SOIL SURVEY

of

SOUTHEAST VANCOUVER ISLAND AND GULF ISLANDS, BRITISH COLUMBIA

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J. H. DAY, L. FARSTAD

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D. G. LAIRD
Canada Department
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Acknowledgment

The soil survey of southeast Vancouver Island and the Gulf Islands was undertaken as a co-operative project by the Experimental Farms Service of the Canada Department of Agriculture, the British Columbia Department of Agriculture, and the University of British Columbia. The British Columbia Department of Agriculture provided field assistants and the University provided office facilities.

During the course of the survey, assistance in the field and laboratory was given by Messrs. H. W. R. Chancey, G. Dargie, A. J. Green, H. J. Hortie, C. C. Kelley, J. D. Lindsay, T. M. Lord, J. S. D. Smith, A. P. Tzogoeff, A. Van Ryswick and S. A. Vernon. Mr. Lord also prepared some charts for the report.

Appreciation is extended to Mr. R. H. Spilsbury, Forester-in-charge, Research Division, Forest Service, Victoria for his contributions to the work in the field, his many helpful suggestions and aid in preparation of the section on native vegetation. Dr. J. G. Fyles, Canada Department of Mines and Technical Surveys, provided guidance on the geology of the area and has written the geological section of this report. Thanks are extended also to members of the Experimental Farm at Saanichton and the Provincial Agricultural Representatives who served in an advisory capacity during the course of the survey.

Dr. A. Leahey and Dr. P. C. Stobbe, Principal Pedologists, Central Experimental Farm, Ottawa, have assisted with many problems of the survey. Dr. Leahey reviewed the manuscript.

Base maps were supplied by the Canada Department of Mines and Technical Surveys, and by the British Columbia Department of Lands and Forests.

The soil maps were prepared for publication by the Cartography Section of the Division of Field Husbandry, Soils and Agricultural Engineering at the Central Experimental Farm, Ottawa.

INTRODUCTION

This report and the accompanying map present information both general and specific about the soils, crops and agriculture of the southeast portion of Vancouver Island. The first survey began in 1938 when the B.C. Forest Service initiated its reforestation program of planting cut-over lands in the Coastal Region. This first survey was primarily concerned with the problem of land classification as between agricultural and forestry use. The data, which formed the basis for a broad plan of land utilization were summarized in the form of a land class map. Three broad classes of land were recognized; namely, arable, forest, and an intermediate class where small acreages of arable land occurred, scattered throughout large areas of forest land.

The most difficult problem of land use involved those lands situated along the foreshore adjacent to the Island Highway and classified as non-arable but containing fractions suitable for cultivation or improved pasture. In view of the favorable climate and location of these lands, it was decided to study this area in greater detail.

This report is the result of these investigations. The first part of the report concerns itself with a general description of the area covering early history, natural resources, and industries as well as economic and social aspects. It also includes sections on physiography, drainage, climate, native vegetation and geology.

The main body of the report is devoted to description and classification of the soils. The soils are described in detail; the distribution and area of each is noted and their use, for agriculture or other purposes, is discussed. The soils are given a productivity rating based on profile observations and landscape features combined with physical and chemical data. These ratings, until verified by field tests, cannot be considered as other than tentative.

Problems associated with these soils are discussed. Some of them are inherent soil properties, such as low natural fertility and undersirable physical characteristics; others concern erosion, cost of clearing, artificial draining, water supply and irrigation.

The soil map, printed on a scale of one mile per inch, identifies soil areas by colors and symbols. The map also indicates location of towns, highways, railroads, schools, churches, lakes and rivers. The report and the soil map are complementary and both should be consulted when seeking information about the soils of a mapped area.

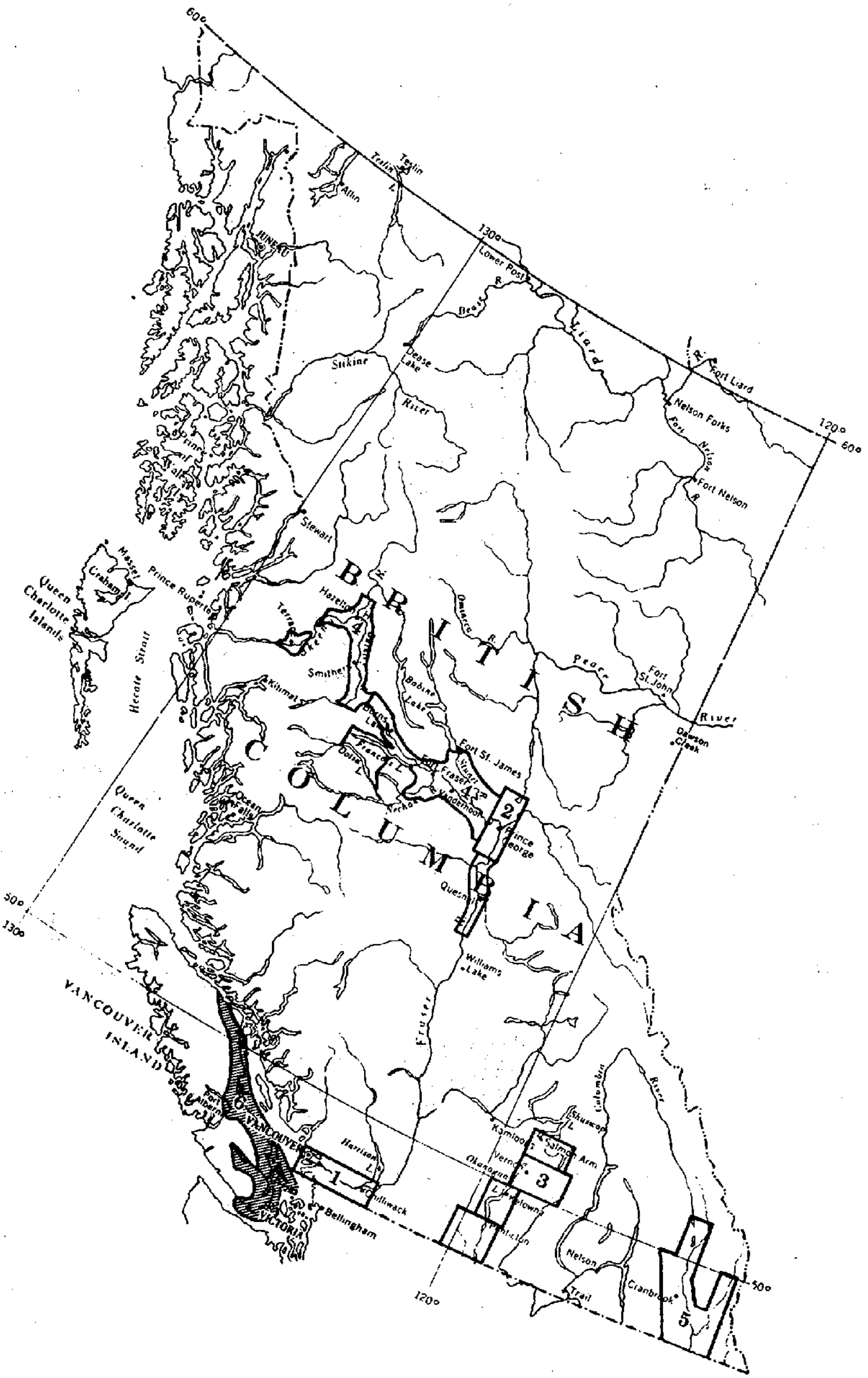

FIG. 1—Map of British Columbia showing locations of surveyed areas for which reports and maps have been published. (1) Lower Fraser Valley, (2) Prince George area, (3) Okanagan and Similkameen Valleys, (4) Quesnel, Nechako, Francois Lake and Bulkley–Terrace areas, (5) Upper Kootenay and Elk River Valleys, (6) Southeast Vancouver Island and Gulf Islands.

DESCRIPTION OF THE AREA

Location and Extent

The area surveyed on Vancouver Island covers the relatively narrow coastal plain along the east and southeast coast, and the valleys on the west coast at the head of the Alberni and San Juan Inlets. The surveyed area also includes Denman, Gabriola, Galiano, Hornby, Kuper, Mayne, Moresby, North and South Pender, Provost, Quadra, Saltspring, Saturna, Sidney, Thetis, Valdes and a number of smaller islands in the Strait of Georgia.

The total area surveyed approximates 710,900 acres. This area represents 8.4 per cent of the land area of Vancouver Island and Gulf Islands and includes all the arable and potentially arable land with the possible exception of one or two small areas on the west coast and at the north end of the Island.

For general location see index map, Figure 1.

Early History

Captain James Cook landed on Vancouver Island at Nootka Sound in 1778 and made the first serious attempt to explore the coast. Here gardens were planted and the first importation of livestock including cattle, sheep, pigs and poultry took place between 1786 and 1790. Colonization of the Island, however, was not seriously attempted until 1843 when James Douglas, an employee of the Hudson's Bay Company, was instructed to explore the southeastern shore for a suitable site for trading headquarters. Impressed by "the open park-like aspect and abundance of nutritious grasses", he established Fort Camosun on the present site of Victoria. The Company cleared land, imported livestock and by 1847 some 300 acres were under cultivation. In 1849 Vancouver Island became a Crown Colony under the auspices of the Hudson's Bay Company and in 1866 it became part of British Columbia. By 1856 there were only 30 independent settlers and discontent was rife, due to the restrictions placed on settlers resulting from the heavy cost of clearing, the lack of markets and competition from Oregon and California.

Colonization in general was extremely slow but gradually small settlements became established near Victoria such as those at Sooke, Saanichton and Duncan. Nanaimo was founded in 1852 and this was followed by a settlement in the Alberni Valley in 1860 and another, two years later, in the Comox Valley. The development of the coal mines at Nanaimo, the establishment of a sawmill at Alberni in 1861 and the completion of the Esquimalt and Nanaimo Railway in 1886 did much to encourage and stabilize agriculture.

The rapid expansion of the logging industry and the development during recent years of many secondary industries, have stimulated agricultural production through providing an important local market for farm produce; they have provided, at the same time, remunerative employment for surplus farm population. Thus, while benefiting on the one hand through local markets, agriculture on the other hand has been forced to compete with logging and industry for available labor.

Natural Resources and Industries

The economy of Vancouver Island and the Gulf Islands is based on the four primary industries—agriculture, forestry, mining and fishing, as well as on the secondary industries that stem from them.

Agriculture

Vancouver Island and the Gulf Islands make up a Canada Census Division and, since all agricultural production is contained within the area under review, data covering the census division are applicable to the surveyed area.

Neither Vancouver Island as a whole, nor even the area under review, is considered to be primarily agricultural, yet agriculture is, nevertheless, an important factor in its economy. The wealth created annually through agricultural production approximates $10 million. There are approximately 193,300 acres of occupied farmland (4) and of this 65,900 acres or slightly over one-third, are improved; 81,700 acres are under forest and the balance is largely waste. There are 3,327 farms and almost one third of these are nine acres or less in size; the average area per farm is 58 acres.

Vancouver Island and the Gulf Islands are ideally suited for a diversified agriculture. A wide variety of farm enterprises from livestock ranching through mixed farming, to intensively specialized lines such as cut flowers and bulb growing, may be observed.

Dairying, followed by poultry raising, are the two major farm enterprises and they, in fact, provide approximately one half of the agricultural income for the area (3). While winter conditions are ideal for dairying because of the mild climate, the drought conditions during the summer months tend to increase production costs. Poultry raising makes good use of land that is submarginal for crop production.

FIG. 2—Daffodils ready for the eastern cut-flower market. Courtesy of B.C. Government Travel Bureau.

The long growing season and mild winters make the production of nursery stock and greenhouse crops profitable enterprises. These specialty crops include cut flowers, seeds, bulbs, bedding plants, holly, nursery stocks, rhubarb, etc. Illustrating this line of production, in 1954 4 million cut flowers (daffodils and tulips) were shipped by air express from the area and during the same year 40,000 lb. of English holly were also shipped (1). Income in 1950 from nurseries and greenhouses totalled more than $1 million and represented 45 per cent of British Columbia production from such sources. This revenue was derived from about 420 acres in addition to about 2 million square feet under glass (3). About one half of British Columbia's greenhouse space is located on Vancouver Island and the Gulf Islands.

The long growing season and mild winters favor the production of another group of cash crops—potatoes and other vegetables. About 3,000 acres are devoted to the production of these crops and the income exceeds $500,000 a year. Over 600 acres produce small fruits with an annual value of well over $300,000.

The more important agricultural districts are those of the Saanich Peninsula, Cowichan Valley, Comox–Courtenay area, Alberni Valley and the Sooke–Metchosin district.

The Saanich Peninsula which includes much of metropolitan Victoria is approximately 20 miles long by 5 miles wide. It is a densely populated area with an intensive type of agriculture being practiced. Since a market for fluid milk is immediately at hand, dairying is an important industry. A considerable acreage is devoted to such crops as bulbs, flower seeds, cut flowers, vegetable crops and small fruits. Keating and Gordon Head, well-established strawberry growing centers, are in this area.

Cowichan Valley is one of the leading dairy farming and poultry producing areas on Vancouver Island. Duncan, with its creamery, poultry packing plant and cold storage facilities in addition to adequate rail and highway connections, provides a first-class outlet for farm products. At the same time an excellent local market exists in the lumbering centers at Cowichan Lake, Youbou, Honeymoon Bay, Chemainus and other points. A pulp mill soon to be in operation at Crofton will provide a further outlet for farm products.

The Comox–Courtenay area is best known as a dairy and mixed farming district though poultry raising is an important industry. This area represents the largest compact unit of agricultural land on Vancouver Island. Courtenay is the marketing and distributing center and is the terminus of the rail line. The coal mining center at Cumberland, lumbering throughout the district and the R.C.A.F. base at Comox add to the importance of the local market.

The Alberni Valley is an industrial area based on logging with sawmills, pulp mills and plywood manufacture. Fishing, too, is of major importance. Agriculturally the valley is relatively small but contains some very fertile soils used for dairy farming and the production of fruits and vegetables for the local market.

An appreciable acreage of tillable land is to be found in the Sooke–Metchosin district. Mixed farming, sheep raising and dairying have been the major agricultural interests over the years. Recently, however, market gardening and production of small fruits have been gaining ground in the Sooke area with strawberries becoming an important crop in the Colwood–Metchosin district.

Forestry

Forestry is the major source of wealth on Vancouver Island. It has less than 4 per cent of British Columbia's land area yet has over 20 per cent of the mature timber (24). The total B.C. cut in 1953 was approximately 5.3 billion board feet, valued at $512 million. Of this, 40 per cent or 2.1 billion feet was taken from Vancouver Island. In 1956, the estimated B.C. production was 6.1 billion board feet, valued at $640 million; the Vancouver Island output was valued at about $256 million. Vancouver Island is the leading timber producing region in the Province.

Mining

Non-metallic minerals including coal and structural materials have proved to be of greater value over the years than metallic minerals. Structural materials secured at various points include sand, gravel, building stone, limestone and clays for industrial purposes (20) (8). Coal mining has contributed markedly to the development of the area and to the Province from the early days of settlement until about 10 or 15 years ago when most of the coal mines closed.

In respect to the metallic minerals, copper and iron ore are of some importance, particularly iron ore in recent times. The production value of Vancouver Island mines (1956) approximates $16 million (24).

Fisheries

Fishing, too, contributes to the economic well-being of the area though perhaps in a minor way; it, combined with trapping, makes use of less than 1.5 per cent of the total labor force.

Salmon caught commercially are taken elsewhere for processing but herring reduction plants are located in the area. In 1954-55 roughly half of British Columbia's total herring catch was taken from the waters adjacent to the area (26) and much of it is handled at these reduction plants. A whaling station located at Coal Harbour near Port Hardy is the only one of its kind operating at the present time along the entire Pacific coast of North America. This station is of interest agriculturally in that it provides protein feed for poultry and livestock and also fertilizer.

Shrimp fishing is a thriving industry in the area. A major portion of the oyster production in British Columbia comes from inter-tidal leased grounds which are adjacent to the area.

Hydro-Electric Power

Major sources of hydro-electric power are located on the Campbell, Puntledge and Jordan rivers; minor sources occur throughout the area. A transmission power line with branches to all important points extends from Campbell River to Victoria. Additional power is imported from the mainland by means of a submarine cable. Undeveloped hydro-electric power resources on Vancouver Island are estimated at 228,000 horsepower (17).

Manufacturing

Secondary industries are rapidly accounting for an ever increasing portion of the productive wealth of British Columbia. Estimated gross value of manufactured products for 1956 reached $1.8 billion; for Vancouver Island and the Gulf Islands the figure was $178 million.

The industries of the region are built upon its natural resources. Forestry, in addition to being the major primary industry, provides raw materials for a large proportion of the manufactured goods. Sawmills followed by pulp and paper mills are the two leading manufacturing industries; the veneer and plywood industry is expanding rapidly. Food processing is next in importance; other manufacturing interests include shipbuilding and Portland cement manufacture.

Tourist Industry

Tourist traffic is becoming a rather important item in the economy of Vancouver Island and the Gulf Islands. Camping facilities, modern motels and hotels are available at all centers of interest. There are 12 Provincial parks in the area under review which are readily accessible; each is of particular interest because of a characteristic feature.

There is a variety of interests to attract sportsmen. Both salt and fresh water sport fishing are available. Strict regulations of game laws provide good deer hunting and upland game birds and water-fowl are protected throughout the rural districts. The larger wild animals in the area are wolves, bear and cougar. Among the fur-bearing animals are marten, weasel, mink, muskrat and beaver.

Population

Vancouver Island and Gulf Islands have a population (1956) of 256,355 and of this about 246,000 or roughly 95 to 96 per cent is confined to the surveyed area. Likewise, 99 per cent of the farm population is confined to this area. Victoria, the capital of the Province and located at the Southern end of the area, had in 1956 a population of 54,584; the metropolitan area including the city itself had a population of 120,869 (5). Other commercial centers with their population as listed from south to north include Duncan—3,247; Ladysmith—2,107; Nanaimo—12,705; Port Alberni—10,373; Alberni—3,947; Courtenay—3,025 and Campbell River—3,069.

The population (1956) of the area is distributed approximately as follows: 68 per cent is urban which appears to be 4 to 5 per cent higher than was the case in 1951; 28 per cent is non-farm rural and 4 per cent represents the farm population. This proportion of non-farming population is high and consequently some farm products, notably milk, fail to meet the local demand.

A review of the primary and secondary industries presents an excellent picture of the region, yet what the population does for a living is best expressed in the following data showing the distribution of the labor force which for 1951 totalled 82,161 (24). Such data are available for census years only:

Industry Groups	Per cent
Service	30.9
Manufacturing	18.4
Trade	13.2
Forestry and Logging	13.0
Construction	6.4
Transportation and Communication	6.3
Agriculture	3.4
Finance	3.0

Each of the other industrial groups, including fishing, mining, trapping and electricity fell below 2 per cent.

The labor force covered in the data does not include housewives or persons attending school. The agriculture, forestry, mining and fishing groups refer to primary industry alone, thus agriculture covers the production of primary products only. The processing of foods is included under manufacturing. In 1951 there were 2,739 occupied farms and the 3.4 per cent or 2,785 persons, constituting the agriculture labor force, suggest that nearly all the farms in the region are operated as one family affairs.

The large 'Service' group (30.9 per cent) includes education, health, government, business services and personal services including hotels, restaurants, etc. This service group is unusually large due to the fact that the seat of government for British Columbia is located, with all its attendant services, within the area.

