A Comparative Study of Forest Policy and Management Practices in Scotland and British Columbia, with particular reference to the use of <u>Pinus Contorta</u> in Scottish forestry.

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ERRATA - VOLUME 1

Page	Line	For	Read
87	10	"Dukes of Asholl"	"Dukes of Atholl"
89	11	"Lathan (1957)"	"Latham (1957)"
92	13	"Foresty"	"Forestry"
114	31	"entensive"	"extensive"
124	15	"10.65 million"	"0.65 million"
136	24	"<u>Rvaciona buoliana</u>"	"<u>Ryaciona buoliana</u>"
141	3	"6,500 peat"	"6,500 feet"
152	3	"several authors,"	"several authors have commented,"
170	2	"suggestion was "	"suggestion that was"
176	24	"try farm licences"	"tree farm licences"
215	9	"weigh scaling"	"weight scaling"
228	4	"were needed"	"was needed"
260	23	"Salaman and McBride (318)"	"Salamon and McBride (1966)"
272	11	"endanagered"	"endangered"
274	4	" possible"	"possibly"
300	7	"<u>Albies lasiocarpa</u>"	"<u>Abies lasiocarpa</u>"
304	17	"Barns (1937)"	"Barnes (1937)"
327	1	"Brisish Columbia"	"British Columbia"
358	14	"western montain"	"western mountain"
360	6	"recorded that Montane"	"recorded Montane"
382	26	"Firstly"	"Lastly"
391	20	Delete "western yew (<u>Taxus brevifolia</u> Nutt.)	
404	22	"falling with"	"falling within"
430	19	Delete "to require"	

ERRATA - VOLUME 2

437	2	Delete "a"	
437	10	"handwood"	"hardwood"
437	12	Delete "a"	
437	24	"<u>Juneus</u>"	"<u>Juncus</u>"
443	2	"0.25 MM c.f."	"25 MM c.f."

Page	Line	For	Read
449	3	"sibsidies"	"subsidies"
451	5	"activity"	"activity"
451	8	"felling trees"	"felling of trees"
451	21	"in whcih are"	"in which are"
488	19	"faciliated"	"facilitated"
513	11	"Scotish"	"Scottish"
527	16	"had pan"	"hard pan"
545	14	"Lock Naver"	"Loch Naver"
546	20	"stand"	"stands"
551	20	"to be useful"	"to be a useful"
559	3	"scots pine"	"Scots pine"
609	21	"823 M c.f."	"381 M c.f."
621	14	"sanguionlentum"	"sanguinolentum"
655	17	"of damaging epidemics"	"of damaging scale"
666	21	"bases,"	"base,"
671	20	"supply fir"	"supply for"
676	21	"Birish"	"British"
678	2	"properity"	"prosperity"
713	3	"stablising"	"stabilising"
713	11	"which have"	"which has"
733	21	"conduct of a"	"conduct a"
817	9	"Initally"	"Initially"

ERRATA - ANNEXURES

Annex.	Appx.	Section	Amendment
1	A	3	2nd line from end of section. For "licenc-holder," read "licence-holder"
1	A	5	lines 6 and 7. For "repeated", read "re-pealed"
1	A	10	3rd page of Section 10, line 18. For "the amout of", read "the amount of"
			5th page of Section 10, line 21. For

"contemplatind", read "contemplated."
6th page of Section 10, line 17. For
"licnesor's" read "licensor's"
Add the following reference:
"Salamon, M. & C.F. McBride (1966). High temperature drying. A comparison of western hemlock and balsam fir (*A. amabilis*) dried at high temperatures. Br. Columbia Lumberm. Vol. 50. No. 11.

TABLE OF CONTENTS

ABSTRACT OF THESIS

The preface and introduction describe the method of study and discuss the general scope and outline of the thesis. The objective of the thesis is to provide a comparison of forest policy and forest management practices in Scotland and British Columbia. The first part of the thesis aims at providing a background to the comparison by recounting, in summarised form, the forest histories of the two countries. There are no consolidated forest histories of British Columbia extant, to the author's knowledge, and the account of the British Columbia forest history has been derived from many sources, published and unpublished, and consolidated by the author. The forest history of British Columbia is recounted in three periods. The first period deals with the early history from 1849 to 1912, when virtually uncontrolled exploitation of the forest occurred and policy aimed at the development of a forest industry and of rail communications. It was also a period of devastating forest fires and inadequate forest fire-fighting resources. The second period described covers the years from 1913, immediately after the enactment of the Forest Act of 1912 and the formation of the British Columbia Forest Branch (now the Forest Service), to 1945 when a Royal Commission conducted by Chief Justice G. McG. Sloan investigated the Province's forest position. Sloan recommended the adoption of a sustained yield forest policy by the Province. The period from 1946 to date is primarily an account of the introduction and development of the sustained yield policy, with its new forms of tenure and management units, the rapid development of industry and the growing

ability to fight forest fires.

The forest history of Scotland is better documented and consolidated in published works than is that of British Columbia and following a brief description of the destruction of the primeval forest, the growth of replanting from the sixteenth century onwards, with an increasing use of exotics, is traced. The establishment of the Forestry Commission in 1919 and the policy of replanting as a means of providing timber reserves for use in periods of national emergency, particularly during war, is described. The influence of nuclear weapons on this policy and its changes to a policy of practising forestry as an economic venture, coupled with the fostering of industrial development is mentioned. The two forest histories and policies are then compared.

Whereas the State forest authority in Britain operates under a single Governmental structure, the forests of British Columbia, although vested in the Province, are affected by the Canadian federal structure of Government. The complications and effects of this latter position are described in a chapter dealing with the role of the Canadian Government in British Columbia's forest policy and management practices.

Next, separate reviews of the literature concerning forest policy and management practices are made and the problems posed by workers in the two countries are discussed. During the reviews, particular attention is paid to <u>Pinus contorta</u>, a species with which the author has had management experience in British Columbia and which is being used extensively for afforestation in Scotland.

From observation of the species in Britain and based on his management experience, the author was concerned about the presence of basal sweep or bowing in the south coastal provenances of _Pinus contorta_ currently being planted extensively in Britain. The amount of basal sweep and its approximate value for industrial use were investigated in replicated Forestry Commission experiments at Wykeham (Yorkshire), Achnashellach and Millbuie. These experiments cover a range of Coastal and Inland provenances. From an analysis of results, the author concluded that the south coastal provenances should not be planted unless techniques of site drainage can be substantially improved and that alternative provenances should be investigated more fully for use in afforestation, even though their growth rates are slower.

The thesis concludes with recommendations for the two areas under study.

PREFACE

The study described in this thesis was carried out under the Programme of Special Study and Research of the University of Edinburgh, under the supervision of Professor J. N. Black, with Doctor C. J. Taylor, of the Department of Forestry and Natural Resources. The study commenced on 1st June 1966, for a prescribed minimum period of three years, as a full-time student, with leave of absence for two years to pursue studies in Canada.

The intent of the study was to make a comparison between the forest policies and the forest management practices applied in Scotland and British Columbia with a statement of reasons (or suggested reasons) for similarities and differences. In the course of these studies, the position of <u>Pinus contorta</u> in the two areas became of particular interest and the study was expanded to give special attention to the suitability of North American provenances of this species for afforestation of British heathland and peats.

The study commenced in British Columbia where the author's practical experience of forest policy and management practices was enlarged by extensive study of the literature and a series of visits to selected areas to fill in gaps in knowledge of local conditions. Work commenced in Britain in late September, 1967 with a tour of all

Scottish Conservancies during which thirty-five Commission forests, five private forests, two sawmills, one chipboard plant and the new pulp mill at Fort William were visited as a means of familiarisation with conditions. Whilst British literature had been studied in British Columbia prior to departure for Scotland, it was necessary to enlarge this reading in Scotland. In pursuing the study of provenances of lodgepole pine and upon the advice of the Forestry Commission Silviculturist in Scotland, experimental planting areas on the Wykeham Moor, near Scarborough, Yorkshire, at Achnashellach in Wester Ross and at Millbuie, on the Black Isle were employed for the Collection of data. The latter were summarised and analysed, employing the University of Edinburgh KDF-9 computer. The programmes were written by the author in Atlas Autocode apart from the statistical analyses, where a standard programme was available and was modified for use in this study.

The author is indebted to many individuals and organizations for their assistance. Touching, as the study does, upon many facets of forestry, forest industry, government and politics and upon points of information which do not always appear in published works (sometimes because it has not been considered to be in the public interest to release them), it would have been very difficult to form a balanced judgment and opinion without the generous assistance and advice which have been given. It would be most unwieldy to mention all those concerned by name but it is hoped that those who are not so mentioned will recognise that the author's sincere appreciation and gratitude are directed to them.

The supervision and direction of Professor Black and Doctor Taylor were applied in a way which gave the author freedom to use a maximum of initiative in pursuing the study and in drawing conclusions whilst, at the same time, the requirements to be met were stated and advice given on how these requirements might best be met. This approach has been most highly appreciated and for it and the genuine interest which these gentlemen took in the study, I express my gratitude and thanks. My thanks are also due to Mr. D. Malcolm of the Department for statistical assistance. The Forestry Commission could hardly have done more to assist. The Director-General, Sir Henry Beresford-Peirse supported the study and authorised the author to make visits and conduct discussions with and through the Conservators. The Scottish Conservators and their staffs, both forest officers and foresters, spared no effort in providing guidance on forest tours and in discussion, permitting rapid familiarisation with conditions and professional opinion. In this connection also, special thanks are given to Mr. G. D. Rouse, Conservator for Harvesting, who accompanied the author during the initial ten days of the familiarisation tour and to Mr. E.J.M. Davies. For much information and sound guidance in connection with lodgepole pine provenances, particular mention must be made of Mr. R. Lines, Silviculturist; Mr. J. R. Aldous, Research Officer and Mr. J. Weatherell, Research Forester. There are many others of the Commission who helped.

In the Scottish private forestry sector, Mr. J. F. McGarva, woods manager for the estate of the Countess of Seafield; Mr. A.N.S. Kinnear, woods manager for the British Aluminium Company, Fort William, and Mr. T. H. Woolridge, a director of Riddoch's Sawmills, were of much assistance. Mr. Budden of Scottish Pulp and Paper (a division of Wiggins-Teape Ltd.) was most helpful in describing the nature of the operations conducted by the Fort William mill.

Apart from direct assistance in the study, it would be remiss of me not to express my deep thanks to Dr. R. M. Gorrie, Editor of Scottish Forestry, for his cheerful encouragement during the course of the study.

In British Columbia, because of a close connection with the forestry profession and with the forest industry over the past seventeen years, it is natural that a good deal less advice was needed (or sought) than was the case in Scotland. The accumulation of experience and knowledge during those years has not proceeded without assistance which, in a sense, paved the way for the study and this assistance is highly appreciated by the author. For his direct assistance, I do wish particularly to thank Dr. C. D. Orchard, former Deputy Minister and Chief Forester of British Columbia who supplied his manuscript of the earlier stages of B. C. forest history. Also, to Mr. L. F. Swannell, Chief Forester of British Columbia for his assistance and advice in a number of problem areas.

The study was conducted largely at the author's own expense, but sincere thanks is expressed to those (who wish to remain nameless) who made financial contributions toward the study.

Finally, it remains to thank my wife for her unceasing patience and encouragement and for the typing of the extensive notes and drafts leading up to this thesis.

Kelowna,
British Columbia

Alan Moss.

INTRODUCTION

The Shakesperian character Dogberry in "Much Ado About Nothing" stated that "comparisons are odorous: - -" or, in more commonly quoted words "odious". Disregarding the literary interpretations of a "comparison" as a "joke" and the description of Dogberry as"a foolish officer", the more common contemporary usage of the quotation implies that comparisons are to be avoided. The author disagrees, on the assumption that there is much to be learned from comparisons, providing that they are undertaken in an objective way, rather than undertaken with the intent to improve the image of one subject in relation to the other, i.e., provided that no biased judgement is applied to the comparison.

This principle is, however, extraordinarily difficult to apply in practice, particularly in the fields of forest policy and forest management, where politics, economics, amenity and many other considerations, including fashion and expediency, intervene with the theoretical purity of the subject. It is barely possible, if forest policy is to be presented in a comprehensible way, to isolate it but, on the other hand, an attempt to present it with a detailed explanation of background would result in a document of such tedious length as to cloud the basic issues. The author has attempted to be concise whilst at the same time providing sufficient background to policy to give it reason, if not always logic.

Definitions of the term "forest policy" have been provided by Schlich (1922); the Empire Forestry Society (1953) and Greeley (1953), amongst others. Naturally, all such definitions differ in content and emphasis but most have the common ground that policy is determined by the social and economic objectives which it is hoped to achieve. What these are will depend, amongst other factors, on the political structure and climate, forest history, the educational and technological levels of the population, as well as population density; the significance of the forest area and its volumes to the general economy and the demands of the population in terms of forest use. It does not follow, however, given a certain set of circumstances, that a forest policy is developed which perpetuates the forest, as is demonstrated by the forest histories of both British Columbia and Scotland. It is highly important, in terms of long-term economic considerations, that the effects of forest policies are better understood, whether they be public or private policies. In the modern world of developing technology with its emphasis on rapid change the validity of long-term policies is more readily cast into doubt by those wishing to do so, but efforts in this direction have not shown radical progress because of the long-term nature of the forestry enterprise and the increasingly large capital costs involved in establishing modern forest industries. By comparing the forest policies of British Columbia and Scotland - two areas in very different forestry positions - it is hoped to contribute to a better understanding of the policy functions required.

The number of definitions of "forest management" which are extant are more numerous than those of forest policy and vary widely in their content and emphasis. For the purposes of this thesis, it has been convenient to view forest management as the application in practice, in accordance with the factors of the locality, of the governing forest policies. The field of management is increasingly more complex and subject to technological change. More so than policy, it is subject to continuing change at an accelerating pace and is including more and more fields of knowledge within its scope. In themselves, these changes are causing policy adjustments and management in a particular land area must increasingly examine and compare management in other land areas, adopting applicable practices, in order to remain effective. Whilst the foregoing concepts are expressed in general terms, it is hoped that this thesis will make their importance self-evident at a factual level.

With its vast reserves of virgin forest British Columbia, in its early days, had no forest industry, a small population and low income. There was a natural requirement for an industry to provide employment and its establishment in a virtual wilderness involved crude forms of forest utilisation, practised in an environment of obstacles which required energy and inventiveness to overcome them. The forest was also used to encourage railroad construction and this era saw the "alienation" from Crown ownership into private ownership of some valuable forest land and timber. As it became evident that timber was increasing in value to an extent and at a rate which had not been anticipated, a policy of retaining Crown ownership arose. The sale of Crown timber to an expanding industry brought increasing revenues to the impoverished Province and these revenues were directed to general development of roads, schools, hospitals and other capital investments necessary to modern community life. The standards of forest management were not commensurate with the rate of utilisation and over the vast acreages were applied in an "extensive" way. Forest fires frequently burned uncontrolled over very large acreages and this, together with a lack of reforestation over much logged land and forms of logging which deteriorated the stand quality ("high-grading"), created a gradually increasing acreage of land which was (and is) not satisfactorily restocked or which bears degraded forest. As the economy continued to improve, a policy of sustained yield forest management was introduced and at the present day involves the imposition of allowable annual cuts on many forests, the gradual increasing of the annual acreage of reforestation, tree breeding research and emphasis upon closer utilisation of the existing mature stands. Since there are regions of British Columbia where the level of industrial capacity is inadequate to utilise the sustained yield capacity, the policy of encouraging industry has continued and this is particularly true in recent years of the pulp and paper fields where expansion has possibly been too rapid and has exceeded, if only temporarily, the demands of the market.

In Britain, the natural forests established after the last ice age were virtually destroyed - a process which involved soil degradation following denudation. In Scotland, the introduction of agriculture, including sheep farming, ship building and iron-smelting, as well as other practices, had their place in the process of destruction and replanting began about two centuries ago, mostly by private landowners. A remarkable variety of exotic species was introduced, as will be described later in this thesis. The modern era of forestry in Britain may be said to have begun during the 1914-18 War. With its high populations and the interference of German naval forces with sea transport, the necessary imports of timber to sustain the British Isles were severely restricted and food imports were naturally afforded precedence. Heavy inroads were made into the existing forests to the extent that replanting by the newly -created Forestry Commission was stepped up to an unprecedented rate to provide a timber reserve for possible future emergencies. The plan was long term and, over a period of approximately fifty years, was aimed to provide Britain with one-third of her timber requirements, instead of the almost insignificant proportion (about 3 percent) then supplied. The 1939-45 War interrupted this cumulative process and resulted in the utilisation of much of the existing forest, although the very young forests were virtually untouched apart from providing thinnings. The Second World War seemed to confirm the need to continue the major policy objective of planting forests as an economic reserve for possible future national emergencies. But the invention and proliferation of the atomic and hydrogen weapons changed concepts of warfare. As in other Western democracies, including Canada, military thinking emphasised that future wars which might occur would probably be, in their "organised" stages, of very short duration. In this concept, the existence of a strategic timber reserve would have little influence, if any, on the outcome of a war involving strategic nuclear weapons. Moreover, in the event of a major nuclear strike against Britain, because of her limited land area, it appeared probable that much of the forest would be destroyed and irradiated, so that its significance in terms of assistance to the survivors would be small. A reappraisal of British forest policy has now led to an emphasis on the extension and use of forests for the best economic advantage and the new policy includes the encouragement of industry to utilise the maturing forests. Apart from certain other declared policies which will be brought out later in this thesis, it has been a consistent feature of Forestry Commission policy that the forests are to be used as a means to provide maximum employment. The implications of this aim in relation to the aim of maximum economic benefit are interesting and are discussed later.

The Forest Service in British Columbia is a revenue producing department at the present time, whereas the British Forestry Commission is a spending department. It is only in recent years that expenditures in the Province by both the Federal and Provincial governments have exceeded Forest Commission expenditures. Direct revenue and other receipts from Provincial forests far exceed those of Britain, reflecting in part the reduction of mature acreages in the Province and the expansion of afforested areas in Great Britain. In its present economic situation, there is a frequently expressed desire to strengthen Britain's forestry position so as to reduce the large (in excess of 200 million pounds sterling) timber import bill and this concept could well justify the great efforts being made to create a relatively large forest estate.

Much of the afforested land in Britain is privately owned and currently constitutes about one-half of the total forest. Because of its land acquisition programme and rate of afforestation, the estate of the Forestry Commission will soon exceed those of the private woodland owners.

In Britain, the sole governmental authority formulating and directing forest policy as well as executing it is the British Government itself, acting through the Forestry Commissioners. In British Columbia, the natural resources of the Province are vested by the British North America Act in the Provincial Government. However, the Canadian Government is active in the fields of forest research, trade and commerce and other activities and is a substantial beneficiary from Provincial forestry in the corporate and individual income tax fields. Both Governments are involved in expenditures on Provincial forestry. It is worthy of note that the political objectives of the current Governments or, at least, their methods of achieving the objectives, are different. Canada and British Columbia have not been governed by parties of declared Socialist views in their entire history and, economically, their history has generally been one of development of resources and the encouragement of private enterprise to invest capital in the process. Welfare programmes have been introduced but have generally been within the concept of being based upon ability to earn, Government revenues themselves having been restrained by the need to limit taxation so as to retain private incentive. The upgrowth of social economics in the United Kingdom has involved the introduction of social benefit programmes which, along with other factors, have caused comparatively high levels of taxation to be introduced. With Britain's present balance of payment difficulties it has been difficult to reduce taxation and the political climate has not permitted the reduction of the increasingly costly social benefit programmes which would be difficult to justify within the existing Canadian majority political concept of "ability to pay". The author does not intend, within this thesis, to comment in any detail on these and other differences in domestic political outlook but feels it necessary to emphasize that they have an influence upon economic aims within Britain and Canada. Population levels, dependence on exports, standards of living, the average age of populations, degree of mechanization and many other factors contribute to variations in economic aims and techniques.

British policy in the planting of exotic species is described in the thesis and from the description emerges the fact that, at different time periods, certain species have been highly favoured over others. In the 18th. and 19th. centuries, for example, widespread plantings of European larch (Larix decidua Miller) were made in Scotland, initially by the Duke of Atholl. Subsequent disease problems as well as increasing emphasis on rapid growth rates led to its fall from favour and emphasis passed to other species. Currently, Sitka spruce (Picea sitchensis (Bongard) Carriere) and shore and lodgepole pines (Pinus contorta Douglas and P. contorta var. latifolia S. Watson) are favoured in Scotland, the former because of its rapid growth rate and the two latter because of their hardiness and tolerance to exposure. In the Pacific North-West, the natural geographic range of P. contorta is very large, extending as it does from Alaska to the high Sierra of California and inland across the Coast, Cascade and Rocky Mountains to the eastern foothills of Alberta. In British tests of provenances from this range, it was provisionally concluded that the "south coast" provenances - those growing as shore pine on the coast of the States of Washington and Oregon - were to be preferred for British afforestation because of their faster growth rate.

The popularity of lodgepole pine is indicated by the planting, by the Forestry Commission of 14,000 acres in Scotland, out of a total of 58,000 acres, in 1964 with the acreage being increased more recently. Private owners planted additional acreage. If an average afforestation cost of 75 pounds sterling is employed, the annual Forestry Commission expenditures in Scotland alone on lodgepole pine are, and have been for some few years past, in the region of one million pounds sterling annually. The bulk of these plants are of "South Coast" provenance. At the level of expenditure concerned and since the rate of lodgepole pine afforestation is expected to increase very markedly over the next few years, the question of using the correct species and provenances of that species is of vital concern.

The author has had fifteen years of experience in the management of and industrial utilization of lodgepole pine in the Okanagan Valley of British Columbia. Initially because of its small diameter, it was poorly regarded by the sawmiller but its straightness of form, the good grade of lumber produced from it and the development of suitable logging and sawmilling techniques eventually overcame the diameter handicap and the species has now become commercially important. Its use by pulp mills in recent years has added to its importance and in its larger diameters (approximately in excess of ten inches) it has a limited use in plywood manufacture. With this background and with the clear indication of large expenditures on afforestation of the species in Britain, the author was concerned to note that the south coastal provenances planted in Britain appeared to be subject to heavy butt sweep (also referred to as "butt curvature" and "sabre butt"). Clearly, if the potential of the provenance was seriously affected by this defect, (which to the author was a startling one) to the extent that the advantages of its greater growth rate were to be markedly reduced, then its selection in preference to other provenances ought to be questioned and the policy favouring it possibly revised. Whilst there is considerable justification for the viewpoint that maximum wood volume should be grown in a given time on the assumption that some means will be found to utilise it, there is little justification for applying the viewpoint in an unqualified way. Wood with heavy sweep, particularly when it affects the larger diameter butt section of the tree is not, by any current indications so valuable as wood of straight form. It is more difficult and costly to cut and transport, less productive to saw into lumber and more difficult to debark. It is subject also to the presence of reaction wood. For these reasons, an investigation of butt sweep in <u>P. contorta</u> in Britain was undertaken as having an important bearing on current policy and management practices.

Following a review of the question of presenting money figures on a common value basis and in consultation with Doctor C. J. Taylor, it was decided to present Canadian figures in Canadian dollars and British figures in pounds sterling. Problems connected with standards of living, the recent devaluation of the Pound as well as certain artificialities in the establishment of rates of exchange indicated that the course selected was the most sensible for purposes of this thesis.

The unit of measure employed for roundwood volume is the true cubic foot, employing the conversion of 1.2732 Hoppus feet equals 1 cubic foot.

Certain differences in terminology occurred during the study and a glossary is appended to the thesis to clarify these differences.

In this thesis, brief forest histories of British Columbia and Scotland are presented and compared, as a necessary background to an understanding of the present policies. As further background information, the role of the Government of Canada in British Columbia's forest policy and management practices is described since this role has had a considerable influence in some areas. The review of literature follows and is concerned with policy and management as they exist at the present day. The problems posed by workers in the two countries and possible future developments are presented next, and are followed by the investigation into basal sweep of Pinus contorta in Britain. Finally, the major conclusions of the thesis are drawn and recommendations are made for the investigation of other worthwhile areas of study.

PART 1

THE FOREST HISTORIES OF BRITISH COLUMBIA AND SCOTLAND AND THEIR COMPARISON

THE ROLE OF THE CANADIAN GOVERNMENT IN BRITISH COLUMBIA'S FOREST POLICY AND MANAGEMENT PRACTICES

CHAPTER 1

THE FOREST HISTORY OF BRITISH COLUMBIA

1. General:

Whilst, in British Columbia, there are many sources of historical forestry references available, relatively few consolidated accounts have been written. In Britain, a number of forest histories are available. The situation led the author into writing a forest history of the Province but the result is too detailed and lengthy to include in this thesis - it is hoped to publish it separately at a later date. The following summarised version is derived from it.

2. British Columbia Forest History up to 1912:

a. Early History:

In the year 1849, Vancouver Island was made into a colony of Great Britain and was leased by the Crown to the Hudson's Bay Company. Nine years later, in 1858, the mainland area was created as the Colony of British Columbia and these events were followed, in 1866, by the uniting of Vancouver Island into British Columbia, with Victoria as the capital. Quite some time afterwards, in 1871, the Province entered into Confederation with the Dominion of Canada.

The new Province contained vast acreages and volumes of forest. The acreage was approximately 170 million acres and the volume (4" d.b.h.+) was in excess of 500,000 MM cubic feet.* Not all of this was, or is, usable but the fact remains that the resource was huge, an untouched segment of the northern coniferous belt and, in terms of economic <u>forestry</u> potential, made the Province easily the most important in Canada. Ormsby (1958), Meares (1790) and other writers have referred to the interesting period prior to 1849, when the visits of the Spaniards, Captain Cooke, Captain Meares, Archibald Menzies, David Douglas and Simon Fraser and others occurred and when the first botanical descriptions, seed and specimens from British Columbia reached Great Britain. Up to 1849, however, the vast forests had scarcely been affected by human exploitation since, from the time of the original discovery of British Columbia three centuries earlier, very little immigration of any significance had occurred. The exploitation by the native Indian population for canoes and other simple uses was of little consequence since the number of Indians has been estimated as being only seventy thousand in 1835. The major hazards to forest growth

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* Detailed inventory figures are given elsewhere. The symbol "M" refers to thousands and "MM" to millions, in accordance with normal B. C. Forestry practice. Thus the figure given is 500,000,000,000 cubic feet.

undoubtedly lay in the activities of forest fires, insects and pathological organisms.

The early fur-trading economy of the Province eventually gave way to a gold boom economy which, in its turn, failed. Orchard (1964) has described how, only then, did the small population turn to the timber resource as a means of livelihood. The great volumes of standing timber which were available led, almost inevitably, to excessive waste during its utilization.

Innis (1956) has related how substantial British Preference Tariffs permitted the growth of the Eastern Canadian lumber industry in support of British naval strength. The Province of British Columbia, because of its undeveloped state, was hardly affected but, with the abolition of the Preferences, joined in the expanding trade with the United States under the United States - Canadian Reciprocity Treaty of 1854. Innis attributes much of the early growth of British Columbian industry, however, to demands arising from the Gold Rush of the late 1850's. In 1886, the completion of the trans-continental Canadian Pacific Railway track permitted the development of markets on the Canadian Prairie and hastened the construction of sawmills in the interior and coastal regions of the Province. Later, the construction of the Panama Canal permitted significant volumes of sea-borne lumber exports to be sent to Britain and Europe.

Orchard (1964) has held that the position in the United States at this time, involving "the wholesale theft of publicly owned timber, fire and the general abuse of land and timber resources.............assisted by inadequate law, personal greed and public apathy and popular government subject to pressure, looking always to the popular course with a view to the next election - led eventually (in that country)* to some effective control measures". He held that these measures influenced outlook and sentiment in Canada. Ormsby (1958), however, has described how the British Columbia Legislature, about 1896, was not so alarmed about the possibilities of destruction of the forest as they were desirous of achieving the rapid economic development of the Province. In any event, Orchard (1964) and others have described how, beginning in 1871, the Province ceded to the Dominion Government, Railway Grant Lands to border the projected trans-Continental Railway and subsequently, up to 1912, freely granted many millions of acres in aid of railway and wagon road construction and for other purposes. The obtaining of a grant was extraordinarily easy and this led to many deplorable situations - most of the 210 schemes which won

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* Author's parentheses.

legislative approval failed to materialise and much of the land, including the bulk of the Dominion Railway Grant was subsequently taken back into Crown ownership.

b. The Development of Industry:

The twenty-five years from 1895 to 1920 have been described by MacIntosh (1964) as a period of expansion such as had not been achieved before by the Canadian economy and British Columbia shared to the full in this expansion. Before the year 1911, however, there was very little production of pulp or paper and the wood-using industry remained small in relation to the large standing volumes of mature and overmature timber. Orchard (1964) has pointed out that total revenues from stumpage and royalty payments to purchase standing timber for utilisation and the low stumpage and royalty values per unit of volume were quite insufficient to provide funds for silvicultural practices (and these funds were not available from other sources) or for any thought of conservation practices.

Logging at this period removed only the best quality logs in commercially desirable species such as Douglas fir (Pseudotsuga Menziesii Franco) and western white pine (Pinus monticola Dougl. ex Lamb). Larger logs which could not be moved by oxen had to be left in the woods. Another reason for leaving large logs might be that the sawmill saws were not big enough to cut them. Oxen gave way to horses and then, after about 1890, horses gave way to steam.* Orchard (1964) has characterised the Government's role during the earlier part of the period 1884 to 1912, as being nothing more than an effort to control cutting and to collect some revenues.

After the year 1900, Ormsby (1958) has recorded that American lumber interests, which had moved westward across the pine forests of Michigan, Wisconsin and Minnesota, reaching Oregon and the Puget Sound, entered British Columbia and built several large sawmills. They reduced labour costs by the introduction of steam locomotives, donkey engines and other power machinery - a policy toward more intensive mechanization which has continued to the present day and which has partly led, by the increase of labour productivity, to the relatively

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* The process was not so clearcut as these statements might indicate. Horse extraction persisted for much longer in parts of the Interior and the author employed them as late as 1955 in the Okanagan Valley. Steam was rapidly introduced in areas of large-sized timber but in areas of smaller sized timber, the tendency was for horses to be replaced, at a later time, directly by gasoline and diesel engines.

high labour rates applying in the Province at the present day. It is also of note that American interests own and control the majority of the Province's industry at the present time.

c. The Development of Policy and Legislation:

The policy of the Government during the period from 1849 to 1912 was based upon the social and economic need to develop communications and industry. To this end, the forests were allocated, in various forms of subsidy and encouragement, to potential investors and manufacturers. The various tenures existing in the Province are summarised in Annexure I to this thesis and the earlier forms, as has been mentioned, were sold or given away in large areas and with largesse.

Reverting briefly to the ceding of land for railway construction, the Province ceded twenty miles of land on each side of the roadbed of the trans-Continental Canadian Pacific Railway to the Dominion Government. Because some of the area was valueless for agriculture or other productive enterprise, another 5,470 square miles (known as the "Peace River Block") were ceded in lieu in 1880. These lands were repossessed from the Dominion in 1930, apart from 14,476,000 acres which had been removed for National Parks. On Vancouver Island, the Province granted lands and forests for 20 miles on each side of the

82.9 miles of line of the Esquimalt and Nanaimo Railway and these lands have remained in private ownership. Of the other Railway Grants, the Province recovered more than 4 million acres by purchase in 1912, according to Orchard (1964). These and other experiences, led to a change of policy in which public ownership of forest land was favoured. The results of this policy may be judged from the following figures derived from information given by Anderson (1950) and the British Columbia Department of Lands and Forests (1957).

TABLE 1. Percentages of State Forest Ownership in Northern Hemisphere Democracies

Country	Year	Percentage of State/Crown Forests by Area
Belgium	1948	10.7
Finland	1938[1]	35.1
France	1938	13.25
Netherlands	1947	14.8
Norway	1932	10.2
United States[2]	1957	28.0
Canada	1957	69.0
Western United States[3]	1957	66.0
British Columbia	1957	94.0

Notes: 1. Allowance made for loss of territory in 1944.

2. Including Alaska.

3. Encompassing eleven states and a part of another.

The percentage of Crown forest ownership in British Columbia is thus very high amongst the western democracies.

Because of financial difficulties, the Provincial Government, prior to 1912, issued cutting rights to encourage the growth of industrial capacity but also to obtain direct revenue to assist in overcoming the general financial problems. These cutting rights were embodied in renewable and transferable* licences and were issued in large numbers. The carrying charges, however, were made too high by the Province and an anticipated increase in capital value did not occur, resulting in the withdrawal of the system within three years of its inauguration. An entirely new system of timber disposal was adapted in 1912 which retained all unalienated forest lands under public ownership, only the timber being sold.

Many of the leases and licences issued prior to 1912 are still in existence. The heaviest concentration

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* i.e. the licences, provided that charges had been paid, could be automatically renewed at the expiry of their fixed period of tenure. Also, the licence holder could transfer his licence, by sale or otherwise, to another party. It was this latter provision which led to large scale speculative investment in the licences.

of those issued lay on Vancouver Island and in the Vancouver Forest District and subsequently gave a marked economic advantage to industry located in these areas because of the fixed rates of royalty applying to them. Whereas most of the Interior industry has subsequently purchased its timber from the Crown on the basis of an appraised stumpage and royalty, the early tenures have remained on a simple royalty basis. Rental and taxation charges on the early tenures have been increased by the Government in an attempt to derive increased overall revenues and a considerable number of the tenures have been incorporated into tree farm licences and have thus been brought within the current sustained yield policy of the Province. In those cases where, because of location or for other reasons, private tenures have not been brought within the sustained yield policy, various attempts have been made by Government to retrieve the land to unfettered Crown ownership (see Annexure I) as quickly as possible even though this involves the liquidation of mature and overmature growing stock without, in most cases, provision for reforestation.

A further principle of policy which evolved prior to 1912 was that all timber from Crown lands must be manufactured within the Province, although later, under the Forest Act of 1912, special cases for timber export could be approved by an Order-in-Council.

Throughout the period under consideration, the administration of forests was a function of the Department of Lands and all timber disposal legislation was embodied in the Provincial Land Act. This Act progressed from direct sales of land at varying prices (from one dollar per acre and up) to provisions for issuing leases, licences and pulp licences (see Annexure I). Timber royalties, liens for failure to pay royalty and certain taxes were introduced. Provision was made for gaining access to timber and for transporting products of the forest over rights-of-way across private land, where the location of the land would otherwise block access. Timber land was classified as first or second class according to the volume of timber per acre on it. Ground rent for land, stumpage payments for cut logs and a form of tenure known as "Hand-Loggers' Licences" to suit the need of small logging operators, were established.

Apart from these provisions for timber disposal under the Land Act, other matters were made the subject of specific legislation in a variety of Acts. Among items not previously mentioned were Acts prohibiting the employment of Oriental labour on timber licences and Acts providing for the scaling and marking (for identification purposes) of logs. It is significant to note, since it is in contrast to the system of payment for timber which is employed by the Forestry Commission in Britain, that stumpage and royalty payments for timber in the Province continue to be based on the scale of cut produce, as and when cut, rather than on the standing volumes of timber offered for sale (although these volumes influence the appraisal of the stumpage values). The scale of cut produce also forms the basis of cut control in the modern sustained yield tenures. Initially, log scaling was conducted in board feet (the Official British Columbia Log Scale), which has since been superseded by the British Columbia Cubic Foot Scale in all tenures where the legal provisions permit it.

Various Mining Acts and Amendments to them were passed, having an effect on forestry. The "free miner" was given the rights to the timber on his mineral claim and until 1948, a Crown Grant of the mining claim surface carried with it ownership of the timber. Orchard (1964) has stated categorically that this principle was misused in some cases to secure title to timberlands. Sloan (1956) has given extensive evidence and comment upon the problem.

The other highly important evolution of policy which occurred, impelled by very strong social and economic demands, was concentrated upon the reduction of destruction caused by forest fires. In all, a total of eleven "Bush Fire Acts" and amendments were passed. For a period, two devices were employed which were contrary to the principles of British law - if a person accused another of starting a forest fire the burden of proof of innocence rested on the defendant and half of any fine levied was paid to the informer. Perhaps more than anything else, these provisions demonstrate the element of desperation which was involved in the efforts to control forest fires. Subsequently, the accused person had to be proved guilty of "gross carelessness and negligence" and later still of a lack of reasonable care and attention. A statutory fire season was introduced and precautionary measures to be taken when lighting campfires was specified. Fire protection measures were imposed on Provincially chartered railways (railway construction and operation being a common cause of forest fires) and on steam equipment located in the forest. By 1912, British Columbia had a reasonably comprehensive fire prevention legislation. There was little money available, however, for the vital work. The legislative appropriation for fire protection in 1910 was 97,208 dollars, a very small sum indeed by present day standards.

In spite of the various policy and administrative developments which have been described, the overall forest policy of the Province and the condition of its industry, when viewed from the present day, were rudimentary. Basically, policy was a subject of the exigencies of the moment, a series of reactions to changing social and economic pressures and it lacked long-term coherence. The vast size of the forests and their potential value were only dimly comprehended and lent justification to localised destruction to meet the pressing need for finances to develop the Province. Useful ideas, legislation and development did occur but it gradually became clear that a better, well co-ordinated policy was needed. The Royal Commission of Inquiry on Timber and Forestry (1910) was to provide the impetus for the formulation of this policy.

The Commission made a review of the forestry situation, noting the lack of accurate information in many aspects, including the forest inventory and the annual rate of cutting. It recommended that a complete cruise of all Crown-granted Timber Lands* should be undertaken in order to eliminate certain Government difficulties in assessing their value and in taxing them. They also recommended that rental and royalty payments made by timber leaseholders and timber licence holders should be equalised; that timber leases should be made subject to the regulations concerning logging methods, disposal of logging debris, protection from forest fire and other forestry matters and that leaseholders who did not already possess

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* A description of these lands is given at Annexure I.

the right, should be allowed to renew their leases in 21 year periods.

In connection with timber licences, the Commission felt that their 21 year terms of tenure should be extended and that licence rentals, fees and royalty should be made subject to possible annual adjustment by the Legislature or by Order-in-Council as circumstances demanded, instead of remaining at a fixed level.

The Government had issued pulp leases and some of these had timber on them capable of being made into sawlogs. The Commission believed that a lessee with this situation should apply for the sawtimber, if he wished to cut it, within a specified period of time, since it did not automatically form a part of the pulp lease. If he did not apply, then he should forfeit all right to cut sawtimber on the lease. The particular form of sawtimber licence which was envisaged would only be issued to holders of pulp leases and would terminate on the termination of the pulp lease to which it applied. The abolition of Hand Loggers' licences was also recommended.

The Commission wanted to see more regulation of logging practices, including measures for the disposal of logging slash; the assumption by Government of the responsibility for the general protection of the forests from fire, with compulsory powers to direct men to aid in fire-fighting; and the formation of a Government Department of Forests to be financed from a sinking fund derived from timber royalties.

This brief summary of the period up to 1912 may be conveniently concluded with the passage, by the Provincial Legislature, of the Forest Act of 1912. The first such Act within the Province, it incorporated the previous legislation and some of the recommendations of the Royal Commission of 1910. Instead of a Department of Forests, a Forest Branch was formed within the Department of Lands and the proposed Sinking Fund was not then, or since, created. Provision was made within the Act for the sale of Crown timber anywhere, in any quantity and for any period of time by competitive sealed tender - a new departure.* The Act also authorised the constitution of

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* The sale of timber by public auction was not approved until 1921 but found little favour over the sealed tender method of bidding until about 1940. After 1940, public auctions gained in favour and sealed tenders were almost discarded. By about 1964, and partly as a result of Government concern about very high bidding at some public auctions (a practice which placed some of the administrative procedures for allocation of sustained yield cuts to industry in jeopardy) sealed tender bidding was tending once more to become the usual practice.

permanent forest reserves, within which no land could be sold, settled or occupied, by proclamation of the Lieutenant-Governor of the Province. In contrast to previous Acts, the provisions for securing rights-of-way for transportation of the products of the forest and for fire protection were relatively elaborate. A Provincial Forest Board was authorised, to consist of the Chief Forester (ex officio) and not more than five professional foresters, or officials, of the Department. The Board possessed wide powers. It could, for example, compel the attendance of witnesses and require that they produce documents and accounts related to forestry matters and it had the powers of "any judge of the Supreme Court" (of British Columbia). It could recommend and itself make, forest orders. This interesting and extraordinary body could theoretically have run the forests on its own but it gradually fell into disuse and was eliminated in 1924. Its disappearance is compatible with the prevailing tendency towards Ministerial policy-making, with the Forest Service being primarily responsible for policy implementation and administration.

In retrospect, the Forest Act of 1912 was the foundation of modern forest policy and to a considerable extent, management in the Province.

3. British Columbia Forest History from 1913 to 1945:

a. Population Growth:

It is important to an understanding of the growth of forest policy and management practices in the Province to realise how small populations in the large Province have been. Orchard (1964) has quoted the following figures, covering the period from 1871 to 1962.

TABLE 2. The Growth of Population in British Columbia.

Year	Population[1]
1871	36,247
1881	49,459
1891	98,173
1901	178,657
1911	392,480
1921	524,582
1931	694,000
1941	818,000
1951	1,155,000
1961	1,629,000
1962	1,659,000

Note: 1. Up to and including 1921 these figures are taken from the "Canada Year Book - 1921". From 1931 to 1962, the figures are taken from "B.C. Facts and Statistics 1962, page 6.

The population in 1966 was approximately 2 millions.

b. <u>The Development of Industry and Markets-1913-1945</u>:

The first Chief Forester of British Columbia, from 1912 to 1915, was H. R. MacMillan, later to become a prominent forest industrialist. His views on the need for industrial growth, whilst Chief Forester, were reported in the Forest Branch Annual Report (1912) and quite apart from demonstrating the consistency of his thinking throughout his career, they represented a continuity of major policy trends which had been evident practically from the foundation of the Colony. He pointed out that at the (then) annual rate of cut, making no allowance for annual growth, it would take the industry approximately 250 years to use up the mature, standing timber. Although good logging practices (i.e. close utilization) would have produced a large quantity of low-grade material from the Provincial forests in addition to the high-grade material already being produced, the additional material could not then have been sold profitably. A major drawback to the marketing of British Columbia lumber at the time was a prejudice against it, in both Eastern Canadian and foreign markets, as a result of a lack of knowledge of its qualities. The situation was subsequently corrected by the introduction of a Government trade extension program. In spite of the importance of sea-borne exports, the main market for British Columbia forest products, at about 1915, was the North American continent with the Canadian Prairie market consuming at least sixty percent of the Province's total production.

The mechanisation of woods operations continued. In the Coastal Region, as has been mentioned previously, steam donkey engines had virtually replaced oxen and horses for log extraction, a change described by Whitford & Craig (1918). The use of ground cables was giving way to early forms of "high lead" and "overhead cable" systems, although log chutes were still in considerable use on steep ground. Twenty-one logging railways were in use by 1916, but later, with the development of automotive transport, they were to be replaced almost entirely by roads. Most coastal logs were towed by sea to the mills and it was the cheapness and flexibility of this mode of transport, as well as the ready and cheap access to overseas markets provided by the sea which assisted the more rapid development of the Coastal, as compared to the Interior industry.

In the Interior, horses were still in general use for extraction but logging machinery was becoming more common. In places, the river driving of logs was still practised.

All trade commodities experienced a price boom after the 1914-1918 War but, in 1921, a period of readjustment and deflation began. The volume output of wood products increased steadily but at too fast a rate with the result that prices decreased, partly due to overproduction, in 1925. By 1931, it had become clear that the Province's forest industries were involved in the prevailing world-wide state of depression. In the same year the decision of Great Britain's leading wood importers to purchase the entire timber export supply of the Soviet Union had virtually closed, temporarily, one of the Province's important markets. Although British Columbia had become the leading North Pacific lumber exporter, the effects of these conditions were not overcome until about 1938, when the Provincial Forest Branch (1938) considered that normal business conditions had returned. However the pulp and paper industry remained in a condition of distress and restrictive import quotas which had been imposed by the United States on roof shingles continued to have a crippling effect on the shingle industry.

In spite of occasional setbacks in trade with Great Britain, such as had occurred in 1931, that country continued to be the Province's best export lumber customer, as reported by the Forest Branch (1939). In 1939, the outbreak of the Second World War resulted in increases of those exports, in spite of a shortage of shipping. The

Forest Branch (1941) reported that marked increases in United States consumption at attractive prices also occurred and the Provincial wood products industry grew rapidly under these influences. The market demand was such that a Dominion Wartime Timber Control was established (Forest Branch (1940 and 1942)). By 1942, the demand for lumber was so great that the industry was officially declared to be "essential", price ceilings were established for sales to the booming American market and the British Timber Controller made product specifications more liberal, so as to facilitate an increased rate of production.

The rate of production from logging had kept pace with the great increase in production.* But these rapid changes had produced a general concern to introduce more orderly procedures into utilization of the forest and, as a consequence, the Honourable Mr. Justice Gordon McGregor Sloan was appointed sole Commissioner of a Royal Commission to investigate the situation and to make recommendations to the Provincial Government. (Province of British Columbia (1943)). The work of this Commission is described later.

c. Land Tenure Developments: 1913-1945:

The land tenure developments in the Province, up

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* Statistics of annual cut, market shipments and related matters are included in Annexure 2, hereto.

to 1944, have been described by a Forest Service author (Anon, unknown date).

Until 1913, to encourage immigration and to provide early settlers with a means of livelihood, it had been considered socially necessary to permit the settlers to acquire limited acreages of land from the Crown. By that year, the policy may be summarised as:

(1) To prevent the alienation of Crown land valuable chiefly for timber.

(2) To make available for settlement all timbered areas suitable for agriculture but only after the timber had been removed.

(3) To prevent the acquisition of timber through the pre-emption or purchase of land, ostensibly for agricultural purposes or, conversely, to ensure that no bodies of merchantable timber could be acquired except by public sale at an upset price safeguarding the public interest.

(4) To prevent the uninformed, bona-fide settler from locating in some timbered, non-agricultural tract where he could not be successful, in an economic sense.

From 1913 until 1945 a variety of Legislative amendments were enacted, affecting Crown grants, timber leases, timber licences, wood pulp leases, pulp licences, pulp timber sales, timber sales and hand loggers' licences.

These amendments are reflected in the descriptions of tenure given in Annexure I.

d. Forest Reconnaissance 1913-1945:

The creation of the Provincial Forest Branch in 1912 has been noted. It at once engaged in a widespread reconnaissance of the forests in order to improve the state of knowledge about them. As an indication of the scale of this work (and, because of the number of personnel available to do it, of its low intensity), the British Columbia Forest Branch (1912) and (1913) reported a rapid start, 5,616,000 acres being reconnoitred in 1912 and 12,308,000 acres in 1913. In addition, a Land Examination Program classified land for forest reservation and for agriculture. Reports of individual forests were made, one of the first of these being of the Babine Forest, the survey of which was completed in 1927 - the report included an estimate of the productive capacity of the forest, designed to permit preliminary plans for management to be drawn up (B. C. Forest Branch (1927)). Typical reports on forest reserves included an age class (20 year classes) - area distribution, estimates of accessible sawlog timber volumes by species and estimates of quantities of minor products. Comments on the sustained yield capacity (after a theoretical normal distribution of age classes had been achieved by regulation) and on the prospects for natural reforestation, were made. In addition, data for immature stands were presented, broken down into forest compartments varying from 1,000 to 35,000 acres in extent, showing the number of trees per acre by species. Regional reports of forest resources were also published.

Whitford and Craig (1918) made a surprisingly accurate estimate of the Provincial forest resource, based on reports of the British Columbia Forest Branch, timber owners, timber cruises, surveyors and others. Their estimate of the timber in the Coastal Region which was suitable for sawing into lumber, was 214,300 MM feet board measure, B.C. Log Scale and, in the Interior Region, 136,535 MMfbm - a total of 350,835 MMfbm. About twenty years later, F. D. Mulholland was cited by Sloan (1945) as estimating that there were 155,129 MMfbm of sawtimber in the Coastal Region and 99,370 MMfbm in the Interior - a total of 254,499 MMfbm.* Mulholland conceded in 1944 that his figures were very conservative and that an increase of ten percent should be added to the Coastal figure.

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* These figures have not been converted into cubic feet because of uncertainties in determining appropriate conversion factors. Since they have been superseded by later, more accurate inventories their interest is now mainly historical.

e. Forest Reservation 1913-1945:

The Forest Branch (1912) reported that the Dominion Government, which still held the British Columbia Railway Belt, had placed one-half million acres of it into permanent reserves, not including National Parks and raised the question of urgently creating Provincial forest reserves. The Provincial Government began to act in 1914 and, by 1944, had established seventy-five million acres of these reserves (B.C. Forest Branch (1914) and Sloan (1945)). In principle, the reserves did not (and do not now) preclude the use of agricultural, grazing, coal and mineral land located within them and very few restrictions are placed on public recreational activities. As has been mentioned, however, the inclusion of the timber standing on a coal, oil or mineral claim, within the claim, was practised until 1956, after which the timber was not included. Timber was sold from the Forest Reserve under timber sale contracts and other forms of temporary tenure but, by 1945, there was no adequate program of forest management to perpetuate the reserved forests, as is evidenced by Sloan's (1945) comment that 678,000 acres were not satisfactorily restocked following logging. The process of forest liquidation, under gradually improving administrative control, continued.

f. Forest Fire Protection 1913-1945:

The major destruction caused by forest fires has been a dominating influence on forest policy-makers throughout the Province's history. In 1912, the manpower allocated specifically to fire protection was pathetically small in relation to the scale of the problem. The Forest Branch Annual Report (1912) noted that the average area patrolled by one Forest Branch patrolman in that year was about 900,000 acres and access into the forest was generally poor. In 1915, the Forest Branch was quite unable to cope with the fires and logging operators supplied much assistance - mutual arrangements of this kind have been continued since.

A system of Government operated lookout stations was introduced and the Forest Branch (1938) reported that 50 of them were in use by 1938. The use of aircraft for air patrol and transportation work began. Soon after 1913, thousands of miles of horse trails and telephone lines were constructed and, by 1932 during the depression, most of these improvements had been lost owing to the Government's financial inability to maintain them. Two-way radio equipment later replaced the telephone lines, starting with the purchase of 40 medium frequency sets in 1940 (B.C. Forest Branch (1940)). The progress which was achieved in improving access into the forest was very limited in relation to the scale of the problem. In 1945, for example, although Forest Service suppression crews were able to reach 52 fires in an average time of 37 minutes (from receipt of the fire report) the average attack time on another 8 fires was 9 hours and 20 minutes. In 1920, power forest fire pumps were introduced.

Railways continued to be a major forest fire threat. The most dangerous practices involved gross carelessness by constructors clearing rights-of-way; the dumping of live coals away from railway stations; the failure of railway companies to equip and maintain efficient spark-arresters on locomotives and the failure to fight fires which they had started. The Dominion Board of Railway Governors, upon application by the British Columbia Government, passed an order which stringently regulated and placed responsibilities upon the Dominion chartered railways whereas railways operating under Provincial charter were placed under the provisions of the Forest Act for purposes of fire prevention.

It is symptomatic of the dominant interest directed toward forest fire protection and the level of damage caused by forest fire in British Columbia that other forest considerations have been and are subjugated to its solution. In clear cutting operations it is usual to create a considerable amount of slash on the logging site and in certain areas thisis supplemented by unmerchantable windfall lying on the site before logging. This accumulation of slash is viewed by a majority of professional foresters as a potential fire hazard and in forest cover types such as the Interior Douglas fir type, the additional problem of producing damaging insect infestations may be included with the fire potential. The Forest Service have long favoured disposal of accumulated slash by broadcast burning or by piling and burning. Whilst some efforts have been made to control the intensity of heat developed in a broadcast burn, the aim of removal of the potential fire hazard has usually taken precedence over considerations of possible damage to the soil structure and its fertility and over silvicultural considerations, particularly those of obtaining natural regeneration following logging. Professional opinion is, to some extent, divided on these questions but nevertheless, Government policy has long required the burning of logging slash in the coastal Region and the Forest Service is currently introducing a similar policy in the Interior.

Reference to the damage caused by forest fire in the Province and the costs of constraining fire damage is contained in the statistical evidence in Annexure 4 - this evidence indicates that grave problems still exist, not the least of which is the rapidly increasing cost of fighting fire, coupled with increases in the damage cost.

Forest protection has long been carried out under financial arrangements based on taxation of forest private ownership and the forest industry, on an acreage or volume basis, whether in permanent or temporary tenures. The protection costs have mostly exceeded the protection tax revenues and the Government, in paying the balance of costs, frequently contributes a majority proportion. Public fire fighting effort (which is usually conducted by the forest industry) is, except under certain specified circumstances, recompensed by Government at fixed rates of pay. These rates are usually set well below those which the industry actually pays its own employees for fighting fire. It may be construed that the rates are set at a lower level for purposes of economy during a severe fire season but also to discourage incendiarism.* Persons accused of incendiarism or of a refusal to obey a legitimate order to fight fire are accountable to law.

