add an average of 5 per cent to costs.

COSTS (for 5 miles of road per year)

	$
Shovel, 110 day shifts @ $387 plus 80 night shifts @ 80% efficiency, 25% higher maintenance; 15¢/hr. labour premium.	42570 34150
Drill, 60 day shifts @ $374 and 50 night shifts (as above) @ $385.	41690
D8 cat, 60 day shifts @ $409 and 50 night shifts (as above) @ $430.	46040
Loader, 50 shifts @ $290.	14500
Trucks, 2 x 50 shifts @ $238.	23800
Spreader cat, 50 shifts @ $284.	14200
Culverts, 18 @ $150	2700
17 @ $1500	25500
Foreman @ $17,000 per year	17000
Night foreman, 80 shifts @ $100	8000
	270160

5% added costs (location charges)	13508
	283669

∴ One mile of road costs $56,734 (say $57,000)*.

4.243 Bridge costs

1. Before Guidelines.

In the Chilliwack Provincial Forest, the 'average' bridge is dirt-filled, has a 50 ft. span and is designed to take an impact load of 100 tons. Assuming $100 a lineal foot, cost is $5000 ea.

2. After Guidelines.

A design is required to meet a 25 year flood; extra care in construction to meet fisheries requirements and some relocations, are assumed to add about 20% to costs. Bridges need to be reconstructed, if used in the second and subsequent passes. Assuming $120 a lineal foot, cost is $6000 ea.

4.244 Road maintenance.

1. Before Guidelines.

Spur and branch roads are assumed to require maintenace for an average of three years, including the year of construction. Cost is assumed to be $2000 per mile year.

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* The reader is drawn to the attention of a study of the environmental costs in logging road design and construction, which was published after the above calculations were completed. Ottens (1975) used the Wilson Creek Forest Road project in the Nelson Forest District from 1972 to 1974 as a case study to develop and verify a cost accounting system to determine the cost of imposing environmental and aesthetic constraints on logging road design and construction. Ottens calculated that the extra cost of meeting B.C. Forest Service standards for environmental protection, was 18.6% of the total construction cost. His figures were $55,472 per mile of road without environmental expenditures, and $68,159 with these expenditures. Although the absolute values of these figures are considerably higher than those assumed in this thesis, the percentage increase due to environmental protection constraints are very similar.

2. After Guidelines.

Fire access roads have to be maintained until the last remaining tract of timber in the area has been removed. After spur and branch roads have been abandoned for several years in between passes, these will require reopening where necessary for future timber harvests. Renovation is assumed to be approximately 20% of the original cost, and includes removal of brush, repair of slides and washouts, replacement of culverts as well as major reballasting and ditching. 20% of $57,000 is $11,400 (say $11,000).

4.245 Other logging costs.

1. Before Guidelines.

The figures below, were obtained from Richardson (pers. comm.) and represent his interpretation of the average costs incurred for logging Paleface and Depot Creeks in 1974 figures. (Operational overheads and administrative expenses represent an average cost per cunit for all harvesting operations within T.S.H.L. A00050, operated by Cattermole Timber Ltd.)

COSTS*

	($/cunit)
Yarding and skidding	11.44
Log Transport	12.23
Contractual costs	0.15
Forestry costs (excluding 10 ft. clause)	0.38
Log making	3.00
Operational overheads & administrative expenses excluding interest charges)	12.19
	39.39

2. After Guidelines.

The above-mentioned costs are also applicable after the guidelines, plus certain miscellaneous cost

*Cost items are based on B.C.F.S. Appraisals Method; component costs may be found in any B.C.F.S. Appraisal Manual.

items as follows:

COSTS (Physical operating)

	($/cunit)
Falling 10 ft. trees	$0.12
Planting deciduous trees along water courses; (i.e. 300 ch. creeks per sq. mile; 1/3 planted; 1 ch. wide @ $100 per acre)	0.02
Filter Strips (i.e. assuming 1/3 roads along creeks require strips, which delay logging for 2 years and add to subsequent logging costs)	0.36
Wildlife corridors (i.e. take out 5% of the area form every 10th watershed, adding 17¢/cunit to logging costs when they occur).	0.02
Recreation (add 18¢/cunit to logging costs in every 5th watershed).	0.04
Surround of uniqe features (i.e. take out 1% of the area from every 2nd watershed.)	0.01
Special streambank treatment (add 50% to logging costs for every 2nd watershed).	0.17
Modified setting shapes (add one landing for every 5th setting).	0.10
Extra planning and engineering.	0.36
Perimeter blowdown (extra exposed perimeters add to blowdown, which increases salvage costs).	0.17
	1.37

Total costs after guidelines:

Logging costs before guidelines.	39.39
Miscellaneous costs after guidelines.	1.37
	40.76

It should be noticed that log transportation costs per cunit were assumed to be constant, before, and after the guidelines. Improvements in road construction and design may improve average hauling speeds, but the average hauling distance per cunit is also increased because of the alternate patch cutting system.

4.246 Moving and site improvement costs

No moving and site improvement costs were included in this evaluation. A minimum facility camp and work shop were situated at the entrance to Paleface Creek, for use when logging this creek and Depot Creek. The additional moving in and moving out costs for these mobile facilities as a result of guide-lines were assumed to be negligible. In more inaccessible and remote areas of Coastal B.C., these costs would be appreciably higher because of the more complete nature of camps and shops. Moving costs would include the following at the start and finish of each logging pass:

1. Depreciation on buildings due to moving damage.
2. Building positioning, wiring, water and sewage hook-up.
3. Loading and unloading buildings.
4. Barging between sites.
5. Transfer of fuel and tanks.
6. Administration and supervision.

The capital costs of site improvements would include campsite preparation and the establishment of a dump and booming ground. These facilities would have to be reopened at the start of the second and subsequent passes. As regards Cattermole Timber's operations, both dump and booming ground are in permanent locations on the Fraser River next to their mill.

4.247 Interest charges

Two rates of interest were used in this calculation, 6 per cent and 10 per cent, in order to find out the sensitivity of the final result. Calculations were extremely long and time consuming, and, therefore, will be not shown in detail. A brief description of the method is as follows: Interest charges on the average unamortized investment from the previous year were added on to the latter figure, giving the total investment at the start of the year. The total investment in bridges, new roads and reopened roads in that year were added up (figures were taken from the basic data for the net present worth analysis), and amortized by the proportion of stumpage allocated to these costs multiplied by the year's harvest. The difference represented the net investment during that year, which may be positive or negative depending on how many roads and bridges were constructed in that year. This figure was either added or subtracted from the investment at the start of the year, giving the total unamortized investment at the end of the year. Interest was charged on the average investment during the year, i.e. the investments at the start and end of the year divided by two. The same procedure was repeated for each year of harvesting and, or, road construction. The following example illustrates the calculation of interest charges for the second year of the pre-1972 Guideline Operation for Paleface Creek:

YEAR 2

Unamortized investment at start of year:	$139200		
Interest costs from previous year:	$ 6960		
Investment at start of year:			$146160
Investment during year:			
Roads, 1.4 mi. @ $44000		$62040	
Amortized by stumpage:			
Roads: $6.40/C cf			
Bridges: $0.28/C cf			
13140 C cf. x $6.68		-$87775	
Net investment during year:			-$ 25735
Unamortized investment during year:			$120425
Average investment for year:	$\frac{146160 + 120425}{2}$		=$133293
Interest charge on average investment @ 10%			=$ 13329

At the end of the calculation, the total unamortized investment was divided by the total harvested volume in order to obtain the interest charge per cunit. In view of the difference of opinion as to the length of the leave period and when firebreaks, wildlife reserved areas and fisheries protection belts should be harvested, several different alternatives were quantified:

1. The total developable volume will be harvested in four passes i.e. two passes for the majority of the timber, and two passes for remaining areas. A total of 10 years will elapse between each pass.
2. As above, but only with 5 years between each pass.
3. Firebreaks, wildlife reserved areas and fisheries protection belts will be excluded from future logging. A total of 10 years will elapse between passes.
4. As above, but only with 5 years between each pass. For purposes of simplicity only the 'average cut per year' data previously used, were assumed in this analysis.

4.148 Results of the analysis.

Results of the C.O.F.I. method of analysis are presented in Table XII to XV. The first two tables illustrate the cost increases under four different interpretations of the guidelines, at an interest rate of 10 per cent; the other two tables show the results of calculations using a 6 percent rate. These tables show that the interest charge not only showed the largest increase in the guideline alternatives, but also was highly sensitive to changes in the interest rate. For Paleface Creek, at a 10 per cent rate of interest, interest charges rose from $1.48 per cunit before guidelines to a maximum of $97.47 for assumption E (Table XIII). Re-evaluation at the 6 per cent alternative gave a considerably smaller increase, from $0.31 per cunit to $14.94 per cunit. This implies that calculations of cost increases due to the guidelines will differ very widely, depending on what rate of interest was assumed in the calculation of interest charges. It was also evident that the leave period assumption was very important. Unamortized investments were

TABLE XII

SUMMARY OF COST IMPACT OF 1972 COAST LOGGING GUIDELINES FOR DEPOT CREEK (i = 10%)

	Pre-Guidelines		After 1972 Coast Logging Guidelines							
Assumption:	A		B		C		D		E	
Total Available Volume:	113260 C cf.		92710 C cf.		92710 C cf.		113260 C cf.		113260 C cf.	
Total Years to Harvest:	7		11		16		23		38	
Costs	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.
Roads (miles)	16.0	6.21	15.2	9.34	15.2	9.34	16.8	8.45	16.8	8.45
Bridges (units)	4	0.18	4	0.26	4	0.26	8	0.42	8	0.42
Road Mtce. (miles)	62.9	1.11	93	2.01	112.0	2.42	153.0	2.70	209.0	3.69
Reopened Roads (miles)	-	-	3.8	0.37	3.8	0.37	6.3	0.61	6.3	0.61
Interest Costs	@ 10%	1.28	@ 10%	4.62	@ 10%	8.71	@ 10%	14.00	@ 10%	64.89
Other Logging Costs	-	39.39	-	40.76	-	40.76	-	40.76	-	40.76
Total:		48.17		57.36		61.86		66.94		118.82
Total Harvesting Costs:	$5.46 MM		$5.32 MM		$5.74 MM		$7.58 MM		$13.46 MM	

Key:

Assumption A: Av. Cut/yr. = 21470 C cf.; Total volume is harvested.
Assumption B: Av. cut/yr. = 21470 C cf.; 5 years between passes; firebreaks etc. not harvested.
Assumption C: Av. cut/yr. = 21470 C cf.; 10 years between passes; firebreaks etc. not harvested.
Assumption D: Av. cut/yr. = 21470 C cf.; 5 years between passes; total volume is harvested.
Assumption E: Av. cut/yr. = 21470 C cf.; 10 years between passes; total volume is harvested.