Transportation

The portion of Vancouver Island under review is well provided with transportation facilities including railways, motor roads and air fields. The Esquimalt and Nanaimo Railway operates a main line from Victoria to Courtenay (140 miles), with branches to Cowichan Lake and Port Alberni; the Canadian National Railway has a line from Victoria through Metchosin, Sooke and other points to Cowichan Lake.

A good boat service connects Victoria and Nanaimo with the mainland and a coastal service is maintained between Victoria, Vancouver and the Gulf Islands. The ports of Victoria, Nanaimo and Alberni provide direct sea connections for export of lumber, canned fish and other products to the markets of the world.

The Island Highway, a splendid scenic route, traverses the length of the surveyed area for a distance of over 200 miles from Victoria to Kelsey Bay. The road between Nanaimo and Victoria was opened in 1884 and now constitutes the most westerly link of the Trans-Canada Highway. An excellent system of primary and secondary roads radiates to the various settlements.

Bus and motor freight lines provide daily service to most settlements.

Airlines have scheduled service between Victoria, Nanaimo, Vancouver and Seattle, and also between Comox and Vancouver.

Social Services

The portion of Vancouver Island and the Gulf Islands under review is well provided with schools, churches and all other services which have come to be recognized as more or less essential.

Elementary schools are well distributed and meet quite effectively the needs of the population. Where schools are not available locally, school bus service is commonly provided. Junior and Senior High Schools are established in the centers of population. There are also a number of well-established private schools for boys and girls.

Victoria College, which is affiliated with the University of B.C., is located at Victoria and provides the first two years of a regular university course.

Most if not all of the more common religious denominations are represented in the larger centers of population and several are commonly found in most rural districts.

Hydro-electric power is available in all settled areas; 83 per cent of the farms are reported to use electric power (6). The entire area is served by telephone service.

Many, if not most farm homes are provided with running water.

Hospitals are located at all the larger centers in the surveyed area. District nurses and welfare workers are available throughout the region.

Libraries are located at many centers throughout the area.

Agricultural Extension Services

Agricultural interests are served by the Canada Agriculture Experimental Farm at Saanichton on Saanich Peninsula and Illustration Stations located at a number of points within the area. District agriculturists are located at Duncan and Courtenay. The extension services of the Provincial Department of Agriculture are centered at Victoria and specialists in various fields such as pathologists, veterinarians, entomologists, agronomists and horticulturists are readily available for consultation.

Physiography, Relief and Drainage

The surveyed area lies partly within the Insular Mountain and partly in the Coastal Trench physiographic divisions. Thus, as might be expected, a wide range in elevations occurs throughout the area.

The Insular Mountain region is the most westerly physiographic division (Fig. 2) in the province and forms the mountains of the Queen Charlotte and Vancouver islands. This chain of mountains is not uniformly developed and while characterized by numerous erosional features, attains an elevation up to 6,000 feet. The mountain foothills, marked by steep slopes and much rock outcrop, clearly define the maximum limit of possible agricultural land. Within the Insular Mountain system two inter-mountain valleys or basins possess topography suitable for agricultural development. They are the Alberni Basin at the head of the Alberni Canal and the San Juan River Valley.

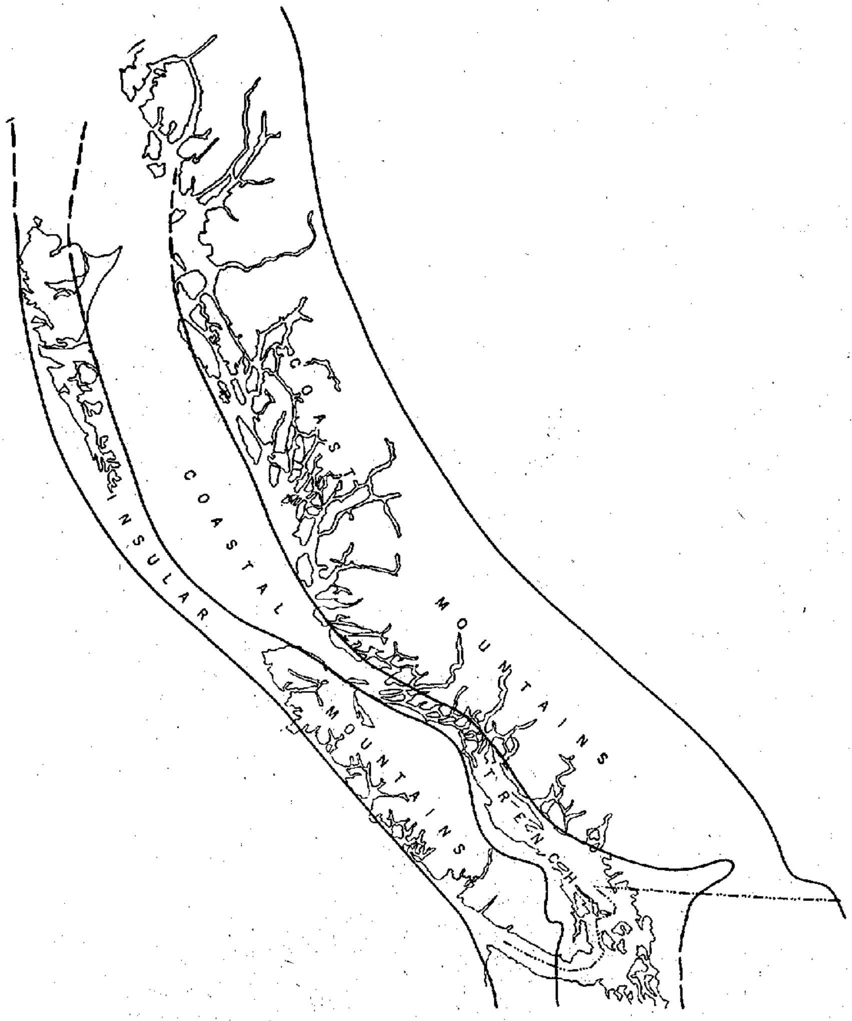

Fig. 3—Physiographic divisions of the southwestern portion of British Columbia.

The Coastal Trench, which extends from the Gulf of California to Cook Inlet, Alaska, takes the form of a series of submerged longitudinal basins in British Columbia. In the area under review the Coastal Plain extends from sea level to an elevation of approximately 500 feet and ranges in width from 1 to 15 miles. (see Fig. 3). The topography of the Plain consists mainly of undulating to rolling upland surfaces. Much of the shoreline is rugged being characterized by wave-cut cliffs, steep promontories, off-shore rocks and islets. Deltas are found at the mouths of many streams which dissect the area. Between the streams rolling moraines, hills, ridges, kame and kettle topography, lacustrine and marine basins and outwash plains form a heterogeneous landscape pattern with an essentially unaltered glacial-drift-type relief. The Gulf Islands, perhaps more severely planed and scoured by glaciers, contain several valleys which parallel the northwest–southeast trend of the Coastal Plain.

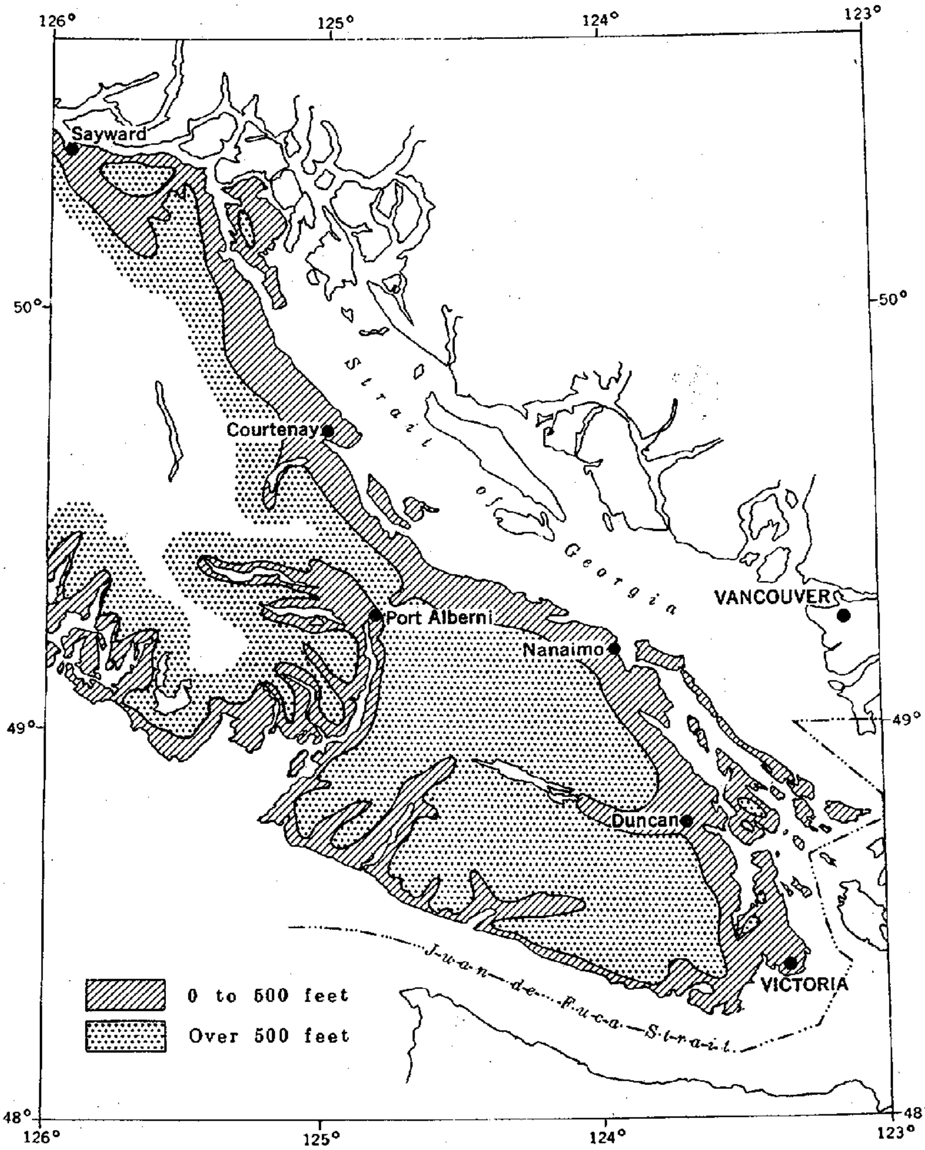

FIG. 4—The Coastal Plains area of the southern portion of Vancouver Island and Gulf Islands.

Rivers are numerous but relatively small as might be expected. The principal ones include the Jordan, Sooke, Cowichan, Koksilah, Nanaimo, Qualicum, Englishman, Stamp, Sproat, Puntledge, Quinsam, Oyster, Campbell and Salmon rivers.

There are several large lakes which, while generally situated outside of the surveyed area, are of considerable importance. Most are located at elevations above that of the major agricultural areas, and may serve as excellent reservoirs for irrigation and household water supplies. They include the Sooke, Shawnigan, Cowichan, Nanaimo, Horne, Great Central, Sproat, Comox and Upper Campbell lakes.

The area is, for the most part, well drained, but a wide range in moisture conditions may be observed in most localities. For instance, a sequence characteristic of many districts is the presence of excessively drained knolls and terraces, adequately drained slopes, poorly drained flats and undrained swamps.

Climate

Vancouver Island lies under the influence of a maritime climate which is quite variable as a result of topographic and latitudinal influences. It is characterized by cool, relatively dry summers and mild wet winters. The Insular Mountains ensure very heavy total annual precipitation and relatively narrow ranges of temperature on the west coast, and thus cause what may be recognized as the Outer Coast climate (2). In this area precipitation ranges from 72 inches at Jordan River near the south end of the Island to 142 inches at Tahsis in the north. One weather station of particular interest, though no longer in operation was situated on the west coast at Henderson Lake. It reported an average total precipitation of 264 inches, the highest in Canada. Alberni, situated deep in the Alberni intermountain basin, has 69 inches.

The climate of the east and southeast portion of the Island, where most of the surveyed area lies, is influenced by the Olympic and Insular Mountains resulting in the development of what has been described as the Inner Coast climate. Here precipitation and cloudiness are reduced and the range in temperature is somewhat increased. Victoria and Sidney, near the junction of the Straits of Georgia and Juan de Fuca, reflecting 'rain shadow' effects of the Olympic Mountains, receive 27.1 inches and 30.7 inches of precipitation respectively, and of those amounts, only 3.4 and 4 inches fall during the months June to September inclusive. Farther north along the east coast precipitation increases. For instance at Nanaimo, annual precipitation totals 37.9 inches; Campbell River still farther north, receives a total of 55.7 inches.

The Inner Coast climate may be subdivided into three fairly well defined climatic types which are described as follows:

Cool Mediterranean Climate—The natural environment throughout the Saanich Peninsula and on the adjacent islands is, in many respects, similar to that of much of the northern Mediterranean region. The summer temperatures are somewhat lower but the drought during the summer months is, generally speaking, just as marked. Rainfall for the two month period, July and August, does not average more than 1.3 inches. Bright sunshine, too, is a feature of the area, particularly adjacent to Victoria where an annual average of 2193 hours is recorded. This is more sunshine than is recorded in any other part of the Province. The oak parkland vegetation and the Black or 'prairie-like' soils add further support to the statement that the Saanich Peninsula has a cool Mediterranean type of climate. It is interesting to observe that this represents the farthest poleward advance of a true Mediterranean climate on the earth's surface (18).

Transitional Climatic Type—A transitional type of climate covers the narrow lowland extending along the coast from the Saanich Peninsula to Comox. This climatic type, as the term indicates, is transitional from the climate of the Saanich Peninsula to the fully developed maritime climate prevailing to the north and west. Brown Podzolic and Concretionary Brown soils are the most common.

Maritime Climate—The maritime climate prevailing in the intermountain valleys and immediately to the east of the Insular Mountains is considerably modified compared with the Outer Coast climate. Here the total annual rainfall is much less, varying as it does from about 55 inches at Courtenay to 74 inches at Cowichan Lake. Summer rainfall (July and August) is, as would be expected, very much less. Podzol and Peat soils are the most common.

Table 1 provides the climatic data for the recording stations in the surveyed area. The data as arranged indicate rather clearly a marked difference between the three climatic areas in respect to mean annual precipitation, rainfall during July and August and total hours of sunshine.

Table 1 Climatic Data for Stations in the Surveyed Area

		Precipitation in Inches			Temperature °F.			Sunshine Hours
	Elevation	Mean Annual	4 mos. June-Sept.	2 mos. July and August	Mean Annual	4 mos June-Sept.	2 mos. July and August	Annual
SAANICH PENINSULA AREA—COOL MEDITERRANEAN CLIMATE								
Victoria	228	27.1	3.4	1.1	50	58	60	2192
Dom. Observatory	730	27.2	3.1	1.1	50	62	64	
Cordova Bay	112	32.1	3.7	1.3	49	58	60	
James Island	176	27.5	3.5	1.3	50	60	62	
Pat Bay Airport	53	33.6	4.2	1.6	49	59	61	
Sidney	200	30.7	4.0	1.5	49	60	62	2038
Pender Island	200	30.2	4.2	1.6				
Average		29.8	3.7	1.4				
Range		27.1–33.6	3.1–4.2	1.1–1.6				
SAANICH PENINSULA TO COMOX LOWLAND—TRANSITIONAL CLIMATE								
South to North								
Sooke	125	46.1	4.7	1.4	49	58	59	
Shawnigan Lake	455	42.9	4.8	1.6	48	60	63	
Cowichan Bay	175	35.5	4.4	1.7	49	61	63	1805
Duncan	28	39.3	4.7	1.8	50	62	65	
Ganges	36	38.0	4.6	1.7	49	60	62	
Chemainus	40	41.4	4.9	1.7	—	—	—	
Nanaimo	100	37.9	5.5	2.0	50	61	64	
Nanaimo Airport	104	42.5	4.9	2.1	47	58	61	1832
Departure Bay	60	33.8	5.3	2.0	50	62	65	
Parksville	300	31.9	5.2	2.2	46	57	59	
Denman Island	180	50.4	5.8	2.0	—	—	—	
Comox Airport	75	46.3	5.9	2.7	48	59	61	
Cape Lazo	125	41.8	5.5	2.2	48	59	62	
Average		40.6	5.1	1.9				
Range		31.9–50.3	4.4–5.9	1.4–2.7				
TERRITORY ADJACENT TO THE COASTAL PLAIN—MARITIME CLIMATE								
Cowichan Lake	58	74.8	7.2	2.3	49	60	63	1454
Alberni (Beaver Creek)	300	68.5	6.7	2.4	49	61	64	
Cameron Lake	600	57.6	6.3	2.1	—	—	—	
Cumberland	523	57.8	7.8	3.0	48	60	62	
Courtenay	150	55.5	7.3	3.1	—	—	—	
Campbell River	50	55.7	7.5	3.3	—	—	—	
Average		61.6	7.1	2.7				
Range		55.5–74.7	6.2–7.5	2.2–3.3				

Evaluating Adequacy of Precipitation

Recently Thornthwaite (29) devised a method for evaluating the adequacy of precipitation for plant growth in a given locality by comparing it with water need or potential evaporation. This term may be defined as "the amount of water that would be transferred from the soil to the atmosphere by evaporation and transpiration if it were constantly available in optimum quantity". It thus is an expression of thermal efficiency in that the values are derived from mean monthly temperatures and take into account the variation in length of daylight during the growing season. Theoretical values for water surplus and water deficiency may, therefore, be computed and quantitatively expressed.

Factors of temperature, precipitation, evaporation and transpiration from a land surface fully covered with vegetation are used in calculating the data. Suitable adjustments for latitude and possible duration of sunlight are made. Treating precipitation as an income and water need (potential evapotranspiration) as outgo, an approximation of the monthly consumptive use of water may be determined. Further interpretation provides information relative to total water need, daily water requirement, and approximate date at which soil moisture will be drawn upon.

The soils of the area have soil moisture storage capacities which average 3.2 inches in the effective rooting zone. Using three inches as the average storage capacity it has been found that moisture deficiency occurs in the area during the growing season. However, the intensity of this deficiency varies with the climatic zones discussed above. The amount of the moisture deficiency at several places in the three climatic zones is shown in Table 2.

A summary of climatic features for 12 weather stations in the area is given in Table 3. The vegetation period commences about mid-March, ends in late November, and the average duration is 252 days. The mean date of drought point, or time when soil moisture deficiency begins, will be seen to vary with soil moisture-holding capacity. Soils with a 2-inch storage reach the drought point about one to two weeks before the soils with 3-inch storage, and the 4-inch soils 10 to 14 days later. The 'day degrees' above 42°F. in the vegetative period is a measure of the intensity of heat in the growing season. It can be said that Alberni and Duncan are 'hot-spots' compared with some other stations.