Forest fire preventive measures have generally not included restriction of public access into the forest

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* Although the author has been unable to obtain definite evidence, it is commonly reported that, during the depression of the 1930's, fires were set by unemployed men who then hoped to be employed and earn pay for fighting the fires.

except during actual forest closures in times of very high fire hazard. In one sense this is a curious state of affairs since it is known that a considerable number of fires are started by campers, smokers and sportsmen. The position is an exception to the situation previously described, in which the problem of forest fires takes precedence over other considerations. The reasons for the virtually unrestricted public access to the forest are mainly political in nature and stem from the general view that the access is a right, rather than a privilege. Consequently, the relative question of whether or not free access is actually in the public interest seldom arises. The problem of fires caused by the public has been approached with publicity and public education programs and in these fields the long-established Canadian Forestry Association of British Columbia, an organization supported by government, industry and private donations has been and is, active.

The Second British Empire Forestry Conference of 1923, held in Canada, issued a Committee Report to "make suggestions for better forest fire protection". This report formally set out much of the reasoning behind the British Columbia forest protection policy.

g. Forest Pathology and Entomology 1913-1945:

The Dominion Government has held and continues to hold, a vital and dominant role in the fields of forest entomology and pathology in British Columbia, particularly in research. The position can perhaps best be summarised by stating that knowledge, research facilities and forest insect work have gradually increased, with marked progress from about 1955 onwards. Control methods, employing all known techniques, from the introduction of special logging regulations to aerial spraying have been extended, usually by co-operative work of the Provincial and Dominion Governments and industry. It cannot be asserted, however, that the enormous extent of the entomological and pathological problems present in British Columbia has been tackled on a comprehensive scale in terms of control action. It is true to say that major insect epidemics receive attention in control action but lesser outbreaks are usually allowed to take their course under observation. With limited resources available, a comprehensive control programme remains a future goal and practical limits are imposed on what can be accomplished. The gradual removal of the large amounts of overmature and mature growing stock in the Province's forests and their replacement by thrifty young growth is itself a form of control and should lead to a lower scale of destruction. The work of the Dominion Government in these fields is described in greater detail in a later section of this thesis.

h. Forest Research 1913-1945:

Following a period of rather sporadic investigation into conditions affecting the reproduction of various commercially valuable species and into questions of tree growth, a small Research Division of the Provincial Forest Branch was formed in 1927. The Aleza Lake* and Cowichan Lake forest experimental stations were established prior to 1934. Green Timbers forest nursery was established and four other areas reserved by the Province for experimental and demonstration purposes at Green Timbers, Campbell River, East Thurlow Island and Discovery Passage. The work of the Research Division, however, was virtually brought to a standstill from 1931 to 1937 and, again, from 1939 to 1945. In the former period shortage of funds during the depression and, in the latter, shortage of personnel during wartime, were responsible. A number of volume and yield studies were conducted, however, and the results were expressed in tabular form for the Forest Branch reconnaissance and survey work. Most of these tables are now out of use but the basic data from which they were derived still form a part of the Provincial Inventory data.

Most of the research studies conducted in the Coastal Region were directed toward producing a sensible

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* Subsequently closed down.

silvicultural policy to be applied to the logging of Crown lands.* A programme directed to this end was started in 1921. At that time, the Forest Branch (1921) considered that the policy should include the following principles:

(1) It must ensure that a sufficient production of log volume per acre would be achieved to make the logging operation economical.

(2) The silvicultural system of felling must not be so costly as to make logging unprofitable.

(3) It should, as far as possible, encourage the regeneration of the most valuable species.

There was, about this time (1921), an evident disparity of professional opinion which has been noted earlier in remarks on slash burning and which has continued to the present day. It was noted, in the process of research study, that natural regeneration was best obtained (in the Coastal Region) on unburned sites and that broadcast slash burning usually delayed this regeneration. The finding led to the conclusion that as little slash burning should be done as was consistent with fire protection requirements. In practice, however, slash burning was being rapidly extended with a sense of urgency, to do everything that could be done to counteract the

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* The policy was to be largely based upon studies of natural regeneration, growth and yield and the effects of thinning.

disasters of fire.

Following the lack of research activity by the Research Division during the depression, the tempo of study revived about 1937 and included investigation of factors surrounding seed production, seed dissemination, survival of disseminated seed and germination and survival of natural seedlings. No general success was or has yet been achieved from direct seeding experiments, although studies continue. The studies were later expanded to include the influence of contemporary logging systems upon natural regeneration possibilities.

The Interior forests have been recognized for many years - certainly since 1925 - as having forest management problems which differ markedly from those of the Coastal Douglas fir Region (Forest Service Annual Report (1925)). In the Northern Interior, spruce-alpine fir mixtures are common and it was found that most of the overmature and mature stands had, as their merchantable timber volume content, about 85 percent spruce (*Picea glauca* (Moench) Voss) and 15 percent alpine fir (*Abies lasiocarpa* (Hook.) Nutt.). However, the logging methods then in use* considerably altered these proportions so that the alpine fir, inferior in size and economic volume, would form the greater proportion of the resulting forest. The research objective in these stands was the development of a method of logging which would produce a valuable second-growth and, at the same time, be economically feasible. This has led, eventually at the present day, to the widespread use of a clear-strip system of felling, with tractor scarification to assist the natural regeneration of spruce.

In the pure lodgepole pine (Pinus contorta, var. latifolia S. Watson) forests of the Interior, the objectives were to cut the stand so as to produce the best possible future forest and to determine whether or not it

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* The logging method was a primitive form of selection felling, commonly known as "high-grading". This entailed the removal of the larger, sound and more profitable spruce and light cutting of the smaller diameter, less valuable alpine fir in the under-storey. The residual stand usually had little possibility of developing into a stand of a volume equalling that of the original stand, since the bulk of residual stems were suppressed and past middle age. Thus the silvicultural results were poor.

would be preferable to reforest the sites with lodgepole pine or to replace it with another species. These questions will be mentioned again in greater detail, in the Review of Literature contained in this thesis.

These and other research studies conducted in the Interior largely concentrated, as in the Coastal Region, on the methods and problems of obtaining natural regeneration. In addition, small scale thinning research, experiments with exotic species and soil and site studies were conducted.

i. Logging Waste:

Reference has been made above to the problem of logging waste in the period up to 1912. The Committee on Silviculture in Canada, British Empire Forestry Conference, 1923, commented on the large amounts of waste in logging operations in the Coastal region of British Columbia. Recognising that the situation was largely attributable to economic conditions, it still represented an enormous loss in the timber supply. Forest utilization waste has continued to be a major problem up to the present day and its reduction has been a consistent policy aim. Quite apart from the cost of disposing of it for fire protection reasons and the physical barrier which it sometimes presents to artificial regeneration operations, it has represented a direct financial loss to the Government in terms of stumpage and royalty.

j. Reforestation Operations: 1913-1945:

Following after the establishment of forest nurseries and the development of techniques for growing nursery stock, the Forest Branch (the only agency which is engaged in tree plant production in the Province) had, by 1937, prepared enough land at Green Timbers Nursery to provide for a potential production of three million trees annually. The severe forest fire year of 1937 influenced the Government to announce a policy of planting 10,000 acres of logged land each year.*

Sloan (1945) in his Royal Commission report noted that about one million acres of forest land in the Coastal Region was not satisfactorily restocked. About 40 percent of this land was considered to be plantable, since it had not been occupied by hardwood scrub following

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* The 1937 fire year, probably more than anything else, ended the "dispute" as to whether slash burning should be compulsory or not. The staggering losses from fire caused the Government to take all measures likely to improve forest fire protection, including compulsory slash disposal and snag felling and to accept the known adverse effects of slash burning on the obtaining of natural regeneration. This, in turn, increased the reliance upon artificial regeneration in the Coastal Region.

logging, and ought to be planted over the ensuing 25 years.

By 1943, the Forest Service tree plant production potential had reached 20 million trees a year. The statistics of planting operations in British Columbia are given in Annexure 5.

k. Grazing: 1913-1945:

The administration of grazing in the Province has been a function of the Forest Branch since its formation in 1912. It was not until 1919, however, that a Grazing Act and regulations became effective, by which time problems of local overgrazing were apparent. The number of stock grazing on Crown land (including forest grazing) had risen by 1945 to 109,000 cattle, 5,000 horses and 39,000 sheep. The downgrading of range by epidemics of grasshoppers and poor range management continued throughout the period of years under consideration.

l. Labour: 1913-1945:

It is worthy of note that, during the Depression, unemployment was reduced by two co-operative Dominion-Provincial programmes, namely the National Forestry Programme and Relief Forest Development Projects. The Alternative Service Workers programme during the Second World War directed conscientious objectors into fire protection work in the Province, at a time when personnel for the work were scarce.

m. Provincial Parks: 1913-1945:

By 1939, the British Columbia Government had reserved some 41 areas for use as parks and these covered more than six million acres. At that time, few of them had been developed to provide access. By 1945, there were 52 parks, covering almost eleven million acres (16,901 square miles). The practice of classifying parks into three categories (Classes 'A', 'B' and 'C') was introduced, the classification relating to the degree of protection from the alienation of their resources which was afforded to them.

n. Forest Finance: 1913-1945:

Statistics for the Provincial Government's revenue and expenditures are summarised in Annexure 4. In 1937, the average annual value of production in primary industries in the Province was given in the Forest Service Annual Report (1937) as:

TABLE 3 The Average Annual Value of Production of the Primary Industries of British Columbia (1937)

Industry	Millions of Dollars	Percent
Fisheries	17.7	10
Agriculture	47.0	27
Mining	48.6	27
Forests	63.3	36

o. <u>The 1945 Royal Commission of Inquiry</u>:

It was becoming quite evident, particularly during the Second World War when forest production was rising rapidly and every effort being made to meet wartime demand, that a number of problems were reaching serious proportions. The Honourable Mr. Justice Gordon McGregor Sloan was appointed, in consequence, as a single Royal Commissioner and given wide scope and powers of investigation into the field of forestry. His report led to the introduction of new policies.

By the year 1942, the primary forest industries amounted to more than 1,600 logging operations supplying logs to 551 sawmills, 4 large plywood plants, 76 shingle mills and 7 pulp and paper mills. The secondary wood-using industries totalled 198 establishments. The value of forest production was almost 125 million dollars*, based on an investment capital of at least 350 million dollars. In the same year, 31,686 persons were employed for the twelve month period and received salaries and wages of at least 350 million dollars. Other statistics are given in Annexure 3. The average hourly wage in logging in 1942 was 75 cents.

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* gross value, including loading and freight within the Province and the value contributed by the wood using industries. (Sloan (1945)).

The Commissioner estimated that the land in British Columbia could be classified as follows:

TABLE 4 Classification of the British Columbia Land Surface as Estimated by the 1945 Royal Commission.

Class	Area in Acres	Percent
Land capable of producing commercial timber	75,023,000	32
Land incapable of producing commercial timber	154,678,000	66
Agricultural Land	4,702,000	2
TOTALS	234,403,000	100

The Commissioner believed that, in the Coastal Region, the overmature forest should be removed to bring the forest to normality, so as to realise the potential for increment and obtain a normal distribution of age classes. When this process was completed, continuous production on a sustained yield basis could be achieved but, until that time, the problem was to spread out forest production so as to avoid a hiatus in industrial production. A sustained yield programme would not be possible on the Coast until the mature forests were replaced.* The Interior, as a Region, showed a relatively balanced division between mature and immature stands.

The Commissioner considered the reduction of productive forest areas caused by forest fires, other pathological agents and logging. In all, there were 20 million acres of forest land in the Province which were not restocked in a satisfactory way, almost one million of them being in the Coastal Region. The rate of clear-cutting each year in the latter Region was approximately

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* It is clear, from these remarks, that the Commissioner equated the term "sustained yield", in 1945, to the concept of an equalised annual production. In the author's view this is a narrow interpretation. There are very few forests indeed which can be managed to produce equalised annual cuts whilst, at the same time achieving other desirable forestry objectives. The Forest Service, in implementing the policy were less rigid and permitted certain flexibilities in annual cuts, as well as recognising that in some managed forest units, a period of annual cuts in excess of current growth rates was desirable pending a closer approach to normality. In the author's view, arrangements of this kind fall within the meaning of the term "sustained yield".

65,000 acres, of which it was estimated that about 50 percent would restock naturally, in varying degrees, over a period of years. The Forest Service had been planting from 10,000 acres to 15,000 acres per year in the Coastal Region since 1940, so that at least 20,000 acres per year were being added to the one million already denuded. The Commissioner insisted that the denuded productive land areas should be replanted, that areas logged in the future should be left in a productive condition and that young forests must be protected from fire.

Sloan went on to estimate that the total annual allowable cut in the Coastal Region should be 3,483 million feet, board measure (approximately 500 MM cu. ft.), but in the author's opinion this should have been at least 4,500 MM fbm (approximately 700 MM cu. ft.), based on Sloan's data, since the increment on young growth succeeding the logged mature stands was omitted. It was apparent that coastal Douglas fir was being overcut and that other species would have to be brought into greater use. In the Interior, the increment exceeded the annual depletion.

The annual waste of wood left behind after logging was estimated to be about 750 MM fbm (about 12 MM cu. ft.), against a total annual log production of 3,000 MM fbm (about 450 MM cu. ft.) and further heavy losses occurred in sawmilling conversion processes. The use of portable sawmills was noted as being particularly wasteful.

From a study of the alienation of Crown land, Sloan concluded that most of the alienations*were controlled by a very few men and that the success of any future policy of planned forest management would depend, to a degree, upon the extent to which these men co-operated with the Crown. Because the Crown could impose conditions upon those holding cutting rights on Crown lands and still retained unalienated title to 39 percent of the merchantable timber lands in the Coastal Region, on which terms could be imposed at the time of disposition, there should be little difficulty in securing this co-operation.**

* The percentages of acreage were:

	Crown Unalienated	Temporary Alienations	Other Owners	Total
Coast	39	47	14	100
Interior	86	9	5	100

** The suggestion of obtaining co-operation by coercion is evident. The results of this type of thinking have not tended to improve relations between Government and industry, even though "co-operation" may have been obtained.

The Commissioner felt that no real attempt had been made, between 1925 and 1945, to manage properly the Forest Reserves, even though this objective had been enunciated in 1925 by the Government. The fault lay in a lack of sufficient funds and adequate staff to conduct the necessary research work. Sloan stated:

> "Forest revenue accruing to the Crown must be recognised as capital to be invested in our forests to ensure their continued productivity. To persist in the pursuit of any other policy is to initiate a deserved disaster."

The same point had been made by the Commission of Inquiry of 1910.

The industry had complained, during Sloan's hearings, that there was no opportunity for it, under the forest laws and existing forms of tenure, to plan a permanent operation or to do other than liquidate the forest. Sloan agreed and recommended a new form of tenure to permit a measure of private forestry. This recommendation led to the creation of tree farm licences (see Annexure 1).

He also felt that the objective of future forest management should be to change from the (then) existing system of unmanaged and unregulated liquidation of the forest to a planned and regulated policy of forest management, leading eventually to a programme ensuring a sustained yield from all the productive land area. He defined "sustained yield" as "a perpetual yield of wood of commercially usable quality from regional areas in yearly or periodic quantities of equal or increasing volume". Whilst recognising the increases in yield which could be effected by silviculture, he did not feel it (silviculture) to be an "essential ingredient" of the definition. The realisation of the aim of multiple purpose use of the forests was as important as the balancing of cut and increment.

Having described the objective of future forest management, Sloan (1945) described how it was to be attained. Adequate funds must be provided for fire protection; a forest closure system should be introduced during periods of high fire hazard and logging methods should be regulated to secure natural regeneration.* A new kind of privately managed tenure ought to be created, in which the Crown would contribute forest to add to private acreage so that the combined area would, in the second rotation, produce enough timber on a sustained

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* With the logging operator paying for artificial regeneration when natural regeneration failed - a suggestion which has not been adopted except in tree farm licences, where allowances for costs are made in the stumpage.

yield basis to maintain production of the manufacturing unit (of the owner of the private acreage) on a profitable basis in perpetuity. This new form of tenure was, thus, to be appurtenant to a particular manufacturing plant.

The Commissioner identified the main obstacles to the practice of private forestry as the uncertainties of future markets, the risk of fire and burdensome taxation. He recommended certain taxation relief to operators who practiced forestry.

Apart from this form of privately managed tenure, another kind would supply the Coastal log market or small manufacturing plants with timber on a basis of sustained yield management. This kind of privately managed tenure would be formed from a merger of private holdings whose owners had no conversion plant; of areas under municipal management or of areas designated for watershed protection or other multiple forest use.

In the Interior, it was recommended that mills should be licensed to ensure that the industrial productive capacity could be supported by the timber lying within economic hauling distance of the various mills, in perpetuity. In the event, Interior mills have not been licensed.

A recommendation that a Forestry Commission should be formed to administer the forests and given powers to regulate its own financing from forest receipts was not implemented and a recommended Interior Advisory Council to deal with multiple use questions was not formed.

Upon the advice of the Commissioner, the Department of Forestry at the University of British Columbia was raised to the status of a faculty.

4. British Columbia Forest History from 1946 to 1967.

a. General:

Following the Second World War and up to the present day, the politics of British Columbia have been largely concerned with the industrialization of the Province, particularly in the fields of roads, power supply and the Provincially owned Pacific Great Eastern Railway. Along with development of these items has gone the development of natural resource industries - forestry, mining and oil. It is only during the post-war period that Government revenues have approached levels permitting these developments. The post-war period has also seen rapid inflation. Sherman (1966) has noted that the 1948-49 Provincial budget was $77,000,000.00 - more than double that of three years earlier. The cost of living was increasing rapidly. In the three years up to January 1946, the index went up less than three points to 119.9. In the next eleven months, it jumped seven points and then remained relatively stable for three months. Then, in a year, it increased twenty three points to 150. The population had reached 1,047,000 by 1948 and the costs of social services had increased, in the years, from \$9,000,000.00 to \$19,000,000.00. In 1950, the budget was \$105,000,000.00. In addition to inflationary trends, the Government still experienced financial problems and found it necessary, by 1948, to impose an unpopular 3 percent sales tax. A compulsory hospital care insurance plan was cancelled because of high deficits in its operation. The post-war period has been characterized by Provincial Government criticism of the arrangements for the division of revenues between Federal and Provincial Governments and Federal expenditures of monies derived from the Province, a question which will be mentioned again later in this thesis.

b. Forest Policy and Administration:

(1) Tenures:

In 1945, the Department of Lands of the Province was reorganized as the Department of Lands and Forests, with a Deputy Minister of Forests included. (B.C. Forest Service (1945)). In effect, this made the Forest Service a separate department of government. Also, in 1945, a Public Relations Division of the Forest Service was formed. Legislation was enacted which led to the creation of the important tree farm licence tenure for private forest management under government supervision and the public sustained yield units for Forest Service management, both with the objective of sustained yield forest management (B.C. Forest Service (1947). These tenures are described in Annexure 1. The Tree Farm Licences were much critisized publicly as noted by Moss (1956), primarily because they were issued to larger companies with the financial ability to manage them, thereby restricting the private enterprise of the small operator. Their issue was eventually curtailed and then stopped. By 1964, there were 41 tree farm licences with more than 7 million productive acres and including more than 1.5 million acres of private land. Because very little of the forest land in the Interior had been alienated into private ownership, the bulk of private land in tree farm licences is to be found in the Coastal Region. The formation of public sustained yield units continued and, in 1965, there were 75 of them, containing 69,781,944 productive acres.

An important policy question during the period was the question of survival of the "small" logging operator or company in the face of competition from the large integrated companies. Also, the questions of insufficient inventory data and the waste incurred during logging assumed increased importance with the introduction of sustained yield management. The questions were interrelated in that, if better inventory information and less waste in the public sustained yield units would permit increased annual cuts, then the problem of timber supply to small operators would be a less pressing problem. The government was also determined to adhere to the principle of free enterprise with a restriction of bureaucratic control. By 1963, their stated future courses of action (Williston (1963)) were:

(a) To ensure a sustained supply of timber for sale in the public sustained yield units and to attend to such matters as achieving more accurate inventories so as to achieve accurate allowable annual cuts.

(b) The Government policy of requiring tree farm licencees to employ contractors (other than the licencee's own employees or shareholders) to harvest some of the annual cut would be fully implemented for T.F.L.'s 13 to 39 (most of these were in the Coastal Region). Licences 14 to 23 required 30 percent as the contracting portion and licences 13 and 24 to 39 required 50 percent.

(c) Subject to limitations of available funds and trained personnel, the reforestation of cut-over lands would be intensified.

(d) Consistent with efforts to increase the allowable cut, there would be a gradual insistence of more complete utilization of wood on the ground.

(e) In certain cases, where a high incidence of defective timber occurred, the Government would encourage improved utilization practices so as to remove all merchantable volume and prepare the ground for regeneration of a new forest.

Somewhat later than this, changes were made in the form of certain Timber Sales with the specific intent of supplying timber to pulp mills and, later, for use in public sustained yield units. The administration of timber sales, involving a distribution of the annual sustained yield cuts to established operators has become complex and is described in Annexure 1.

One of the factors leading to changes in timber sales was the growing recognition that regeneration of logged sites was a pressing problem (Williston (1967)). In the Interior, the need has given rise to changes and refinements in silvicultural systems of felling, including scarification of the seed bed and/or slash burning. However, the responsibilities of the timber sale licencee did not go beyond this and the Forest Service was not engaged in reforestation of these sites on an adequate scale. If the operator were to be responsible, the inclusion of the added costs of complete reforestation into the stumpage appraisal would, in many instances, result in an inadequate financial compensation to the operator. Consequently, the Province (1964) amended the Forest Act to permit the Minister to compensate the licencee, in whole or in part, for silvicultural treatment or for constructing a primary access road, either by "an offset against stumpage or by payment from funds appropriated by the legislature for that purpose". To date (1965), this principle has only been applied to about 12 timber sales and there is some controversy on the question of whether rates of compensation are adequate. It is the intention of the Government to place more responsibility on the industry for the forest management of public sustained yield units rather than to build up a very large Forest Service to perform all of this function.

Another very important form of tenure, created in 1960 by an Act of the Legislature was the Pulpwood Harvesting Area, which is described in more detail in Annexure 1. In return for an undertaking to build a pulp mill within a specified period, the Government would allocate first priority to purchase pulp timber from a given public sustained yield unit or group of units within a designated pulpwood harvesting area. It was expected, according to the Minister of Forests that the pulp mill operator and the logging operator would enter into agreements whereby the latter would undertake to remove the pulpwood, tree tops, species unsuitable for lumber, etc.

for the pulp mill operator. If the logger was uninterested, the pulp mill operator would have the legal right to remove the material in question by his own means, even though he was not the timber sale licencee. To this must be added that pulp chips produced by sawmills are still a preferred source of raw material for pulp, being generally cheaper than chips produced at a pulp mill from round wood.

As a result of the Pulpwood Harvesting Agreements pulp production in British Columbia, which had more than doubled in the decade ending in 1965 when it reached 3.2 million tons per annum, was expected to double again in the succeeding five years (British Columbia Hydro and Power Authority (1967)). A tripling of pulp capacity has been predicted for the decade following 1965, to reach a forecast annual total of 9 million tons by the mid 1970's. Newsprint and paper production, which had more than doubled in the decade ending in 1965, when it reached 1.5 million tons was expected to reach 3 million tons annually by the mid 1970's. Expansions of many of the existing 17 pulp and paper mills, plus the construction and subsequent expansion of some 15 to 20 mills within the ten-year period ending about 1975, will call for total planned capital and prepaid expenditures approaching 1,500 million dollars. The actual and proposed expansion is on a startling scale which has been termed the "pulp explosion".

This rapid expansion is not without its drawbacks. A spokesman for a large integrated forest products company* pointed out in 1965, whilst the newsprint marketing field was good, that for pulp was uncertain. Other countries were planning new pulp production and he anticipated a total world available supply of about 11 million tons by the end of 1967, with a corresponding demand of 9 million tons. By the early 1970's, taking into account only the planned increase for British Columbia, the supply would increase to 14 million tons and the demand to 11 million tons. At the time of writing, it is clear that this trend is occurring and a number of British Columbia pulp mills are not working at full annual production, particularly those selling a substantial portion of their production in the open market, and prices are tending to be lower. It remains to be seen what influence this trend will have on the proposed pulp mill construction programme.

A new form of forest tenure was created, in effect, by amendments to the "Taxation Act" of the Province. This was the classification known as 'tree farm land', with provisions for special taxation of Crown granted forest land, intended to encourage the dedication

* The Honourable J.V. Clyne, Chairman of the Board, MacMillan, Bloedel and Powell River Ltd.

of suitable private land to forestry. The tenure is described in Annexure I.

(2) Close Utilisation:

The major new forms of tenure - tree farm licences, public sustained yield units, pulpwood harvesting areas and changed timber sale contracts - which have resulted from the introduction of a sustained yield policy in British Columbia have been mentioned briefly. The Government was aware of several influences affecting the potential level of cutting under sustained yield and have emphasised the importance of "close utilisation" of mature stands being cut. The Pulpwood Harvesting Areas, apart from the effect, highly desired by Government, of accelerating the industrialisation of the Province, has intensified (but to a degree which is not yet evident) closer utilisation, both in forest and plant. This closer utilisation will, to the extent that it is practised, cause upward revisions of annual allowable cuts. The potential of those pulpwood harvesting agreements currently in effect does not, however, provide the desired standard of forest utilisation throughout the Province and cannot be expected to allow a cut equal to the potential sustained yield capacity of the Province to be reached, at least for many years. The Government therefore introduced its "close utilisation" or "smallwood" policy (Williston 1965).

In the Interior, close utilization meant cutting trees to a 7" d.b.h. minimum cutting diameter, (to a 6" diameter top) instead of about 11 inches d.b.h. The allowable cuts of public sustained yield units were recalculated to this standard. The difference between this cut and the previous one was determined and allocated pro rata to existing quota holders*, new quota holders and a Forest Service reserve for contingencies and sale of minor products such as cedar poles and piling. The general allocation of the increase in cut between major users would be

- 50% to sawlog operators who contracted to utilize to the 7" d.b.h. close utilization standard.
- 40% to pulp utilization, bearing in mind the commitments under pulpwood harvesting area agreements, in which the Crown undertook to provide the P.H.A. licencee with a given volume of wood.
- 10% Forest Service reserve to be used for pole sales, piling, emergency sales (e.g. fire or insect killed timber, etc.

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* A quota may be defined as the amount of wood which an operator is allowed to remove from a P.S.Y.U. annually, subject to his performance and certain other conditions.

These proportions could, however, be varied. An operator who did not wish to cut "smallwood" but to confine his utilization to "normal sawlogs" would be restricted to stands without a significant volume of small trees.* The operator contracting to remove to 7" d.b.h. close utilization standard, would receive the increase in quota (i.e. he could cut more timber) and would be restricted to stands containing a significant volume of small trees. A lower rate of stumpage was provided for smallwood, as an added incentive to log it. In the Coastal Region, the new allowable cuts in P.S.Y.U.'s would be calculated to a 9" d.b.h. close utilization standard, instead of the usual current minimum sawlog utilization diameter of 13" d.b.h.

Operators applying for smallwood were required to prove that they had a contract of more than one year's duration for the sale of roundwood or chips for pulp. Where Pulpwood Harvesting Areas already existed, this roundwood or chips must be offered to their holders on a first refusal basis.

This relatively new smallwood utilization proposal will probably undergo, in the author's view, considerably more amendment before it is in wide-scale use.

c. <u>The Forest Inventory</u>:

Following the Royal Commission on British

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* The trees, in all cases, are to be mature or included in a stand that is mature.

Columbia forestry of 1945, another Commission, also with Chief Justice Gordon McGregor Sloan as sole Commissioner, was appointed a decade later and reported in 1956. Sloan had much comment on the various matters before him. He noted that the primary need for a reasonably accurate knowledge of the forest was to enable the evaluation of forest policy and administration relating to conditions of tenure, incidence of taxation, protection from fire, insects and diseases, improved standards of utilization and forest management in general, designed to ensure a continuity of production and sustained yield. Improving accuracy of inventory, coupled with the effects of logging, fires, insects and decay on the one hand and of increment on the other made the accuracy of any inventory subject to a time limit. The reported timber inventories through the years had increased from about 40,000 million cubic feet in 1910 to about 110,000 million cubic feet in 1955. The latest published figures of inventory in the Province are contained in the Government publication, "The Continuous Forest Inventory of British Columbia - Initial Phase - 1957". A stratified random sampling technique was employed. The accuracy objectives were to produce estimates of gross cubic foot volume by species in the entire Province by seven inventory zones with a sampling error not exceeding ten percent at a probability of .95.

Each inventory zone (ranging from 4 million to 40 million acres in size) contained a number of sub-zones of approximately one to two million acres in size. In each sub-zone, the <u>ultimate</u> accuracy objective was similar to that used in inventory zones, except that the accuracy applies to the gross volume of all species collectively. It can be readily appreciated, under these circumstances, that difficulties arise in the application of Provincial Inventory figures to specific management units, if the degree of accuracy is to be known. An element of uncertainty exists in P.S.Y.U.'s as to whether annual allowable cuts are too high or too low and Government policy and practise are aimed at intensifying management unit inventories so as to achieve a predetermined accuracy. The massive nature of the inventory task, even with the Federal Government financial assistance that has been provided, will be readily appreciated and remarkable progress has, in fact, been made. The inventory is <u>continuous</u> and the published material falls behind the actual Government knowledge of the Inventory position between the anticipated periodic reports.

<u>d. Sustained Yield:</u>

Whilst the term "sustained yield" is a common forestry concept in Europe, and is, in some cases, regarded as "classical" (implying outdated) it has become for

British Columbia, with its history of liquidation, a lodestone, a vaulting of a major obstacle and a definite turn towards prudency in which the history of the United States and Canada had not leant encouragement. It is commonly used in public pronouncements and its uniqueness emphasized. It has, since first propounded officially by Sloan, in 1945, been largely accepted by all social strata and industry.

It should not be assumed, however, that the policy is without its critics. As an example, one professional economist (Pearse (1967)) has pointed out that it is unlikely that equal annual harvests would maximize the value of the forest resource as the demand for forest products fluctuates over time. A fixed supply of timber in the face of changing market demand would cause timber values to fluctuate more widely than if supply were permitted to respond to price. The aim of stability was inconsistent with the changes required for economic growth. In spite of these and other criticisms, it is clear that British Columbia forest policy is committed to sustained yield which is forming the basis for a very rapid evolution of administration and management practices at the present time. This evolution is so rapid that a summary of the position at a given time is liable to be very quickly out of date.

e. Forest Protection:

(1) Fire Protection:

Chief Justice Sloan noted, by 1956, that a marked improvement had occurred since 1945, in the allocation of funds to fire protection but that the position was still unsatisfactory. The total noted expenditure, after appropriate adjustments, was $3,805,000.00 for the fiscal year 1956-57, as compared to $784,512.00 for 1944-45. The apparent increase of 400 percent was probably reduced by about one-half because of increased labour and material costs. During the twenty-five year period 1930-54, 6,426,475 acres had been burned over the Interior and 737,692 acres on the Coast. These figures did not include the holocaustic and unfought fires which raged from time to time over unoccupied northern territories of the Province, most of them caused by lightning. An apparent improvement occurred for the six years 1950-55, during which a total of 1,063,611 acres was burned. Nevertheless, the losses have remained heavy up to the present, as in the serious 1967 fire season. Increasing timber values make the financial losses increasingly heavy and expenditures are increasingly high with the advent of air water bombing, and increased helicopter usage, as well as the increasing costs of labour. All of the methods open to Government and industry, such as forest closures, early shift working in the woods, slash disposal and so on, are employed and, viewing the situation in a detached manner, it appears that fire losses will remain an endemic problem of major concern in British Columbia for the foreseeable future. About 30 percent of fires started may be attributed to campers and smokers. In the author's view, there is an apparent anomaly in the Province's forest policy whereby the public makes free use of the forest except under the severest hazard conditions, when forest closure is normally employed. In many areas of the Province, the public exercises what is regarded as the public right of forest use through the fire season and may not be debarred for fire hazard reasons other than by forest closure by the Minister of Lands and Forests. It may be that continuing fire damage and costs will cause adjustments to eliminate this anomaly.

In 1967, the Forest Service commenced the introduction of compulsory slash burning, long practised in the Coastal Region, into the Interior. As has been mentioned previously, the practice of burning slash remains controversial. Escaping slash fires continue to be damaging to adjacent stands of timber, the burning is a deterrent to natural regeneration under many conditions and leads to the necessity of planting, increasing management costs and the effects on the soil are not thoroughly understood. Initially, at least, it is proposed that burning in the Interior should be selective. About half of the clearcut areas (75,000 acres) in the Interior are considered by the Forest Service to be suitable for burning but it is not proposed to burn all of this acreage as yet, because of a shortage of sufficiently trained Forest Service staff to assist logging operators and because of the extensive, existing areas of older slash that the Forest Service propose to burn, in part, themselves, to create fire breaks in some areas of contiguous slash.

(2) Forest Insects and Disease:

Sloan noted, in 1956, that an accurate estimate of losses from these causes was very difficult to make. In the decade 1944-54, losses from known, specific infestations of insects were well in excess of 130 million cubic feet. The accumulated volume of decay in the forest was estimated at 24,482 millions of cubic feet.

f. Reforestation:

The question of reforestation is dealt with in some detail in the Review of Literature in this thesis. The accumulation of areas not satisfactorily restocked continued during the period, in spite of increasing planting programmes. In 1966, a record 19,070,700 trees were planted on 46,935 acres by all agencies.

g. Forest Utilization:

The cut from the Provincial forests continued to increase during the period under consideration. Changing economic concepts and the need to achieve higher values of recovery at economic cost levels had led to the establishment of integrated operations so that the log would find its way to the best, most profitable use, being converted into lumber, veneer, plywood, pulp and a variety of other products according to its species, size, grade and other relevant and related factors. The dominant feature in log utilization is the production of lumber by sawmills, a situation that is likely to continue as long as high-grade lumber can be produced from old-growth stock. In a second-growth economy, lumber production is expected to be a less distinctive feature.

In addition to integration, there have been changes in the pattern of supply with a large number of mills entering into the logging business themselves, either directly or indirectly; an increase in utilization of mill residues; an increase in flexibility resulting from modernization of milling techniques permitting greater latitude in the use of various species and, generally, the gradual evolution from mills of the old design cutting heavy timbers to faster mills with lighter and more efficient equipment. Coupled with this has been the virtual disappearance of the wasteful, portable mills and great increases in the production of sawmill chips for pulp mills.

A number of specific improvements made during the period were the introduction of air-tongs and log grapples for log loading; the large-scale introduction of rubber-tyred skidding machines into the Interior; the introduction of portable steel towers for high-lead logging in the Coastal Region; the rapid development of Northern British Columbia and the introduction of new small log conversion machines which produce lumber and chips in one pass.

In spite of these improvements, a general decline in profitability is evident in both the pulp and lumber section of the industry, since about 1962.

h. Forest Research:

The British Columbia Forest Service Research Division is a relatively small organization, of limited finances. Because of these factors, it is unable to deal with a wide variety of problems needing attention and has concentrated its efforts into particular fields. Top priority has been assigned to all questions covering seed supply such as seed year periodicity; seed crops, quality and maturity; collection, storage, extraction and cold storage of cones and seed; seed dissemination relative to natural regeneration; and races and provenances of coastal Douglas fir. A tree breeding programme is restricted to coastal species, particularly Douglas fir, seed orchards are being established from plus trees but genetic studies, other than on seed, are generally deferred. The programme includes studies of natural regeneration and direct seeding.

Site classification studies are proceeding at a modest pace but studies of thinning, pruning and improvement cutting are of low priority. Very little other work is foreseen under current Research policy because of the severe financial restrictions noted.

The aspects of research conducted by the Government of Canada are considered below.

i. <u>Multiple Use</u>:

The problems of multiple use continued to increase during the period with the various agencies and organizations pressing their claims publicly and privately. The difficult question of access into the forest continued to occupy attention and is probably not yet solved in a manner capable of meeting future demands. Almost all interests have a concern in obtaining free access. The main controversies occur in the fields of forestry, game management, grazing, mining, watershed management, salmon breeding and recreation.

j. Education:

Forestry education has increased rapidly during the period with the Faculty of Forestry at the University of British Columbia expanding its post-graduate programme and placing more emphasis on the field of forest products. The Burnaby Institute of Technology commenced the training of forestry and forest products technologists, a new kind of training for British Columbia. In addition, a number of new vocational training courses were introduced. The functional structures of the British Columbia Forest Service and the forest industry, considered together, present an exceedingly complex range of skills and training.

CHAPTER 2

THE FOREST HISTORY OF SCOTLAND

1. General:

A number of eminent foresters and authors have given accounts of Scottish Forest History. In a number of ways, the history is distinct from that of England and Wales, but there are many aspects in common, particularly in more recent times.

2. Scottish Forest History prior to 1914:

Anderson (1967) has described the early history, from the time of the last Ice Age. He relied upon such evidence as has accrued from pollen analysis, residual evidence and other material to reconstruct an outline of the events which almost led to the complete destruction of the primaeval forest covering Scotland and to the formation of the extensive peat soils of the Scottish Highlands. Dickson and Innes (1959) have summarised the situation. In brief, the Highlands appear to have been colonised by birch (*Betula* app.) following the retreat of the ice some 12,000 years ago. The birch was followed, in the boreal period, by birch/pine natural forest with dense hazel (*Corylus*) undergrowth. Later, in the sub-boreal period, elm (*Ulmus*) and oak (*Quercus*) appeared. Climatic changes, following the sub-boreal period, erased considerable areas of

Highland forest and replaced it with the blanket bog which persists to the present day in many areas of northern Scotland.

Heavy inroads were made into the forests by iron smelters, shipbuilders and housebuilders in the sixteenth and seventeenth centuries. More destruction occurred with the upsurge, for economic reasons, of sheep farming with the forest being cleared and/or burned to improve pasture.

Anderson (1967) has stressed that the planting of occasional trees in Scotland occurred in the centuries before 1600 but it was not until the sixteenth century that early plantations, mainly for amenity, began to be established. A feature of the seventeenth century was the widespread expansion of tree planting by the land owners. The mass planting of parks and estates started after 1660 and included experimentation with alien trees or the use of native species (e.g. Scots pine - _Pinus sylvestris_ Linn.) under conditions unnatural to them. The success of some of these experiments, however, led to the extraordinary expansion of large-scale afforestation which occurred in the eighteenth century. At Bargally, foreign trees and shrubs, many from eastern North America, were planted prior to 1729. Silver fir (_Abies alba_, Miller) and Norway spruce (_Picea excelsa_ Link) were planted at Drumlanrig in Dumfriesshire, before 1680. Many other records of plantings in Scotland, about this period, are extant but evidence of the existence of woodland management for commercial purposes is meagre.

After the Risings of 1715 and 1745, attention turned more and more towards exotic species. Large scale attempts to grow trees for commercial purposes, in the national interest, were made by landowners following the example set by the Earls of Argyll, Breadalbane and Fife, and the Dukes of Asholl and others. In central and eastern Scotland, larch (Larix decidua, Miller) from central Europe became popular and Scots pine was used extensively in the lowlands. The more valuable species of hardwoods were not neglected, however. Nor did the increased use of European larch make Weymouth pine (Pinus strobus, Linn.), Norway spruce and Silver fir unpopular. The third Duke of Argyll was responsible, between 1743 and 1761, for planting many rare trees at Inveraray, including a number from eastern North America. However, the most important development of the period was the heavy use of European larch.

By 1845, the estimated area of plantations in Scotland was no less than 549,699 acres. European larch, Scots pine and Norway spruce continued to be the favoured species and a variety of hardwoods were of lesser importance. Douglas fir, Sitka spruce (Picea sitchensis, Cara), Corsican pine (Pinus nigra, Arnold), Sabine's pine (P. sabiniana, Dougl.), Deodar (Cedrus deodara, Loud.) and Macedonian pine (P. Peuce, Grise.) were growing in limited numbers on a variety of properties and the first two species, from the Pacific North-West, were destined to become very popular. The climax of popularity for Douglas fir occurred in the 1930's whilst Sitka spruce is very popular indeed at the present day.

From this history and subsequent events, it is clear that Scottish forestry has been dominated for considerably more than a century, by the use of exotic species. Those from western North America were introduced through the activities of such indefatigable collectors as David Douglas and the formation, in 1850, of the Oregon Committee to investigate further the western species. The Oregon Committee consisted of a group of gentlemen interested in the introduction of new trees and shrubs.

At the present day, European larch has lost much of its popularity because of its susceptibility to diseases (particularly larch canker fungus (Dasyscypha calycina Fuckel) and its relatively slow rate of growth. Sitka spruce and shore pine (lodgepole pine) are now the major species for planting primarily because of the rapid growth rate of the spruce and the tolerance to site and exposure of the latter.

As Edwards (1963) has expressed it, the classical pattern of forestry founded on the management of natural associations cannot be applied in Scotland and the normal safeguards of the natural forest are replaced by artificial methods of control. Amongst the exotic plantations, there may still be found, on the land surface of Scotland, remains of the former natural woodland in the form of hardwood scrub or remnants of former large tracts of Scots pine, the latter usually 150 - 250 years of age and diseased.

Lathan (1957) has written of the early and modern history of the British Timber Trade.

3. Scottish Forest History from 1914 to date:

a. General:

The initial destruction of the mature and some immature forests in Scotland and Britain generally, as well as marked changes in the timber trade, occurred during the two world wars of 1914-18 and 1939-45, when enemy sea blockades made timber importation into the Islands hazardous and difficult. The resultant severe overcutting of the standing timber and the crises of supply were major factors in the establishment of the Forestry Commission at the end of the first world war and in the resurgence of private forestry which followed the second world war. In essence, it was these major events, coupled with the very impressive performance of both the public and private sectors in artificially establishing a substantial forest estate in Britain which form the substance of Britain's forest history from 1914 until quite recently. The changes have produced much debate, much legislation and the British have achieved what appears to be a working balance between public and private enterprise, in spite of some evidence to the contrary.

The State, as in British Columbia, has been the main producer of forest tree plants and the developer of planting techniques and, in a number of respects, exercises control over private forestry. In the following abbreviated account, the author has relied heavily upon Forestry Commission reports and data and the work of Anderson (1967).

Before 1919, Great Britain had no national State forest policy as such, even though special Commissions were appointed from time to time. As a result of the severe shortages of timber which developed during the first world war and the evident dangers, in a national emergency, of undue reliance on imported supplies, a Forestry sub-committee of the Reconstruction Committee was appointed in 1916. This sub-committee (the Acland Committee) proposed a large conifer afforestation programme and the maintenance of the three million acres of privately owned woodlands then existing, in a productive state. As a result, the Forestry Act of 1919 was passed by Parliament. It had the objectives of increasing the supplies of home-grown timber against a future emergency; of providing a reserve against the possible future exhaustion of the world's virgin forests and of lessening the drift of the British rural population into towns and cities. The Forestry Commission was created and empowered to acquire land, to promote the supply and conversion of timber, to establish and carry on forest industries, to promote education and research in forestry, to make planting grants and to give advice to owners of estate woodlands and others.

The Forestry (Transfer of Woods) Act of 1923 transferred the majority of the existing Crown woods - for example, the New Forest and the Forest of Dean - to the Forestry Commissioners.

The Commission underwent a major political and administrative adjustment in the Forest Act of 1945, when the Commissioners were required to comply with directions of the Ministry of Agriculture and Fisheries and the Secretary of State for Scotland, acting jointly (or, where matters affecting only one country were concerned, by the appropriate Minister). The land acquired by the Commission was vested in the appropriate Minister who could then place it with the Commissioners or manage, let or sell land not so placed. The 1945 Act also provided for the appointment of National Committees for England, Scotland and Wales, to have such functions as the Commissioners saw fit to devolve upon them.

The Forestry Act of 1947 provided for the dedication of private woodland to forestry and dealt with the enforcement of a covenant of dedication. A description of the Dedication Scheme is included herein at Annexure 1.

b. <u>Organization</u>:

Under the Forestry Act of 1919, the Commission executive control devolved upon two Assistant Commissioners, one for England and Wales and one for Scotland. Foresty Commission headquarters (in London) dealt with policy, finance and the staff establishment, as well as such matters as supply of seed, stores and equipment, education, research and publications. The country was divided into a small number of divisions (by 1930, there were three in Scotland and by 1938, four) under the direction of the Assistant Commissioners.

During the second world war, however, functions changed and the Commission staff was divided into Timber Supply and Forest Management sections. At the end of the war, another complete reorganization was made, following the passage of the Forestry Act of 1945. National

Committees were appointed for each of England, Scotland and Wales and dealt with acquisition of land, cultural operations estate management (including houses), private forestry and national forest parks. At the London headquarters, the posts of Director-General and Deputy Director-General were created to assist the Commissioners in the execution of policy and for administrative and technical co-ordination. Other new appointments were a Director in charge of Research, Education and Publications, a Controller of Finance and an Information Officer. Regional Directors of Forestry were placed in charge of Commission operations in each country but these have recently (in 1965) been abolished and all forest Conservancies (the equivalent of Forest Districts in British Columbia) brought under the direct control of headquarters. The Conservancies themselves were re-defined in 1945 into eleven Conservancies with a Conservator in charge of each, those in Scotland being designated East, North, South and West.

A partial reorganization, as mentioned above, occurred in 1965, as a result of the recommendations of the Parliamentary Estimates Committee. These recommendations included a reorganization of the Commissioners to include a proportion of full-time executive Commissioners and the reorganization of the London headquarters on a functional basis. The three stated functions are now administration and finance; forest and estate management and harvesting and marketing, each in charge of a full-time Commissioner. The abolition of the separate Directorates for England, Scotland and Wales was accompanied by the appointment of Forestry Commission Senior Officers for Scotland and for Wales to act as intermediaries between the Commissioners and the forestry and ancillary bodies in these countries. These arrangements are expected, by the Forestry Commission, to permit business arising in Scotland and Wales to be dealt with in those countries. However, the author has noted that many professional foresters in Scotland currently oppose the changes, particularly the abolition of the Scottish headquarters at Edinburgh and of the office of Regional Director for Scotland. Another change made in 1965 involved the removal of executive authority from the National Committees which are now continuing in an advisory capacity.

c. Finance:

A Forestry Fund was established in 1919 and is operated as a sinking fund. All Commission expenditures are made from it and all receipts, together with the annual Parliamentary Grants-in-Aid are paid into it. A summary of the operations of the Forestry Fund from 1919 to the end of 1965 is contained in Annexure 6. The Report of the Commissioners for the year ending 30th

September 1966 showed that the capital account stood at 281 million pounds sterling, of which 114 million had accrued as interest charged at the current British Treasury borrowing rate for each year since 1919. During 1966, 14 million pounds of new money was drawn from Treasury to swell the capital account and 15 million pounds was charged as interest for the single year. The position is discussed in more detail in the Review of Literature given later in this thesis.

d. Forestry Operations:

(1) State Forest Operations:

(a) Land acquisition and Planting:

The Acland Committee proposed, in 1917, that the three million acres of private woodland in Britain should be kept productive and 1,770,000 acres of conifer afforestation should be added, of which 493,000 acres should be planted in the first twenty years. It was also proposed to acquire, during the first decade, 20,000 acres of woodland to be replanted with larch at an unspecified rate. By 1939, the Commission had acquired 655,000 acres of land (88 percent of area proposed by the Acland Committee) and 368,900 acres (75 percent of the Acland proposals) had been planted. By the end of 1965, the State had acquired 2,546,128 acres of land, of which 1,524,606 acres were in Scotland, as follows:

TABLE 5 Land Acquired by the Forestry Commission up to and including 1945, in Scotland.

		Acres
1.	Grand Total Acquired.	1,524,606
2.	Total acquired by lease or feu[1] arrangements	309,221
	a. Forest land	186,393
	b. Other land	122,828
3.	Total acquired by outright purchase	1,215,385
	a. Forest land	630,591
	b. Other land	584,794

1. The feuing of land, peculiar in Britain to Scotland, involves the sale of the land in perpetuity but subject to an annual payment by the purchaser to the "principal", or vendor. The annual payment, through long-term inflationary trends or by arrangement, is usually nominal in amount. The principal, at the time of feuing, may introduce restrictions on the future use of the land, which are binding on all future holders and tenants of the feu.

From Table 5, it is clear that the acreage of land suitable for forestry acquired by the Commissioners in Scotland up to the end of 1945, was 816,984 acres.

The Commission land position at the end of 1965, in the whole of Britain and in Scotland, was:

TABLE 6 Land Acquired by the Forestry Commissioners, up to and including 1965, in Great Britain and Scotland.

	G.B. (ac)	Scotland (ac)
1. Total Area	2,655,260	1,530,256
2. Forest land: Total	1,859,498	912,274
a. Under plantations	1,550,441	721,345
b, To be planted	309,057	190,929
3. Other land: Total	795,762	617,982

Some of the land shown in Table 5 was, however, managed by departments of Government other than the Forestry Commission. In Scotland, for example, 43,700 acres of forest land and 270,765 acres of agricultural and other land were managed by the other departments. Basically, the reason for this lies in the fact that, in purchasing land in Scotland the Commission inevitably acquires land unsuitable for agriculture or forestry but capable of supporting red deer. In North Scotland Conservancy, the Commission has (as of 30th September, 1966), the following lands:

TABLE 7 Land Held by the Forestry Commissioners in North Scotland Conservancy as at 30th. September, 1966.

			acres
1.	Under plantations		203,809
2.	To be planted		80,353
3.	Agricultural and other land		313,356
		TOTAL	597,518

During 1967, the British Prime Minister announced that the annual planting rate in Scotland would be increased to 50,000 acres per year (from about 30,000 acres) with most of the increase to be in the crofting counties. For many years, the depopulation of the Highlands, with its people moving to the urban centres to the south, has posed a problem, both from economic and cultural points of view. The increased planting in the crofting counties will undoubtedly be designed to provide employment for the Highlander but it also implies that an accelerated land acquisition programme by the Forestry Commission will occur.

Anderson (1967) has commented on the quality of the Commission planting programme. Thousands of acres have been planted with Norway Spruce in Scotland.

However, most of these stands did not grow well, as compared with other exotics, and are now being converted. The process usually involves the removal of all Norway spruce trees, apart from a specified number which are left to form standards in the next rotation, and underplanting with Sitka spruce. In the case of the native Scots pine, Anderson (1967) has expressed the opinion that the Commission has been prejudiced against it because of its slower rate of growth in relation to Norway spruce, Sitka spruce and poplars (Populus spp.). He agreed, however, that the pine should not be planted over rich rock formations, especially at the higher elevations. The pine has remained popular with many Scottish private woodland owners because most of the private woodlands are located in the east and north-east where the drier climate is more favourable to it. European larch sustained a disastrous loss from disease in the 19th century and since that time, its use has largely given way to the use of Japanese and Hybrid larches (Larix leptolepis Murr. and L. eurolepis A. Henry.) and to Douglas fir. It has, however, retained some popularity because of its general utility.

Since the second world war, a great deal of reliance has been placed upon the more recently introduced exotic conifers and especially upon Sitka spruce, Japanese larch, Hybrid larch, Douglas fir, shore pine and lodgepole pine. At the present time, as will be shown in the Review of Literature, the trend is toward the use of Sitka Spruce and lodgepole pine, which are used almost exclusively on the Scottish peats. This trend is also marked in Northern Ireland. Returning to Scotland, some American silver firs (_Abies_ spp.) are used on a smaller scale, as well as some western hemlock (_Tsuga heterophylla_, Sarg.). Corsican pine held some popularity but its use in Scotland appears to have been entirely abandoned, owing to die-back associated with the fungus _Brunchorstia destruyens_. Anderson (1967) has emphasised the view that since the timbers of the fast-growing exotic species are less valuable than those of the well-tried species* and since the growth rates of these fast growing exotics** are, under good site conditions, not strikingly faster, it was unwise to rely so heavily on the newer exotics. Recently, the experimental use of fertilisers has indicated that very high growth responses may be obtained in Sitka spruce and, to a lesser extent, logepole and shore pines growing on the Scottish peats. These effects and the species are discussed in more detail later in this thesis.

(b) <u>Thinning Operations:</u>

During the first few years after 1919, the

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* namely Scots pine, European larch and Norway spruce.

** namely lodgepole pine, Japanese larch and Sitka spruce.

opportunities for the Forestry Commission to carry out thinning operations in Britain were limited but the scope was increased with the transfer of some 60,000 acres of former Crown woodland, including young plantations, to the Commission in 1923. Probably about 53,000 acres of forest were thinned during the Commission's first twenty years of existence, mostly for fence posts, pit props and hedge stakes. In 1965, in Scotland alone, 19,604 acres of forest were thinned to produce 10.7 millions of cubic feet of thinnings. In North Scotland Conservancy, in the same year, 2,141 acres were thinned to produce 1.7 millions of cubic feet.

