Forest Research Branch

FOREST LAND CLASSIFICATION FOR THE UNIVERSITY OF BRITISH COLUMBIA RESEARCH FOREST

by

D. S. LACATE

Résumé en français

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ABSTRACT

A forest land classification procedure for obtaining an inventory of the land resource for forestry purposes is described. Soil, vegetation and mensurational data are related to relatively homogeneous areas of the land (Land Units) which are mapped on airphotos with field survey checks. Examples are given of the secondary interpretive grouping of Land Units for various management purposes —yield predictions, reforestation and road location.

RÉSUMÉ

Une méthode de classement des terres forestières devant permettre de faire l'inventaire des ressources qu'offrent les terres au point de vue de l'exploitation forestière, est décrite par l'auteur. Les données relatives au sol, à la végétation et aux mensurations dendrométriques ont trait à des aires de terrain (unités géodésiques) relativement homogènes, inventoriées d'après des photos aériennes et vérifiées à l'aide de relevés au sol. L'auteur cite des exemples de groupement secondaire interprétatif d'unités géodésiques pouvant servir à diverses fins d'aménagement, à savoir: prévisions de rendement, reboisement et tracé de chemins ou de routes.

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Forest Land Classification for the University of British Columbia Research Forest

by

D. S. LACATE[1]

INTRODUCTION

A review of many of the approaches used to classify land, soils and forest "sites" has been prepared by Rowe (1962). He stressed that purpose is implicit in all classifications and different purposes lead to different classifications. Conklin (1958) pointed out that there is no single best way to classify resources of an area—in this field of work, as in others, "best" depends on the circumstances and the goals set forth. Best for forest management may well be a system allowing rapid subdivision of the landscape according to physiographic likeness and unlikeness as suggested by Hills (1950).

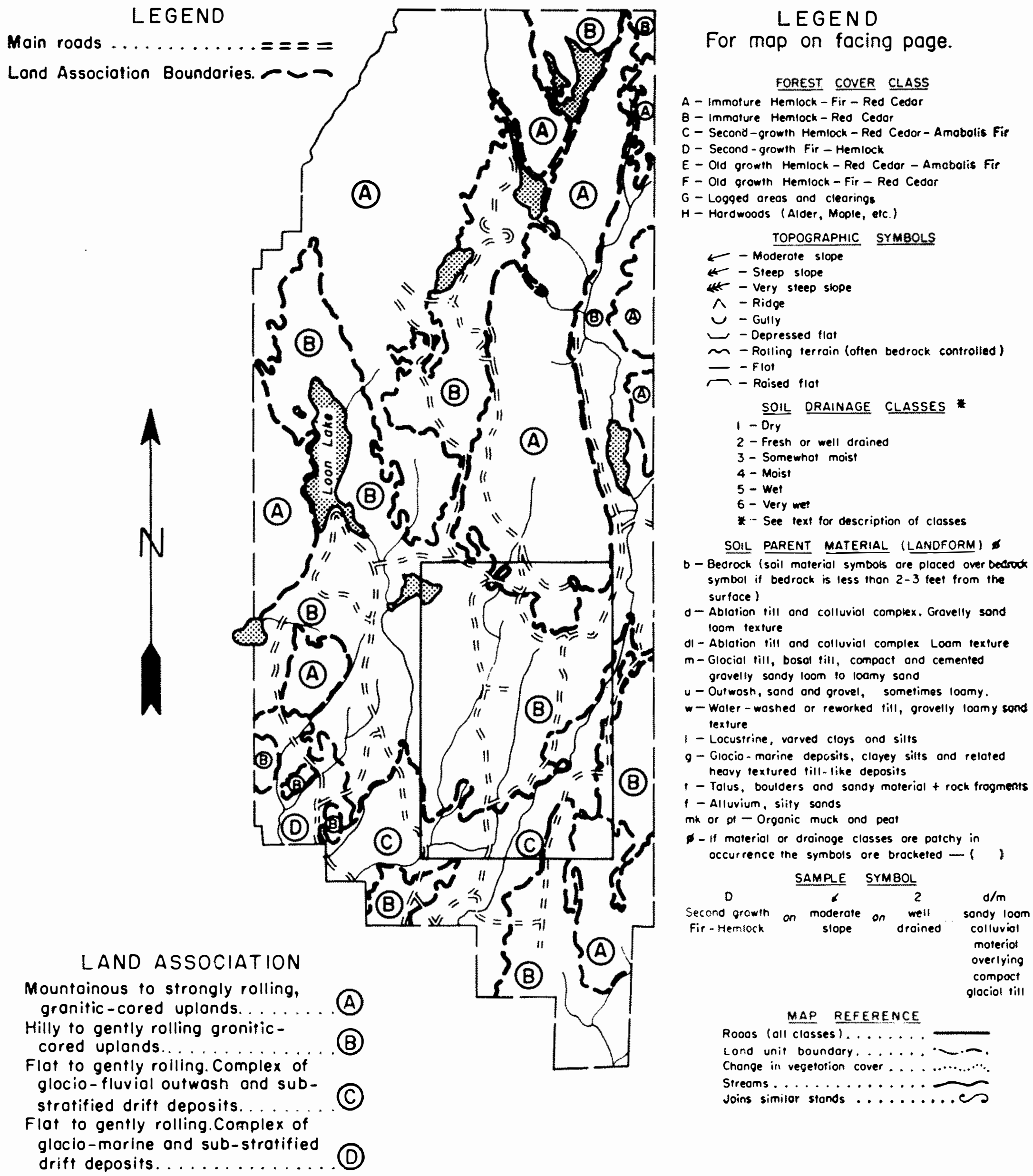
In recent years several research projects in site classification and land appraisal have been initiated on the U.B.C. Research Forest. Major emphasis has been on the factorial approaches to site classification and on ecological studies of forest habitats. For example, Eis (1962) collected data to develop mathematical formulae for predicting both site index and plant communities using selected environmental factors. Bajzak (1960), and Smith and Bajzak (1961), reported on relationships among site index and thirteen major site variables which could be measured or estimated on airphotos. Graduate students under the guidance of Krajina have given attention to the ecology of the forests and forest habitats of the Coastal Western Hemlock and Douglas Fir Zones (Krajina 1961 and 1962), basing their classifications primarily on the vegetation.

An alternative to the foregoing approaches is the classification of land into geographic divisions or units that are relatively homogeneous with respect to the more stable features of landform, as reflected in slope, surficial geology, soil and vegetation. Such "Land Units" provide a framework to which forestry information and estimates of potential for forestry uses can be related, and subsequently extended over adjacent landscapes using airphotos and airphoto interpretations. This report describes the application of this procedure at the University of British Columbia Research Forest, located 25 miles east of Vancouver.

The objectives of this project were (1) to demonstrate a land classification suitable for forestry research and forest management and (2) to describe, classify and map the 9,800-acre forest as to its surface geology, vegetation, soils and topography. Because the U.B.C. Research Forest was established to serve as a full scale experimental, research and demonstration area, the land resources of the forest were mapped at a very detailed level at a scale of 1:12,000. For present forest management and operational needs fewer subdivisions than those shown on the Land Classification map (Figure 1) would usually be required. For example, for operational purposes all the dry talus, shallow over bedrock Land Units, the dry till, shallow over bedrock, and the dry outwash soils and gravel, shallow over bedrock, could be grouped together in a single class—the main features important for productivity and accessibility ratings are that these land areas are dry, and have a shallow soil mantle.