Table 2 Soil Moisture Deficiencies Expressed in Inches for Season

(Stations in each climatic zone are listed from south to north)

Cool Mediterranean Climate		Transitional Climate		Maritime Climate	
Victoria	10.6	Sooke	8.4	Cowichan Lake	6.0
Dom. Observatory	12.9	Shawnigan Lake	9.3	Alberni	5.7
Cordova Bay	11.0	Cowichan Bay	9.7	Cameron Lake	6.5
James Island	11.5	Duncan	9.7	Cumberland	5.8
Pat Bay Airport	9.6	Ganges	9.3	Courtenay	7.0
Sidney	10.2	Nanaimo	8.6	Campbell River	7.1
		Departure Bay	9.1		
		Parksville	9.0		
		Denman Island	8.8		
		Comox Airport	7.7		
		Cape Lazo	9.0		
Average	11.0		9.0		6.3
Range	12.9—9.6		9.7—7.7		7.1—5.7

Table 3 Climatic Factors Affecting Plant Growth in Southeast Vancouver Island

	Cool Mediterranean Climate		Transitional Climate						Maritime Climate			
	Sidney	Victoria	Sooke	Shawnigan Lake	Duncan	Ganges	Nanaimo	Cape Lazo	Jordan River	Cowichan Lake	Alberni	Cumberland
Altitude above mean sea level	100	228	125	455	28	35	85	125	10	545	300	523
Mean annual temperature °F	49	50	49	48	51	49	50	48	48	49	49	48
Yearly precipitation (inches)	30.3	26.9	45.4	42.1	38.6	37.3	37.2	42.1	71.2	73.1	67.8	57.6
Beginning of vegetative period*	Mar. 8	Feb. 26	Mar. 6	Mar. 22	Mar. 2	Mar. 8	Mar. 10	Mar. 23	Mar. 13	Mar. 15	Mar. 15	Mar. 23
End of vegetative period	Nov. 22	Dec. 4	Nov. 20	Nov. 15	Nov. 22	Nov. 20	Nov. 21	Nov. 6	Nov. 24	Nov. 15	Nov. 15	Nov. 10
Duration of vegetative period (days)	259	281	259	237	265	257	256	228	256	245	245	232
Mean date last frost in spring	Mar. 31	Feb. 28	Apr. 21	May 2	May 4	Apr. 7	Apr. 12	Apr. 13	Apr. 4	Apr. 26	May 12	May 14
Mean date first frost in fall	Nov. 16	Dec. 7	Oct. 27	Oct. 17	Oct. 6	Nov. 4	Nov. 3	Oct. 24	Nov. 5	Oct. 19	Oct. 10	Oct. 11
Duration of frost-free period (days)	230	282	189	168	155	211	205	194	215	176	151	150
Day degrees above 42°F. in vegetative period	2976	3014	2723	2815	3434	2995	3269	2795	2263	2970	3376	2837
Precipitation during vegetative period (inches)	14.7	15.6	21.7	16.7	19.6	17.7	18.6	16.1	34.5	31.9	30.2	24.4
Water deficiency during vegetative period (3-inch storage)	10.2	10.6	8.4	9.3	9.7	9.3	8.6	9.0	3.7	6.0	5.7	5.8
Mean date of drought point—												
(2-inch storage)	May 26	May 18	June 7	June 7	June 8	June 5	June 8	June 4	July 2	June 26	July 1	June 18
(3-inch storage)	June 8	June 2	June 19	June 19	June 21	June 14	June 22	June 14	July 13	July 6	July 9	July 3
(4-inch storage)	June 19	June 13	July 1	July 1	July 1	June 29	July 3	June 24	July 24	July 15	July 18	July 13

*Vegetative period is considered as the period during which the mean temperature is at or above 42°F.

Native Vegetation

On Vancouver Island the climate is exceptionally favorable for tree growth and dense forests of Douglas fir *(Pseudotsuga menziesii)* provide the dominant cover. In spite of this a number of more or less distinct plant associations are apparent in the surveyed area and these show the differences in climate and soils.

Saanich Peninsula with a Cool Mediterranean Climate

At the southern tip of Vancouver Island, on the Saanich Peninsula and at other points, particularly in the vicinity of Comox, a forest–grassland association is quite distinctive on well-drained sites. "The characteristic forest cover consists of Garry oak (*Quercus garryana*) and Douglas fir (*Pseudotsuga menziesii)* with arbutus *(Arbutus menziesii)* occupying the more exposed coastal fringe and shallow rocky soils. Where drainage is impeded, grand fir *(Abies grandis)* is dominant. In the grassland openings red fescue *(Festuca rubra*) and herbaceous plants such as camus (*Camassia leichtennii*) and *Zygadenus venenosus* are conspicuous" (27). Arbutus, by the way, is distinctive in that it is the only broad-leaved evergreen tree native to Canada.

The grassland vegetation on the one hand and the oak–arbutus combination on the other suggests drought conditions and this plant association further indicates the presence of soils belonging to the Black group. Neither the oak–grass type of vegetation nor the associated black soils are found above the 150 foot elevation.

The open park-like character of the landscape was the major feature which attracted the attention of Sir James Douglas when he first visited the area in 1843.

Eastern Coastal Plain—Saanich Peninsula to Campbell River with its Transitional Climate

Douglas fir is the dominant species in the forest throughout this area. Precipitation, as reported, is somewhat higher than that on the Saanich Peninsula but the summer period is still dry.

Spilsbury and Krajina, (28) discussing plant association on the east coast of Vancouver Island, report that Douglas fir, Western hemlock, and salal association (*Pseudotsuga menziesii–Tsuga heterophylla–Caultheria shallon*) may be considered to be the climax type for the area. Its presence indicates well drained uplands and fluvio-glacial benches where there is little or no lateral movement of moisture and hence the vegetation depends entirely upon the moisture received directly in the form of rain. Under extremely dry conditions or on shallow, stony or gravelly soils, lodgepole pine (*Pinus contorta*) is frequently a feature of the association, along with arbutus on coastal fringes.

Under more abundant soil moisture conditions and yet well drained, such as on upland soils of medium to fine texture, and foothills or slopes receiving ground water from higher elevations, another plant association is to be observed. These sites are readily distinguished from the one just described through the presence of sword fern (*Polystichum munitum*) which replaces salal. Douglas fir reaches its highest development here.

Two plant associations are distinguished on the muck and peat soils: western red cedar, red alder and skunk cabbage association (*Thuja plicata–Alnus rubra–Lysichitom kamtschatcense*) are observed on muck soils particularly on those sites characterized by a moving water table. Lodgepole pine, labrador tea, sphagnum moss associations (*Pinus contorta–Ledum groenlandicum–Sphagnum capillaceum*) are confined to peat deposits where the water is more or less stagnant.

On recent alluvial soils abundantly provided with moisture yet freely drained, one may expect to find western red cedar, grand fir, maidenhair fern (*Thuja plicata–Abies grandis–Adiantum pedatum*) association.

Most, if not all of the virgin timber has been removed from the coastal plains and the present cover consists of coniferous young growth alternating with alder, willow and maple. Stands of alder (*Alnus rubra*) and willow frequently become established following removal of virgin timber and dominate the vegetation for periods up to 50 years, but usually give way to a coniferous forest in much less time.

Surveyed Areas West and North of Coastal Plain under a Maritime Climate

Douglas fir is still the dominant species but is encroached upon by western red cedar and western hemlock in the more humid areas. Amabilis fir (*Abies amabilis*) and mountain hemlock (*Tsuga mertensiana*) are found on the higher slopes. Maple (*Acer macrophyllum*) and alder (*Alnus rubra*) have invaded many logged areas as second growth.

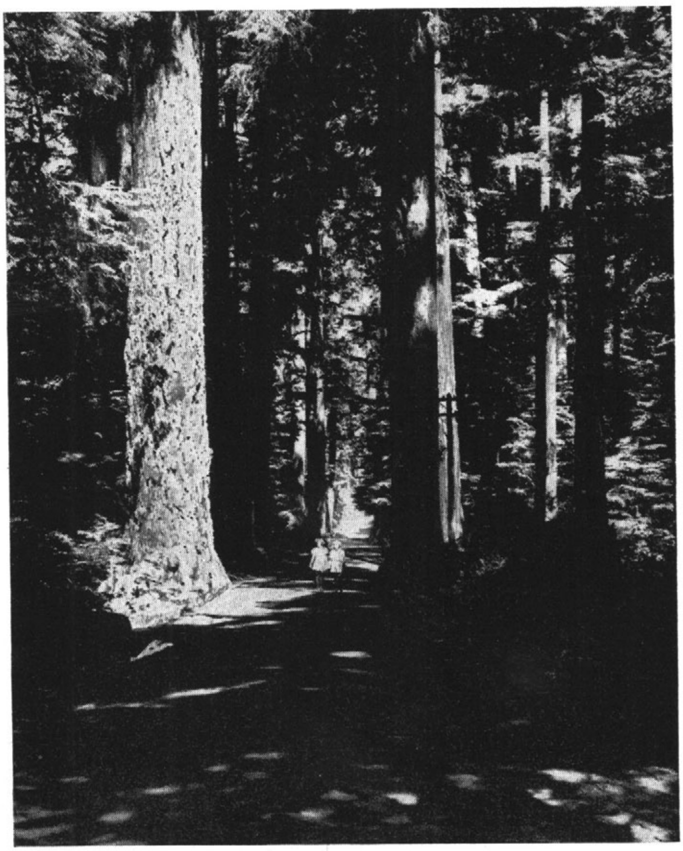

Fig. 5—A mature stand of Douglas fir, hemlock and red cedar in MacMillan Park (Cathedral Grove) on the highway from Parksville to Alberni. Courtesy of B.C. Government Travel Bureau.

GEOLOGY OF THE SOIL PARENT MATERIALS[1]

by

J. G. FYLES[2]

The soils of Vancouver Island are developed on many kinds of unconsolidated materials. Most of these soil parent materials were transported to their present position and deposited in their present form by glaciers, rivers, lakes and the sea during successive changes of climate and landscape hundreds to thousands of years ago. A few are modern river, shoreline, and swamp deposits. On sloping ground the soils commonly have developed either upon an eroded surface resulting from downslope creep of the earth material or upon an accumulation of 'crept' material. Only in a few small areas are the soils formed upon products of 'in place' weathering of bedrock.

Bedrock and Soils

Most soils are composed largely of mineral particles and consequently their characteristics are controlled to some degree by the nature of the rocks from which they have been derived. Most of Vancouver Island is underlain by dark volcanic rocks (basalts etc.) consisting of small grains of minerals rich in calcium, iron, and magnesium. These rocks yield hard boulders, pebbles, and sand grains but break down through weathering and abrasion into loamy and clayey debris. Associated with the volcanic rocks are subordinate amounts of limestone, and of more resistant sedimentary rocks such as chert, argillite, tuff, and greywacke. These contribute to the soils in a variety of ways but generally are not abundant enough to modify the soil characteristics. Granitic rocks, which make up sizeable parts of the Island, contain more potassium and sodium than the volcanic rocks but much less calcium, magnesium, and iron. They yield an abundance of resistant boulders and pebbles, and break down into debris of sandy texture.

Shales, sandstones, and conglomerates occupy large parts of the eastern coastal lowland of Vancouver Island between Duncan and Campbell River and are also found in Alberni Valley, in Cowichan Valley, and at Sooke.

Chemically they are intermediate in composition between the volcanic and granitic rocks. The shales consist dominantly of silt- and clay-sized particles and readily break down into debris of loamy to clayey textures. Pebble- and sand-sized pieces of shale in soil parent materials commonly disintegrate into fine material in the soil. The sandstones and conglomerates are more resistant than the shales but much less so than the volcanic and granitic rocks. Their disintegration products are generally of sandy to loamy texture. Gravel-size pieces of sandstone in soil parent materials commonly disintegrate in the soil into the constituent sand and silt.

Most of the soil materials of Vancouver Island are mixtures of particles derived from many different rock sources. Resistant gravel and boulders in such soils have been contributed largely by the granitic and volcanic rocks;

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[1] Published by permission of the Director, Geological Survey of Canada, Department of Mines and Technical Surveys, Ottawa.

[2] Geologist, Geological Survey of Canada.

sand-size particles are mainly individual mineral grains derived from granitic rocks and sandstones but also include fragments of the volcanic rocks, of hard sedimentary rocks, and of quartz veins; silt and clay has largely been supplied by the volcanic rocks, shales, and sandstones. Some of these soil materials—particularly the glacial tills and marine materials derived from them—change in texture from place to place with changes in the bedrock source. A very few soils consist of particles derived from a single kind of rock.

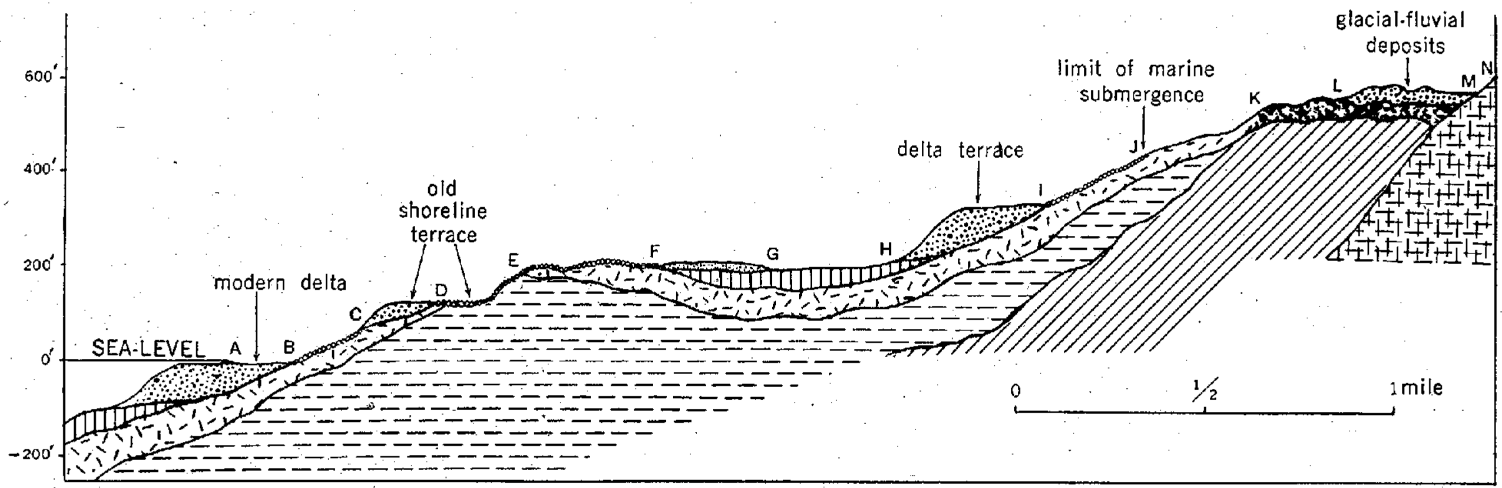
History of Soil Parent Materials

The deposits upon which the soils of Vancouver Island have developed are much younger than the rocks discussed above and have originated since the major topographic features of the region (mountains, lowlands, etc.) took on their present form. Glaciers appear to have spread across southwest British Columbia and disappeared again several times. The principal parent materials relate to events that took place between the last two glacial invasions, during the last glaciation, and during post-glacial time.

The oldest soil parent material of importance originated prior to the last glaciation when rivers buried the eastern coastal lowland of Vancouver Island beneath sands and gravels several hundred feet in thickness, whose remnants now form white cliffs from Saanich to Cape Mudge. Then the rivers changed in character and cut much of the sand and gravel. Next glacial ice spread across the entire region, eroding more of the pre-existing materials and spreading a blanket of glacial till* a few feet to more than 100 feet in thickness on the lowlands and on the floors and sides of valleys. At the climax of this glaciation, ice filled the depression between Vancouver Island and the mainland and buried all of Vancouver Island except, perhaps, the summits of a few of the highest mountains. As the ice sheet melted and grew thinner and separated into a series of remnant glaciers, rivers flowed on, within, and beneath the ice and along its margins. When the ice disappeared the deposits of these streams remained as ridged, hummocky, and terraced gravels and sands.

Upon retreat of the glaciers, the sea entered the Strait of Juan de Fuca, the Strait of Georgia, and the inlets along the west coast of Vancouver Island, and covered the greater part of the present lowlands. This depression of the land relative to the sea is attributed to the weight of the glaciers. Vancouver Island has risen and tilted relative to the sea since retreat of the glaciers, so that now the highest marine deposits, formed while the glaciers were melting, are found at an elevation of 50 feet along the west coast of the island, 300 feet at Victoria and Alberni, 400 feet at Nanaimo, 500 feet at Qualicum, and 600 feet at Campbell River. During the interval of marine submergence, varied sea-bottom and seashore materials accumulated on the present lowlands of Vancouver Island; in places wave erosion cut through the glacial deposits to expose the underlying interglacial sands and gravels. As the land rose, streams cut gullies into the marine, glacial, and interglacial deposits, leaving gravelly and sandy terraces perched on valley walls and depositing series of gravelly deltas where the rivers reached successive positions of the seashore. Shells in the marine deposits and plant materials in the deltas record a climate similar to that of southern coastal Alaska. Since establishment of the present seashore, several thousand years ago, most rivers have built sizeable deltas at their mouths and a few have developed broad flat floodplains. Alluvial fans, landslide debris, "creep" deposits, and peaty swamp deposits have been accumulating in favorable places since disappearance of the glaciers and emergence of the land from the sea.

* Till is a compact, concrete-like mixture of clay, silt, sand, gravel, and boulders deposited by glacial ice.



GEOLOGICAL MATERIALS

- Thick marine and river gravels and sands
- Thin gravelly marine deposits
- Marine sand and silt
- Marine clay
- Sandy glacial till
- Loamy or clayey glacial till
- Interglacial sand and gravel; older glacial and interglacial deposits
- Shale and sandstone
- Volcanic rock

TYPICAL SOILS

- A-B Cassidy, Chemainus
- B-C Dashwood, Bowser
- C-D Qualicum
- D-E Qualicum
- E-F Dashwood, Bowser, Parksville, Shawnigan
- F-G Puntledge, Merville
- G-H Cowichan, Fairbridge
- H-I Qualicum
- I-J Dashwood, Bowser
- J-K Shawnigan
- K-L Royston
- L-M Qualicum
- M-N Rock

Fig. 6—Diagrammatic vertical section showing materials beneath the eastern coastal lowland of Vancouver Island. Geological relations are typical of the country between Campbell River and Lantzville.

Relation of Soils to Geology

Under a given set of climatic and biologic conditions, variation of the soil from place to place is controlled by the texture and stoniness of the soil parent materials, the slope of the ground surface, and the moisture relationships within the ground. The moisture relationships (drainage) are controlled in turn by the slope of the ground surface, the texture of the solum, the permeability of the subsoil materials, and (where the subsoil is coarse-textured) the level of the ground water table.

Materials of a given geological origin commonly vary from place to place in the above respects and will thus give rise to several different kinds of soil. Moreover, materials possessing the same texture, stoniness, slope, and drainage, and which therefore are assigned to a single soil series, may have originated in several different geological environments. For example, the Qualicum soil series is developed on interglacial sands and gravels, glacio-fluvial gravels and sands, marine gravels and sands, and delta- and river-terrace gravels and sands. Thus in the following discussion, a single soil series may appear in several different geological categories.

Soils on Interglacial Materials

The thick interglacial sands and pebbly gravels exposed on the cliffs of Cape Mudge, Cape Lazo, Qualicum River, Cowichan Head, etc. are generally covered by glacial till and are far below the soil. In a few places, however, the till cover has been removed by waves along former sea shores and only a foot or two of marine gravel covers the interglacial deposits. In such places the thin marine gravel and the interglacial sand or gravel combine to give excessively drained stony to sandy soils of the Qualicum series. Such soils are present on the Saanich Peninsula, between Lantzville and Fanny Bay, and between Comox and Oyster River.