The markets for pit props and mining timber were highly important in the sale and disposal of thinnings. Prior to the outbreak of the second world war, more than 80 percent of the mining timber used in British collieries was imported but, by 1950, almost half of the requirements of the Scottish Division of the National Coal Board were home-grown. The volume of round props used in Scotland in that year was 13,320,000 cubic feet in sizes of from 2-1/2 to 6 inches top diameter. The average annual consumption of sawn mining timber during the five years preceding 1950 was 9,540,000 cubic feet and, by 1950, about 60 percent of the consumption was home-grown. More than half of the sawn timber supplied was in the form of crown trees, running in dimensions from 5 ft. x 4 ins. x 2 ins. to 6 ft. x 6 ins. x 3 ins. During the second world war, Scotland's woodlands produced 65 million cubic feet of sawn mining timber and 99 million cubic feet of pit props. However, the mining market has now declined, partly through closures of uneconomic pits and partly through the substitution of some wood items by steel arches. Thinnings are, however, disposable from State forests to the pulp mill at Fort William, to board mills and to box factories. As the post-war plantations reach a size where utilization is possible, the potential volume of marketable thinning is growing rapidly. The Forestry Commission, in an attempt to reduce costs has mechanized the thinning operations to a considerable extent and although horse skidding is still employed, it is giving way to double drum winch extraction, employing a small tower mounted on a light tractor and a main cable with haulback. For short skids the cable simply passes through a block and for longer skids, overhead supports are employed. The method includes provision for skidding into the cable, over short distances, before skidding up or down the rack (or skid-trail) to the landing. The economics of the method appear to be somewhat questionable at the present time, although it is necessary to add that the method is still quite new and subject to improvement. In the mechanization of British woodland operations, the Scandinavian influence is marked.

Fellings in Scotland in 1965 covered 565 acres and produced 1.82 million cubic feet and in North Scotland Conservancy covered 336 acres, producing 0.72 million cubic feet.

(c) Roads:

During 1921 and 1922, unemployment relief schemes were used in Britain and were directed mainly toward road building. Again, in 1947 and 1948, unemployment relief concentrated on road building. As in the relief schemes put into effect in British Columbia during the depression of the 1930's, the results, in terms of the subsequent value of the improvements constructed were somewhat dubious. The road projects were not well prepared, were expensive, and construction occurred close to unemployment areas rather than in locations where the roads were most urgently needed.

A more recent problem with the forest roads has lain in their alignment and spacing. The roads were constructed at a time when mechanized cable extraction was not generally foreseen and, consequently, they are frequently not well situated for current forestry operations. In addition, the truck hauling of thinning produce has developed into the use of gross load weights (including weight of the vehicle) of up to about 20 long tons - a load for which the road bearing capacity is frequently inadequate. The road width is sometimes inadequate for both cable extraction and hauling operations and difficulties are encountered on steep slopes in providing turn-round points for the vehicles.*

Since 1948, when the former Engineer Branch was merged into the general organization of the Commission, a more satisfactory road construction policy has emerged.

(2) Private Forest Operations:

As mentioned above, the Acland Committee Report of 1917 had recommended, in the private forestry sector, that the existing 3 million acres of privately owned

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* The larger vehicles used in British Columbia usually have an arrangement permitting the reach to be disconnected or folded and the trailer is hauled onto the back of the cab section, a practice which markedly shortens the overall length of the vehicle and eases turn-round problems. The British vehicles, partly because bucking is done in the woods, producing short (up to 12 ft. lengths for pulpwood) lengths have double sets of bunks on a fixed bed. Thus the vehicles cannot be shortened for return trips and turn-round.

woodland should be brought into and/or maintained in a productive state. State aid was offered in the form of planting grants and, for a few years, unemployment relief grants were available to clear up the debris of the wartime fellings, in preparation for planting, and for clearing scrub. Up to 1929, about 10,000 acres were cleared of scrub, 21,000 acres of felled woodland were cleaned for planting and 73,000 acres (66 percent of the private sector target set by the Acland Committee) was planted. It is doubtful if this rate of planting made up for first world war arrears because of normal, postwar annual fellings. Private owners were dissatisfied with the conditions attached to the planting grants, heavy taxation and death duties were discouraging to them and relations between private owners and the Government were strained.

In 1932, the Royal Scottish Forestry Society (formerly the Royal Scottish Arboriculture Society) decided that its main task was to encourage private forestry. In 1938, the Forestry Commission called a conference and meetings to discuss the problems of private forestry. A Committee of the Highlands and Islands had made recommendations on forestry, including some for a revision in the scale of planting grants and in death and succession duties. In the later case, money realised by the woodland owners as a result of relief from the duties were to be used in forestry.

In October of 1940, the Royal Scottish Forestry Society declared that its policy was based on six principles as follows:

(a) The setting up of a forest authority to direct private forestry.

(b) The registration of all private woodland owners, who would undertake to manage their woods satisfactorily or suffer them to be acquired by the State.

(c) The assurance of a market of an economic price for the timber produced.

(d) The provision of planting and maintenance grants.

(e) The retention of the system of felling licences* with the imposition of replanting conditions and;

(f) Elimination of the rabbit pest.

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* The felling licences were a wartime measure under which no private felling could be conducted without a licence, stating the conditions of felling, from the Forestry Commission. The system was retained and is still in effect.

It is perhaps remarkable that an independent Society should have proposed to circumscribe the prerogatives of private ownership to this extent and proposed regulated prices and marketing, even at the gain to the private owner of the planting and maintenance grants. The proposals do reflect on the considerable dependence of the private forest owner on Government financial assistance.

The Forestry Commission (1943) stated their post-war forest policy and recommended indefinite retention, for private forestry, of the wartime licensing system as the only means of conserving the growing stocks of timber. It was also proposed that substantial help should be given by the State to private woodland owners who were prepared to dedicate their woodlands to commercial forestry. Those owners who were not prepared to dedicate their woodlands suitable for commercial forestry to that purpose would be subject to compulsory acquisition by the State - a situation considered by the Commission to be the only alternative.

After a period of discussion on the policy proposals, the Commission issued "The Supplementary Report on Private Woodlands (Cmd 6500) (1944)", dealing with the proposed Dedication Schemes. It offered higher subsidies to those private owners who dedicated their land to forestry and supported the setting up of Regional Advisory

Committees but did not accept the proposals to have separate forest authorities for private and State forestry and did not assure the private owner of guaranteed markets and prices.

In 1945, the Royal Scottish Forestry Society restated its objectives, the essential one being to work for the advancement of forestry. In the same year, a body named the Scottish Joint Forestry Committee was set up and was composed of five members from the Royal Scottish Forestry Society, four from the Scottish Landowners' and Property Federation and four from the Home Grown Timber Merchants' Association of Scotland.

The Forestry Act of 1947 put the Dedication Scheme into law. It was not too well received by the private owners. Some legal flaws in it were removed by 1954. The intricacies of land tenure made it difficult and, in some cases, legally impossible for an owner to place his estates into the scheme. As a result, a special class of "approved woodlands" was created for these areas, under which forestry was practised according to a plan approved by the Commission and the private owner received some of the privileges offered to owners of dedicated woodlands. The dedication and approved woodland agreements are described in Annexure I. In spite of the problems, some 30 percent of the private woodlands in

Britain were dedicated within about seven years of the passage of the 1947 Act.

The 1947 Act also fixed the ultimate objective of national policy, in terms of effective forest area within the United Kingdom, at 5 million acres, of which 2 million acres would be from existing woodland and the remainder from afforestation operations. The total area was expected to provide a third of the country's wood supply during normal times or the whole supply during a short emergency period.

The "Hill Farming Act" (1946) and its amendment by the "Livestock Rearing Act" (1951) provided subsidies for the planting of specified shelter belts. The former Act indicated that the afforesting of 100 acres would displace 110 sheep and the afforesting of one million acres would reduce the sheep stock of Great Britain by 4.2 percent and mutton production by 2.2 percent. Wool would be reduced by 1,460 tons per year. It is worthy of mention that the history of Scottish forestry, certainly since 1919, has been marked by varying degrees of controversy between the alternate (or combined) uses of forestry, sheep grazing and red deer and grouse hunting. Like forestry, the sheep industry is subsidized by the Government. The sheep and red deer overwintering ranges (which may coincide) tend to be favoured tree planting areas or, alternatively, access to them from the surrounding mountains and hills may be blocked by planted forests with their surrounding fences. Both sheep and deer are damaging to forest and are excluded from plantations by fences.* Perhaps the least controversial land use, mainly centred on the eastern Scottish moors are the low investment, high revenue grouse sporting areas. They are not subsidised and their economic position is relatively strong as compared to other potential uses. Controversy over land use is based on economic, amenity and traditional viewpoints and problems are increasingly being subjected to scientific examination and experiment. Besides the Forestry Commission, the other major organisations involved in the land use questions are the Department of Agriculture, the Highland and Islands Development Board and the Red Deer Commission, as well as many private landowners.

The controversial Forestry Act of 1951 has been described as placing the Forestry Commission in a position of overwhelming dictatorship with no appeal; as hasty and secretive (by its opponents) and as a development of forest

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* In some areas, a small population of red deer has penetrated the fences or actually been fenced in and there are indications that the animals are adapting to the forest environment in which their ancestors lived.

policy (by a proponent). It provided powers to the Forestry Commission to fulfil its task of promoting and maintaining adequate reserves of growing timber in the country. Control of all fellings, with expanded powers over those of wartime, was given to the Commission, although minor exceptions were made for certain types of felling. The expanded powers included the power to impose replanting and stand maintenance conditions in the terms of a felling licence. The Commissioners can also direct that growing trees are to be felled to prevent their deterioration or to improve the growth of other trees, the owner having a certain right of appeal or the right to require the Minister concerned to buy the trees or land. The Act affords preferential treatment to dedicated and approved woodland owners. The Regional Advisory Committees, including the four in Scotland which corresponded to the Conservancies, were made into statutory bodies. The Home Grown Timber Advisory Committee (set up by the Board of Trade in 1949 to represent forest owners and the timber trade) which the Forestry Commissioners must consult on certain matters, was also made statutory.

The Chairman of the Forestry Commission, referring to the compulsory powers conferred upon the Commission by the Act of 1951, announced, in 1953, that they would be used sparingly. It is probably correct to state that the

Commission have, in fact, acted in this way although there can be little doubt that the inference of powers to be used if necessary has been of assistance in achieving the Commission's aims. At the same time, the Commission had lost its jurisdiction over any agricultural land which it had and might have in the course of land acquisition. The Department of Agriculture has powers to prevent the acquisition of land for forestry purposes by the Commission, but does not have the powers over private persons.

The Committee on Marketing of Woodland Produce (Forestry Commission (1956)), also known as the "Watson Committee", considered and reported on measures which might be taken within the home timber industry to improve arrangements for marketing produce from privately owned woodlands. The report of the Committee made it clear that the Forestry Commission would become increasingly interested in the marketing of timber - not only would sales from the State forests increase but, because of the State's financial interest in dedicated and approved woodlands (through grants and subsidies), the forest authority would be concerned to see that much private timber was properly marketed in the future. It remains to be seen how effective this forecast will be. For example, the State is currently supplying all of the pulp timber to the Fort William pulp mill, with no supplies from private owners, even though many of the latter lie within an economic hauling distance from the mill and a percentage of the State supplies is being delivered from outside the 80 mile hauling radius considered to be economic. The private owners were not included in the pulpwood supply agreement of the Commission and their own negotiations have, so far, proved to be abortive.*

The Watson Committee foresaw a diminution of supplies of large-sized timber and rapidly increasing supplies of small-sized timber, with two main consequences. Firstly, the post-war home-grown timber trade would be smaller in scale than the pre-war one and, secondly, its regrowth would be in a new direction, calling for initiative, new methods and new plant. The Forestry Commission would have the important function of fostering new industries and there would have to be better co-ordination between standing timber owners, in both State and private sectors, and timber traders.

In the past, the Committee noted, British woodland output had been quite small - sometimes less than 5 percent of the total British consumption of lumber and timber products. Emergency outputs, with attendant

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* At the time of writing, however, it is reported that joint efforts are being made to overcome this anomaly.

depletion had, of course, been much higher. The underlying principle of the Government's policy was to make good the losses and build up an adequate reserve of standing timber against a future emergency. The policy aim was to produce, on a regular basis, a volume of timber equal to one-third of the total consumption. The total British demand for timber and its products and the range of potential uses were large but the market for pulpwood and similar products was notably deficient in comparison with other countries - a substantial handicap to the utilization of the home resource with its growing production of thinnings. However, the achievement of better standards of lumber preparation and service equal to that of imported wood; the removal of prejudice against home-grown timber and the recognition that Britain could no longer afford to buy the cream of the world's timber, even at very moderate prices, would greatly assist the ability of home-grown timber to displace foreign timber in the British market. The strong public monopoly buyers in Britain - the Transport Commission, the National Coal Board and the Post Office* - made entensive use of imported timber. Some "equally strong authority", the Watson Committee thought, was needed to ensure that home-grown wood was not ruled out of these purchases by

* The Post Office runs the British telephone system and has a large consumption of poles.

prejudice, rather than because of quality. The Committee observed, however, that neglect or wrong treatment of the forests had left considerable amounts of poor quality standing timber. Also, little was known about the wood quality of the recently introduced exotic coniferous species which had been planted in the previous thirty years. Both silviculture and woodland management would benefit from an increased scientific knowledge and greater commercial awareness of this factor. Another point made by the Committee stressed that any increase in sawmilling capacities must be accompanied by employment of modern sawmilling techniques and higher consumer service standards. The introduction of lumber grading rules and abandonment of the practice of selling "mill-run" lumber would increase the competitive position of the home, in relation to the imported, product.

Three main interests were identified in the Home Timber Industry. These were the private growers of timber (landowners), the home timber trade (trade merchants) and the State (Forestry Commission). The private landowners held most of the mature and semi-mature timber in Britain with the woodlands generally forming part of a composite estate including agricultural land and land held for amenity, sporting or other purposes. The individual estates ranged from several thousands of acres in size downwards, with a large proportion having less than 250 acres of woodland in them. The attitude of the owners toward forest management ranged from keen professional interest to apathy. The Watson Committee expressed its prime concern for woodlands managed, or capable of being managed, on a commercial basis and toward the expectation of owners assisting the Government's forest policy, that their woodlands would be an asset and not a liability to the overall financial position of an estate. Typically, the large estate employed an estate agent or factor (estate manager) but very few employed professional (University qualified) foresters, relying rather upon a head forester (an experienced, trained technician) and a permanent labour force. In other cases, for reasons of cost or choice, an owner might retain or call in a professional firm of land agents for advice and assistance in silvicultural and management problems, or forestry consulting firms for actual operational work such as fencing, draining, replanting and thinning. The private woodland owner in Britain was, the Watson Committee felt, an individualist with little contact with other woodland owners. Association or close co-operation in management and sales co-ordination or promotion were lacking and the co-operative forestry societies had developed relatively slowly.

The Co-operative Forestry Society (Scotland) Ltd.

had been founded in 1911 and had a membership, in 1956, of about 700 owners, owning 250,000 acres or about one-quarter of the total of privately owned woodland in Scotland. Other Associations covered parts of England and Wales. The Societies provided assistance to their members in management and marketing. In spite of an offer by the Forestry Commissioners in 1948 to assist private forestry co-operative schemes (some loans, grants and guarantees were actually made), the Watson Committee saw little chance that the existing societies would extend their scope of operation without greater support from woodland owners.

In Scotland, the woodland owners were represented by a number of organizations, including the Scottish Landowners' Federation and the National Farmers' Union. The former, amongst it activities, took a special interest in forestry - an interest which was shared by the professional land agency bodies. The technical and professional aspects of forestry were (and are) represented in Scotland by the Royal Scottish Forestry Society and the Society of Foresters of Great Britain. Membership of these two societies includes practising woodland owners and any person with knowledge of, or interest in, forestry.

The United Kingdom Forestry Committee was formed in 1948, with the launching of the government post-war forestry programme, in order to provide a single voice for British woodland owners. It included members elected by the Country Landowners' Association, the Scottish Landowners' Federation, the two Royal Forestry Societies and members with experience of land agency, forest economics and the timber trade. In essence, it was a co-ordinating Committee, meeting as occasion demanded, and it had a Scottish sub-committee. It had no professional staff and did not engage directly in promoting the affairs of individual woodland owners.

The Home Timber Trade consisted (and now consists) of several hundred merchants throughout Britain who bought home-grown timber and converted it for sale to industrial and other consumers. The Scottish association was separate from, but maintained a close liaison with, the Association for England and Wales. The associations jointly, or separately, presented trade views to government departments, including the Forestry Commission and supplied trade representation to the various consultative bodies serving the home timber industry. The Home Timber Merchants' Association of Scotland was not a trading concern and its 116 members handled about 90 percent of the total amount of timber converted in Scotland. Associate members of the Scottish organization were mostly timber importers who, nevertheless, converted home timber from time to time.

The Timber Trade Federation of the United Kingdom dealt with the much larger and more elaborately organized imported timber trade. The members were principally timber importers, agents and brokers but, also, non-importing timber merchants dealing in imported timber. Each of these groups had its own section or association linked into the Federation. The Timber Research and Development Association was largely financed by the Timber Trade Federation to promote the use of timber generally and it included some home timber merchants as members. It was concerned with home-grown as well as imported timber and co-operated with the Home Timber Associations.

The Watson Committee noted that, apart from its other functions, the Forestry Commission had assumed responsibility in the development of new timber consuming industries and had played a leading part in the negotiations leading to the establishment of a number of valuable projects.* The Committee attributed the Commission's

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* One of the latest of these is the establishment, in 1965, of Scottish Pulp and Paper Mills, a division of Wiggins Teape and Co. Ltd. at Fort William, with a guaranteed timber supply from the Forestry Commission, as well as Government assistance in construction financing.

ability to encourage industry to its complete information on the forest resource, including its geographical distribution, and to the ability to offer substantial guarantees of supplies from its own woodlands, guarantees which the unco-ordinated private sector had been unable to provide.

The Watson Committee also inferred that some owners sold timber without knowing its volume or the variable prices offered and paid for similar parcels. Price stability in Britain was relatively poor, although national fixed price agreements with the National Coal Board had achieved stable price levels for home-grown mining timber.* The Committee noted that the high cost of rail transport in Britain, put an economic radius on this method of moving home-grown timber. In Scotland this led to an increasing use of road transport, particularly since a number of railway branch lines, considered to be uneconomic, were closed. Recently, in 1967, the Government imposed increased taxation on road transport to direct the movement of goods back to rail and, to some extent, to relieve the great pressure for more and better roads. In Northern Scotland and the Highlands generally, rail facilities are not available in many areas so that

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* In Scotland, however, there was no guaranteed minimum quantity of purchase, as in England and Wales.

the effect of the new taxation is to raise road operating costs without any particular benefit to rail transport. It appears to be probable that regions of Scotland will be exempted from the new taxation - an exemption which would materially assist wood transportation costs. The Watson Committee certainly did not visualise Government action which would increase these costs but felt that, to supply large scale wood processing plants there might be no alternative other than to subsidize, on a temporary basis, the carriage of surplus materials to markets outside the normal economic hauling radius. If transport costs continued to rise, wood producers in remote areas might have to be given financial assistance on a selective basis. The Forestry Commission is doing this, in a way, with Scottish Pulp and Paper Mills by indirectly subsidizing material delivered from outside a specified radius from the Fort William plant. This arrangement will be discussed later in this thesis.

The Watson Committee felt that the produce from privately owned woodlands should be integrated with the rapidly growing output from the State woodlands and the total output integrated into the total pattern of British timber consumption. The concept involved a planned and regular flow of production; a fair share of the market to private owners; provision of means to absorb production surpluses; a healthy timber trade, capable of expansion; continued research effort and adequate returns for private owners.

Basically, very little has been accomplished in achieving the marketing objectives of the Committee. A recommendation to form a strong and effective single British association of private woodland owners was implemented, although the Scottish Woodland Owners' Association was formed separately. However, there is considerable unofficial Government criticism on the effectiveness of these bodies in the wood marketing field. To the author, the reluctance of many private owners to enter into co-operative marketing agreements is quite understandable since they would presumably not only be foregoing their prerogative of direct price negotiations but would be entering a field of activity, the future of which contains uncertainty, with both factors indicating a policy of awaiting developments before acting. There is also a clear reluctance to aid a procedure which might be suspected of increasing the existing, if latent, Government powers in the commercial field. The Government, for its part, probably feels quite justified in extending its influence in this field because of the subsidies and concessions made to owners of dedicated and approved woodlands and because of its concern that the national aims of the forest policy should be realised.

The Watson Committee also believed that a central consultative body representative of all the principal interests concerned in the marketing of home-grown timber was necessary. The Home-Grown Timber Advisory Committee, an existing body, could function in this role, after reconstitution. A Special Committee on Finance was also proposed to overhaul and simplify the whole system of financial assistance to private owners.

In spite of the freely expressed misgivings of the Watson Committee in the field of privately-grown timber and timber marketing, there has been substantial evidence, in the period since the second world war, of the private landowners' confidence in the future prospects of forestry as an asset in the economy of estate management. In 1965, for example, private owners in Great Britain planted 31,200 acres with the aid of Commission grants and about 1,700 acres without grants, of which total 15,000 acres, or about one-half, was planted in Scotland.

Whilst some of the recommendations of the Watson Committee have been implemented, it appears that the major objectives have not yet been achieved. The idea of joint marketing of roundwood in co-ordination with Forestry Commission sales has not become effective. The state of the lumber industry is parlous and its plant efficiency leaves much to be desired. Its marketing methods are correspondingly quite undeveloped and the competitive position in relation to imported lumber is poor.

By the 31st. September, 1965, private owners in Scotland had placed 335,836 acres into the Dedication Scheme and 37,098 acres into the Approved Woodlands scheme. In 1964, there were 1.2 million acres of forest in Scotland classified as high forest, coppice and coppice with standards and 0.5 million acres of scrub and felled areas - a total of 1.7 million acres of forest land. By ownership, this area consisted of 1.0 million acres of private wood-land (0.55 million acres of high forest, coppice and coppice with standards and 0.45 million acres of scrub and felled areas) and 0.7 million acres of Forestry Commission woodland, 10.65 million acres of high forest, coppice and coppice with standards and 0.05 million acres of scrub and felled areas.

An historical survey of private forestry in Britain would be incomplete without mention of private, syndicated forestry, a post second world war development. Several syndicates, mostly of wealthy individuals who have reason for concern about levels of succession duty in relation to their own estates, have invested large sums of money in forest land and operations, partly to take fair advantage of the relevant taxation and estate duty concessions made for dedicated and approved woodlands. By transferring a portion of his wealth into a forest investment, he reduces the value of his estate for succession duty purposes, at least temporarily. The position stems from the fact that, under current legislation for dedicated woodlands, the value of the forest crop is not normally taken into account for succession duty purposes until the crop is felled and its value realised in monetary terms.

The largest number of syndicates is managed by Economic Forestry Limited. The Economic Forestry Group is an association of woodland owners and management and investment consultants, among whose aims is the creation of 100,000 acres of productive woodland in Britain, in a wide variety of investment but under one management. The woodlands, as they are acquired and established are grouped into separate management areas, each of about 10,000 acres. It is expected that, in time, each forest management area will have its own integrated forest industries, designed for complete utilization of the woodland products. The organization already has its own marketing company - Timber Utilization Limited. The Group's financial advisory services include:

(a) The integration of carefully planned forestry investments into family financial schemes to produce maximum savings of income tax, surtax and estate duty. Detailed attention is given to problems of saving estate duty, both before and after the death of a woodland owner.

(b) The preparation of detailed financial plans, showing the expected future annual receipts and expenditures, estimated over a long period of years, with amendments from time to time to allow for changes in the Group's policy and conditions of working.

(c) The arranging of the distribution of surplus net income annually or at frequent intervals.

The Forestry syndicates, in a sense, have competed with the Forestry Commission in the acquisition of land and have been responsible for a considerable flow of private capital into forestry.

e. The General Policy of the State:

The Forestry Commission, in 1959, summarized the policy aims for the State forests, to give effect to policy as determined by the Forestry Acts, as follows:

(1) To achieve an orderly expansion of timber production by extending the areas of forest at a steady rate by means of new planting, and by managing all Forestry Commission

forests in accordance with the principles of sustained yield.

(2) To manage the estate of a commercial enterprise and, within the limits set by the other policy objectives, to earn the highest possible return on the capital invested.

(3) To give attention to the aesthetic and protective, as well as the productive role of the forest.

(4) To provide employment in rural areas, especially where the need is greatest, and to build up and maintain a thriving body of forest workers and their families.

(5) To foster socialized and industrial development ancillary to forestry.

(6) To pay due regard to recreation, sporting interests, fauna and flora.

This summary reflected important policy changes from previous national aims. In spite of the potentially uneconomic aim of providing permanent employment*, the

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*The provision of permanent employment is not, in itself uneconomic if practised within the context of economic forest management. There may be sound national reasons to provide permanent employment, even though this policy may lead to uneconomic forestry operations. The author found, in some instances in Scottish forestry, that uneconomic forestry practices and forest labour positions were explained as being justified on the basis of the national aim to provide permanent forest employment.

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emphasis of the new policy is placed upon profitable, rational forestry. A major factor dictating this change was the effect upon Britain's military defensive capability of the development of nuclear weapons and their delivery systems. The massive destructive capability of the weapons could quickly paralyse Britain and the emphasis upon a timber reserve for war conditions was reduced, in the view of the policy-makers. Consequently, the initial policy aim of providing a timber reserve for national emergencies was dropped and the use of the forest for economic advantage, upgraded.

CHAPTER 3

A COMPARISON OF THE FOREST HISTORIES AND POLICIES OF SCOTLAND AND BRITISH COLUMBIA

1. General:

The foregoing forest histories of Scotland and British Columbia are concise and much detail, particularly that of a nature considered extraneous to this thesis, has been omitted. The following comparison is made to bring out the fundamental similarities and differences of the two areas and, whilst it is based on the histories as related above, it is not restricted to them, where useful comparison can be made.

2. The Forest Resources:

a. Area and Condition:

The differences in the area and condition of the two forest areas are very marked indeed. British Columbia, according to the B.C. Forest Service (1957), has an estimated 118 million acres of commercial forest area, whereas Scotland has almost 1.2 million acres at the time of writing. The differences in total standing volumes of timber are even more marked, since a greater proportion of the British Columbia area carries mature or overmature natural forest* than is the case in Scotland. A further major difference lies in the fact that the forests of British Columbia are still mostly natural, virgin stands, whereas those of Scotland are almost entirely established by planting. Whilst natural regeneration plays a large part in the establishment of new stands following logging (particularly in the Interior), the Provincial planting programmes are being increased rapidly so that it may be assumed that planted forests will form a substantial percentage of the future forests.

The <u>average</u> growth rate potential per acre of the Scottish forest land is considerably higher than the <u>average</u> per acre for British Columbia. The standards of tree utilisation are also closer, although the gap is narrowing. Subject to the species planted, it would appear that a very high proportion of the Scottish forests can be managed on a rotation of between 40 and 60 years, a figure which is comparable to the 60-year average rotations predicted for second-growth stands in the Pacific Northwest Douglas fir region. The British Columbia Interior forests, with the possible exclusion of some Wet Belt forests will

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* According to the Forest Service's Inventory (1957) there are 306,000 MM cu. ft. of sound wood volume in the commercial forests which is in trees larger than 10 inches d.b.h. Of this, 191,000 MM cu. ft. is classified as usable.

require longer rotations of up to 150 years, under "extensive" forest management. The apparent advantages to forest economics in Scotland of this high productivity may be offset, at least partially, by the quality of the wood being grown - this question receives more detailed consideration later in this thesis. With the relatively high Treasury interest rates currently applying in Britain and because of other factors, there has been a very marked tendency in Scotland (a tendency which is also in evidence in British Columbia) to emphasise the need for accelerated growth rates and shorter rotations, so as to obtain a quicker return on the investment. For example, the growth rate of Sitka spruce is a primary reason for the favour accorded to it at the present time. There is a body of professional opinion which proposes to increase the rapid growth rate still further by fertilization at periodic intervals with nitrogenous fertilisers. The subject of fertilization is also receiving considerable attention in British Columbia for the same reason. There are inherent difficulties in these proposals when applied to fast growing species, the major one - that of wood quality - having been mentioned.

The growth rates and rotations applying in Scotland, as well as the high production per acre, are achieved under intensive forestry practices, particularly the use of periodic thinning at intervals of from 3 to 5 years. Thinnings of this type are not practised in British Columbia and there are examples of first thinnings being opposed by the Forest Service on the grounds of current economics, even though much thinnings would produce more profitable stand conditions at a later stage in the rotation. The strong emphasis on the profitability of forestry currently applied in Britain has resulted in questions being raised as to the wisdom of continuing close planting distances which imply early thinnings of a financially unprofitable nature. At the present time, these are simply questions and no marked changes in management practices have occurred. At the present time, therefore, there are extreme differences in the application of thinnings in the two areas and, whilst there are trends toward less thinning in Britain and more thinning in British Columbia, it seems to be likely that the difference will exist for many years to come.

The natural stands or forest cover types of British Columbia are usually of intimately mixed species, whereas the planted forests of Scotland are normally monocultures. It is true to state, however, that plantings in British Columbia are usually of the most valuable species of the former mixture occupying the site. For example, in the Interior Engelmann spruce - alpine fir -

lodgepole pine natural mixtures (_Picea Engelmanni_, Englemann; _Abies lasiocarpa_ Nutt.; _Pinus contorta var- latifolia_, S. Watson) it is usual, when planting after a clear felling, to plant only the Engelmann spruce. However, the planted areas in British Columbia will quite often become mixed stands by the admixture of natural regeneration of other species. Whilst the normal practice in British Columbia is to regenerate stands, naturally or artificially, with a species which was a component of the original stand, Scotland's afforestation is almost entirely based on exotic species which were not included in the former natural forests, the major exception being Scots pine (_Pinus sylvestris_ Linn.). Scottish forests contain some of the more important native British Columbia species such as Douglas fir, Grand fir, Western hemlock, Sitka spruce and lodgepole pine. The latter two species are currently favoured, because of the rapid growth of Sitka spruce and the combination of good growth rate and tolerance to harsh site and climatic conditions demonstrated by some provenances of lodgepole pine. It is significant, in relation to the areas of forest land and scale of forest utilization existing in the two areas, that the annual rate of planting in Scotland, by the Forestry Commission and private woodland owners, reached the impressive total of 45,000 acres during 1965 - a figure which it is planned to increase markedly in the near future. The figure, on a similar basis, for British Columbia was 52,000 acres and the Forest Service are increasing the acreage, subject to the availability of trained personnel, seed and nursery facilities.

It is of considerable significance to forest economics that the size of forest units for management purposes is vastly different. The Forest Service manage the public sustained yield units of British Columbia which average almost one million productive acres per unit and the industry managed tree farm licences average 255,000 acres per licence - these areas between them comprise a great preponderance of the Province's forest land. The smaller, private, certified tree farms which have not been incorporated into tree farm licences average 22,000 acres each and they are almost all located in areas of high growth rates. By contrast, the Commission forests in North Scotland Conservancy average 5,260 acres each, the largest being 20,000 acres and the smallest less than 1,000 acres. In a large management unit, an advantage of more economic working can usually be achieved in such areas as long-term road costs; staffing costs; concentration of operations and forest inventory.*

The intensities of management, as briefly mentioned above are very markedly different. The tree farm licence of British Columbia which, of the large tenures, currently has the best standard of management might employ about 5 supervisory staff and 50 workers** per 200,000 acres. The Commission might typically employ a total field staff and crew of about 10 men per 2,000 acres. In 1965, the Forestry Commission employed, throughout Britain, 2,500 workers and the Forest Service in British Columbia employed 3,900 (including temporary personnel). It should be borne in mind, however, that the bulk of Forest Service personnel are administrative, as against actual forest workers employed by the Commission. It is clear that the number of men per acre employed in the intensively managed forests of Scotland is much higher than

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* The stratification of the forest will usually result in each stratum containing larger areas of forest and assuming that the same accuracy of inventory is to be achieved and that the co-efficients of variation are the same, permits a lower sampling intensity in each stratum than is the case for strata containing small acreages.

** These figures are an approximation of the position on the Okanagan (West) Tree Farm Licence (No. 9) in 1960, of which the author was the forest manager.

in British Columbia. In the Canadian Province's forest policy there is no stated intent that the Forest Service should build up a permanent work force and provide employment. In fact, the Minister of Forests has recently announced the Government's intention to restrict the personnel expansion of the Forest Service and to involve industry to a greater extent than at the present time in the management of the sustained yield units. The differences in manpower employment and policies are partly attributable to the relatively dense population levels of the British Isles and the light levels of British Columbia. These levels have also influenced the urgent drive for high productivity levels in the Province, a feature of forest working which has only recently become of major concern in British forestry.

Because of the mature and overmature condition of British Columbia forests and the fact that the natural pathological agents are established* the damage inflicted by them constitutes a more serious problem, in quantitative terms, than is the case in Scotland where the thriftiness of the younger forests and the exclusion, to date, of some of the natural foes from the exotic plantations reduce

* Also, some damaging agents are of recent introduction, such as the European Pine Shoot moth, Rvaciona buoliana.

the possible extent of the problem.* This is not to state, however, that severe pathological problems do not exist in Scotland and there are apparent risks of major damage from unforeseen agencies in the exotic plantations.

The question of the relative damage caused by wildlife in the two areas is difficult to state quantitatively. In British Columbia, it is generally accepted that damage to trees by game is endemic and is not a serious problem, other than locally, in comparison to other forms of damage. Considerable attention has, however, been paid to the activities of seed-eating mammals and control by poisoning and deterrents, both on an area basis and in seed treatment, have been employed. In Britain, there is a sensitive appreciation of animal damage to the extent that heavy fencing costs are almost invariably incurred to exclude from young plantations deer,

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* For example, in the lodgepole pine stands examined by the author in Yorkshire and Scotland, no signs of stem lesions were noted such as those commonly caused by *Cronartium stalactiformae* A & K and *Atroprellis piniphila* (Weir) Lohman & Cash in the Okanagan Valley. (Molnar, A.C. (1954). Severe canker damage to immature lodgepole pine in British Columbia. Unpublished.)

sheep and rabbits. The artificial introduction of Myxamatosis in Britain has largely destroyed the rabbit population and damage from this source is now minor. The exclusion of sheep and deer has created problems, particularly where afforestation has occurred in their usual overwintering areas at the lower elevations and the animals have been excluded from them. There is a growing interest in the questions of land use planning and some interesting experiments are being conducted to determine the compatibility, in terms of single or multiple land use by the various land users.

There is a considerable and justified concern amongst Scottish foresters on the damaging effects of high speed winds. Very strong gales, occasionally exceeding 100 miles per hour, blow from the Atlantic Ocean or, occasionally, from the North Sea and they have caused extensive damage to the plantations. The most critical conditions appear to occur where plantations have been established on soils, including peat, underlain at shallow depth by a soil layer or a water table impervious to root penetration. Various proposals have been made to counteract potential wind damage in existing stands and they have included cutting before a critical tree height (70 feet or thereabouts) is reached and cutting according to site hazard predictions. The proposals for determining site hazard ratings vary but include a physiographic approach. Other proposals, directed toward future afforestation, include the development of techniques for deeper ploughing so as to achieve deeper drainage and permit deeper root penetration. A recent example of wind damage in Scotland occurred during the gale of January 14th - 15th, 1968, when the estimated volume of windblow and windbreak was 40 million cubic feet in Commission and private forests. The amount would sustain the small existing Scottish industry for a period in excess of two years at normal operating levels and has resulted in emergency action to assure as complete utilization as possible. It is apparent that normal cutting schedules will need to be deferred in many areas until industrial capacity again becomes available. There is little doubt, even though control measures are introduced, that damage by windstorms will present a continuing problem to Scottish forestry in future years.

Damage by wind is also a severe problem in British Columbia, particularly in the mature and overmature forests, on moist sites and with shallow-rooted species. The opportunity for the salvage of merchantable timber is frequently denied by the rate of deterioration in quality of the fallen trees (especially thin barked species much as the spruces and lodgepole pine where dehydration is rapid and splitting of the trunk occurs in approximately six weeks). Heavy losses have also been incurred in many logging areas where the disturbance of the hitherto untouched canopy has opened the way to wind damage. The partial cutting of mature virgin spruce stands in the Interior will almost invariably result in windblow except in the most sheltered localities, as will clear cutting practices which leave isolated seed trees or small groups of seed trees. Thus the factor of wind exposure has had a marked effect on the silvicultural systems of felling employed in some forest cover types. Although it is known that periodic heavy damage is caused by wind storms, there are no reliable, overall estimates of losses available.

By far the most spectacular and damaging phenomenon in the Province is that of forest fire, statistical material for which is given in Annexure 4. The large amount of damage caused and the periodic heavy expenditures incurred in control have had a fundamental influence on Provincial forest policies and have actually excluded or curtailed other desirable forms of forest activity. Fire is also a damaging agent in Scotland but to a much less severe degree.

Finally, the topography of British Columbia is very rugged and mountainous in parts, although there are considerable areas of rolling plateaux in the Interior. The tree line for commercial forests is variable but may be said to extend to about 6,500 peat above mean sea level, although it does vary, of course, with latitude, longitude and exposure. In Scotland, there are steep slopes in many areas but the topography is generally more gentle and rolling. The soils show considerable differences. The peats and hard pans of Scotland do not occur so significantly in British Columbia where glacial tills and alluvial soils are of great importance.

The oceanic climates of the Lower (Southern) Coastal Region of British Columbia and the West Coast of Scotland bear quite marked similarities of rainfall and temperature. Progression eastwards from the western coastlines tends, in both areas, toward lower rainfall and greater extremes of temperature. There are no areas of Scotland, however, which are strictly comparable to the semi-arid Dry Belt of the Interior or to the semi-Continental climate of Northern British Columbia. These few comments are made to give a general background, since it is not the author's purpose to enter into a detailed comparison of the edaphic factors of the environments, an approach which would not materially assist the overall purposes of this thesis.

3. The Forest Policies:

The modern period of forest policy development in the two areas is of remarkably similar duration. In British Columbia, it may be said to date from 1910, following a recognition of the need to control industrial exploitation, whilst, at the same time, encouraging the development of industry, and of the need to control the ravages of forest fires. In Britain, it may be said to have commenced in 1919, as a result of the heavy liquidation of the remaining resource during the first world war, at a time when the normal importation of supplies was greatly reduced.

There the similarity, to a considerable extent, ends. British Columbia had a vast, existing resource which it has employed to stimulate provincial development and to produce wealth. Because of the very size and potential value of the forests, the powers of decision of the professional forester have been heavily circumscribed by political decision to an extent which is not apparent in Britain, where the position of the resource in the national economy has not exposed policy to the same intensity of political interest and where, in consequence, the professional forester has been able to exercise considerable direct influence on policy. At various periods in the forest history of British Columbia, political policies have used the forest resource to subsidise and stimulate railway construction, to develop a forest industry and to forward general Provincial economic development, The financial revenues of the forest have been used by the Government for these activities rather than for the perpetuation of the forest, although the trend has gradually changed. The process has been one of controlled liquidation, albeit accompanied by increasing sophistication and major measures to achieve protection, better utilization standards, renewal of the resource and sustained yield harvesting. The present-day sustained yield policy in British Columbia, which in its administrative aspects, has no counterpart in Britain will only be fully effective when the rate of reforestation corresponds to the rate of depletion by logging, fire and other pathological agents, assuming that it is not the intention to reduce the Provincial forest land area, and the Provincial Government is endeavouring to achieve this rate of reforestation. Nevertheless, there are about 25 million acres of forest land in the Province which are reported to be understocked ("not satisfactorily restocked") or degraded as a result of past logging and fires. Some of the biggest areas have been occupied by brush growth and would be expensive to restock. The lands which are not satisfactorily restocked following logging represent, in part, the cost of raising capital for purposes other than forestry, by the Federal and Provincial Governments and the cost of the policy of encouraging industry to establish. Whilst these policies were, in the author's view, quite justifiable in earlier times, any further degradation of the forest area will clearly lead to serious consequences for the Province and greater financial expenditures in the forests are clearly necessary at the present time. In other terms, it may be said that the loss of forest acreage has permitted a much lower percentage of forest revenue to be expended on the forest than is normally permissible. The presence of large amounts of standing timber, much of which needed to be utilized (otherwise it would be lost) and low forest expenditures, coupled with the wish to encourage industrial expansion has left stumpage rates low in many instances - a trend which has been continued in the recently introduced Pulpwood Harvesting Areas.

By contrast, the Scottish resource, at the commencement of the modern policy period, had been largely destroyed. The new forests of Britain have been established at great cost by capital derived from sources other than forestry. On the 30th September, 1966, the

Forestry Commission's capital account* stood at 281 million pounds sterling, of which 114 million pounds sterling had accrued as interest on Treasury loans.

As a result of these expenditures which has supported both Commission and private planting of new forests, the position has now been reached where the policy of encouraging the establishment of new industry to deal with the increasingly large volumes of merchantable timber becoming available, is of importance. The ultimate objective of the Commission is to supply thirty percent of Britain's wood needs from its own and private forests. However, the cost of wood to industry is higher than that in British Columbia, a perfectly understandable position when one considers the relative levels of expenditure per unit of area; its quality for some uses is lower, so that its competitive use for some end-uses, such as construction, is in some doubt. The increasing world demands for wood will possibly lower to some extent, the required grades for some of these end-uses. The recent establishment of the Scottish Pulp and Paper Ltd. mill at Fort William is a recent example of encouragement of a wood utilization industry, involving

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* Consisting of all the Commission's loans from Treasury and accrued interest at the various annual rates of interest charged over the period since 1919, less Commission revenues.

wood supply guarantees and a Government loan toward construction. Also, there is a policy in existence which aims at the establishment of a modern and re-vitalized lumber industry, as well as further expansion of the pulp industry.

In summary, British Columbia has derived large nett revenues from its forests by a gradually slowing process of liquidation, whereas Great Britain has expended large sums of money to create a resource. British Columbia, in the process, has acquired a large industry which is still expanding and Great Britain is commencing industrialization, particularly in Scotland. The produce of British Columbia is, of course, very largely exported whereas that of Britain is for home consumption, although finished paper exports and re-exports are of importance. The economic importance of forestry in relation to the overall economy is far greater in British Columbia than in Great Britain, although forestry will clearly occupy a more important position in the economy of the Scottish Highlands than in most areas of Britain.

It is of interest to note the degree of involvement of the State and Provincial forest services in the processes described. In Scotland (indeed, in Great Britain as a whole), the Forestry Commission manages its own forests to the extent that it employs permanent field staffs and work forces at the forest locations. It frequently conducts its own thinning, logging, hauling and sale of produce, although it will also employ contractors - a method which appears to be used increasingly. In addition, it has entered into log conversion in the past, although the trend is now markedly toward leaving this aspect to industry. Nevertheless, Government loans are used as a means of encouraging new industry. The importance of timber supply from private land is recognized and the Commission is endeavouring to co-ordinate these supplies with its own.

In British Columbia, the process is quite different. The bulk of the forest land is owned by the Crown and vested in the Province, private land being of low relative importance, except locally. A number of lease and licence tenures have been co-ordinated into the public policy by incorporation (in a voluntary sense) into Tree Farm Licences.* The Forest Service does not enter into the actual conduct of logging which is a function of the industry, but controls it through administrative

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* The Tree Farm Licences concerned received in return for this incorporation, additional Crown land within the licence. The licencee manages the area under the supervision of the Forest Service. The system is explained in greater detail in Annexure 1.

processes. Whilst forest District headquarters have some similarities to Conservancy headquarters, the situation at lower levels of organization is very different. In British Columbia, the local Forest Ranger provides for local administration, protection and inspection but there is no permanent, local labour force comparable to those in Britain. Fire fighting and reforestation crews are usually temporary employees. In British Columbia, industry is involved in reforestation and protection activities on a considerable scale and frequently acts in a forest management capacity. These activities by industry are rare in Britain. There is no real equivalent in the Province to the private land owner of Britain. It is also interesting to note that British forest management professional staff in Government employ is usually located at the forest or group of forests which they are managing. This is usually true of industry forest managers in British Columbia, but responsibility for the Government managed public sustained yield units is mostly a group responsibility with the Professional foresters concerned being located at Forest Service central headquarters at Victoria and at District Headquarters. The Forest Ranger conducts much of the local supervision and detailed direction. However, it is considered by the author that this situation must change and that professional foresters will need to be located at the public sustained yield units.

The foregoing is, at best, a general comparison of the position and, for the sake of clarity and conciseness, it is not intended to be otherwise. Some of the points made and other points of comparison will be evident, in a more detailed way, from the Reviews of Literature, which follow later.

CHAPTER 4

THE ROLE OF THE CANADIAN GOVERNMENT IN BRITISH COLUMBIA'S FOREST POLICY AND MANAGEMENT PRACTICES

1. The Structure of Governments:

The governmental structure and powers applying in Scotland are quite different from those applying in British Columbia and, because of their relative effects on forest policy particularly in the field of forest finance, the differences need to be stressed. In Britain, State forest policy is entirely in the hands of the central government in London, working through the Forestry Commission. The Commission receives advice from Scottish organizations but power rests with the central government. The Secretary of State for Scotland provides a strong influence in the central government in decisions on Scottish policy, particularly since he is currently a member of cabinet but, again, power rests with the central government and with the British Parliament. Thus, it is clear that the formulation of State forest policy and the delegation of powers for the execution of the policy are unified. The usual disadvantages of centralised government, i.e. the tendency toward "blanket" regulations in which it is sometimes difficult to apply flexibility to suit local needs and the tendency toward the creation of large administrative staffs with a resulting ponderous machinery, are offset, to a variable degree, by the ability to exercise sole command of State forestry and to receive and allocate all funds from and to it, to ensure execution of policy in practice. The Forestry Commission is the recipient of direct revenues from the State forests and, the central Government receives indirect revenues from corporate and individual income, and other, taxes.

Compared to British Columbia, the structure is relatively monolithic. It is the purpose of this chapter to bring out some of the problems to forestry resulting from the Canadian federal structure of government.

2. Dominion of Canada Lands in British Columbia:

Innis (1956) has described how, at the Confederation of the provinces and colonies to form the Dominion of Canada, natural resources were made the cornerstone of provincial finance - self government and, with it, certain rights of assets, including the Crown or public lands were conceded to each province by the Imperial Government. The Dominion, however, held jurisdiction over such matters as Dominion chartered railways, Defence, National Parks, Indian Affairs, international waters and certains aspects of taxation and overseas trade. The practicalities of jurisdiction were, and are, more complex than the principles.

Several authors, among them the British Columbia Royal Commission of Inquiry on Timber and Forestry (1910), Beall (1953), the British Columbia Forest Service (1952) (1953)*, Sloan (1945), (1956) and Irwin (Irwin, H. S. (1956). Evidence given at Vancouver before the Sloan Commission and cited by Sloan (1956) has dealt with the history and effects of the Provincial railway grants ceded to the Dominion Government to assist in financing railway construction. These grants related to the trans-Canada Canadian Pacific Railway and to the Esquimalt-Nanaimo railway on Vancouver Island. Most of the former grant was returned to the Provincial Government in 1930 but most of the latter became private land, in spite of Provincial efforts to recover it. Timber berth tenures granted under Dominion jurisdiction are described

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* The Forest Service have also dealt with the subject in their "Supplementary report on proposed amendments to Parts IV and V of the Forest Act in the matter of Timber leases and Special Timber Licences designed to bring legislation in line with modern conditions", being an unpublished report to the Select Standing Committee on Forestry and Fisheries of the British Columbia Legislature.

at Annexure 1 and the Dominion also formed National Parks and Forest Reserves within the trans-Continental Railway Grant, the latter being identified by Sloan (1956) as the historical forerunners of the Provincially created Public Working Circles.* In returning the Railway Grant Lands to the Province, the Dominion Government retained the National Parks, of which there are 1,671 square miles in south-eastern British Columbia, according to the 15th British Columbia Natural Resources Conference (1964).

There are approximately 550,000 acres of Indian Reserves in the Province, 90,000 acres of Military Reserves and small areas of other Federal lands. Hodgins (1964), acting in the capacity of Chairman of a Forest Resource group, has estimated from Provincial inventory data that the National Parks and other Federal lands contain a portion of the total Provincial forest resource

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* Initially, the Province created "Public Working Circles" with gazetted boundaries. To ease the administrative difficulties involved in amending boundaries, "Sustained Yield Units" were created, the only real difference between them being that the boundaries of the latter were not gazetted. For practically all purposes, the two areas are identical in intent and are normally referred to jointly in this thesis as "Public sustained yield units" - a name in current use in British Columbia.

amounting to approximately one-tenth of one percent (by volume) and that only a small fraction of this is suitable for forest products. The forestry significance of Federal lands from the Provincial viewpoint is, therefore, minor.

3. National Forestry Conferences:

Orchard (1964) has described the Ottawa Forestry Conference of 1906, called by the Canadian Government, which succeeded in focussing attention onto forestry matters. The second National Forestry Conference was held at Montebello, Quebec in 1966. The Canada Department of Forestry (Can. Dept. of For. (1966) National Forestry Conference. Summaries and conclusions) reported on the estimate of future demand for wood and the results of papers and discussions on the best way to meet these demands, considerations which formed the bulk of the Conference's work. McKinnon (McKinnon, F.S. (1966). What is the present state of Canada's forest resources? Summary by plenary session chairman. National Forest Conference. Summaries and conclusions 13-16) made remarks of particular interest in considering relations between the Canadian and British Columbia Governments, since he is the Deputy Minister of Forests for the Province. He noted that the general forest inventory programme, supported by joint Federal and Provincial expenditure under the Canada Forestry Act had supplied statistics suitable for broad management planning but that a programme of detailed surveys was needed for use in management operations. It was apparent, he stated, that depletion by fire, insects and disease must be reduced and that prompt regeneration of every acre of productive forest land was needed. The latter would need substantial money appropriations which should be raised on a cost-sharing basis between Federal and Provincial Governments under the Canada Forestry Act. The general level of forest management practice in Canada left much to be desired, particularly in the fields of silviculture and access.*

The National Forestry Conference also dealt with questions of recreational, wildlife and other uses. Whilst the Conference focussed attention on areas of concern in Canadian Forestry it did little, in the author's view, to accomplish practical results. Indeed, it may have led to

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* In the author's view, these remarks point up the main area of contention between the two Governments. Depletion by the pathological agents mentioned and silviculture are fields of Federal research in the Province. Access and regeneration are both areas in which the Province, acting alone, has been unable to make the necessary level of effort. The reference to joint financing touches on the crux of the financial problems which will be discussed later.

the Canadian Government's withdrawal from some areas and to a less desirable situation than existed before, for reasons to be given later.

4. Fisheries:

Under the provisions of the British North America Act, the Canadian Government holds jurisdiction over Fisheries. Many British Columbia rivers are spawning grounds of salmon and are important to the Coastal salmon fishing industry. Overlapping areas of interest exist between the forestry and fisheries fields and may lead to co-operative endeavour or to disagreement. Two relevant examples will illustrate this.

The Canadian "Fisheries Act" prohibits, amongst other things, the placing of chemicals or logging debris in water frequented by fish. The Canadian Government has acted in co-operation with the Provincial Government in approving aerial spraying on Vancouver Island and log spraying for control of Ambrosia beetle to ensure that chemicals do not enter water containing fish or, if they do, that their concentration is held at non-toxic levels. Similarly, co-operation exists in defining acceptable levels and kinds of effluent discharged from pulp mills. However, relations are not always so compatible. A dispute arose in 1966 when the Canadian Government prohibited the floating of logs down a salmon-spawning river near Quesnel. The Provincial Government, apparently unconvinced that damage to the spawning beds would occur and considering the prohibition to be an interference with its jurisdiction over the forest resource, approved the floating of the logs with concurrent research into the effects. The logs subsequently were floated under conditions of public disagreement between the two Governments.

5. The Federal-Provincial Forestry Agreements:

Beall (1953) has described the Federal financial aid which was allocated to Canadian provinces in 1939-40 in connection with the National Forestry Programme (a youth training scheme) and the supply of alternative service workers (conscientious objectors) for fire protection work during the period of labour shortage of the Second World War.

In 1949, the Canada Forestry Act permitted, amongst other matters, the establishment and maintenance of Forest Products Laboratories and the entry of the Canadian Government into financial agreements with the provinces or forest owners. The subsequent agreements of 1951 provided for the Federal Government to pay one-half of the cost to the Provinces of the completion and maintenance of their forest inventories during the succeeding five years and also to pay one-fifth of the cost to the Provinces of reasonable programmes of reforestation of Crown lands. British Columbia entered into these agreements and subsequent agreements covering cost-sharing of forest fire protection and reforestation. The amounts were not large over the five year period from 1960-61 to 1964-65 - the Province received a total sum of $13,815,276.00. The termination of the Forestry Agreements was announced by the Canadian Government in 1966 and they are now being allowed to expire, purportedly as an anti-inflationary measure.