TABLE XIII

SUMMARY OF COST IMPACT OF 1972 COAST LOGGING GUIDELINES FOR PALEFACE CREEK (i = 10%)

	Pre-Guidelines		After 1972 Coast Logging Guidelines							
Assumption:	A		B		C		D		E	
Total Available Volume:-	108610 C cf.		90900 C cf.		90,900 C cf.		108610 C cf.		108610 C cf.	
Total Years to Harvest:	10		14		19		26		41	
Costs:	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.
Roads (miles)	15.7	6.40	14.0	8.78	14.0	8.78	15.9	8.34	15.9	8.34
Bridges (units)	6	0.28	10	0.66	10	0.66	12	0.66	12	0.66
Road Mtce. (miles)	86.9	1.59	104.0	2.29	121.0	2.66	149.0	2.74	199.0	3.66
Reopened Roads (miles)	-	-	6.6	0.80	6.6	0.80	6.6	0.67	6.6	0.67
Interest Costs	@ 10%	1.48	@ 10%	5.07	@ 10%	9.95	@ 10%	18.96	@ 10%	97.47
Other Logging costs	-	39.39	-	40.76	-	40.76	-	40.76	-	40.76
Total:		49.14		58.36		63.61		72.13		151.56
Total Harvesting Costs:	$5.34 MM		$5.30 MM		$5.78 MM		$7.83 MM		$16.46 MM	

Key:

Assumption A: Av. cut/yr. = 13140 C cf.; Total volume is harvested.
Assumption B: Av. cut/yr. = 13140 C cf.; 5 years between passes; firebreaks etc. not harvested.
Assumption C: Av. cut/yr. = 13140 C cf.; 10 years between passes; firebreaks etc. not harvested.
Assumption D: Av. cut/yr. = 13140 C cf.; 5 years between passes; total volume is harvested.
Assumption E: Av. cut/yr. = 13140 C cf.; 10 years between passes; total volume is harvested.

TABLE XIV

SUMMARY OF COST IMPACT OF 1972 COAST LOGGING GUIDELINES FOR DEPOT CREEK (i = 6%)

	Pre-Guidelines		After 1972 Coast Logging Guidelines							
Assumption:	A		B		C		D		E	
Total Available Volume:	113260 C cf.		92710 C cf.		92710 C cf.		113260 C cf.		113260 C cf.	
Total Years to Harvest:	7		11		16		23		38	
Costs	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.
Roads (miles)	16.0	6.21	15.2	9.35	15.2	9.35	16.8	8.45	16.8	8.45
Bridges (units)	4	0.18	4	0.26	4	0.26	8	0.42	8	0.42
Road Mtce. (miles)	62.9	1.11	93.0	2.01	112.0	2.42	153.0	2.70	209.0	3.69
Reopened Roads (miles)	-	-	3.8	0.37	3.8	0.37	6.3	0.61	6.3	0.61
Interest Costs	@ 6%	0.57	@ 6%	2.23	@ 6%	3.67	@ 6%	4.48	@ 6%	11.99
Other Logging Costs	-	39.39	-	40.76	-	40.76	-	40.76	-	40.76
Total:		47.46		54.98		56.83		57.42		65.92
Total Harvesting Costs:	$5.38 MM		$5.10 MM		$5.27 MM		$6.50 MM		$7.47 MM	

Key:

Assumption A. Av. cut/yr. = 21470 C cf.; Total volume is harvested.
B. Av. cut/yr. = 21470 C cf.; 5 years between passes; firebreaks etc. not harvested.
C. Av. cut/yr. = 21470 C cf.; 10 years between passes; firebreaks etc. not harvested.
D. Av. cut/yr. = 21470 C cf.; 5 years between passes; total volume is harvested.
E. Av. cut/yr. = 21470 C cf.; 10 years between passes; total volume is harvested.

TABLE XV

SUMMARY OF COST IMPACT OF 1972 COAST LOGGING GUIDELINES FOR PALEFACE CREEK (i = 6%)

	Pre-Guidelines		After 1972 Coast Logging Guidelines							
Assumption :	A		B		C		D		E	
Total Available Volume:	108610 C cf.		90900 C cf.		90900 C cf.		108610 C cf.		108610 C cf.	
Total Years to Harvest:	10		14		19		26		41	
Costs	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.	Quantity	$/C cf.
Roads (miles)	15.7	6.40	14.0	8.78	14.0	8.78	15.9	8.34	15.9	8.34
Bridges (units)	6	0.28	10	0.66	10	0.66	12	0.66	12	0.66
Road Mtce. (miles)	86.9	1.59	104.0	2.29	121.0	2.66	149.0	2.74	199.0	3.66
Reopened Roads (miles)	-	-	6.6	0.80	6.6	0.80	6.6	0.67	6.6	0.67
Interest Costs	@ 6%	0.31	@ 6%	2.88	@ 6%	4.80	@ 6%	6.25	@ 6%	14.94
Other logging costs	-	39.39	-	40.76	-	40.76	-	40.76	-	40.76
Total:		47.97		56.17		58.46		59.42		69.03
Total Harvesting Costs:	$5.21 MM		$5.11 MM		$5.31 MM		$6.45 MM		$7.50 MM	

Key:

Assumption A. Av. cut/yr. = 13140 C cf.; Total volume is harvested.
Assumption B. Av. cut/yr. = 13140 C cf.; 5 years between passes; firebreaks etc. not harvested.
Assumption C. Av. cut/yr. = 13140 C cf.; 10 years between passes; firebreaks etc. not harvested.
Assumption D. Av. cut/yr. = 13140 C cf.; 5 years between passes; total volume is harvested.
Assumption E. Av. cut/yr. = 13140 C cf.; 10 years between passes; total volume is harvested.

more than doubled over a 10 year leave period at a 10 per cent rate of interest, and road maintenance costs were also significantly increased. The total cost of harvesting in either of the two drainages shows an overall decline in assumption B when compared to the other four alternatives. This was because the increase in cost per cunit in this guideline assumption was not great enough to offset the reduction in volume harvested. The reader should not be misled into understanding this to be a reduction in harvesting costs _per se_ under the guidelines. The volume not available in these drainages would have to be obtained elsewhere at the increased cost per cunit.

4.149 Discussion of results.

The results of this analysis show that regardless of the way in which guidelines are interpreted and what interest rates are used in the calculation, these are still substantial cost increases. A comparison of the increased logging costs per cunit with current market prices would indicate that if all the above-mentioned costs were taken into account in stumpage price calculations, a net deficit would result. The size of this deficit would depend on what leave periods and interest rates were considered appropriate. These results clearly substantiate the fears recently expressed by Mr. W.E.L. Young (Chief Forester, B.C. Forest Service):

> "...increasing costs of roads and environmental protection will mean that within a decade the forest industry will not be a net producer of revenue to the provincial government." (McMurray, 1975b)

Young mentioned the additional costs of government administration needed to assess equitable stumpage rates, as well as the higher costs of road building associated with the logging guidelines. It should be remembered that in the previous calculations, the additional cost of planning road locations and cutting block layout were those incurred by say a consulting firm in preparing an acceptable cutting permit. Costs which are incurred by other government agencies for natural resource inventories in proposed development areas, impact studies, and administrative expenses for cutting permit reviews have not been considered in this analysis. In view of the more extensive development areas proposed under the guidelines, these costs are likely to be substantial.

In order to determine the increase in logging costs due to guidelines in the Chilliwack Provincial Forest, cost increases per cunit were calculated from the results shown in Tables XII to XV and multiplied by the average annual C.U. harvest between 1970 and 1974, i.e. 77088 cunits. Table XVI shows the range of possible total cost increases incurred <u>each year</u> using both Paleface and Depot Creek cost assumptions. The third column represents a weighted average total yearly cost for both drainages. These results indicate that under certain assumptions, the total yearly cost increase for the Chilliwack Provincial Forest is not very large and may be offset by other benefits of the guidelines. Assuming that a 6 per cent interest rate is suitably representative of the long run social rate of return, and that assumption E (ten year interval between all passes) is the minimum acceptable (Ingram *pers. comm.*) the most realistic cost figure appears to be $1.423 MM. If primary firebreaks and other deferred areas are harvested more than 10 years after the main body of timber has been removed, this figure would be considerably increased.

TABLE XVI

YEARLY LOGGING COST INCREASE ALTERNATIVES FOR THE CHILLIWACK PROVINCIAL FOREST ($000)

Cost Basis:	Paleface Creek		Depot Creek		Average	
Assumption	i = 6%	i = 10%	i = 6%	i = 10%	i = 6%	i = 10%
A	-	-	-	-	-	-
B	632	711	580	708	606	709
C	809	1,115	722	1,055	765	1,085
D	883	1,772	768	1,447	824	1,606
E	1,623	7,895	1,423	5,446	1,521	6,645

Key:

Assumption A. Av. cut/yr. = 13140 Ccf; Total volume is harvested.
Assumption B. Av. cut/yr. = 13140 Ccf; 5 years between passes; firebreaks etc. not harvested.
Assumption C. Av. cut/yr. = 13140 Ccf; 10 years between passes; firebreaks etc. not harvested.
Assumption D. Av. cut/yr. = 13140 Ccf; 5 years between passes; total volume is harvested.
Assumption E. Av. cut/yr. = 13140 Ccf; 10 years between passes; total volume is harvested.

In order to determine for how long this additional cost will be incurred, some assumptions had to be made as to the size (and duration) of the future harvest in the Chilliwack. The 1962-3 Inventory Report for the Chilliwack P.W.C. (B.C.F.S., 1968), indicated a mature volume of about 4 MM cunits. If it can be assumed that the annual cut was approximately 80,000 cunits between the time of the last inventory and the year of introduction of the Coast Logging Guidelines, then the total mature volume remaining at the end of 1972 would have been 3.2 MM cunits. Two years of harvest under the guidelines represent a removal of 160,000 cunits of timber from an area twice as large as it would have been prior to the guidelines (i.e. as a result of patch logging). Therefore, the 160,000 cunits in uncut patches are unavailable for harvesting until the end of the chosen leave period. This leaves 2.88 MM cunits for harvesting on an alternate cut and leave basis, at the start of 1975. Assuming that 30% of this timber will be deferred and/or regarded as physically inaccessible for future harvesting, it will take approximately 12 years to complete the first logging pass. If this figure is greater than the average leave period for all sites, then, there may be continuity of supply for at least 24 years (ignoring any utilization improvements or maturation of previously immature timber in the meantime). The additional yearly harvesting costs due to guidelines will be incurred throught this 24 year period. A rough estimate of the present value of these future costs was obtained by assuming that the $1.423 MM figure represented a constant cost annuity over the 24 year period. Discounted at a 6 per cent rate of interest, the present value was found to be approximately $17 MM.

4.2 Evaluation of intangible costs and benefits.

4.21 Introduction

The evaluation of intangible costs and benefits (in the sense that they are produced and distributed in the absence of a market mechanism) has made significant headway in recent years, especially in the field of recreation. Coomber and Biswas (1973) provided an excellent up to date review of a number of monetary and non-monetary methods of evaluating environmental intangibles. In general, it appears that concern is increasingly focusing on the hard core of relevant issues concerning intangible costs and benefits and how we can go about making some useful estimates. Meaningful analyses have frequently been hindered in the past by a lack of information concerning non-market values. Equally important is an intuitive feeling by many people that somehow the value of say hunting and fishing is priceless or is something that cannot be quantified, and indeed should not be quantified. However, it is obvious that no goods or services are priceless in the sense of an infinite price, and, furthermore, that there is a definite individual and collective limit to how much we will give up to enjoy the services of any outdoor recreation facility or to preserve some scenic value. Furthermore, economics can take account of values of an aesthetic, deeply personal or even mystical nature (Knetsch and Davis, 1972).