Glacial Till Soils

The till related to the last glaciation of the region is the most widespread earth material of Vancouver Island, and its rolling to hilly upper surface controls the topography of most of the lowland, even where the till is covered by marine deposits. The till of the region is bouldery, compact, and concrete-like. As can be seen in many uncribbed wells, dry till near the ground surface is pale grey and exceedingly hard and commonly breaks into horizontal plates. Moist till at greater depths is darker grey and somewhat softer but nonetheless will stand in vertical excavations. Local residents commonly refer to the dry till as 'hardpan', and the moist till as 'blue clay'. The till is of stony sandy loam texture throughout most of the Vancouver Island lowlands, but stony loam and stony clay loam tills are found here and there as, for instance, around Courtenay, near Nanaimo, and in Alberni Valley. The loamy to clayey tills contain much material derived from shale or volcanic rocks. Some of the sandy tills have come from a granite or sandstone source but most of them are sandy because they contain much material derived from the interglacial sands.

Most soils on unmodified tills are stony or gravelly and of sandy loam to loam texture. They belong to the Shawnigan, Royston, Stamp, Sproat and Quinsam series. The compact till forming the substratum of such soils effectively prevents water from moving downward, so that soils in low places are subject to flooding during the winter and those on higher ground are not as dry in summer as would be expected from their texture. Such unmodified till soils are found only outside the areas of postglacial marine submergence; that is above an elevation of 50 feet along the west coast of the island, 300 feet at Alberni and Victoria, 300 to 400 feet between Victoria and Nanaimo, and 400 to 600 feet between Nanaimo and Campbell River. Below these elevations till forms the substratum of the soils over wide areas but the solum itself is developed on marine materials derived from the till. Some of these marine soils differ little from the unmodified till soils but many are distinctly finer or coarser in texture. In a few places above the limit of marine submergence the till surface has been washed by streams or covered by a few inches of glacio-fluvial or alluvial gravel, giving rise to stony, sandy soils of the Dashwood series.

Soils on Glacio-fluvial Deposits

Gravels and sands deposited by glacial meltwater streams form ridged or hummocky areas and flat 'terraces' or 'benches'. They support exceedingly dry sandy to stony soils of the Qualicum and Kye series. Small areas of moister Dashwood soils are found where lenses of till lie within the glacio-fluvial gravels. The most extensive glacio-fluvial deposits occur just above the highest marine deposits (that is at the elevations listed in the last paragraph) where major valleys lead from the mountains onto the coastal lowland.

Marine Soils

Most soils of the lowlands of Vancouver Island are developed on materials that have been deposited in the sea or modified by the sea. These marine materials are stony, gravelly, sandy, loamy, and clayey in texture and typically form a 'veneer' or 'mantle' 1 to 5 feet thick on hills or slopes and 5 to 30 feet thick on low ground. In most general terms this marine mantle has been formed by the washing action of waves upon the surface materials of slopes and hilltops and consists of fine materials containing few stones on low ground and coarser materials containing many stones on sloping ground. In a few places there are more distinctive and commonly thicker marine deposits such as gravelly shoreline spits, bars, or terraces, and loamy to clayey tide-flat or lagoonal muds.

The marine soils are most varied in texture (range from clay to stony sand) where the former sea shores were underlain by sandy till and were exposed to sizeable waves; these conditions apply to the greater part of the eastern coastal lowland of the island. More uniform (more clayey and less sandy) marine soils are found where the till is of finer texture (loam to clay loam), where waves were smaller (e.g. in landlocked basins such as Alberni Valley) and where rivers poured muddy water into the sea.

Within those large parts of the eastern coastal lowland occupied by sandy-textured till, marine soils on slopes and hilltops are principally gravelly loamy sand, loamy sand, and stony sand but locally include gravelly to stony sandy loam. Most of them contain boulders. Commonly these materials are less than 5 feet thick, contain discontinuous layers of clay, and rest upon an impervious substratum of compact till or rock. Hence they are not as dry as would be expected from their coarse texture and sloping topography.

These thin, varied marine deposits are the principal parent materials of the Dashwood, Bowser, Shawnigan, Lazo, Langford, Cadboro, and Sandwick soils. Much drier granular marine soils, belonging to the Qualicum or Kye series, do occur here and there where the deposits described above thicken to form shoreline terraces, spits or bars, or where they rest upon interglacial sand or gravel instead of till. Where sloping ground gives way to flat ground or a broad depression, the gravelly granular marine deposits wedge out and are replaced by clays, silts, and fine sands. Some of the clayey materials contain isolated boulders. The sandy and silty marine soils in such situations are classified as Parksville, Puntledge, Tolmie, or Merville, and the finer-textured soils are termed Cowichan, Saanichton, or Fairbridge.

Generally the sandy and silty soils rest upon clay and hence are relatively moist. They are commonly found along the edge of a depression or flat area, whereas the clayey materials come to the surface at a greater distance from sloping ground. On rolling ground where hills and hollows are only a few tens of feet across, the marine soils vary in texture from hill top to depression in the same way as those described above but to a much smaller degree. The depressions are floored by more or less stony, loamy to clayey materials whereas slopes and hills are mantled by loose gravelly to stony sandy loam only slightly coarser in texture and slightly more stony than the till. Some of the soils in such situations are assigned to the Shawnigan or Cadboro series and others are designated as complexes such as Dashwood–Parksville or Shawnigan–Dashwood.

In areas of loamy and clayey till that have been subject to marine inundation, clayey, silty, and loamy soils of the Cowichan, Tolmie, or Alberni series are found on low flat ground and stony to gravelly loam soils of the Royston or Stamp series occupy sloping ground and hilltops. The marine materials on slopes and hills are slightly coarser in texture and slightly more stony than the till upon which they lie and locally contain discontinuous layers of sand and gravel that do not occur in the till. Nonetheless, the soils developed on them commonly do not differ significantly from soils developed on unmodified till of the same type outside the areas of marine submergence.

Delta Terrace and River Terrace Soils

Deltas that were built by the rivers of Vancouver Island where they reached former higher sea shores, and alluvium that accumulated along river bottoms upstream from these deltas remain today as flat 'terraces' or 'benches' underlain by gravel and sand. The delta terraces are outside the river valleys but generally are adjacent to them. The river terraces are found along the valley sides, and only locally are they extensive enough to be distinguished in soil mapping from the eroded areas forming the valley walls.

Most of the delta and river terrace deposits are excessively drained, medium to coarse loamy sands and gravelly loamy sands and support soils belonging to the Qualicum, Somass, and Kye series. Locally areas of silty Merville soils and of clayey Cowichan soils occupy the marginal parts of river and delta terraces, particularly where they abut against higher ground. In most places such fine-textured soils are drier than similar-textured marine soils because the clays or silts are thin and are underlain by excessively drained sands or gravels.

Modern Alluvial Soils

Bottomlands bordering the rivers of Vancouver Island and deltas at the river mouths are largely built of gravel and sand although parts of many of them bear a surface veneer of loamy, silty, or clayey alluvium or of swampy organic material. Soils developed upon coarse-grained alluvial deposits are assigned to the Cassidy series, and those on loamy to clayey alluvium to the Chemainus series. Alluvial soils associated with the smaller rivers of the region are principally gravelly, and where they include finer-textured Chemainus soils these generally form small irregular patches surrounded by coarse-textured soils. Larger areas of Chemainus soils are found on the floodplains and deltas of the larger streams, and particularly bordering the lower reaches of rivers such as the Courtenay, Somass, Nanaimo, and Cowichan, which flow into landlocked bays. In winter and spring, many of the bottomlands and deltas are subject to flooding, but in summer, when the water table commonly drops a few feet and up to 15 feet below the ground surface, the coarse-textured alluvial soils are exceedingly dry and the finer-textured soils (which commonly rest upon a coarse permeable substratum) are drier than would be expected from their texture. On the other hand, dugouts sunk into the coarse subsoils below the water table provide a ready source of irrigation water.

Alluvial fans, built by streams where they flow from steep mountainside gullies onto flatter ground, encroach upon the lowlands of Vancouver Island along the east side of Alberni Valley and in a few places along the inland edge of the eastern coastal lowland. Most of the materials surfacing these fans are exceedingly stony or gravelly sandy loams or loams, or consist almost entirely of stones. In some places they are dry but elsewhere water flows intermittently on the ground surface. Loam or clay loam soils more suitable for agriculture are found on the lower, marginal parts of some fans, where the fan deposits are less gravelly and do not contain large stones. These fine-textured fan deposits consist of alternating layers a few inches thick of loamy to clayey material and of coarse angular sand or fine gravel; commonly the sandy or gravelly strata are water bearing. Some soils developed upon such fine-textured fan deposits are assigned to the Chemainus series, but others are included in larger areas of Alberni, Cowichan, or Stamp soils. In a few places such fine alluvial materials fill depressions adjacent to the fans and give rise to soils like those developed upon marine deposits of similar texture.

SOILS

Soil Formation

The nature of a soil is a result of the combination of climate, living organisms, and soil moisture operating on the parent material over a period of time at that place. All these factors come into play in the genesis of every soil. The relative importance of each differs from place to place; sometimes one is more important, sometimes another. The interaction of these soil forming factors as observed in the Vancouver Island and Gulf Islands area has resulted in many different soil types. For example, the Cool Mediterranean climate prevailing in the south end of the area, with its high moisture deficiency and lower rainfall, has encouraged grass–oak vegetation and the resulting Black soils are high in organic matter, moderate in reaction and base saturation. In the central part of the area the climate is Transitional with somewhat higher rainfall and lower moisture deficiency. The vegetation is mainly coniferous but does include the oak–grass association. Here the soils are more leached, soil reaction and base saturation lower, soil colors brighter. In the northern part of the area under a Maritime climate characterized by still higher rainfall, and still lower moisture deficiency, the soils are brightly colored, strongly leached, of strongly acid reaction and low base saturation.

Here Podzols and peat deposits are more common. On the west coast, notably in the Alberni Basin, also under a Maritime climate the soils are strongly leached, very brightly colored and contain many concretions.

In addition to these broad climatic differences there are also local differences due to changes in soil moisture supply. For example, soil moisture deficiencies are greater at the top of long gentle slopes than at the bottom, therefore different soil profiles are being formed. Furthermore, sands are more droughty than loams or clays and consequently soil development will be more weakly expressed in sand than in the finer materials.

The characteristics that a soil acquires, as the result of the interaction of the various soil forming factors, are reflected in the development of more or less distinct layers or horizons. A cross section of these horizons starting at the surface and including the relatively unaltered parent material is known as a soil profile (see Figure 7). The A_{00} and A_0 horizons are accumulations of litter on the surface of the mineral soil and differ in degree of decomposition. The A_1 horizon is an accumulation of organic matter within the uppermost mineral material while the A_2 horizon is a layer of maximum eluviation or leaching of soil constitutuents occurring just below the A_0 or A_1 horizons. It normally is the most acidic horizon in the profile. The A_3, AB and B_1 horizons

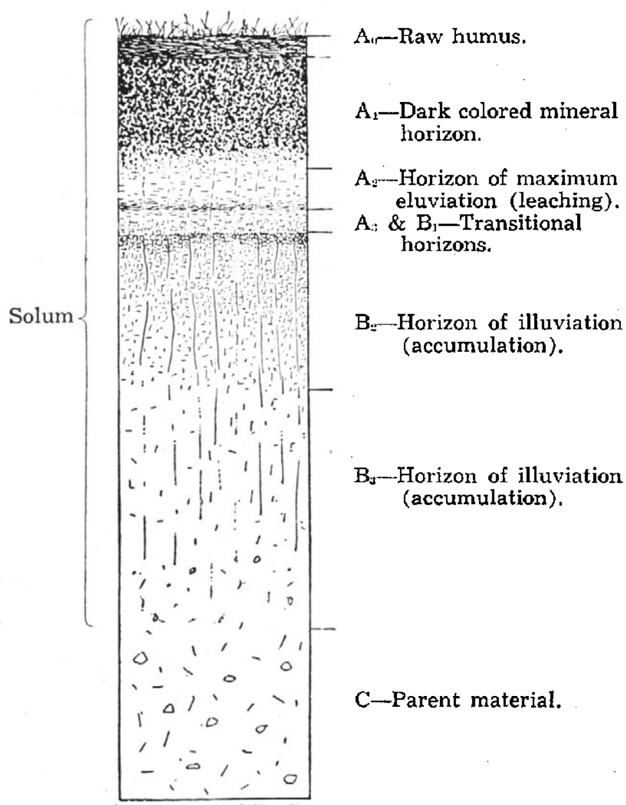


Fig. 7—Diagram of a soil profile showing various horizons. Some profiles may not have all these horizons clearly developed. Where it is necessary to subdivide a horizon a second digit is used, for example, the B_2 horizon may be subdivided into B_{21}, B_{22}, etc.

are transitional. The B_2 horizon is a layer of maximum illuviation or accumulation and may be subdivided into B_{21} and B_{22}. B_3 horizons are transitional to the C or parent material, which in turn, may be subdivided into C_1 and C_2 according to the degree of alteration. D horizons are underlying material that is different from that in which the solum (A and B together) has formed. Horizons with 'g' subscripts are poorly drained or gleyed.

Soil Classification and Mapping

The systematic study and classification of the soils of an area is a slow and difficult undertaking requiring extensive field operations during the summer followed by drafting and laboratory analyses during the winter. The soils profiles are subjected to systematic examinations by means of test pits at intervals sufficiently close to permit the sketching of soil boundaries, topography and other features on the base map or aerial photograph. In examining the soil profile, along with other things, the surveyor attempts to evaluate the soil horizons or layers in respect to number, thickness, arrangement, color, texture and structure. Many other characteristics are also considered such as the presence or absence of hardpans, permeability, effective root-feeding zone, available moisture capacity, general nutrient supply, relief, drainage, erosion and all other factors which influence soil character and land use.

Soil Series and Types

The examination of soils, as described above, permits the establishment of various taxonomic units. The soil series is made up of soils similar in regard to parent material, morphology, drainage condition, relief and other external characteristics. The series are given convenient place names taken from the general locality in which they were first established. The soil series are usually subdivided into types according to the texture of the surface soil. Thus textural names such as loam or clay, when added to the series name, gives the name of the soil type, e.g. Chemainus silt loam.

Land types are areas in which the soil type is of less importance than some factor such as relief, parent materials and age of same, or drainage. Land types used in this report are coastal beach, tidal flats, rough stony land, rough mountainous land and eroded land.

The soil type and the land type are the basic mapping units. Complexes of two or more soil series, or of soil series and a land type, are also shown on the map. In complex areas the soil units occur in an intimate mixture and the components cannot be shown separately at the scale of mapping used. Complexes are denoted on the map by a symbol for the most important components. In practice inclusions of less than 15 per cent of the map unit are not recognized on the map. Such areas are denoted only by the symbol for the dominant soil. These are the reasons that often a soil area on the map does not represent a uniform or homogeneous soil throughout its entire area.

The term variant is used to designate a soil which differs in one or more respects from the soil series with which it occurs, but which was not separated due to its limited extent.

For purposes of taxonomic classification the soil series can be grouped into great soil groups. The soils within a great soil group must be of the same genetic type and have similar characteristics as to kind of soil horizons, soil color, soil morphology and general chemical characteristics. The great soil groups occuring in the area are described below.

Great Soil Groups

The soils of Southeast Vancouver Island and Gulf Islands belong to the following great soil groups and their extent of the total area of 710,900 acres is as indicated in brackets: Brown Podzolic (48.7%), Concretionary Brown (12.4%), Acid Dark Brown Forest (3.1%), Black (2.2%), Podzol (3.7%), Dark Gray Gleysolic (7.4%), Rendzina (0.1%), Alluvial (7.3%), Organic (3.1%). In addition land types and water amount to 12 per cent of the area.

Brown Podzolic Soil Group

Brown Podzolic soils are characterized by an A_0 horizon 1 to 2 inches thick of dark grayish brown to nearly black moderately well-decomposed organic litter. An A_2 is generally absent but may be up to ½ inch thick under rotted logs. It is pinkish gray to gray and very strongly acidic. The B_2 is yellowish brown to strong brown and the color fades into the B_3 horizon. Concretions are absent. The parent materials are medium to medium high in base-saturation but non-calcareous.

These soils are distributed over the area south of Campbell River exclusive of the Alberni Basin. The vegetation is second growth fir, hemlock, maple, red cedar. At one time there were many large fir and hemlock trees which provided excellent lumber. Grasses are uncommon in the forest understory.

Shawnigan, Royston, Haslam, Dashwood, Bowser and Qualicum soil series belong to this great soil group.

Concretionary Brown Soil Group

Concretionary Brown soils are characterized by an A_0 horizon about 2 inches thick. An A_2 or AB horizon usually is absent but may attain 1 inch in thickness when present and it is pinkish gray or gray to light reddish brown and may contain small gray concretions. The B_2 ranges from dark reddish brown to yellowish red or pale brown. The B_2 contains concretions, which are hard spheroids developed by cementation of soil mineral materials. The concretions are 2 to 5 mm. in diameter and promote a very porous, open structure. The B_3 is lighter in color and contains fewer concretions than the B_2. Stones and gravel are commonly coated with iron compounds. The B horizons are low and the C horizons medium to high in base-saturation. The C horizons are non-calcareous.

The soils of this Concretionary Brown group tend to show a higher value for loss-on-ignition: organic matter ratio than do the other soil groups. This tendency together with the presence of concretions, reddish soil colors and low bulk densities suggest that the Concretionary Brown group has some weakly expressed characteristics of latosolic soils. Concretionary Brown soils are distinguished from Brown Podzolic soils by the concretions and usually brighter colors.

These soils are located chiefly in the central portion of the area, particularly in the Alberni Basin. The vegetation is the same as that found on Brown Podzolic soils.

Sproat, Stamp, Puntledge, Alberni, Fairbridge and Somass soil series belong to this soil group.

Acid Dark Brown Forest Soil Group

Acid Dark Brown Forest soils are characterized by an A_0 horizon ½ to 1 inch thick, over an A_1 2 to 13 inches thick, which is dark grayish brown, very dark brown or black, has cloddy–granular structure and firm (brittle) consistence. The B horizon is brown to light yellow brown fading with depth.

In the A horizon, base saturation is less than 50 per cent and the C:N ratio is greater than 13.5. The B horizon also is medium and the C horizon highly base-saturated. The parent material is non-calcareous. The loss-on-ignition: organic matter ratio ranges from 2 to 4. The brittle consistence, low bulk density and high ignition: organic matter ratio observed in these soils are similar to those values found in the Ando soils of Japan which are formed on volcanic ash.

The vegetation generally is first generation Douglas fir and hemlock with a few deciduous species, and an understory of grass. These are new forests developed by invasion of the former vegetation which consisted of grass with a canopy of scattered garry oak. In some places the grassy 'prairies' still persist.

The soils are located in Courtenay, Duncan and Nanaimo districts. Sandwick, Lazo, Merville and Saanichton series belong to this soil group.

Black Soil Group

Black soils are characterized by an A_0 horizon ½ to 1 inch thick, over an A_1 8 to 13 inches thick which is dark grayish brown, very dark brown or black, granular, and of friable or slightly hard consistence. The B is brown to light yellowish brown, the color fading with depth.

In the A_1 horizon base-saturation is greater than 50 per cent and the C:N ratio is less than 13.5. The B horizons are of medium base-saturation, and the C horizon is non-calcareous and highly base-saturated. These soils are distinguished from the Acid Dark Brown Forest soils by the nature of the A_1 horizon.

These are located principally around Victoria. Their vegetation is identical to that of the Acid Dark Brown Forest soils. The Cadboro, Langford and Esquimalt soils belong to this soil group.