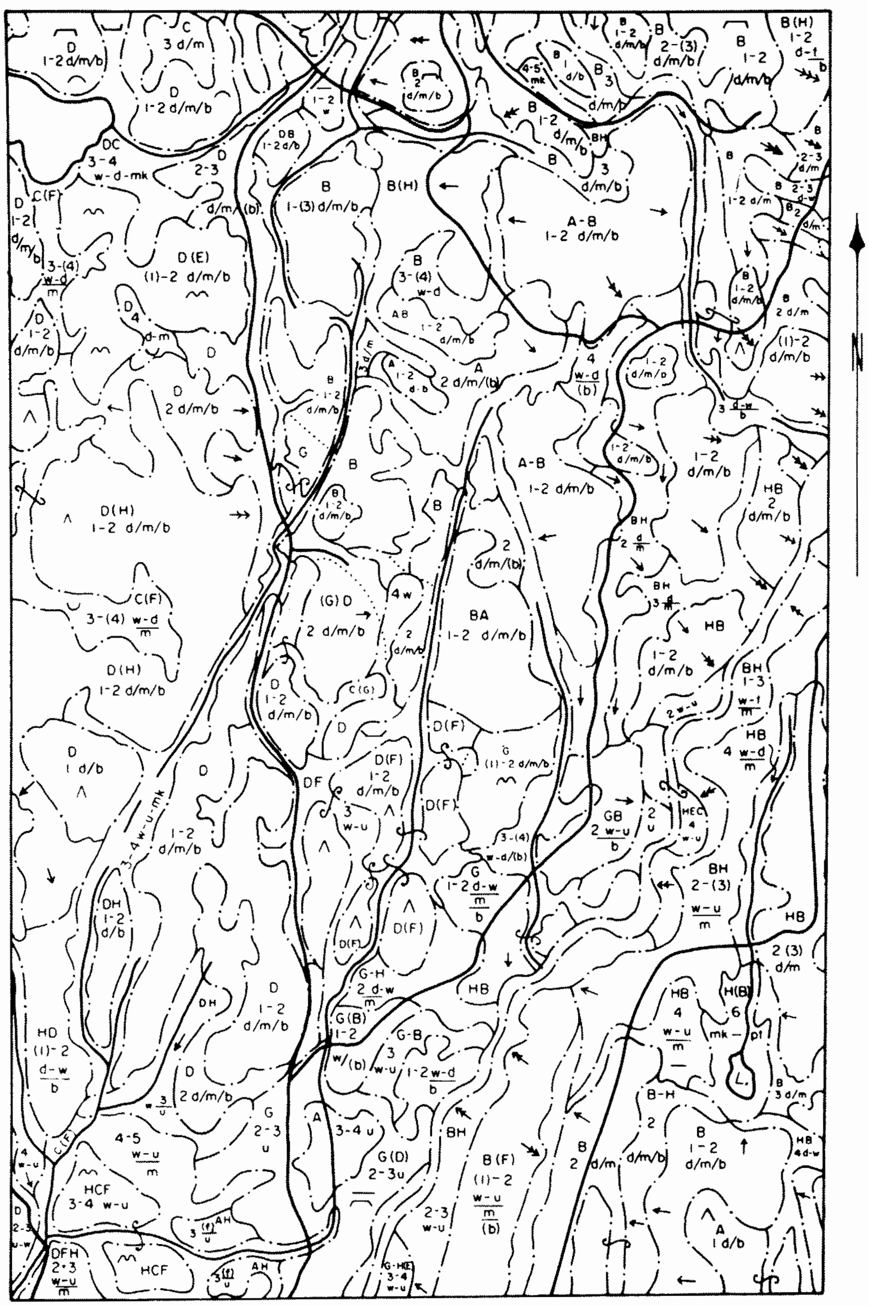
[1]Research Officer, Forest Research Branch, Dept. of Forestry, Victoria, B.C.

Figure 1. Land Classification Map



Scale 1″ = 6000′ approximately

Figure 1A. Land Association map of U.B.C. Research Forest



Scale 1″ = 1500′ approximately

Figure 1B. Sample of detailed Land Unit mapping (rectangular area marked on Land Association map, Figure 1A).

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The results of this land inventory may require some minor revisions as additional information is accumulated. The co-operation and assistance of members of the U. B. C. Forest Research Committee and the staff at the Research Forest during field work are gratefully acknowledged. The writer also wishes to thank Dr. J. H. G. Smith of the Faculty of Forestry for his assistance and advice on various phases of this project.

OUTLINE OF LAND CLASSIFICATION PROCEDURE

A method of classification that can be applied over large areas using airphoto interpretation is desirable. Airphotos present a continuity of topography, relief, vegetation and other features not obtainable on the ground, and are a major aid in the collection of information on landscapes, their forms, and the vegetation they support.

In its stress on the more stable, structural features of land, the classification used is similar to the land studies in Australia described by Christian (1958), and to the land and site classification techniques used by Hills and his co-workers in Ontario (Hills 1950, 1961, and Hills and Pierpoint 1960). The method employed sets characteristics of the vegetation and features of the soil *within* geomorphologic divisions of the land surface. In the definition of the boundaries of these divisions, however, full use is made of all significant ecological features revealed through changes in patterns of vegetation and soil. Two units of classification are used, the Land Unit and the Land Association.

Forest *Land Units* are the relatively small, homogeneous segments of the land surface which have a characteristic topographic form and internal geologic structure, and with which are associated distinctive types of soils and vegetation. They are morphological units or divisions of the landscape that can be readily observed on airphotos of scales 1:12,000 or 1:16,000. Their boundaries can be defined just as exactly as forest cover type or soil series boundaries, for in most cases their boundaries follow physiographic changes from concave to convex topography, from shallow soil to deep, from steep to moderate slopes, etc. (See Figure 2). The essential features of a Land Unit are physiographic, i.e. it is characterized by slope, slope position and terrain structure. For example, a single Land Unit could be described as follows: a smooth, upper, steep slope composed of gravelly sandy loam colluvium, shallow on bedrock, dry. Common indicators of this Land Unit in the field are *Douglas fir—Gaultheria** association and minimal podzol soil profile.

To a limited extent, different vegetation and soil profile types can occur in the same *type* of Land Unit, either in different places at the same time, or at the same place at different times—due to modifications by fire, wind, soil creep, logging, etc. or, alternatively because of the absence of such disturbances on a given area for a long period of time. Although similar to the "Land Unit" used by Coaldrake (1961) the present use of the "Land Unit" places greater emphasis on the *form and structure* of the terrain as the integrating framework for soils and vegetation.