It appears that the two types of logging guidelines being investigated have a number of intangible costs and benefits which are particularly difficult to assess. Not only have the effects of the guidelines on the multiple resource to be determined over time, but also their additional value to society in terms of improved fishing and hunting benefits and so on. Only with this type of information available can a meaningful comparison be made with the forestry costs and benefits already calculated.

4.21 Significance of Available Data.

The majority of available data for resources other than forestry have been quoted in the section describing the Chilliwack Provincial Forest. These data are not very helpful in assessing the absolute value of other resources, let alone any additional value derived from the guidelines. An in-depth review of forest research on environmental impacts and protection outside B.C may have revealed some useful relationships, which might have been quantified and related to the Chilliwack Provincial Forest. The sheer magnitude of such an undertaking and doubtful applicability to the conditions in Coastal B.C. prevented the author from taking this approach. It was also not clear as to whether or not such an analysis could be confined to the boundaries of the Chilliwack Provincial Forest. Logging impacts on other resources in a limited area may result in a mere redistribution of other resource users to possibly underutilized facilities of comparable quality elsewhere. On this basis it may be more valid to study regional or Provincial impacts rather than be confined to a specific area. If the objective is to maximize the economic rent derived from all resources, it becomes very difficult when the forest resource is managed within the arbitrary limits of a P.S.Y.U. boundary. There can be little doubt however, that the Chilliwack River valley possesses many unique qualities and there would certainly be a considerable loss in 'primary benefits' (Pearse, 1971) if consumers were obliged to transfer their activities elsewhere due to serious logging impacts. In summary, it appears that a quantitative analysis of intangible costs and benefits is not justified in this study primarily because of a lack of data.

4.22 Methodology of evaluation.

On the basis of the above discussion, it was decided to undertake a brief qualitative analysis of the more important intangible aspects of the guidelines. It was not the author's intention to engage in an intensive scientific review, but to outline some improtant issues which have frequently been ignored by advocates of the guidelines and which must be considered when costs and benefits are compared. The reader is directed to a useful summary of the available literature relevant to B.C. concerning the influences of harvesting and post-harvest practices upon the forest environment and resources (Bell et al., 1974). This reference provides a review of impacts and should be referred to for more detailed background information.

4.23 Impact on Local Employment.

The impact of both sets of guidelines on local employment in the Chilliwack area is likely to be minimal. Section 2.42 showed that between 1970 and 1972, between 183 and 273 persons could be directly connected to the local annual timber harvest. This represents a small proportion of the total labour force. As discussed in Section 3.6, the guidelines may have the effect of drawing away local primary and secondary wood processing facilities a lot earlier than before. Instability may result in non-diversified communities which are heavily dependent on the local timber processing industry for employment. In contrast, those less dependent and more orientated to other sectors of the economy (e.g. service and trade), may stand to benefit from increased employment in recreation activities, and say fisheries management. However, it is not certain that the guidelines could bring about such a dramatic change in recreation, fishing and hunting benefits to accomodate lost employment even in popular areas like the Chilliwack. The effect of removing Environmental Protection Forest from allowable annual cut calculations would reduce harvesting quotas, and could lead to an absolute decline in the number of people employed in the forest industry. It should be remembered that any timber shortages resulting from this policy may in fact be compensated for by improving utilization standards which, in turn, may imply increased employment.

4.24 Impacts on Recreation and Aesthetics.

The 1972 Coast Logging Guidelines make provisions for an increasing recognition and enhancement of recreational values. In several instances these appear to be confusing and ill-defined, and certainly conflict with some recreation activities. The more extensive basis of harvesting may mean that visual logging impacts are increased. This means that forest engineers must devote more time to the process of planning during the reconnaissance phase of road construction, in order to reduce this possibility. Adamovich (1971) provided some useful suggestions as to how visual impacts could be reduced. Aside from roads however, the 'giant checker-board' image of a patch cutting system also constitutes a significant visual impact (although it is recognized that beauty is in the eye of the beholder).

No matter how well roads are constructed in mountainous terrain there is still a great likelihood of slides and washouts, although their frequency may be reduced. Assuming that it is too expensive to maintain all roads (main, branch and spur) and that only those for fire access will be maintained between passes, the visual impacts of erosion are now distributed over a much greater developed area. The benefits of cutting on a more extensive basis mainly accrue to road-oriented activities, assuming of course, that fire access roads are constructed and maintained to sufficiently high standards for public vehicles. Wilderness enthusiasts who are concerned with the maintenance of a forestenvironment in its pristine state for as long as possible, are likely to suffer a considerable disbenefit although it should be remembered that they represent a minority group. In general, because more forest lands are developed under the guidelines, recreational use of these same lands will increase. The visual environment is often regarded as an important component of the total satisfaction derived from specialized activities such as hunting and fishing, and in the near perspective an alternate patch cutting system may be more pleasing that total clearcutting. However, these additional benefits will only be important when roads are satisfactorily constructed and regularly maintained for the benefit of road orientated recreationists.

4.25 Impact on Wildlife.

The provisions made in the 1972 Coast Logging Guidelines for enhancing wildlife values include restricting clearcut size and deferring areas of timber deliniated as 'critical winter range' or 'wildlife migratory corridors'. Adequate winter range appears to be very important for the maintenance of deer populations where snowfall is the major regulatory factor governing habitat selection. Although it is difficult to define the dominant variable defining suitable winter range, it appears that mature timber having a crown closure greater than 65 per cent with arboreal lichens (Alectoria spp.) is important (Jones, 1974; Eastman, 1974). Wildlife migratory corridors are essential for the unrestricted passage of animals between summer and winter ranges. Provided that risk of windblow is minimal in these areas, such measures could contribute significantly to the maintenance of existing deer populations. A possible increase in the number of deer may result from the alternate patch cut harvesting policy under the 1972 Coast Logging Guidelines. Where wildlife values are considered to be important, the guidelines suggest that the size, shape and orientation of clearcut openings will be adjusted to meet their requirements. These provisions increase the forest edge effect, and make more of the clearcut areas available for browsing than before. However, where wildlife values are regarded as being significant, it is not clear that an alternate patch logging system is the most suitable. Ideal conditions for deer populations include a diverse age class structure of mature, immature and cut-over blocks, with the latter being orientated along contours and local topography. Immature stands adjacent to clearcut areas should be sufficiently well developed to provide cover for these animals. The 1972 Coast Logging Guidelines however imply, in practical terms, square cutting blocks and the removal of alternate patches after say 10 to 15 years, resulting in two principal age classes. Furthermore, long and narrow clearcuts extending along contours at high elevation will be very difficult to regenerate naturally, because the full potential of valley winds for seed dispersal is lost. The objective of obtaining rapid regeneration by artificial and natural means also conflicts with improved forage production. The fundamental problem lies in the attempt to manage wildlife values on an extensive basis with inadequate information and regardless of land-use priorities. A more meaningful approach would be to define specific localities where wildlife values are important, and to manage these more effectively by intensive methods. To attempt to maintain an even distribution of wildlife over developed areas regardless of their relative wildlife value is not a correct interpretation of multiple use management and can only lead to a suboptimal solution.

4.26 Impact on Fish and Water Quality.

Forest harvesting methods used in the past have frequently resulted in the removal of forest cover in a manner that exposes streams to direct solar radiation, and causes increases in stream temperature. Careless road and bridge construction practices have resulted in undue erosion and sedimentation. Undoubtedly this has had an adverse effect on fish populations and water quality. The alternate patch cutting system advocated by the 1972 Coast Logging Guidelines is by no means an ideal solution to these problems. Total water yield will be decreased because more timber is left unharvested in a given area which results in increased transpiration losses. By reducing clearcut size, the melt period is extended and so early peak flows may be reduced and low stream flows increased during dry summer months. Under normal clearcut harvesting procedures the primary source of sediment is from timber access roads rather from logging disturbance. The alternate patch cutting policy does not proportionately reduce the number of roads required to harvest a given volume of timber. Archer _et al_. (1972) stated that between 80 and 90 per cent of total stream sedimentation originated from natural erosion processes. On this basis it would appear that the advocated timber cutting system would have very little beneficial impact, and may even increase the number and distribution of streams affected by sedimentation problems.

Frederiksen (1970) found that patch-cut logging with forest roads, in steep unstable headwater drainages, increased sedimentation compared with a control by more than 100 times over a 9-year period. In an adjacent clearcut watershed with no roads, and using a skyline as apposed to a conventional high-lead system, sedimentation increased three times that of the control. Frederiksen stated that landslides associated with forest roads moved the largest volume of soil, and that they occurred most often where roads intersected stream channels. Total clearcutting with skyline yarding was found to have a much smaller influence on the occurrence of landslides. This study suggests that we can expect a minimal deterioration in water quality arising from sedimentation, where distrubance from road construction is minimized by reduction of midslope road mileage through the use of specially designed yarding systems. A patch cutting system and the use of conventional high-lead equipment in Coastal B.C. is not an ideal solution to the problem. More attention should be given to making skyline systems operationally feasible, in order to reduce the principle cause of sedimentation, i.e. access roads on steep mid-slopes.

The preservation of a specified width of timbered green-strip adjacent to streams also offers a deceptively simple solution to the stream protection problem, and a number of setbacks are apparent. Firstly, 'What is a stream that is worth protecting?' There are countless rivers, streams and freshets flowing through forested land in Coastal B.C., and imposing a reserve on all streams would remove a major part of forests from timber production. Secondly, the additional edge-effect increases risk of blowdown, and this physical disturbance in addition to salvage operations may be more detrimental to fish habitat and water quality than if these trees were removed in the first place.

In conclusion it may be said that the full benefits of the guidelines for stream and water quality protection cannot be realized until there is a more comprehensive inventory of streams in terms of their habitat characteristics, fish populations and relative value. An alternate patch cutting system combined with filter strip along streams is a very expensive undertaking, with doubtful overall benefits. It is essential that their effectiveness be confirmed before they are undertaken.