Podzol Soil Group

Podzol soils are characterized by a dark brown semi-decomposed A_0 horizon 2 to 3 inches thick. The A_2 horizon is 1 to 5 inches thick, light reddish brown, grayish brown, gray or white and very acidic. The B_2 is brown, yellowish brown, or reddish brown. There is an accumulation of sesquioxides and humus in the horizon and sometimes it may be cemented by these compounds. The B_3 is generally paler in color than the B_2. The C horizon is medium to highly base-saturated. When imperfectly drained, mottling may appear in both the surface and subsurface horizons.

These soils occur largely in the Courtenay–Sayward area. Some weakly developed podzols occur in the Jordan River Valley on the west coast. Generally the soils at higher elevations have a continuous and distinct Podzol development. Most of the Podzols observed were developed on coarse drift and lie outside the mapped area.

The vegetation is essentially mixed conifers dominated by Douglas fir, hemlock and red cedar with an undercover of ferns and mosses. Quinsam, Memekey, Kye, Custer and Sayward series belong to this soil group.

Dark Gray Gleysolic Soil Group

Dark Gray Gleysolic soils are poorly drained and are characterized by an A_0 1 to 3 inches thick, over a dark brown or black A_1 5 to 8 inches thick. The A_2 or AB horizon is 4 to 8 inches thick, very pale brown to grayish brown and frequently mottled. The B_g is yellowish brown to pale yellow with many brownish mottles. The whole profile is medium to highly base-saturated.

These soils are distributed throughout the entire area. They have a second growth vegetation largely of red alder, willow, maple and red cedar. The understory is composed largely of shrubs and forbs. Cowichan, Parksville and Tolmie soil series belong to this soil group.

Alluvial Soil Group

Alluvial soils are youthful and lack a well developed soil profile. They are characterized by thin organic litter over an A_1 horizon 2 to 6 inches thick which is very dark brown to black, and granular. It is medium acidic in reaction and may be mottled in the lower part. The C horizon is grayish brown to light brownish gray bedded or stratified materials. It may be mottled, buried profiles may be present, and it is non-calcareous though moderately well base-saturated.

The Alluvial soils occur on the deltas and flood plains of most of the rivers of the area. The largest areas are at Duncan, Nanaimo and Sayward. Some areas are subject to occasional flooding by spring runoff water, or by sea water during the spring tides. Soil drainage conditions are variable and soil drainage members were not established.

The vegetation consists mainly of mixed forests dominated by Douglas fir, red cedar, alder and maple. Chemainus and Cassidy complexes belong to this soil group.

Rendzina Soil Group

The Rendzina soils are characterized by a black granular A_1 horizon 12 to 24 inches thick which contains mollusc shells. The C horizon consists of shells, gravel, sand and organic debris.

In addition to being youthful profile development has been inhibited by the presence of large quantities of calcareous materials. There has been considerable accumulation of organic matter in the solum, but free lime is still present in or near the soil surface.

This soil group is represented by Neptune soil series which occurs as a discontinuous band along the seashore. The native vegetation is usually grass with a few scattered trees.

Organic Soil Group

The organic soils are confined to the poorly and very poorly drained soils having an organic surface more than 12 inches thick and underlain by a gleyed horizon. Division of this group is made according to the degree of decomposition of the plant material.

Metchosin series is representative of the Muck soil and consists mainly of the well-decomposed remains of sedge, grasses, roots and woody plants. The greater part of the Muck is shallow and rests on a gleyed subsoil.

The Peat deposits represented by the Arrowsmith series, consist of the accumulated organic remains of plant successions. Usually the species can be readily identified since the plant remains are relatively undecomposed. Sphagnum moss, Labrador tea and woody plants are the dominant species. These deposits are frequently very deep and strongly acid in reaction.

Table 4 Classification of the Soils of Southeast Vancouver Island and Gulf Islands

1. Soils developed on coarse-textured glacial till	*Group*
Well drained	
Cadboro gravelly sandy loam	B
Quinsam gravelly sandy loam	P
Shawnigan gravelly sandy loam	BP
Sproat gravelly sandy loam	CB

2. Soils developed on medium-textured glacial till

Well drained	
Royston gravelly loam	BP
Sandwick gravelly loam	ADBF
Stamp gravelly loam	CB

3. Soils developed on shallow medium-textured glacial till underlaid by shale and sandstone

Well drained	
Haslam shaly loam	BP

4. Soils developed on coarse-textured marine materials underlaid by glacial till or marine clay

Well drained	
Dashwood loamy sand and gravelly loamy sand	BP
Langford loamy sand, sandy loam and loam	B
Lazo loamy sand, sandy loam and loam	ADBF
Imperfectly drained	
Bowser loamy sand	BP
Sayward loamy sand	P
Poorly drained	
Parksville sandy loam	DGG

5. Soils developed on medium to fine-textured marine materials underlaid by marine clays or glacial till

Moderately well drained	
Merville loam and sandy loam	ADBF
Moderately well to imperfectly drained	
Puntledge fine sandy loam	CB
Poorly drained	
Tolmie fine sandy loam, sandy loam, loam and sandy clay loam	DGG

6. Soils developed on fine-textured marine materials

Well drained	
Alberni clay	CB
Fairbridge silt loam to silty clay loam	CB
Memekay clay loam	P
Saanichton clay	ADBF
Poorly drained	
Cowichan clay loam	DGG

7. Soils developed on coarse-textured fluvial, glacio-fluvial, aeolian and marine materials

Rapidly drained	
Esquimalt gravelly sandy loam and sandy loam	B
Qualicum loamy sandy and gravelly loamy sand	BP
Well drained	
Kye loamy sand and gravelly loamy sand	P
Somass loamy sand and gravelly loamy sand	CB
Imperfectly drained	
Custer loamy sand	P

8. Soils developed on medium-textured alluvium with undifferentiated drainage

Chemainus fine sandy loam to loam and silt loam to clay loam	A

9. Soils developed on coarse-textured alluvium with undifferentiated drainage

Cassidy gravelly loamy sand, loamy sand and gravelly sandy loam	A

10. Soils developed on beach sand, shells and organic debris
Well drained
Neptune gravelly loamy sand to sandy loam .... R

11. Soils developed on organic materials
Poorly drained
Arrowsmith peat .... Pt
Metchosin muck .... M

12. Miscellaneous land types
1. Coastal beach
2. Eroded land
3. Made (or reclaimed) land
4. Rough mountainous land
5. Rough stony land
6. Tidal flats

Legend:				
ADBF	Acid Dark Brown Forest		M	Muck
A	Alluvial		Pt	Peat
B	Black			
BP	Brown Podzolic		P	Podzol
CB	Concretionary Brown		R	Rendzina
DGG	Dark Gray Gleysolic			

Soils Developed on Coarse-textured Glacial Till

Well Drained

CADBORO SERIES

Cadboro soils, comprising 3,945 acres, occur mostly in the southern portion of the Saanich Peninsula and under an annual precipitation of just below 30 inches. These soils have developed from compact gravelly sandy loam glacial

FIG. 8—Natural pasture land on Cadboro–Langford complex. The trees are Garry oak.

till or wave-modified till which contains moderate numbers of cobbles and stones. They belong to the Black soil group. They may be recognized by 8 to 10 inches of dark brownish black to black permeable granular sandy loam (A), which grades into 10 to 12 inches of yellowish brown, compact gravelly sandy loam (B), over compact and very slowly permeable gravelly sandy loam till (C).

Gravelly sandy loam is the dominant textural class, although there is some variation in the amount of gravel present.

The native vegetation is largely an oak–grass association although in places stands of first-generation Douglas fir with an understory of grass occur. Also there may be found occasionally, a mixed forest of Douglas fir, hemlock, maple and alder.

These soils have rolling morainic topography. The profile is naturally well drained, permeability is moderate except in the parent material where it is very slow. Lateral movement of water occurs over the surface of the parent material during the winter season.

The following is a description of a profile typical of the Cadboro series:

Horizon	*Depth in inches*	
A_0	1- 0	Dark brown well decomposed forest litter. pH 5.3.
A_1	0- 9	Black (10 YR 2/1 moist, 3/1 dry*) sandy loam, loose fine granular structure. Plant roots abundant, horizon boundary very gradual. pH 5.8.
B_1	9-19	Brown (10 YR 5/3 moist, 6/3 dry) gravelly sandy loam, weak fine subangular blocky structure which crushes readily to fine granules and single grains. Few stones and cobbles. 50 per cent gravel. Plant roots are common, horizon boundary is gradual. pH 5.9.
B_2	19-32	Yellowish brown (10 YR 5/4 moist, 6/4 dry) gravelly sandy loam, similar in structure to B_1, hard consistence. Root mat at bottom of horizon; horizon boundary is abrupt. 20 to 25 per cent gravel. pH 5.9.
C	32+	Gray (10 YR 5/1 moist, 6/1 dry) compacted gravelly sandy loam till. Dense massive structure, impervious to water and roots. pH 5.7.

Some variation in profile characteristics within the series is permitted. The A ranges from 2 to 12 inches in thickness with a variation in color and organic matter content. The content of gravel and stones is variable due to wave-washing. The presence of a loamy sand to loam texture with a distinct pebble-line places the profile in the Langford series, with which Cadboro is often in complex association. Cadboro grades into Shawnigan series in the area of the Saanich Peninsula, and a satisfactory separation is often difficult. A poorly drained series in the same catena as Cadboro has not been found. The depressions are filled with fine-textured materials on which are found Tolmie or Cowichan series.

*Munsell Soil Color Charts, 1954 Edition. Munsell Color Company Inc. Baltimore 2, Maryland. U.S.A.

Agriculture

The Cadboro series provides some of the better agricultural soils on the Saanich Peninsula. They are well supplied with organic matter, nitrogen and phosphorus, and the degree of base-saturation is very satisfactory for most crops. They are particularly suited for the production of crops such as strawberries, vegetables and cut flowers for an early market, but because of their high permeability and low moisture holding capacity, are not well suited to dairying unless irrigated to maintain crop growth from mid-June to September.

Throughout the Victoria metropolitan area, soils of the Cadboro series are being rapidly withdrawn from agriculture for urban housing.

Quinsam Series

Quinsam soils comprise about 8,955 acres mainly in the Campbell River–Sayward area, which constitutes the northern portion of the surveyed area. They are also occasionally encountered elsewhere above the 700 to 1,000 foot level. They have developed on parent material similar to that of the Cadboro, Shawnigan and Sproat series, except that the till has not been modified by wave action.

The Quinsam series belongs to the Podzol soil group. It is characterized by 1 to 2 inches of gray platy sandy loam (A_2) over 18 to 20 inches of reddish brown to yellowish brown permeable gravelly sandy loam (B).

This in turn lies over pale brown to grayish compact and very slowly permeable gravelly sandy loam till (C).

Gravelly sandy loam is the dominant textural class. There is some variation in the amount of gravel present.

The native vegetation is mainly second growth Douglas fir, hemlock, balsam and red cedar. Red alder is common on cut-over areas. The understory consists of shrubs, of which salal is dominant.

These soils usually have rolling to strongly sloping morainic topography. The profile is naturally well drained and permeability of the solum is moderate. The parent material is very impermeable and promotes lateral movement of water as evidenced by mottling.

The Quinsam series has the following characteristics:

Horizon	*Depth in inches*	
A_0	2½– 0	Well to moderately well decomposed organic layer containing considerable amounts of charcoal and woody material. pH 5.2.
A_2	0– 1	Gray (10 YR 5/1 moist, 6/1 dry) sandy loam, weak granular and platy structure. Friable and porous. pH 4.7.
B_2	1– 9	Reddish brown (5 YR 4/4 moist, 7.5 YR 5/6 dry) grading to yellowish brown (10 YR 5/6 moist) with depth. Gravelly sandy loam, single grain and moderately coarse subangular blocky structure with a fairly well developed ortstein. Firm and hard consistence, horizon boundary is clear. pH 5.4.
B_3	9–20	Yellowish brown (10 YR 5/4 moist, 6/4 dry) gravelly sandy loam. Weak fine to medium subangular blocky structure, friable consistence. Lower boundary clear, pH 5.5.
C_1	20–30	Brown (10 YR 5/3 moist, 6/3 dry) gravelly sandy loam, very firm and very hard consistence, slightly mottled. Coarsely layered and wedgelike structure. pH 5.8.
C_2	30+	Gray massive gravelly sandy loam till, impermeable to roots and water.

There are stones and boulders scattered through the profile.

Soil characteristics which are variable are as follows: The A_2 horizon is more pronounced in a northerly and westerly direction where it may attain a thickness of 3 inches. The development of ortstein or orterde roughly follows the magnitude of the A_2 horizon. The Quinsam series is frequently associated with the Sayward series.

Poorly-drained profiles of Quinsam series are readily recognized but have not been separated because of their limited extent.

Agriculture

Soils of the Quinsam series are not used at present for agricultural purposes. The very high clearing costs, stoniness, low fertility and acidity are factors militating against development for agriculture. Their site index for forestry varies from medium to high and they are currently producing high-quality timber.

Shawnigan Series

Shawnigan soils, comprising some 79,250 acres, occur mainly in the southern part of the area. These soils have developed from compact gravelly sandy loam glacial till which contains moderate numbers of cobbles and stones. They belong to the Brown Podzolic soil group. They are characterized by 18 to 20 inches of pale brown and light yellowish brown permeable granular gravelly sandy loam (B), over a gray compact and very permeable gravelly sandy loam till (C).

Gravelly sandy loam is the dominant textural class although there is some variation in the amount of gravel present.

The native vegetation is mainly second growth Douglas fir, balsam hemlock, red alder and maple with an understory of shrubs. The many large stumps furnish evidence of a one-time heavy stand of virgin timber. Red alder and fireweed are common in burned or cut-over areas.

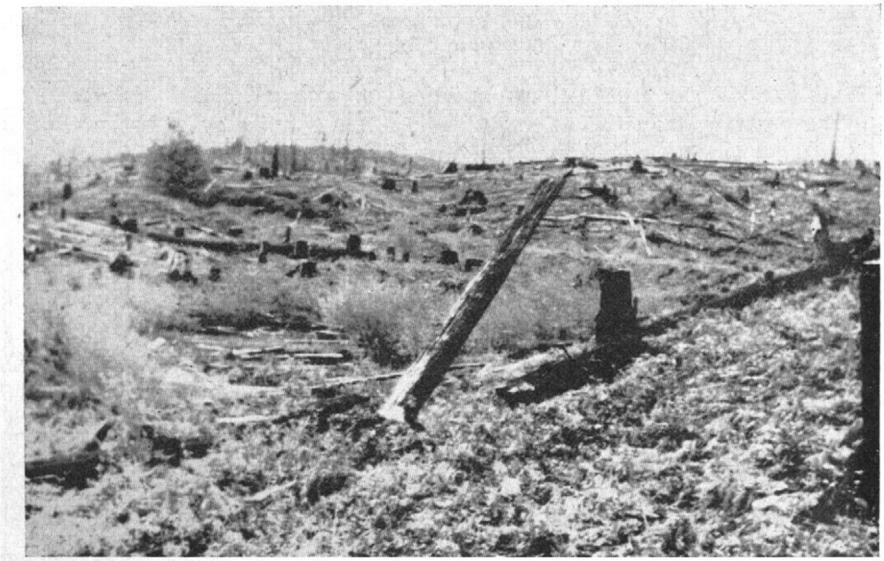


FIG. 9—Logged and burned-over Shawnigan gravelly sandy loam. The topography is sloping. Courtesy of R. H. Spilsbury.

These soils have rolling morainic to steeply sloping topography. The profile is naturally well drained and permeability is moderate except in the parent material where it is very slow. Lateral movement of water over the parent material is common during the winter and early spring.

A typical Shawnigan profile has the following characteristics:

Horizon	*Depth in inches*	
A_0	3- 0	Dark brown organic litter, generally quite fibrous and composed of needles, twigs, leaves and moss roots. pH 5.1.
A_2	0- ¼	Gray (10 YR 6/1 moist, 7/2 dry) sandy loam with weak fine platy structure.
B_2	¼- 9	Dark brown (10 YR 6/3 dry, 4/3 moist) gravelly sandy loam; weak fine granular and weak medium subangular blocky structure. Horizon is porous and very splotchy. Iron oxides coat the sand and gravel separates. About 20 per cent of the horizon is gravel. The lower horizon boundary is smooth and gradual. pH 5.9.
B_3	9-19	Yellowish brown (10 YR 5/4 moist, 6/3 dry) gravelly sandy loam, somewhat lighter in color than B_2. Structure as in B_2, friable consistence. Iron coatings are less marked. About 25 per cent of the horizon is gravel. Lower horizon boundary is abrupt. pH 5.9.
C_1	19-30	Grayish brown (10 YR 5/2 moist, 6/2 dry) compact gravelly sandy loam. Frequently of coarse wedge-like structure, distinctly mottled. Roots generally matted in this horizon. pH 5.7.
C_2	30+	Gray (10 YR 5/1 moist, 6/1 dry) compact massive gravelly sandy loam till. Extremely hard and impermeable to roots and water. pH 5.7. At 5 feet—pH 5.2.

Some variation in profile characteristics is permitted. The A_2 is often absent but, when present, may extend into the B_2 along roots for a distance of ½ to 2 inches. This condition occurs mainly at higher elevations where Shawnigan grades into Quinsam. The number of concretions in the B_2 ranges from none to very few.

Shawnigan grades into the Dashwood series and is intimately associated with it over a very extensive area.

Poorly drained profiles were not mapped, though readily recognizable, because of the scale of mapping and limited occurrence.

Agriculture

Soils of the Shawnigan series are of minor importance agriculturally; however, a limited acreage, particularly that located on the Saanich Peninsula, has been brought under cultivation. It is not anticipated that any major agricultural development will take place on these soils in the immediate future. Topography, the high cost of clearing, stoniness and inherent low fertility discourage extensive development. These soils have a medium to high forest site index and in the past produced much of the timber removed from the coastal region.

Sproat Series

Sproat soils, comprising about 10,660 acres, occur mostly in the Alberni basin. They have developed on compact gravelly sandy loam glacial till which contains moderate numbers of cobbles and stones. They belong to the Concretionary Brown soil group. They may be recognized by 18 to 20 inches of reddish brown to yellowish brown, permeable subangular blocky gravelly sandy loam that is concretionary (B), over gray massive very slowly permeable gravelly sandy loam till (C).

Gravelly sandy loam is the dominant textural class. There is some variation in the amount of gravel present.

The native vegetation is mainly second growth Douglas fir, hemlock and red cedar with an understory of shrubs. The many large stumps suggest a one-time excellent stand of virgin timber. Red alder is common on cut-over areas.

These soils occur on rolling morainic and steeply sloping topography. The profile is naturally well drained, permeability is moderate except in the parent material where it is very slow. Lateral movement of water over the parent material is common during the winter. The moisture deficiency during the summer months is not so pronounced as in the Shawnigan soils and, as would be expected, the surplus during the winter is much greater.

The following description is typical of Sproat soils:

Horizon	*Depth in inches*	
A_0	4- 0	Very dark gray brown (10 YR 3/2 moist) organic layer of decomposing forest litter. Fibrous mass of needles, moss, twigs, etc. pH 6.5.
A_2	0- ½	Light brownish gray to pinkish white (10 YR 6/2 to 7.5 YR 7/2 dry) sandy loam, weak platy structure, friable and porous. pH 6.1.
B_2	½- 9	Reddish brown (5 YR 4/4-3/4 moist, 7.5 YR 5/6 to 10 YR 5/6 dry) gravelly sandy loam. Very weak medium subangular blocky structure. Scattered concretions occur throughout. Horizon boundary is smooth and clear. 50 per cent gravel. pH 5.7.
B_3	9-18	Yellowish brown (10 YR 5/4 moist, 6/4 dry) gravelly sandy loam. Compound weak granular and weak medium subangular blocky structure, friable and porous. Few concretions present; 35 per cent gravel. Horizon boundary is smooth and abrupt. pH 6.0.
C_1	18-30	Gray (10 YR 5/1-5/2 moist 6/3 dry). Compact gravelly sandy loam till in thin wavy layers. Mottling is common and root mats are present between the layers. pH 5.9. Horizon boundary is abrupt.
C_2	30+	Gray (10 YR 5/1, 6/3 dry) sandy loam till. Stones and gravel are common; impervious to water and roots. pH 6.0.