The *Land Association* is an aggregation of geographically associated Land Units. Each Land Association (mosaic of Land Units) covers a large area and separates, for example, hilly lands from the valleys, the valleys from the plains, etc. It is primarily a geographic classification unit to which generalizations of basic data can be related for regional comparisons and planning. The Land Association is most useful at the reconnaissance level in the establishment of the outer limits of the areal distribution of various Land Units. In the U.B.C.

*Botanical names are listed in Appendix I.

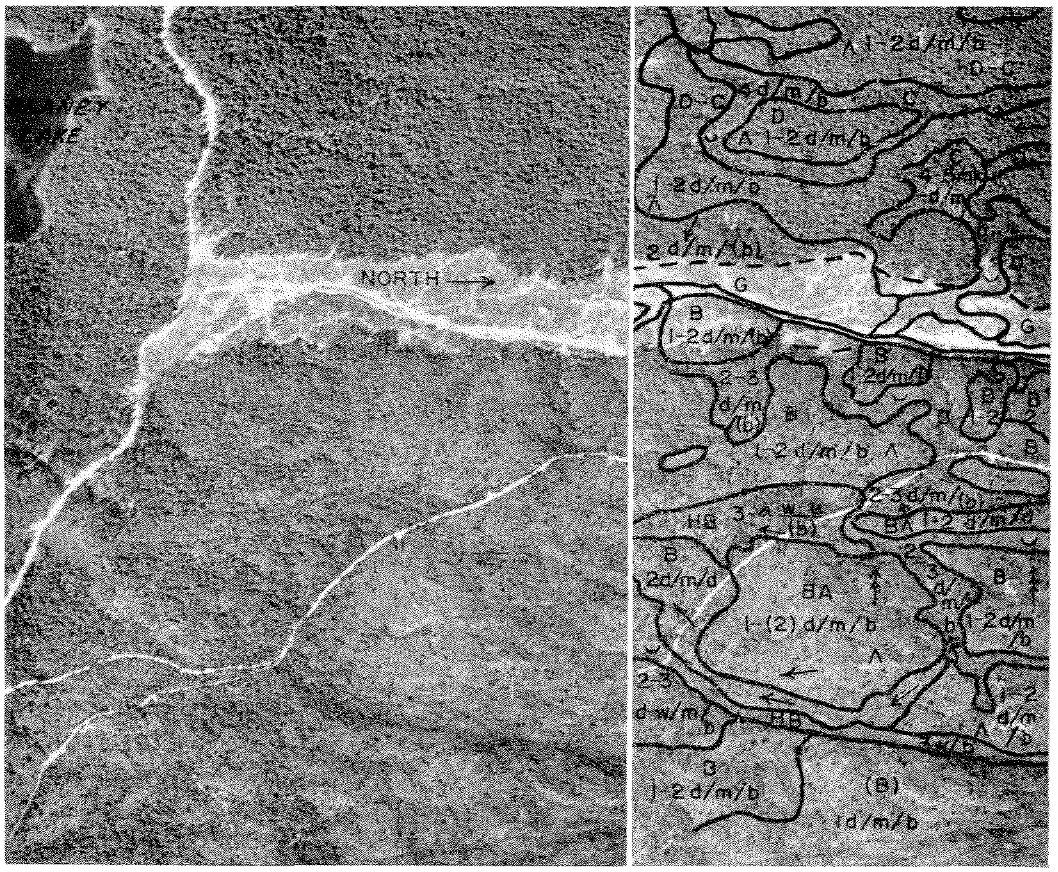

FIGURE 2 Stereo-pair airphotos illustrating the type of terrain included within Land Associations A and B. Land Unit boundaries are shown on this portion of the Research Forest which lies northeast of Blaney Lake (scale approximately 1:16,000).

Research Forest four Land Associations have been recognized. Land Associations A and B, both composed of glacial till over bedrock, are separated on the basis of different topography and the dominance of certain Land Units. For forest management purposes the differentiation of Land Association A from B is useful, for it separates the steep rocky lands from the more accessible and more productive lands. Land Associations C and D are separated from A and B on the basis of differences in surface form and parent soil materials; Land Association C is predominantly composed of sorted outwash sands and gravels, and Land Association D is predominantly glacio-marine deposits.

Airphotos at a scale of 1:60,000 are most useful for initial Land Association identification and mapping. Land Association boundaries are fitted to significant topographic and geologic boundaries on the earth's surface. Where these features are obscured, as in the heavily forested areas of coastal British Columbia, the boundaries can frequently be determined by the reciprocal use of characteristics of the vegetation, soil and terrain. The Land Association, in its present application, includes one or more *catenary associations* of soils—a catenary association being a group of associated soils "developed from one kind of parent material but differing in characteristics due to differences in relief and drainage" (Anon. 1951).

The same Land Unit may occur in more than one Land Association, but with varying areal importance. In the Research Forest, for example, the Land Unit composed of dry to well-drained shallow till on bedrock ridges occurs in Land Associations A, B, C and D, but its relative importance within each Land Association in terms of per cent area occupied is 62%, 35%, 2% and 16% respectively.

This system of classification, based on the identification and mapping of Land Units and Land Associations, establishes areas of the land surface as major units for forest management. It differs from the Unit Area Control Management concept, for example, which is based primarily on characteristics of the forest stand and vegetation (LeBarron 1958 and Hallin 1954). As forest management is directed to areas of land for purposes of timber production it seems logical to emphasize those physiographic variations in land that basically relate to productive capacity, regeneration potential, accessibility and erosion hazards.

THE FOREST AREA

Location and History

The University of British Columbia Research Forest lies within the Southern Pacific Coast Section (C.2) of the Coast Forest Region (Rowe 1959), and is located on the south fringe of the Coast Mountains. The forest is bounded on the north and east by Garibaldi Park and on the northwest by Pitt Lake (Figure 3). Its southern boundaries are approximately four miles north of Haney, B.C.

The primary tree species of the area are Douglas fir, western hemlock and western red cedar. Other species of limited importance in the Forest are western white pine, grand fir, amabilis fir, yellow cedar, sitka spruce, red alder and broadleaf maple.

Summaries of the logging and fire history in the area are presented in the U. B. C. Faculty of Forestry Bulletin (Anon. 1959) and by Walters and Tessier (1960). The oldest trees are 800-year-old Douglas fir, the most common age of the old growth is 300-350 years. The oldest of the second-growth stands, located on the Pitt Lake slope, is 120 years of age and probably originated following a fire about the year 1840. Younger second-growth stands have become established on a fairly extensive area which was burned over in 1868.

In 1921 logging operations were started on the east side of the Forest by Abernethy and Lougheed Logging Company, and this became one of the largest railway logging operations in the province. In 1925 a fire started near Alouette Lake (east of the forest boundary) and burned 1,560 acres and in 1926 and 1931 additional fires did extensive damage between Marion and Mike Lakes.

Brown and Kirkland Company logged Timber Berth 351, a part of which was located in the northwest corner of the present Forest, from 1926 to 1931.

Climate

Continuous weather records have been maintained since 1946. Data on precipitation, temperature ranges and averages, frost-free period and hours of bright sunshine have been summarized by Griffith (1960).