4.27 Impacts on Site Productivity.

Concern has been expressed as to the renewability of high elevation forests in Coastal B.C., which are being managed on a sustained yield basis (Kimmins, 1972; 1974a). To date, the total area harvested in the Mountain Hemlock Zone has been relatively small, and most of the so-called 'high elevation logging' has taken place in the wet subzone of the Coastal Western Hemlock Zone, between the elevation of 2000 and 3500 feet. The Severe Site Guidelines reflect a desire to reduce undesirable logging impacts such as erosion which results in a loss of topsoil, a suspected loss in site productivity, and sediment in streamflow which may adversely affect fish populations and water quality. A reduction in future site productivity may appear to have immplications concerning a reduction in the future level of sustained yield, although increased volumes due to more intensive forest management and improved timber utilization must also be considered. The overall objective of management proposed by the Severe Site Guidelines was to 'protect' or 'sustain' productivity levels for difficult sites. The criterion selected was to keep undesirable logging impacts to a satisfactory level on those sites where a satisfactory regeneration plan had been prepared. Sites which did not satisfy this requirement were to be left as Environmental Protection Forests. Both objective and criterion appear to be satisfactory per se, but are liable to be misinterpretated in the following way. Firstly the difference in perspective between high and low elevation sites has yet to be recognized, and criteria should be established which show an appreciation for high elevation conditions. At the moment there is a tendancy to take management criteria suitable for low elevation sites and apply them to high elevation conditions. For example, foresters tend to get distraught when there is relatively little natural regeneration after clearcutting, or that artificial regeneration has not shown sufficient promise after 4 or 5 years. It must be realized that it may take appreciably longer for regeneration to reach breast height under natural conditions, for example up to 25 years or longer on 'low' or 'severe' sites. Before drawing conclusions about possible losses in site productivity, a realistic regeneration lag factor should be incorporated into the Hanzlik formula. There is also concern that future site productivity will be reduced because a significant proportion of the total available nutrients may be removed when the tree biomass is harvested (Kimmins, 1974c). The implicit assumption here, is that exactly the same site productivity, reflected in the size and distribution of harvestable volumes, is as important in the future as it is at present. Such an argument is debatable and takes no account of changes in technology, relative prices or the costs of preventing initial site degradation in relation to the benefits. The present net worth of any losses in the future is very small, and might easily be compensated for by improved site productivity and better timber utilization on good sites at low elevation. However, there is no conclusive evidence to support or reject the theory that an initial loss of nutrients can be adequately compensated for by nutrient accumulation over a 90 or 100 year rotation. Although the Severe Site Guidelines advocate the deletion of Environmental Protection Forest from the allowable cut calculations, the basic alternate patch cutting policy still means that logging operations will proceed to the more 'difficult' sites a lot faster than before. A progressive clearcutting policy would have meant that these sites could be harvested farther in the future. The relative price of wood may then be sufficiently high not only to cover the higher harvesting costs in difficult terrain, but also be sufficient to accomodate any environmental protection costs as are deemed necessary. Under the guidelines, the people of B.C. are forced to bear these additional costs a lot sooner.

4.28 Impacts on Forest Protection.

The Severe Site Guidelines outline the necessity of reducing the use of slashburning on ecologically sensitive sites with steep slopes and shallow soils commonly found in high elevations in Coastal B.C. For many years, slashburning has been considered as a very useful tool for fire protection and silvicultural purposes. At low elevations, it has been used with considerable success to maintain desirable seral stages (e.g. Douglas-fir stands), to improve access, to favour desirable regeneration as well as in reducing fire hazard (Kimmins, 1973). Kimmins stressed that external costs of slashburning should also be considered, such as damage to streams, damage to fish, loss of future productivity due to loss of nutrients as well as direct costs of escaped slashburns. These impacts appear to increase in more 'difficult' terrain, and the guidelines implicitly assume that these externalities outweigh the benefits of slashburning to such an extent that it is no longer justified. This assumes that alternative methods of abatement or prevention are available in high risk ecologically sensitive sites - which is frequently not the case. Smith and Gilbert (1974) analysed rates of spread and fire damage to forest cover types in B.C. They showed that although only 0.016 and 0.039 per cent of 'HB' and 'HC' (Growth Type No. 7) stands are burned annually in the Vancouver Forest District, problems of higher rates of spread from discovery to initial attack and control are accentuated in the higher elevations. The highest rate of spread from discovery to initial attack was found to be 8.4 acres per hour in the 2000 to 2999 foot elevation class. The highest control difficulty has been experienced in the 4000 to 4999 foot elevation class, where spread averaged 12.8 acres per hour from discovery to control Significant increases in control difficulty were directly related to increasing slopes. The magnitude of these figures suggest that before slashburning is stopped in high elevation areas, adequate attention is given to alternative methods of hazard abatement. The Forest Service is obligated under the Forest Act to reduce fire hazard as much as possible, and adoption of the recommendations in the Severe Site Guidelines without viable alternatives would be a clear contravention of that Act.

5.0 DISTRIBUTION OF COSTS AND BENEFITS.

In the previous sections an attempt was made to outline the economic, social and environmental implications of the logging guidelines. Effective decision making however, requires that the problem of equity is also taken into account. This means, how the costs and benefits of logging guidelines are distributed throughout society. Before discussing any equity implication, the costs and benefits must be classified on a common definitional and conceptual basis. The Policy, Planning and Evaluation Directorate of Environment Canada (1974) has recently developed such a classification system for environmental costs on the basis of work by Dales (1968) and E.P.A. (1972a; 1972b). An attempt will be made to classify the cost of logging guidelines on the basis of their system. Environmental costs were considered to be of two general types: pollution control costs and pollution costs. (Pollution was defined in the broad sense of air, water and solid wastes, but noise pollution and aesthetic degradation were also included.) Pollution control costs referred to the amount of money spent by public or private parties to <u>prevent</u> some of the damaging or noxious effects of wastes. This may be considered to represent the total cost of preventing erosion, sedimentation, aesthetic degradation and impacts of logging on fish, wildlife and recreation and so on. 'Pollution costs'on the other hand are the money value of the damages caused by wastes after they are released into the environment. For example, they may represent the socio-economic cost to society of the effects of progressive clearcut logging without guidelines. Included are 'damage avoidance costs' which prevent the harm that pollution causes (e.g. treating municipal water supplies to reduce high sediment content), and 'damage costs' resulting from pollution damage that is not prevented (e.g. loss of spawning beds, loss in site productivity etc.). These costs are illustrated in Figure 11. For the purpose of this discussion, only pollution control costs (or the financial cost of logging guidelines) will be examined in more detail.

Environment Canada (1974) stated that these may be subdivided into three main categories: catch-up costs, expenditures and annualized costs. 'Catch-up costs' refer to the additional costs which are necessary to meet present environmental (guideline) standards. 'Expenditures' include catch-up costs and the costs which are already being incurred. They are necessary to assess the short run economic impacts of closing the gap between the required or desired level of environmental protection and the actual level. Once this gap has been closed, then expenditures will tend to approximate 'annualized costs' which are the actual accrued costs for a one year period. Previous calculations of the cost per cunit increase due to guidelines have resulted in an estimate of the annualized cost for the Chilliwack Provincial Forest i.e. $1.423 MM. Because of the varying interpretations of the guidelines, it is likely that there will be catch-up costs of varying degrees throughout Coastal B.C. The differences in cost between Assumptions B, C and D when compared to Assumption E in Tables XII to XV may be considered as estimates of catch-up costs if Assumption E will lead to the desired level of environmental protection. All three categories of cost were divided into 'public sector costs' and 'industrial sector costs' with 'public' meaning government plus private individuals, and 'industrial' referring to business firms (Figure 12). This cost subdivision is extremely important when discussing the financial impacts of logging guidelines,

Figure 11

TYPES OF ENVIRONMENT COSTS

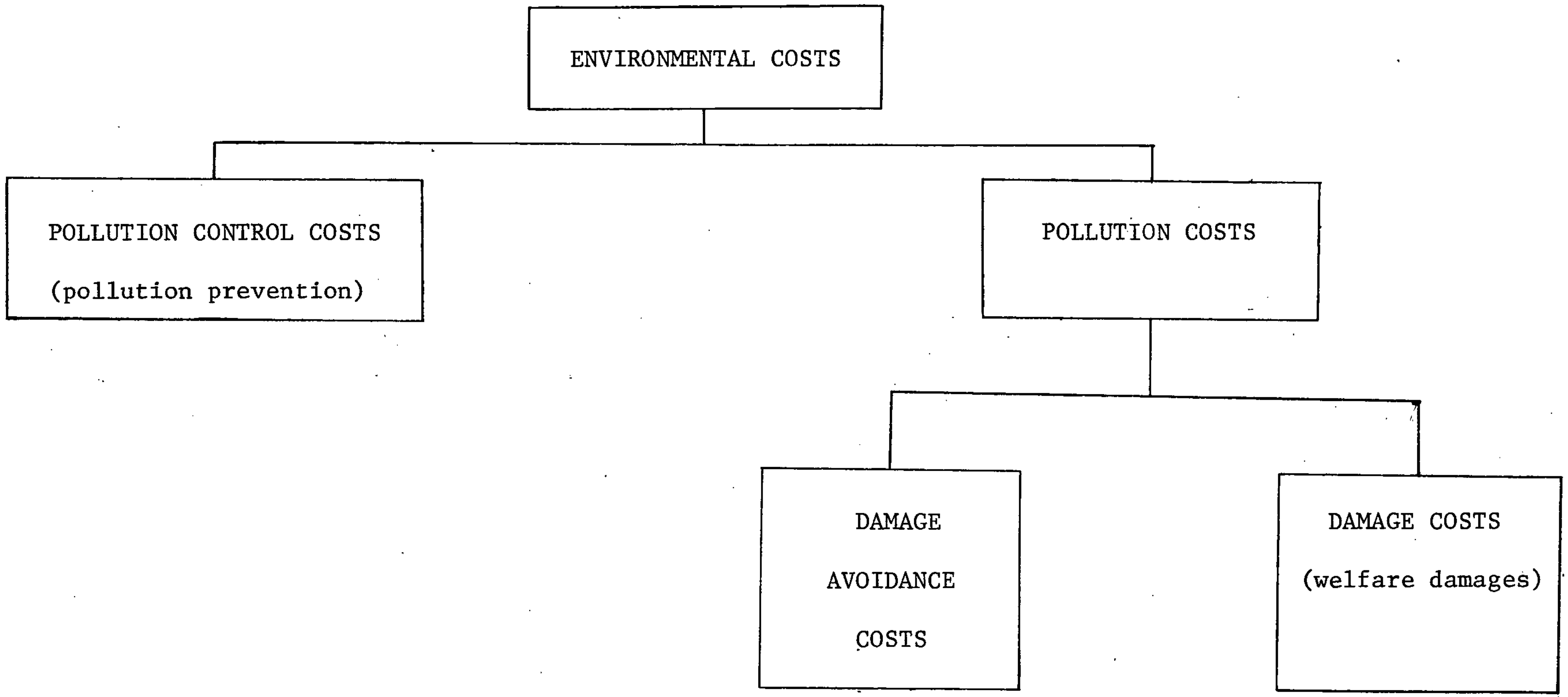
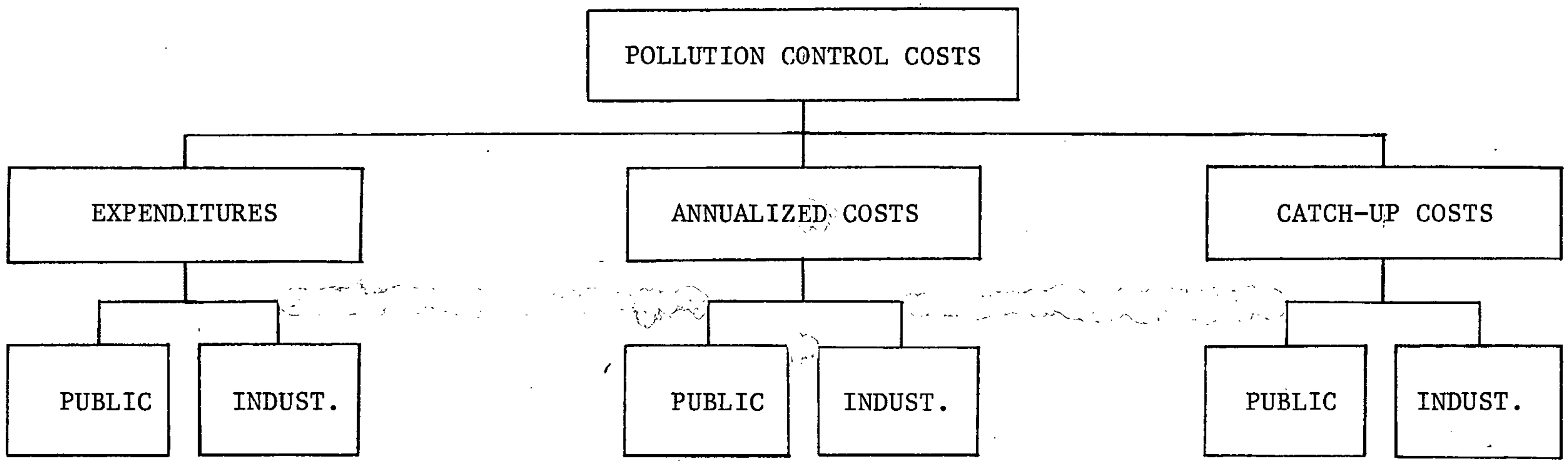