6. Forest Finance:

The amount of direct and indirect revenue being derived from the British Columbia forests, by comparison with expenditures, have been the subject of comment by several authors, all advocating greater expenditures. McKee (1965), a former Deputy Minister of Forests is a recent example. The Council of Forest Industries of British Columbia (1966) have published the revenue figures for 1966, indicating a revenue of 126.1 million dollars to the Provincial Government; 108.1 million dollars to the Canadian Government and 10.8 million dollars to municipalities. The British Columbia Forest Service, in the same year, reported direct revenues (i.e. excluding taxation revenues and mostly derived from stumpage and royalty) of 50.9 million dollars and expenditures of

23.9 million dollars. The actual expenditures of the Canadian Government on British Columbia forestry and the forest industry are difficult to determine but, in the author's estimation, would not exceed 20 million dollars in 1966. It is worthy of note that the Federal Government revenues quoted above (108.1 million dollars) are mostly derived from corporation taxes on the forest industry and do not include income and other taxes paid by the 77,000 direct employees in the industry, who draw wages and salaries in excess of 425 million dollars per year. Also, the expenditures of the Provincial government are subject to marked increase in years of severe forest fire occurrence.

7. The Federal-Provincial Rural Development Agreements:

The Canadian Agricultural Rehabilitation and Development Act of 1961 (Department of Forestry, Canada (1965)) enabled the establishment of federal-provincial programmes of alternate land-use; soil and water conservation; rural development and research aimed mainly at correcting the serious national problem of low income in the rural areas. Because British Columbia is a relatively wealthy province and because of its few low-income rural families, the money allocation to the Province under the ARDA programme is much restricted. In Canada as a whole, during the period from 1st April, 1962, to 31st. March, 1965, the shareable costs amongst the Canadian provinces, excluding British Columbia, were 59.7 million dollars and the Federal contribution was 31.4 million dollars (Department of Forestry, Canada (1966)). In British Columbia, for the same period, the shareable cost was 3.9 million dollars and the Federal contribution was 2.0 million dollars. An additional Federal contribution of 1.0 million dollars went toward national research which, because of its Canada-wide implications, was not shared by the various provinces but was borne wholly by the Federal Government.

Under the Rural Development Agreements covering the period from 1st. April, 1965, to 31st. March, 1960, there is a maximum Federal annual contribution of 25.0 million dollars, of which British Columbia has been allocated 1.7 million dollars per annum, or 7 percent (Department of Forestry, Canada (1965)).

The majority of the A.R.D.A. projects in the Province have dealt with soil and water conservation and have consisted mainly of the rehabilitation of irrigation systems in the Interior, including both increased water storage and distribution system renovations. An aspect having more direct significance to forestry is the Canada Land Inventory. Basically, this Inventory is a general land use classification, including estimates of potential for agriculture, forestry, recreation, water conservation and multiple uses. Spilsbury (1966), who is in charge of the British Columbia Forest Service Research Division, has expressed the belief that any rating of land for forestry must be based on a proper knowledge of the soil. This belief was based on the outcome of a co-operative study by Spilsbury, Arlidge, Keser, Farstad and Lacate (1963) and subsequent studies by Lacate, Sprout and Arlidge (1965) and Moss, Lacate, Sprout and Arlidge (1965) in which it was found that a soil taxonomic classification, combined with the technique of land form recognition and the use of aerial photographs, produced a rapid survey of "land units" roughly corresponding to the soil series category. These land units could be assigned a number of characteristics to describe them. However, whilst there must be a reasonably close relationship between land units and the potential for tree growth, considerably more research could be conducted, since relationships established by authors concerned related to average values only. The results indicated that a considerable heterogeneity existed within a land unit or like land units.

Apart from these studies into land classification, which are of potential importance, the forest land capability programme of A.R.D.A. has classified, for land use purposes, a "special sale area" of 1.7 million acres between Prince George and Quesnel. The area has been described as the centre of a "fantastic development and population increase" resulting in an unprecedented (for British Columbia) demand for land for urban, industrial, agricultural, forestry and speculative uses. The survey is to be employed (and thus tested for its practical usefulness) in Provincial government land use administration.

Thus, the main aspects of the A.R.D.A. Programme, of interest to forestry, is the land capability programme for forestry. The use of A.R.D.A. classifications, as currently made, is likely to be of limited use to forest management at the management unit level because of the scale of mapping (i.e. degree of detail) employed in most areas.

8. Forest Products Research:

The Canadian Government (Canada Department of Forestry (1966)) employed 22 professional staff and 34 support staff at the Vancouver Forest Products Laboratory in 1965 and proposed to increase both categories by about one-third in 1966. The laboratory conducts research into the general fields of timber engineering, plywood, utilization, wood chemistry, wood preservation, wood biology, engineering physics and physical chemistry, pulping and fibre research and biometrics. The research is of interest to forest management in its potential effect of raising standing timber values by improving the competitive position and values of products. Progress in these directions will generally aid in permitting closer utilization of existing mature and overmature stands, as well as providing incentives for greater attention toward and development of, the practice of silviculture. In 1966, projects of particular interest to forest management may be summarised as:

a. The effects of age, site and tree characteristics on lumber recovery from Douglas fir in the British Columbia Coastal Region.

b. Log and tree quality evaluation (Interior Douglas fir and western white spruce).

c. The manufacture of lumber from defective logs.

d. Sampling methods for evaluating volumes of logging residues.

e. Methods of woods extraction of small material and logging residues.

f. Characteristics of machinery for small log utilization.

The Federal Government occupy the products research field almost exclusively.

9. <u>Forest Research</u>:

Forest research in British Columbia is conducted by the Forest Research Branch of the Canada Department of

Forestry and the British Columbia Forest Service Research Division, the former being a better financed, housed and equipped organisation than the latter. In addition, industry conducts forest research and co-operates in a number of projects of the governmental organisations, although the contribution is not large in financial terms.

As an indication of the field of activity, the Federal Forest Research Laboratory, located in Victoria, pursued the following projects in 1966:

a. Ecology: Factors influencing the regeneration of commercial tree species; the development of trees and their dependence on environment.

b. Fire: The relationship of fire behaviour to the physical structure of the fuel complex; the moisture regimes of western red cedar and western hemlock logging slash.

c. Land Classification: Forest land classification and its interpretations for forest management. (This project was closely connected with the A.R.D.A. Land Capability Programme mentioned above.)

d. Mensuration: The relationship between the crown width diameter ratio of western white spruce trees and the stand density, age and site.

e. Soils: The effect of burning logging slash on the soil fertility.

f. Tree Physiology: The physiology and biochemistry of Douglas fir reproduction; the influence of environment on the growth and physiological processes of important British Columbia tree seedlings.

The work of the British Columbia Forest Service Forest Research Division, a separate organisation is described later. In general, it has concentrated on reforestation research, including tree breeding and cannot readily extend beyond these fields because of financial limitations. The two organisations co-ordinate their work so as to reduce overlapping of effort and, from the point of view of the Federal organisation, to orient research toward Provincial needs, within the limits of the Federal policy and capability.

10. Forest Entomology and Pathology Research:

This field of research in British Columbia is exclusive to the Federal Government. The Forest Entomology and Pathology Branch of the Canada Department of Forestry* is based at Victoria, under the same administration as the Forest Research Branch, and also maintains a laboratory at Vernon in the Interior of the Province. Because of the advanced age and low vigour of much of the Province's

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* The Department was dissolved in 1968 and its functions redistributed to other Departments of the Canadian Government.

softwood forests, they are subject to rapid depreciation in value by the progressive development of decay and by periodic, wide-spread mortality resulting from attacks by bark beetles, defoliating insects and disease. Consequently, they need frequent inspection and an insect and disease survey is conducted annually by the Branch (Canada Department of Forestry (1965)). Since, with the passage of time and increases in areas of plantations and younger forests, the existing insect and disease problems will change to a considerable extent, investigations have and are being conducted into seed, forest nursery and new plantation problems. Foreign insects and pests with a potential to cause extensive damage in British Columbia are also studied.

A number of co-operative insect control operations, including aerial spraying and trap tree programmes have been conducted in the Province and the Branch has assumed responsibility for advising upon these programmes and assessing their results.

Like all of the Federal research organizations described above, the programmes of the Entomology and Pathology Branch are formulated with the assistance of an advisory committee appointed from various interested groups.

11. <u>The Canada Department of Mines and Technical Surveys</u>:

The "Roads and Resources" programme, administered by the Canada Department of Mines and Technical Surveys, was started in 1958. The programme is a separate one from the expiring forest access road programme which have been conducted under the Joint Forestry Agreements described above. According to the Resource Development Branch, Canada Department of Mines and Technical Surveys (1966), it is a co-operative undertaking by the Canadian Government with each province, under which the Canadian Government is making available a total amount of 75 million dollars over a period set originally at five years but later extended, for some provinces, to periods of up to eleven years. The Federal Government pays 50 percent of the cost of approved provincial roads to resources (of any kind and including forests) up to a maximum of 1.5 million dollars per annum per province, with an overall maximum of 7.5 million dollars per province. During the period from 1958-59 to 1966-67 (8 years), British Columbia received 6.8 million dollars in Federal payments under this programme, which has been administered in the Province by the Department of Highways. The major benefit to forestry lies in the gaining of main access routes into areas previously difficult to enter and this, of course, greatly facilitates rational utilization, protection and management.

12. Federal Government Relations with the British Columbia Forest Industry:

The Canadian Government has a considerable influence on the profit capability and development of the British Columbia forest industry, primarily through its activities in the taxation field. The major source of revenue, other than personal income taxes is the Corporation tax on company profits. Taxes on construction materials are another source of revenue.

The Federal Government assists industrial research through the Industrial Research Council, which makes grants to company and other research organizations. In addition, special corporate income tax allowances are provided under the Canadian Income Tax Act as an incentive for the forest industry to conduct its own research. The future of both of these incentives is in jeopardy following the announcement by the Department of Finance (Canada) (1966) that federal incentives for research would be reduced as an anti-inflationary measure.

Also of financial importance is the incentive provided for corporations located in Canada to have a certain percentage of Canadian ownership - this permits companies who have roughly a minimum of 25 percent Canadian equity participation to have a special, favourable depreciation allowance on production machinery and to have a reduced taxation rate on dividends (distribution of earnings or profits of a corporation).

13. Political Policies:

The foregoing briefly describes the activities of the Canadian Government in relation to forestry and the forest industry. It has been noted previously that forestry in British Columbia is far more subject in practice to variations of political theory and practice than it is in Great Britain, because of the relative importance of the forest resource to the overall economy. Consequently, the political relations of the Canadian and British Columbia Governments have had a great deal to do with the forest policies of the Province, particularly in terms of forest financial policy.

In general terms, it is true to state that neither the Canadian or the British Columbia Governments have ever been formed by a left-wing party, rather they have been Governments dedicated to private enterprise rather than socialism. It is remarkable, however, that the two Governments have seldom been of the same political party - a major reason for the cool relations which have frequently existed between the two Governments.

Sherman (1966) has described how, in 1933, the Province was in severe financial straits, with the Federal Government refusing to write off the Provincial debt unless it acquired the supervision of Provincial finances - a suggestion was totally unacceptable to the Provincial Government. In 1940, the Rowell-Sirois Commission reported on the financial controversy between the Dominion and Provincial Governments with the result that, in 1942, the provinces gave up the income tax field to the Federal Government for the remainder of the Second World War.

At the time, this move appeared to be logical. The Canadian Government had very heavy defence expenditures and, in any event, personal income taxes in British Columbia were not a very great source of income. But after the war, the Province began a period of rapid development which has continued to the present day. In 1939-40, the Provincial Government revenues had stood at 32.6 million dollars but by 1948-49, they were 77.0 million dollars. During the same period, however, populations and the cost of living increased rapidly and the demand for costly social services naturally increased. The ceding of the income tax rights which the Federal Government declined to return to the Province at the end of the war, proved to be highly embarrassing to the Provincial Government. By 1945, income taxes raised in the Province amounted to 160 million dollars, of which a mere 14.5 million dollars was returned to the Provincial Government by the Federal

Government, under the 1942 Agreement. The position led to the imposition, by the Province, of a sales tax on all commodities purchased within the Province.

The lack of finances for forestry, to which the author has referred above, is not new. Sherman (1966) has, for example, quoted the Provincial Finance Minister, the Hon. Herbert Anscomb, as saying in 1950:

> "We should have thousands and thousands more people, and a highly industrialised and prosperous Province, but we have neglected the full development of our natural resources, agriculture, fisheries, mining and forestry, on which the basis of our future rests,and this neglect was mainly due to the lack of necessary funds."

This was, and is, a traditional approach for the Provincial politician in power and the only answer to the problem was held to be the provision of more money by Ottawa. In 1966, the Provincial Premier (The Rt. Hon. W. A. C. Bennett) stated that the Federal Government retained 82 percent of the direct corporation tax and 76 percent of the direct personal income tax paid on earnings in British Columbia. He stated, "British Columbia has repeatedly pressed for a more equitable sharing of these direct revenue resources".

Without belabouring the point by quoting a number of particular examples, it is quite clear that the British Columbia Government has been, and is, strongly dissatisfied with its financial receipts from the Federal Government. There is every indication that the Federal Government attempted to enter the forestry field in Provinces, with the formation of a Department of Forestry and the advent of the Federal-Provincial Forestry Agreements. There is little question that the Canadian Government would have liked to participate with its personnel in Provincial forestry, at least in those areas to which it was contributing funds. There is little question also that the Provincial Government, mindful of past history and opposed to anything that might represent an erosion of its jurisdiction, conferred by the British North America Act, over natural resources opposed the entry of the Canadian Government into fields other than the research field and wanted the Federal contributions made, without their use being specified and left to the discretion of the Provincial Government. As a result of these attitudes and because of other factors, the Federal Government has begun its withdrawal from the field, including the dissolution of the Canada Department of Forestry and the distribution of its functions to other Departments of Government.

These events cannot be said to have resulted in a satisfactory solution for the problems facing British Columbia forestry. In particular, the raising of sufficient funds to rehabilitate those acres not producing wood to their capacity, to reforest those currently being logged (where natural regeneration is not being obtained) and to introduce more widespread and sophisticated silviculture to the forest appears to be a remote possibility so long as the major proportion of the Federal and Provincial revenues from the forest and its dependent industry are diverted to other activities. In brief, the joint and overall financial responsibility toward the resource is inadequately recognized and organised.

The contrast to the financial position in Great Britain is apparent. Even though private woodlands form a large proportion of British forests, an effective single authority exists with the result that more national allocations of money to forestry have been made. Until a more rational solution of the forest finance position in British Columbia is found, it is difficult not to view the Federal system in its present form, as having obvious drawbacks.

CHAPTER 5

REVIEW OF LITERATURE - BRITISH COLUMBIA

A. FOREST POLICY

1. General Remarks:

This review is undertaken so as to deal, in the main, with forest policy first and forest management subsequently. The major policy makers in the Province may be defined as the Legislative Assembly of the Province to which the Minister of Lands, Forests and Water Resources presents his proposals for amendments to the Forest Act or other legislation governing the forest policy. Under the direction of the Minister is a Deputy Minister of Forests and the British Columbia Forest Service, whose powers of regulation, which are mainly administrative, are defined in the Forest Act. There is also a Select Standing Committee of the British Columbia Legislature which deals with questions of forest policy and administration referred to it by the Minister, normally involving public hearings on the questions concerned. The role of the Forest Service in policy-making should not be underrated, since there is little question that many policy proposals to the Minister stem from it. The forest industry plays an active part in policy formulation, mostly through industry Associations such as the Council of Forest Industries, the Interior Lumber Manufacturers'

Association and the Truck Loggers' Association. Partly because of the great economic importance of the forest resource to the Province, the forest policy field is very active politically and, in this review, it will be necessary to include reference to speeches and unpublished reports, as well as scientific publications to arrive at a clear definition of policy.

Forest tenures play an important role in the Province's forest policy, since their terms and conditions incorporate many of the aims of policy. For example, the pulpwood harvesting area agreements were designed specifically to encourage the growth of the pulp industry. A description of the tenures is included at Annexure 1 but the circumstances of their introduction and the results of them are included in this review.

It is not the intention herein to review all of the provisions of the Forest Act. Much of its content deals with points of administration which may be regarded as normal to a State forest authority. Rather, it is the intent to review some of the more important modern provisions and their importance.

2. Tree Farm Licences:

Moss (1956) has described tree farm licences and some of the reactions to them. In essence, a tree farm licence is a forest area (which may contain one or more working circles) managed by industry on a sustained yield basis, in accordance with a management and working plan written by a professional forester and approved by the Forest Service. A licence was granted to supply a specified manufacturing plant or plants with forest produce.

The tenure was introduced by the Provincial Government as a result of the recommendations of Sloan (1945), acting as a Royal Commissioner. The objectives of the Government were to achieve rational, sustained yield management of the forest lands, by industry, so as to produce a maximum return in wealth and wood. Secondly, it was hoped to stabilise and perpetuate the forest industry and those communities which were economically dependent, in whole or in part, upon the industry. The history of the Pacific Northwest wood utilisation industry had involved forest liquidation, in which industries had been developed to a point beyond the growth capacity of the area to sustain them indefinitely, only to disappear with the exhaustion of the wood supply. Under these conditions, the existence of some communities had become unstable and the Government by a sustained yield policy, as applied in try farm licences, hoped to prevent these tendencies. Thirdly, the Government hoped to achieve closer utilisation of the forest crop and, fourthly, the perpetuation of the forest resource.

Moss pointed out other benefits. The tenure permitted a number of professional foresters and forestry staffs, employed by industry, to engage in forest protection, silviculture and other aspects of forestry instead of being solely concerned with questions of wood supply to plants. Without this involvement of industry Government efforts to properly manage the forests would continue to be stultified, unless the strength of the Forest Service was increased. In addition, the security of tenure and management control acquired by those sectors of industry which had been granted tree farm licences would encourage industry to provide forest road access at an accelerated rate, at a time when there was a serious inadequacy of forest access in many areas of the Province. Rational forest management, including better coordination of operations, reforestation and acquisition of forest inventory information would be advanced to an unprecedented extent.

The acceptance of tree farm licences by industry was generally good but some sectors vigorously objected and produced controversy. Many companies depended for their timber supplies on logs produced from Timber Sales - temporary tenures of Crown timber which were offered for sale at that time, by public competition.* Some of these companies pointed out that tree farm licencees were not subject to public competition in cutting the timber within a licence and, consequently, always paid the upset price. It was also claimed that this difference gave the tree farm licencee an unfair competitive advantage when bidding for a Timber Sale.

Another objection held that the establishment of tree farm licences would mean the disappearance of the "small" sawmill operator or logger, since the licences were usually only granted to larger companies with the financial ability to develop and manage them. The description "small", as applied to logging operators, was confusing since a small Coastal operator might log, for example, two million cubic feet of logs per year whereas his Interior counterpart would cut about one hundred thousand cubic feet, with corresponding levels of capital investment.

Moss (1956) also noted the objection that the issue of a tree farm licence increased the value of a company and enabled its owners to make a rapid, untaxed,

*The procedure was, and is, for the Forest Service to appraise the value of the standing timber per unit of volume (stumpage and royalty) and offer the timber to public competition at an "upset stumpage and royalty" below which the bid price may not go. Bids were made per unit of volume and the highest bidder acquired the timber sales. Later modifications of this procedure are described under "public sustained yield units" below.

capital gain by selling the company. Whilst the Minister of Lands, Forests and Water Resources possessed, under the tree farm licence agreement, powers to prevent the transfer of a licence to another party, he was unable to prevent a change of ownership by sale of shares, where the corporate identity and, hence, the licencee remained unchanged. Another objection holds that the original method of approval (or rejection) of the issue of licences by Cabinet decision at closed meetings should be changed to a system of public hearings at which those objecting could state their case in public, and public hearings were subsequently adopted.

The public controversy over tree farm licences reached significant proportions and other forest users - cattlemen; miners; irrigation interests and recreational users, particularly those concerned with fish and wildlife -entered into it, motivated by a concern that their user interests would be adversely affected. These objections were held by Moss (1956) to be largely unfounded, since the tree farm licence agreements specifically reserved to the Crown and did not convey to the licencee, certain rights of jurisdiction over these uses within the licence. Although questions of forest use have assumed increased importance in recent years and pressures upon the forest have increased, the problems of tree farm licences do not appear to have exceeded those applicable to Crown forest land generally. In addition, other uses have benefitted from the improved road access provided by the forest industry within the licences.

Finally, Moss (1956) noted that some tree farm licencees, fearing catastrophic fires, objected to a retroactive ruling (subsequent to the signing of a number of licence agreements) by the Deputy Minister of Forests that their area of occupancy* was the entire licence area. The area of occupancy of a timber sale operator was the timber sale area and the objecting licencees held that their responsibility for fire fighting should be held to their logging areas (cutting Permits) within the licence. The area of occupancy of a licencee was not, however, changed.

Sloan (1956), acting as a Royal Commissioner, commented on the foregoing and other problems at some length. He considered the complaint, strongly emphasised by the British Columbia Truck Loggers' Association, that tree farm licences would aid in the disappearance of the independent logging industry because of the tendency of large forest industry corporations to conduct their own

*Technically, the area over which an operator is responsible for fighting forest fires, up to a maximum contribution of the number of men and the amount of equipment currently working within the area.

logging operations. He felt it to be in the public interest that an adequate field of operation for an independent logging industry should be maintained and protected. Subsequently, all tree farm licences issued and some of those already in existence were required, by the government, to contract a portion of their logging operations, not less than thirty percent of the allowable cut of the Crown land portion of the licence, to independent loggers. Sloan did feel, however, that the additional complaint that tree farm licences created monopolies in which Crown timber was sold to the licencee without competition, greatly undervalued the contribution which the tree farm licence policy should make to the permanent, sustained and increasing production of manufactured commodities.

The allocation of licences received close attention. Sloan stated that the two basic reasons for the granting of a licence were to support conversion plant of proven value to the community and to provide an inducement for private forest land owners (owners of Crown grants, timber leases and licences and other older forms of tenure) to include their lands, along with the allocated Crown land, within the tree farm licence, thereby bringing the private lands under the sustained yield management program. On this basis, he noted that the latter objective had been overlooked in the Interior, since the area of private land which had been brought under forest management by the tree farm licence policy was insignificant.* He added that

*This was hardly surprising, since the areas of private land held by companies with plants located in the interior were insignificant in relation to the very large areas of unalienated Crown forest land. The much higher percentage of privately owned forest land in the Coastal Region was largely present from the historical fact that the Coastal industry developed more rapidly than the Interior one and many more of the early timber leases and timber licences were taken up in that Region. At the time of Sloan's investigation, Interior tree licences contained more than 99 percent of Crown land. The Coastal licences contained 13 percent of Crown granted forest land, 25 percent of lands formerly held under temporary tenures which had been made permanent by their inclusion in the tree farm licences and 62 percent of previously unalienated Crown land. In the author's view, the Government was fully justified in awarding the Interior tree farm licences for the stabilisation of the industry and its dependent communities and for the purpose of involving industry directly in the sustained yield programme and to this extent, disagrees with the view expressed by Sloan.

first priority in the granting of licences must be given to pulp and paper industries and other large conversion units, so as to achieve the perpetuation of the export trade and other social and economic objectives. Whilst some more licences were granted on this priority, the major development of the pulp and paper industry in recent years has been achieved through the medium of another, later form of tenure - the pulpwood harvesting area - which is discussed below. Sloan (1956) also held that priority in the award of a tree farm licence should be given to a major holder of private timber, particularly if he placed within the licence a volume of timber equal to one-half or more of the volume of Crown timber with the proposed licence area.

Amongst other recommendations for changes to the tree farm licence scheme, Sloan felt that a percentage of the annual cut, not less than the original percentage of Crown timber in the licence, must be manufactured in the licencee's own plants. Up until this recommendation, licence agreements specified a minimum of eighty percent of the annual cut and Sloan's purpose in recommending this change was rather obscure. There had been objections to the perpetual length of tenure which had been a distinguishing feature of the licences issued up to that time and Sloan recommended that, in future, a term of 21 years or, alternatively, a term when the sum of actual annual cuts from the licence area (regardless of the original tenure from which the cut was made) had reached a volume not less than the total volume of private timber contributed by the licencee to the licence. The early licences, whilst perpetual in term, could be cancelled unilaterally by the Government for failure to adhere to the terms and conditions of the licence and/or the approved Working Plan. In proposing a shorter term of tenure, Sloan intended that the tenure could be renewed where performance of the licencee was satisfactory and evidently felt that this was a better approach to the problem than the cancellation of a perpetual term for unsatisfactory performance.

The objection, mentioned above in connection with the comments of Moss (1956), that tree farm licences, by reason of the fact that they could purchase their licence timber on a non-competitive basis, had an unfair advantage over non-bidders of tree farm licences when bidding on other, unalienated Crown timber was heard by Sloan (1956) and following his death, the evidence presented was dealt with by Morrow (1960). Morrow considered that tree farm licencees did have advantages, but not unfair ones. The licencees, because of their assured timber supply, were better enabled to finance their operations. They also paid lower performance deposits, subject to forfeiture to the Crown for lack of adequate performance, than did timber sale holders and they could, because of these two financial advantages, plan road building on a long-term basis. However, he added that licencees also had a disadvantage in being required to make a compulsory contribution of his own timber; in not being allowed to liquidate timber as he wished and in having heavier responsibilities for fire protection and insect control. He recommended that certain administrative changes should be made in timber sales, so as to lower performance deposits and that the entire problem of forest tenure should be taken under advisement by the Government.

Although the author has been unable to trace specific written opinions on the subject, it is clear from the problems mentioned and from other problems* that the Government were under heavy political pressure to discontinue the issue of tree farm licences. The issues were primarily social ones, with economic overtones. In any event, although a limited number of licences were issued following Sloan's (1956) findings, their issue was eventually discontinued and policy developments led to the creation of other types of tenure.

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* a scandal arose concerning alleged bribery in the acquisition of tree farm licences, for example.

3. Public Sustained Yield Units:

In addition to a recommendation to form "private working circles" (tree farm licences) under the sustained yield policy, Sloan (1945) proposed that "public working circles" should be established. These were formed under the names of "public working circles" and "sustained yield units" and, at the present time, they are usually referred to as "public sustained yield units", the term used in this review. The units are described in Annexure 1. Basically, they are administered by the Forest Service under the sustained yield policy but they are seldom managed so effectively as a tree farm licence since they do not have a locally resident professional staff or comparable management and working plans, although the latter are being developed. Technically they may be considered as operating under a regulated annual cut, with protection against forest fire and a variable degree of reforestation. Although control is maintained over the silvicultural systems of felling employed in the units, the Forest Service does not normally allocate the specific area from which the cut is to be made but tends to grant cutting privileges, through the medium of a "timber sale" tenure, upon application by industry. Applications to cut timber considered to be immature are, however, usually rejected.

Sloan (1956) has cited the evidence of Orchard (then holding the combined appointments of Deputy Minister of Forests and Chief Forester) that it was the ambition of the Forest Service "to have eventually one half of the Crown lands included in forest management licences (tree farm licences) and one-half in the public working circles (public sustained yield units)."* Orchard also noted that it might be necessary to postpone the preparation of working plans for public sustained yield units, where adequate forest inventory data were not available.

It is worthwhile to refer to the forest inventory at this point. Prior to the publication, by the British Columbia Department of Lands and Forests (1957), of the "Continuous Inventory of British Columbia - Initial Phase", inventory information had frequently been general in nature and sketchy. The Continuous Inventory was based on a stratified random sampling technique. The sampling strata were composed of forest cover types or groups of these types, segregated by age classes, which were recognised in the forest classification. The accuracy objectives of the forest inventory were to produce estimates of gross cubic foot volume by species, for the entire Provincial forests, with a sampling error not exceeding 10 percent at a probability of .95. The accuracy of the

*Author's parentheses.

estimates of gross volume, at a defined close utilisation standard, in live merchantable trees of ten inches dbhob and larger, in mature forest stands in the Province was ±4 percent sampling error. In each of the seven inventory zones into which the Province was divided, the sampling error, under similar conditions, ranged from ±6 percent to ±10 percent. Each inventory zone consisted of a number of sub-zones, of approximately one to two million acres each in size. In each of these sub-zones, the <u>ultimate</u> accuracy objective was set at the level of that for the inventory zones, with the modification that the accuracy applied to the gross volume of all species collectively. The foregoing accuracy objectives do not take into account non-sampling errors, such as might occur in the measurement of trees or in the application of tree volume tables.

In addition to the inventory of mature forests, growth estimates were made for all of the forest. These estimates were considered, by the Forest Service, to be adequate for the large areas to which the figures applied but to be of unknown reliability when applied to smaller areas. The British Columbia Department of Lands and Forests (1957) also stated that the sampling errors for the mature forest inventory, given above, were only indications of the accuracy of zonal volume estimates and that no assumption of their reliability should be made when applied to smaller, local units of area.

As a consequence of this position, a serious problem arose in applying the forest inventory to the individual sustained yield units and made the accurate calculations of yield and annual allowable cut difficult. Whether or not the Forest Service took a conservative approach to the problem is undetermined, since the yield calculations have not been released by the Government. Statements to the effect that the annual allowable cuts are too low have been made and the situation is, of course, critical in those units where the level of allowable cutting has resulted in a cut-back of industry production. The Forest Service has been pursuing a programme of inventory intensification in public sustained yield units, to achieve an appropriate accuracy level for yield calculation. The process is likely to take a number of years to complete and, in the interim, it is likely that the completion of formal unit working plans will be held in abeyance.

With reference to the aim, expressed by Orchard in the hearings before Sloan (1956), that half of the Provincial Crown forest should be placed into tree farm licences and the other half into public sustained yield units, Sloan thought that it would be many years before this objective was achieved and the 90 million acres of productive forest land in the province were included in the licences and units. Nevertheless, the British Columbia Forest Service (1965) noted that there were somewhat more than 79 million acres in the Province under sustained yield management by 1965. Of this figure, almost 70 million acres were in public sustained yield units and almost 9 million acres in tree farm licences, with relatively minor acreages of the other sustained yield tenures - tree farms, farm wood-lots and Christmas tree permits. Thus, remarkable progress was made in placing forest acreage under the sustained yield programme but the ratio of tree farm licence acreage to public sustained yield unit acreage, which the Forest Service originally hoped to see, was not achieved for the reasons given previously in discussing tree farm licences.

In summary, the evidence before Sloan (1956) stressed the inadequate degree of management by the Forest Service in the public sustained yield units. Management was limited to containing the cut within approved limits and to the inclusion of restrictive convenants in the timber sale contracts issued within the units concerning logging methods. The forest inventories and surveys were held to be inadequate for management purposes. Sloan (1956) did not disagree but pointed to the inadequate staffing of the Forest Service administrative framework as the cause.

Apart from the position of the forest inventory, mentioned above, Sloan expressed the view that the annual allowable cuts of the sustained yield units did not take the factor of accessibility into strict account and, therefore, the lack of access roads, especially into the Coastal sustained yield units, was a matter of much concern. The Provincial Government had (in 1956) a five-year programme of forest access road construction in the public sustained yield units. It was proposed to build 1,460 miles of access roads throughout the Provincial forests at a total estimated cost of approximately 41 million dollars, to be provided through the Forest Development Fund.*

*The fund was authorised to borrow money or to receive advances from the Provincial Treasury, as authorised by the Legislature. It could collect revenues from forest developments and make loan repayments. The evident intention was to have, eventually, a self sustaining fund. However, it was abolished, along with others of its type at the end of 1956, in favour of placing all receipts directly into, and making all expenditures directly from, the Provincial consolidated fund. During the existence of the Forest Development Fund, from the fiscal year 1950-51 to 31 December 1956, the gross expenditure from it was only 2,370,135 dollars. In 1956-57, the Legislature voted an appropriation of $2,278,000. from consolidated revenue for the construction of forest access roads. Although this was a substantial increase, it was far less than the $8,000,000. per year, for a five year period, envisaged in the proposed road programme. Even at that, only 900,000 dollars of the 1956-57 appropriation was actually expended on road and bridge construction and maintenance and only 32.3 miles of road were built with it.

The plan was not carried out and it became clear that the efforts of the Provincial Government, acting alone, were inadequate to meet the need. The Federal Government began to make contributions under the Federal-Provincial Forestry Agreements (now in process of expiring) and the Roads to Resources Programme, with the result that greatly increased road building activity has occurred in recent years.

The annual cut from the public sustained yield units is released for logging, by the Forest Service, through the medium of Timber Sales. Under a system of quota allocation to established operators, an operator may apply for a timber sale carrying a sufficient volume of timber to provide for his quota, in an area of his selection. Sloan (1956) recommended that this system should be modified to a system in which the Forest Service selected the cutting areas one year prior to the time that the timber would be open for bidding. The recommendation has not been implemented to date.

In fully-committed public sustained yield units*, a tendency toward excessively high bidding for timber sales developed. A company wishing to expand the volume of its operations within a public sustained yield unit could buy

*A unit in which the sum of operators' quotas equals the annual allowable cut for that unit.

another quota-holder's business. However, where it outbid a company which had applied for a particular timber sale it acquired not only the timber sale but also the quota of the applicant. In a few instances, companies used this latter approach and some timber sales were bid up to very high and obviously uneconomic levels of stumpage and royalty in an effort to acquire quota from another operator. Similarly, operators wishing to acquire timber from a public sustained yield unit in which they held no quota would occasionally try to do so by excessively high bidding. The Government acted to correct the situation. Williston (1961), Minister of Lands, Forests and Water Resources stated that companies or individuals engaged in logging in public sustained yield units would be afforded a degree of protection against ruinous bidding practices. The new system provided an applicant for a timber sale with an option to bid by sealed tender, rather than at a public auction and only those operators who were established (i.e. held quota) within a unit could apply for a timber sale. Where sealed tender bidding was chosen and another bid exceeded that of the applicant, he was given an opportunity to equal the higher bid and, should he do so, to be awarded the timber sale. This arrangement was a departure from the previous principle of selling timber by free public competition. Later, Williston (1963) noted that the introduction of the sustained yield programme had resulted in a loss of free enterprise, "in the classical economist's definition", in the Province's forest industries. He felt that this regulated departure would result in the introduction of more regulations, a prediction which appears to be borne out by the complexities of public sustained yield unit administration at the present day (see Annexure 1). Williston (1963) did state, however, that he was against further protective regulation, in spite of pressures upon the Government to introduce more.

The circumstances surrounding the creation of a new form of tenure - the pulpwood harvesting area - are reviewed below. The objective of their creation was to offer a guaranteed supply of timber to new pulp mills and, thereby to stimulate the expansion of the pulp industry. Williston (1965) stated that during 1964, an alternative method of providing a supply had been employed by an amendment to the usual method of issuing timber sales. The Forest Act, at the time, required that timber sales would be restricted to a specified area. The Government, however, had declared, by Order-in-Council, that the Finlay Sustained Yield Unit was a "Special sale area" and this action had permitted the Forest Service to draw up a timber sale contract that did not designate a specific area of land. The contract simply gave the licencee the right to log a stated volume of timber each year within the boundaries of the Finlay Sustained Yield Unit for a specified number of years.*

In order that the Forest Service could retain control of the logging process, the licencee was required to submit a cutting plan to the Chief Forester and to apply for cutting permits conforming to this plan. So as to avoid the cumbersome procedure of needing an Order-in-Council to issue these "Cutting Permit Timber Sales" (originally described by Williston (1965) as "timber sale harvesting areas"), the Forest Act was amended to permit the Forest Service, when authorised by the Minister, to issue them. Unless the Forest Service permitted an exception, all Interior holders of this type of timber sale would be required to have plants capable of utilising trees of 7.1 inches dbhob and larger to a 6-inch diameter top. The Coastal operators would not be required to meet these standards but would have to cut to the Forest Service close utilisation standards for the Coastal Region. The management responsibilities of the licencees were to include a fire protection pre-organisation plan with

*This arrangement was held to be particularly suitable for the Finlay S.Y.U. because of the distribution and size of its timber.

provision for a stand-by crew of men throughout the fire season and adherence to the silvicultural provisions of the Cutting Permit subsequently issued by the Forest Service. For the latter work stumpage would be adjusted for the additional operating costs involved. Subsequent to these announcements by the Minister, the Forest Service (Stokes 1967) issued proposals for the modified timber sale tenure to the forest industry as a basis for discussion.

The objections to tree farm licences as a threat to the survival of an independent logging industry and the action of Government in requiring tree farm licencees to contract a portion of their logging have been discussed previously in this review. The Government went to some length to emphasise that public sustained yield units would not threaten this independent industry. Williston (1963a) emphasised that he did not wish to introduce more protective regulation than was necessary to guarantee forest management in the Province, with restrictions designed to ensure better forest management. He pointed out that the entrepreneur was subjected to other potent pressures than those stemming from restrictions upon forest utilisation. In the growth of the Province's forest economy, it had been the pattern for an individual to start an operation and to increase its value by his industry.

Upon approaching retirement age and being faced with succession duties upon his estate, he would frequently make all or part of his assets liquid (so that his heirs could pay the duties) by the sale of this business or by the formation of a public company. Over the years, however, the industrial units had increased in size and value to the point that very few individuals had the financial resources to purchase an operating unit. It had also become increasingly difficult for an individual to establish an operating unit, even of modest size, under which the supply of raw material was limited by the sustained yield policy and, also because of the succession duties placed upon individuals. In the large Vancouver Forest District in 1963, there were only about 461 established licencees operating within the sustained yield units, about half of whom were cutting more than 100 MMcf. per annum.* About 65.1 MMcf (53.3%) of the production from the public sustained yield units in the District was controlled directly by the industrial manufacturers, whereas 57.1 MMcf, being the balance of the current annual allowable cut, was available for sale to the Vancouver log market. These figures indicated that a strong, independent group of logging

* Other relevant statistics relating the increase in size and decrease in numbers of sawmills in the Province are included in the Annexures to this thesis.

operators still existed in the units, dependent upon the sale of Crown timber for their timber supplies. Williston indicated that the Government supported the continued existence of independent smaller operations and expressed the belief that, as the Province became involved in second-growth (second rotation) forest management, the operations would tend to become smaller and would function in thinning operations.

Based on this reasoning and policy aims, Williston (1963) held that Government action should consist of:

a. Ensuring that a sustained supply of timber for sale was available in the public sustained yield units and attending to those matters (e.g. more accurate forest inventories) which might affect the allowable annual cut.

b. The implementation of the clause inserted in the contract documents for tree farm licences numbers 13 to 39 inclusive under which the licencee was required to obtain a stated proportion of his annual cut from contractor logging, rather than from his own operations.

c. The intensification, subject to limitations of available funds and trained personnel, of the reforestation of cut-over lands. The Government was also accelerating the reversion of immature timber areas and logged areas, from timber berths and timber licences, to the

Crown, so as to increase the annual allowable cut available from the public sustained yield units.

d. Consistent with efforts to increase the allowable cut, there should be a gradually increasing insistence for more complete utilisation of wood left on the ground following logging.

e. In the case of timber stands where there was a high incidence of defect present, Government action should encourage improved utilisation practices so as to remove all of the merchantable volume and prepare the ground for the regeneration of a new forest.

It is evident from the foregoing that many of the actions taken by the Government to adjust and change past policies to the new situation which arose following the introduction of the sustained yield policy were largely administrative in nature. The problems of the inadequacy of the strength of the Forest Service, noted by Sloan (1965), for the management of the Crown forests were increased by the cessation of the tree farm licence scheme. The Government dealt with the question and Williston (1967) made an indication of the course of future policy. He pointed out that timber sale contracts had originally dealt simply with logging and matters connected with logging, such as the avoidance of unnecessary damage to a residual stand or to young growth and the disposal of logging slash. The need for the regeneration of logged sites had gradually come to be recognised as a pressing problem and, in the Interior, this need had led to the adoption of more sophisticated systems of felling and to refinements in logging techniques. To enhance the opportunities for natural regeneration in the Interior, specified methods of site preparation, such as slash disposal and mechanical scarification had been added. The Government had recognised, however, that the inclusion of some of the added costs in the stumpage appraisal would result, in many cases, in an inadequate allowance for these costs to the operator, because of the rules governing the appraisal of stumpage, applicable in British Columbia. Industry had not been slow to point this out, particularly in connection with mechanical site scarification in some Interior forest cover types and with site rehabilitation in the decadent western red cedar - western hemlock (Thuja plicata Donn - Tsuga heterophylla (ref.) Sargi) forest cover types of the Interior wet belt.* In the

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*Operators in these stands were required to log and recover all merchantable volumes, cut down all remaining trees of 8 inches d.b.h.o.b. and larger and to burn the resulting slash.

Coastal Region, operators were concerned about the effects of including planting costs in the stumpage appraisal. As a result of these and other problems, the Forest Act had been amended in 1964 to permit the Minister to compensate a licencee, in whole or in part, for the approved cost of carrying out silvicultural treatment or constructing a primary access road either by "an offset against stumpage or by payment from funds appropriated by the Legislature for that purpose." The Consolidated Revenue Fund, in the case of Crown timber sold as a timber sale (and excluding that in tree farm licences) was required by the amended legislation to make available a sum of money** to pay the cost of reducing the hazard created by the removal of timber or to ensure or promote the growth of a second crop or of silvicultural treatment incident to the removal of the existing stand.

The whole question of cost allowances for silvicultural and protective measures in timber sales is still controversial, with much of industry claiming that the rebates paid are less than the actual costs incurred. By December 1966, the Interior Lumber Manufacturers'

**The sum consists of 75 cents per cunit of the average annual cut for the preceding five years for which information is available.

Association (1966) reported that only 12 timber sales in each Forest District were eligible for rebates under the new arrangements, the limited number allowing the Forest Service time to assess the problems before expanding the system.

Having described the development of timber sales and the rebate system, Williston (1967)) stated that it was proposed to involve industry to a considerably greater extent in management practices. It was not the policy of the Government to build a tremendously large Forest Service to perform all of the functions required for public sustained yield units, since the costs must eventually be derived from the operation of an economic industry.

4. Pulpwood Harvesting Areas:

As described above, the major forms of tenure introduced to implement the sustained yield policy recommended by Sloan (1945) and adopted by the Province were initially tree farm licences and public sustained yield units. For the reasons given, the issue of tree farm licences was halted before the aim of the Forest Service, to place half of the Crown forests into the licences, was realised. The public sustained yield units have also been modified in many cases by the issue of overlapping pulpwood harvesting areas. In order to view these harvesting areas in perspective, it is considered necessary to refer to earlier history.

Sloan (1956) noted that, in 1944, there had been 571,000 acres of pulp licences, pulp leases and pulp timber sales in the Province. These were forms of tenure of long standing and their issue had been consistent with the Government policy of encouraging the growth of the pulp industry. The policy had shown some success, insofar as the volume of wood entering pulp mills* had increased from 109,000 cords in 1916 to 1,180,000 cords in 1954. But, in comparison to the total Canadian production of pulp and paper products, including newsprint, and within the context of the steadily increasing volume of pulp production throughout the world, the British Columbia production for 1955 remained insignificant. Sloan concluded that a favourable economic climate, in which the pulp and paper industry could operate and expand, was desirable.

The Government evidently concurred with these views. Williston (1960) expressed his belief that improved waste utilisation in the expanding Interior sawmill industry was imperative so as to achieve a more competitive position for the industry, to create better site

*including normal logs, wood salvaged from logging operations and chips manufactured from sawmill residuals.

conditions for the next rotations (by reducing the amount of wood left lying on the ground) and to reduce forest fire danger on logged sites. He reviewed the progress in forest utilisation being made in various sub-regions of the Interior but concluded that the area then being managed on a sustained yield basis could produce, approximately, an additional 2,450 tons of pulp per day derived from current available waste in the forest and from species not being cut for lumber. This was the equivalent of about 750,000 tons of pulp per year, or about one-half of the total production of Coastal pulp mills in 1958. Williston noted that the Food and Agricultural Organisation of the United Nations had estimated that, from the actual world production of pulp in 1955 (56 million metric tons), the indicated world demand would grow to 88 million metric tons by 1965 and 134 million metric tons by 1975. Much of this future pulp, Williston held, would come from the forests of northern Canada.

But a major difficulty remained. Potential investors in pulp mills required an assured supply of timber prior to making a commitment to construct a mill. Although the public sustained yield units were producing sawlogs and could produce additional volumes of pulp logs, the pulp companies needed more definite assurance than simply knowing that these additional volumes could be available. To meet this problem the Government had evolved a new form of tenure - the pulpwood harvesting area (Williston (1961)). The tenure is described in Annexure 1 hereto. Under it, the Government entered into agreement with parties who would undertake to establish an integrated pulp industry, for which the Government would give these parties the first priority to purchase the pulp timber from a given public sustained yield unit or group of units. It was expected that the pulp mill operator and logging operator having timber sales within the units included in a pulpwood harvesting area would reach agreements under which the latter would undertake to remove the pulpwood, tree tops and species unsuitable for lumber for supply to the pulp mill. If the logger were not interested in an agreement of this kind, the pulp mill operator would have the legal right to remove the pulp material employing his own loggers.

Williston foresaw an upsurge of pulp chip production, made from sawmill residues. Also, he felt that the new market for pulpwood, tops and species unsuitable for lumber would increase the value of and profitability of a timber sale.*

The issue of the pulpwood harvesting areas in the Province and the attraction to the pulp industry of the relatively generous terms offered, resulted in what has been termed the "pulp explosion". The British Columbia Hydro and Power Authority (1966) published a review of the pulp industry in which it was reported:

(1) The value of the province's total forest production exceeded 1,000 million dollars

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*It cannot be said that all of these trends have developed. The supply of pulp chips from sawmill residues has increased and forms a cheaper source of supply than do round logs, tree tops, etc. Where pulp mills are using round logs, the logging is frequently carried out by their own crews or contractors rather than by sawmill industry logging contractors. A noticeable trend of consolidation has taken place, in which the new pulp mills have purchased sawmills thereby acquiring sawlog quota and supplies, ensuring the continuance of the chip supply at relatively low prices and gaining a free hand in the logging of pulp material on the sawmill's timber sale areas.

in 1966. The value of gross annual production of the pulp and paper industry exceeded 300 million dollars.

(2) Pulp production in British Columbia, which had more than doubled during the decade ending in 1965, when it reached 3.2 million tons, was expected to double again in the succeeding five years. The predicted production for the mid-1970's was 9 million tons.

(3) Newsprint and paper production, which more than doubled in the decade ending in 1965, when it reached 1.5 million tons, was expected to reach 3 million tons annually by the mid-1970's.

(4) The expansion of many of the seventeen existing pulp and paper mills, plus the construction and subsequent expansion of some 15 to 20 mills, planned within the ten-year period ending about 1975 would call for total planned capital and prepaid expenditures, approximating to 1,500 million dollars.

(5) The world demand for kraft (sulphate)

> pulp was growing at a rate of 8 percent per annum, faster than the demand for other forms of pulp. Most of the Province's existing, and all of its proposed, capacity was for the production of kraft pulp.

The policy of entering into pulpwood harvesting area agreements in return for guarantees of pulp mill construction has materially assisted in achieving the predicted rapid growth of the industry.

There has been some adverse comment. Clyne (McMillan, Bloedel and Powell River Ltd. (1965)) predicted that, with the increases in British Columbia and world production, the total available supply of market sulphate pulp would reach about 11 million tons by the end of 1967, at which time demand would have reached only 9 million tons, leaving a surplus of 2 million tons. Between 1968 and the early 1970's, the planned increase in supply from British Columbia alone would increase the total world supply to 14 million tons, with a corresponding world increase in demand to 11 million tons.*

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*Clyne's predictions, to date, appear to have been substantially correct and brief pulp mill closures have occurred in the Province in recent years to allow demand to overtake supply. There appears to be a likelihood that overall demand will not equal the capacity for supply untill after 1972.

Williston (1965), however, referred to expressions of concern that the sudden upsurge in pulp production would have an adverse effect on the world market but could not believe that a very real problem existed. Whereas the established mills in the Province had long since established their markets, the new ones were tending to associate themselves with foreign companies which would be able to sell, or use most of the new produce. The Companies concerned had world-wide marketing organisations and their ability and judgment was such that the Minister could not believe that they would invest many millions of dollars in costly ventures, if they were not convinced that they could dispose of the product.

5. <u>The Close Utilisation Policy</u>:

The tree farm licences, public sustained yield units and pulpwood harvesting areas are the major forms of tenure which have resulted from the adoption of the sustained yield policy in British Columbia. The Government have been aware of the several influences which affect the potential annual level of cutting in these tenures and have insisted in increasing degree that industry must practice closer utilisation of the mature timber stands being cut. The pulpwood harvesting areas, quite apart from the effect, highly desired by Government, of accelerating the industrialisation of the Province, has intensified closer utilisation of the stand, both in the forest and in the plant. This closer utilisation will increase the current sustained yield annual cut from the forest. The potential of the pulpwood harvesting areas cannot be expected, however, to provide the desired standard of forest utilisation throughout the Province for many years. As mentioned previously, pulp chips from sawmill residues are still a cheaper form of wood supply than is round pulp wood and salvage wood. It is reasonable to expect, therefore, that this source of supply will be fully utilised by the pulp mills before large-scale round wood supplies are utilised. Moreover, the capacity of wood supply provided by some pulpwood harvesting area agreements is considerably in excess of current plant capacity. Provision has been made in them for plant expansion but, until this occurs, the surplus of pulp wood presumably will not be utilised. Finally, not all sustained yield units are included in pulpwood harvesting area agreements and because of the obvious need to introduce additional pulp capacity, over and above that already planned, in an orderly progression, it seems likely that a considerable period of years will elapse before all sustained yield units are utilised for pulp round wood and pulp salvage wood production. Whilst remarkable progress has been made in effecting a more complete utilisation of the logs delivered to plants and whilst progress has been made in effecting more complete forest utilisation, the Government has been, evidently, of the opinion that more rapid progress must be made in the latter field. Sloan (1956) reviewed the problem of plant and forest waste and suggested courses of action. Although the Minister of Lands, Forests and Water Resources referred on occasion to the desirability of closer utilisation of the forest resource, he first enunciated a proposed policy to the industry in 1965 (Williston (1965)) without, however, going into detail.

One of the basic principles in the formulation of a smallwood policy, he stated, was that the allowable cut calculations for a managed unit had to be based on forest utilisation to a given standard, without attempting to direct the particular end use to which the wood would be put. In the Interior, the allowable cuts would be calculated to two standards of utilisation, 11 inches dbhob+ and 7 inches dbhob+ and, on the Coast, the standards would be 13 inches dbhob+ and 9 inches dbhob+. The higher figure, in each case, represented the smallest trees suitable for sawlogs.*

*More accurately, they were the standards used by the Forest Service for the allocation of sawlogs in public sustained yield units. A number of sawmills were actually utilising trees of a smaller size but as average figures, they are reasonably representative of the overall standards of utilisation in the Province.

Taking the Coastal region as an example, the volume of standing timber between 13 inches d.b.h. and 9 inches d.b.h. was a volume which had not been allocated to operators as sawlog quotas and which the Government proposed to allocate in two different ways. To illustrate the principles of allocation of this volume, Williston (1965) used the example of the Kyuquot public sustained yield unit. In this unit, forty percent on the unallocated volume would be set aside for those established operators who already held sawlog quotas. Any of these operators who was prepared to utilise all timber down to 9 inches d.b.h. on his operation could thus have his annual allowable cut increased in proportion to the sawlog quota he already held. The remaining 60% of the allowable cut resulting from the unallocated timber would be sold to one or more pulp manufacturers in the form of competitive "pulp timber cutting permit sales". It might be, Williston noted, that any new pulp mills which did not have an assured supply of timber would be given the advantage of being able to match any bonus bids made by others. On the other hand, some such sales might be made on the basis that wood was offered to a particular mill on a first refusal basis at market price. Williston stressed that these were ideas which had not then been incorporated into Government forest management regulations. The 40% - 60% ratio might vary between public sustained yield units depending on the forest inventory. It was also pointed out that the trees between 9 inches d.b.h. and 13 inches d.b.h., under discussion, were mature trees and not immature trees.

Having considered the allotment of the smallwood, Williston dealt with the formulation of rules to govern the operating areas. The normal sawlog operators, who did not elect to cut trees below 13 inches d.b.h. would have to confine their logging operations to stands in which at least 60 percent of the volume was in trees of 13 inches d.b.h. or larger and they would not receive an increase in their quota. Those operators who contracted to utilize all trees down to 9 inches d.b.h. would be required to confine their logging operations to stands in which a designated proportion of the volume was in trees between 9 inches and 13 inches d.b.h. Thirdly, areas designated to be sold as pulpwood timber sales would be confined to forest types and areas that had not, in the past, been used at all for sawlogs. Because economics would be the deciding factor in smallwood logging, the Forest Service definition of suitability of stands for pulp timber sales would change from time to time. However, the Forest Service would offer these sales for bid unilaterally and would control their location.