The region as a whole is warm and dry during the summer and comparatively mild and wet during winter months. Precipitation follows the general pattern for the southern coastal region of British Columbia—October to March is very moist with an average monthly precipitation of 11.24 inches, and the other six months are relatively dry with the average monthly rainfall being 3.98 inches. The average annual precipitation for the 12-year period 1946 to 1957 ranged between 62 and 107 inches (average 91.33 inches).

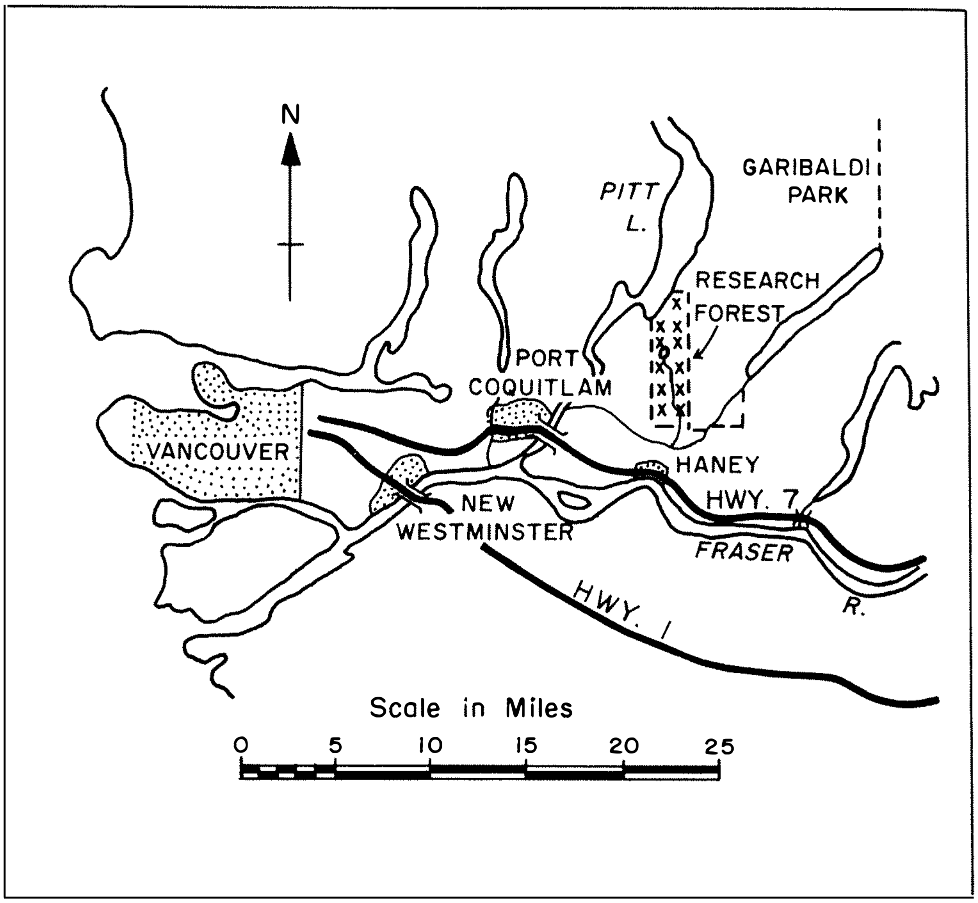

Figure 3 Location of study area

The average frost-free period is 193 days (the shortest of 156 days in length occurred in 1950 and the longest of 225 days in 1947).

Geology and Topography

The underlying bedrock is mainly quartz diorite and granodiorite. Volcanic rocks and granite occur locally around Loon Lake, Gwendoline Lake and in the northeast portion of the forest. The bedrock is overlain by glacial till, outwash, glacio-marine and lacustrine deposits of varying thickness and extent. The distribution, structure, and form of these surficial deposits and associated soil types is described later in greater detail.

The major drainage is by the North Alouette River in the east and Blaney Creek in the west. Elevations on the forest range from sea level (Pitt Lake) to 2,600 feet A.S.L.; the southern part of the forest lies below 1,200 feet A.S.L. and has a general southerly to south-westerly slope. North of this, three major north-south valleys occur; the western depression contains Loon Lake, the eastern valley Marion Lake and the North Alouette River, and the central valley Placid Lake, Blaney Creek and Blaney Lake. The most northerly part is characterized by a ridge that slopes steeply to Pitt Lake in the west and more gently to Gwendoline, Katherine and Eunice Lakes in the east.

METHODS

The first step was an exploratory study in 1960 to obtain information on the local forest and land patterns. Broad geomorphologic units or Land Associations were identified and mapped on air photos, the boundaries being located with reference to major "breaks" in the terrain and its accompanying pattern of vegetation cover. Land Units (subdivisions of the Land Association) were then identified and mapped by studying conditions in the field in combination with airphoto interpretation. Detailed information on the forest cover, understorey vegetation and soil profile of Land Units was obtained in the field. These data were related back to correlative features visible on the airphotos, such as slope characteristics and forest stand structure.

In 1961 over one hundred 1/5-acre plots were established to obtain productivity ratings for various Land Units. On each plot all trees were tallied in one-inch diameter classes, and the height and age of several dominants were taken. Characteristics of the vegetation and micro-relief within, and surrounding each sample area were recorded. Morphological features of the soil were examined in a soil pit excavated on each plot. Forest Land Unit boundaries were corrected and refined as the survey progressed. A final map (Figure IB) was then prepared.

LAND DIVISIONS

Land Associations and Land Units of the Forest are illustrated on the land classification map (Figure IA & B). The Land Units are described in terms of forest cover, topography, landform structure, and soil drainage. A sample of Land Unit mapping is presented on the stereo-pair airphotos (Figure 2).

Four Land Associations were identified. The percentage of the total area included within each Association is as follows:

	Total Area of Research Forest
	%
Land Association A	42.5
Land Association B	43.9
Land Association C	7.8
Land Association D	2.2
Water and Streams	3.6
	100.0

Land Association A—Mountainous to Strongly Rolling, Granitic-Cored Uplands

This Land Association has rugged, mountainous topography and extensive areas of shallow soils. The granitic bedrock is generally overlain by dense, compact glacial till which is nearly impervious despite relatively little clay and a high percentage of sand. This is partly a result of the weight of glacial ice beneath which the till was deposited and partly a result of mechanical composition; fine particles fill voids between coarse particles and bind them together to form a natural "concrete" (Armstrong, 1957).

Soils have been developed on a complex of ablation till and colluvial material which overlies the till, (throughout this paper the term *colluvium* and the symbol "d" will be used for this material which is generally unsorted and of a gravelly sandy loam texture).

The forest and vegetation cover is extremely variable due to the range in land features included in the Land Association and the sequence of logging and repeated fires. The distribution of forest cover types by Land Units is shown on the land classification map (Figure 1B). The geographic distribution of some common Land Units are illustrated in the profile diagrams (Figure 4). Table 1 summarizes the composition by Land Units of Land Association A.