Figure 12

POLLUTION CONTROL COST COMPONENTS



and raises the problem of income distribution and equity. The current stumpage appraisal procedure is designed to establish a net value of a tract of timber to be harvested by subtracting from the estimated value of the products that can be removed, the costs that are necessary to realize these values, including a return to the operator. In other words a stumpage price represents the residual value of standing timber. If Government policy requires that the operator meets additional logging standards, then this should be reflected in a reduction in the stumpage price he has to pay for the timber and not a reduction in the allowed profit margin. Any reduction in Government revenue would necessarily have to be compensated for by increased taxation of private individuals. It is not clear however that society as a whole should have to pay for increased environmental protection standards. A more equitable solution would be to increase the cost of hunting and fishing licences and perhaps charge entrance fees for recreationists. After all, it is these people which presumably wanted more environmental protection to protect their own interests in the first place. The desires of special interest groups should not be reflected in a burden upon society as a whole, or for that matter on logging operators who are improperly assessed for stumpage. Comments made by private industry (see Section 3.5) suggest that current stumpage appraisal calculations have not taken full account of the additional costs of logging guidelines, and every effort must be made to remedy this situation in the future. One important cost which has so far been ommitted from the discussion, is what the U.S. Council on Environmental Quality has termed 'transaction costs' (Environment Canada, 1974). Transaction costs are the costs of research, development, planning, monitoring, and enforcement needed to achieve environmental goals and standards. Part of the Canada Department of Environment's budget and that of the Provincial Government agencies connected with administering the guidelines would comprise the bulk of this cost. These costs are likely to increase a great deal in the future as a result of the more extensive nature of logging under an alternate patch cutting system.

6.0 FINAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The previous analyses and discussion have attempted to outline some of the more important issues associated with the 1972 Coast Logging Guidelines and the Severe Site Guidelines. In economic terms it was shown that the alternate patch cutting philosophy common to both sets of guidelines was a major factor contributing to increased logging costs and an overall decline of up to 60% of the potential economic rent per developed acre. The size of the increase in logging costs per cunit was found to be very sensitive to interest rates and the length of the leave period between consecutive harvesting passes. It was estimated that the application of logging guidelines to harvesting operations in the Chilliwack Provincial Forest would result in an extra annual cost of at least $1.423 MM over the next 24 years. Furthermore it appeared that if all of the guideline recommendations were fully implemented, the size of the extra cost would mean that Coastal B.C. forests would no longer represent a revenue producing resource.

Although the nature and significance of future timber deferrals and utilization improvements is uncertain, the alternate patch cutting system with long leave periods suggested that local timber supply shortages may develop in the near future. This would have significant impact on small undiversified communities highly dependant on the local timber processing industries for employment. In this regard the guidelines may contradict one of the sustained yield objectives of community stability. The logging industry was found to be fourth in importance in the Chilliwack area, and no major impacts on future employment may be expected in this case.

Although the guidelines were intended to reduce environmental impact, the previous discussions would seem to indicate that problems of erosion, sedimentation and aesthetic impact may even be increased overall, because of the more extensive basis for development. Windblow problems are also likely to be more significant. The size of increased recreational benefits realized from the guideline recommendations was considered to be very dependent on whether or not access roads are maintained to a sufficiently high standard for public access.

In general, it may be said that some form of logging guidelines was long overdue, and that these documents represent a good 'first approximation' solution to the problem. However, it is imperative that they be constantly reviewed and updated in the light of changing socio-economic circumstances and results of research. Recent concerns expressed by Government agencies, private industry and university suggest some guideline revisions will be necessary in the near future. Although economic analyses have shown the serious financial implications of the guidelines in their present form, this should not be interpreted as meaning that more environmental impacts are necessary to keep the logging industry in business. On the contrary, it may merely mean that the guidelines as presently interpreted are an inefficient means with which to obtain multiple use objectives. It is the opinion of the author that more attention has to be devoted to the problem of land-use planning and the establishment of land-use priorities. In this way funds can be more specifically directed to achieving clearly stated objectives in an efficient manner. The present system of protecting all resource values on an extensive basis will inevitably lead to unresolvable conflicts.

Although the 1972 Coast Logging Guidelines were originally intended to be flexible, the most important aspect - the alternate patch cutting system - has been applied to all development areas. If continued, this basic policy may have profound economic, social and environmental consequences. Serious consideration should be given to the possibility of more careful progressive clearcut logging. The money saved in interest charges from road development under the existing guidelines would adequately pay for measures such as streambank reforestation with hardwoods, careful road construction and maintenance, and rapid reforestation of clearcut areas. On the other hand, more sophisticated silvicultural systems could be applied to areas where say wildlife and fisheries values are of particular importance.

In terms of high elevation forests, it may be useful to delineate temporary Environmental Protection Forest boundaries which represent the limit of economically accessible timber. Normal logging costs together with the estimated cost of environmental protection measures required would have to be included in the analysis. This boundary would represent the level to which timber can be satisfactorily harvested from both an economic and ecological point of view at a given point in time. This implies that the limits may change depending on future price increases, technological improvements and environmental concern. It would therefore be incorrect to delete the total area of these forests from allowable annual cut calculations. Some reasonable allowance should be made for areas which are likely to be harvested in the future. This policy would not require the vast amounts of extra roads required under the usual logging guidelines, and would certainly increase the returns to the Provincial Treasury because economically sub-marginal stands would no longer be harvested.

In terms of future research needs, the efficiency by which guidelines implement sustained yield objectives and the extent to which the aforementioned financial analyses apply outside of the Chilliwack Provincial Forest should be determined. In addition there is a need to relate the results for Paleface and Depot Creeks to the Dewdney P.S.Y.U. as a whole, using appropriate mathematical modelling approaches.

Two major fields may also be worth investigating. Firstly, the possibility of introducing logging systems which have much longer yarding distances should be studied because the most significant environmental impacts from harvesting in mountainous terrain are related to the access roads. The "Grabinski" conversion of conventional high lead systems has been used very successfully in Washington State by the Department of Natural Resources and yarding distances of up to 1500 feet are common. This compares with an average of 600 feet for operations on the Coast of B.C. The number of roads required could be considerably reduced using this system, and the cost saving would easily compensate any minor reductions in volume production. Secondly, serious attention should be given to the use of more intensive forest management techniques on good sites at low elevations. Yields per acre can be significantly improved by using higher yielding species, more effective initial spacing, thinning and fertilization. The improved volume production might provide an alternative to harvesting of high elevation forests until more can be learned about how they can be managed by economically and ecologically sound methods.

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APPENDIX I

Copies of:

Planning guidelines for Coast logging operations.

Interim guides - logging on severe sites - Vancouver Forest District.

FOREST SERVICE

VICTORIA, BRITISH COLUMBIA

September 29, 1972.

PLANNING GUIDELINES FOR COAST LOGGING OPERATIONS

A. The general practice shall be to clear-cut to the close utilization standards, with the objective of creating even-aged stands on the sites harvested. Logging must be conducted in such a manner that fire hazard is reduced to an acceptable standard and the cutting area is satisfactorily prepared for the future crop. In addition to cutting all species to a minimum diameter limit, falling of all trees ten feet and over in height, regardless of merchantability will normally be required.

Of great concern is the matter of protection of water quality and the maintenance of a managed environment suitable for the preservation, protection, and regulation of other users of the forest habitat. Measures must be taken to ensure that all protective forest cover is not removed, but rather that sufficient trees or blocks of forest are left to meet the necessary requirements of the other users. Protective cover requirements will vary with wildlife species present and their habitat requirements, size of stream, type of bed, water-flow continuity, the present or potential value for fish and game, human consumption, and recreational use. Wildlife and fish habitats of significance must receive special consideration. Normally, many different types of forest cover will be present over the greater percentage of any managed unit and they must be recognized and deliberately incorporated into area plans. These include:

(1) inaccessible trees which occur in steep rocky canyons and on steep bluffs;

(2) tree growth occurring on unstable, erodible cutbanks,

(3) leaning trees along water-courses and shorelines which cannot be removed without causing environmental damage;

(4) fast-growing deciduous trees of suitable species, not subject to extra-site encroachment, planted along water-courses or shorelines either prior to logging or after slash burning;

(5) primary timbered leave strips for fire control and their replacements;

/2

(6) leave blocks which will not be cut until adjacent blocks are reforested to the stage required to assure compatible integrated use;

(7) filter strips between roads or openings and waterfront or stream banks, held temporarily pending stabilization of run-off within the developed area;

(8) pre-established second-growth timber or satisfactorily renewed immature stands resulting from earlier cutting or from other causes such as fires, and not forming part of present cutting areas.

(9) forest cover in parks or other ownerships not being cut over;

(10) needed wildlife corridor patches held pending re-positioning into renewed forests or alternative areas;

(11) forest recreational use development areas;

(12) forest utilized as "surround" for unique features;

(13) forest temporarily held in pocket or strip for recreation areas, pending development and eventual re-positioning into alternative areas;

(14) forest temporarily held on alternate "50 percent" cut program for watershed protection, held pending development of new forest on adjacent cut-over areas to the stage required to assure compatible integra.ed use.

(15) stream-face or shoreline blocks subject to special treatment, stand improvement, or special cutting system.