There are stones and boulders scattered through the profile. The A_2 horizon is often absent, but can be usually found under rotten logs. The upper ½ inch of the B_2 horizon occasionally is weakly cemented. There are slight variations in soil texture of the surface horizons due to wave washing.

Poorly drained profiles of Sproat series are readily recognizable but were not separated; they are found to a limited extent.

Agriculture

These soils are not being used agriculturally. Development will be difficult and slow since they need clearing, are stony and low in fertility. Topography, too, is a factor limiting their use for agriculture; their present use is forestry, for which they are well suited.

Soils Developed on Medium-textured Glacial Till

Well Drained

Royston Series

Royston soils cover about 22,020 acres and are located chiefly around Courtenay. They have developed from grayish brown compact clay loam glacial till which contains gravel and stones. They belong to the Brown Podzolic soil group. Royston soils are characterized by 18 to 20 inches of dark brown to yellowish brown gravelly loam with weak blocky structure (B). The C horizon is compact, very slowly permeable till.

Gravelly loam is the dominant textural class. Some areas are more gravelly and stony than others.

The vegetation consists of dense stands of Douglas fir, balsam fir, hemlock and red cedar. The undergrowth is thick and is mainly salal, swordfern, huckleberry and Oregon grape.

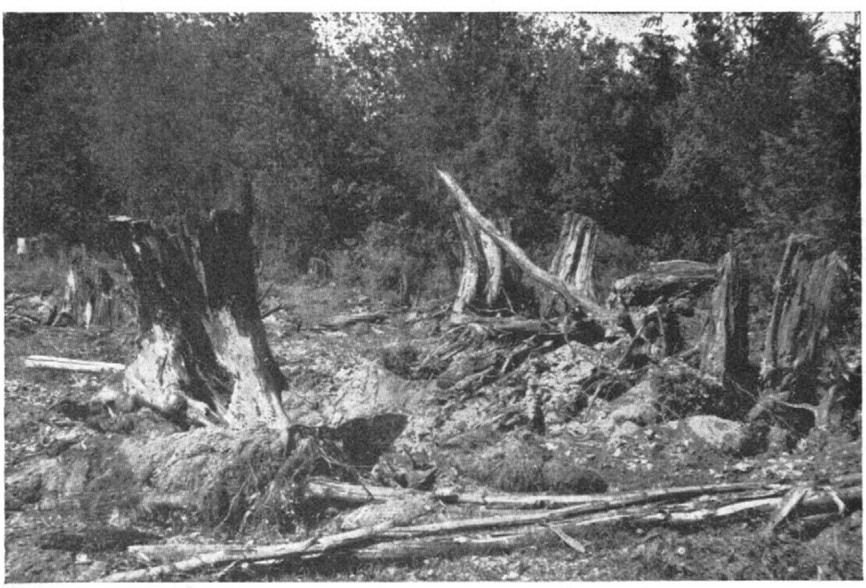


Fig. 10—Royston gravelly loam being cleared with stumping powder. The stumps are Douglas fir, the second growth is alder, willow and Douglas fir.

These soils have undulating to steeply sloping topography. The soil is well drained, permeability of the B horizon is moderate but that of the C is very slow. Water moves laterally over the parent material during the winter.

The following description is typical of the Royston series:

Horizon	Depth in inches	
A_0	2- 0	Dark brown plant remains varying greatly in state of decomposition. pH 4.8.
B_2	0- 9	Dark brown (10 YR 4/3 moist, 7.5 YR 5/6 dry) gravelly loam. Weak medium subangular blocky structure, stones and gravel coated with iron staining, a few concretions. Roots abundant, very permeable. 50 percent gravel. pH 5.7.
B_3	9-20	Brown (7.5 YR 4/4 moist, 10 YR 6/4 dry) gravelly loam, moderate coarse subangular blocky structure. Few roots; gravel coated with iron staining. 25 percent gravel; horizon boundary is abrupt. pH 6.0.
C_1	20-36	Brown (10 YR 5/3 moist) to yellowish brown (10 YR 5/6 moist, 6/4 dry) clay loam, pseudoplaty; partially weathered and strongly mottled. pH 5.0.
C_2	36+	Dark greyish brown to dark yellowish brown (10 YR 4/2 to 4/4 moist, 6/4 dry) gravelly light clay loam till. Impervious to roots and water. Many dark spots and stains. pH 5.1.

There are occasional stones and boulders scattered throughout the profile and on the soil surface. Occasionally an A_2 horizon can be found, particularly under logs; however, it is not considered a regional feature. A few concretions may be present.

A poorly drained profile resembling Tolmie series was recognized but not established as a soil series because of its limited occurrence.

Agriculture

Very little agricultural development has taken place on Royston soils in spite of their accessibility. Clearings are small, scattered, and used mainly for hay, pasture, grain crops and vegetables. Tree fruits and berries seem to do well. Clearing costs are high since the forests are dense and stumps numerous. Stones are sufficiently numerous to require removal. The gravelly and stony places of this series are submarginal for agriculture. For forestry purposes Royston soils have a very high site index. This suggests that their ultimate use may be that of a farm forest in which selected fractions are used for agriculture and the remainder for forest use. The soil moisture-holding capacity is moderately high and about 3.9 inches can be stored in the profile. Even so, it may be desirable to irrigate crops during the dry summer season.

Sandwick Series

Sandwick soils, comprising 1,690 acres, occur almost entirely in the Courtenay area. They have developed from greyish brown compact clay loam glacial till which contains moderate amounts of gravel cobbles and stones. They belong to the Acid Dark Brown Forest group of soils. They may be recognized by 8 to 12 inches of dark brown to black gravelly loam, well-developed granular structure and very permeable (A), over 10 to 13 inches of dark brown to light yellow brown permeable gravelly loam (B). A clay loam till forms the compact and slowly permeable parent material (C).

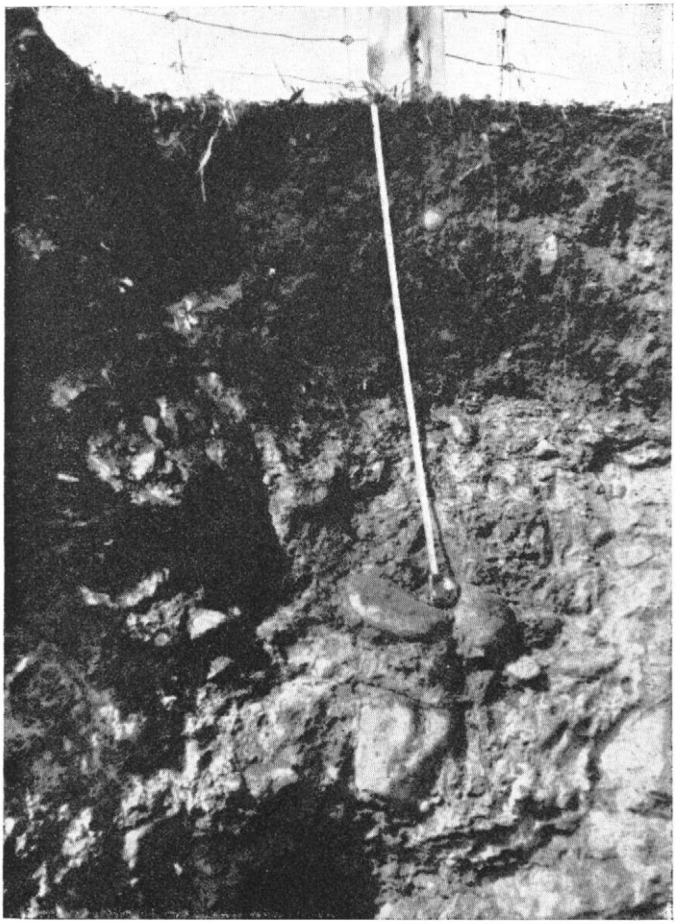


FIG. 11—Sandwick gravelly loam, an Acid Dark Brown Forest soil developed on glacial till.

Gravelly loam is the dominant textural class although there is some variation in the amount of gravel present.

The native vegetation is largely an oak–grass association although, throughout an appreciable portion of the series, stands of first generation Douglas fir with an understory of grasses have become dominant. This represents a recent (perhaps less than 100 years) invasion of the oak–grass association. Relic oak trees may occasionally be found among the young fir trees.

These soils have gently undulating to steeply sloping topography, usually with a southern aspect. The profile is naturally well drained, permeability of the A and B horizons is moderate but very slow in the C horizon. Lateral movement of water over the parent material is indicated by mottling.

The following soil description typifies the Sandwick series:

Horizon	*Depth in inches*	
A_0	1- 0	Brown to dark brown forest litter
A_1	0- 9	Very dark brown to black (10 YR 2/2 moist, 3/2 dry) gravelly loam; strong coarse granular and medium subangular block structure, friable consistence, 27 per cent gravel. pH 5.2. Horizon boundary is clear.

B_1	9–16	Dark grayish brown (10 YR 3/2 moist, 4/3 dry) gravelly loam, compound moderate medium granular and weak coarse subangular blocky structure. Friable and porous, many roots; color becomes lighter with depth. 20 per cent gravel. pH 5.3. Horizon boundary is clear.
B_2	16–22	Dark yellowish brown (10 YR 4/4 moist, 6/4 dry) gravelly loam becoming lighter in color with depth. Structure as in B_1, 20 per cent gravel. pH 5.3. Horizon boundary is abrupt.
C_1	22–39	Brown (10 YR 5/3 moist, 6/4 dry) heavy loam, massive structure. Few roots, 16 per cent gravel. pH 5.4.
C_2	39+	Dark grayish brown (10 YR moist, 6/4 dry) gravelly clay loam till of massive structure. Impermeable, many dark stains. 21 per cent gravel, scattered stones thoughout the profile. pH 5.6.

The A_1 horizon varies in thickness from 2 to 10 inches but averages about 7 inches. Those profiles with thin A_1 horizons generally have lighter soil colors, and occur in the Sandwick–Royston transitional areas.

Sandwick series is similar to Cadboro series.

Agriculture

Soils of the Sandwick series are limited in occurrence, but being confined largely to one district, they are of considerable agricultural importance. They are relatively fertile being well supplied with organic matter and total phosphorus. However responses to applications of lime, nitrogen and phosphorus are anticipated when cropped intensively. Green manure crops should become an integral part of the cropping practice. These soils are considered to have reasonably high moisture-holding capacity, however insufficient precipitation during the growing season results in an acute moisture deficiency. Irrigation may be expected to increase crop yields. Specialty crops such as tree and cane fruits, vegetables and potatoes are commonly grown though at times forage crops are included in the rotation.

The soils of this series under oak–grass vegetation may be readily brought under cultivation while those under a coniferous forest involve rather excessive clearing costs. Stoniness varies somewhat and is often a factor hindering agricultural development and use.

Stamp Series

Stamp Soils, comprising 18,290 acres, occur in the Alberni Basin. They have developed from grayish brown compact clay loam glacial till which contains moderate amounts of gravel and stones. They belong to the Concretionary Brown group of soils. They may be recognized by 10 to 12 inches of yellowish red gravelly loam, with many concretions, lying over 12 to 14 inches of yellowish brown gravelly loam (B). The clay loam till is grayish brown and very slowly permeable (C).

Gravelly loam is the dominant textural class. There is a considerable variation in the degree of stoniness.

The native vegetation consists of second growth Douglas fir, hemlock, cedar and alder. The understory is dominated by salal, with sword fern and Oregon grape.

The Stamp series has undulating to steeply sloping topography. The soil is well drained, permeability of the B horizon is moderate but that of the C is very slow. Water moves laterally over the parent material during the winter.

A typical profile has the following characteristics:

Horizon	*Depth in inches*	
A_0	2- 0	Dark brown organic mat consisting of needles, leaves, wood and moss which is semi-decomposed. pH 5.2.
A_2	0- ½	A thin transition horizon. pH 5.5.
B_2	½-12	Yellowish red (5 YR 4/6 moist, 7.5 YR 5/6 dry) very friable gravelly loam. Concretions are concentrated in the upper two inches. Strong medium granular and moderate fine subangular blocky structure. 40 per cent gravel. pH 5.3. Horizon boundary is clear and smooth.
B_3	12-24	Yellowish brown (10 YR 5/6 moist, 6/4 dry) friable loam containing a few fragments of partially weathered parent material. Moderate coarse blocky structure. 15 per cent gravel. pH 5.2. Horizon boundary is abrupt.
C_1	24-26	Dark yellowish brown (10 YR 4/4 moist, 6/4 dry) somewhat mottled, partially weathered till. pH 6.1.
C_2	26+	Dark yellowish brown (10 YR 4/4 moist, 6/4-5/3 dry) impervious clay loam, very firm and very hard consistence, amorphous structure. Considerable brownish staining on cleavage faces. pH 6.0. A few stones and cobbles are scattered through the profile.

The A_2 horizon is generally absent but may be observed under rotted logs. Variation in gravel and stone content is quite marked. Only the well-drained member has been classified. The poorly drained member resembles Tolmie, and is very limited in extent.

Agriculture

The present use of Stamp soils is for forestry. Very little, if any, is cultivated. The high cost of clearing and need for stone removal discourages development. The soils are low in organic matter and nitrogen, and soil reaction is medium to strongly acid. The soils, where used agriculturally, will probably respond to applications of fertilizer and lime. They have a fairly high moisture-holding capacity, but even so there is a marked moisture deficiency during the growing season.

Soils Developed on Shallow Medium-textured Glacial Till Underlain by Shale and Sandstone

Well Drained

Haslam Complex

The Haslam soils cover 14,725 acres mainly around Nanaimo, but other areas occur on the Gulf Islands and in the vicinity of Courtenay and Duncan. They have developed mainly from glacial scoured consolidated shale and sandstone and belong to the Brown Podzolic soil group. The soil profile is characterized by 2 inches of dark brown granular shaly loam (A) which gives way to 6 to 10 inches of yellowish brown subangular blocky and very permeable shaly loam (B). The parent material (C) consists of fractured and moderately permeable shale or sandstone.

Shaly loam is the dominant textural class but occasionally fine sandy loams or light clay loams may be encountered.

The vegetation consists of Douglas fir, hemlock, cedar, maple and shrubs somewhat less dense than on most other medium-textured soils.

The Haslam soils occur mainly on elongated parallel ridges and knolls having gently to steeply sloping topography. The soil is well drained and permeability is moderate. The fractured parent material does not impede the movement either of water or of roots.

The following profile description is typical of the series:

Horizon	*Depth in inches*	
A_0	1- 0	Partially decomposed organic debris.
A_1	0- 2	Dark grayish brown (10 YR 4/2) light loam of weak granular structure. Friable, many shale and sandstone fragments. pH 6.5.
B_2	2- 5	Yellowish brown (10 YR 5/4) light loam. Weak medium subangular blocky structure, friable consistance, many soft shaly fragments. pH 6.0.
B_3	5-12	Dark yellowish brown (10 YR 4/4) friable shaly loam. pH 6.0.
C_1	12-18	Yellowish brown weathered shale mixed with loam. Shale fragments occupy about 70 per cent of the horizon. pH 6.0.
C_2	18+	Yellow brown slightly weathered and shattered shale, densely packed but permeable to roots and water. pH 6.0.

The Haslam series is rather variable since much adulteration with glacial deposits has probably occurred. In some places igneous stones and gravel are common. In depressions the soil generally is quite deep, in some instances resembling the Fairbridge series. An A_2 horizon commonly occurs under logs or beneath a thick A_0 horizon. The A_1 varies from 1 to 3 inches in thickness and is commonly best developed in the more open sites.

Agriculture

Selected areas of this soil complex, where the solum is deep by reason of deposition of glacial material over the shale, are used for general farm crops, mainly hay and pasture. The majority of the soils, however, are not suitable for agriculture because of droughtiness, low fertility, and the frequency of rock outcrops. Ultimately this soil may be utilized for farm forests, for which it is best suited.

Soils Developed on Coarse-textured Marine Materials Underlaid by Glacial Till or Marine Clay

Well Drained

Dashwood Series

The Dashwood soil series covers 73,910 acres in the Oyster River–Shawnigan Lake Area. This soil has developed from very coarse-textured marine materials underlain by glacial till and belongs to the Brown Podzolic soil group. They are recognized by 25 to 30 inches of yellowish brown loose permeable gravelly loamy sand (B) over gray, often mottled, very slowly permeable gravelly sandy loam till or marine clay (D).

Gravelly loamy sand is the dominant soil textural class (72,970 acres) followed by loamy sand (940 acres).

The vegetation consists mainly of Douglas fir, hemlock, some lodgepole pine and red alder. There also are a few arbutus trees in the forest. The understory is dominated by salal, sword fern and bracken.

The topography is gently sloping to sloping. In some areas kame-like and strongly rolling morainic topography is common. Soil drainage ranges from excessive to moderate while permeability varies from rapid to moderate in the solum. The D horizon is very slowly permeable and induces lateral movement of seepage water.

The following description is typical of the Dashwood soil series:

Horizon	*Depth in inches*	
A_0	1- 0	Dark brown forest litter of leaves and twigs. pH 6.5.
B_2	0-10	Yellowish brown (10 YR 5/6 moist, 6/4 dry) loose structureless gravelly loamy sand. Stones are coated with iron stains. pH 5.8.
B_3	10-25	Yellowish brown (10 YR 5/8 moist, 6/4 dry) loose structureless gravelly sand. pH 6.0.
C_1	25-36	Light yellowish brown (10 YR 6/4 moist, 7/3 dry) loose structureless gravelly sand, mottled in lower part. pH 6.0.
D	36+	Gray (10 YR 6/1 moist, 7/1 dry) gravelly sandy loam glacial till, much mottled in upper part. pH 5.7.

At higher elevations and at the northern end of the area the A_2 horizon becomes thicker and continuous, in which case the soil resembles Sayward series which is a Podzol. In imperfectly drained positions, the Dashwood blends into Bowser series which is also a Brown Podzolic.

There is considerable variation in the degree of stoniness. There usually are pronounced pebble lines and, occasionally, a prominent stone line lies over the till. In places the till lies at depth or is absent. When the depth to till is more than 4 feet, the soil is mapped as Qualicum series.

Agriculture

Very little if any of this soil is used for agriculture. The stoniness, coarse texture, low fertility and low moisture-holding capacity are factors militating against development of this soil, and clearing costs are high. The best use of this soil is for forestry for which it is well suited. The impermeable D horizon maintains the perched water table well into the summer months, thus creating a condition favorable for tree growth. If farm forests develop into commercial enterprises, these soils will prove to be valuable as timber sites.

Langford Series

The Langford soil series covers 8,525 acres and occurs at Victoria and Metchosin. The soil has developed from coarse-textured marine materials underlain usually by glacial till. Langford soils belong to the Black soil group. They are recognized by 10 to 12 inches of very dark brown, very permeable loamy sand, sandy loam or loam (A_1) over 10 to 12 inches of yellowish brown highly permeable loamy sand or loam, often gravelly or stony, (B); over gray impermeable gravelly sandy loam till (D).