TABLE 1. LAND UNITS OF LAND ASSOCIATION A, MOUNTAINOUS TO ROLLING GRANITIC-CORED UPLANDS

Land Units		Total Area of Land Association A
General Description	Mapping Symbols* for Soil Drainage and Materials	%
Dry, shallow colluvium and till on bedrock	1 and 1-2 d/m/b	62.0
Fresh to moist colluvium and till on bedrock	2 and 3 d/m/b	26.0
Fresh to moist colluvium and till, deep	2 and 3 d/m	7.0
Moist coarse till and colluvium	3 and 4 d or w / m / (b)	3.0
Wet to very wet soil materials	5 and 6 drainage classes on all materials	0.6
Miscellaneous inclusions		1.4
		100.0

*See Tables 3 and 4, Appendix II for keys to soil characteristics symbols.

Land Association B—Hilly to Gently Rolling, Granitic-Cored Uplands and Valleys

Covering approximately the same total land area as Land Association A, this Land Association occurs throughout the forest. In the north it is confined to the Marion Lake–North Alouette River Valley, the central depression running from Blaney Lake to Gwendoline and Eunice Lakes and a strip of land around the north and east shores of Loon Lake.

Land Association B is characterized by a higher proportion of deeper soils than is found in Land Association A, and by less rugged terrain. Gravelly sandy loam colluvium overlying unweathered, compact, glacial till and/or bedrock is the most common structural pattern of the terrain. In draws and low-lying areas reworked till and poorly sorted sands and gravels mantle glacial till. A small area of rich, loam colluvium is situated near Loon Lake camp. Patches of talus, and varved, lacustrine clays and silts are minor inclusions.

An organic cap, often 6–8 inches thick, mantles the glacial drift and bedrock on many areas supporting old-growth stands. In moist draws a deep muck is often present.

A summary of the area occupied by various Land Units in this Land Association is presented in Table 2. Forest cover type and Land Unit distributions are illustrated on the map (Figure 1B), and Figure 5.