Williston (1965) also dealt with forest depletion.

In the face of demands for more timber, the Forest Service had gradually adopted a position in which allowable cuts were based on virtually all of the mature trees available in a unit, whether or not they would be difficult to harvest. This had led the Forest Service to a position in which it had little or no reserve in hand as a precaution against possible overcutting. In consequence, it was held that sound wood wasted in logging must be taken into account as a part of the allowable cut.* In the future, Williston (1965) stated, the volumes shown as having been utilised in the Forest Service stumpage and royalty accounts (and derived from the scaling or weighing of extracted wood) would constitute the first part of the depletion record but another part would be derived from Forest Service fieldmen's estimates of sound wood volumes left on the ground. The Government proposed to make any such volume of wasted wood a part of the operator's quota, based on the utilisation standard to which he was working. Thus the performance of an operator would, to

*Since the measure of the allowable cut is the scale of logs extracted, sound wood wasted in logging had not been accounted for. If the scale of logs in a given year in a given unit equalled the annual allowable cut, any sound wood which was wasted would give an actual overcut.

some extent, determine how much of his quota he actually recovered, although Williston claimed that a concession was made to such an operator insofar as the volume of wasted wood would not be subject to payment of stumpage. In implementing this aspect of the new policy, however, a distinction would have to be made between poor utilisation and deliberate waste of much of the timber on a given area. Deliberate waste would continue to be the subject of cash penalties.

Williston (1965) noted the existence of an incentive whereby an operator would pay a fixed low rate of stumpage (20 cents per cunit) for the salvage of wood left behind after logging. This rate would continue to apply to salvage operations in areas of the Coastal Region that had previously been logged to a 13 inch d.b.h.+ standard. However, where the operator was logging down to 9 inches d.b.h. he would receive the corresponding increase in quota and his stumpage would be based pro-rata on the sawlog volume (volume of trees 13 inches d.b.h.+) at normal rates of stumpage and royalty and on the smallwood volume at a fixed rate of 55 cents per cunit.

As a development of the close utilisation policy and with the advent of speedier logging and milling machinery, Williston (1965a) noted that the Forest Service had been encouraging the measurement of logs by weight as a basis for billing for Crown revenue and for allowable cut control in the public sustained yield units. The method was faster than conventional scaling practices but Williston recognised that there would be many situations not suited to this type of wood measurement. For example, there had been relatively little interest in the Coastal region, partly because most of the logs were placed in water before scaling. The system of weigh scaling to which the Minister referred was actually a system of weight scaling and ratio sampling. Fraser (1964) has written a guide giving appropriate formulae for use with the system. Fraser and Highsted (1966) have discussed weight scaling in its relation to conventional scaling practices and Moss (1966) has published the results of a field trial to ascertain the suitability of weight scaling in a particular Interior area.

In March of 1965, the Chief Forester (McKinnon (1965)) issued a draft policy statement, following an 18-month period of discussion with industry on the subject of close utilisation. The statement included a provision for lower flat rate stumpage to encourage close utilisation and it anticipated that future stumpage appraisals for timber sales would be based on the logging costs associated with closer utilisation.* In addition, operators making application for close utilisation timber sales so as to obtain an increased quota and a reduced average stumpage would have to show proof of contract for the sale of roundwood harvested (in the smallwood diameter range) or for chips. Also, when scaling under cubic foot log scale rules, only decay would be allowed as a deduction from the gross scale.** When exercising cut control, an operator's quota would be balanced against the nett scale of the logs which he cut plus a measure of the wood wasted on the ground. The statement also made other minor adjustments to Williston's (1965) original proposals. Industry largely

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* The cost information available to the Forest Service evidently did not include costs for close utilisation and the flat rate stumpage for small material was intended to be an interim measure until adequate cost data could be acquired.

** The scaling practice up to this time had allowed a variety of deductions, such as cross-check, ring-check and sweep. It may be assumed that the Forest Service decided that deductions for these defects, which are important in lumber utilisation, did not apply when sawmill residues were chipped or when round wood was moved directly to pulp mills. In addition and of significance, was the fact that the forest inventory made allowance for decay, waste and breakage. It was far more easy and accurate, in establishing a cut control related to the annual allowable cut on a public sustained yield unit, to allow deductions only for decay. The lumber industry, for obvious reasons, objected to this proposed reduction of defect allowances.

opposed the policy but, although minor adjustments were made, the policy remained substantially the same. The number of operators voluntarily applying for timber sales under close utilisation standards had been very limited and it is to be anticipated that the Government will proceed in the direction of making close utilisation mandatory particularly in those public sustained yield units where substantial volumes of mature trees are in the smallwood category.***

6. Tree Farms:

Apart from the major forms of tenure discussed, tree farms are worthy of mention. Sloan (1956) noted that they were created, in effect, in 1951 by amendments to the Taxation Act which were intended to encourage the dedication of suitable private land to forestry. Most of the discussion and controversy which has occurred over tree farms has dealt with problems of certification of them and levels of taxation applicable to them. The British Columbia Forest Service (1966) reported that there was a

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*** The Minister of Lands, Forests and Water Resources announced, immediately prior to the time of writing that close utilisation will be made mandatory in public sustained yield units, such as the Okanagan Sustained Yield Unit, where substantial volumes of mature small trees occur.

total acreage of 1,276,291 acres of tree farms in the Province with an annual estimated productive capacity of 55,725 M.c.f. Of the total acreage, 342,449 acres had been incorporated into tree farm licences. The tenure is described at Annexure 1.

7. <u>The British Columbia Continuous Forest Inventory</u>:

The forest inventory of the Province has been mentioned on a number of previous occasions in this thesis. The British Columbia Department of Lands and Forests (1957) published the results of the initial phase.

Three main stages were employed in the Inventory - forest classification, forest sampling and compilation. A complete 1:31680 air photographic coverage of the Province facilitated the stratification of all forest areas into forest types. The typing was carried out by ground and air observation of a high percentage of forest areas, followed by the definition of all forest types on the air photographs. Subsequent to forest typing and the transferral of forest cover detail to base maps by radial line plotting, all forested, non-forested and fresh water areas were planimetered. Acreage and descriptive data concerning ownership, forest type, accessibility and numerous other variables were then recorded on electronic punch cards for later sorting and collection of data into appropriate groups and for the final integration of areas with average values per acre, derived from sampling.

Stratified random sampling was employed, the sampling strata consisting of groups of forest types recognised in the forest classification. Most of the field work in sampling was expended in the establishment of sample plots to provide estimates of gross wood volume and recoverable sound wood volume. The sampling was planned independently in each of seven forest inventory zones ranging in size from four million to forty million acres and the planning aimed at achieving an acceptable reliability of estimates in the Province and in each zone. All of the trees and tree sections measured on standard sample plots or in volume, decay, waste and breakage studies were recorded on electronic punch cards and average values per acre were derived for application to the forest types recognised in forest classification.

The accuracy objectives were to produce estimates of gross cubic foot volume by species in the entire Province, by zones, with a sampling error not exceeding ten percent at a probability of .95. Each inventory zone contained a number of sub-zones of approximately one to two million acres in size. In each sub-zone, the <u>ultimate</u> accuracy objective was similar to that used in inventory zones, except that the accuracy applied to the estimate of gross volume of all species collectively.

The accuracy of estimates of gross volume at a close utilisation standard* in live, merchantable trees of ten inches d.b.h. and over in the mature forest stands in the Province and in each inventory zone was:

	Sampling Error (Per Cent)
Zone 1 (North Coast)	±10
Zone 2 (South Coast)	± 7
Zone 3 (Northwest Interior)	± 9
Zone 4 (North Central Interior)	± 8
Zone 5 (South Central Interior)	± 8
Zone 6 (Southeast Interior)	± 6
Zone 9 (Northeast Interior)	±10
British Columbia	± 4

The sampling errors were an indication of accuracy of the mature forest volume estimates and were based on an analysis of gross volumes derived from sampling. However, no assumptions can be made from them as to the reliability of estimates within more localised units of area. No estimate was made by the Forest Service, of non-sampling errors such as those related to the taking of tree measurements or the applicability of volume tables.

*One foot maximum stump height and 4-inch diameter top.

These errors were difficult to define or measure and were assumed to be compensating in an extensive inventory.

The forest inventory was compiled between 1951 and 1957, the Province paying 5 million dollars and the Government of Canada paying 3 million dollars to make up the total cost of 8 million dollars. The unit costs varied from 2 to 20 cents per forested acre, averaging 7 cents. On the total area, the cost per acre average 3½cents. These costs included air photograph and base mapping operations.

8. Sustained Yield and Allowable Cut:

The terms sustained yield and allowable cut are well-known to forestry but it is worthwhile to review the implication placed on them in the context of British Columbia forestry. Sloan (1945) defined "sustained yield" as "a perpetual yield of wood of commercially usable quality from regional areas in yearly or periodic quantities of equal or increasing volume." By "regional areas" he meant a sustained yield unit capable of being managed under one and the same working plan. He held it to be technically impractical in an economic and social sense to assume as a hypothesis that any area of any size could be placed under sustained yield. It should not be so large that objectives having social implications could not be achieved, nor so small that it did not include the necessary range of growing stock to provide an annual yield large enough for profitable operation. In spite of his use of the word "periodic" in the definition, as an alternative to a fixed annual yield, Sloan stated that the objective should be to bring irregularities into balance over relatively short periods so as to minimise interference with the establishment of a regular series of age-classes in the next rotation. The management of a forest with the intent of harvesting large areas of it at infrequent intervals was, to him, a negation of the principles of sustained yield and the social aspects implicit in it. The general concept expressed by Sloan very closely resembles the forestry principles of the German and French schools, both as practised intensively in Europe and extensively, for example, in India.

Walters (1965) was possibly not referring directly to the sustained yield policy but he did refer to what may be termed "traditional forestry." He felt that foresters in a new country, such as Canada, tended to look to European forestry practice for guidance in reaching towards fully managed forests and tended to defend existing pioneer practices by declaring that, since European utilisation standards had not been reached, European management standards could not be equalled. He held, however, that some of the more famous European forests were the culmination of generations of forest culture in an age when the trees were sometimes considered to be more important than those whom they served. The standard of forestry practice to which Canadian foresters aspired was developed when time was immobilised by lack of change. Walters held that in all industries constant change was now inevitable and normal and submitted that Canadian foresters should make a formal appraisal of the probable impact of technological change on forestry practice to arrive at a basis to establish long term forest policy.

Pearse (1967) was direct in his objections to the sustained yield policy. He stated that provincial natural resource policies suffered from a lack of economic logic and attacked the Sloan Reports of 1945 and 1956. It was unlikely that equal annual harvests would result in maximum financial returns so long as the demand for forest products fluctuated overtime and the small variations permitted from the prescribed annual sustained yield cut were unlikely to help the situation very much. The most serious economic implication of the sustained yield policy, however, was the pursuit of the normal forest, implying that the old growth must be cut gradually and in approximately equal annual amounts for a full rotation. There was a very large economic cost in carrying old growth inventory in this way and the value of second growth crops was foregone so long as old growth was maintained on the land. Another fault lay in the use of Hanzlik's formula to establish yield.* There were no economic variables in the formula at all.* Another example of a purely technological goal in British Columbia forestry was that of aiming for maximum growth in volume (not value) of wood. Also studies showed that economically optimum rotations differed substantially from maximum volume rotations and were usually much shorter. In effect the allowable cuts in British Columbia were considerably too low, and, in any event, they were either too high or too low to maximize the value of the resources to the Province on a whole. Pearse also disputed the technological principle

*The use of Hanzlik's formula is not, however, a matter of policy. The author, for example, employed other formulae in establishing yield on Tree Farm Licence No. 9 without objection by Government. The author also considers it to be a somewhat superficial view to infer that economic variables cannot be dealt with by other means, even though a particular formula is employed.

that fuller utilisation was always desirable. He maintained that the quality of wood which it was desirable to move was determined by well established economic constraints. It should be the lowest grade or size, the value of which, when harvested, would cover the cost of harvesting it. There was also an inattentive attitude towards the conflicting demands on forests.

In spite of these objections to forest policy, it is notable that alternatives of a constructive nature, presented in a comprehensive manner, do not appear to be extant. It is possible that critics in attacking the system have failed to present convincing alternatives. In any event, the sustained yield policy appears, at the present time, to be well established in the Province and accepted generally by industry, government and the resource managers.

9. Forest Protection:

a. Fire Protection:

The importance of the threat of forest fires to the resource in British Columbia has been stressed in the brief forest history already related. The great damage caused and the escalating costs of suppression continue to be of great concern.

Sloan (1945) remarked that fire protection, from both personnel and equipment standpoints, was grossly inadequate. In 1956, (Sloan (1956)) he noted a very marked improvement but held that the effort was still inadequate, because of lack of funds.

Statistical information on forest fires in British Columbia is given in the Annexures hereto but some of Sloan's (1956) observations are worthy of note at this point. The total noted expenditure on fire protection for the year 1956-57 was 3,805,000 dollars, compared to 781,512 dollars for the fiscal year 1944-45. Taking into account increased labour and material costs the real increase in value represented by these expenditures was probably about 200 percent. There had been appalling losses from fire during the period 1930-54, when 6.4 million acres had been burned over in the Interior and 0.7 million acres on the Coast. Based on the assumption that the productive forest area of the Province was on a sustained yield basis at a rotation of 100 years, the Province was suffering a fire loss equal to 20.5 percent of the productive area in each rotation. These figures did not include the holocaustic and unfought fires, mainly caused by lightning, which burned from time to time in the 68 million acres of unoccupied northern territory. There was an apparent improvement during the period 1950 to 1955, during which a total of 1.1 million acres had been burned.

During the decade from 1946 to 1955, Sloan (1956) noted, 28.15 percent of fires had been caused by lightning, 5 percent by industrial operations, 14 percent by campers and 18 percent by smokers. In 1955 alone, smokers and campers caused 400 fires, accounting for 29 percent of the fire fighting costs and burning over an area of 14,000 acres. The prevention of man-caused fires had typically been conducted by a two-fold approach - regulation and education. Regulation consisted, for example, of laws governing forest closures, slash burning, a permit system for the lighting of fires, safety appliances on engines and other similar provisions. Sloan doubted the efficiency of these regulations in the absence of a police agency to see to their enforcement but, even so, he admitted that it was impractical, if not impossible, to police the vast forested areas. Sloan did note that man-caused fire losses had not increased during the decade in spite of a great increase in the number of recreational users and he attributed this to a better consciousness on the part of the general public. He concluded that the programme of public education should be continued and expanded.

Sloan also held that penalties for breach of the regulatory provisions should be severe. He also found that the Forest Service could exercise only a limited control over the numbers and locations of forest fires and performed their main function in controlling them, once they had occurred. Detection was an important part of the control process and a total of 406 forest fire lookouts were needed.*

In 1956, the Forest Service was maintaining sixteen suppression crews during the fire season. This type of crew had done valuable work and extinguished 92 percent of the fires which they attacked during the previous decade before they had spread over 5 acres. But the proportion of fires attacked by the suppression crews was low - in 1955, they attacked only 158 fires out of 1,384 occurring in the Province and Sloan (1956) attributed this fact to a lack of access roads and trails. Sloan estimated that there were about 2,000 miles of existing roads and trails outside tree farm licences in 1955 and that planned construction would bring the total up to 5,000 miles. Even so, this latter mileage would still not permit suppression crews to reach every reported fire within 24 hours, let alone reaching the Forest Service objective of controlling every fire within twenty-four hours. Sloan added however, that British Columbia is a vast, rugged and mountainous country and he doubted if the twenty-four-hour

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*In 1944, there were 64 and, in 1956, 140. Sloan (1956) was recommending 266 more lookouts.

control objective of the Forest Service could be achieved by the use of roads and trails alone. Fixed wing aircraft and helicopters should play an increasingly valuable part.

Sloan (1956) concluded that more expenditures were needed to strengthen the fire protection agencies of the Forest Service and these should be provided by the Crown through an increase of its existing contribution of four million dollars per year. The fire protection tax* should not be increased, since industry was already spending considerably more on protection that it was paying in fire protection taxes as is reflected in the statistics in the Annexures. He was critical of Government of Canada financial assistance to the Province. It was not until 1956 that Canada had agreed to make annual grants-in-aid of fire protection. Prior to this, in 1954-55, Dominion revenues from the forest industries of the Province amounted to 112.8 million dollars and its total expenditures on forestry in the Province (forest surveys, conservation and research) amounted to 1.1 million dollars, less than one percent of revenues. Sloan noted that the additional grants-in-aid of fire protection would probably not affect this percentage materially.

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*A tax, based on volume cut or on acreage, imposed upon the forest industry to raise funds for fire-fighting.

Amongst other subjects discussed by Sloan were forest closures, slash burning, the area of "occupancy" in tree farm licences**, fire protection in the Peace River area and a government assisted insurance undertaking, covering fire losses in mature and immature forests.

There is an apparent anomaly in British Columbia in the recognition of a public right of free access into the Crown forests when an important proportion of forest fires are caused by man. The right is not unqualified in that the public may be debarred from entry by a forest closure imposed by the Government and entry may also be controlled by industry on roads classified as Industrial Roads under the provisions of the Provincial Industrial Transportation Act. In spite of these qualifications, however, the number of man-caused forest fires remains high. A special Committee of the B. C. Legislature (1964)

**as mentioned in connection with tree farm licences, some licencees objected to being responsible for fire fighting throughout the licence area and wished to be responsible for only the Cutting Permit (logging area), as a parallel to the timber sale operator. Sloan agreed with these objections and found the Forest Service policy to be discriminatory. However, his recommendations on this point were not adopted by the Government.

upon the request of the Minister of Lands, Forests and Water Resources considered the question of public access on privately administered roads. The Committee gave the following opinions.

(1) The Private Roads Act, 1963, represented a definite step forward, toward solution of the public access problem. It had increased the awareness of industry of the desirability of providing for public access over privately administered roads. It appeared that cooperation by industry would continue and expand.

(2) One of the major provisions of the Private Roads Act relieved the industrial operator of responsibility for fires caused by the general public using the privately administered roads. 1963 had been a season of exceptionally low fire hazard and the Committee did not feel that it should be taken as a reliable yardstick of the overall effect of the Private Roads Act.

(3) In view of these factors, the Committee recommended that draft legislation should be delayed for at least one more year, when a similar Special Committee of the Legislature should be instituted to review the situation.

(4) In the interim, an Interdepartmental Committee to study pressing access problems and to advise the Deputy Ministers of separate departments of Government, should continue to function.

(5) The Interdepartmental Committee should consider the unification of the multiplicity of entry permit procedures on privately administered roads on Vancouver Island. The Committee should also develop an arbitration procedure to settle access disputes. The Special Committee would welcome the extension of the programmes of picnic and camping sites started by several forest companies within their areas of occupation.

The balance of the Special Committee's opinions dealt mainly with multiple use and recreational questions.

Logging slash disposal is an important facet of the Forest Service programme for prevention of fire. Sloan (1956) noted an apparent trend away from broadcast burning toward spot burning but the trend was not maintained. In 1955, for example, 19,551 acres of slash were treated, of which 17,031 acres were spot burned and 2,520 acres, broadcast burned. But in 1966, the British Columbia Forest Service (1966) reported that 61,858 acres were broadcast burned and only 4,500 acres were spot burned, out of a total of 66,358 acres.

During the decade from 1957 to 1966, almost 480,000 acres were reported to have been broadcast or spot burned in the Vancouver Forest District.* One of the disadvantages of broadcast burning is the damage caused when fires escape control. During the same decade (1957-1966) 26,004 acres of forest cover were burned by escaping slash fires at an estimated nett damage value** of almost 780,000 dollars.

Basically, the Forest Service programme of compulsory slash burning was for many years restricted to the Vancouver Forest District. In 1967, the Forest Service moved toward the implementation of Section 116 of the Forest Act in the Interior. Phillips (1967) who was in charge of the Forest Service Protection Division noted that Interior logging, prior to the Second World War, had principally involved some form of partial or selective logging. Since the War, log production and areas of contiguous slash created by clear felling, had increased. A number of costly fires that had been almost uncontrollable

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* The total is derived from the Forest Service Annual Reports for the years concerned.

** consisting of nett damage to forest cover, nett damage to cut products and nett damage to equipment and property.

because they involved some of these slash areas, had occurred. The objective of slash burning was to reduce slash to a relatively safe condition, Phillips held, and provided natural reproduction with a chance to establish and be relatively free from later destructive burning. If natural reseeding is not present, it was feasible to plant the areas*. In 1966, the Forest Service and cooperating timber sale operators had burned 26,000 acres of slash. During the same year about 250,000 acres had been logged in the four Interior Forest Districts but, of this, only slightly more than half were clearcut and only slightly more than half of the clearcut areas, i.e. about 75,000 acres, were suitable for burning. Phillips stated, however, that slash burning of this acreage each year was not feasible because of a shortage of sufficiently trained Forest Service staff to assist the many logging operators that would be involved and because of the extensive existing areas of older slash that the Forest Service must burn in part, to create fire breaks in some of the areas of contiguous slash. Thus, initially, at least, a small scale programme was envisaged. Phillips described the

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* It should be noted, however, that some studies indicate that slash burning reduces the chances of natural regeneration

administrative procedures which were visualised and suggested that possible feelings that Forest Service stumpage allowances for slash burning were inadequate or incorrect should not delay a start being made on an Interior slash burning programme.

Quite recently, objections to the large scale slash burning operations, conducted each autumn in the Province, have been raised because of the alleged air pollution which it causes.

b. Forest Insect Pests and Disease:

The main subject of insect pests and diseases has been discussed under the chapter dealing with the role of the Government of Canada in British Columbia, particularly with reference to research.

Sloan (1956) mentioned the difficulties of compiling accurate loss estimates. In the decade from 1944-54, losses from known specific infestations of insects were well in excess of 800 million board feet (about 150 million cubic feet), excluding any losses in the Kamloops Forest District, losses of increment following non-fatal defoliation and losses in value in beetle infested sawlogs and plywood logs.

More extensive information was available for decay.

The average annual sawlog cut, for the ten year period 1944 to 1953, in the Coastal Region was 2,854,775 M.f.b.m. B.C. log scale (about 570 MM.c.f.) and there was an estimated volume of 374,671 M.f.b.m. (75 MMc.f.) of cull material present in the logs, in addition. In the Interior the corresponding figures were 778,229 M.f.b.m. (130 MM.c.f.) with an additional 119,115 M.f.b.m. (20 MM.c.f.) of cull. These figures referred only to logs of Douglas fir, western red cedar, western hemlock and spruces. Sloan (1956) also estimated that the nett (sound) volume in all the mature and overmature stands in the Province, for the species mentioned was 96,305 MM.c.f. and the accumulated volume of decay was an additional 24,482 M.M.c.f.

10. Reforestation:

During the last two decades, a certain amount of controversy has existed in British Columbia on the question of reforestation policy. Sloan (1956) gave his estimate of forest acreages in British Columbia which had not satisfactorily restocked and, for comparison, included his earlier estimate (Sloan (1945)).

Acreages Not Satisfactorily Restocked in B. C. (Sloan 1956)

Year	Coast	Interior	Total
1945	918,000	19,134,000	20,052,000
1955	1,723,168	10,140,951	11,864,119

Sloan estimated that 80,000 acres per annum were being logged in the Coastal Region but planting was only being conducted on areas in which Douglas fir was the predominant species and these areas were being logged at a rate of 40,000 acres per year. Of this latter acreage, he assumed that 10,000 acres per annum would not restock naturally and would need to be planted. By a similar process of reasoning, he held that planting should be extended to areas in which species other than Douglas fir were predominant and of these areas, it would also be necessary to plant 10,000 acres per annum.

In addition, Sloan (1956) continued, forest fire losses of timber had amounted, in the entire Province to an average of 30,448 acres per annum for the decade 1946 to 1955. Of this total, he assumed that 5,000 acres were being lost annual in the Coastal Region and, of this 3,500 acres per annum would not restock naturally and should be replanted.

In Sloan's view, therefore, there was a need, eco..omic considerations apart, to plant 23,500 acres per annum in the Coastal Region alone, to keep pace with current logging and forest fire losses. The actual performance of both the Forest Service and private companies amounted to an average of 9,000 acres per year during the decade from 1946 to 1955, of which the Forest Service planted an average 6,000 acres per year. Based on the ownership pattern of the Coastal forest lands which were not satisfactorily restocked, Sloan concluded that the Crown should be planting 12,000 acres of the total requirement of 23,500 acres needed to meet current requirements.

There was, also, the question of the land which was already not satisfactorily restocked. Of the 1.7 million acres estimated as being not satisfactorily restocked in the Coastal Region in 1955, the Crown owned about 900,000 acres. The Crown, Sloan wrote, should plant 36,000 acres per year in order to reclaim this backlog in 25 years. Thus, the total Crown annual planting program in the Coastal Region should cover 48,000 acres, using 38.4 million plants (at 800 plants per acre), at a cost of almost 2 million dollars per annum. Sloan expected that at least a part of this cost would be borne by the Federal Government.

The Forest Service, in evidence before Sloan, had not agreed with Sloan's reasoning and maintained that it was only possible to plant <u>economically</u> 100,000 acres of the Coastal acreages which were not satisfactorily restocked. It appears that the Service had decided that areas invaded by deciduous growth were uneconomic to plant whereas Sloan held that, after making due allowance for the exclusion of certain poor site areas from a reforestation programme, the Forest Service was placing too much stress on the economics involved. Its estimates of areas to be planted were far too conservative. There was common ground between the Forest Service and Sloan, in their estimate that about 75 percent, or 675,000 acres of the land not satisfactorily restocked in the Coastal Region had been invaded by deciduous growth, representing the loss of approximately 50 million cubic feet of annual growth volume.

It is pertinent that the British Columbia Department of Lands and Forests (1957) reported that there were 18.4 million acres of forest land bearing non-commercial forests or not satisfactorily restocked, in the Province. 12 million acres of this land was carrying non-commercial cover, such as stagnated lodgepole pine*, poorly formed aspen or well established deciduous brush. In the Coastal Region, highly defective stands and stands of stunted, coarsely limbed western red cedar, growing on poorly drained sites, comprised a large portion of the forest

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*The stands are very heavily stocked areas of lodgepole pine whips in which the individual tree growth is very slow because of intense competition for light, water and nutrients.

classed as non-commercial. The remaining 6.4 million acres were classified as not satisfactorily restocked and 2.9 million acres of this were reported to be "not plantable" owing to topographic conditions or the presence of excessive amounts of tree debris and deciduous brush.

Of the 3.5 million acres which were considered to be "plantable" some could be expected to restock naturally. It appears that the Forest Service's proposed planting programme, with which Sloan (1956) disagreed, was based on these figures. Stated in tabular form, the figures were:

Forest Land Not Satisfactorily Restocked in B.C.

(B.C. Department of Lands and Forests (1967))

Regeneration Status	Coast	Interior	Province
Plantable	356,555	1,625,596	1,982,151
Natural Restocking Expected	104,954	1,372,826	1,477,780
Not Plantable	362,567	2,611,792	2,434,290
TOTAL	824,076	5,610,214	6,434,290

Sloan's (1956) information on the Interior requirements for reforestation were scanty. The Forest Service had expressed the opinion, in evidence before him that planting in the Prince George Region (north central Interior) was uneconomic. As with the Coastal figures, Sloan asserted that a wider discretion in determining planting requirements, than that guided solely by the recoverable values measured by the demands of the immediate timber economy, should be exercised. He recommended, as an initial step, that a nursery should be established at Prince George. Moss (1955) had given evidence before Sloan on the situation in the Southern Interior. The total acreages planted were very small indeed and Moss noted that increased effort was necessary, if the Province were to use the land properly. There was a need for nursery expansion and research into planting techniques. However, because of the high costs of artificial regeneration in the Interior, there should not be automatic reliance on planting but, rather, the silvicultural systems of felling should be designed with the objective of compromising between the most economical methods of logging and the most economical methods of obtaining suitable reforestation. The Government should recognise that higher logging costs than average might be justified for the sake of long-term economy, with the corollary that these higher costs should be reflected accurately in a reduced stumpage rate. It should also be recognised that, in a condition of having some overmature and some thrifty stands in a wide variety of stand compositions, various methods of felling should be employed in accordance with the local stand conditions. Sloan concurred with these views.

Wright (1966), in discussing the sustained yield policies of British Columbia, emphasised that an agressive and effective reforestation programme can contribute more to increasing allowable cuts than can any policies aimed toward increasing the volumes utilised (per unit of area) through direct and indirect regulation. Along somewhat the same lines expressed by Moss (1955) but referring to the Province as a whole, he stressed the importance of closely coordinating the conduct of the logging operation itself with the reforestation plan.

A feature of trends in reforestation in recent years has been the growth of private planting, a major portion of this growth being attributable to tree farm licences where the licencee is required (and has an effective incentive) to plant. Sloan (1956) noted that during the 3-year period, 1953 to 1955, private planting had grown almost to equal Government planting, in the Coastal Region. The Council of Forest Industries of British Columbia (1968) reported that, in 1966, companies on tree farm licences and other private owners planted 35,693 acres and the Forest Service planted 12,886 acres in the entire Province. The same source stated that, in 1968, private companies expected to plant about 30,000 acres and the Forest Service, about 20,000 acres.

Another estimate of the ratio of reforestation required in the Province was given by Hoffmeister (1965). He stated that statistics reported by the Forest Service showed that 26 million acres of potentially productive land in the Province were not carrying usable growth. He also noted that the Government of British Columbia (1965) had written that the Forest Service must confine planting to high quality sites which were potentially liable to invasion by deciduous brush. The Chief Forester had estimated that thirty percent of acreage cut over in the Province would need some form of artificial regeneration. Based on the (then) annual acreage cut over, this would mean that some 100,000 acres annually must be planted to keep pace with current logging depletion. Hoffmeister stated that lack of funds appeared to be the reason for restricted planting.

The Canadian Institute of Forestry (Vancouver Section) (1967) presented a brief to the British Columbia Government, dealing with reforestation within the Coastal public sustained yield units. In 1967, there were six public sustained yield units in the Vancouver Forest District with a total stumpage revenue to the Government of 10.5 million dollars annually*. Although the Forest

*assuming an average stumpage and royalty rate of seven dollars per cunit.

Service did not publish, in its Annual Reports, the areas of land, within public sustained yield units which were not satisfactorily restocked, the Vancouver Section found that there were in excess of 160,000 acres of productive forest land lying idle in the six units of the Vancouver Forest District. Most of this land, denuded by logging and fires, was covered with brush and weeds and it was estimated that 135,000 acres would require treatment before planting. The remaining 25,000 acres were ready for planting.

The Vancouver Section brief continued that more than 50,000 acres were cut over annually in the Forest District on areas where the responsibility for reforestation remained with the Forest Service. Of this 50,000 acres, about 25,000 acres (one-half) would restock naturally within five years. Of the remaining 25,000 acres per year which required reforestation, 15,000 acres required immediate restocking to avoid early invasion by brush species. In 1966, the Forest Service had planted approximately 8,000 acres per year in the Vancouver Forest District and the programme for 1967 would be approximately 12,000 acres. At this (1967 projected) rate, the unplanted area was adding at least 13,000 acres per year to the existing backlog of 160,000 acres. The Section pointed out that, if all areas which were not satisfactorily re-stocked were to be replanted, an additional 16 million cubic feet could be added to the annual allowable cuts, representing an additional direct stumpage revenue to the Crown of 1,120,000 dollars per annum. It was pointed out that most private companies, realising the value of immediate restocking on areas that would not restock naturally were replanting that portion of their current private land logging areas immediately. Planting costs were quoted as being approximately thirty dollars per acre* and, at an average annual growth rate of 100 cubic feet per acre, the pay-back period, on the basis of an average stumpage of about seven dollars per cunit, would be about four years.

The Section urged that the Forest Service should be provided with adequate funds to carry out these minimum measures:

a. All areas currently being cut and requiring artificial regeneration should be planted as soon as possible at a minimum rate of 25,000 acres per year.

b. The rehabilitation of the plantable backlog areas should proceed at a rate of not less

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*Presumably, however, this cost would exclude the costs of preparation of ground, including brush clearance.

than 5,000 acres per year.

c. Adequate research should be commenced to solve the problem of rehabilitating the 135,000 acres (which had a timber growth capacity of nearly twice the average growing site) of lands covered with brush or impedimenta to planting. Currently 1,000 acres per year should be rehabilitated as an initial measure.

In his reply to the brief, the Minister of Lands, Forests and Water Resources (Williston (1967a)) stressed that the Government must pay attention to the entire forest estate and not just one region. In the past few years, the Interior forest harvest had grown to nearly one-half of the total estimated harvest for the Province and it appeared that foresters in that Region were preparing to support immediate planting after logging to reduce the regeneration waiting period. As a second point, the Forest Service was supplying virtually all planting stock in the Province and planned to reach 75 million trees annually by 1975. The Minister could not predict what proportions would be available for Coast or Interior, nor the proportion of company to Government planting. For the preceding four years, however, priority of supply had been given to industry and, as a result, a large part had gone to reducing the Coastal backlog of planting. One of the difficulties experienced for a few years prior to 1966 had been the shortage of seed from suitable sites, which had seriously handicapped nursery expansion. This situation had been rectified except in species such as Western white spruce (Picea glauca. Voss.). The recommendation of the Vancouver Section that a start be made on replanting the backlog of areas carrying brush or other impedimenta to planting was stated to be quite impractical since the Provincial Inventory Programme, based on a survey of each sustained yield unit every ten years, was ambitious and, combined with the factor of periodicity of seed crops, appeared to be as practical a programme as could be maintained for many years. The Government had not, however, overlooked the necessity for more planting and the increased programme under way was fully supported, funds available for 1967-68 having been increased by approximately 200,000 dollars. This amount was planned to be in the nature of an annual increase.

The British Columbia Forest Service (1966a) reported that, in 1966, rapid nursery expansion was in progress, with some work being carried out by inmates of penal institutions. In the same year, 19 million plants left the nurseries, 3.6 million of them being transplants.

The production of transplants was expected to increase further because of increases in the production of Interior species* and the enlarged capacity of Forest Service - industry cooperative transplant nurseries. The limitations of seed supply and shortages of trained personnel had hindered the rate of expansion.

11. Forest Utilisation:

The development of the pulp and paper industry has been described as a part of the review of pulpwood harvesting areas, given above. In addition, statistical information referring to industry and its markets is included in the Annexures to this thesis. However, some reference can usefully be made, in a selective way, to other aspects of industry utilisation.

Sloan (1956a) noted that logging is British Columbia's primary industry. Logs had continued to flow to plants in ever increasing volume, from a volume of 577 M.M.f.b.m. in 1944 to a volume of 2,417 M.M.f.b.m. in 1956, and this increase had been largely attributable to the larger log cut in the Interior. Changing economic concepts and the necessity of achieving higher values of product recovery at economic cost had led to the

* Transplants, rather than seedlings, are commonly used in the Interior.

establishment of integrated manufacturing operations. In these, the log would be directed to its best possible use as lumber, veneer, plywood, pulp and a variety of other products, according to the log's species, size, grade and other relevant attributes. He stressed, however, that the production of lumber by sawmills would remain the dominant factor in log utilisation so long as the production of high-grade lumber from old-growth stock was feasible. In a second-growth (second rotation) economy, he predicted that lumber production would be less distinctive. In the decade preceding 1956, the major developments affecting sawmilling in the Coastal Region had been the changes in the pattern of log supply resulting from a large number of mills entering into the logging field (directly or indirectly), the increase in utilisation of mill residues, the increase in latitude in the use of various species consequent upon modernisation of milling technique and, generally, the gradual evolution from mills of the old design cutting heavy Douglas fir timbers to faster mills with lighter and more efficient equipment manufacturing hemlock and other species, as well as Douglas fir. The process, in Sloan's view, should continue provided that the Government, as the monopolistic owner of the resource, recognised the value of social and economic values which were far greater in long term significance and worth more than receipts from timber sales alone. Sloan likened the role of Government at that time, to that of a shopkeeper selling his goods to everyone who could afford to buy at the prices asked. The time had come it seemed to him, when the sale and disposal of Crown timber must be the reflection and instrument of a policy in which the indirect values, such as the stability of communities and the general welfare of the people at large, must be the dominating factors. Unless the responsibility, inherent in Crown ownership, to strengthen the economy as well as merely adding money to the Treasury, were accepted, then the only rational alternative that Sloan could see was the orderly disposal of Crown productive forest lands to private enterprise.

A considerable amount of literature is extant on the various aspects of logging. Since it is of importance to management it cannot be reasonably excluded from this thesis but will be dealt with only briefly. McIntosh and Gunn (1959) have studied salvage yarding at two settings on Vancouver Island and found that delay time and hookup time accounted for 25.4 percent and 23.0 percent of the total paid time, respectively. McIntosh (1960) studied log loading methods on utilisation at seven Coastal logging operations and has reported on the advantages and disadvantages of air-tongs, log grapples and standard tongs, used on log loaders. McIntosh (1963) also compared two logging methods - pre-logging and re-logging* - on a Coastal setting and found that, from both utilisation (recovery per acre) and economic viewpoints, pre-logging was the better method.

A variety of logging studies have been conducted in the Interior. Nixon and Gunn (1957) conducted felling and bucking time studies and published a variety of tables, as well as defining general factors affecting the timings. Stewart (1956) studied comparative costs of six partial cutting treatments on a commercial in forest near the Slocan Valley, in the Interior Wet Belt. He found that the (then) commonly used minimum diameter limit combination of 16 inches d.b.h.o.b. for western white pine (Pinus monticola D. Don), 12 inches for western red cedar and 14 inches for other species provided the logger with a maximum financial return for the logging operation. The raising of the diameter limits to 19inches d.b.h., or the removal of an equivalent volume to that produced by the 19-inch d.b.h. limit whilst concentrating on tree spacing

* Pre-logging is the process of removing smaller stems before the main logging operation, to reduce losses through breakage, whereas re-logging implies the salvage of usable material after the main logging operation.

and vigour caused an increase in the percentage relationship of production costs to volume of product. The lowering of the diameter limit to 12 inches d.b.h. for all species barely affected the ratio, leading Stewart to the view that only marginal returns were obtained from white pine trees between 12 and 16 inches d.b.h. and other species between 12 and 14 inches. It also showed, said Stewart, that when a clear-cut was required, enforcement of cutting down to 12 inches d.b.h. should involve the logger in no hardship and that, with some slight compensation, the cutting of even smaller trees could be required.

Gunn and Guernsey (1958) studied tractor skidding timings at five Interior operations but because of many variables, found comparison difficult. They found, however, as did McIntosh and Gunn (1959) in the coastal region that the hook-up phase was costly (taking up 25.2 to 40.2 percent of total skidding time). They also found, in terms of unit volume, that it was more economical to skid large volumes for longer distances than to skid small volumes for short distances. At all distances skidded, the cost per unit volume decreased as the turn volume increased.

McIntosh and Csizmazia (1965) studied five lodgepole pine logging operations in the Interior in order to relate various factors to productivity, with the emphasis on felling and skidding rates. The information gathered was tentative but could provide a basis for more detailed studies. However, it did appear that the most efficient felling unit in lodgepole pine was a one-man crew. As in other studies mentioned, hookup was the largest single time factor affecting skidding production, accounting for 24 to 41 percent of skidding time. A high rate of skidding production was noted for the wheeled tractor, as compared to the tracked machine, and it was attributed to the higher travelling speed of the former.

The remarkable degree of mechanisation which has occurred and is still proceeding in British Columbia and Canadian forests has given rise to some thought on its effects on the practice of silviculture. Smithers (1964), although clearly referring to the changes in Eastern Canada, held that little quantitative research into the problems posed by the mechanical revolution had been conducted by research silviculturists. It was accepted that cost reductions due to logging mechanisation must be sufficiently great to offset any increases in silvicultural costs caused by the new logging methods. The critical areas, according to Smithers, where increases in silvicultural costs could be anticipated included damage to advance regeneration; slash disposal; artificial seeding and planting; site deterioration and intermediate cutting. Whether or not advance regeneration should be protected was a decision to be made for individual stands but Smithers felt that artificial regeneration, in most cases, would improve stem distribution, species composition and genetic quality to produce higher returns at the next harvest than would stands developed from advance regeneration. Some of the costs of artificial regeneration should therefore, be charged, as costs of removal of advance regeneration. In the case of slash disposal, Smithers pointed to the dangers of fire hazard and pest insect breeding. Apart from lopping and scattering, breaking down slash during scarification - and windrowing or piling and burning he felt that broadcast burning promised great cost reductions provided that simple manipulation techniques could be effected on an operational scale. Smithers continued that the securing of natural regeneration had been a major aim of Canadian silviculturists in the past and attempts had been made to employ partial-cutting systems such as the alternate and the progressive clear-strip systems, patch clearcuts, seed tree blocks and uniform shelterwood systems to secure it. However, he cited Wright (1963) and Crossley (1964) in support of his statement that the costs of partial cutting methods including road, camp and other improvement maintenance, losses from blowdown and inefficiencies in logging methods in all likelihood equal or exceed the costs of planting clearcut areas. With the event of cheap mechanical logging it could well be desirable to rely mainly upon artificial regeneration, avoiding the costly partial cutting methods.

The avoidance of logging slash, by the removal of complete trees from the site, Smithers pointed out, would undoubtedly cause some deterioration in the nutrient status of forest soils. However, a considerable percentage of the total nutrient absorbed by the tree was retained in the foliage, branches and bark and the possibilities existed, with full tree logging, that slash could be processed at some central point and redistributed over the logging area as a mulch or that commercial fertilisers could be applied. Other sources of site deterioration might include the aggravation of erosion conditions, the deterioration of water quality through silting, and structural damage to the soil which would reduce water intake and retention. However, the trend towards large, rubber-tyred vehicles (and from tracked vehicles) with increased mobility should reduce both the intensity and concentration of erosion and compaction hazard. It did not appear that modern mechanical logging would be any more damaging in these respects than many of the older logging practices.

Although intermediate cutting and thinning had not been practised to any extent in Canadian forests, many silviculturists believed that mechanised thinning in the plantations was both feasible and desirable. Research silviculturists, in consequence, must determine the optimum initial spacing required and must perfect row thinning techniques which would capitalise on the inherent efficiencies of mechanised logging. The benefits of mechanical thinning would be in increased production and reduced transportation costs from areas close to processing plants, combined with earlier write-off of planting costs, rather than through quality improvement of the final crop.

Apart from the considerable amount of research into logging methods, costs and efficiency, the growth of industry has been aided by research into aspects of plant utilisation. Amongst earlier studies, that by Jenkins (1931) gave information on the volume and forms of mill waste. Jenkins and Guernsey (1937) dealt with the utilisation of sawmill waste and sawdust for fuel at a time when the development of the sawdust burner for domestic heating was an important factor.* Later studies into waste problems were conducted by Guernsey (1949), McBride and Rymer (1949) and McBride (1952), covering waste utilisation in the Southern Coastal Region, the utilisation of sawmill waste for pulpwood and sawmill residues in the Prince George Area, respectively.

The Coastal Region has for many years, employed a common log grading system which has both assisted in defining the use to which a log has been put and in determining its value. This has not been the case in the Interior. McIntosh (1964) suggested four grades (No. 1; No. 2; No. 3 and cull) for Interior Douglas fir logs. He had described the exterior characteristics of each proposed log grade and the grades and values of the lumber derived from them. In addition, in order to assist in tree and stand valuation, he attempted to correlate the proposed log grades with a tree classification system. Because the important defects in Douglas fir - shake and decay - are not outwardly visible in the tree and no sure indicators of their presence or extent were found, tree quality could not be evaluated as exactly as log quality. Of importance to this kind of study, Cxizmazia, McIntosh,

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* The burner virtually disappeared in the face of competition from oil and, later, natural gas.

McBride and Gunn (1966) have described the analytical procedures for developing log and tree quality classification systems. However, log grading is still not generally employed in the Interior and stand valuation is frequently based simply on volume considerations.

A great deal of literature is extant on sawmilling and it is not proposed to attempt to review it in a comprehensive way. A relatively recent trend of particular importance and interest has been the investigation of small log utilisation. McBride (1963) found that the sawing of lumber from small logs in a conventional sawmill had several disadvantages, namely a low rate of production, a lower yield and a higher percentage of narrow width lumber than occurred with larger diameter logs. On the other hand, there was a higher recovery of pulp chips from the solid residues and a trend toward better grades of common lumber. Also, the fact that no clear lumber was produced made the log conversion process suitable for automation. The basic problem with small logs, McBride felt, was one of materials handling in which a large number of small logs must be moved. Some British Columbia Interior sawmills, he found, were operating successfully on logs with average top diameters of 8 to 10 inches and, by adopting efficient methods and automating as much as possible, a profit could be made. The mills giving high lumber recoveries from small logs were of three types. Firstly, were mills with a circular head-saw and line-bar band resaw; secondly, those with a circular head-saw, oscillating cant gang and circular resaw and thirdly, those with a circular head-saw and circular resaw, both of narrow kerf. More conventional mills tended to process the small logs as quickly as possible, treating lumber recovery as a secondary matter. McBride found that the most profitable approach appeared to be to make lumber from the small log and chip the remainder, rather than chip the whole log. The new Chip-'n-Saw profiling machine and another machine which chipped logs into a square cant and then passed it through a sash gang held the possibility of being very profitable.* McBride stressed the great importance of accuracy of sawing and quality of product when cutting small logs. With the development of the pulp industry in the Interior, the quantity of chips produced from small logs could become an important source of supply and an important factor in

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* In view of the Government policy of close utilisation, it can be readily appreciated that these new machines are of great importance and, possibly, may be the only way to maintain many Interior sawmills in profitable operation when the policy is enforced.

the development of small log sawmills.

The large quantities of lodgepole pine available in the Interior and the relatively low level of utilisation which the species had, led to studies of its potential as a lumber species. Dobie and McBride (1964) conducted studies at four Interior sawmills and found that, with the right kind of equipment and sawing methods for small logs, economical lumber yields and marketable grades could be obtained from lodgepole pine. The good average grade of lumber produced was striking. Guernsey and Dobie (1966) reviewed the properties and utilisation of lodgepole pine, noting that it had been ignored by logging operators in the Interior because of its small size but the cut had increased by 300 percent in the period 1954-64, because of advances in logging and milling technology. Although the pine was being used for a wide variety of products, lumber accounted for about 70 percent of its utilisation.

Although some lumber in British Columbia is sold in a green condition, the great preponderance of it is kiln-dried. Although the drying operation itself is sometimes of questionable profitability, it does ensure a more consistent sale of products, particularly since housing codes frequently specify it. Salaman and McBride (318) tested amabilis fir and western hemlock under a high temperature drying schedule and dried the lumber in fifteen percent less time than was used in normal commercial practice. However, there was a great loss of value in the clear grades of lumber.

As mentioned previously, some criticism and suggestions have been directed at Government forest policies in British Columbia on the grounds that they do not sufficiently take economic principles into account. The Government has usually rejected these opinions. A suggested method of gauging the effects of forest policy in co-ordination with forest utilisation has been put forward by the British Columbia Research Council. The basic concept is to set up a financial model of the forest economy and prevailing forest policies for computer operation. By entering the financial effects of changes in the economy and in policy, the Council proposed to test policy changes on the model before they were introduced.

Information and statistics on the British Columbian forest industry are available in publications of the Dominion Bureau of Statistics (1959 and 1962). The Department of Northern Affairs and National Resources (1957) has also published statistics. A number of publications have been issued by the Bureau of Economics and Statistics of the Provincial Department of Industrial

Development, Trade and Commerce (1965, 1966, 1966a, 1966b). The British Columbia Forest Service also publishes some relevant data in its Annual Reports and this has been summarised in Annexures to this thesis.

The Bureau of Economics and Statistics (1966b) has estimated that almost 36 percent (980 million dollars) of the net value of all commodity production in British Columbia comes from the forest based industries. About one-half of the total dollars generated in the economy are attributable to the activity of the forest industries - an approximation which includes the share of ancillary business - construction, machinery and the service industries - attributable to the forest industry. 24.6 percent of all of Canada's exports were forest products and 36.7 percent of these (about 9 percent of all Canadian exports) were British Columbia forest products. 11.8 percent of British Columbia's employed labour force worked in the forest industries and earned approximately 425 million dollars in salaries and wages. Indirectly, there were about 1.5 forest dependent jobs outside the industry to every 1 within. These figures serve not only to emphasise the great importance of British Columbia's forest to both the Canadian and Provincial economies, but also to stress how dependent the forest industry is upon exports.

The extraordinary growth of the Provincial forest economy is readily demonstrated by the following figures, reflecting the position in 1965:

a. Logging produced 1,533 M.M.c.f. (of all products) of timber - a 42 percent increase in 10 years.

b. Lumber production was 6,940 M.M.f.b.m. of softwood and hardwood lumber - a 41 percent increase in 10 years.

c. Plywood production was 1,615 M.M. square feet (3/8" rough basis) - an increase of approximately 114 percent in 10 years.

d. Shingle production was 1,816,000 roofing squares of western red cedar shingles.

e. All Wood Pulp production was 3,248,000 tons of chemical and groundwood pulps - an increase of 138 percent in 10 years.

f. Paper and Paperboard production was 1,532,000 tons of newsprint, other papers and paperboard - an increase of 111 percent in 10 years.

g. Laminated Wood Products was an industry started in 1953, with one small plant producing 700 M.f.b.m., valued at 200,000 dollars. The industry, in 1965, consisted of 9 plants having an annual production in excess of 5 million dollars.

Another important source of statistical information is the "Regional Index of British Columbia", published by the British Columbia Bureau of Economics and Statistics (1966c). The index provides general information, including forestry information for the 10 regions, followed by specific data on the areas within the region.

It is only in comparatively recent years that the northern portion of the Province has undergone significant economic development. The Vancouver Board of Trade (1965), through its Primary Resources Committee, has reported on northern British Columbia resource development. Amongst its conclusions were a series of recommendations for improved road and rail access into the region. In addition, effective liaison was necessary between the Provincial Department of Lands, Forests and Water Resources, the Department of Agriculture and the Department of Recreation and Conservation to ensure the best use of marginal lands for agriculture in these northern latitudes. On these soils, forestry might be a higher land use. Two major factors, the Board noted, placed emphasis on the need to provide advanced education facilities in the north. Firstly, the average age of the population was surprisingly low (83 percent under 45 years of age) and secondly, the anticipated growth in mining, pulp and paper manufacture and forest management would create a growing need for workers with advanced technical training. Also, silvicultural methods should be developed for northern conditions to ensure prompt and effective reforestation. The administration of forest protection, depletion and regeneration in the Region had become more complex and it was recommended that additional Forest Districts should be established.

The actual economic position of the industry is difficult to determine in detail. Those companies which have share distribution to the public, publish financial statements which indicate that most are making a profit. Most of these companies are of the large, integrated type and are readily able in most cases to acquire capital requirements needed for plant expansion, timber acquisition and other uses. Where companies of this type are not making a profit, there are usually good reasons for it. It is not unusual for a new plant, for example, to sustain a loss, especially if the full depreciation of plant and equipment which is allowed for income tax purposes is taken. It is worthy of note, however, that the published financial statements are frequently couched in general terms and detailed analyses of operational profitability are seldom possible, it being normal practice for much of the relevant data to be held confidential within management. In the case of privately owned companies, the data are usually also held in confidence and financial statements are also held in confidence, other than to the taxation authorities.

The Northern Interior Lumbermen's Association has, however, issued a study of 25 member mills by the chartered accountants, Price, Waterhouse and Company (1967). The study aimed at the aggregation of financial data on the operating results of the selected member companies to provide an indication of the overall financial health of the membership. The 25 companies and their subsidiaries sold in excess of 50 percent of the reported volume of lumber sold by all N.I.L.A. members in the four years 1963-66 (2,694 M.M.f.b.m. out of 4,434 M.M.f.b.m.). A number of ground rules were observed to bring the companies accounts onto a common basis. The results showed that the aggregate of all companies' net profit declined from an average of 10 cents per M.f.b.m. in 1963 to an average net loss of 3 dollars per M.f.b.m. in 1966. The change was partly due to cost increases but, at the same time, it was notable that sawmills in the western segment of the Region all made a nett profit for each of the four years of the study, whereas those in the eastern segment all made a nett loss. In considering these results, it should be borne in mind that the Interior lumber prices are subject to cyclical change which affects the industry much more markedly than the large integrated industries are generally affected by changes in individual product prices.

All forest product markets, by and large, have tended to present problems in recent years, although Interior lumber prices showed strong gains in 1968. The instability of the pound sterling in 1966, for example and some of the measures taken to stabilise it affected British Columbia exports to Britain adversely. Again, potential problems in the marketing of lumber in the United States have occurred. Dusting (1967) has reviewed the problem which is basically one of the United States Western lumber industry seeking protectionist legislation to debar or hinder Canadian lumber exports to the United States domestic market. The inability of the Canadian domestic market to consume the Canadian lumber production is a well-known fact and pressures to reduce exports are clearly to be taken seriously.