Forest land within a watershed will be harvested under the multiple use concept. Consistent with the incorporation of forest recreation, game habitat, and watershed management into cutting plans designed to accommodate these and other resource uses, mature timber, extending to stream borders, may be harvested using such special measures as deemed necessary. These measures will prevent stand decadence and ensure the renewal of forest growth along water courses within a time sequence logical to a managed forest environment. Only in this way can quality stream maintenance, as well as the needs of people, be provided for simultaneously. Examples of using special measures where necessary may include: approved forms of selective cutting,

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cutting narrow strips or smaller patches, mechanical or other powered methods of controlling the direction of tree fall, felling of trees from opposite banks and lifting clear to avoid environmental damage, etc. Such measures will often involve precise timing of critical operations, such as road and bridge development, stream clearing or improvement and other forestry operations that can best be done at certain times of the year, depending on the circumstances within the particular managed unit.

B. The size, shape and orientation of clear-cut openings shall be based on an analysis of forest regeneration, logging economics, fire protection, fish and wildlife production, soil protection, aesthetic appeal, water quality maintenance, etc. In other words, utilization of all resources and compatible integrated use shall dictate the size, shape, and orientation of each individual proposed opening. Normally, the openings should be kept as small as practicable and, as a basic guideline, the size of a clear-cut opening will not exceed 200 acres unless the aforementioned factors dictate otherwise.

C. Logging in deferred areas, adjacent to the initial clear-cut openings, will be considered when hazard has been abated and restocking requirements are met within the first opening and the maintenance of other resource values is assured.

D. Clear-cutting will be based on an alternate system of cut and leave patches. The location of the patches must be adjusted to meet the needs of other integrated uses. Also, an alternate patch system is required to reduce the potential for increased water temperature, sediment, and logging wastes that could reach perennial streams or lakes. The percentage of the total stream face or lake to be opened during any one phase of patch-logging will depend on the sensitivity of the particular area to logging disturbances. As a guide, no more than 50 percent of a stream or lake face will be opened during one phase. At no time during the same phase will two cut openings be permitted to face each other across a perennial stream unless the maintenance of other resource values has been assured.

E. All logging adjacent to streams, stream-beds, and lakes must be regulated so as to ensure there is no violation of stream protection requirements. Setting boundaries and yarding plans shall coincide with water-courses so that there is no yarding damage. The protection of water quality will normally require care and special measures in falling, bucking, and yarding away from the stream or lake, and cutting will not commence until the boundaries have been approved.

4/

F. Cutting within approved openings adjacent to streams or lakes when required will be regulated so that a filter-strip adjacent to the stream or lake will be reserved until the last logging sequence within the opening. To effect good stream-bank clean-up, care and special measures will be taken in falling, bucking, and yarding away from the stream or lake.

G. Stands which would be uneconomic to treat will be excluded from within approved cutting boundaries unless their inclusion is necessary to the creation of the proper size, shape, and orientation of the treated site in its finished form. Similarly, certain stands or portions of stands which could be economically treated, but whose exclusion is required by the proposed pattern of cutting, will be excluded from the approved cutting boundaries.

H. Approval for further cutting in untouched stands will only be given where acceptable logging plans and utilization standards pertain to the timber in question and to any adjacent stands of lower value which should be logged. Rehabilitation planning for older partially logged or poorly stocked old growth forest must be co-ordinated with the plans for logging the adjoining standing green timber or it will be necessary for the proposed new cutting to be deferred to some future date.

I. All satisfactorily-stocked immature forests of manageable proportions surrounding or adjacent to mature merchantable timber will be reserved and protected.

J. All roads, (main roads, secondary roads, spur roads, and skid trails) must be planned, located, designed, constructed, used and maintained in such a manner that their impact on the total managed unit will be an acceptable minimum by:-

(1) locating roads away from streams, narrow canyons, slide areas, and marshes;

(2) locating roads on benches, ridge tops, and flatter slopes to minimize harmful disturbances and improve road stability;

(3) prescribing for each road those design specifications that are best adapted to given slopes, topography, and soil materials;

(4) disposing of the slash and debris concurrently with construction;

/5

(5) building culverts large enough to handle a 25-year frequency storm. Aprons or troughs should be installed where needed to carry runoff water over unstable fills to the undisturbed soil below the culvert;

(6) minimizing soil disturbance in road construction by working only while soil moisture conditions are favourable (i.e. not too wet)

(7) adopting regular maintenance programs which should include inspection and clearing of ditches and culverts as well as grading of roads;

(8) constructing cross drains and water bars on skid trails, spur roads, and secondary roads to control and direct runoff which collects at the road, particularly away from creeks;

(9) revegetating cutbanks and fill slopes where necessary in some areas to prevent erosion.

K. Operating plans and proposals are subject to approval prior to implementation and the Forest Service will consult with other resource managers to ensure that their input will assist in attaining the basic objective of maintaining an environment satisfactory and suitable to the needs of all British Columbians.

L. These guidelines are considered to be an essential facet to an effective base for planning, resource allocation and management of operations and constitute the minimum requirements for forward planning. However, they must not be construed as being absolute. Particular forest units, special circumstances, or needed objectives and policies will also dictate the resultant planning and treatment required for development and cutting plans.

I. T. Cameron, R.P.F.
Chief Forester.

INTERIM GUIDES - LOGGING ON SEVERE SITES - VANCOUVER FOREST DISTRICT

INTRODUCTION

The Reuter Report (High elevation reforestation problems in the Vancouver Forest District) has focussed considerable attention on present forest practices. There is little doubt that regeneration success on severe sites is frequently unsatisfactory. Efforts to regenerate for example, high-altitude clear cuts have achieved only partial success - planting as a standard procedure involving limited species choice, shows progressively higher failure rates with increased elevation. Current clearcutting methods and slash burning practices are generally not compatible with natural regeneration in terms of size of opening and damage to advance regeneration during logging.

For practical purposes, most land over 2,500 feet elevation is involved - nevertheless, full recognition of the individuality of severe-site habitats is needed. To maintain reasonable site productivity, by minimizing erosion and encouraging regeneration, adjustments in stand treatments and logging techniques are needed on any site where extremes of climatic, edaphic and topographic features are encountered. Because of site variability, silvicultural treatment must be determined on the basis of a site - specific recommendation for all forest units under Management; Pre-logging examination is essential.

Forests of limited productivity in the Mountain Hemlock Zone, even if marginally economic at this time, may be excluded from logging and held as environmental or protection forests. The productivity of these and other forest types, the application of research and the designation of silvicultural treatment may be arrived at by noting and using bedrock geology, surficial deposits, habitat types and land from to segregate management units.

It is apparent that information to fully substantiate guidelines for logging extreme sites does not exist. Research must fill information gaps and provide knowledge for guide modification, on a rational basis. As a further adjunct to reforestation choice, research emphasis will be given to nursery and plantation trials of high elevation species (yellow cedar, mountain hemlock and true fir).

I. Objective

To sustain productivity levels of severe forest sites by adjusting present management practices and allowing greater flexibility of silvicultural choice. Natural seeding and the utilization of good quality advance regeneration to restock logged areas is to be encouraged; reliance on plantations of one or two low-slope conifers should be reduced as well as the subsequent high costs attributable to plantation failure.

Exceptions to the clear cutting, opening size and site protective constraints that follow will be allowed if the regeneration plan is developed from appropriate habitat mapping accompanied by realistic site specific interpretations.

II. Stand Treatment

The management of high elevation stands requires that as a prerequisit to preparation of the regeneration plan the area be thoroughly examined before it is logged.

In considering management alternatives for those areas with acceptable advance regeneration the objective should be to protect any existing advance regeneration that is of a quality as defined on Page 4.

Preservation of advanced regeneration requires proper planning, logging method adjustment and good timber utilization (hazard reduction). Often improvement in residual stocking is needed; fill-in planting and the retention of adjacent seed sources for longer periods of time may be required.

1) Clearcutting

Clearcutting should be confined to those forest habitats with the following characteristics:

A. Relatively deep soil phases. (i.e. clearcutting should be avoided on shallow soils with frequent bedrock outcrops).

B. Well-drained to moderately well-drained soils.

C. Underlying bedrock types which are favourable in terms of stability.

D. Stable geomorphic characteristics, especially slope angle.

2) Size of openings

In many instances, the shape and size of clearcut openings must be modified and reduced from present maximas. Opening size should vary with presence or absence of advance regeneration. Where advance regeneration is absent, openings should be kept small enough to provide for adequate natural seeding when required. Unit upper and lower size limits will vary between north and south facing aspects, slope, location and density of advanced regeneration, protection requirements (disease and fire hazards), wind resistance, environmental factors affecting germination and survival, economics, etc. Specifically, opening size must conform to the following.

A. The effective seed dispersal distance of the adjacent stand should be considered when designing opening size and shape. If the clearcut is a square it should not exceed 40 acres in size. If the clearcut is larger than 40 acres the width of the clearcut should not exceed 20 chains. (The 40-20 rule).

B. No adjacent clearcuts to be logged until previous clearcut is satisfactorily stocked, unless such additional clear-cuts comply with 40-20 rule. ie. the operator can extend a 20 chain wide strip indefinitely as far as regeneration is concerned.

C. Where applicable, small blocks of timber may be employed as seed sources. They should be positioned for good seed dispersal and ease of harvest later. Mechanical scarification may be employed to reduce hazards and prepare sites where suitable.

3) Site Protection

Continued site productivity and the protection of advanced regeneration depends on a well-designed logging plan. Logging equipment must be suited to the terrain. Due consideration must be given to design, location and construction of roads to minimize regeneration damage and soil disturbance. Logging activity, the use of tractors and other equipment must be controlled by adequate supervision. Specific constraints are:

A. Slash burning should be drastically reduced. Sound silvicultural reasons will be required before slash burning will be approved.

B. No tractor or skidder logging on slopes exceeding 30 per cent. On lesser slopes the surface drainage patterns must be re-established to pre-existing conditions after logging has been completed.

4) Economics

The intemperate application of management policies designed to protect understories and encourage natural regeneration may have an adverse effect on wood production and economic return particularly where access is difficult and operating seasons are short. On the other hand, few restrictions to high elevation silviculture and planning may increase, drastically, the costs of reforestation, reduce even further the marginal productivity of some sites and ultimately force a reduction in allowable cuts.

Where a prescribed treatment will lower log production below the economic threshhold, it may be necessary to withhold the harvest of these stands until more optimal conditions for logging and reforestation exist.

III. Residual stands

Many stands have an understory of advanced growth with potential reforestation value. Because of wide variation in the quality and quantity of understory regeneration, a pre-and post-logging evaluation of stocking is required.

Unfortunately, better information is needed to correlate the physical appearance, age and quantity of residuals with requirements for future growth. The radial effect of high lead logging may cause excessive scarring of understories - balsam wooly aphid can pose a serious threat to amabilis fir. In these later instance, however, no aphid infestation has been found above 2700' in the Vancouver District - nor does scarring damage to balsam at cool elevations seem to acerbate the incidence of heart rot. Growth response of Amabilis fir, following logging is not significant for about 4-6 years. Moist habitats with good drainage and cooler summer temperatures favour Amabilis fir. Response is poor on dry rocky soils.