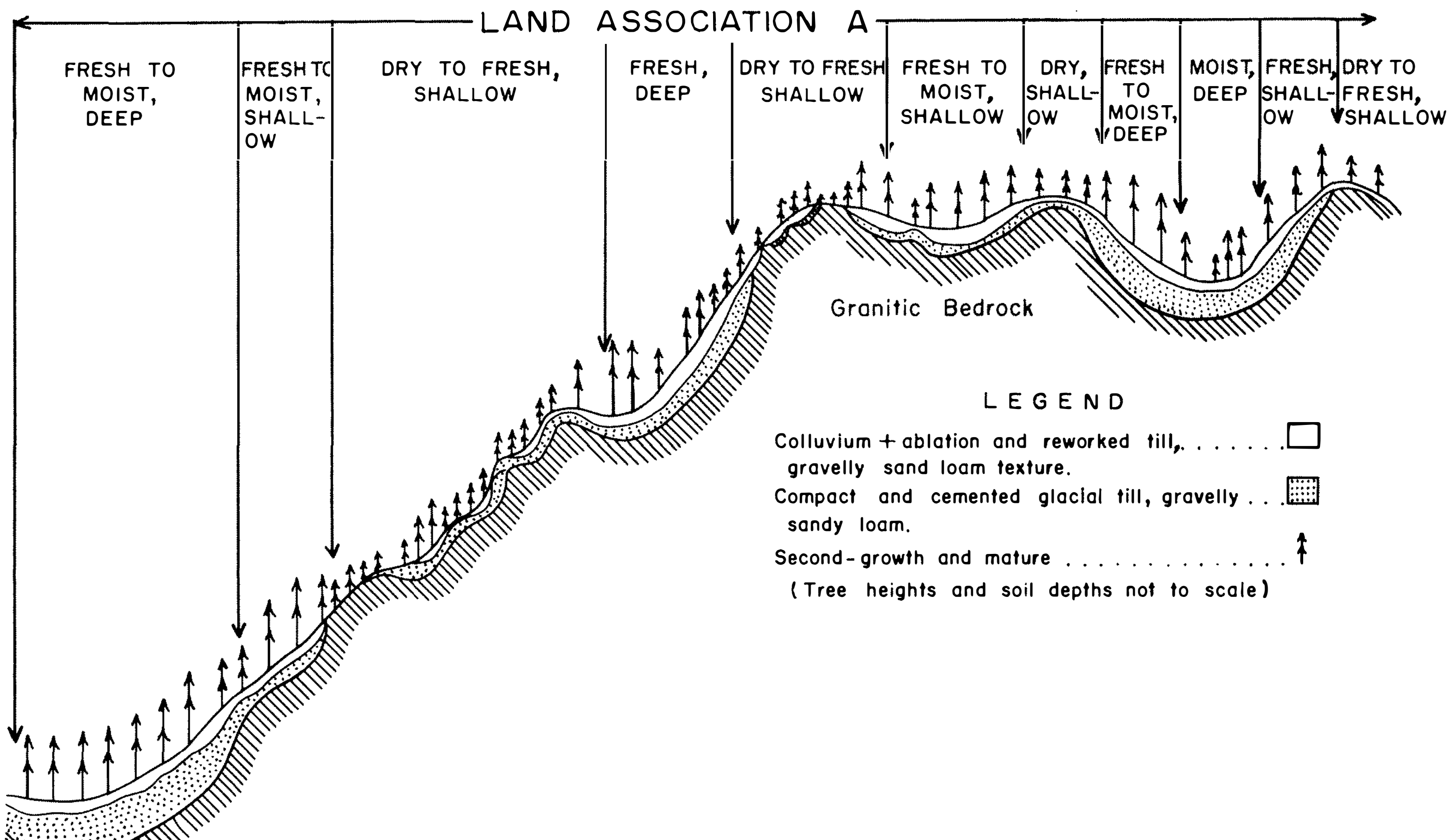

FIGURE 4 Profile diagram of representative land units of Land Association A

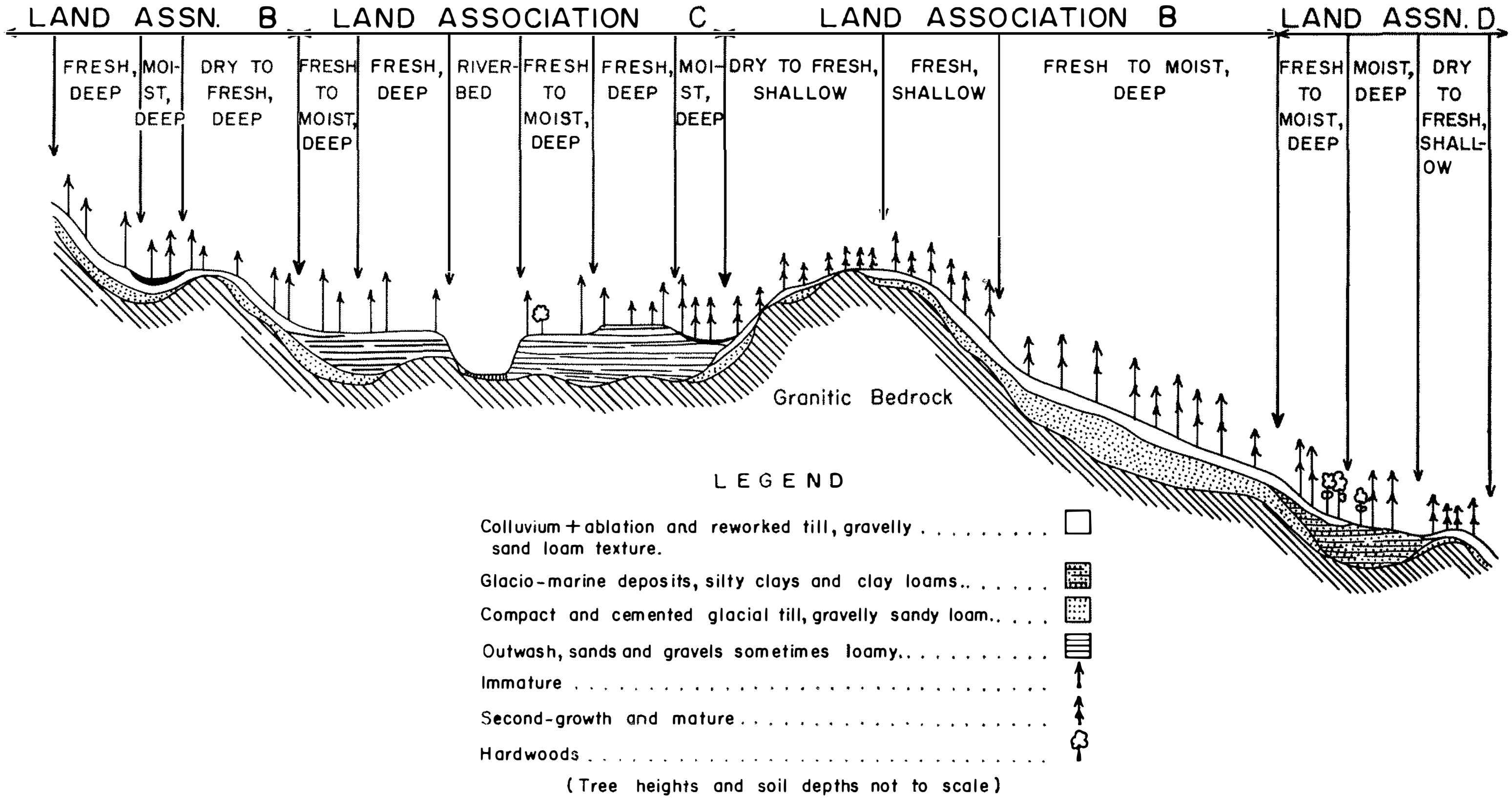

FIGURE 5 Profile diagram of representative land units of Land Associations B, C and D

TABLE 2. LAND UNITS OF LAND ASSOCIATION B, HILLY TO ROLLING GRANITIC-CORED UPLANDS AND VALLEYS.

Land Units		Total Area of Land Association B %
General Description	Mapping Symbols for Soil Drainage and Materials	
Dry to fresh shallow colluvium and till on bedrock	1 and 2 d/m/b	35
Fresh to moist colluvium and till on bedrock	2 and 3 d/m/b	19
Fresh to moist colluvium and till, deep	2 and 3 d/m	25
Moist washed till	4 w or w/(b)	11
Moist to wet washed till and muck	4 to 6 mk-w	5
Fresh to moist loam colluvium	2 and 3 d_l/m or d_l/m/b	1
Miscellaneous inclusions of outwash, alluvium, etc.		4
		100

Land Association C—Flat to Gently Rolling, Complex of Glacio-Fluvial and Sub-Stratified Drift Deposits

This Land Association comprises the lower parts of the North Alouette River and Blaney Creek valleys, and a strip of land between these two water courses. Outwash sand and gravel terraces and deltas are the common landforms. The soil materials are quite deep. Although these sediments are generally permeable, tree rooting is restricted on some terraces by discontinuous iron pans and cemented layers. Temporary, perched water tables occur above these layers for short periods during the year. Except for terrace scarps and the occasional bedrock knoll the topography is flat to gently sloping. The Land Units included are summarized in Table 3.

Much of this Land Association was logged in recent years, partly due to its accessibility and low relief. Stands of immature hemlock, cedar and Douglas fir, and hardwoods (which have invaded some of the logged areas and moist lowlands) constitute the major portion of the forest cover (see Figures 1B and 5 for forest cover type and Land Unit distributions).

TABLE 3. LAND UNITS OF LAND ASSOCIATION C.

Land Units		Total Area of Land Association C %
General Description	Mapping Symbols	
Fresh to moist sands and gravels	2 and 3 u and w-u	57
Moist sands and gravels and recent alluvium	3 and 4 w-u and f/u	18
Moist to wet washed till and muck	4 to 6 mk-w	9
Dry to fresh colluvium and till on bedrock	1 and 2 d/m/b	2
Fresh to moist colluvium and till, deep	2 and 3 d-w/m	7
Moist washed till and muck (draws)	3 and 4 d-w-mk	7
		100

Land Association D—Flat to Gently Rolling, Complex of Glacio-Marine Deposits and Sub-Stratified Drift

Although limited to the southwest corner of the forest and occupying only 2.2 per cent of the total area, this Land Association contains some of the most productive land. Glacio-marine deposits are dominant over a rolling to flat topography. Some inclusions of bedrock knolls and islands of till occur within the Association (Figure 5). These glacio-marine drift deposits have a silt loam to silty clay texture. Stones and sand lenses are scattered throughout. Armstrong (1957) states that "the stones and part of the fine materials were transported by floating ice and the remainder of the fine material carried by meltwater and sea water."

The per cent of the total area that various Land Units occupy in Land Association D is summarized in Table 4.

Second-growth hemlock-fir stands are the common forest cover. Old-growth cedar, hemlock and fir are scattered in patches in draws and on protected slopes. Alder, broadleaf maple and vine maple occupy some very productive, fresh and moist, glacio-marine Land Units.

TABLE 4. LAND UNITS OF LAND ASSOCIATION D, FLAT TO GREATLY ROLLING COMPLEX OF GLACIO-MARINE DEPOSITS.

Land Units		Total Area of Land Association D %
General Description	Mapping Symbols	
Fresh glacio-marine clays	2 and 3, g and w-g	62
Moist glacio-marine clays	4 and 4-5 g	8
Moist colluvium and till	3 and 4 w-d/m	14
Dry to fresh colluvium and till on bedrock	1 and 2 d/m/b	16
		100

DISCUSSION

Soil

It should be re-emphasized that in this study soil and vegetation data are related to relatively homogeneous segments of the land. Soil series and soil phases have not been set up as the primary objects of study. Soil depth phases—the vertical dimension of the land—are not named as subdivisions of soil series or soil types, but are shown on the map by the use of fractionated symbols, e.g. d/b refers to colluvium over bedrock (less than 30 inches from the surface) and this is the shallow phase of a soil on deep colluvium; slope phases were assigned to each Land Unit as it was mapped.

Evidence of soil creep, slides and slumping is reflected in many soil profiles on upland terrain and it is evident that geomorphological processes cannot be ignored in the study of forest soils and soil genesis in mountainous terrain. Buried profiles, overlain by colluvial-alluvial caps varying in thickness from 6″ to 30″ were observed on many lower slopes. On some upper slopes the surface horizons of a profile have been removed or disturbed by gravitative transfer.