Three textural classes have been encountered, loam 3,485 acres, sandy loam 3,885 acres, and loamy sand 1,155 acres.

As on Cadboro series, the vegetation on these soils is dominantly an oak–grass association. Some small areas are under grass. The soils usually have a southern aspect.

The topography is gently sloping to sloping. The soil is well drained, permeability of the A and B horizons is rapid to moderate. The D horizon is very slowly permeable and promotes lateral movement of seepage water.

The following description is typical of Langford loam:

Horizon	*Depth in inches*	
A_c	0- 3	Very dark gray (10 YR 3/1 moist, 4/1 dry) friable loam of moderate medium granular structure. pH 5.9. Horizon boundary clear.
A_{11}	3-10	Very dark gray (10 YR 3/1 moist, 4/1 dry) loam, weak very coarse and moderate medium granular structure, friable. A few small rounded gravel fragments. pH 6.1. Horizon boundary diffuse.
A_{12}	10-13	Very dark greyish brown (10 YR 3/2 moist, 5/3 dry) sandy loam; weak granular to single grain structure; friable. pH 5.4.
B_2	13-20	Dark brown (10 YR 4/3 moist, 5/3 dry) coarse sandy loam; slightly firm. Compound weak coarse blocky and weak fine granular. Some scattered gravel. pH 5.5. Horizon boundary abrupt.
B_3	20-26	Brown (10 YR 4/3 moist, 5/4) loose gravelly sand containing much gravel and some cobbles. pH 5.6. Slightly mottled; moist from seepage. Boundary is wavy and abrupt.
D_1	26–49	Olive brown (2.5 Y 4/4 moist, 6/2 dry) strongly weathered gravelly sandy loam till. Amorphous structure, highly mottled. Friable and slightly hard consistence. pH 5.5. Horizon boundary is very gradual.
D_2	49+	Very dark greyish brown (2.5 Y 3/2 moist, 5/2 dry) amorphous gravelly sandy loam till. Firm and very hard consistence.

The A horizon ranges from 8 to 14 inches thick and the soil texture ranges from loamy sand to loam. The D horizon usually occurs at a depth of 21 to 26 inches but may occur very near the surface. Under such conditions, the gravel content of the surface layer is very high.

Langford series is associated with Cadboro series which it strongly resembles. In poorly drained positions, Tolmie soils are common.

Agriculture

These soils are easily cleared for cultivation. In the vicinity of Victoria, much of it is under urban development and the remainder of it used for tree fruits, potatoes and pasture.

The soil is fairly well supplied with organic matter and nitrogen. Data are not available, but it is expected that total phosphorus is favourable and that the exchange complex is moderately well saturated.

The coarse-textured types are drouthy and irrigation is needed for best returns.

Lazo Series

The Lazo soil series covers 1,770 acres and occurs at Courtenay, Hornby Island and Duncan. The soil has developed from coarse-textured marine materials underlain usually by glacial till. Lazo soils belong to the Acid Dark Brown Forest soil group. They are recognized by 8 to 12 inches of black very permeable loamy sand, sandy loam or loam (A_1); over 9 to 11 inches of yellowish brown highly permeable loamy sand or loam, often gravelly or stony (B); over gray very slowly permeable gravelly sandy loam till (D).

Fig. 12—Lazo loamy sand, an Acid Dark Brown Forest soil. Note the concentration of gravel and stones over the glacial till D horizon.

Three textural classes have been encountered, loam 315 acres, sandy loam 245 acres and loamy sand 1,210 acres.

The vegetation is dominantly an oak–grass association. In some areas first generation Douglas fir with an understory of grass may be found, and in other areas, as at Cape Lazo, the vegetation entirely is grass. These soils usually have a southern aspect.

The topography is gently sloping to sloping. The soil is well drained, permeability of the A and B horizons is rapid to moderate. The D horizon is very slowly permeable and promotes lateral movement of seepage water.

The following description of Lazo sandy loam at Cape Lazo is typical of the series:

Horizon	*Depth in inches*	
A_1	0-11	Black (10 YR 2/1 moist, 3/2 dry) friable sandy loam, medium cloddy-granular structure with firm or hard consistence (brittle). Low bulk density, fluffy when cultivated. pH 5.5. Horizon boundary clear.

B_2	11-17	Dark yellowish brown (10 YR 4/4 moist, 5/4 dry) sandy loam with weak fine granular structure and firm or hard consistence. A few pebbles. Horizon boundary is gradual. pH 6.0.
B_3	17-21	Yellowish brown (10 YR 5/4 moist, 6/4 dry) gravelly sandy loam containing scattered stones forming the surface of an erosion pavement. Strong medium blocky structure, friable or very hard consistence. Faintly mottled. pH 6.0.
D_1	21-30	Gray (10 YR 5/1 moist, 7/1 dry) mottled gravelly sandy loam, firm and extremely hard consistence. Coarse wedge-like structure. pH 6.0.
D_2	30-48	Gray gravelly sandy loam till containing scattered stones and boulders. Extremely hard, somewhat mottled, impermeable. Similar to the parent material of Shawnigan series.

The A_1 ranges in thickness from 8 to 12 inches. The texture of the solum is variable and there may be lenses of gravel and cobbles in the solum. The depth to the D horizon ranges from 20 to 40 inches. The D horizon is usually glacial till but may be marine clay or rock.

The brittle consistence and low bulk density observed in this soil are believed to be the same as those found in the Ando soils of Japan which are formed on volcanic ash.

Agriculture

These soils are easily cleared for cultivation. Analytical data is not available but the soil is considered fairly well supplied with organic matter and nitrogen. However, in common with similar soil types, it is anticipated that in the course of cultivation this soil will respond to applications of nitrogen and phosphorus.

The coarse-textured types are drouthy and irrigation is needed for optimum returns.

Imperfectly Drained

Bowser Series

Bowser soils cover 39,085 acres. It is distributed mainly on the east coast from Campbell River to Duncan. These soils have developed on coarse-textured marine materials underlaid by glacial till or marine clay and belong to the Brown Podzolic soil group. They are characterized by 20 to 30 inches of reddish brown loamy sand containing many iron cemented clods, over 4 to 6 inches of yellowish brown to reddish brown strongly cemented ortstein (B). This in turn lies on a very slowly permeable gravelly sandy loam till or marine clay (D).

Loamy sand is the only textural class encountered. Gravel and stones are uncommon.

The vegetation consists of Douglas fir, hemlock and red cedar with red alder dominant on logged-off areas.

The topography is gently sloping. The soil is imperfectly drained and permeability is rapid to moderate in the solum. The D horizon is very slowly permeable. The combination of gently sloping topography and slowly permeable D horizon has encouraged lateral movement of seepage water. Dissolved iron and organic matter have precipitated to form a strongly cemented layer, over the D horizon, and to a lesser extent ortstein clods scattered through the B horizon.

A typical Bowser soil has the following characteristics:

Horizon	*Depth in inches*	
A_0	1- 0	Dark brown fibrous semi-decomposed organic mat. pH 4.5.
A_1	0- 2	Dark reddish brown (5 YR 3/3 moist, 4/3 dry) loamy sand, moderate granular structure (mull), friable. pH 5.2.
A_2	2- 2½	Light reddish brown (5 YR 6/3 moist, 7/3 dry) loamy sand, loose and porous. pH 5.2.
B_2	2½-20	Dark reddish brown (5 YR 3/4 moist, 4/6 dry) loamy sand. Weak fine subangular blocky structure. A few large (1 to 3 inches diameter) irregularly shaped very firm strongly cemented clods scattered through the horizon. Roots abundant. pH 5.9.
B_2G	20-26	Yellowish brown (10 YR 5/6 moist) to reddish brown (5 YR 4/4 moist) cemented loamy sand; an ortstein layer. pH 5.9.
D	26+	Very pale brown (10 YR 7/3 moist) to white (10 YR 8/1 moist), mottled, compact silt loam. pH 5.8.

Variations from the above profile occur in the series. The A_1 may be absent. The A_2 horizon is usually absent and when present is only weakly developed. The D horizon generally is gravelly sandy loam till, similar to the parent material of Shawnigan series, and usually occurs at depths of 3 to 4 feet. The degree of development of the ortstein layer and of the cemented clods in the B horizon is variable.

The Bowser series is frequently associated with Dashwood, Parksville and Custer series.

Agriculture

Only a small percentage of this soil is cultivated and it is used mainly for hay and pasture. The soil is cold and late and seepage water maintains the subsoil in a moist condition throughout most of the year. The moisture-holding capacity of the solum is moderately low, total phosphorus is distinctly low and the exchange complex is quite unsaturated. Generally the Bowser is an inferior soil for agriculture.

Sayward Series

Sayward soils cover 2,895 acres in the Campbell River and Sayward areas. They have developed on coarse-textured marine materials underlaid by glacial till or marine clay and belong to the Podzol soil group. They are characterized by 1 inch of gray leached loamy sand (A_2) over 18 to 20 inches of dark reddish brown and reddish very permeable loamy sand, containing iron cemented clods (B). Beneath this lies 20 to 30 inches of dark grayish brown permeable sand showing strong iron cementation and mottling at lower depths (C). This in turn overlies a very slowly permeable, gravelly sandy loam till or marine clay (D).

Loamy sand is the only textural class encountered. Gravel and stones are uncommon.

The vegetation consists of Douglas fir, hemlock, red cedar and red alder.

The topography is gently sloping. The soil is imperfectly drained; permeability is rapid to moderate. The D horizon is very slowly permeable and maintains a high water table during the rainy season. Precipitated iron and organic matter have formed a cemented layer over the D horizon and to a lesser extent, ortstein clods are scattered through the B horizon.

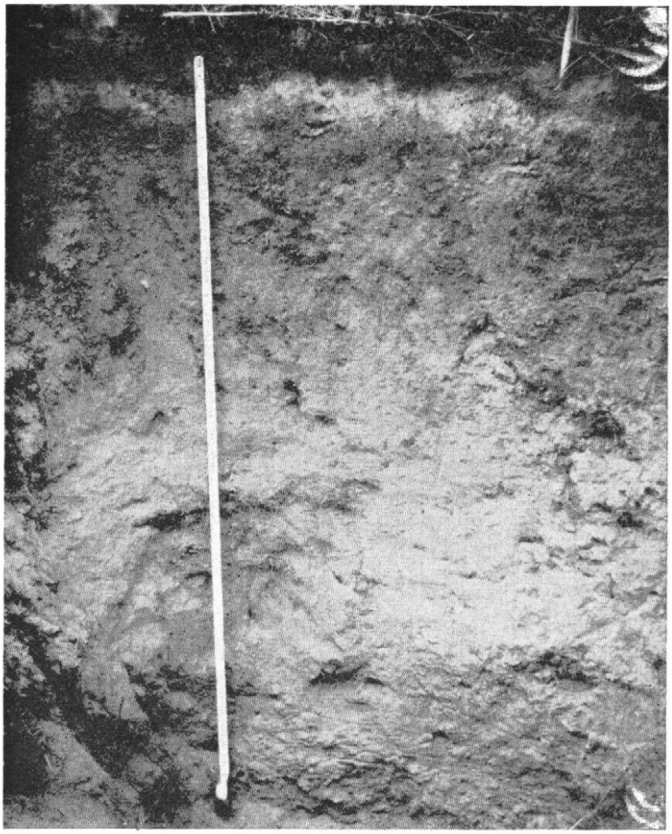


FIG. 13—Sayward loamy sand, a Podzol. Note the white A_2 horizon.

A typical Sayward profile has the following characteristics:

Horizon	*Depth in inches*	
A_{00}	2½– 2	Undecomposed leaves, needles and twigs.
A_0	2– 0	Moderately well decomposed fibrous organic remains of above horizon. pH 5.3.
A_2	0– ½	Gray (5 YR 6/1 moist, 7/1 dry) loamy sand, loose consistence and single grain structure. pH 5.0.
B_{21}	½– 3	Dark reddish brown (5 YR 3/4 to 4/ moist, 10 YR 5/6 dry) friable loamy sand, weak fine subangular blocky structure which contains large (1 to 3 inches diameter) irregularly shaped strongly cemented clods. pH 5.2.
B_{22}	3–15	Similar to above but containing fewer cemented clods. pH 5.5.
B_3	15–19	Yellowish red (5 YR 5/6 moist, 10 YR 6/4 dry) loamy sand with numerous large cemented clods which are very hard. pH 5.6.
C	19–50	Dark grayish brown (2.5 Y 4/2 moist, 5 Y 6/3 strongly cemented clods; prominently mottled. pH 5.6.
D	50+	Olive (5 Y 5/3 moist, 2.5 Y 6/4 dry) highly mottled plastic clay, amorphous structure. pH 5.6.

The A_2 horizon is always present and in places attains a thickness of 1½ inches. The degree of cementation in the B is variable. The D horizon generally is gravelly sandy loam till which occurs at depths ranging from 3 to 4 feet, but the depth is variable and is related to topography and position on the slope. The profile is perhaps slightly better drained than Bowser series.

Sayward series is frequently associated with Kye and Bowser series.

Agriculture

This soil is at present used entirely for forestry purposes and should continue to be so used. The problems associated with development of the soil are the same as for Bowser series.

Poorly Drained

Parksville Series

Parksville soils cover about 5,505 acres. They are distributed mainly in the Qualicum Beach–Campbell River area. The soil has developed on coarse-textured marine material underlaid by glacial till or marine clay and it belongs to the Dark Gray Gleysolic soil group. The profile is characterized by 5 to 6 inches of dark grayish brown, very permeable granular sandy loam (A_1), lying on 4 to 5 inches of brown permeable loamy sand (B). This in turn overlies 14 to 16 inches of yellowish brown or reddish brown mottled loamy sand (B_g), which rests on light brown compact and slowly permeable gravelly sandy loam till or marine clay (D).

Sandy loam is the dominant textural class encountered, although some areas have a thin layer of loam on the surface.

The vegetation consists of red cedar, red alder, willow and occasionally cascara. Devil's club is sometimes present in the understory of shrubs.

The topography is level. The soil is poorly drained, permeability of the solum is moderate while the D horizon is very slowly permeable. The soil receives seepage water from the higher adjacent areas.

The Parksville series has the following characteristics:

Horizon	*Depth in inches*	
A_{00}	1-0	Raw undecomposed litter of leaves, twigs and grass.
A_{11}	0- 3	Very dark grayish brown (10 YR 3/2 moist, 4/2 dry) friable loam of medium granular structure. pH 5.3. Horizon boundary is clear.
A_{12}	3- 5	Dark grayish brown (10 YR 4/2 moist, 5/2 dry) friable sandy loam of weak granular to single grain structure. pH 5.5. Horizon boundary is abrupt.
B	5- 9	Brown (10 YR 5/3 moist, 6/3 dry) friable loamy sand, single grain structure. pH 5.7. Horizon boundary abrupt.
B_{g1}	9-18	Light yellowish brown (10 YR 6/4 moist and dry) firm loamy sand with yellowish brown mottles. pH 6.0.
B_{g2}	18-24	Pale brown (10 YR 6/3 moist) with many prominent yellowish brown (10 YR 5/8) mottles. pH 6.2. Horizon boundary is abrupt.
D	24+	Light brownish gray (2.5 Y 6/2 moist) plastic sandy clay with many prominent yellowish brown mottles. Very slowly permeable. pH 6.3.

The surface texture varies from sandy loam to heavy loam. The B horizon may be very thin or absent when the D horizon is close to the soil surface. The depth to the D horizon varies from 16 to 30 inches. Where the profile is very shallow, the drainage is poorer and the A_1 thicker and mucky in character. Pebble lines are commonly encountered and the D horizon may consist of glacial till, marine clay, or less commonly of rock.

Parksville series is associated with Lazo, Dashwood and Bowser series. It resembles the Tolmie series but is distinguished on the basis of its coarse-textured solum.

Agriculture

Very little, if any, of the Parksville series is cultivated. The soil occurs in very small pockets and, thus, it will be difficult to apply specific management practices.

The soil is well supplied with organic matter and nitrogen in the A horizon but the B horizons are notably deficient. The soil is saturated for much of the year and is slow to warm up in the spring. Artificial drainage is required.

Soil Developed on Medium to Fine-textured Marine Materials Underlaid by Marine Clay or Glacial Till

Moderately Well Drained

MERVILLE SERIES

The Merville series covers 3,645 acres in small 'islands' at Courtenay, Parksville, Nanaimo and Duncan. This series has developed on medium to fine-textured marine materials underlaid by marine clay or glacial till and is placed in the Acid Dark Brown Forest soil group. Soils of the Merville series are characterized by 6 to 10 inches of dark brown granular permeable sandy loam or loam (A_1), lying on brown granular to subangular blocky very permeable loam (B), which, in turn, overlies gray very slowly permeable plastic marine clay (D).

Loam is the most common soil texture (3,500 acres) but sandy loam also occurs (145 acres).

The vegetation consists largely of grasses with scattered oak trees. Some of this vegetative type has been invaded by Douglas fir and maple among which relic oaks may sometimes be found.

The topography is gently sloping. The soil is moderately well drained; permeability of the A and B horizons is moderate while that of the D is slow. During the winter months the soil is saturated to within a foot of the surface.

A typical Merville loam has the following characteristics:

Horizon	*Depth in inches*	
A_0	1– 0	Dark brown organic matter. pH 6.0.
A_1	0– 8	Very dark grayish brown (10 YR 3/2 moist, 4/2 dry) loam, weak coarse subangular blocky and moderate medium granular structure. Friable and soft consistence. pH 5.0. The horizon boundary is gradual.

B	8-17	Dark brown (10 YR 4/3 moist and dry) silt loam, weak coarse subangular blocky structure, friable consistence. pH 5.6. Horizon boundary is abrupt.
B_g	17-34	Dark grayish brown (10 YR 4/2 moist, 6/3 dry) silt loam with many prominent brownish yellow mottles. Amorphous structure. pH 6.1.
D	34+	Grayish brown (2.5 Y 5/2 moist, 10 YR 8/1 dry) silty clay plus many brownish yellow mottles. Amorphous and plastic. pH 6.8.

The A_1 horizon may range from 3 to 14 inches in thickness. Soil texture of the solum is usually constant but may change with depth owing to the mode of deposition. The depth to the D horizon varies from about 25 to 40 inches. Gravelly layers may occur in the B horizon.

Merville series is commonly associated with Puntledge and Tolmie series.

Agriculture

Only a few small patches of uncleared land are still to be found. Tree fruits, small fruits, potatoes, hay and coarse grains are commonly grown.

The virgin soils are well supplied with organic matter and nitrogen, but once brought under cultivation these disappear rather rapidly. Natural manures supplemented by nitrogenous fertilizers are recommended. Potash, too, is recommended for forage crops and phosphates may be expected to give a response with other crops. Soil reaction is strongly to medium acid in the A and B horizons and the exchange complex of these horizons is strongly unsaturated.

The soil moisture storage capacity is 1.4 inches in the top foot, and for best results irrigation water must be provided. The non-capillary porosity and permeability of the A and B horizons are adequate to handle rainful intensities or irrigation rates in the order of 1.5 inches per hour.

Moderately Well to Imperfectly Drained

PUNTLEDGE SERIES

Puntledge soils cover about 11,705 acres principally in the Courtenay and Parksville areas. They have developed on medium- to fine-textured marine materials underlaid by marine clay or glacial till and they belong to the Concretionary Brown soil group. The soil is characterized by 15 to 18 inches of yellowish red to yellowish brown granular to subangular blocky very permeable silt loam (B) lying on gray highly-mottled plastic slowly permeable marine clay (D).