12. Forest Research:

The Canadian Government plays an important role in forestry and forest products research in British

Columbia, as has been mentioned previously. In addition, the British Columbia Forest Service (1961) has a Research Division which pursues its own programme of research, in coordination with Federal research. The policy of the Division, in formulating its programme is to select the most useful and urgent problems involving a real and undesirable situation with the expectation of arriving at a practical solution, capable of direct implementation as a procedure or regulation. Secondly, because of limited research staff and facilities, emphasis is placed on empirical methods and fundamental studies are not undertaken unless they are essential to a clearly defined, practical objective and their are no alternative subjects in the same field requiring study. Thirdly, wherever possible, basic research on forest problems must be referred to other organizations with encouragement for them to coordinate their studies to Forest Service needs. The funds and research positions available for the Division are strictly controlled by the Government and no substantial increases were foreseen in 1961.

Based on these limitations, the Research Division has largely restricted its activities to several aspects of the field of reforestation. Top priority has been assigned to all problems pertaining to seed supplies.

Particularly, information was needed on all of the commercially important species throughout the Province including a knowledge of seed year, crops, quality, maturity and problems relating to collection, storage, extraction and cold storage of cones and seed. Other facets for study were seed dissemination relative to natural regeneration and studies of races and provenances, the latter starting with a study of coastal Douglas fir. Studies in the latter field, in the Interior, were deferred pending production of a master working plan to coordinate trials on a comprehensive basis.

The tree breeding programme was restricted to coastal species because of shortages of personnel and funds. In this programme, top priority was assigned to the establishment of the necessary seed orchards from plus trees, including the testing of progeny, so as to provide seed of improved genetic quality. Other genetic studies were deferred or assigned a low priority and tree breeding of Interior species has not been attempted.*

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* The shortage of funds has been severe. The author unsuccessfully attempted to gain financial support from Southern Interior tree farm licencees for the Research Division to conduct a preliminary survey in the Region as a prelude to tree breeding programmes.

Studies in natural regeneration were to receive high priority and would overlap into seed crop studies. Seed dissemination in terms of numbers of viable seed, germination, survival, distribution etc. in relation to seed bed and site factors needed study. Studies on methods of site preparation and empirical pilot trials demonstrating field application on a practical scale were required to allow suitable recommendations to be made to forest management personnel. Direct seeding would receive attention.

In addition, studies concerned with nursery practice would receive top priority. They would include correct cultural requirements and practice for each species, methods of maintaining fertility in existing nurseries, requirements for new nurseries, cost reduction by the use of chemical weed killers and soil sterilants and improved seed bed stocking through better methods of assessing seed quality, seed treatments and method of sowing. Finally, in the regeneration field many urgent problems of planting received top priority. In all Forest Districts, more information was needed on methods of handling planting stock and where, when and what to plant. Little was known about spacing - species relationships and the importance of cleaning to stand formation.

Despite the emphasis on regeneration, it was considered essential to study site classification, even at a modest pace. Studies on thinning, processing and improvement cutting were not given a high priority. In defence of this position, it was stated that changing economic conditions and methods of utilisation might completely alter conventional practices in the future. About all that could be anticipated was a need to know how to establish a young stand so that, with a minimum of treatment (cleaning, first thinning) it will produce a maximum volume of pulp-sized timber in the shortest time. also, studies in cutting methods would not be given priority except on Forest Experiment Stations established for this objective.

The foregoing statement of policy is still in effect and a subsequent memorandum of the British Columbia Forest Service (1964), although discussing in greater detail that part of the programme dealing with reforestation research, did not change the policy.

13. <u>Multiple Use of Forests</u>:

Sloan (1956) directed his attention to problems of multiple use of the forest. The question of public access on private roads has already been reviewed, in relation to fire protection. However, it is of interest to review briefly, the positions of the various interests in relation to various aspects of multiple use.

a. Road Access:

Section 56 of the Forest Act (Province of British Columbia (1966a)) defines access roads built in tree farm licences as private roads. Although deemed to be private property the public is entitled to use the road, but the owner may require any person to obtain his permission to do so and may restrict use of, or close, the road to public use if material damage could result or life or property were endanagered. However, if the owner unlawfully withholds permission to use the road, the person applying to use it may apply to the Minister of Lands, Forests and Water Resources who may grant the right to use the road under such conditions as he may see fit but not inconsistent with any regulations approved pursuant to the "Industrial Transportation Act".

The Industrial Transportation Act (Province of British Columbia (1955)) defines an industrial road as one constructed or existing for the transportation of natural resources, raw or manufactured, or the transportation of machinery, materials or personnel by means of motor vehicles and includes bridges, wharves, log dumps and works forming part of it. A company operating an industrial road is authorised to make by-laws, rules and regulations relating to the road for approval by the Minister of Industrial Transport. Once approved, they are binding on all persons and the company may use "reasonable force" to prevent violation or enforce observance.

The work of the Special Committee of the British Columbia Legislature (1964) in connection with public access on privately administered roads has already been reviewed along with its references to the Private Roads Act, 1963. In addition, there are a number of other provisions governing road ownership and taxation. The legal position under these laws and regulations is complex and, in a number of aspects, has not been thoroughly tested legally. However, it is clear that, with the exception of powers conferred under the Industrial Transportation Act to prevent public access for reasons of safety, the Provincial Government intends to limit the rights of ownership of a forest road owner so as to ensure free public access in almost all circumstances.

b. Game Management and Access:

The views of the Provincial Game Commission on access into the forests were perhaps best expressed by Hatter in evidence given to the Sloan Commission (Sloan (1956)). The Game Commission accepted logging as one of the factors to be considered in the management of sport fish and game resources. Its influence had been beneficial, as demonstrated by increased deer and grouse populations on Vancouver Island and possible, by increases of deer and moose in sections of the Interior. However, fur bearing animals and trout populations might be adversely influenced by the removal of forest cover. In sustained yield logging, by contrast to the extensive clear-cutting practices of the past, the Game Commission saw a closer fulfilment of good land use principles, conducive to maintenance of stable wildlife and fish populations. Hatter stressed that access to lakes, streams and hunting territory was an important problem in managing the wildlife resource for maximum yield, particularly since wildlife was a "perishable commodity" which could not be stockpiled and the surplus stored for future use, but must be harvested.

Logging operations located at higher elevations were increasing steadily, causing an increase in the diversity of types of cover and possibly contributing to the progressive lateness of deer and moose migrations to lower lands as a result of new food supply created away from winter ranges. The hunter, having adequate access to higher elevations, could utilise the deer population and materially reduce damage to regeneration and young stands. Hatter expressed the view that the regulations governing the rights of access over roads were virtually identical regardless of the type of tenure, except for the length or duration of ownership. Under tree farm licences, the tenure would be perpetually in the hands of the operating company* whilst, in the public sustained yield units, the main roads would be perpetually in the hands of the Crown and the subsidiary roads under the operator for the duration of his operations. Under timber sales the roads would be in the hands of the operator for the duration of his operation and, from thence, in the hands of the Forest Service.

Hatter stated that complaints of lack of access over recently completed roads** might not be entirely based on an objective viewpoint since in reality the complainants (hunters, fishermen, campers and woods travellers) still had the same right of access as existed be-

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* At that time, as described previously, the tenure of tree farm licences issued was for a perpetual term, subject to satisfactory performance by the licencee. Shorter terms of tenure were later introduced by the Provincial Government.

** almost invariably constructed by the forest industry.

fore the road was constructed. However, because of slight differences in policy arising from differences in individual judgement of the owner or person responsible for maintenance of a road there was a distinct possibility of the sporting public being, temporarily, at least, deprived of access that rightfully belonged to them. Hatter noted that this possibility was evidently contemplated when powers were conferred upon the Minister to enforce public access on such terms and conditions as he saw fit, upon private roads within tree farm licences. However, hunting was subject to short open seasons and the season could be over before an appeal to the Minister was dealt with. This was the feature of tree farm licences about which the hunter was most apprehensive. Whilst the tree farm licence contained all reasonable assurances that the privileges of the hunter, fishermen and trapper would be respected, they felt that they could not always rely upon the unbiased judgement of the owner.

c. The Forest Industry and Access:

Sloan (1956) noted that it was undoubtedly true that some logging operators looked with disfavour upon any users at all, of their forest roads. The view was based on several factors, which were:

(1) The danger of forest fires caused by careless

hunters.

(2) The danger of road accidents. Roads were often narrow and trucks carrying loads up to 50 tons required space to stop and frequently could not pass a car. Insurance companies were reluctant to insure logging equipment using access roads also used by the public.

(3) The destruction, usually by gunfire, of expensive equipment by vandalism.

(4) The deterioration of roads caused by persons driving over them when they were soft.

There were other private road owners who were willing to open their roads to the public, subject to obedience to rules regulating their use.

Sloan (1956) also felt that a grave fire risk was placed upon tree farm licencees who were obliged to admit the public who were using the areas at an increasing rate. He suggested that some modification of the burden of fighting fires imposed on tree farm licencees should be alleviated.* There had been complaints from industry that the Government had refused to delay the opening of the deer and grouse seasons at a time of extreme fire hazard

* This was subsequently done in the Private Road Act, 1963.

and Sloan held that a close liaison should be maintained between the Forest Service and the Game Commission, so as to avoid the opening of the hunting season at such times. It was noteworthy that the Forest Service, on its own private roads, had never sought to curtail public access except by closures - a policy which Sloan felt was subject to criticism because of the dangers inherent in the indiscriminate use of the roads.

d. The Forest Industry and Grazing:

Representatives of the forest industry, giving evidence before Sloan (1956) also referred to grazing. Sloan referred to the evidence of Moss, speaking for the Interior Lumber Manufacturers' Association. Basically, Moss emphasised the need for a proper integration of land uses, if conflicts were to be avoided. With reference to tree farm licences he recommended that applications for rights or privileges of any kind should be referred to the licencee at some stage of processing but preferably prior to granting. The licence could thus be kept fully informed and should be permitted to make recommendations. Later, the Forest Service did follow this procedure.

The Select Standing Committee on Forestry and Fisheries (1967) reported that it had heard representations from the British Columbia Cattle Growers' Association,the

British Columbia Wildlife Association and the Provincial Government Fish and Game Branch on the use of Crown range.** It appeared that the three groups were in general agreement and supported the multiple use of forest land. They argued that a study should be undertaken by the Forest Service to test the feasibility of grass-seeding in certain logged-over areas to try and improve the range carrying capacity for both domestic stock and game animals.*** The major game problem presented, appeared to be the lack of winter grazing for the California Big Horn Sheep, although other game animals were affected. A suggested solution visualised the purchase of some uneconomic ranches in key winter grazing areas. The question of acquiring additional land by simply cancelling grazing permits was ruled out, since it was recognised as being an integral part of a ranch.

e. <u>The Grazing Industry and Forestry</u>:

Sloan (1956) has outlined the three different ways

** Crown-owned grazing land which is frequently leased to graziers. It includes and, in this context, means Crown forest land over which grazing permits have been issued.

*** It was believed that a period of grazing would ensue until the forest re-established itself, producing a system of shifting grazing.

in which it is possible to acquire grazing land. Grasslands, not classed as forest lands, may be purchased outright from the Crown. Grazing leases are issued by the Lands Branch of the Department of Lands, Forests and Water Resources under the provisions of Section 82 of the Land Act. These are usually long-term leases, up to 21 years and, if not required upon its expiry for some higher economic use, preferential right to renew the lease for a period to be determined by the lands branch is given to the lessee. Rental for the lease is charged on an acreage basis and the lease area is subject to land and school taxes. Only the lessee's grazing stock is allowed to graze on the lease and he is obliged to fence the area and manage it in accordance with sound grazing practices. A grazing lease becomes, in effect, an integral part of the private ranch holdings of the lessee. There is no relationship between the size of the ranch and the amount of land held under grazing lease tenure.

The third method of acquiring grazing privileges is by means of a permit system authorised under the Grazing Act, the administration of the Act being a Forest Service responsibility. In compliance with the Act, grazing districts were formed, coinciding with the Forest Districts in boundary and in name. The grazing permits, issued annually by the District Foresters, authorise the permittee to graze a specified number of cattle, horses or sheep on a defined unit of Crown range for a specified grazing period. Specific management practices are required, as against the very general requirement of good management required of a grazing lessee. The permittee has no right or title to the land itself and he may be grazing his stock in common with one or more other permittees. Permit fees are charged on a per capitum basis, according to the class of stock involved and the length of the authorised grazing period. The ratio between land held in fee simple, under grazing lease or used under grazing permit varies widely from operation to operation. In 1955, there were about 1.5 million acres of open grassland held under private tenure, another 1.5 million acres of similar land classification in Crown ownership and approximately 8.5 million acres of forested Crown range land. Practically all of the Crown range land in use lies within the Kamloops and Nelson Forest (Grazing) Districts.

The problems presented to Sloan by the agrologists in charge of the Forest Service Grazing Division were many. Such aspects as improved range inventory, refined range management plans and range conditions and trend studies were largely nullified unless backed up by adequate inspections to ensure that approved management plans, seasons of use and rates of stocking were being properly followed by the permittees. These inspections could best be carried out by the local Forest Ranger but there were an inadequate number of Rangers in the grazing areas. Many ranges did not have adequate management plans and problems included the turnout of stock too early in the season, poor distribution of stock on the range and overstocking. An increased construction of range improvements such as stock bridges, cattle guards, drift fences, mud hole fences, stock trails and water development and limited amounts of range seeding, noxious weed control and wild meadow improvement had been financed through the Range Improvement Fund. The limitations were basically imposed by the lack of practical and economically feasible techniques. Thus, for example, the seeding of open grassland had to be carried out on a dry farming basis to ensure success. Over much of the Crown grassland needing rehabilitation roughness of terrain and the stony nature of the soil made the necessary cultural practices impossible. Also, only the most productive sites would yield returns commensurate with costs. In most cases, the rehabilitation of depleted grassland would depend upon conservative range management practices.

As against the difficulties of rehabilitating degenerated range, the seeding to grasses of exposed mineral soil areas on recently logged or burned forest range had proved to be successful and has provided improved quality and quantities of forage whilst, the agrologist claimed, helping to control erosion and improving soil conditions. Results, to that date (1955), indicated that the establishment of forest reproduction was not unduly delayed*. The practice of grass and legume seeding and the resultant improvement in soil conditions should ultimately aid tree growth.

The cattlemen complained to Sloan (1956) that loggers operating under timber sale contracts caused damage to their property and cattle, in breach of the timber sale contracts, without there being effective means of redress. Another type of damage was that caused by logging debris to water diversion ditches. In these cases, Sloan noted that the Forest Service could suspend or cancel the timber sale contract, with consequent forefeiture of deposit in whole or in part and the grazing lessee could sue for the damages he suffered. In the absence of a sufficient Forest Service field staff to ensure compliance

*But, as mentioned elsewhere, experiments are being conducted to determine the effects more accurately.

with the timber sale covenants, Sloan suggested that the Forest Service be empowered to reimburse the rancher for his damage or loss from the timber sale deposit of the wrongdoer.

Portable sawmills located on leased or permit grazing areas caused loss of flesh and grade of the cattle. The building of logging roads to river banks for log floating purposes caused losses of cattle which thereby gained access to the river and onto shore ice. Vehicles of hunters, campers and loggers caused degrade of cattle, particularly when they were being grass-finished for the market. As described previously, the cattlemen also expressed their fear that their existing forest grazing as well as its future potential, could be curtailed by the tree farm licences.

f. Mining and Forestry:

It is not the purpose of this review to trace the growth and importance of the mining industry. Although secondary in economic importance to forestry, it has undergone very rapid growth in recent years and is a vital industry to the Province. The introduction of sustained yield forestry and the creation of public sustained yield units and tree farm licences caused concern to the mining industry.

Sloan (1956) stated that, in 1955, the total sum spent on major items of expenditure by the mining industry was 138.5 million dollars and it paid 35 million dollars in dividends. Interior mining accounted for about 75 percent of the Provincial production. In 1954, there were 22,166 mining claims in existence, covering a land surface area of 1,145,000 acres or 1,789 square miles. The size of the industry has increased very greatly since then.

Two large Associations represent different segments of the industry. The British Columbia and Yukon Chamber of Mines represents the prospectors and smaller mining companies, chiefly engaged in development work. The Mining Association of British Columbia represents the large producing companies. The interests of the two Associations, in their respective fields, are parallel and correlated.

The Chamber of Mines expressed concern that the powerful forest industry might be more and more inclined to look upon British Columbia as a vast "tree farm" and by means of subtle restraint and refusal to cooperate, would gradually discourage and destroy the initiative of those who discovered and developed new mineral deposits. The Chamber pointed out that a large part of the land surface of British Columbia was covered with overburden but that new aerial techniques for discovering magnetic anomalies made it possible to locate ore bodies covered in this way. Undoubtedly, some of these discoveries would be made in areas covered by heavy growth of timber. The Chamber of Mines proposed a programme designed (inter alia) to guarantee prospectors access to and right to prospect for minerals upon any areas of the Province, the right to use all roads constructed by tree farm licencees, the right to the use of free timber in tree farm licence areas for mining operations generally, and the right to construct roads and trails, to secure surface rights and to develop water power in the licence areas.

The Mining Association (of the larger companies) emphasised that timber supplies should continue to be available to the producing mining companies which, in 1954, consumed 8.2 million board feet of lumber and 1.6 million lineal feet of round timbers for lagging, stulls, props and other mining uses. The men and materials employed per acre of mineral deposit, the Association said, provided a startling comparison of the "higher-use-value" principle as between the forest and mining industries. It was, therefore, important that the comparatively small annual requirements of wood of the mining industry should be effectively guaranteed to it and should not fall under the control of other interests. The Mining Association suggested that tree farm licences should not include areas where the most important basic industry was mining. If this could not be done, adequate and readily available stands of timber should be placed in reserve for the sole use of mining operations. Tree farm licences should clearly define the rights of free miners and mining companies in all matters where there might be conflict. In particular, the rights of free miners to prospect, explore, locate, record and develop mineral claims, placer claims, coal deposits and other forms of tenure for mining purposes should be restated and clearly defined. The Association also wanted the same right to acquire and use timber for mining purposes kept on an unchanged basis, whether or not a mine was located within a tree farm licence. Alternatively, where prior timber disposal had occurred, the tree farm licence should be required to guarantee to supply a free miner operating within the licence area adequate quantities of timber at favourable, or arbitrated, prices. Other requirements were also stated.

Sloan (1956) felt that, where mining properties were in existence and being developed on an area of Crown forest prior to the award of a tree farm licence in the area, then suitable provisions to permit the mines to acquire timber should be written into the licence contract. Where large mining properties needed timber from a public sustained yield unit they should compete for it. In the case of a mineral deposit being discovered in a public sustained yield unit the Forest Service could set aside or reserve a small area, at upset stumpage price, to assist in the development of the property.

Moss, in evidence before Sloan (1956) on behalf of the Interior Lumber Manufacturers' Association, stated that the miner should be responsible for marking the boundaries of mining claims for recognition by persons engaged in forestry. The number of mining claims held on speculation was, in some cases, unnecessarily high. These factors caused cost increases to the licencee and Government by creating a need for surveys and the determination of the particular rights exercised on the claims. Considerable sums of money were involved in taking a forest inventory and frequent changes of claims made these expenditures questionable in some localities. In addition, it was pointed out, in certain of the older mining claims the claimant held a prior right to use the timber on the claim, although the timber remained in the ownership of the Crown. Cases had occurred where claim owners had offered to waive their prior right of use in return for financial recompense from the lumber industry. The Interior Lumber Manufacturers' Association did not think that a mining claim owner should be able to deal in the sale of Crown timber in this way. Sloan recommended that amendments to the Mineral Act should be made to correct the abuses and appropriate amendments were subsequently made.

g. Watershed Management:

Sloan (1956) made general reference to watershed management, in terms of annual water yields and their relationship to the removal of forest cover, but noted that the emphasis on this aspect appeared to have subsided since 1944-45. However, there are current indications that interest in this aspect is reviving. Golding (Golding, D. L. (1968). Regulation of water yield and quality in British Columbia through forest management. Thesis. University of British Columbia.) has studied water yield and concluded that, because Canada's present water administration is inadequate for the future, the federal government should assume responsibility for initiating action on water resource development and that the provinces should be willing to forego some degree of provincial rights in the interest of comprehensive management of the resource. In a field study on the Okanagan (West) Tree Farm Licence (No. 9), in the Okanagan Valley, he concluded that, if a financial rotation were employed instead of the one currently employed and water were considered to be an important secondary product, water yield could be increased by five percent.* Golding recommended a comprehensive research programme, to commence with intensively instrumented research watersheds in the Coastal and Interior Regions.

h. General Multiple-Use Questions:

Moss, in giving evidence before Sloan (1956), on behalf of the Interior Lumber Manufacturers' Association, commented that legislation governing forest land was contained in a variety of Acts of the Legislature. It was the impression of the Association that coordination

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*Since the author wrote the Working Plan concerned, however, he must point out that the rotation of the spruce working circle was selected to provide trees of an acceptable size to existing and planned utilisation plants. The use of a financial rotation in the area would result in a need for a pulp mill which is currently considered unacceptable in the Okanagan Valley because of water pollution problems.

between the various Departments of Government administering the Acts was inadequate. Sloan recommended that the Government should set up an inter-departmental committee representing the different branches of the Government which exercised jurisdiction over matters relating to forestry, land, grazing, mining, petroleum and natural gas, water and game administration to examine the various Statutes under which functioned. By appropriate correlation and delineation of each land-using interest future conflicts would be avoided or minimised. This Committee should seek the assistance of the (proposed) Provincial Advisory Council which should, in turn, call upon the Northern and Southern Interior Advisory Boards for an expression of their opinion.*

Since the issue of the Sloan (1956) Report a number of amendments to legislation and other actions relating to the multiple use of forests have been carried

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* Sloan had recommended the formation of these Boards to advise the Government in forestry, including multiple-use aspects, but they were not formed, evidently because the Government preferred to liaise with existing Associations of various kinds. Consequently, the proposed Boards are not discussed in detail in this Review.

out. Until very recently, attention to the problems by the Government has taken a subsidiary place to that given to various aspects of sustained yield forestry. Williston (1967) emphasised, however, that attention would be given to multiple use. He noted that the Government must consider what other potential than forests there may be in the forest land. The decisions which had to be made on land use were becoming increasingly complex as the Province developed. In the past, competition between recreation, agriculture or forestry had not mattered because the land area was ample to meet all demands. The point had been reached, however, where some kind of land utilisation guideline must be formulated, from which to administer. For more than 15 years, the Minister noted, the Forest Service had been trying to administer forest land on a sustained yield basis but the problems had become more and more complex and required more and more regulations.

The Government, Williston continued, was committed to the management of public forest lands for the continuous production of wood crops. There was, however, a tendency to overlook the relationship between the importance of this form of management in relation to the many other values derived from forest land. In effect, a very small fraction of the forest land area under sustained yield management - about one or two percent - would be logged in any one year and other values associated with forest land could be perpetuated at the same time. Williston was not implying that sustained yield forest management would automatically resolve all forest land use problems, but it did provide a sound basis for multi-use management, provided that the many agencies involved worked together with a common purpose. 85 million acres, or 62 percent, of the productive forest land were under sustained yield management at the time, with more being added. Williston asserted that the forest manager must ensure that liaison is maintained between such specialists as the hydraulic engineer, the logging engineer, the range manager, the recreation officer, the fish and game officer and the mining engineer. Thus, provided that a cooperative spirit was engendered in the resource user, multi-use management would result.

In the Province a considerable amount of forest area was being lost to the demands for public and industrial roads, transmission lines, pipelines, hydro-reservoirs, settlements, recreational reserves and other uses. Most of the demands were legitimate ones and, in the Minister's view, must be met, although, with the progress being made in the land inventory*, improvements in location and a better basis for land settlement decisions would become available.

The single purpose reserves were another matter and the demands of well-intentioned but often poorly informed public groups could frequently destroy the chances for multi-use management. These pressures were real and, if the Government yielded to them, then extensive areas of valuable timber and rangeland would be "locked up". The forest manager's best defence was to convince the public, by example, that it was possible to preserve the aesthetic values of the forest complex whilst, at the same time, harvesting the renewable resources in perpetuity.

14. Forestry Education:

It is fitting to conclude this review of British Columbia forest policy with a brief mention of forestry education and professional qualifications. Bratt (1966) has produced, in diagramatic form, a functional structure of the modern forest industry which demonstrates the great range of specialties which are needed for its forest

* The land inventory is a part of the A.R.D.A. programme and has been briefly described previously in dealing with the role of the Canadian Government in Provincial forestry.

and plant operations. He has allocated the skills into four levels of training viz. University training; senior technological or university training; technical and technological training, and vocational training.

The University of British Columbia, Faculty of Forestry (1967-68) grants the degree of Bachelor of Science in Forestry (B.S.F.) upon completion of four years' work in the Faculty. Various options are offered and graduates from any option are eligible for registration in the Association of British Columbia Foresters after presentation of a Thesis to the Association and the gaining of two years of suitable experience following graduation.* The objective of training is to provide a strong, well-rounded professional forestry training, and, at the same time, to give the student through his choice

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* The Association of British Columbia Foresters (1964) is empowered by the "British Columbia Foresters' Act" to register members or license extraprovincial residents to practise forestry in the Province. Only persons registered by the Association are authorised to use the title of "forester". The Council of the Association is authorised, under the Act, to exercise certain disciplinary powers in connection with unprofessional conduct and other matters and the Association possesses a code of ethics.

of options, an opportunity to supplement his knowledge of allied sciences as a background for further specialised education. The electives are so arranged that a student wishing to proceed with graduate studies in a particular specialty may do so without the necessity of having to take, before commencing his graduate programme, a number of extra pre-requisite undergraduate courses. The main phases of technical forestry or allied fields taught are forest land management; forest business management, forest harvesting; forest wildlife management; silvics (including forest entomology and forest pathology) and wood science. The Faculty also offers Master of Forestry and Master of Science degrees in the major branches of forestry and forest and wood sciences, the Master of Applied Science degree in forest engineering and the degree of Doctor of Philosophy. It is the sole place of professional forestry training within the Province.

The British Columbia Institute of Technology is the major source of supply of trained forest technologists within the Province. The normal two-year courses are considered to be terminal and students wishing to take a University training are not usually recommended to take a technical institute course. The B. C. Institute of Technology (1965-66) offers courses in forestry technology and forest products technology. The training of technologists in these fields is a relatively recent development in the Province and acceptance for employment has been remarkably good. The first year enrolment for forest technology training is running at about 90 students and applications for training are well in excess of this number. Other courses within the forestry field are planned.

The B.C. Institute of Technology (1967 - 68) also offers three types of courses under their advanced technical extension programme. Credit courses are offered to those students employed in industry or commerce who wish to obtain credit toward a Diploma of Technology. Tutorial courses are held to prepare students for external qualifying examinations in any field closely related to the Institute's regular programmes. Finally, specialised courses are provided where a demonstrated demand exists for post-secondary training or re-training and where the Institute's resources can provide the quality of training required. Under these heads, Forest Products Technology offers specialised courses in wood seasoning; introduction to pulp and paper technology; introduction to wood technology and introduction to wood utilisation, as well as credit courses in writing and contemporary thought; mathematics; introductory physics; general chemistry;

draughting; engineering materials; forest science and forestry utilisation. In the field of forest technology, there are offered a course in forest science and specialised courses in introduction to forestry; introduction to air photo interpretation and new cruising techniques. Credit courses are offered in writing and contemporary thought, mathematics, draughting, surveying, forest science, forest mensuration, fire control, photo-interpretation and mapping, forest utilisation and logging. The Regional Junior College at Castlegar also trains forest technologists in a two-year programme.

There are various vocational and adult education courses available in the Province and some lumber Associations conduct their own lumber grading courses. Finally, it should be mentioned that the British Columbia Forest Service trainsits own Forest Rangers and Assistant Rangers at its own Ranger School.

B. FOREST MANAGEMENT:

Following the selective review of British Columbia forest policy, it is convenient to refer to the forest management practices of the Province. Because of the wide range of climatic, topographic, edaphic and ecological factors of the locality prevailing within the Province a great variation of management practice occurs. The approach adopted is to relate the practices to regions and to forest cover types. The research literature has been drawn upon quite extensively where this either clarifies current practice or where it indicates what future developments may occur.

1. The Management of the Interior Subalpine Forests:

Rowe (1959) has described the Interior Subalpine Section as a much fragmented forest, occupying the mountainous uplands which surround the Fraser and Nechako plateau up to the treeline. In its northern part, beyond latitude 53 degrees, it is the principal forest area of Interior British Columbia. Indeed the "spruce type group", as defined by the British Columbia Department of Lands and Forests (1957) and composed of the Interior subalpine section and the relatively small Sitka spruce areas of the Coastal region, occupies 46 percent of the total of 118 million acres of forest growing on productive and low site land within the Province. It is thus the most extensive type group in the Province. In the Interior, the spruce type group occupies 52 percent of the 103 million acres of productive sites. The spruce type group is also the largest in volume, amounting to 8,259 million cubic feet, ten inches d.b.h.+, out of the total of 19,075 million cubic feet in the Province. In the Interior, the corresponding figures are 8,157 million cubic feet out of 13,567 million cubic feet. Unquestionably, therefore, the Interior subalpine forests are of great importance.

The characteristic species throughout the forest is Engelmann spruce (Picea Engelmannii Engelm.) and associated with it is alpine fir (Albies lasiocarpa, Nutt.) which increases in abundance at higher altitudes and dominates at the treeline. According to Rowe's Description, extensive stands of the pioneer lodgepole pine clothe areas of past fires. However, Moss, Lacate, Sprout and Arlidge (1965) have suggested that some pure lodgepole pine stands are stable and not a sub-climax stand, whether established following fire or not. Rowe (1959) described how, in eastern British Columbia, the Interior subalpine forests make contact with the western red cedar - western hemlock - Douglas fir stands of the Columbian forests. To the north and east both white spruce (Picea glauca Voss.) and black spruce (Picea mariana B.S.P.) enter the forests from the Boreal region. Westward, on the lee side of the Coast range, western hemlock (Tsuga heterophylla Sarg.) with some western red cedar (Thuja plicata D. Don) and amabilis fir (Abies amabilis, Forbes) associates with the Engelmann spruce and some scattered western birch (Betula *papyrifera var. subcordata* Sarg.) also appears. Along the upper altitudinal boundary, the whitebark pine (*Pinus albicaulis* Engelm.) is usually represented on exposed rocky slopes and, in the southeastern areas, the mountain hemlock (*Tsuga Mertensiana* Sarg.) and alpine larch (*Larix Lyallii* Parl.) have a local occurrence.

The bedrock, according to Rowe, is largely of Palaeozoic sediments with Tertiary extrusions, although long-continued erosion has exposed the granitic cores of some of the mountains and produced surface materials of wide variability. Soil development has also been variable, lithosols and shallow podsols being most frequent, with brown wooded and brown podsolic profiles being of occasional importance.

The Society of American Foresters (1954) has defined the forest cover types falling within the Interior subalpine forests, those of economic significance being:

Type 201 - White spruce (and other types in the succession).

Type 206 - Engelmann spruce/alpine fir.

Type 218 - Lodgepole pine.

For purposes of giving management prescriptions, however, the British Columbia Forest Service (1958) has grouped

Types 201, 206 and others into "Spruce-balsam* and associated species" and this classification is used in this thesis.

Stanek (Stanek, W. 1966. Occurrence, growth and relative value of lodgepole pine and Engelmann spruce in the Interior of British Columbia. Thesis. University of British Columbia.) has reviewed the classification of the forests in British Columbia and felt that more ecological studies are required to complete definitions and to rate the productivity of the forest associations of the Engelmann spruce - alpine fir zone. It was notable that vegetative associations had frequently been named differently by different authors.

b. The Interior Spruce Forest Cover Types:

(1) Type Definitions:

The Society of American Foresters (1954) has published definitions of these cover types. In the northern Interior, white spruce is pure or predominant but the

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* "Balsam" is the common name for balsam fir (*Abies balsamea* Mill.) as well as for alpine (or subalpine) fir (*Abies lasiocarpa* Nutt.). For the latter species, the author uses the common name "alpine fir" in this thesis. However, the use of the name "balsam" for *A. lasiocarpa* has persisted both in government and industry.

stand may contain birches (Betula spp.), aspen (Populus tremuloides Michx.), cottonwood (Populus balsamifera L.) in minor amount. The type extends from the Northwest Territories southward into British Columbia as far as latitude 54 degrees, where it begins to pass into the Engelmann spruce-alpine fir type and it generally occupies lower benchlands and slopes bordering the rivers. It is a climax type and, when burned, may be replaced by the aspen type (Society of American Foresters' Type 217) or by the poplar-birch type (Type 203). As succession from these types occurs, the white spruce-birch type (Type 202) may be developed before the climax type is re-established.

The Engelmann spruce-alpine fir type is a climax type and, in the Southern Interior, characteristically lies above the Interior Douglas fir type. North of latitude 52 degrees, it begins to be replaced by the white spruce type (Type 201) and, after a fire, it tends to be replaced by the same type.

(2) Stand Development and Silvicultural Treatment of the Interior Spruce Types:

As outlined in the review of British Columbia forest policy, there has always been a problem in British Columbia with the size (diameter) of tree which it has been possible to cut and utilise economically. In the case of the Interior spruce types, this led from a period of uncontrolled cutting into a period of partial or selective fellings, controlled either by diameter limits or tree marking which left in their wake residual stands of small trees. In theory, these stands would then grow to merchantable size but, in practice, many of them grew very slowly. It became recognised that the partial cutting of the old, virgin stands was impractical and resulted in such evils as the leaving of residual stands of old, suppressed stems which could not realistically be expected to grow into a valuable stand, insect attack, extensive blowdown, death from exposure and regeneration only of the less valuable species. This recognition led to the present era of clear felling in strips and scarification of the site to aid the natural regeneration of spruce. This interesting process is now reviewed in more detail.

Barns (1937) studied the development of spruce stands at the Forest Service Aleza Lake Experimental Forest. His work and that of others were reported on by Fraser and Alexander (1949). They reported that Garman (1929), Barr (1930) and Griffith (1931) had indicated the general conclusion that some improvement of seed-bed conditions was necessary to favour the natural regeneration of an adequate proportion of spruce after the logging operation. Barnes (1937) and Pogue (1946) suggested that the low proportion of spruce (and high proportion of alpine fir) left in the residual stands after logging was no cause for alarm. Barnes (1937) suggested, based on his analysis of mature stand development, that a cyclic development took place, in which the mature trees developed to maturity and complete crown closure at a rapid rate, suppressing the younger age-classes. Maturity was marked by a short period of constant slow growth followed by rapid weakening and thinning by disease, insects and windthrow, all of which had the effect of opening the stand and starting the cycle again by the release of the understorey. The length of the cycle appeared to be about 120 years. Logging of the mature spruce somewhat paralleled the natural opening of the canopy and Barnes (1937) concluded that where the logging operation destroyed a minimum of advance growth, a second crop, predominantly spruce, would mature in 120 years.* McKinnon (1940) summarised the studies prior to 1940 and concluded that the understorey and its conservation was the key to the problems of logging this cover type. He, together with Alexander (1946), advocated changing the cutting limit for spruce from a fixed limit of 12 inches to a flexible limit

* The minimum amount was unspecified but was estimated to be 20 percent in the areas which Barnes studied.

as high as 18 inches d.b.h., to satisfy the residual stocking requirements of individual areas. Alexander's study also indicated that the complete removal of alpine fir to the absolute minimum merchantable limit (about 10 inches d.b.h. at that time) would be desirable, so as to utilise it and reduce susceptibility to damage from spruce budworm (*Archips fumiferana* Clem.).

After reviewing this work, Fraser and Alexander (1949) warned that in the Aleza Lake experiments, some care was taken to protect the residual stands and the winter horse-logging methods employed were typical of those causing the least possible destruction to residual stands. The rapid increment response of the residual stands to the opening or removal of the upper canopy might be representative only of the best conditions in the Prince George Forest District.

Fraser and Alexander (1949) noted that, whilst the virgin stands in the Aleza Lake forest had a gross average annual increment of 90 cubic feet per acre, they had a gross, average, annual negative increment of 94 cubic feet per acre from tree mortality. The net loss was attributed to overmaturity and the resulting greater susceptibility to insect and pathological losses. It was concluded that all spruce should be removed to a 13 inch d.b.h. limit and all alpine fir to the absolute minimum merchantable limit of 9 inches d.b.h., so as to reduce the high risk of carrying trees over this size. To further justify this approach, it had been found that areas logged to an approximate d.b.h. limit of 12 inches for all species had developed increments of from 120 to 160 cubic feet per acre per year within 20 years of logging. In effect, Fraser and Alexander (1949) were recommending the removal of all mature trees and the "building up" of the residual stands into healthy size and age distributions, more amenable to selection felling. The immediate management problems foreseen, under these proposals, were the conservation of advance growth and the development of methods of obtaining a desirable stand composition by species where supplementary reproduction was needed to provide adequate stocking.

Variations of these systems of logging "high risk" values to a specified d.b.h. limit, leaving a residual stand which was expected to grow to form the next crop, were to form the major silvicultural systems in the Interior spruce types for a number of years. It is interesting to note that, before the studies described above were made, Barr (1925) had reviewed silvicultural practices in the spruce region of the eastern United States and had suggested that the two outstanding features of practice there might serve as the foundations of practice in northern British Columbia. The features were, firstly, that clear cutting is preferable to any variation of the selection system, when a diameter limit is used in the selection system and, secondly, that the primary object in handling spruce stands is not to maintain or increase the proportion of spruce in the spruce-alpine fir mixture but to manipulate the stand to produce a second crop of whichever of these species can be made to follow cutting in the most economical manner.

The management practices developed in the Aleza Lake forest experiments, in the western white spruce area were also applied to the Engelmann spruce forests of the Central and Southern Interior. There is a considerable difficulty in distinguishing western white spruce and Engelmann spruce from each other since the morphological differences are not great and are variable. Garman (1957) has dealt with the controversial subject and has stated that, because of genetical variation and ecotypic response, as well as probable crossing, the species are not clear-cut, but are composed of many varied populations throughout the range which he considered. It is perhaps only to be expected, under the circumstances, that little differentiation has been made between the species for purposes of defining silvicultural practice.

In the Engelmann spruce-alpine fir forests of the Southern Interior, Smith (Smith, J. H. G. 1950. Silviculture and management of Engelmann spruce in British Columbia. Thesis. Yale University.) reported on silviculture and management, based on a review of the literature and on examination of timber sales, following logging, for wind damage, natural regeneration and logging damage. He concluded that more research was needed into logging methods and for the determination of minimum economic volumes of cut for given areas. Growth and yield, mortality and reproduction should be studied for the several systems which the United States Forest Service experience had shown to be preferable to diameter-limit or medium to heavy selection cuts. Cutting methods to favour the stocking of spruce over that of alpine fir must be adopted. It was certain, Smith held, that light selection cutting, salvage-group selection and alternate strip clear-cutting would reduce windfall and probably increase spruce regeneration. The survey of windfall had demonstrated the advantages of single-tree selection, controlled by marking, over diameter limit cutting. At the same time it was evident that, on extremely boggy soils or in overmature timber, some form of clear-cutting was preferable to single-tree selection.

Smith stated that wind damage could be reduced by arranging cuttings to progress against the direction of the prevailing wind, by reducing the size of openings in the stand, by careful cutting of stand borders and by cutting less than 40 percent of the merchantable volume of the stand. A reduction in wind damage was necessary to prevent build-up of bark beetle populations and cutting to a light intensity would accomplish this. Also, more careful cutting would reduce the incidence of decay by reducing damage to the bark of the residual trees. Market and product research was necessary to develop ways of utilising alpine fir in order that it could be grown in a shorter rotation than the pathological rotation of 130 years. In practical cutting, Smith noted, the use of horses skidding short logs* resulted in the least damage. The physiological changes which occurred from exposure after heavy logging would cause up to 40 percent of the losses of alpine fir due to mortality.

Under a great variety of conditions, Smith found that, on the average, Engelmann spruce accounted for only 32 percent of the advance growth, with proportions on individual timber sales ranging from 5 to 45 percent. Alpine fir averaged 66 percent of the advance regeneration and reproduction and small amounts of lodgepole pine and

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*logs not exceeding 22 feet in length which are not usually bucked again before sawing.

Douglas fir were present. Smith's observations confirmed the opinions of other investigators, who had concluded that the reproduction of spruce was best on moist mineral soil, on rotting wood and in openings of the virgin stand. Regeneration was stabilising best on northern exposures because of more moist conditions and Smith felt that, on these exposures, the reduction of humus by slash burning would be likely to increase the regeneration, provided than an adequate seed source was present. Timber sales which had been cut to a 12 or 14 inch d.b.h. limit averaged 586 spruce and 1,200 alpine fir of natural regeneration per acre and whilst Smith considered the total to be satisfactory, he felt the proportion of species to be unsatisfactory. He referred to a specific sample plot located in the Okanagan Valley (Forest Service experimental plot 286) which had indicated that the best natural regeneration of spruce had occurred in the most lightly cut plot, from which 34 percent of the original volume had been renewed.*

The question of windfall was, however, important and Smith pointed out that, although heavy selection cuts controlled by tree marking, rather than diameter limits had reduced windfall, losses were still extremely high.

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* But later examination of this area was rather inconclusive, owing to a lack of experimental objectives (British Columbia Forest Service (1959). Moss (1960) has also commented on this sample plot.

It would be better to cut more lightly but wind damage would be reduced still more by group selection or strip clear-cutting techniques, especially when the virgin stand was generally of poor vigour and, also, where adequate advance growth was absent.

Stettler (1958) studied the residual stand left after logging of an Engelmann spruce-alpine fir stand at Myra, near Kelowna in the Okanagan Valley. The stand had been cut to a 12-inch d.b.h. limit, for all species, when they contained fifty percent or more of their volume which was suitable for the manufacture of lumber. In brief, Stettler found a high mortality and reduction of residual stems related to wind damage, with the remnants of the upper canopy and slender spruce poles being chiefly affected. Poor quality stems suffered more than good ones and the overall mortality had offset the gross growth in basal area over the 28 year period. It was also found that mortality increased with increased cutting intensity. The surviving poles and trees showed significantly higher radial growth (release growth) than did the corresponding control stems in the adjacent virgin stand, more so in alpine fir than in spruce, but most of this release growth occurred on poor quality stems. The advance growth in the residual stand had suffered a considerable reduction and the height growth of the surviving stems was extremely slow. New regeneration (that established following logging) had obviously been facilitated by hand piling and burning of slash, with spruce seedlings showing a definite preference for spots of exposed mineral soil. Stettler concluded that, under the wind-exposed conditions prevailing on the cutting area, the careful preservation of spruce poles during the logging process proved to be of little value to the next crop. All of the components of the residual stand - trees, poles and advance growth - contributed only indirectly to the potential future of the stand. Their main value may have consisted in providing seed as well as some shade for succulent seedlings and in hindering the formation of excessive brush. Finally, the next harvest would be recruited largely from stems which established after logging. It was research findings and management experience with this kind of result which gradually brought selection cutting of spruce stands, whether controlled by diameter limits or tree marking, into disrepute and the recognition was undoubtedly reinforced by the disappearance for economic reasons, of horse logging and the advent of mechanical logging. The latter, even under good supervision, produced much damage by debarking of the thin barked spruce, alpine fir and lodgepole pine and in other ways.

Glew (1963) has evaluated the cutting practice in the white spruce-alpine fir stands of the Northern Interior. Administrative control of logging had developed from the fixed diameter limit selection fellings into the use of higher diameter limits intended to reduce the intensity of cutting and then to single tree marking. He cited reports by Fraser (1948) and DeGrace (1949) in which they found that tractor logging often reduced the survival of remaining trees to 35 percent of the potential residual stand. This discovery led to the introduction of the system known as single tree marking. However, Glew stated that it soon became obvious that the forest type could not be managed under a "blanket" silvicultural system because of the extreme variability of stocking, soil, site and micro-climate. As a result, a form of clear-cutting, the alternate strip method, was introduced by the Forest Service to complement single tree selection and the logging process was followed by site scarification.

Single-tree selection* was first applied in the Northern Interior in 1951 and, by 1962, about 78,200 acres had been logged on this basis removing, on the average,

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* The selection and marking of trees to be felled, by eye, using a marking guide designed to achieve a cut, in volume, of a percentage of the original stand.

very nearly 50 percent of the original volume. Enough timber was left for a second cut but the percentage of alpine fir in the residual stands had increased to 55 percent. If this could not be utilised, bearing in mind the short pathological rotation of the species, the second cut might only be marginally economic. In addition, regeneration was unsatisfactory except on exposed mineral soil. There was no evidence of release growth in the residual stands. However, Stettler (1958) had found that release growth seldom occurred in spruce during the first 8 to 10 years following logging and Glew's areas of study had been logged only 5 to 7 years previously.

Alternate strip clear-cutting was first applied in the Northern Interior in 1954 and, by 1962, approximately 146,800 acres had been laid out in cut and leave strips. Although scarification was introduced in 1956, the considerable backlog of logged, unscarified areas present in 1962 was still increasing. According to Glew, the heavy windfall which occurred following logging was largely attributable to unsatisfactory strip layout. The total blowdown loss on 2,730 acres examined was 275 M.c.f. of stems 7.1 inches d.b.h.+ with the trees generally falling in a northeasterly direction. This level of loss could contribute to an increase in the Alaska spruce beetle (<u>Dendroctonus borealis</u> Hopk.). Scarification was introduced in 1956, because the bulk of logging in the northern Interior is conducted during the winter on deep snow and did not disturb the raw humus layer.

Illingworth and Arlidge (1960) have described five spruce-alpine fir ecological associations in the Northern Interior and Glew (1963) noted the number of seedlings which established on some of these and on other sites, following scarification. Glew expressed a number of conclusions and generally favoured a clear cutting system with scarification. Whilst practices should continue to aim at obtaining natural regeneration, a strong artificial regeneration programme was needed to complement it and nursery facilities should be expanded.

Moss, Lacate, Sprout and Arlidge (1965) investigated the usefulness and practicability of a landform-soil-vegetation system of site classification in the Engelmann spruce-alpine fir-lodgepole pine complexes occurring in the Okanagan Valley and made tentative management comments on the results as applied to glacial tills. Drainage was a major factor in site productivity and species occurrence. Lodgepole pine predominated, on the average, on the rapidly and well drained mapping units with a decline in the volume and stocking per acre of the species as drainage became more impeded. Conversely, Engelmann spruce showed a reverse trend, favouring moist sites and being virtually absent from the driest sites. Thus, lodgepole pine should be managed to occupy the driest sites, the intermediate sites should be scarified to obtain a spruce-lodgepole pine mixture and wettest sites (which, in any event, are difficult to machine scarify) should be planted at once with spruce, possibly with small admixtures of other species, before brush invasion of the site.

(3) Natural Regeneration of Spruce:

In the foregoing sub-section (2) of this Review, frequent reference has been made to the problems of re-forestation in the Interior spruce forest cover types. These problems are of major concern to management, particularly under the sustained yield policy. A number of studies have aimed at defining the factors influencing the regeneration of spruce and alpine fir. That of Smith (Smith, J. H. G. 1955. Some factors affecting reproduction of Engelmann spruce and alpine fir. Thesis. Yale University.) is probably the most comprehensive and, since other studies do not disagree with his findings to any significant extent, only his conclusions need be mentioned. After stating the effects upon germination, seedling growth, and seedling mortality of spruce and alpine fir of various seedbeds, the intensity of light and temperature he recommended that on sites where advance growth was not present, stands should be clear-cut and the site scarified and, where advance growth was present, group-selection and scarification should be practised.

The techniques of scarifying the site received attention. Decie and Fraser (1960) conducted mechanical scarification trials over 2,000 acres of the northern Interior during 1956-59 and made recommendations on the procedure, including a method of assessing results. Gilmour and Konishi (1965) conducted a preliminary evaluation of scarification methods and the resulting regeneration. They concluded that average annual costs varied between 9 and 12 dollars per acre, excluding supervisory costs. Costs could, however, exceed 17 dollars per acre under unfavourable conditions. It was found that glacial tills and sandy soil could be scarified during wetter periods than could silts or clays and, as might be expected, that southern aspects could be scarified earlier than northern aspects. Alluvial soils on flood plains, black muck soils associated with alder swales, margins of swamps and other areas of restricted drainage all showed poor regeneration results after scarification and were not recommended for scarifying. The Oploponax site type, associated with poorly drained clays was recommended either for pre-scarification* during a good seed year, or for planting. The authors recommended tractor scarification but concluded that other treatments such as direct seeding, planting, burning etc., would be necessary to augment scarification in the Prince George Forest District.

Prochnau (1963) investigated the direct seeding of white spruce and alpine fir with variable results. Like other authors, he concluded that the preparation of mineral seedbeds was essential for good establishment of these species and also emphasised the need for protection of the seed against rodents. Moisture and temperature conditions immediately after germination was the third main factor affecting the results.

Arlidge (1967) has reported on the period of time for which scarified seedbeds remain receptive for germination of spruce seed in the Prince George Forest District. The investigation was carried out on sites of average or better productivity, on which the mineral seedbeds were artifically seeded for each of the first four years following the year of scarification. The mean success of the seedings decreased from 62.8 percent in the year of scarifying and 52.7, 38.7, 36.9 and 24.0

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*Scarification prior to logging.

percent for the succeeding four years. The success, however, varied directly with seedbed size. On large seedbeds survival was greater and the decrease in survival due to seeding-year effect was much less on small seedbeds. There were some indications that greater success was achieved on areas scarified by large tractors, than on areas scarified by medium and small tractors.

A potential threat to spruce seedling survival on the scarified plots lay in the presence of an abundance of naturally established, vigorous birch seedlings. Arlidge also noted that the very slow height growth of the spruce seedlings was a disturbing feature, especially since the sample areas had high site productivity values. If the generally poor growth performance were to be confirmed by a survey of all scarified areas in the region, then Arlidge recommended that the high productivity sites should be planted so as to ensure a more profitable realisation of their potential productivity.

Ackerman and Johnson (1962), working in the subalpine region of Alberta, tested the practicability of planting white spruce (<u>Picea glauca</u> (Moench) Voss. <u>var. Albertiana</u> (S. Brown) Sarg.) during the entire frost-free period. They found that the level of mortality which occurred was acceptable in any month of planting. Weather and soil conditions affected the level of mortality which was lower earlier in the season. On the average, mortality increased and the rate of height growth decreased progressively with the deferment of the planting from May, through the intervening months, to October. The effects of the month of planting on current height growth were still evident in the fifth year after planting.

The British Columbia Forest Service (1966) was conducting a number of research projects in the Interior spruce forests, mostly directed at reforestation and including work on direct seeding and spacing trials. At the time of writing a number of these studies are incomplete and, consequently, are not included in this review.

(4) Pathology and Entomology:

(a) Entomology - Entomological considerations are of importance to the management of the Interior spruce forests, particularly in view of the proportion of overmature and mature stands, of declining vigour. However, it is considered to be outside the scope of this review to present a comprehensive summary of the extant literature. Keen (1952) lists and describes a large number of species, including those of commercial concern and his publication is of value to the practising forest manager. The Advisory Services available from the Canada Department of Forestry have been mentioned elsewhere and are also of value to the manager. The Forest Entomology and Pathology Branch have also published a considerable number of contributions relating to the insects of the spruce-alpine fir forests. As mentioned previously, very little in the nature of large scale control operations has occurred in the Interior spruce forests. The prevention of insect outbreaks does receive attention, however, from both Government and industry forest managers. The practice of "hot logging", involving the immediate removal of logs from the woods as they are cut is common throughout the Region. Progressive or contiguous logging is practised to only a varying degree and has the effect of directing the flight of emerging bark beetles from old to new logging slash instead of to standing trees. Efforts are made, in terms of logging layout and practices such as the rounding of leave strip corners, to reduce windfall to a minimum and, where windfall occurs, salvage operations are normally carried out. The practice of slash burning is of doubtful effect on insect population control, since logging slash in the spruce forests is usually difficult to burn unless it has been allowed to dry for one summer, by which time its attraction for bark beetles is past. Where insect outbreaks causing mortality do occur, logging operations are usually conducted to salvage the dead and affected trees. Whilst these operations do have some controlling effect in the removal of dying trees, they are frequently too late to prevent the migration of beetles to surrounding trees.