(a) Acceptable advanced regeneration

Local examinations of advanced growth (e.g. balsam), released by logging from overstory competition, may provide some clue as to its potential reforestation value. In the absence of local information about advanced growth and its capabilities, the following criteria must be met:

1. Sufficient advanced growth must be sampled to determine disease condition and average age. Stems or stands exhibiting mistletoe infections or excessive rot should be disqualified. Age, as a factor of release potential, is difficult to assess - some trees over 100 years are capable of release. Nevertheless, stem crown quality can deteriorate with age. A decision to accept or reject can often be based on a sampling of bole and crown characteristics to determine quality. Generally, residuals over 70 years of age may be judged inadequate as replacement stands.

2. Crown length and size must be capable of sustaining good growth. Extensive, well-shaped crowns are usually associated with "seedling-size residuals" in the younger age classes. As a rule, quality class 1 stems ("zeros", 0 - 10 inches d.b.h., good stem and crown) are favored. In borderline situations, stem classes above 1.1 inches should only be considered as an adjunct to quality class I stocking in

deciding whether or not standards have been met. These "second quality" stems must also rate high on the scale of value for crown vigor, stem shape, age and disease condition.

3. Minor abnormality in stem form, such as crowded branch internodes or slight crooks are acceptable if they can be outgrown after release and the seedling or sapling has suffered no mechanical damage.

4. Residual stands containing 250 well-distributed seedlings (quality class 1, zeros) per acre after logging can be considered stocked. Stands having less than 250 seedlings may be eliminated and a new stand started unless seedling residuals can be readily upgraded by fill-in planting or heavily supported by quality stems above 1.1 inches d.b.h. Pre-commercial spacing, for quality and growth, may be necessary.

IV. Limited Timber-growing sites (Protection forest)

Many severe habitats (e.g. upper slope) appear marginal in terms of growth potential and available nutrient levels. Also, critical is the potential for soil erosion and compaction. Unless harvesting can be carried out economically without significant deterioration of such habitats, then harvesting should be prohibited. Stands whose major tree elements have site indices of less than 65 (base 100) or soil mantles of less than 1 foot over bedrock should not be logged.

The occurrence of mountain hemlock is an indication of decreasing stand productivity - total stand growth being poor where mountain hemlock occurs in frequency greater than 30 percent of the stand. Within the forest subzone of the Subalpine Mountain Hemlock zone, forest units on moderately dry rocky habitats or habitats with shallow soil appear obvious candidates for protection forests. Similarly, most units which can be classed as being mesic with shallow to deep soils fall within the same protection class. Economic selection (removal of better stems) of even the marginal stand at lower elevations in the Mountain Hemlock zone, is not recommended as a means of stand replacement - reservation from cutting, except experimentally, is indicated. Unless upper slope research determines otherwise, forest harvest should be restricted to moist habitats with deep soils supplied with temporary or permanent water seepage.

The guidelines are not intended to resolve all resource allocation or conflicts at high elevations. Cutting must comply with other published guidelines for coastal logging operations. Full account must be taken of the recreational,hydrological, edaphic etc. features of the area.

APPENDIX II

Net present worth computer program.

```
0001           REAL TA,GNAC,GSAC,MNAC,PNAC,PSAC,TVOL,FVOL,CVOL,HVOL,BVOL,CYVOL,MA
              *IN,BRANCH,SPUR,MTCE,REOPEN,DR,DC,INT(3),MTCOST(3),MNCOST(3),MSAC,L
              *YMT,NDESC,NDR,DCOST
0002           INTEGER CREEK,OPERAT,CA,YR,NER,SER,CCPAT,CCNO,A,B,C,D,E,  NORTH(4)
              *,SOUTH(4),V,BURN,S,ULIM,ROTATN(2,3,5),BRIG1,BRIG2,BGCULV,SMCULV
0003           DIMENSION YIELD(2,3,5),FP(3),CP(3),HP(3),BP(3),CYP(3),F(3),C(3),H(
              *3),B(3),CYPR(3),CY(3),CT(3),CC(3),CZ(3),CF(3),CG(3),CO(3),BRCOST(3
              *),SPCOST(3),RECOST(3),BRIG1C(3),BRIG2C(3),SMCULC(3),BGCULC(3),PLCO
              *ST(3),PLANT(2,3,4,5,3),SUMNDR(3,2,5,2,3),TSCNDR(3,2,5,2,3)
0004           COMMON/B1/ROTATN,YIELD
0005           COMMON/B2/NORTH,SOUTH
0006           COMMON/B3/FP,CP,HP,BP,CYP,F,H
0007           COMMON/B4/CY,CT,CC,CZ,CF,CG,CO,MNCCST,BRCOST,SPCOST,RECOST,BRIG1C,
              *BRIG2C,SMCULC,BGCULC,PLCOST,INT,MTCOST
0008           COMMON/B5/PLANT
         C     TITLES
0009           DIMENSION CRK(5,2),OPR(14,5),CAS(9,2)
0010           DATA CRK/'DEPO','T CR','EEK',2*' ','PALE','FACE',' CRE','EK',' '/,
              *OPR/'TOTA','L VO','LUME',' REM','OVAL',' OPE','RATI','ON',6*' ','A
              *CTU','AL O','PERA','TION',10*' ','1972',' GUI','DLIN','E OP','ERAT
              *','ION',8*' ','SEVE','RE S','ITE ','GUID','ELIN','E OP','ERAT','IO
              *N',' (E.','P.F.',' PER','MANE','NT).',' ','SEVE','RE S','ITE ','GU
              *ID','ELIN','E OP','ERAT','ION',' (E.','P.F.',' SEM','I-PE','RMAN',
              *'ENT)'/,CAS/'ACTU','AL P','LUS ','AVER','AGE',' CUT',' PER',' YEA'
              *,'R','AVER','AGE ','CUT ','PER ','YEAR',4*' '/
0011           WRITE(6,400)
0012      400  FORMAT('1',37X,'*********************************************
              *****')
0013           WRITE(6,401)
0014      401  FORMAT(38X,'*',6X,'FINANCIAL IMPACT OF LOGGING GUIDELINES',7X,'*')
0015           WRITE(6,402)
0016      402  FORMAT(38X,'*',21X,'IN THE',24X,'*')
0017           WRITE(6,403)
0018      403  FORMAT(38X,'*',11X,'CHILLIWACK PROVINCIAL FOREST',12X,'*')
0019           WRITE(6,404)
0020      404  FORMAT(38X,'*',1X,'(IN TERMS OF DISCOUNTED PRESENT VALUE OF EXISTI
              *NG',1X,'*')
0021           WRITE(6,405)
0022      405  FORMAT(38X,'*',14X,'AND SUCCESSOR CROP)',18X,'*')
0023           WRITE(6,406)
0024      406  FORMAT(38X,'*************************************************'
              *//)
0025           WRITE(6,407)
0026      407  FORMAT(18X,'KEY:'/)
0027           WRITE(6,408)
0028      408  FORMAT(12X,'A1 = B.C.F.S APPRAISED COSTS AND MARKET PRICES FOR APR
              *IL 1974')
0029           WRITE(6,410)
0030      410  FORMAT(12X,'A2 = C.F.I ESTIMATED COSTS AND MARKET PRICES FOR APRIL
              * 1974')
0031           WRITE(6,409)
0032      409  FORMAT(12X,'A3 = CATTERMOLE TIMBER LTD. COSTS AND MARKET PRICES FO
              *R APRIL 1974')
0033           WRITE(6,411)
0034      411  FORMAT('0',11X,'B1 = NO SLASHBURNING')
0035           WRITE(6,412)
0036      412  FORMAT(12X,'B2 = SLASHBURNING')
0037           WRITE(6,413)
```

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FORTRAN IV G COMPILER        MAIN         03-10-75         23:55:11        PAGE 0002