Soil profiles were classified as to sub-group (Anon. 1960) on most sample plots. In Land Associations A and B, minimal podzols occurred on slopes and ridges where the soil was shallow to bedrock. On Land Units with deeper soils, minimal and orthic podzols, and acid brown wooded soils, were most common. Concretionary brown soils were observed on some moist, deep colluvium/till materials; gleyed acid brown wooded soils were common in moist areas. In old-growth stands in Land Associations A and B, acid brown wooded and orthic podzol soils were common on the better-drained conditions, ortstein and gleyed podzols where drainage was imperfect, and eluviated gleysols and peaty gleysols where drainage was poor.

In Land Association C minimal podzols and orthic podzols are associated with dry to well-drained soils, and acid brown wooded profiles on well-drained to moist conditions. Acid brown wooded and orthic podzol profiles predominate on somewhat moist and well-drained Land Units within Land Association D. Gleyed acid brown wooded soils are associated with moist areas, and gleysols with poorly drained areas.

Soil Drainage

A major criterion used to subdivide the land surface into significant units for forestry is soil drainage, viz., the frequency and duration of periods when soil is free of saturation or partial saturation (Anon. 1951). Soil drainage can be assessed on the basis of differences in soil colour, depth to mottling or gleying, depth to impermeable material, topographic location, size of watershed, depth to existing water table, and the texture, structure and permeability of the solum.

It was found that depth to mottling could not be relied upon to determine drainage class. Frequently it was little more than a measure of depth to impermeable materials. The intensity of mottling, however, was a useful criterion for separating drainage classes.

On the Research Forest where compact, cemented glacial till or bedrock lie close to the surface over a great percentage of the area, the downward removal of water is restricted. Lateral movement of water in the soil takes place at the contact between the colluvium surface material and the indurated glacial till beneath (as lateral seepage of water is important in the Research Forest, all changes in slopes which would divert seepage water from an area, or which would tend to concentrate seepage in another locale, were carefully noted and mapped on the air photos). Many changes in soil profile features were tied in to these changes in slope and to the varying size of watershed above and below each field sample point.

For airphoto interpretation purposes it might be better in some areas to abandon soil profile drainage characteristics and adopt instead visible surface drainage characteristics as suggested by Curtis (1963). As an illustration, the following land surface "drainage classes" (1) rapid shedding, (2) shedding, (3) normal, (4) receiving, (5) receiving-restricted removal, and (6) enclosed, can be used on the Research Forest in place of the (1) dry, (2) fresh, (3) somewhat moist, (4) moist, (5) wet and (6) very wet soil drainage classes outlined in Appendix II, Table 3.

Vegetation

Specific plant communities were not assigned to all the Land Units identified and mapped. Field observations indicated that many of the associations described by Krajina (1961, Appendix B) could be fitted into the Land Unit framework. Although some plant associations were found on more than one type of soil, and changes in vegetation and Land Unit boundaries did not always coincide, generally one plant community predominated on each Land Unit.

In second-growth stands within Land Associations A and B, for example, Douglas fir—*Gaultheria* associations predominated on dry, colluvium, shallow on bedrock. This association can also occur on dry, flat to gently rolling Land Units on outwash materials. The moss associations were common on moderately productive, well-drained, deep colluvium/till, on outwash materials and on some waterwashed deposits. In several instances, as on an outwash terrace, it was apparent that a dense tree canopy was favouring a moss cover in locales which were surrounded by *Gaultheria* type.

The *Polysticum* associations occurred on several different soil types which had developed on terrain of variable structure. The supply of seepage water throughout the growing season, rather than soil type, seemed to be the major factor influencing the distribution of this plant community. This association was most common on somewhat moist to moist colluvium/till Land Units. It also occurred on somewhat moist to moist fine-textured, glacio-marine Land Units and on sandy and gravelly terraces where the water table was near the surface. Although *Polysticum munitum* rhizomes were generally in mineral soil, on several occasions they were traced to moist, surface and subsurface decaying wood.

APPLICATION

This Land inventory describes the kinds of land present, their areas and locations—information that can be used to group Land Units on a basis of productive capacity, ease of regeneration, erosion, vegetation competition and accessibility. It is also important for forest research in locating specific forest and land conditions required for a particular study.

In Table 5 the Land Units are grouped into production "capability classes" based on site index data for Douglas fir. The data were collected on Land Units supporting second-growth Douglas fir–western hemlock stands. When estimates of forest productivity are related to recognizable Land Units, this information can then be applied to other forested or non-forested Land Units having similar morphology. For example, areas of dry, shallow colluvium on bedrock support poor stands. Structure and form of the land are the major factors to consider in separating out these shallow-soil areas which can be found on all topographic positions, ridges, slopes, valleys, etc. Where dense forests mask topographic features, characteristics of tree canopy, texture of the crowns and tree heights can be used as aids to delineate Land Units of similar morphology and use-capability.

A single-purpose forest productivity map can be produced by using the data in Table 5 and colouring portions of the Land Unit map (Figure 1B) according to the classes outlined.

Information of use in the preliminary assessment of reforestation potential can also be derived from the Land Unit Map (Figure 1B), where the location of productive and non-productive land is shown. The descriptions of soil and land provide guides as to accessibility, seed bed and soil moisture conditions of various Land Units. Brush invasion problems can be expected, for example, on somewhat moist to moist glacio-marine and colluvium/till Land Units. This information and economic criteria will govern the selection of the areas that warrant expenditure for restocking. For projects dealing specifically with reforestation assessment more detailed studies on vegetation competition, seed bed conditions, etc. would be needed; and if forestry experience and data are related to recognizable units of the land surface they can be applied to similar areas within a management unit.

TABLE 5. SITE QUALITY RATINGS ASSOCIATED WITH COMMON LAND UNITS OF THE RESEARCH FOREST.

Land Capability Class	Forest Land Units	PLOT DATA			
		Site Index for Douglas fir		Range in Rooting Depth in Inches	No. of Plots
		Average	Range		
1. Best land for Douglas fir production	Well drained to somewhat moist, deep, glacio-marine materials. 2–3g.	167	165–175+	24–54	5
	Well drained to somewhat moist, deep, colluvium/till. 2–3 and 3d/m.	161	150–175+	30–54	19
2. Very good land for Douglas fir production	Well drained, deep colluvium/till. 2d/m.	147	135–155	28–52	14
	Well drained to somewhat moist, deep, sandy and gravelly outwash. 2 and 2–3u.	150	140–155	36–62	3
3. Good land for Douglas fir production	Well drained, somewhat shallow, colluvium/till/bedrock. 2d/m/b.	134	120–145	20–36	9
4. Fair to poor lands for Douglas fir production	Dry to well drained, shallow, colluvium/till/bedrock. 1–2 d/m/b.	119	(80)–105–130	8–28	7
	Dry to well drained sandy and gravelly outwash. 1–2u.	120	—	28	1
5. Poor lands for Douglas fir production	Dry shallow, colluvium/till/bedrock. 1d/m/b.	90	80–105	0–16	4
	Wet and very wet muck and muck over bedrock areas.	No data available			

The Land Unit map (Figure 1B) also provides data of use in road locations and construction cost estimates. Sources of gravel are indicated on the map by the distribution of outwash ("u") and waterwashed till ("w") materials. Areas composed predominantly of soils shallow-to-bedrock are indicated by the distribution of Land Units having fractionated symbols with "b" (bedrock) as the denominator e.g. d/b, w/b, etc. The topographic symbols drawn in each Land Unit describes in general terms the location of ridges, draws, steep slopes, etc. Seepage areas can be expected wherever the soil drainage class for the Land Unit is 3, 4, 5 or 6. For any given road location a more detailed analysis of the strip of land along the proposed route would be desirable. The Land Unit map does serve, however, as a valuable starting point for developing plans for specific purposes and courses of action.