(b) Pathology - The relationship of forest pathology to management is quite similar to that of forest entomology. Probably the standard work of reference for the manager is that of Boyce (1948) and numerous contributions and articles are published by the Forest entomology Branch, Canada Department of Forestry. The Branch also provides some advisory service to the forest manager.*

Packer and Johnson (1960) have studied decay associated with logging injury to spruce and alpine fir. They analysed scars of varying ages and found variations in the incidence of infection in various localities and between species. Loss through decay in 14-

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*For example, Molnar (1961) provided the licencee of the Okanagan (West) Tree Farm Licence (No. 9) with a list and description of forest diseases pertinent to management of the licence.

year old scars was a rather small percentage of the tree volume but could be extensive in a particular log (the butt log for tractor scars and the top log for broken tops). Scarred roots weakened by decay could increase the amount of windfall. Engelhardt, Foster and Craig (1961), in studies of importance to the salvage of wind-damaged trees, found marked differences between the rates of deterioration in alpine fir and spruce, following windthrow. Although deterioration losses were equivalent at the end of three years, subsequent decay destroyed 77 percent of the average gross volume of the spruce and only 29 percent of the alpine fir, after ten years' decay. It was advisable to salvage fallen trees as soon as possible, they felt, and, on the assumption that salvage is uneconomical after 50 percent of the gross volume has been destroyed, it must be completed by the sixth year in spruce and later in fir.*

*They noted, however, that considerations of log and species values could vary this conclusion considerably. In the author's experience, spruce must be recovered before it has been through about two months of a warm summer, otherwise its value is heavily reduced, at least for lumber and plywood purposes, by deep longitudinal splitting along the grain through loss of moisture.

It should be added that, amongst forms of damage caused by animals, the eating of seed by mammals and preventive techniques have received considerable study. The work of Wagg (1963) in Alberta will serve as an example. Cage feeding of deer mice (*Peromyscus maniculatus*) and red-backed mice (*Clethrionomys gapperi*) from the white spruce forest showed a daily maximum consumption of about 1,000 seeds of lodgepole pine per animal and about 2,000 seeds of white spruce. Both species consumed the same amounts and both preferred lodgepole pine. Meadow voles (*Microtus* spp.) readily ate seedlings of both species after germination and red-backed mice ate them to a lesser degree.

(5) The Position of Management:

Moss (1960) has argued against the selective cutting of overmature and mature spruce forest and has favoured forms of clear-cutting and seed-bed preparation on suitable sites to obtain natural regeneration but with planting and seeding on higher quality sites. He has favoured slash burning only as a fire prevention measure in areas of heavy slash but not as a silvicultural measure, subject to further research into the effects of burning on the various soils. Wright (1959) has generally favoured clear-cutting and planting in relation to the Canadian spruce forest as a whole. Haddock (1961) has not entirely agreed and has emphasised that either true clear-cutting or "apparent" clear cutting (i.e. the removal of an overwood from an accidental or natural advance growth), or true selection or any variation between these systems might be a great improvement over existing practice. However, the introduction of a new system implied that some sort of plan, based on a much better understanding of ecological conditions and the probable future stand development, was not only prescribed but actually carried out on the ground during the course of logging. However, the finding of a satisfactory system, quite apart from its application in practice, would require a great deal more money to be spent for research and extension programmes and in planning initial forest development, including road systems. Even so, Haddock mentioned that it was unrealistic to expect any classic silvicultural system to work perfectly when it was superimposed on a decadent, overmature and totally untended stand. He continued that too often the logger pursued his legitimate aim of producing the cheapest possible logs at the same time as Governments controlling sale contracts endeavoured to obtain the maximum immediate returns in stumpage and taxes, frequently from low quality crops. A continuation of this sort of compromise, Haddock stated, would doubtless continue to produce "silvicultural slums".

The Brisish Columbia Forest Service (1958) has published its recommended methods of stand treatment for the variable conditions within the spruce-alpine fir stands. It notes that alternate strip clear cutting, patch logging, clear cutting leaving single seed trees or groups or blocks of them and selection felling, with marking or diameter limit control are in common use. A description of these systems is accompanied by a key, setting out choices of factors and indicating the corresponding silvicultural system to employ. The key appears to be for management use at the technical level. The recommended methods are not necessarily applied in tree farm licences, where the licencee may apply any silvicultural system of his choice, once it is incorporated in the approved working plan.

c. The Interior Lodgepole Pine Forest Cover Type:

(1) Type Definition:

The Society of American Foresters (1954) has defined the type as one in which lodgepole pine (Pinus contorta var. latifolia S. Wats.) is pure or predominant and significant volumes (in excess of 20 percent of the total volume) of other species are absent from the stand. Minor amounts of a considerable number of species may be present. The type is one of the most distinctive subclimax types of western North America and the major species has a broad range of moisture and temperature tolerance. Whilst it characteristically occurs at middle elevations in the mountains, it may tend to replace ponderosa pine (*Pinus ponderosa* Laws.) at lower elevations and usually runs well up into the zone occupied by the spruce-alpine fir type. Typically, the lodgepole pine type is a pure pine stand and is frequently very densely stocked. It is generally recognised as a sub-climax type but, frequently, its replacement by climax species proceeds slowly or not at all and it may, thus, behave like a climax type.

The British Columbia Forest Service (1957) has noted that the lodgepole pine type group occupied a total of 18.9 million productive acres in the Province, 21.4 percent of this total area being covered by mature stands; 8.2 percent bearing old immature stands and 70.4 percent, young immature stands. In the Interior, the productive and low site land areas occupied by the type group are as follows:

FOREST AREAS OCCUPIED BY THE INTERIOR LODGEPOLE PINE TYPE BY SITE CLASS AND AGE GROUP (IN ACRES)

Productive Forest			
Young Immature	Old Immature	Mature	Total
13,179,385	1,511,349	4,024,269	18,715,003

L o w S i t e F o r e s t

Young Immature	Old Immature	Mature	Total
2,216,652	2,188	15,164	2,234,004

Productive & Low Site Forest

Total
20,949,007

(Derived from Table A-3 Interior, Continuous Inventory of British Columbia, Initial Phase 1957.)

The volume* of lodgepole pine in the Interior is 20,443 M.M.c.f., of which about one-half is mature and the remainder immature. In the Coastal region, there are 229 M.M.c.f., of which about one-half is classified as mature. Maturity, in these instances, refers to the maturity of the individual trees, whether or not it occurs in a stand which is generally immature or mature.

(2) Stand Development and Silvicultural Treatment of the Interior Lodgepole Pine Forest Cover Type:

The literature dealing with lodgepole pine is extensive. Tackle and Crossley (1953) have listed 442 items in their bibliography and, consequently, it is

*Sound wood volume reduced for waste and breakage anticipated in logging to a rough utilisation standard for live, merchantable trees of 12 inches d.b.h. and larger.

proposed to be highly selective in this portion of the review.

The work conducted by the Canada Department of Forestry research workers on the eastern slopes of the Rocky Mountains in Alberta has been of value to British Columbia Interior forest managers. Crossley (1955) studied the production and dispersal of lodgepole pine seed in a 58-year old fully-stocked lodgepole pine stand and found that small amounts were released continuously, reaching a maximum at the time of cone-ripening in September-October. The maximum showed marked variations in quality, however. Seed was disseminated, in the area of study, for a distance of at least 330 feet downwind from the stand margin during the snow-free period. Under suitable snow conditions, seed would travel much farther on the crust.

Crossley (1955a) also reported on the variety of research into lodgepole pine which was being conducted in Strachan Experimental Block in Alberta to determine suitable silvicultural practices for thinning, harvesting and regenerating lodgepole pine. The various methods of cutting being tried included strip clear-cutting and scarification. Crossley (1956) later reported on the fruiting habits of lodgepole pine from studies conducted in juvenile stands (17 years of age), immature stands (55 years) and overmature stands (140 - 250 years). He found that, whilst a single tree behaved consistently in producing its cone crop, there was a wide variation between trees. A few trees were apparently non-fruiting in the stand, the percentage of them (by number of stems) increasing with increasing suppression of stems. The individual trees which bore cones produced variable numbers annually but, over 20 years, did not fail to bear some each year. The individual cones of the species are either serotinous or non-serotinous, the former opening immediately upon maturity and the latter opening when subjected to a temperature not less than 45 degrees C. - a temperature which does not occur in the tree crowns under natural conditions. The individual tree may bear all, or almost all, serotinous cones or non-serotinous cones or it may bear a mixture of the two kinds. However, once the pattern for an individual tree is set, it remains unchanged for many years. Most of the juvenile trees, however, have their cones open, whilst similar majorities in the immature and overmature stands bore theirs closed. From this, Crossley concluded that the pattern changed between the 17th. and 55th. years. Crossley felt that these characteristics were probably inherited. It appeared that, since young stands are not prolific fruiters and bear very few serotinous cones, they were unlikely to be succeeded by adequate natural regeneration, if destroyed by forest fire. Conversely, mature stands would provide an adequate, if not abundant, supply of seed in serotinous cones to provide for regeneration following a fire. Finally, Crossley noted that, in shelterwood or seed-tree fellings where trees are to be relied upon to provide seed for natural regeneration annually, those classed as open-coned would be the most efficient and should be reserved from cutting.

In another study, Crossley (1956a) investigated the natural release of seed from serotinous cones borne on lodgepole pine slash and the effects on this release of varying degrees of overhead shade cast by residual stand crown canopies. These effects are of importance to management where it is intended to obtain natural regeneration following logging. He found that "normal crown openings" in a thinned stand would allow enough sunlight to reach the floor to heat an exposed cone in the slash to the maximum for the local temperature conditions. Slash should normally be placed so as to situate a maximum number of cones below 6.5 inches above the ground level since, above that height, no significant cone temperature differences were noted. Below it, progressively higher cone temperatures were noted as the ground surface was approached. The nature of the ground surface affected cone temperatures up to 3 inches above ground, but not to any great extent.

Crossley's findings had thus indicated the possibility of employing clear-cutting, with lopping of slash to place the cones close to the ground, as a means of securing natural regeneration of lodgepole pine. But, in another study, Crossley (1956b) investigated strip clear-cutting and mechanical scarification as a means of inducing lodgepole pine regeneration. He found that, under the favourable weather conditions experienced during the study, mechanical pre-scarification was physically feasible and was the only treatment that resulted in an acceptable degree of stocking. With seed available from the marginal stands, he found that the presence of cone-bearing slash made very little difference to the presence of regeneration. Most of the germination occurred during the first year. Crossley suggested that all of the costs of scarification should not be charged against regeneration but also in other directions, as in the case where slash disposal to reduce the hazards of fire, bark beetle infestations and pathological diseases could lead to windrowing of the slash with simultaneous scarification.

Ackerman (1962) also investigated lodgepole pine regeneration following clear-strip cutting, scarification and slash disposal but, whilst he found that seedbed treatment was necessary to obtain adequate regeneration, the level of stocking attained did not compare favourably with the results obtained by Crossley (1956b), using pre-scarification. Ackerman believed that this was due to less efficient utilisation of the slash-borne seed supply and he felt that investigation of methods and timings of post-logging scarification should be continued in an effort to correct this situation.

Horton (1955) conducted a study on the density and growth trends of a young lodgepole pine stand, established after a fire, in good and poor site conditions. He found indications that direct relationships appeared to exist between potential site productivity, stand density and both maximum and average heights. Where the stand density was not so great as to retard height growth then, the better the site, the greater the density and height growth appeared to be. From this, he felt that, if thinning could be economically justified in lodgepole pine stands, the best sites which were usually more densely stocked, should receive priority. At an earlier date, however, Fraser (1949) studied stands in the north-central Interior of British Columbia, which were aged from 90 to 120 years and of site index 60 to 80*. The

*The "site index" refers to the average height of dominants and co-dominants at 100 years of age.

stands had been cut for railroad ties (sleepers) removing only the dominant and co-dominant pine and reducing the pine volume by some 52 to 80 percent. Fraser found, 22 years after logging, that the residual pine continued to develop as in uncut stands of similar sites and ages but, on the other hand, the volume growths of those spruce and alpine fir which were present showed rapid increases. To Fraser, this indicated that, where lodgepole pine occurs in admixture with an understorey of spruce and alpine fir, the pine should be cut to the minimum diameter which is economically possible so as to favour the growth of the potentially vigorous understorey.

Blyth (1957) has investigated the subsequent effect of partial cutting of lodgepole pine stands to an economic diameter limit, varying from 10 to 14 inches d.b.h., in Alberta. The study included stand age classes for ten year intervals from 50 to 110 years and stands logged from 10 to 30 years previously. Blyth's findings generally agreed with those of Fraser in that he found no perceptible increase in the diameter growth rate of the trees left to form the residual stand. The lodgepole pine regeneration was very poor and Blyth concluded that continued partial cutting would result in a drastic lowering of the pine growing stock and ultimately in the almost complete elimination of the species from the stand.

In effect, the work of Fraser (1949), Blyth (1957) and other authors has shown that the partial cutting of lodgepole pine stands, above a certain age (about 40 years), to an economic diameter limit does not result in acceptable growth of the residual stand or, in the conditions studied, in satisfactory natural regeneration. This result does not necessarily invalidate the conclusion of Horton (1955), who suggested silvicultural thinning in immature stands. The early growth of lodgepole pine in British Columbia Interior conditions is known to be exceptionally vigorous but, on the other hand, it falls off very rapidly in middle age. It may well be that any thinnings should be carried out at a very early age to achieve a spacing that will take maximum advantage of the early vigour. Smithers (1957) appears to support Horton's (1955) suggestions. He concluded that the most important factor in the development of lodgepole pine stands was the initially high density of seedlings following disturbance by fire. In some cases, the density was as high as 500,000 stems per acre. In spite of this excess, mortality in terms of basal area and cubic foot volume per acre appeared to be normal when compared with data for other intolerant pine species. The basal area increment and yield were also consistent with the physiographic conditions in which the pine occurred. Smith thus felt it to be reasonable to expect that, if the stocking could be reduced by intermediate cutting or by controlled harvesting, the yields of merchantable timber per acre would be increased and the rotation ages to produce large-sized round wood products, reduced. He suggested that dense reproduction could be reduced to 1,500 stems per acre or less by low thinnings without a sacrifice of current growth.

Crossley (1956c) has investigated the possibilities of employing chemicals to reduce the density of young, stagnating lodgepole pine stands. He found that ammonium sulphamate reduced densities as much as 68 percent during the five-year period following spray application. The herbicides 2-4-D; 2,3,5-T and Brushkiller (a trade mixture of the former two) were the most promising, frequently killing 90 percent of the pine over a period of from 3 to 5 years after application. At the same time, mortality of the white spruce in the understorey was considered to be quite light.

The actual thinning operations conducted in lodgepole pine stands in British Columbia for silvicultural reasons are insignificant in area.* Joergensen

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*The areas cut under "economic diameter limit" fellings are not included in this statement since they are basically exploitation cuts.

(1957) has listed the active experimental thinnings as totalling 18.9 acres. Illingworth (1964) has made an interim report on 14 acres of these thinnings in the Kootenay Valley and inferred that there is a questionable advantage in thinning such 53 year old stands, since undisturbed or very lightly thinned stands gave a better production of material suitable for utilisation. Clark (1957) had earlier arrived at much the same conclusion, in making limited conclusions on an unreplicated thinning experiment at Quesnel. It appeared to him that increased growth could be obtained on individual trees by thinning in young stands but he was doubtful that total wood production would be increased by thinning, even if the cut material were utilised. In order to increase diameter growth to the best effect, frequent but light thinnings in the young stands should be the general rule.

Some investigation has been made into the question of site types in lodgepole pine stands. Smithers (1956) investigated the value of site indices, then in use in Alberta, as a means of estimating forest site productivity and found that, within the scope of his study, they could not provide a valid estimate, owing to the undue influence of the number of stems per acre. He suggested that a productivity rating derived from physiographic characteristics of the site appeared to be the best type for use in dense lodgepole pine stands. Horton (1956) recognised four phytogeographic divisions of the range of lodgepole pine in Alberta based on geographic, physiographic and vegetative differences - i.e. montane, subalpine, high foothills and low foothills. However, he did not subdivide them into pine associations since he looked upon the whole as a varying continuum. Duffy (1964) studied the relationship of productivity to soil series in Alberta and found certain differences which need not be enlarged upon herein. It is of interest to note, however, that he experienced some difficulty in determining whether or not a lodgepole pine stand was fully stocked for a given site condition. Ackerman (1962a) proposed a mensurational method of predicting density in lodgepole pine stands by diameter growth analysis. Whilst the site studies are of use, their direct application in management in British Columbia is most limited. Probably the most useful work, within limits, for management purposes is the preliminary site classifications, based on plant indicators, made by Illingworth (1958). He identified five principal site types and mentioned four more of limited occurrence. He found important differences in productivity between the five principal types, although tree height and basal area differences were not always obvious. Although each of the five types tended to assume the appearance of the next type of lower productivity following a forest fire, each community retained many of its characteristic elements (although they might be much reduced in abundance and vigour) and could be reliably distinguished. Of particular interest was Illingworth's statement that forest succession to other forest cover types took place in four of the types whilst the fifth type was self-perpetuating as a lodgepole pine climax.

Whilst, in practical management, the plant indicator classification can be extremely useful in making local decisions, such as the appropriate logging procedures and regeneration aims, it is of very limited use in site mapping of the large forest management units in British Columbia since the types are virtually impossible to identify on air photographs of normal scales and ground mapping would be very costly and onerous. A system which has the potential, although it is still in an experimental stage is that initiated by Lacate, Sprout and Arlidge (1965) and continued by Moss, Lacate, Sprout and Arlidge (1965). The latter experiment has been mentioned previously and consisted of a land classification of 15,000 acres in the spruce working circle of the Okanagan (West) Tree Farm Licence in the Okanagan Valley. The primary objective was to identify and determine the distribution of "land units" using a continuation of physical features that would be of practical use in the field and in the stereoscopic examination and subdivision of the landscape on aerial photographs. The land units were identified and described by features of the soil, the vegetation and their physiographic position in the landscape. The soils in any one land unit were similar in parent material and profile development, the range being within that generally recognised for a soil series. They occupied fairly specific physiographic locations which were defined as to gradient and position in the landscape. A distinctive vegetative cover was associated with each land unit. Whilst the land units, so defined were quite specific and would usually provide a basis upon which productivity and other forest management interpretations could be made, they were not capable of delineation on a map because of their small size. To overcome this difficulty, "mapping units" were employed which contained a major land unit and, normally, minor inclusions of one or more other land units.

In the course of the definition of land units eleven vegetation site types were identified for both spruce-alpine fir and lodgepole pine. It is interesting that, of these, only one of Illingworth's (1958) site types for lodgepole pine and one of Arlidge's (Illingworth & Arlidge (1960)) site types for spruce-alpine fir were present, the remainder being variations of these two. Volume productivity figures were developed for mapping units located on one soil parent material and, whilst there was a considerable overlapping of results for individual volume sample plots within the mapping units, the averages indicated that the dryer, freely drained sites were probably permanent lodgepole pine sites, whilst the moderately well drained sites were the most productive with a falling-off in volume per acre as drainage became more impeded. The less productive sites (those freely drained or with impeded drainage) had a higher stocking per acre than the moderately well-drained, highly productive mapping units. The average stocking of lodgepole pine decreased as drainage became progressively more impeded and that of spruce increased, falling lower again on the sites with impeded drainage. It was concluded that this system of forest land classification could be usefully applied by management to the Tree Farm Licence and adjacent areas with similar land units by reason of:

(a) The differences in average productivity and economic values which were apparent between the mapping units studied.

(b) The probability that functions such as average maximum total height of spruce, number of stems per acre and stem diameter distribution are correlated with land units and are, on the average, different for each mapping unit.

(c) The immediate use to which mapping unit productivity data could be put to arrive at a more accurate forest inventory, calculation of yield and annual allowable cut, road locations and logging planning.

(d) The relationship of reforestation requirements to land units and mapping units would permit more informed decisions to be made on site preparation for natural regeneration or for a planting programme.

It was also felt that longer term benefits would accrue from the applications of basic knowledge about the land units to thinning operations and the evident advantage of correlating research projects and visual observations to recognised land units. Once the land units had been defined, it was found that they could be quite readily recognised visually on the ground.

In a discussion of the overall problems of managing lodgepole pine, Moss (1955a) pointed out that the major problem confronting management was the economics of utilisation and marketing. He felt however, that the problem would be largely overcome within the next decade.* He also felt that regeneration should be obtained naturally because of the high costs of planting in relation to final stand value.

(3) The Regeneration of Lodgepole Pine:

A number of studies closely connected with the regeneration of lodgepole pine have been reviewed in the foregoing section. Further, brief comment can, however, be usefully made.

Clark (1961) reported on regeneration conditions in cut-over stands in the Kamloops Forest District. Utilisation of the stands included in the survey had varied from stands clear-cut for pit props, box shooks and sawlogs, to partial cuts for poles, railroad ties and sawlogs. The period from the time of cutting up to the time of examination varied up to about 15 years and areas

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* The problem has been largely overcome by the introduction of improved logging techniques and specialised, small log conversion machines of revolutionary design. There is no great economic difficulty in utilising pine down to 9 inches d.b.h. to a 6 inch diameter top. However, the Forest Service close utilisation standards (7 inch d.b.h. to a 6 inch diameter top) which are becoming obligatory in some areas are held, by industry, to be difficult to attain economically.

which had burned since logging were included in the survey. Clark found that, on the average, restocking was unsatisfactory and mainly attributed this defect to inadequate disturbance of the seedbeds. In most cases, an adequate seed source for lodgepole pine and other species was present and the best stocking occurred on the disturbed seedbeds which made up less than one-third of the total seedbed area.

The residual stands themselves were of poor quality, subject to windthrow - and of an age when very little, if any, release growth could be expected. It was unlikely that it would provide a second cut within a few decades. Many of the residual stems in the pole and tree classes and some in the regeneration class, were infected with dwarf mistletoe (*Arceuthobium* (*Razoumofskya*) sp.) and a considerable proportion of the advance regeneration was infected with *Cronartium* rusts. Clark identified three main site types, all of which had been previously classified as climax sites for Interior spruce forest cover types, the Interior Douglas fir forest cover type and the Interior Douglas fir - western larch type. This factor suggested that the areas should be converted to the climax stand. Clark recommended scarification trials, preferably where a seed source was present. When a seed source was not available, direct seeding should be tested as a means of converting to the climax species. As an alternative, planting of the climax species should be carried out. Clark's observations on the subject of release growth agreed with those of Fraser (1949) and, from studies of stumps, he noted a general slowing of growth in unstagnated trees at about 30 years of age. He recommended that another study of release growth following logging of older stands should be made and that cleaning and thinning trials should be conducted to determine whether the rapid growth of the species up to 30 years of age could be maintained over a longer period. Also, the Canada Department of Forestry should study effects of the *Cronartium* rusts on regeneration and of dwarf mistletoe on wood quality, together with methods of control and eradication. Finally, Clark recommended that the Forest Service Management Division should encourage the removal, or at least the felling, of all diseased and deformed stems during the logging operation and the encouragement of maximum seed bed disturbance by the removal of certain restrictive clauses from timber sale contracts.

(4) Problem Analyses for the Interior Lodgepole Pine Forest Cover Type:

Illingworth (1961) conducted an analysis of problems relating to lodgepole pine in the south-east

Interior. Crossley (1956), as noted previously, had studied the fruiting habits of the species in Alberta and made findings which were in contrast to the general opinion in the State of Montana, U.S.A., that the bulk of pine seed is disseminated from open cones. Illingworth, noting this position, recommended that studies be made in various parts of the British Columbia Interior to determine the character of pine seed sources and their relative importance. Certain thinning studies were also recommended. At the time of Illingworth's analysis, it was the policy of the Forest Service to disallow (i.e. refuse to issue) timber sales in stands of thrifty, mature pine with a well distributed advance growth of some spruce and alpine fir. He suggested a revision of this policy to permit pine to be logged to the smallest diameter that was economically feasible, with the trees being felled into the most dense alpine fir thickets, thus thinning them out and safeguarding the least dense patches. Also, he theorised, shade from the residual stand might discourage lodgepole pine and favour spruce and alpine fir. As against this suggested method of conversion to another species, there were places where mills had made large investments in specialised equipment and, presumably, the mill owners would prefer to continue to utilise pine. In these cases, the question of conversion or not should be investigated as an economic problem and for its effects on management. These studies should include small scale studies of conversion by natural regeneration or direct seeding. Finally, Illingworth recommended the ecological classification of lodgepole pine sites which he had previously made (Illingworth (1958) should be improved and extended to other zones.

Armit (1966) conducted a similar analysis in the north-central Interior and predicted that, within the next decade, radical changes in utilisation and harvesting techniques would require the application of intensive silvicultural practices to ensure adequate regeneration. He referred to the meagre knowledge of the ecology of the region and reviewed literature on silvics, ecology and silviculture which was likely to be applicable to local environmental conditions. In addition, he recommended a ten-year programme of research to be undertaken by the British Columbia Forest Service and listed additional studies worthy of the attention of other research organisations in the Province. The silvicultural studies which he proposed for the Forest Service Research Division included site scarification; methods to improve the quantity and dispersal of seed-release from serotinous cones in slash; slash burning effects; direct seeding and planting trials; species trials; cleaning and spacing trials (to determine standards of stocking for regeneration); provenance trials and methods of consistently producing high quality seed from seed production areas. The silvical (autoecology) studies should include annual seedfalls and seed disposal patterns in relation to the environment; seasonal and zonal variation in serotiny of pine cones and the effect of environmental factors upon germination, survival and phenology of pine, including seedbed condition, soil, nutrient requirements, microclimate and aspect. Lastly, the Forest Service Research Division should produce an ecological forest site classification, developed from vegetation and factors of the environment and it should, by means of a tree-breeding programme, develop superior crosses or strains of lodgepole pine.

Amongst the studies which Armit proposed for other research organisations in the Province were a classification and investigation of soils; soil environment; interactions and relationships of stand densities and stand treatments with soil properties, snow and moisture conditions, radiation intensities, plant activity, foliage development and energy assimilation; influences of the natural ecological community and its phenological development.

These proposals can only be regarded as highly ambitious when compared with the actuality of lodgepole pine research. In 1966, the British Columbia Forest Service Research Division (1966) reported upon, or listed, only seven current studies.

(5) Pathology:

This section of the review is not intended to detail the pathological problems of lodgepole pine but to mention some problems of importance to management, where there have been investigations to any extent.

(a) Entomology - Keen (1952) has listed and described the insect enemies of the Interior lodgepole pine forest cover type. Of these, *Dendroctonus spp.* are of considerable importance to management and studies on them are continuing. For example, Robinson-Jeffrey and Grinchenko (1964) have described a new fungus, *Ceratocystis huntii sp., nov.*, occurring in blue-stained lodgepole pine attacked by the mountain pine beetle (*Dendroctonus monticolae* Hopk.).

(b) Rusts and fungi - Molnar (1954) investigated severe stem canker damage to immature lodgepole pine (53 years old) and found that two associated fungi, the rust fungus *Cronartium stalactiformae* A. & K. and *Atropellis piniphila* (Weir) Lohman & Cash were responsible for causing stem cankers of significance to wood quality and value, leading to tree mortality. Molnar stated that both fungi might be expected to occur in endemic form in the Province unless environmental changes, favourable to their propagation and development, occur. In the instance studied by Molnar, only 13 percent of the trees were free from infection and the author has seen a number of instances of at least as heavy an infection in other parts of the Okanagan Valley. It appeared to Molnar, from the high percentage of stem infections and the frequent occurrence of multiple and extensive cankers, that economic losses would be permanent for the life of the stand. Moreover direct control measures were not feasible at the then-existing level of utilisation of lodgepole pine*. Although Molnar felt that the early removal of infected trees might control Atropellis, these measures would not be effective against Cronartium, which produced its spores on an alternate host. The diseases, in Molnar's view, illustrated one of the potential problems of future intensive management of lodgepole pine.

Eades and Roff (1957) reported on red heart (or

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* The author conducted uncontrolled thinnings in these stands, recovering all except very lightly infected trees. The infection continued to spread to the remaining trees, however.

red heart stain), a common defect of lodgepole pine throughout its geographic range in the Province, although it does not occur in every locality. The defect, when present in lumber, was usually considered to be only one of appearance but, in products such as poles, railway ties and pit props it was often assumed to denote the early stages of decay and to be capable of development into decay under service conditions. Eades and Roff identified three main causal organisms and, of direct interest to management, found that branch stubs were the most common infection court, whilst trunk scars and broken tips were of lesser importance.

Baranyay and Stevenson (1964) conducted surveys of diseases and other forms of damage in lodgepole pine in Alberta which had established naturally following a forest fire. Eighteen years after the fire, 18.5 percent of the trees had died and in the next 3 years, another 27.7 percent died. These rates of mortality were not considered to be excessive, in view of the large numbers of trees remaining. The most important destructive agent was <u>Armillaria mellea</u> (Vahl. ex Fr.) Quel. and the most important non-infectious destructive agents were game and rodents.

(c) <u>Climatic Injury</u> - Much of the lodgepole pine stands occurring in British Columbia are subject to winter injury to their foliage. MacHattie (1956) has reported on the phenomenon known as "red belt" injury as it occurred in Alberta and conjectured that it resulted from sharp temperature rises occasioned by arctic air in the valley bottom being abruptly displaced by strong, dry warm winds. The extent and frequency of this effect are less marked in British Columbia than in Alberta, since the climate is truly Continental in the latter area, lying as it does, in the lee of the Rocky Mountains. Another important form of damage in British Columbia is the breakage of tops by snow or bending of stems by snow. At the present stage of management little can be done in the way of treatment to counteract these forms of damage.

(6) Current Management Practices:

Although, from the foregoing review, it is apparent that some useful research has been conducted into various aspects of lodgepole pine, there is a great deal more which ought to be conducted to arrive at solutions much needed by management. Whilst broad principles are recognisable, their application in specific localities and to specific sites is till fraught with uncertainty. It is only in recent years that lodgepole pine in the pure or almost pure stands of the Interior lodgepole pine forest cover type has been utilised in quantity by industry and that management has become possible at an economic level. This factor alone has greatly increased the need for better management information. Linked with this situation is the fact that until recently, lodgepole pine plants for artificial regeneration were not being produced in any significant quantity and their volume is still far short of the need.

The British Columbia Forest Service (1958) has stated its management policy for mixed, thrifty, mature lodgepole pine-spruce types and lodgepole pine-fir types. In the case where spruce is present in a lodgepole pine stand and forms more than 20 percent, or where Douglas fir forms more than 35 percent of the volume of the stand, the age of the spruce or Douglas fir trees was to be taken as the governing factor of the stand in the case of sawlog timber sales. Although it is not so stated, these rules were presumably based on the assumption that a sawmiller would utilise the stand on an economic basis and would cut spruce or Douglas fir in preference to lodgepole pine, subject to diameter considerations. The policy continued that sales for railway ties (sleepers) might be granted subject to certain fixed conditions, such as a provision that areas must be logged with horses or, if mechanical equipment were to be used, with no machine in excess of 40 horsepower. In pure lodgepole pine stands (i.e. those stands where neither spruce or Douglas fir reached the designated percentage), then the age of lodgepole pine was to be the governing consideration as to whether the timber was sold or not. It is significant that where the admixture of spruce or Douglas fir was not present in the canopy but formed an understorey in excess of 200 stems per acre, then the stand should not be sold for cutting (subject to a decision otherwise by the District Silviculturist, following a field examination). The latter provision is apparently the one which Illingworth (1961) recommended for review and revision, as mentioned above. It was, presumably, a policy aimed at preserving the understorey of valuable species from the damaging effects of extracting the overstorey of lodgepole pine and appears to indicate that the Forest Service would be prepared to sacrifice the lodgepole pine overstorey volume for this purpose. The policy was partly a reflection of the low commercial value attributed to pine as compared with the other species.

Where a stand was sold under this policy, the Forest Service, favouring even-aged management for the pine, recommended that a form of clear-cutting should be employed, aimed at securing natural regeneration. The natural regeneration would, however, only be sought where the site was best suited to lodgepole pine and where the forest manager wished to grow pine. The prescribed methods of clear-cutting were alternate strip cutting, group cutting or patch logging, the former being preferred for flat or rolling country and the latter two for "heavily glaciated areas" or slopes. In all cases, the removal of approximately 50 percent of the stand was recommended, the remainder forming a seed source which should not be removed until the natural regeneration in the cut strip had reached a cone-bearing stage of growth. The Forest Service proposed that the cut strips would usually be 6 Gunter chains wide, not more than 15 chains long and staggered, with leave strips of 3 chains in width.* The relatively wide strip or patch was considered, by the Forest Service, to keep the amount of side shade cast by the seed source into the cut strips to a minimum and to permit maximum overhead lighting without seriously reducing the ability of the stand to resist windthrow. Slash disposal was stated to be a necessity, since the pine logging slash is rated as presenting a medium to high hazard. Silviculturally, it was stated that the ideal method of slash disposal would be by a "light" broadcast

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* The result may be visualised as a series of elongated group cuts in a continuous uncut stand.

burn (i.e. one producing relatively low heat) but it was noted that this type of burn is difficult to achieve and to control.

As an example of management of the species within a tree farm licence, Moss (1963) prescribed and employed clear-felling under the progressive clear-strip silvicultural system. The clear strips did not exceed 5 chains in width and 40 chains in length and were cut, usually, in a north-south direction to provide maximum side shade, with directional modifications to adjust to difficult topographic conditions. The working section was not less than 15 chains in depth so as to permit at least three clear-strips to be cut within the working section. No clear-strip could be cut until the preceding strip had been satisfactorily restocked with new growth (if natural regeneration were not achieved within 7 years, artificial regeneration would be employed to restock the area by the end of the 10 year regeneration period. As an exception to this system, sites showing clear indications of progressing into spruce or Douglas fir climax stands but which did not have an adequate seed source of these species present were clear-felled without area limitation and planted with the appropriate climax species. Where pine sites were designated for regeneration to pine, cone bearing slash was lopped and scattered but no scarification was conducted. However, windfall which lay on the forest floor before logging, and logging slash, frequently combined to create a density of debris which would preclude the establishment of natural regeneration. In these cases, the debris was usually windrowed and burned, reducing the area of potential damage to the soil and scarifying the logged area.

2. The Management of the Montane Forest Region:

a. General Description of the Forests:

Rowe (1959) has noted that the Montane Forest Region occupies a large part of the Interior uplands of British Columbia, as well as part of the Kootenay Valley. It is a northern extension of the typical forest of much of the western montain system in the United States and comes into contact with the Coast, Columbia and Subalpine forests. Ponderosa pine (*Pinus ponderosa* Laws.) is a characteristic species of the southern portion of the region. Blue Douglas fir (*Pseudotsuga taxifolia* Britt.) is found throughout but more particularly in the central and southern parts and lodgepole pine and aspen (*Populus tremuloides* Michx.) are generally present, the latter being particularly well represented in the north-central portions. Engelmann spruce and alpine fir from the subalpine Region become important constituents in the northern parts, together with white birch (*Betula papyrifera*

Marsh.). The western white spruce (Picea glauca Voss.), although primarily boreal in affinity, is also present here. Extensive prairie communities of bunch-grasses and forbs are found in many of the river valleys.

Rowe has subdivided the region into five sections, four of which occur in British Columbia and these are:

M1 - Ponderosa pine and Douglas fir section.

M2 - Central Douglas fir section.

M3 - Northern aspen section.

M4 - Montane transition section.

For forest management stand treatment purposes, however, the British Columbia Forest Service (1958) has dealt with the stands under headings of:

Douglas fir and associated species.

Yellow (ponderosa) pine and associated species.

Larch and associated species.

The latter subdivisions, however, include areas other than the Montane forest region.

The Society of American Foresters (1954) has subdivided the Montane forest region in a different way again, and has described the following British Columbia cover types:

Type 210 - Interior Douglas fir.

Type 212 - Larch - Douglas fir.

Type 237 - Interior ponderosa pine.

These various approaches make it difficult, in many cases, to correlate recommended stand treatments to specific areas or types within the Montane forest region. Moreover, some authors have not specifically followed any of these subdivisions. The British Columbia Department of Lands and Forests (1957) has recorded that Montane Forest region areas and volumes under the headings of:

<u>Fir Type Group:</u> Pure Douglas fir and Douglas fir-lodgepole pine. There are 6.49 million acres of this type group (6,950 MMc.f.) in the Interior.

<u>Fir-Pulp Species Type Group:</u> Douglas fir mixed with western hemlock, alpine fir or spruce and/or larch. There are 310,000 acres of this type group (420 MM c.f.) in the Interior.

<u>Fir-Spruce Type Group:</u> Douglas fir and spruce with, or without, lodgepole pine or larch. There are 1.18 million acres of this type group (2,420 MM c.f.) in the Interior.

<u>Fir-Yellow (Ponderosa) Pine Type Group:</u> Ponderosa pine with, or without, Douglas fir and larch. There are 1.32 million acres of this type group (1.120 MM c.f.) in the Interior.

Fir-Larch Type Group: Larch with, or without, Douglas fir, lodgepole pine, ponderosa pine and pulp species. There are 2.03 million acres of this type group (1,120 MM c.f.) in the Interior.

Whilst these type groups do not correspond entirely to the Montane forest region, they are sufficiently well correlated to indicate the importance of the region, comprising some 11 million acres and 10,000 MM c.f. of timber 10 inches d.b.h.+.

The literature on this region is quite limited and is reviewed without subdivision into any of the foregoing categories.

b. Stand Development and Silvicultural Treatment:

Clark (1952) has reported on the growth and development of mixed Douglas fir and ponderosa pine stands occupying the semi-arid side-hills of the Okanagan Lake drainages and the Brookmere portion of the Coldwater River Valley. The major forest cover type of these areas, it is broken up by rock bluffs, rock slides and semi-open range and has been subjected to numerous fires, at least one large-scale bark beetle infestation and, in the Okanagan Lake drainage by one or more "economic selection cuts".* These factors had given rise to heterogeneous

* the cutting of only those trees which are economically valuable.

stands with all ages, from 1 to 350 years, occurring within small areas of about 40 acres. Clark found that most of the stands were reasonably well-stocked, with 400 to 1,200 stems of advance growth per acre under 3 inches d.b.h. occurring in the Okanagan area. All of the stands contained on the average, from 100 to 200 pole-size (4 to 11 inches d.b.h.) trees and from 20 to 30 saw timber size (12 to 50 inches d.b.h.) trees per acre. Noting the volumes that had been removed by logging and those that remained, Clark remarked that, although the quality but not the sizes of the remaining trees was probably lowered by logging, there was apparently enough standing volume to permit an immediate economical cut and enough advance growth and pole-sized trees to leave the areas satisfactorily restocked after logging.

In the Okanagan, past logging had removed 50 to 60 percent of the volume of overmature and mature trees and had been followed by substantial increases in gross and net volume increments. However, in the Okanagan stands, about 60 to 70 percent of the volume was in trees of over 12 inches d.b.h. and these trees were contributing only about 35 percent of the current gross growth of the stand and less than 20 percent of the current nett growth. In the Brookmere stands, about 40 percent of the total stand volume was contained in trees of 24 inches d.b.h.

and larger which only contributed 35 percent and 10 percent of the current gross and nett growths respectively. Clark attributed these low returns on the capital volume on the part of the larger trees to low growth and high mortality rates and considered the further growth of these trees to be a poor investment. Consequently, he felt that the first step to be taken by management appeared to be the removal of all trees over 12 inches d.b.h. in the Okanagan and of over 24 inches d.b.h. in the Brookmere area, except where such a step would reduce the stocking to less than 400 advance growth and 100 poles per acre, reasonably well distributed. In the Okanagan, he also felt that Douglas fir of up to 15-16 inches d.b.h. and ponderosa pine up to 15-18 inches d.b.h. could be left standing where required for reasons other than growth.

Based on these findings and by comparisons with normal yield tables for similar types, Clark believed that the average site was capable of producing trees of a desirable size and volumes equal to those removed by previous logging, on a 120-year rotation with 20-year cutting cycles. The net potential productive capacity of the area on this basis and for the continuation of a similar forest cover type would be 50 cubic feet per acre per year, exclusive of any thinnings. However, for preliminary management planning for the next rotation, Clark made allowance for the existing stand conditions, endemic insect and disease losses and irregularities associated with broken topography, rock outcrops and semi-open range and recommended that a nett annual increment figure of 40 cubic feet per acre should be employed.

Brayshaw (Brayshaw, T.C. 1955. An ecological classification of the ponderosa pine stands in the south-western Interior of British Columbia. Thesis, University of British Columbia) has investigated the possibilities of an ecological classification of ponderosa pine stands. The recognition of a climatic climax and the primary succession leading to it were rendered difficult because of the variation in local macroclimate and the additional climatic effects of the fairly great range in altitude required the postulation of a series of climatic climax communities rather than just one. Also, the primary succession could seldom proceed, because of topographic and edaphic conditions, to such a stage that climate could be held to be the sole determining habitat condition. From these and other climatic considerations, Brayshaw concluded that the climactic climax association was a hypothetical community, seldom attained except by chance. It was easier to recognise dynamic equilibrium with a highly variable total environment and the situation was better described as a mosaic of topographic, edaphic, as well as climatic, climax associations, reflecting a pattern of habitat factors. Brayshaw described a number of associations with sub-associations but these did not result in definite site productivity ratings.

An important point made by Brayshaw was that the lower altitudinal limits of ponderosa pine and Douglas fir might be set by the occurrence of lethally high temperatures during the critical first three months of seedling development. Whilst the pine exhibits more resistance to high temperatures than does the fir, soil temperatures well above the lethal threshold were found to occur during a considerable portion of the summer, where dry soil was exposed to direct sunlight.

The successional trend from pioneer ponderosa pine dominance to climax Douglas fir dominance in the mixed stands of the Pseudotsuga zone was also described. Brayshaw noted that the existing logging methods, through the removal of pine, tended to accelerate the trend toward a climax stage of relatively low value from the point of view of both timber production and grazing forage yield. Thus, it was desirable to maintain stands in their more productive earlier successional stages and at a stocking density providing enough shade to induce natural pruning of the pines but not so much as to suppress these trees or the understorey beneath them. Although ponderosa pine was the most commercially valuable tree of this forest, the low nutrient content of its foliage, as compared to that of Douglas fir or aspen poplar showed that it might be desirable to maintain mixed, rather than pure pine stands.

The factors mentioned by Brayshaw had an important influence on the silvicultural system of management employed by the author in the Working Circle of the Okanagan (West) Tree Farm Licence, where Brayshaw conducted part of his study. Also, the lethal soil surface temperatures experienced on unshaded ground and frequently causing high regeneration mortality led to field trials of various planting methods for ponderosa pine and the subsequent development of new methods. These developments are described later. Brayshaw concluded that more research was needed. The breadth of the ecological range of one association (the Agropyron association), the variability of its tree growth characteristics and the diversity of its reactions to disturbance were too great to permit practical use of it. A need for additional work was indicated to establish the precise relationships between other associations. Also virgin stands of ponderosa pine had been difficult to find and Brayshaw suggested the establishment of natural vegetation research reserves.

In another study, Glew and Cinar (1964) examined the results of logging in the Douglas fir, ponderosa pine and western larch complex, which occupies some 513,440 acres in the Kootenay sub-region of the southern Interior. Logging in these stands dated back to the early days of the present century when many trees, merchantable by present day standards, were left uncut and were subsequently removed by another logging operation. Whilst the early logging had simply consisted of the removal of trees at the loggers' choice, the more recent cutting has been carried out leaving seed trees designated by the Forest Service and the study was made to assess the results of this latter kind of logging. A maximum of 5 seed trees per acre of good vigour and crowns were selected and confined to those areas having inadequate natural regeneration. Glew and Cinar concluded, with minor reservations, that although the stands had been logged on numerous previous occasions, conditions had favoured regeneration and stand development. Although there were significant stocking differences between grazed and ungrazed land, they did not favour restriction or preclusion of the grazing of cattle. They felt that the stands could be managed under a "modified selection system" with a series of light cuts. The cuts made in Douglas fir-ponderosa pine stands would, they held, tend to be lighter and at less frequent intervals than those in Douglas fir-western larch stands and future cutting would need to remove "sub-marginal" trees to avoid progressive stand deterioration.

Glew and Cinar (1966) have also studied Douglas fir-lodgepole pine cover types in the Interior Dry Belt, between Kamloops and Quesnel. The semi-arid climate and soils of the Dry Belt produces slow growing trees which often occur in open stands. Individual trees may, however, reach diameters of up to 50 inches and heights of up to 150 feet. The valley floors in the area of examination are at approximately 2,500 feet above sea level and the Douglas fir and lodgepole pine stands generally predominate above 3,000 feet elevation. Since 1955, the most common stand treatment applied to these stands had been the marking of seed trees under similar rules to those of the same authors' study in the Kootenay, described above. Glew and Cinar found that the seed trees assisted in regenerating the logged areas. The residual pole layer was found to be healthy and vigorous, the growth of the residual stand generally increased and the amount of natural regeneration with a more favourable distribution increased. Practically all of the stands contained a substantial amount of advance growth, although the distribution was rarely good. The natural regeneration following logging had greatly improved both the density and distribution of young growth. One point of concern was that the removal of the upper storey by logging had resulted in considerable mortality to the other elements in the stand and Glew and Cinar noted that the greater the intensity of cut was, then the greater was the amount of damage caused. Also, although 5 to 10 percent of the volume was supposed to be reserved as seed trees under the timber sale contracts, it was found that the number of marked seed trees was less than one per acre, a number considered to be inadequate. It was suggested that a lower cutting diameter and more marked seed trees would increase the yield per acre and enrich the distribution of the natural regeneration, provided that damage to the residual stand could be controlled. The co-authors concluded that the seed-tree method had improved stocking following logging but that improvement could be effected by varying treatments for individual stands. However, seed trees were not considered to be necessary or desirable in all instances and treatments could only be prescribed on an individual area basis.

c. Reforestation:

Clark (1966) has studied the effects of season of planting and of aspect on the survival of different classes of Douglas fir planting stock from five different nurseries. He found that survival characteristics, over the first two growing seasons, were considerably different for each of the nurseries. There were no differences in survival as a result of planting location but spring-planted stock had a superior survival (89.0 percent after two growing seasons) over stock planted in the autumn (62.6 percent). The spring planting season in the Montane Forest Region is frequently very short because of moisture conditions and experiments such as this, which investigates autumn planting, are of much interest to management.

Illingworth (1966) is also investigating differences in survival and growth between several classes of Douglas fir nursery stock on a particular site. Initially he has found an excellent survival and unlike Clark (1966), has found a striking absence of important differences between classes and grades of planting stock, a result which he feels emphasises the overriding influence of careful handling and planting.

Again, there are some apparently conflicting results, demonstrating the difficulties of arriving at uniform conclusions, in a study by Clark (1966a) being conducted on a burned area at Clinton. This study aims at determining the reaction of different age classes of Douglas fir to season of planting, exposure of planting site and site preparation. The survival has been very poor for all stocks and seasons but some differences were apparent, initially. Stock planted in the autumn survived better (27.4 percent) than did stock planted in the spring (13.5 percent). The rate of survival by aspect was significantly different after one growing season, with an unexpectedly better survival on the western aspect (27 percent) than on an eastern aspect (13.8 percent). The autumn planting was, however, best on eastern aspects and the spring planting was best on western aspects. A significantly better survival occurred on scarified (33.9 percent) than on unscarified (9.1 percent) spots and this did not vary with aspect or season of planting. The survival was also significantly different between stock classes* and they were more strongly influenced by season of planting than by aspect. The generally poor survival was attributed by Clark (1966a) to late spring frosts, summer drought and, possibly, nursery sources. He concluded that small transplants did not appear to be suitable for the dry sites of the Interior Douglas fir forest cover type and that screefing was necessary on sites with grass competition.

These results and others seem to indicate the risks involved in planting in the Dry Belt. Results can

* 26.7 percent for 2 + 1; 23.2 percent for 2 + 0 and 11.5 percent for 1 + 1 plants.

be, and are, extremely variable and, apart from the factors involved in the experiments mentioned, much appears to depend on climatic conditions during the summer following planting. Although Glew and Cinar (1964 and 1966) were generally satisfied with natural regeneration from seed trees, Brayshaw (1955) and others have stressed the advisability of maintaining a good forest cover to reduce soil surface temperatures and site dessication. The removal of cover appears to expose planting stock to climatic hazards somewhat similar to those which effect natural regeneration and appears to favour silvicultural systems which provide conditions favourable to natural regeneration.

A considerable area of the Montane forest region is subjected to grazing by cattle and, whilst it is a governmental policy to permit this grazing, very little is known about its short and long-term effects. Also, as described previously in this review, some conflicts have occurred between graziers and forestry interests. Clark (1964) is studying the compatibility of obtaining natural regeneration of trees in areas seeded with grass for fodder. The question arose basically from beef cattle growers pressing the forest industry and the Forest Service to sow logged areas, particularly skid trails and temporary logging roads, to grass so as to provide grazing for cattle pending the establishment of natural tree regeneration, whether in a clear felled or selectively logged stand. It was found that germination and survival of Douglas fir were significantly better on mineral soil (screefed) control plots than on grassy spots when seeded, broadcast, with tree seeds and on the former, germination was better where the seed had been covered with one-quarter inch of mineral soil. Clark's interim conclusions were that four-year old grass cover inhibited the germination of Douglas fir but seeding on control spots, particularly where the seed was uncovered, indicated the influence of other factors, mainly that of seed-eating predators.

In another study of interest to the silvicultural aspects of management, Clark (1961a) has studied seed dispersal from Douglas fir in the Montane region to determine the distance of seed dissemination from a marginal seed source and a single seed tree, and the percentage of sound seed in the total amount dispersed in relation to time and distance. He found that the fall of seed within the first chain outside the margin of the stand was high and not significantly different from that immediately inside the stand. Beyond the one chain of distance, the density of distribution fell off rapidly and consistently. The heaviest cone crop which was observed commenced to disperse seed in early August and had dispersed 91 percent of the total by the end of October. The next heaviest crop started seed dispersal in late August and had dispersed only 75 percent by the end of October. A poor, or light, crop started to release seed by the first of September and only 47 percent had been dispersed by the end of October. In the case of a single seed tree, it was found that the majority of seed was dispersed within 2 chains of the seed tree, except with a heavy crop, when the seed was dispersed up to 3 chains in all directions. The larger the crop, Clark found, the higher was the percentage of filled seed. With the heaviest crop which he found, 39 percent of the seed was filled and with the lightest crop, 7 percent. These results indicate, in the author's view, the dangers of relying upon a light cone crop to provide seed for natural regeneration. Also, because of the relatively short distribution distances recorded by Clark, clear cutting is evidently a risky procedure, although an absolute minimum of five distributed seed trees per acre would appear to provide an adequate coverage of seed, questions of site exposure apart. Whilst heavy cone crop periodicity is still the subject of cummulative records, experience indicates that heavy crops on Douglas firs in the Montane Region may be expected approximately every ten years, giving an indication of the maximum natural regeneration period to be considered in establishing a rotation.

The question of obtaining regeneration by direct seeding, offering as it might, a cheaper and effective alternative to planting, has been investigated. Stewart (1958) conducted exploratory direct seeding studies in the East Kootenay area of the Nelson Forest District. His sowings of ponderosa pine and Douglas fir seed showed poor germination in all of the treatments which he employed. Stewart concluded that, for both species, moisture deficiency was probably inhibiting germination and that anti-rodent treatment was necessary when seeding. Various modifications of the seed bed had failed to improve germination because moisture deficiency remained dominant. Finally, he noted that the need to stratify ponderosa pine seed was confirmed. Whilst other direct seeding studies are progressing, there has been insufficient success in obtaining germination and survival to permit the use of the method in normal forestry practice in the Montane Region.

In addition to the planting studies and trials carried out with Douglas fir, the question of ponderosa pine has received considerable attention. Illingworth and Clark (1964) conducted planting trials with the species, noting that, although much of the logged ponderosa pine forest in British Columbia had been lost to agriculture, urban development and other uses, a rough estimate placed the area of plantable ponderosa pine sites which were unsatisfactorily restocked at 60,000 acres. Of the 20,000 acres of this total which were of better than average site productivity, 18,000 acres occurred in the East Kootenay area or in the Rocky Mountain Trench. During the period from 1950 to 1960, approximately 3,820 acres had been planted; 620 acres by a private company in the Okanagan Valley* and almost all of the balance by the Forest Service in the East Kootenay. The weighted average survival of these plantings (23.2 percent) was an indication that, with a few exceptions, the history was one of repeated failures. It had become evident that successful establishment could only be expected in years when relatively cool, moist weather prevailed during the growing season. Some means of improving the plant-soil moisture relationship during years of less clement weather must, therefore, be sought. The trials were conducted in the Parkland zone of the Montane Region, notable for its low precipitation and high summer temperatures. In this zone, the mean annual precipitation varies between 10 and 20 inches, much of it falling as snow. Long periods of

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* The author directed these plantings, as Woodlands Manager of the company concerned.

sunshine during the summer, together with an inflow of hot, continental air from the south, result in daily high temperatures. For example, July maxima of greater than 95 degree Fahrenheit are not uncommon. The trials conducted by Illingworth and Clark were in two series and involved a series of tests of watering, shading, planting in ploughed furrows, screefing, root trimming, planting stock classes supplied by various nurseries and planting stock grades. The conclusions reached were, firstly, that lack of soil moisture is the factor most limiting for plantation establishment on denuded pine sites. Secondly, it was found that site preparation methods which reduced vegetative competition for moisture could improve survival dramatically, were economically justifiable and should be regarded as an essential part of forest practice in the forest type. Finally, it was concluded that many influences, including nursery regime and seasonal effects, produced variability in planting stocks and weakened traditional expressions of survival potential, such as age and morphological grades. However, in the absence of more acceptable criteria, Illingworth and Clark concluded that large 2 + 1 transplants appeared to be best suited for survival and growth on dry ponderosa pine sites.