0038     413   FORMAT('0',11X,'V1 = COASTAL HEMLOCK')
0039           WRITE(6,414)
0040     414   FORMAT(12X,'V2 = DOUGLAS FIR')
0041           WRITE(6,415)
0042     415   FORMAT('0',11X,'S1 = OPEN STOCKING')
0043           WRITE(6,416)
0044     416   FORMAT(12X,'S2 = SPARSE STOCKING')
0045           WRITE(6,417)
0046     417   FORMAT(12X,'S3 = NORMAL STOCKING')
0047           WRITE(6,418)
0048     418   FORMAT(12X,'S4 = DENSE STOCKING')
0049           WRITE(6,419)
0050     419   FORMAT(12X,'S5 = VERY DENSE STOCKING')
0051           WRITE(6,420)
0052     420   FORMAT('0',11X,'L1 = OPTIMISTIC NT TO PLANT')
0053           WRITE(6,421)
0054     421   FORMAT(12X,'L2 = AVERAGE NT TO PLANT')
0055           WRITE(6,666)
0056     666   FORMAT(12X,'L3 = PESSIMISTIC NT TO PLANT')
0057           WRITE(6,888)
0058     888   FORMAT('0',11X,'INTEREST RATE = 8%')
0059           WRITE(6,789)
0060     789   FORMAT('0',11X,'FIGURES BELOW SHOW SUCCESSOR N.D.R AS A PROPORTION
              * OF TOTAL N.D.R.')
         C     MAIN PROGRAM BEGINS HERE
0061           CALL YEAR
0062           CALL PRICE
0063           CALL COST
0064           CALL LAG
0065           CALL PLANTS
0066     430   CONTINUE
0067           CALL SET(180,SUMNDR,0)
0068           CALL SET(180,TSCNDR,0)
0069     220   READ(5,1,END=10) CREEK,BRIG1,OPERAT,BGCULV,CA,YR,TA,GNAC,GSAC,MNAC
              *,MSAC,PNAC,PSAC,NER,SER,CCRAT,TVCL,FVCL,CVOL,HVCL,BVOL,CYVOL,MAIN,
              *BRANCH,SPUR,MTCE,RECPEN,BRIG2,SMCULV
0070     1     FORMAT(5I1,I2,F5.0,6F3.0,3I1,F5.0,4F4.0,F2.0,3F4.3,F5.3,F4.3,I1,I2
              *)
0071           IF(YR.EQ.-1) GO TO 9999
0072           DO 19 A=1,3
0073           DR=((FVOL*10.*FP(A))+(CVOL*10.*CP(A))+(HVOL*10.*HP(A))+(BVOL*10.*B
              *P(A))+(CYVOL*10.*CYP(A)))/(1.0+INT(A))**YR
0074           DCOST=(TVOL*10.*(CY(A)+CT(A)+CC(A)+CZ(A)+CF(A)+CG(A)+CO(A)))/(1.0+
              *INT(A))**YR
0075           DO 20 BURN=1,2
0076           DO 21 S=1,5
0077           IF(BURN.EQ.1) GO TO 22
0078           ULIM=2
0079           GO TO 23
0080     22    ULIM=1
0081     23    DO 24 V=1,ULIM
0082           IF(CCRAT.LT.1)GO TO 100
0083           IF(V.EQ.2) GO TO 777
0084           Y1=H(A)
0085           GO TO 780
0086     777   Y1=0.0
0087     780   IF(V.EQ.1) GO TO 778
0088           Y2=F(A)
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0089                 GO TO 779
0090         778     Y2=0.0
0091         779     NDRSC=((GNAC*YIELD(V,1,S)/100.)*(Y1+Y2))/((1.0+INT(A))**(YR+NORTH(
                    *CCRAT)+ROTATN(V,1,S)))
0092                 NDRSC=NDRSC+((GSAC*YIELD(V,1,S)/100.)*(Y1+Y2))/((1.0+INT(A))**(YR+
                    *SOUTH(CCRAT)+ROTATN(V,1,S)))
0093                 NDRSC=NDRSC+((MNAC*YIELD(V,2,S)/100.)*(Y1+Y2))/((1.0+INT(A))**(YR+
                    *NORTH(CCRAT)+ROTATN(V,2,S)))
0094                 NDRSC=NDRSC+((MSAC*YIELD(V,2,S)/100.)*(Y1+Y2))/((1.0+INT(A))**(YR+
                    *SOUTH(CCRAT)+ROTATN(V,2,S)))
0095                 NDRSC=NDRSC+((PNAC*YIELD(V,3,S)/100.)*(Y1+Y2))/((1.0+INT(A))**(YR+
                    *NORTH(CCRAT)+ROTATN(V,3,S)))
0096                 NDRSC=NDRSC+((PSAC*YIELD(V,3,S)/100.)*(Y1+Y2))/((1.0+INT(A))**(YR+
                    *SOUTH(CCRAT)+ROTATN(V,3,S)))
0097         100     CONTINUE
0098                 DO 27 L=1,3
0099                 DCMTCE=0.0
0100                 IF(BURN.EQ.1) GO TO 25
0101                 IF(CCRAT.LT.1)GO TO 25
0102                 IF(NER.EQ.0) GO TO 51
0103                 X1=PLANT(V,1,CCRAT,NER,L)
0104                 X2=PLANT(V,2,CCRAT,NER,L)
0105                 X3=PLANT(V,3,CCRAT,NER,L)
0106                 GO TO 52
0107         51      X1=0
0108                 X2=0
0109                 X3=0
0110         52      IF(SER.EQ.0) GO TO 53
0111                 X4=PLANT(V,1,CCRAT,SER,L)
0112                 X5=PLANT(V,2,CCRAT,SER,L)
0113                 X6=PLANT(V,3,CCRAT,SER,L)
0114                 GO TO 54
0115         53      X4=0
0116                 X5=0
0117                 X6=0
0118         54      DCPL=(X1*GNAC*PLCOST(A))+(X4*GNAC*PLCOST(A))+(X2*MNAC*PLCOST(A))+(
                    *X5*MSAC*PLCOST(A))+(X3*PNAC*PLCOST(A))+(X6*PSAC*PLCOST(A))
0119                 DCPL=DCPL/(1.0+INT(A))**(YR+1)
0120                 GO TO 26
0121         25      DCPL=0.0
0122         26      CONTINUE
             C       CALCULATION OF ROAD MTCE BETWEEN PASSES
0123                 IF(YR.EQ.1) GO TO 2
0124                 IF(YR.LE.LYR+1) GO TO 2
0125                 K=LYR+1
0126                 KK=YR-1
0127                 DO 5 M=K,KK
0128                 DCMTCE=DCMTCE+(LYMT*MTCOST(A)/5)/((1.0+INT(A))**M)
0129         5       CONTINUE
             C       CALCULATION OF COSTS FOR ROADS,BRIDGES AND CULVERTS
0130         2       DCMTCE=DCMTCE+(((MAIN*MNCOST(A))+(BRANCH*BRCOST(A))+(SPUR*SPCOST(A
                    *))+(MTCE*MTCOST(A))+(REOPEN*RECOST(A))+(BRIG1*BRIG1C(A))+(BRIG2*BR
                    *IG2C(A))+(SMCULV*SMCULC(A))+(BGCULV*BGCULC(A)))/(1.0+INT(A))**YR)
0131                 DCMTCE=DCMTCE+DCPL
0132                 IF(CCRAT.LT.1)NDRSC=0.
0133                 TSCNDR(A,BURN,S,V,L)=TSCNDR(A,BURN,S,V,L)+NDRSC
0134                 NDR=(DR-DCOST+NDRSC-DCMTCE)/100
0135                 SUMNDR(A,BURN,S,V,L)=SUMNDR(A,BURN,S,V,L)+NDR
```

```
0136     27     CONTINUE
0137     24     CONTINUE
0138     21     CONTINUE
0139     20     CONTINUE
0140     19     CONTINUE
0141            LYR=YR
0142            LYMT=MTCE
0143            GO TO 220
0144     10     WRITE(6,200)(CPK(J,CREEK),J=1,5)
0145     200    FORMAT('1',12X,5A4)
0146            WRITE(6,201)(OPE(I,OPERAT),I=1,14)
0147     201    FORMAT(12X,14A4)
0148            WRITE(6,202)(CAS(K,CA),K=1,9)
0149     202    FORMAT(12X,9A4///)
0150            WRITE(6,203)
0151     203    FORMAT(13X,'S1L1',4X,'S1L2',4X,'S1L3',4X,'S2L1',4X,'S2L2',4X,'S2L3
               *',4X,'S3L1',4X,'S3L2',4X,'S3L3',4X,'S4L1',4X,'S4L2',4X,'S4L3',4X,'
               *S5L1',4X,'S5L2',4X,'S5L3')
0152            DO 204 I=1,3
0153            IK=1
0154            IJ=1
0155            DO 762 S=1,5
0156            DO 762  L=1,3
0157     762    TSCNDR(I,IK,S,IJ,L)=TSCNDR(I,IK,S,IJ,L)/SUMNDR(I,IK,S,IJ,L)
0158            WRITE(6,205)I,IK,IJ,((TSCNDR(I,IK,S,IJ,L),L=1,3),S=1,5)
0159     205    FORMAT(2X,'A',I1,'B',I1,'V',I1,3X,15F8.7)
0160            IK=2
0161            DO 763 S=1,5
0162            DO 763 L=1,3
0163     763    TSCNDR(I,IK,S,IJ,L)=TSCNDR(I,IK,S,IJ,L)/SUMNDR(I,IK,S,IJ,L)
0164            WRITE(6,206)I,IK,IJ,((TSCNDR(I,IK,S,IJ,L),L=1,3),S=1,5)
0165     206    FORMAT(2X,'A',I1,'B',I1,'V',I1,3X,15F8.7)
0166            IJ=2
0167            DO 764 S=1,5
0168            DO 764 L=1,3
0169     764    TSCNDR(I,IK,S,IJ,L)=TSCNDR(I,IK,S,IJ,L)/SUMNDR(I,IK,S,IJ,L)
0170            WRITE(6,207)I,IK,IJ,((TSCNDR(I,IK,S,IJ,L),L=1,3),S=1,5)
0171     207    FORMAT(2X,'A',I1,'B',I1,'V',I1,3X,15F8.7)
0172     204    CONTINUE
0173            GO TO 430
0174     9999   STOP
0175            END
```

TOTAL MEMORY REQUIREMENTS 002238 BYTES

COMPILE TIME =   1.5 SECONDS

```
      SUBROUTINE YEAR
      INTEGER ROTATN(2,3,5)
      DIMENSION YIELD(2,3,5)
      COMMON/B1/ROTATN,YIELD
      DO 7 I=1,2
      DO 6 J=1,3
      READ(5,100)(ROTATN(I,J,K),K=1,5),(YIELD(I,J,K),K=1,5)
  100 FORMAT(5I3,5F6.0)
    6 CONTINUE
    7 CONTINUE
      RETURN
      END
```

TOTAL MEMORY REQUIREMENTS 000210 BYTES

COMPILE TIME = 0.0 SECONDS

FORTRAN IV G COMPILER LAG 03-10-75 23:55:13 PAGE 0001

```
0001          SUBROUTINE LAG
0002          INTEGER NORTH(4),SOUTH(4)
0003          COMMON/B2/NORTH,SOUTH
0004          READ(5,101)(NORTH(I),I=1,4),(SOUTH(I),I=1,4)
0005     101  FORMAT(8I2)
0006          RETURN
0007          END
```

TOTAL MEMORY REQUIREMENTS 000198 BYTES

COMPILE TIME = 0.0 SECONDS

```
                 SUBROUTINE PRICE
                 INTEGER A
                 DIMENSION FP(3),CP(3),HP(3),BP(3),CYP(3),F(3),H(3)
                 COMMON/B3/FP,CP,HP,BP,CYP,F,H
                 DO 8 A=1,3
                 READ(5,102) FP(A),CP(A),HP(A),BP(A),CYP(A),F(A),H(A)
           102   FORMAT(7(F3.0,1X))
           8     CONTINUE
                 RETURN
                 END
```

TOTAL MEMORY REQUIREMENTS 000194 BYTES

COMPILE TIME = 0.0 SECONDS

```
FORTRAN IV G COMPILER        COST              03-10-75        23:55:13        PAGE 0001

0001              SUBROUTINE COST
0002              INTEGER A
0003              REAL INT(3),MNCOST(3),MTCOST(3)
0004              DIMENSION CY(3),CT(3),CC(3),CZ(3),CF(3),CG(3),CO(3),BRCOST(3),SPCO
                 *ST(3),RECOST(3),BRIG1C(3),BRIG2C(3),SMCULC(3),BGCULC(3),PLCOST(3)
0005              COMMON/B4/CY,CT,CC,CZ,CF,CG,CO,MNCOST,BRCOST,SPCOST,RECOST,BRIG1C,
                 *BRIG2C,SMCULC,BGCULC,PLCOST,INT,MTCOST
0006              DO 9 A=1,3
0007              READ(5,103) CY(A),CT(A),CC(A),CZ(A),CF(A),CG(A),CO(A),MNCOST(A),BR
                 *COST(A),SPCOST(A),RECOST(A),MTCOST(A),BRIG1C(A),BRIG2C(A),SMCULC(A
                 *),BGCULC(A),PLCOST(A),INT(A)
0008        103   FORMAT(2F5.3,5F4.3,3F5.0,2F4.0,1X,2F4.0,F3.0,F4.0,F5.4,F4.3)
0009        9     CONTINUE
0010              RETURN
0011              END

  TOTAL MEMORY REQUIREMENTS 00020C BYTES

  COMPILE TIME =        0.1  SECONDS
```

```
FORTRAN IV G COMPILER       PLANTS        03-10-75        23:55:13       PAGE 0001

              SUBROUTINE PLANTS
              INTEGER V,I,CCRAT
              DIMENSION PLANT(2,3,4,5,3)
              COMMON/B5/PLANT
              DO 10 V=1,2
              DO 11 I=1,3
              DO 12 CCRAT=1,4
              DO 13 J=1,5
              READ(5,104)(PLANT(V,I,CCRAT,J,L),L=1,3)
        104   FORMAT(3F4.0)
        13    CONTINUE
        12    CONTINUE
        11    CONTINUE
        10    CONTINUE
              RETURN
              END

  TOTAL MEMORY REQUIREMENTS 00021C BYTES

  COMPILE TIME =       0.0  SECONDS
```