A "site" or land classification based on only one feature—whether landform, soil or vegetation—is inadequate for sound management of *areas of land for forestry purposes*. A better approach is to integrate and relate soils, vegetation and mensurational data to segments of the land surface which can be recognized and mapped both in the field and on airphotos. These land areas can then be grouped into use categories established to meet local management requirements.

APPENDIX I

List of Common and Botanical names of plants referred to in the text.

Common Name	Botanical Name
Amabilis fir	*Abies amabilis* (Dougl.) Forb.
Grand fir	*Abies grandis* (Dougl.) Lindl.
Vine maple	*Acer circinatum* Pursh
Broadleaf maple	*Acer macrophyllum* Pursh
Red alder	*Alnus rubra* Bong.
Western white birch	*Betula papyrifera* Marsh. var. *commutata* (Regel) Fern.
Yellow cedar	*Chamaecyparis nootkatensis* (D. Don) Spach
Salal	*Gaultheria shallon* Pursh
Sitka spruce	*Picea sitchensis* (Bong.) Carr.
Western white pine	*Pinus monticola* Dougl.
Swordfern	*Polysticum munitum* (Kaulf.) Presl.
Douglas fir	*Pseudotsuga menziesii* (Mirb.) Franco
Western yew	*Taxus brevifolia* Nutt.
Western red cedar	*Thuja plicata* Donn
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.

APPENDIX II

Mapping Symbols and Descriptions

TABLE 1. FOREST COVER CLASSES

A Immature western hemlock, Douglas fir and western red cedar.

B Immature western hemlock and western red cedar.

C Second-growth western hemlock, western red cedar and amabilis fir (scattered western white pine and yellow cedar).

D Second-growth Douglas fir and western hemlock (scattered western white pine and western red cedar and western yew).

E Old-growth western hemlock, western red cedar and amabilis fir, scattered western white pine and Sitka spruce.

F Old-growth western hemlock, Douglas fir and western red cedar.

G Logged areas and clearings.

H Hardwoods, mainly red alder and vine maple (scattered western white birch, black cottonwood and broadleaf maple).

TABLE 2. TOPOGRAPHIC OR FORM SYMBOLS

Moderate slope
Steep slope
Very steep slope
Ridge
Gully
Depressed flat
Rolling terrain (often bedrock controlled)
Flat
Raised flat

TABLE 3. SOIL DRAINAGE CLASSES

Class	General Characteristics
1. Dry (Rapid Shedding)*	Moisture is removed from the soil and its physiographic locale rapidly. Dry soils are common on steep slopes, or are shallow to bedrock, and are of light to medium texture (loamy sand to sandy loam). Very coarse gravelly and sandy upper terraces can also be classed as being dry if the water table is below the rooting zone. Soil profile horizons are generally weakly developed. Mottling is absent throughout the profile except where the soil lies very shallow over an impermeable material where some lateral seepage occurs.
2. Fresh (Shedding)	Soil profile is generally well-developed; soils are usually medium textured, although well-drained conditions can occur on heavy-textured, materials where there is some slope to the terrain; mottling can be present in the C horizon and also in the B horizon where impermeable glacial till lies near the surface; water is removed from the soil readily; seepage water, although present for certain periods of the year, is not available throughout the entire growing season.
3. Somewhat moist (Normal)	Transition to moist conditions; soil profile is well developed, mottling extends well into the B horizon; somewhat moist soils generally occur on flat terrain and lower straight to concave slopes, additions of moisture through seepage is common throughout the early part of the growing season, a slowly permeable layer is generally present immediately beneath the solum.

Appendix II—(cont'd)

TABLE 3. SOIL DRAINAGE CLASSES—(Cont'd)

Class	General Characteristics
4. Moist (Receiving)	Generally found on lower concave slopes, gently sloping and flat terrain; organic staining present in upper profile; seepage water is present during a considerable part of the year; colours are generally not bright throughout the B horizon; some gleying may be present and profile may be mottled throughout.
5. Wet (Receiving-restricted removal)	These conditions occur in swamps and depressions; moderately deep organic cap is present; permanent saturation is near the surface; mucky surfaces are common; mineral soil shows gleying and may have prominent mottles.
6. Very wet (Enclosed)	Water is removed from the soil very slowly; very wet conditions occur in bedrock controlled basins and in depressions where seepage water collects, water table is at or near the surface throughout most of the year; gleying is present, organic cap generally thick.

*Surface drainage classes are in brackets.

TABLE 4. SOIL PARENT MATERIALS

Mapping Symbol	Soil Characteristics
b	*Bedrock* (soil material symbols are placed over bedrock symbol if bedrock is less than 30″ from the surface).
d	*Ablation till and colluvium*; gravelly sandy loam texture; unsorted, loose, composed of variable mixture of sand, silt, clay, and angular to sub-angular stones; pH of parent material ranged from 5.5–6.0.
d_1	*Ablation till and colluvium*; *loam* texture; not as stony as the sandy loam colluvium above; generally unsorted; pH of BC and C horizons ranged from 5.5 to 6.2.
f	*Recent alluvium*, floodplain deposits; silty sands are common soil material, generally permeable and loose.
g	*Glacio-marine deposits*, clayey silts and related fine-textured, till-like, marine drift; clay pans are commonly formed; pH of parent material 5.5–6.0, occasionally 6.5.
l	*Lacustrine, varved silts and clays*, stone-free; thin bands of fine sand are often present; deposits are relatively impermeable; pH of parent material ranges from 5.5 to 6.2.
m	*Glacial till* (basal till), compact, dense and cemented gravelly sandy loam to loamy sand; platy structure and pressure lenses common in unweathered material; pH ranged from 5.5–6.0, occasionally a pH of 6.5 was observed.
mk or pt	*Organic muck and peat.*
t	*Talus*, composed of boulders, rock fragments and sandy material deposited primarily through the influence of gravity; usually very permeable; found at the base of steep slopes.
u	*Outwash*; interbedded, sorted sands and gravels, terraces and deltas are usual landform, pH of parent material 5.8–6.0, occasionally as high as 6.5.
w	*Water-washed and reworked till*, generally gravelly loamy sand in texture, inclusions of fine materials and cobbles occur locally; roughly sorted to unsorted, loose; pH of BC and C horizons 5.5–6.0.

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