Other work has been conducted on reforestation problems in the Montane Region. Whilst many problems to management remain to be investigated, progress has been made in arriving at some solutions capable of application in practice, such as improved techniques, resulting in higher survival, for the planting of ponderosa pine.

d. Thinnings:

Whilst thinning practices are virtually non-existent in British Columbia, certain limited investigations have been conducted.

Clark (1966b) has investigated the response of 40-year old ponderosa pine in the Okanagan Valley to the removal of tree competition from circular areas about them, of various radii. Eight years after thinning, trees with reduced competition were growing significantly faster than control trees, particularly where competition had been removed for radii of 20 to 25 feet about them. The study was conducted in young ponderosa pine-Douglas fir stands and gave an indication of the desirable spacing of trees. In addition, it tended to confirm the 8' x 8' planting spacing (681 trees per acre) employed for ponderosa pine, a spacing which permits crown closure and reduction of vegetative competition after about 15 years but which also is sufficiently higher than the indicated desirable stocking at 40 years of age to allow for natural losses and to provide some selection of crop trees.

Illingworth (1964a) has conducted a rather similar investigation on western larch trees in a pure stand with competition removed for radii of 8, 12 and 16 feet around the study trees. After five growing seasons, highly significant differences in diameter increment had occurred between treatments and diameter classes. Illingworth felt that the results provided evidence of the early response of larch to release and support for the heavy thinning grades normally prescribed for Larix species. The percent basal area increment for the small diameter classes was greater than the control and it increased proportionately with thinning weight. During the five years of observation, the thinning had had no detectable influence on height growth. It was noted that, shortly after thinning, about one-third of the trees in the one-inch d.b.h. class and some in the three-inch d.b.h. class had sustained snow press, from which they had not recovered after five years.

e. Entomology and Pathology:

As with other forest regions, there are a number of serious pathological agencies within the Montane forest region, the effects of some of which are increased in their severity by the presence of the mature and overmature forests, of declining vigour. In many cases, severe occurrences of mycological or entomological agents are dealt with by management simply by the utilisation of the stand or trees concerned. The procedure is frequently complicated by a lack of access to the stand and frequently, cases occur where corrective action by logging cannot be taken in time to salvage the timber. In less severe epidemics it is not uncommon for no action to be taken. In a very few instances, control or preventive action is taken by management by means other than by logging. There is, however, no real equivalent in the Montane forest region to the type of situation occuring with western red cedar-western hemlock stands in the Columbia forest region, where decay is so widespread in the mature and overmature stands that it is regarded as a normal feature which is dealt with at a slow pace by logging, replacing the heavily diseased stands by thrifty young growth.

Molnar (1961) has stated that yellow laminated root rot (causal agent Poria weirii Murr.) is one of the most important diseases affecting immature, pole-sized Douglas fir in the Pacific North-West and moderate to heavy damage from it has been recorded in the Southern Interior of British Columbia. Shoestring root rot (causal agent - Armillaria mallea (Vahl. ex Fr.) Quel.) attacks a wide variety of hosts, including some Montane Region tree species. Management action in relation to these diseases is by logging. Amongst diseases of the foliage, which may be expected to become increasingly important in second-growth forests, Molnar has mentioned yellow pine needle blight (causal agent - Elytroderma deformans (Weir) Darker.) and the Douglas fir needle cast (causal agent - Rhabdocline pseudotsugae Syd.). Amongst stem diseases, Atropellis canker (Atropellis piniphila Weir) Lohman & Cash) causes severe branch and stem cankers of ponderosa pine, which is also susceptible to damage from dieback caused by Cenangium ferruginosum Fr. Douglas fir in the Montane forest region and, indeed, throughout the Interior, is commonly parasitised by dwarf mistletoe Arceuthobium douglassii Engelm. which stimulates the production of large witches brooms. It also appears that the most important stem decay of ponderosa pine and Douglas fir is that caused by Fomes pini (thore ex Fr.) Karst., whilst an important butt-rot of the two species is Polyporus schweinitzii Fr. which enters through scars caused by fire. All of these diseases are dealt with solely by logging at the normal time of utilisation or prior to this if it becomes evident that rapid mortality is occurring. The exception, in some cases, is that of dwarf mistletoe occurring in selection forest. In this case, it is usual to give a high priority to the removal of infected trees from the stand.

The most important pathological insects of the Montane forest region have been listed by Keen (1952). The bark beetles _Dendroctonus pseudotsugae_ (Hopk) on Douglas fir, _D. brevicomis_ Lec. and _D. monticola_ Hopk. on ponderosa pine are a constant threat in mature and overmature stands. Whilst logging is employed as a control and salvage measure against these beetles, the former species is susceptible to successful control by trap tree programmes which have been employed by management to control epidemics, albeit infrequently. In addition, the Forest Service, as a result of a widespread epidemic of _D. pseudotsugae_ in the Montane region have required sanitation measures in most of their timber sales, including such operations as burning of slash and debris over 6 inches in diameter and debarking or spraying of stumps. These measures on logging operations cannot be expected, however, to control an epidemic of widespread occurrence but rather, by reducing breeding potential to have an effect toward shortening an epidemic and reducing the chances of a recurrence. The trap tree method has the advantage that it can be applied with rapid control results over large areas. The population can thus be lowered rapidly, although the basic causes of an outbreak are not corrected. _D. brevicomis_ and _D. monticola_ do not appear to respond so readily to trap tree programmes.

Firstly, it is worthy of mention that a variety of cone insects and other insects are a constant problem in the destruction of seed which they cause. The most serious damage appears to be caused by species of Barbara, Dioryctria and Laspeyresia. No control action is taken by management against these insects.

f. The Position of Current Management Practice:

The British Columbia Forest Service (1958), as mentioned above, has made stand treatment recommendations separately for Douglas fir, ponderosa pine, western larch and the species associated with each respectively.

Within the association described as "Douglas fir and associated species", four different types were identified and named Cariboo fir types, Okanagan fir types, Kettle Valley fir types and Stuart Lake fir types. For the prescription of treatment for these types, the Forest Service has established three classes and these are stands possessing an understorey, stands devoid of an understorey and stands with a high endemic beetle population.

In the case of those stands which possess an understorey of desirable species, it was recommended that all mature trees should be removed, with the exception of trees required as a seed source. At the same time, the understorey should be protected from unnecessary logging damage. The number of seed trees to be reserved was defined according to the density and distribution of the advance growth. Deformed or defective stems which were undesirable for the manufacture of lumber should be removed wherever possible.

In the case of those stands, in the Cariboo, Okanagan and Kettle Valley fir types, which were devoid of an understorey, the Shelterwood silvicultural system was recommended. The regeneration felling would remove up to 65 percent of the volume with the best, thrifty trees being left to form the residual stand. The seed tree felling would be made as soon as there was an adequate understorey. In the case of the Stuart Lake fir types, where there was no understorey, the stand treatment should aim, on the moister sites, at favouring the spruce component by marking all veteran fir for removal but preserving intermediate fir poles to provide a basis for the second cut. On the drier ridge tops, where there was a better possibility of obtaining Douglas fir regeneration, the seed tree method of logging was recommended.

Where a stand of Douglas fir and its associated species has a high endemic beetle population, it was to be considered in relation to the extent of the adjacent mature stands and the risk of spread of the infestation. Where this risk was considered to be high, a "beetle sanitation cut" ought to be carried out in an attempt to remove all susceptible or high-risk trees. Once the infestation had been brought under control, the stand should be treated with the objective of obtaining natural regeneration. Often, it was suggested, the "beetle sanitation cut" would resemble a regeneration felling and natural regeneration could, fortuitously, result. The treatment was to include slash disposal and the removal of logs and felled trees prior to the anticipated beetle flight time. In addition, consideration should also be given to a trap tree programme.

In the case of the stands of ponderosa pine and its associated species, the guide to stand treatment has described two cutting methods which have been developed in the United States - the "Improvement-selection cutting" developed in Arizona and "Maturity-selection cutting", based on Keen's ponderosa pine tree classification system. Neither, however, are specifically recommended for use in British Columbia. It suggests, instead, that the seed-tree method is probably the best means of achieving the primary objective of obtaining natural regeneration. Under this method, the stand would be cut to a low diameter (of about 11 inches d.b.h.), reserving between four and eight larger seed trees per acre to provide an adequate seed source and enough partial shade to favour the development of ponderosa pine seedlings. Slash disposal was considered to be mandatory to reduce fire hazard, assist grazing values and for other, unspecified reasons. Lopping of slash so as to lower it to the ground surface and speed up its rate of decay would normally be a satisfactory method of disposal where an increase in the bark beetle population was to be expected after logging.

If the ponderosa pine stands included a wide range of ages and sizes of trees, then the primary objective of treatment, the British Columbia Forest Service (1958) stated, became increment with regeneration as a secondary objective. In this case, the shelterwood system should be employed and the regeneration felling should remove up to 60 percent of the merchantable volume, removing as many trees of poor form and low vigour as possible. All the stems of good form and vigour, capable of accruing increment at an accelerated rate after the logging operation, should be retained standing. It was noted that, since uniform spacing was not necessary in the wind-firm pine, the result of this type of cutting should tend toward a form of group selection.

Finally, in the case of stands composed of western larch and its associated species, the Forest Service recommended clear-cutting, leaving two seed trees per acre, preferably between 12 inches and 16 inches d.b.h. Defective and undesirable residual trees should either be cut down or destroyed. On sites subject to severe dessiccation and high soil surface temperatures, the number of seed trees should be increased to five per acre and on moister sites, there should be approximately five groups of eight to fifteen seed-trees each for each ten acres.

Moss (1963) employed a different silvicultural system from those recommended by the British Columbia Forest Service (1958), for Douglas fir, ponderosa pine and larch stands in the Fir Working Circle of the Okanagan (West) Forest Management Licence. The stands of the Fir Working Circle were found to be extremely varied, both in stem diameter composition, age structure, previous logging history and stocking per acre. The amount of overmature values which were present indicated a need for a rapid coverage of the Circle by logging so as to retrieve as many old trees, before mortality, as possible. Moss divided the area into three stand structure and stocking classes which were named "Moist-site stands", "Dry-site stands" and "semi-open range". It was noted that past experience and observation in the dry-site stands and semi-open range had shown that too great an exposure of the ground surface to insolation gave rise to an extremely long natural regeneration period, particularly for ponderosa pine. Only a combination of a good seed supply, well distributed, a low cone insect population and one or two abnormally wet and cool summers would permit the establishment of natural regeneration in any noticeable quantity. The heavy cutting of stands followed by artificial restocking was to be avoided since, although improved techniques of planting ponderosa pine had been developed (as described under sub-section 'c' above), the hazards to the plants were great and mortalities in excess of 25 percent were to be regarded as normal. Direct seeding was not regarded as a reliable method of reforestation.

Advance growth, even in areas reasonably well stocked with older trees, was frequently absent in some areas of the Fir Working Circle. Although Douglas fir, ponderosa pine and western larch are light demanders, they all require, in the Okanagan, partial shade to establish themselves, the shade being sufficient to conserve soil moisture and to reduce the extremely high soil surface temperatures (165 degrees F. or higher) occurring in July and August on bare, unshaded soil. Natural regeneration, for obvious reasons, established more readily on the moist-site areas. Where it had become established it was usually extremely dense and individual trees had low growth rates with increasing stem mortality from about thirty years of age, upwards.

Moss prescribed the Periodic Selection System with Improvement Thinnings. Because of the variety of stand conditions present, the system might be applied as single tree or group selection or a combination of both. A general economic problem of the area lay in the high proportion of small diameter logs which would be produced from existing mature and overmature stands. Moss argued that large diameter timber of good quality would continue to be a preferred product, in spite of the apparent economic advantages of short rotations.

In order to control the intensity of cutting, "ideal" stem diameter distribution tables were drawn up, for moist sites and the other for dry sites. The intensity of cut on semi-open range was left as a matter for examination and special decision by a professional forester. Prior to logging of the moist or dry sites, a strip tally of diameters and suitable pathological notes are made, along with a detailed map of the forest strata and sub-strata. The actual stem diameter distribution of local sub-strata is then compared with the "ideal" distribution. Tree marking then aims at bringing the stand into an "ideal" condition. Three cutting priorities were established for tree marking which were, briefly, as follows:

Priority 1: Dead and dying trees and all trees 23 inches d.b.h. and larger.

Priority 2: Trees of exploitable size (9 inches d.b.h. and over) which are diseased, misshapen, or otherwise defective or lacking in vigour, particularly if interfering with better stems or promising groups of young growth.

Priority 3: Trees of exploitable size, the removal of which is advisable to bring the stand into conformity with the ideal stem diameter distribution.

In practice, the application of this system had resulted in no cut being taken in some areas because of age or, more usually, because previous logging had removed a high proportion of the tree cover. In many of the areas where logging took place, the total yield was of trees in marking priorities 1 and 2, with a consequent increase in the vigour and health of the residual stand. Moss further prescribed that existing regeneration and advance growth would be protected during and after logging and, in practice, this led to the exclusion of heavy, tracked skidding machines and their substitution by rubber-tyred skidders.

Finally, improvement thinnings up to a maximum of 100 acres per year, imposed for cost reasons, were to be conducted in diameter classes smaller than 7 inches d.b.h., where stocking was too dense. All of these arrangements applied under a felling cycle of 30 years. A local empirical yield table was developed from the forest inventory and the yield was calculated by the General Possible Yield Formula (Heyer's formula).

3. The Management of the Columbia Forest Region:

a. General:

The Columbia Forest Region occupies a large part of the Kootenay River Valley, the upper valleys of the Thompson and Fraser Rivers and the Quesnel Lake area of British Columbia (Rowe (1959). The coniferous forest closely resembles that of the Coastal region. Western red cedar and western hemlock are the characteristic species of this Interior "wet belt". Associated trees are Douglas fir which is of general distribution and, in the southern parts, western white pine (Pinus monticola D. Don), western yew (Taxus brevifolia Nutt.), grand fir (Abies grandis Lindl.) and western yew (Taxus brevifolia Nutt.) Engelman spruce from the Subalpine forest region is important in the Upper Fraser Valley and is also found, to some extent, at the upper levels of the forest in the remainder of the region. At lower elevations in the west and in parts of the Kootenay Valley, the forest grades into the Montane Region and, in a few places, into prairie grasslands. Rowe (1959) subdivided the region into the southern Columbia section and the northern Columbia section.

For forest management stand treatment purposes, the British Columbia Forest Service (1958) has dealt with all stands in the Region under the single heading of "Hemlock-cedar and associated species."

The Society of American Foresters (1954) has distinguished the main cover types of the Region as:

Type 215: Western white pine (a sub-climax type.)

Type 227: Western red cedar-western hemlock.

Type 228: Western red cedar.

The British Columbia Department of Lands and Forests (1957) has recorded the Columbia forest region inventory under the headings of "cedar type group" and "hemlock type group". In the Interior, the cedar type group covers 3.04 million acres (7,760 M.M.c.f.) and the hemlock type group covers 5.06 million acres (14,420 M.M. c.f.). Whilst these type groups do not account for all of the Columbia forest region, they do account for most of it and indicate the relative importance of the region.

b. <u>Stand Development and Silvicultural Treatment:</u>

The literature referring to the Columbia forest region of British Columbia is not extensive in the fields of stand development and silvicultural treatment, a situation which can be attributed to the very high incidence of decay in many of the stands. Whitford and Craig (1918) described the general history, condition and potential of the region under the headings of Interior western cedar type, interior cedar-hemlock type and western red cedar-Engelmann spruce type but they did not suggest any methods of stand treatment. They noted, amongst other things, that the hemlock had a large percentage of defect and was of relatively little value. The British Columbia Forest Service (1958) has remarked that a major percentage of the hemlock-cedar type was in virgin stands containing a heavy percentage of defect to the extent that the western hemlock and alpine fir were practically worthless for saw timber. No market existed for this western hemlock, alpine fir and for a proportion of the cedar.

Much of the stand treatment in the past, as a result of the prevalent decadence, has simply consisted of selective exploitation cutting ("high-grading") in which the valuable species, particularly Douglas fir and western white pine, were removed and the other stems left standing. This procedure has left many acres of valueless trees occupying good growing sites. In consequence of the position of decadence, complicated by severe losses of western white pine through pole blight, believed to be a result of climatic variations, and white pine blister rust (causal agent - Cronartium ribicola Fischer.), attempts to manage the stands have not been proposed, other than the application of methods to convert them into new, young growth.

c. Regeneration:

The British Columbia Forest Service Research Division has conducted a limited number of regeneration studies, mostly coordinated to the stand conversion method.

Clark (1962) has reported on regeneration problems in decadent cedar-hemlock stands. The objectives were firstly to determine the various kinds and amounts of seed bed present on an area disturbed by logging and in an area disturbed by logging and broadcast burning. Secondly, it was an aim to determine whether seed was being dispersed and reaching the ground over the logged and logged-burned areas and to what extent slash interfered with the process. Finally, information was gathered on the amount, by species, of regeneration obtained on the burned and unburned portions of the area with respect to seed bed conditions. Clark found that only 1,815 filled seed per acre were dispersed over the area from the 1960 seed crop, 43 percent of them prior to September 1960. Fifty-seven percent of the filled, dispersed seed was hemlock and 43 percent was cedar. The burned and unburned portions of the area were satisfactorily restocked on the basis of 2-year old seedlings by 1962. Over the entire area, for a three-year period, the ratio of hemlock and cedar germinants and seedlings to other species was 69 to 1. Clark concluded that burning of slash produced a significant increase in the number of desirable seed beds and this, in turn, contributed to a higher ratio of seedlings established in relation to the number of filled seeds dispersed (1 in 20 for the burned area and 1 in 182 for the unburned area). The slash which covered 28 percent of the surface of the unburned area partly interfered with the dispersal of seed and the establishment of seedlings.

Illingworth (1962) conducted an experiment along similar lines to that of Clark (1962) but, whereas Clark made his study at the Shuswap Lakes, Illingworth was located in another area of the Columbia forest region, near the Arrow Lakes. He found that, on a clear-cut patch which he studied, 85 percent of the cedar seed and 58 percent of the hemlock seed catch in 1960 was collected from traps within 100 feet of the marginal seed source. Negligible quantities of seed reached the centre of the area which was irregularly shaped and covered 21.7 acres. Eight years after logging and burning, restocking was proceeding very slowly and was being hampered by brush which was occupying the site. At this time, the area was stocked to approximately 44 percent of the level considered to be satisfactory.

Clark (1966c) continued his studies of regeneration problems in decadent cedar-hemlock with another investigation near Shuswap Lake. On this occasion, he employed a roughly square clear cut area, of which 25 acres had been logged and burned in 1961, 240 acres logged and burned in 1962 and 50 acres logged in 1962 but left unburned. On this occasion Clark found that, by the end of 1965, following a seed year in 1964, that the 1961 burn showed an average stocking of 67 percent, being a decrease from 73 percent in 1964. The 1962 burn showed an average stocking of 9 percent (an increase from 6 percent in 1964) and the combined average stocking was 13 percent. This compared with 73 percent stocking on the 50 acres of unburned heavy slash. It was also noted that, in the burned area, 71 percent of the seedlings were within 330 feet of the standing timber. The majority of the seedlings were establishing on mineral soil and mixed mineral soil-raw humus seed beds and on neutral and west to north-west aspects.

These results do not permit of clearly defined conclusions at the time of writing apart from the clear indication that widespread seed dissemination over large, clear-cut areas cannot be relied upon. This would indicate that, either the clear-cut patches must be reduced in terms of distance from the seed source or that much of the area will need to be planted.

d. Pathology:

(1) Entomology:

The Douglas fir beetle is a destructive enemy of Douglas fir throughout both the Montane Forest Region, to which reference has already been made, and the Columbia Forest Region. Walters (1956) has discussed the biology and control of the beetle and recommended that logging should be conducted on a selective and critical basis so as to make the forest relatively resistant to bark beetle infestations. Trees that were more than 150 years old, particularly slow-growing ones, seemed to be more susceptible to attack than younger, vigorous trees. In particular, outbreaks associated with logging operations could be held at a minimum level by removing logs from the woods within one year of their being infested, with certain restrictions as to date, so as to avoid breeding and flight of the beetles. Logging should be continuous in time and area and fresh slash should be created on contiguous areas so as to absorb beetles emerging from the slash of the previous year. If logging were to be discontinuous in time and area, infested slash should be treated before the new broods emerged from it. Rights of way through forest should be cut, wherever possible, towards the end of summer and immediately prior to use. Residual trees and those on the margins of logging areas should not be injured by fire, skidding or bulldozers, since they could provide favourable breeding habitats. As to remedial control, Walters recommended the piling and burning of slash. The peeling of the bark was a feasible method which might, however, increase the fire hazard. When employed in connection with burning, however, it had the advantage of requiring a less intense burn than did unpeeled, infested material. Finally, Walters suggested spraying of the infested material with a homogeneous emulsion of ethylene dibromide, emulsifier and fuel oil.

Lejeune, McMullen and Atkins (1961) have reviewed the influence of logging on Douglas fir beetle populations and have generally agreed with Walters (1956), with the additional remedial control of the use of trap trees or trap logs in troubled areas. With reference to log and slash disposal, they have specifically recommended that all culls and slash over 8 inches in diameter should be kept to a minimum, tops should be cut to less than 8 inches in diameter and stumps should be cut as low as possible.

(2) Diseases:

Glew and MacLeod (1963) have been investigating the effects of antibiotics (phytoctin; acti-diore BR.) applied as basal and foliar sprays on white pine trees infected with blister rust. The rust, along with inroads made by pole blight and Dendroctonus monticolae Hopk. have caused heavy mortality, to the extent that rational management of the pine is virtually ruled out, despite the fact that the species has always been practically the most valuable in the Province. Whilst initial results of the tests were encouraging, they cannot be considered as conclusive.

Foster, Craig and Wallis (1954) investigated decay losses of western hemlock in the Upper Columbia River region. They found them to be excessive, amounting to 52 and 74 percent of the cubic foot and board foot content of the trees respectively. Twenty-six decay producing fungi were isolated. Sixty-two percent of the total decay was attributed to Echinodontium tinctorium Ell. & Ever. and 25 percent to Fomes pini (Thore) Lloyd. A considerable variation in the fungi responsible for decay was encountered intraregionally. Stand defect losses varied from 38 to 71 percent, some of which variation could be predicted on the basis of site index determinations. Immature hemlock was found to be susceptible to appreciable decay and mature stands reached an advanced stage of deterioration at 250 years of age.

e. Forest Fire:

Because of the overmature and decayed condition of many of the stands in the Columbia forest region clear felling is generally favoured in an attempt to clear the site for a new crop. Because of the extensive defect present, clear felling is frequently made compulsory down to 8 inches diameter, stump height, and the quantities of logging slash left on the site are frequently great. This poses a fire hazard of much greater than average severity. But it is also frequently of a density that physically precludes the establishment of satisfactory natural regeneration and that would make planting a very expensive and difficult operation. Thus, Forest Service policy prescribes burning of slash for both protection and silvicultural reasons and the burns are carried out by the operator, with or without Forest Service participation.

Muraro (1964) has carried out and described such a prescribed burn. The Forest Service timber cruise had indicated, before logging, a gross timber volume of 8,900 cubic feet per acre and, after logging, in addition to the usual logging residue of tree crowns and tops, it was estimated that almost 6,000 cubic feet of cull material per acre remained for disposal by burning. Following the burn, Murara concluded that burning conditions had not been suitable to produce satisfactory hazard abatement or to effect seedbed preparation. Part of the failure was attributed to a reduction of fuel surface area because of needle cast by some of the slash, lack of a sloping land surface, the absence of wind and the high moisture content of the larger fuels. The extreme slash hazard index at the time of the burn and the sluggish fire behaviour indicated that the Coastal slash hazard tables, which were employed, were not a good criterion of fire behaviour in the less hazardous cedar-hemlock forest. Muraro concluded that observations on this and other burns emphasised the need for research to accurately delineate previous and current weather regimes necessary for successful prescriptions.

f. The Position of Present Management:

(1) The British Columbia Forest Service (1958) have postulated that the existing stands of western hemlock-western red cedar probably became established following forest fires. In terms of shade tolerance, they have classified hemlock, alpine fir and cedar as being very tolerant, Engelmann and western white spruces as tolerant, western white pine and Douglas fir as intermediate, lodgepole pine as intolerant and western larch

as very intolerant. In managing the stands, light relationship was stated to be of paramount importance and, if it was desired to regenerate a mixed stand, then succession required the complete removal of the canopy together with the provision of an adequate seed source of the desired species.

(2) Decadent, overmature stands:

The Forest Service proposed that decadent, overmature stands should be clear cut, reserving blocks of seed trees. Since all stems should be cut, it was (and is) the policy of the Forest Service to offer salvage rates of stumpage (a lower rate than normal) for hemlock, cedar and alpine fir provided that all trees were felled which are 8 inches diameter, stump height, or larger. The policy was not mandatory, however, upon the operator because of the dubious economics of this type of timber sale. The practice was to offer a salvage-type sale to an applicant and to endeavour to persuade him to accept the conditions. If the applicant was unwilling to accept the sale on the salvage basis, then a normal timber sale was offered aiming at maximum utilisation and the retention of selected seed trees. In the latter case, the Forest Service did not concern itself with protecting a residual stand which would have been better removed, from damage during logging.

(3) Thrifty Mature Stands:

Under most conditions, the Forest Service did not consider that cutting in thrifty, mature stands was advisable, in view of the very large acreages of high priority timber which should have been harvested first. On occasions when a timber sale was issued, it should have been for the selection system with control by tree-marking and with no control by diameter-limit permitted. It was stated that tree-marking should aim to remove not more than 40 percent of the volume of trees of 12 inches d.b.h. and larger. Larch, cedar and white pine should provide the major portion of the cut, with an increased emphasis upon the latter species where it was infected with either pole blight or blister rust. Larch and cedar were favoured for early cutting because they appeared to have short, pathological rotations in the Wet Belt. In the type of selection cutting which the Forest Service proposed, the time interval between cuts would usually be not more than twenty years and would culminate in a clear-cut with the reservation of seed trees to secure natural regeneration.

4. The Management of the Coast Forest Region:

a. General:

Rowe (1959) has described the Coast forest region as a part of the Pacific coast forest of North America.

It is essentially coniferous, consisting principally of western red cedar and western hemlock with abundant Sitka spruce (Picea sitchensis Carr.) in the north and with the addition of Douglas fir in southern British Columbia. Amabalis fir (Abies amabilis Forbes) and yellow cedar (Chamaecyparis nootkatensis Sudw.) occur widely and, together with mountain hemlock (Tsuga Mertensiana Sarg.) and alpine fir, are common towards the timber line. Western white pine is found in the southern parts and western yew is scattered throughout. Broadleaved trees, such as black cottonwood (Populus trichocarpa Hook.), red alder (Alnus rubra Bong.) and broadleaf maple (Acer macrophyllum Pursh.) have a limited distribution in the region. Arbutus (Arbutus Menziesii Pursh.) and Garry oak (Quercus Garryana Hook.) occur in Canada only on the southeast coast of Vancouver Island and the adjacent islands and mainland. Rowe subdivided the Coast forest region into 4 components which he named Strait of Georgia Section, Southern Pacific Coast Section, Northern Pacific Coast Section and Queen Charlotte Islands Section.

The Society of American Foresters (1954) have defined ten forest cover types falling with the Coast forest region of the Province. For stand treatment purposes, the British Columbia Forest Service (1958) has not attempted to deal with individual forest cover types but has pointed out that the silvical characteristics of cover types and the economics of logging are such that either clear-cutting or the "seed tree method" is mandatory as the silvicultural system of felling. Much of the literature dealing with the Coast forest region does not differentiate between forest cover types to the extent that Rowe had done. The ten forest cover types designated by the Society of American Foresters probably give the best general breakdown of the region, but, for the purposes of this review, the author had adopted the Forest Service approach.

b. Regeneration and Reforestation:

(1) General Problems and Direct Seeding:

Much of the research, of use to management, which has been conducted in the coastal forests has dealt with regeneration. With the heavy clear cutting of the Coastal forests since the early days of the Province's history, this subject has been and is, one of pressing importance.

Godwin (1938) has related how, in 1936, the Forest Service Forest Surveys Division investigated the condition of clear cut lands within the Esquimalt and Nanaimo Railway Land Grant on Vancouver Island; and area containing some of the most productive forest land in the Province. Only 24 percent of the lands were restocking in a satisfactory way, although if areas affected by logging or fires during the previous ten years were excluded, then 45 percent of the lands were satisfactorily restocked. These results were held to indicate that either a period of at least ten years was required before new growth became established or loggers were cutting over such an expanse of ground that restocking by seed from marginal timber became impossible for all but a small percentage of the area. A subsequent study was undertaken on 21,000 acres of the clear felled lands of a large logging company within the Railway Belt which had originally been covered by a fine stand of Douglas fir, with relatively light admixtures of western red cedar and western hemlock. The results were alarming since out of 19,981 acres logged in the previous 17 years, only 5.4 percent were restocking in a satisfactory manner. Godwin noted that 55 percent of the restocked acreage occurred on areas of unburned slash but, in all cases, a surface fire had burned through the stand prior to logging. Where no fire had occurred prior to logging, reproduction in unburned slash areas was unsuccessful. Repeated fires following logging were an important factor in the failure of an area to become restocked and, in the study area, 4,000 acres had been burned more than once. Some of the failure undoubtedly related to the observation that seed dissemination from seed trees on slash burned land reached a distance of ten chains in the direction of the prevailing wind and two chains against it. Patches of non-merchantable timber standing in swampy ground and left behind in the logging were of little or no value as a source of seed. Also, the occurrence of a moss, Polytrichum juniperum, on burned lands limited the establishment of natural regeneration.

The prospects of putting land logged in this manner back into forest were discouraging and Godwin recommended further study into problems of logging operations so as to incorporate the knowledge gained into future cutting plans. More basic research into silvicultural questions and the economics of timber extraction were also recommended.

Earlier, McCulloch (1927) had reported on a survey in the Sitka spruce-western hemlock-red cedar forests, conducted to determine the extent and distribution of species and the effects of various factors upon restocking of areas. It was found that only sparse restocking of spruce had occurred on areas where the species had formerly been dominant, the densest reproduction being that of western hemlock. He concluded that seed supply and seed bed conditions were the two most important factors affecting reproduction of the spruce and recommended further study into them. It is of interest to note that he found fewer seedlings on areas which had been broadcast burned than on unburned areas. The fires had not materially reduced the amount of debris and appeared to produce conditions unfavourable to natural regeneration.

Warrack (1956) reported on the degree of restocking by natural regeneration, after clear cutting and slash burning, of a Sitka spruce-western hemlock stand in the Queen Charlotte Islands. Four years after logging in the particular environment and with a marginal seed source approximately ten chains away, natural restocking was at a satisfactory level. The stand composition and stocking, 10 years after logging compared favourably with that of the original stand. Later, the same author (Warrack (1957) assessed the factors of the environment upon which to develop discussion of the status of regeneration in the Queen Charlotte Islands. Natural regeneration could be expected to establish an adequate crop of western hemlock-Sitka spruce-western red cedar, provided that the extent of the contiguous clear cut areas was limited to 900 acres and, preferably, less; that an encircling seed source within one-half mile distance was left for a period of not less than ten years and that the amount of slash covered not more than fifty percent of the surface. Clear cut sites of high productivity were prone to early reclamation by alders, shrubs and grasses and must be planted within three years after logging. The protection of the plants against heavy deer browsing might be necessary in these cases, in addition to the use of normal fire protection measures. Slash burning resulted in the establishment of purer stands, mostly of Sitka spruce, but was not considered to be a requisite for obtaining regeneration. Warrack suggested that research should be made into seed production and effective seed year periodicity in relation to the regeneration period; into current and post-logging treatments likely to provide the best pattern of seed sources and the preferred seed bed conditions; into the reclamation of rich sites already lost to undesirable brush cover and into planting trials of nursery and "wildling" stock on good sites, immediately after logging.

Heatherington (1959), working on the west and north-west coasts of Vancouver Island has also appraised regeneration problems and has endeavoured to identify characteristics which could easily be observed, which were possibly associated with the success or failure of natural regeneration. In brief, his interim conclusions were that burned areas were less likely to restock than unburned areas because of the destruction of seed and advance growth during burning. However, slash and humus accumulations were reduced, reinvasion by ground and shrub vegetation was delayed and the composition of vegetation was changed. He observed an obvious increase in stocking, with increase in the period since logging, on burned areas and thought that this may have been due to an increase in the period of site receptivity to natural regeneration, after burning. Certain higher quality sites with moist conditions during the growing season were quickly occupied by a dense vegetative cover, precluding natural regeneration. Apart from this situation, site quality did not have much influence upon stocking and other vegetation was only deleterious in extreme cases. Hetherington considered, also that an inadequate seed supply to a logged area was the most frequently occurring and widespread of all factors responsible for regeneration failure, whilst the next most important factor was poor survival. As a good rule, it was felt that if natural regeneration was so poor that advance growth became important, then the area should, if possible, be burned and artifically regenerated.

Garman (1955) has summarised the work of many foresters and authors in the field of silvics associated with the management of cover types in the Douglas fir region and showed that the establishment of adequate natural regeneration within a reasonable period of time following logging was often prevented by component, controlling factors. He proposed that logging practice must provide for an adequate source of seed for regeneration, by reservation of blocks or strips of seed trees adjacent to clear fellings or by leaving seed-trees uniformly scattered over logged areas (basically, shelterwood fellings). In addition, a satisfactory seed bed should be prepared by regulated slash burning or by clear felling without burning. The seed on the ground must be protected from the depredations of rodents and preparations against the loss of seedlings from physical and biotic causes must be made.

In the area of seed production and dissemination, Garman (1951) found that old Douglas fir trees in good locations, bearing good cone crops on receptive sites, will produce twice as many cones as the resulting survival of seedlings. By increasing the data of his particular study, he felt that it should be possible to forecast the amount of regeneration likely to be obtained in a given year for a specific logged area. It was evident, from his study, that on areas bearing scattered seed trees it took more seed to produce a seedling on poor sites than it did on good sites but poor sites did tend to produce more seed on mature trees than did good sites. This higher production, together with a better survival of the seed trees themselves, was enough to ensure the best stocking on the poor sites. The project demonstrated, also, that logged areas having a residual stand of seed trees regenerated more readily than clear cuttings with seed supply from the margin because of higher seed production from isolated seed trees and better survival. In the portion of the study dealing with seed dissemination it was found that, for each of the species Douglas fir, western hemlock and western red cedar, the average amount of viable seed falling from 1 to 5 chains outside a timber stand margin was approximately 10 percent of the amount falling 1 to 5 chains inside the margin.

The question of seed collection in British Columbia is of vital interest to management both in British Columbia and in Great Britain, which derives much of its seed from the Province. Consequently, it is appropriate to digress somewhat from the Coast forest region alone and mention the report of Haddock (1962) which discusses the geographic variation of Douglas fir over its very extensive natural range and has noted that variation in the species is probably clinal (i.e. there are gradients of biotypes along various environmental transitions.) As a result of consideration of climatic data, the distribution of associated species and previously published vegetation maps, Haddock suggested four British Columbia

Coastal and five Interior seed collection zones although, in many instances, the boundary lines were arbitrary and the populations within a single zone far from homogeneous. It was concluded that seed collection by general localities is an inadequate approach. If a seed buyer could not indicate a specific locality or site from which seed is required, then pertinent climatic data for the plantation site should be provided and ought to include average annual temperature, absolute minimum temperature, annual precipitation and precipitation during the growing season. This would enable the seed dealer to better specify the correct seed origin for the site concerned.

Ebell and Schmidt (1964), in collecting records of pollen dispersal and meteorological data, made observations of direct and indirect interest to management. They found, for example, an apparent relationship between July temperature and the initiation of reproductive primordia in Douglas fir, mountain hemlock, grand fir, amabilis fir and alpine fir which, if confirmed, will aid in the forecasting of cone crops. The study was also of value in assessing the degree of pollen contamination at a potential seed orchard site, a factor of importance in the selection of such a site. The study also indicated variations in pollen dispersal rates over variable horizontal and elevational distances which pointed out the inadequacy of regarding elevation as being synonymous with climate. This raised the question about the use of elevation in seed provenance rules and descriptions to guide the transfer of seeds or seedlings in reforestation practice.

Garman (1943) reported on the results of artificial direct seeding of Douglas fir and noted that, on exposed mineral soil the resulting trees had grown markedly taller than on spots where the soil was a mixture of soil and organic matter or decaying wood. Maximum temperatures in the surface layers of mineral soil, soil and organic mixture, and charred wood were 50, 55 and 60 percent higher, respectively, than the maximum summer air temperatures. In some instances, temperatures dangerous to seedlings were reached as early in the year as May. On a freshly burned site, germination was twice as much as on a very gravelly site burned one year before seeding. Amongst the other factors which affected germination and survival were season of seeding; the provision of screen protection for one year; seed consumption by foraging mice and birds; vegetative competition and attacks by <u>Armillaria mellea</u> following prolonged dry periods. Garman suggested that spot seedings should be afforded protection by superimposed wire screens for a period of one year, to afford protection from mice and birds, provide twenty-five percent shade and reduce drought losses.

Later, Garman and Orr-Ewing (1949), with more results at their disposal, published an authorative report on the direct seeding experiments conducted in the southern coastal region from 1923 to 1949. By this time it had become apparent that more of the logged areas on the Coast would have to be regenerated by artificial means. Direct seeding appeared to be an attractive possibility because of cost considerations and the introduction of aerial seeding. Various attempts had been made to restock logged areas with native species and the smaller seeded species had been sown in a broadcast fashion with variable success depending on physical factors such as site, aspect and ground cover. The major portion of the studies, however, had dealt with Douglas fir which had been largely sown on prepared spots. Unfortunately, the studies had been largely negated by the activities of the deer mouse, <u>Peromyscus</u>, and it had become clear that no success in the direct seeding of Douglas fir could be anticipated until the seed could be protected. Physical barriers were costly and the use of broadcast poisons had disadvantages so that greater stress had been laid on the use of repellants. However, at the time of the report, no effective control had been found.

As a result of these and other observations on direct seeding at the Coast, it became evident that future trials would need to be carried out with protection of the seed from rodents and birds. Finnis has conducted most of the work in this field in British Columbia, as well as field trials employing helicopters for seed distribution. He reported (Finnis (1958) that acceptable stocking could be achieved in direct seeding where tetramine was employed as a protective agent. In 1959, (Finnis (1959) he reported on the direct seeding of an east facing slope that had been logged and burned in 1952 and in which tetramine-methocel, tetramine-acetone and endrin were tested as seed protectants. The tetramine acetone dip treatment had a drastically adverse effect on seed germination and both tetramine-methocel and endrin offered some protection against rodents, although more improvement was necessary. He noted also that on the good quality site concerned, the seeding should have been conducted immediately after slash-burning and not three years later, when planting would have been preferable. In another test, Finnis (1959a) again tested endrin and tetramine repellants, employing an acetone solvent and methocel-rhoplex adhesive. Endrin was also tested with SFX-asphalt emulsion adhesive. The acetone treatments showed greatly reduced germination, whereas the adhesives showed no significant difference from control seed. In the same experiment, tests were conducted to determine whether natural seed fall could be protected from rodents by previously seeding a small amount of rodent repellent-treated seed but the prior seeding failed to protect the untreated seed. In addition, mustard was seeded to test its effectiveness as a cover crop to reduce heat injury to Douglas fir seedlings established by direct seeding. Oriental mustard showed some promise but it developed too late to provide shade for the seedlings. Some success was achieved (Finnis (1960) in direct seeding of Douglas fir, treated with endrin or tetramine in a 137 acre block on Vancouver Island, employing a Cyclone (broadcast) seeder. Two years after the seeding, it was found that 71 percent of the area, consisting of favourable seedbeds of mineral soil, mineral soil with shade, moss and moss with shade, contained 88 percent of the seedlings and accounted for the rather uneven distribution of seedlings. The seeding costs were $5.65 per acre, a very low cost when compared to planting, and the average density of seedlings provided an adequate stocking.

Some work has been carried out in the field of helicopter seeding but it has not been extensive. Possibly, this position is a sound one since direct seeding itself has not been proven or developed to the point where it can be viewed as a reliable management tool for the Coastal Region. Finnis (1958a) tested the effect of rate of seeding and altitude of a helicopter on the ground pattern of Douglas fir seed fall. At altitudes of between 100 feet and 400 feet and at rates between 1½ pounds and 6 pounds per minute, the effective swath was consistently about 75 feet in width. In another test (Finnis (1959b), two areas of 525 acres each were seeded by helicopter using endrin latex arasan treated Douglas fir seed at a general rate of one-half pound per acre. Two years later, the number of seedling which were established was considered to be adequate. The distribution of the seedlings was poor but Finnis felt that it could probably be improved.

Finally, in connection with both natural regeneration and direct seeding, Heatherington (1964) has commented that slash burning increased survival, stocking and seedling distribution in a study which he conducted on the west coast of Vancouver Island. He concluded that from 420,000 to 667,000 viable seeds per acre were required to provide full stocking. Also, because of losses of seedlings, surveys of regeneration should equate five first-season, three second-season and two third-season seedlings to one established seedling.

(2) Planting Stock:

As a result of a growing awareness that natural regeneration could not be relied upon to ensure adequate restocking of the Coastal clearcut areas and because direct seeding cannot, at least as yet, be regarded as a reliable form of artificial regeneration, the Forest Service have placed a growing emphasis on nursery practice and planting stock. It is considered to be unnecessary, for the purposes of this thesis, to enter into a detailed review of nursery practice but it is useful to comment briefly on planting stock.

Armit (1965) compared the performance of wildlings from a natural nursery with plants of the same provenance from standard nursery beds in the north Coastal sub-region. He found that the standard nursery plants grew approximately twice as fast in height than did the wildlings. The indications were that development, general vigour and foliage production were distinctly better for the standard stocks which appeared to be healthier and were becoming fully established at a more rapid rate.

Up until 1961, culling practice in the Coastal nurseries had little uniformity and a standard of quality did not exist. Revel (1962) investigated the quality of Douglas fir planting stock and recommended minimum interim standards. Later, he (Revel (1965) tested these interim standards by comparing the growth of six classes of 2 + 0 Douglas fir culls with normal seedlings. As a result, he recommended that trees with certain apparent defects should not be classed as culls.

The use of cold storage for holding plants dormant is well established in the Province. Revel (1965a) investigated the effects of cold storage on 2 + 0 Douglas fir in Multi-wall bags. The seedlings were lifted at monthly intervals and held in storage for periods of up to six months. Revel reported upon the effects of excessive mud and moisture in bags and of length of storage upon survival and initial growth in plantations.

(3) Planting:

By the end of 1966, the Forest Service Research Division were engaged to a limited extent in plantation trials for spacing and survival. Most of the projects, however, remained to be completed.

A planting development which has attracted interest has resulted from the work of Walters (1961 and 1963). Basically, the development involved the growing of seedlings, in a suitable cultural medium contained in a plastic bullet. The bullet is "shot" into the ground with a planting gun and extremely high rates of planting are possible. The plastic bullet is designed in a way which permits the growing seedling to split and shatter it by root pressure. Walters is continuing the development of this mechanised planting system in a variety of experiments, dealing with both design and application. Illingworth (1966a) has reported on a preliminary trial of bullet planting conducted by member agencies of the Coast Reforestation Board. 16,000 bullets, 2½ inches in length and made of styrene plastic, were dibble planted on a wide range of sites during July, 1965. By the end of November, 1965 survival was low, averaging only 17 percent, and the heavy mortality was ascribed to the deleterious effects of insolation. Differences in survival under different seed bed and slash disposal conditions were at least partially explained by the associated degree of exposure. Illingworth concluded that, because of the disparity between lath-house and field environments, the mid-season planting of very young bullet seedlings in the Coastal Region was clearly more hazardous than was theoretically possible.

(4) Tree Breeding:

Almost at the same time as a positive recognition of the need for planting arose, it was recognised that it must be coupled with maximum productivity, upon which tree breeding could have an important effect. With only limited resources at its disposal, the Forest Service

Columbia sample plots. He found that there were substantial financial benefits to be gained from thinning during an enlightened, long term management, whether or not the operations are started at an early age or delayed for thirty years at the expense of a shorter rotation and incomplete utilisation of the gross yield. He added, however, that an active, mostly local, market which could put small logs to a variety of uses at regular intervals was needed. Also, in some countries, a lack of forest area provided a cogent incentive for maximum intermediate yields per acre whereas the existing abundance of overmature forests in British Columbia blunted the impact of necessity, except in the southerly Coastal regions. Warrack held that, in this southerly region, reduced yields, caused by the regulated depletion of mature stands, coupled with the higher cost of log extraction from increasingly difficult terraine would hasten the time when log production would have to be supplemented by intermediate cuttings in immature but very accessible stands. However, several criteria were hindering the ready adoption of thinning practices and they were mostly related to the price competition that thinned trees must meet from raw material from other sources. Pulp chips from improved utilisation and from what were formerly logging and sawmill waste were cheaper than chips made from cordwood produced by thinnings. However, even in the face of this temporarily luxurious supply, utilisation of thinning yields, Warrack felt, was not quite precluded, particularly as the demand for high value thinning products, such as poles and piling, intensified.

d. Pathology:

(1) Disease:

As Foster and Johnson (1963) have remarked, numerous observations have been made of the diseases affecting Douglas fir plantations. They have cited the reference made by Mounce et al (1940) and by other authors to Poria root rot, by Buckland (1953) to Armillaria root rot, by Porter (1959) to dieback pre-conditioned by low temperatures, by Molnar (1959) to drought injury and by Weir (1959) to sunscald. The observations in other stands are also numerous, to the extent that it is not proposed to review them in detail herein.

Foster and Johnson (1963) were concerned with determining suitable sampling methods for the determination of the incidence of disease in Douglas fir plantations - a subject of importance to forest management. Although they found no satisfactory mathematical model for the frequency distribution of the total population of trees, they presented guides to appropriate sample sizes for stated levels of precision, intended for application to other populations similar to those examined.

<u>(2) Insects:</u>

As with disease, the literature containing references to insect problems in the Coastal forest region is extensive. Much of the work is of a fundamental nature and only of indirect or future significance to management. A current major problem is the balsam woolly aphid (<u>Chermes piceae</u> (Ratz.), a species introduced from northern Europe which has caused extensive damage to noble and grand firs. Whilst some efforts are being made to control its spread, the general current policy is to rely upon a natural abatement of its population levels.

<u>(3) Forest Fires:</u>

The statistics of forest fires are given in the Annexures to this thesis. Logging slash has long been regarded, in the Coastal forest region, as a major fire hazard and Williams (1964) has mentioned several important Coastal practices aimed at the reduction of this hazard. During periods of dry weather, logging activities in the region may be restricted to a morning and early afternoon work period or prohibited entirely, under Provincial Government or logging company regulations. Secondly, logging operators, under the terms of the "Forest Act" are required to dispose of their current logging slash, if instructed to do so by the Forest Service, and they may burn additional slash for reasons of their own. To accomplish this slash reduction operators burn relatively large areas of slash each year, usually in the autumn, and they are required to conduct these burns, as much as possible, without damage to adjacent, standing timber or residual timber.* One of the best aids that an operator has, in guaging the fuel and weather conditions was the Slash Hazard Index which could be computed daily from the Fire Danger Tables for British Columbia, published by the Canada Department of Forestry (1961). Williams hypothethised that, for regulating logging activities and planning slash burns in relatively small areas, improved results might be obtained through an adjustment of the hazard index to allow for the effects of exposure, with particular reference to aspect, slope and degree of shading. After tests, he concluded that adjustments of this kind were only justifiable during the autumn.

(4) Animal Damage:

Mitchell (1964) has studied height growth losses due to animal feeding in Douglas fir plantations and has

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* but, in practice, considerable damage can occur from escaping fire.

cited the previous work of organisations and individuals. Amongst the animals causing plantation damage in the region are the Columbia black-tailed deer (*Odocoileus hemionus columbianus* Richardson), the sooty blue grouse (*Dendragapus obscurus fuliginosus* Ridgway) and, to a lesser extent, elk and squirrels. Mitchell found that the average tree height reduction caused by animal feeding in heavily browsed plantations varied from one-half to two feet for a period of 8 to 10 years and he felt it to be unlikely that either tree volume or quality at rotation age would be seriously affected.

e. Forest Management:

Dobie (Dobie, J. 1966. Product yield and value, financial rotations and biological relationships of good site Douglas fir. Thesis, University of British Columbia) has argued that the practice of sustained yield forest management requires the formulation of plans designed to ensure the economic efficiency of the forest enterprise and based on a knowledge of the volume and value of the timber. He analysed the quantity and value of the product yield from four natural Douglas fir stands, aged 63, 86 106 and 145 years in the region, applying linear programming techniques to determine the optimum joint-product yield from each of the stands.

He found that the net value per cubic foot of tree increased with tree size because of reduced handling costs per unit volume and the better quality yield of the larger trees. The financial rotations, at 3 percent compound interest on establishment costs and on the value of the growing stock, were between 60 and 70 years for the sites concerned and, at 65 years, the margin for profit and risk varied from $1,400.00 to 2,000.00 per acre, increasing with increases in stocking. An increase in the establishment costs did not effect the rotation age but reduced the net value per acre of the stand. An increase in the interest rate reduced both the rotation age and the net value per acre of the stand.

Dobie found that many biological variables were found to be significantly correlated with tree value and volume but regression models using only two or three variables were statistically as good as and, from a practical point of view, much better than more involved models. Combinations of diameter breast height, grade of the butt log and crown class provided the best models for value prediction. Dobie considered, as a result of these and other observations, that the volume and the value of timber from the sites in question could be substantially increased by intensive forest management and complete utilisation of the productive capacity of the land.

As has been described elsewhere in this thesis, there are, in the Coastal forest region, considerably greater acreages of active, private forest tenures than are found in the remainder of the Province. There is, also, a considerably greater acreage of these tenures which is incorporated into tree farm licences. The private tenures have, and do, confer upon the owners a degree of freedom of management which does not occur on unalienated Crown lands such as those formed into public sustained yield units, where management, including regulation of logging is controlled directly by the Forest Service. This relatively greater freedom can result in timber liquidation without concern for reforestation but the Government have provided for this possibility, in part by empowering the Forest Service to enter special timber licences or pulp licences which have been logged, to carry out tree planting or other afforestation (Province of British Columbia (1960). In the case of tree farm licences, all lands within the licence are governed by a management and working plan, written by a registered forester employed by the licencee and approved by the Forest Service (Province of British Columbia (1960a). The plan is required, amongst other things, to provide for "growing continuously successive crops of forest products to be harvested in approximately equal annual or periodic cuts adjusted to the sustained yield capacity of the licence area" (Province of British Columbia (1960b). The tree farm licence has included in it, as an integral part of the licence, all forest lands owned by the licencee that are located within any watershed and drainage basin on which the tree farm licence encroaches (Province of British Columbia (1960c). From these provisions and others the Forest Service retains administrative control over logging plans, reforestation plans and other forest activities within tree farm licences throughout the Province.

So far as the public sustained yield units are concerned, formal management and working plans are the prerogative of the Forest Service but have not yet been prepared. It is anticipated that they will be prepared at some future date. Williston (1967) has enunciated government management policy in the units under which it is proposed to require, under the Cutting Permit by which logging may proceed, to require the operator to conduct silvicultural operations, such as site scarification and planting. The operator will also be required to participate in fire protection, by providing a pre-organisation plan and a stand-by crew.

The British Columbia Forest Service (1958) have stated that, on the Coast, silvical characteristics and the economics of logging are such that logging methods are restricted to either clear cutting or the "seed-tree method" and has described current Coast practices in these directions. It is vital that pre-logging i.e. the removal of the understorey from an old stand, prior to logging, for either cedar poles or pulpwood, is good forest practice and is carried out when markets are favourable. The removal of dead and windfall cedar (chiefly as shakes and blanks), from recently logged areas and selected stands of immature timber is currently confined to the south Coastal region but, as the source of raw material diminishes, the Forest Service anticipates a gradual spread to the north. The sale of cedar poles to operators, from stands of from 80 to 100 years old, is encouraged by the Forest Service, but only provided that the Service has marked the poles to be cut.

The lands under industry and Forest Service management have been discussed briefly. It is worthy of note that certain of the activities of the University of British Columbia (1964 and 1965) Research Forest are of interest to coastal forest management. The forest is primarily reserved for student training and for University research. In addition, however, it is managed