Silt loam is the only soil texture encountered. Gravel and stones are rare. On the soil map the soil texture is reported as fine sandy loam instead of silt loam.

The original vegetation consisted of dense stands of coniferous forests which have long since been logged. The present vegetation is mainly red alder, willow and young conifers. Cascara is observed on occasion and the understory consists of shrubs, sword fern and bracken.

The topography is very gently sloping and undulating. The soil is moderately well to imperfectly drained, permeability of the B horizon is quite high but that of the D is very low. During the winter the soil is saturated to within a foot of the surface.

The typical Puntledge soil has the following characteristics:

Horizon	*Depth in inches*	
A_0	2- 0	Moderately well decomposed dark brown fibrous mat of leaves, needles and twigs. pH 4.2.
A_2	0- ½	Dark reddish gray (5 YR 4/2 moist, 7.5 YR 5/4 dry) very fine sandy loam, weak fine platy structure, pH 4.6.
B_2	½- 9	Yellowish red (5 YR 4/6 moist, 7.5 YR 5/6 dry) silt loam, weak medium subangular block structure, friable; contains a very few soft concretions. Many roots. pH 5.5.
B_3	9-15	Yellowish brown (10 YR 5/6 moist, 6/4 dry) silt loam, weak medium subangular blocky, friable. pH 5.6.
D_1	15-24	Pale brown (10 YR 6/3 moist, 7/3 dry) silty clay loam with much yellowish brown (10 YR 5/6 moist) mottling, amorphous structure. pH 6.1.
D_2	24+	Light brownish gray (2.5 Y 6/2 moist, 7/2 dry) silty clay loam with mottling as in D_1 (10 YR 5/8 moist). Amorphous and plastic. pH 5.9.

The A_2 horizon is often absent. The B_2 horizon color ranges from yellowish red to brown (5 YR 4/6 to 7.5 YR 4/4 when moist). Concretions are very limited in this profile. The depth to the D horizon may vary from 1 to 3 feet but averages about 18 inches.

Puntledge series is often associated with the Merville, Bowser and Tolmie series.

Agriculture

Nearly all of the Puntledge soils located in the Courtenay area are cultivated. They are used largely for potatoes, oats, orchard crops, hay and pasture.

Soil reaction is strongly to medium acid. The organic matter and nitrogen contents are relatively high but when brought under cultivation the nitrogen level drops rapidly to a low level. Total phosphorus is low and the soils respond to complete fertilizers. Liberal applications of stable manures or green manures are recommended. The exchange complex is low in base-saturation. Periodic liming should be practiced. The top foot of mineral soil has a moisture-holding capacity of about 1.6 inches. The permeability and non-capillary porosity values are favorable for rapid uptake of water. Irrigation is required during July and August.

Poorly Drained

Tolmie Series

The Tolmie series covers about 21,930 acres and has a wide distribution mainly in the southern portion of the area. They are developed on medium- to fine-textured marine materials underlaid by marine clay or glacial till and belong to the Dark Gray Gleysolic soil group. They are characterized by 6 to 9 inches of very dark brown to black granular fine sandy loam to sandy clay loam (A_1), on 4 inches of gray to grayish brown slowly permeable subangular blocky sandy clay loam (AB). This overlies 8 inches of highly-mottled slowly permeable sandy clay (B_g) which in turn gives way to gray compact very slowly permeable marine clay or glacial till (D).

Sandy clay loam is the most common soil texture (11,915 acres) but loam (7,745 acres), sandy loam (1,225 acres) and fine sandy loam (1,045 acres) also occur.

The vegetation consists of Douglas fir, broad-leaf maple, willows and in the Victoria–Saanich area an occasional Garry oak. The understory consists of shrubs, ferns and bracken.

The topography is mainly level to depressional but in places is gently sloping. The soil is poorly drained. The A horizon is permeable but the horizons below are very slowly permeable and mottled.

Tolmie loam has the following characteristics:

Horizon	*Depth in inches*	
A_0	1- 0	Dark brown semi-decomposed litter of moss, needles, leaves and twigs. pH 5.6.
A_{11}	0- 4	Black (10 YR 2/1 moist, 3/2 dry) loam, strong medium granular structure, friable and soft consistence. Many roots bind the soil together. pH 5.8. Horizon boundary is clear.
A_{12}	4- 8	Dark brown (10 YR 4/3 moist, 5/2 dry) loam, weak coarse subangular blocky structure, friable. pH 5.5. Boundary abrupt.
AB	8-16	Grayish brown (10 YR 5/2 moist, 7/3 dry) sandy clay loam, slightly mottled. Weak coarse subangular blocky structure, friable and slightly hard consistence. Some gravel present. pH 5.2.
BG	16-26	Yellowish brown (10 YR 5/4 moist, 6/4 dry) sandy clay loam with many reddish brown mottles. Weak coarse blocky to amorphous structure, plastic and hard. A pebble line at lower limit. pH 4.9.
D	26+	Gray (10 YR 6/1 moist, 7/1 dry) gravelly sandy loam till. Angular wedge-like structure. Many yellowish brown mottles. Very dense and very slowly permeable. No roots. pH 6.0.

Due to the mode of origin many variations occur in this soil series. The color of the A ranges from dark grayish brown to black and the thickness from 6 to 15 inches. The content of gravel depends on position on the slope. Usually the surface soil is free of gravel but in places where it reaches 35 per cent the solum is thin over the D horizon. The D horizon may occur within 15 inches of the surface but is usually found at a depth of 24 to 30 inches, and usually is marine clay.

Tolmie soils are often associated with Merville, Puntledge and Langford soil series.

Agriculture

Soils of the Tolmie series are used for a great variety of crops; potatoes, small fruits, hay and pasture are probably the most important.

The A horizon of these soils are well supplied with organic matter and nitrogen and moderately so in respect to total phosphorus. The cation exchange capacities are favourable and the exchange complexes are moderately well saturated. The Tolmie sandy clay loam, for instance, an important soil in the Saanich Peninsula, has pH and base-saturation levels about optimum for most crops and does not respond to applications of lime (9).

In general, these fertile soils respond to applications of a complete fertilizer. Drainage is necessary in many areas.

The moisture-holding capacity of the top foot is 1.9 inches, and 2.8 inches for the effective rooting zone. The combination of a relatively shallow soil and a moisture-deficient climate indicate that irrigation is needed for maximum yields.

Field tests indicate that Tolmie soils upon cultivation readily lose their favourable soil structure. Effort should be made to maintain it through frequent incorporation of fibre and by careful tillage operations.

FIG. 14—Erosion of Tolmie sandy clay loam resulting from 3-4 inches of rain, February 15-16, 1949. The topography is gently sloping. Courtesy of J. J. Woods.

Soils Developed on Fine-textured Marine Materials

Well Drained

ALBERNI SERIES

The Alberni series covers 9,705 acres in the Alberni Basin. The soil has developed on fine-textured marine materials and belongs to the Concretionary Brown soil group. This series differs from the Fairbridge in many physical and chemical characteristics. Generally Alberni soils are redder in color and contain more concretionary aggregates in the surface horizons.

The soil profile is characterized by 12 to 15 inches of yellowish red to reddish brown highly concretionary, highly permeable, strongly aggregated clay lying over 6 to 8 inches of yellowish brown to strong brown subangular blocky permeable clay (B) which, in turn, gives way to a mottled yellowish brown and black very slowly permeable marine clay (C).

The dominant textural class is clay. Pebbles and stones are rarely found.

The vegetation consists of Douglas fir, hemlock and red cedar. Large ferns, bracken, salal, Oregon grape and small trees form a dense tangled understory.

The topography is irregular very gently and gently sloping. The surface is hummocky probably due to uprooting trees. The soil is well drained, permeability is medium in the B horizon but very slow in the C.

Alberni clay has the following characteristics:

Horizon	*Depth in inches*	
A_0	2- 0	Slightly decomposed remains of moss, needles, leaves and wood. pH 5.2.
B_{21}	0- 7	Reddish brown (5 YR 4/4 moist) and yellowish red (5 YR 4/4 dry) clay of compound strong coarse granular and moderate medium subangular blocky structure. About 16 per cent of the soil is hard concretions of 2-5 mm. size. Very permeable, many roots, moderately friable. pH 5.5. Horizon boundary is gradual.
B_{22}	7-15	Reddish brown and yellowish clay as above, 10 per cent of this soil is hard concretions. Slightly more compact than above. pH 5.4. Horizon boundary is clear.
B_3	15-22	Yellowish brown to strong brown (10 YR 5/4 to 7.5 YR 5/6 moist) clay, strong medium subangular blocky structure, firm and hard consistence. Very few concretions. pH 5.0. Root mat at the abrupt horizon boundary.
C_1	22-24	Light yellowish brown (2.5 Y 6/4 moist, 7/4 dry) somewhat mottled clay. Firm and hard consistence, moderate medium blocky structure. pH 4.9.
C_2	24+	Light yellowish brown clay as above with coarse blocky structure. Black stains on cleavage faces. Very slowly permeable. pH 5.4.

An A_2 horizon may be present under an especially thick A_0 horizon or under rotted logs. There may be minor variations in the various horizons in respect to color, texture, thickness and drainage conditions.

The Alberni series is associated with the Cowichan series.

Agriculture

The Alberni soils are considered to be well adapted for agricultural use but to date have remained almost entirely under forest. Forage crops, grains, roots and potatoes are successfully grown though the midsummer drought tends to restrict yields somewhat to an average below that of soils adequately supplied with moisture. They compare favorably with Saanichton and Fairbridge soils but it is possible they will lose their structure, puddle and bake, if cultivated when wet. In addition, the heavy dense subsoil may create a problem.

This soil has much the same deficiencies as Fairbridge soils. Proper rotation and application of available barnyard manure increases organic matter content and nitrogen levels and improves crop production. Supplementary applications of complete fertilizers have proved very successful.

The soil has a narrow moisture range within which it can be tilled without damaging structure. Thus, sound tillage practices, the use of crops which provide complete soil coverage for the greater part of the year and the frequent incorporation of organic matter will tend to improve the structure. The soil is strongly acid in reaction and a complete mineral fertilizer is recommended for most crops.

Fairbridge Series

The Fairbridge series, which covers about 35,000 acres, occurs in the area stretching from Shawnigan Lake to Campbell River. The largest blocks occur to the south of Duncan. The soil has developed on fine-textured marine material and belongs to the Concretionary Brown soil group. The soil profile is characterized by 10 to 12 inches of brown to light yellowish brown highly concretionary and very permeable silty clay loam, over 7 to 10 inches of pale brown blocky permeable silty clay loam (B), which lies on pale yellow somewhat mottled coarse blocky very slowly permeable marine silty clay (C).

The dominant textural class is silt loam to silty clay loam. Gravel is infrequently encountered in the profile.

The vegetation consists of Douglas fir, maple, hemlock and an occasional arbutus, alder and willow. Salal commonly forms the understory. There are many large stumps in the forest.

The dominant topography is irregular very gently to gently sloping with a hummocky surface due to uprooting trees. The soil is well drained and permeability is moderate in the D horizon but very slow in the C.

Fairbridge silty clay loam has the following characteristics:

Horizon	*Depth in inches*	
A_0	2- 0	Litter of needles, leaves and twigs over dark brown moderately well decomposed organic debris. pH 4.9.
AB	0- 1	Brown (7.5 YR 5/4 moist, 6/4 dry) silt loam of compound strong medium granular and weak fine subangular nuciform structure. About 25 per cent of the soil is medium sized (2-5 mm.) hard concretions. pH 5.5.
B_2	1-12	Brown to dark yellowish brown (10 YR 4/4 to 4/3 moist, 6/4 dry) silty clay loam of weak medium subangular blocky and strong coarse granular structure. Many hard concretions. Moderately friable. A few pebbles may occur. pH 5.7. Horizon boundary is diffuse.
B_3	12-19	Pale brown (10 YR 6/3 moist, 7/3 dry) silty clay loam, strong coarse blocky structure, a few concretions in upper part. pH 5.2. Horizon boundary abrupt.
C_1	19-24	Pale yellow (2.5 Y 7/4 dry, 6/4 moist) silty clay loam of coarse blocky structure. Very firm and very hard consistence. pH 5.6. Mottled. Gradual horizon boundary.
C_2	24+	Pale yellow silty clay loam as above. Black stains and splotches on cleavage faces. pH 6.0.

In the Campbell River area, a silt loam textural class occurs.

The AB horizon is weakly developed, often absent, and at best a thin transitional layer.

The depth to C horizon ranges from 16 to 24 inches. Fairbridge series is commonly associated with Cowichan series.

Agriculture

Fairbridge soils are rated as highly suitable for general agricultural purposes even though their fertility level leaves much to be desired. The organic matter and nitrogen contents are distinctly low and analyses indicate that the total phosphorus content is also low.

The soils are medium to strongly acid in reaction and the cation exchange capacity while low is moderately base-saturated. The surface soils have a well-developed granular to subangular blocky type of structure which favors aeration and free drainage. Permeability, non-capillary porosity and available water-storage capacity are very satisfactory. However, it has been observed that the surface layers of many cultivated fields, particularly pastures, become very hard and compact. This soil puddling and subsequent packing may be controlled in part at least, through careful management.

Cultivated soils of the Fairbridge series are used largely for dairying. Tree and small fruits including cane fruits and strawberries as well as other crops are also grown. Usually irrigation is advisable if maximum production is desired.

Memekay Series

The Memekay series covers 2,975 acres, most of which occurs in the Sayward area. The soil has developed on fine-textured marine materials and belongs to the Podzol soil group. The soil profile is characterized by 1 to 2 inches of light gray platy clay loam (A_2) over 18 to 22 inches of pale yellowish brown to pale yellow subangular blocky and blocky permeable clay (B). The parent material (C) consists of a mottled very slowly permeable massive marine clay.

The dominant textural class is clay loam. Pebbles and stones are uncommon.

The vegetation consists of hemlock, red cedar, alder, willow and many shrubs in the understory.

The topography is gently to steeply sloping and suggests that the soils are developed on erosional remnants of clay which filled the Sayward Valley. The soil is well drained, permeability is intermediate in the B horizon but very slow in the C.

A typical Memekay soil has the following characteristics:

Horizon	*Depth in inches*	
A_0	3- 0	Dark brown semi-decomposed very fibrous mat of forest litter. pH 4.9.
A_2	0- 1	Light gray (5 YR 7/1 dry, 6/3 moist) friable clay loam with compound weak fine platy and granular structure. pH 4.5.
B_2	1- 7	Reddish brown to yellowish red (5 YR 4/4 to 4/6 moist, 7.5 YR 5/8 dry) clay loam of moderate fine to medium subangular blocky structure; friable. pH 5.6.
B_3	7-21	Strong brown (7.5 YR 5/6 moist, 10 YR 6/4 dry) clay loam of weak medium subangular blocky structure, firm and hard consistence. Horizon boundary gradual. 5.6.
C_1	21-35	Light yellowish brown (2.5 Y 6/4 moist, 7/4 dry) clay loam, moderate coarse to very coarse blocky structure, moderately firm and hard consistence. pH 5.7. Some organic staining. Horizon boundary gradual.
C_2	35-72	Pale yellow (2.5 7/4 moist, 10 YR 7/1 dry) clay loam of very coarse blocky structure, weakly stratified. Some blackish organic staining on cleavage faces. pH 5.9.

The A_0 horizon ranges in thickness from 1 to 3 inches. The A_2 is continuous and at the south end of the Sayward Valley may reach 2 inches in thickness.

Agriculture

These soils have not been cultivated. Their location, topography and heavy clearing cost are the chief factors militating against their present use for agriculture. They are very productive forest soils and well situated for intensive exploitation of their forest values.

SAANICHTON SERIES

Soils of the Saannichton series cover 15,355 acres in the Victoria–Saanich Peninsula area. They have developed on fine-textured marine material and belong to the Acid Dark Brown Forest soil group.

Saanichton soils are recognized by the presence of 2 inches of dark brown granular permeable clay (A_1) over 16 to 18 inches of yellowish brown subangular blocky permeable clay (B) which, in turn, overlies a pale brown, mottled, very slowly permeable amorphous marine clay (C).

The dominant textural class is clay but occasionallly clay loam occurs. Gravel fragments are infrequently encountered in the profile.

The native vegetation is dominantly Douglas fir, although some arbutus, maple and red alder occur. The shrub cover, only moderately dense, consists of snowberry, salal, rose, oregon grape and bracken. In some places, Douglas fir appears to have invaded the Garry oak–grass–shrub association commonly seen on Cadboro and Langford soils.

The topography is gently sloping. The soil is well drained, permeability is high to medium in the solum but very low in the parent material. The C horizon is somewhat mottled at the upper boundary.

A typical Saanichton soil has the following characteristics:

Horizon	*Depth in inches*	
A_0	1- 0	A semi-decomposed layer of needles, twigs, leaves, etc. pH 6.2.
A_1	0- 2	Very dark grayish brown (10 YR 3/2 moist, 4/2 dry) clay loam, strong to moderate medium granular structure which appears to be largely worm casts. Friable, a few small gravel fragments. pH 5.9. Horizon boundary is abrupt.
B_1	2- 6	Brown (10 YR 4/3 moist, 5/4 dry) clay, moderate medium to coarse subangular blocky structure, numerous worm holes, a few small fragile concretions. pH 5.8. Horizon boundary is clear.
B_2	6-11	Yellowish brown (10 YR 5/4 moist, 5/8 dry) clay, weak coarse to very coarse subangular blocky structure, friable and slightly hard consistence. Many roots, scattered gravel which is coated with iron oxides. pH 5.7. Horizon boundary is clear.
B_3	11-19	Light brownish gray (2.5 Y 6/2 moist, 7/4 dry) clay. Amorphous to weak fine blocky structure, firm and hard consistence. pH 5.3. Horizon boundary is clear.
C_1	19-30	Pale brown (10 YR 6/3 moist, 7/3 dry) mottled clay. Amorphous structure which is plastic and very hard. Few roots. pH 5.1.
C_2	30+	Pale brown (10 YR 6/3 moist, 7/3 dry) amorphous clay showing weak stratification. Blackish stains on cleavage faces, an occasional pebble. pH 5.3.

The thickness of the A_1 horizon ranges from 2 to 5 inches with an average of about 3 inches.

A variant included in the Saanichton series and developed on the same parent material is found on southern exposures under grass–oak vegetation. It is distinguished by very dark grayish brown to black A_1 horizons about 10 inches thick. The lower part of the profile is similar to the Saanichton series.

Saanichton clay is commonly associated with Cowichan clay loam which is a Dark Gray Gleysolic on the same parent material.

Agriculture

The Saanichton series is considered as some of the best agricultural soils on Vancouver Island. They are fine-textured and reasonably fertile. The A_1 is well supplied with organic matter, nitrogen and total phosphorus and the B_1 to a 6-inch depth is adequately provided with organic matter and phosphorus though slightly low in nitrogen. The cation exchange is moderately well saturated.

The soil structure is moderately well developed but under cultivation is easily destroyed, hence, tillage and cropping practices should be adjusted to offset this tendency. It is recommended that legumes and organic debris be frequently incorporated in the soil in order to improve structure or at least to prevent its deterioration.

This is one of the most drought-resistant soils in this area. This is indicated by the fact that the available moisture-holding capacity of the top foot is 2.4 inches and 3.7 inches for the solum.

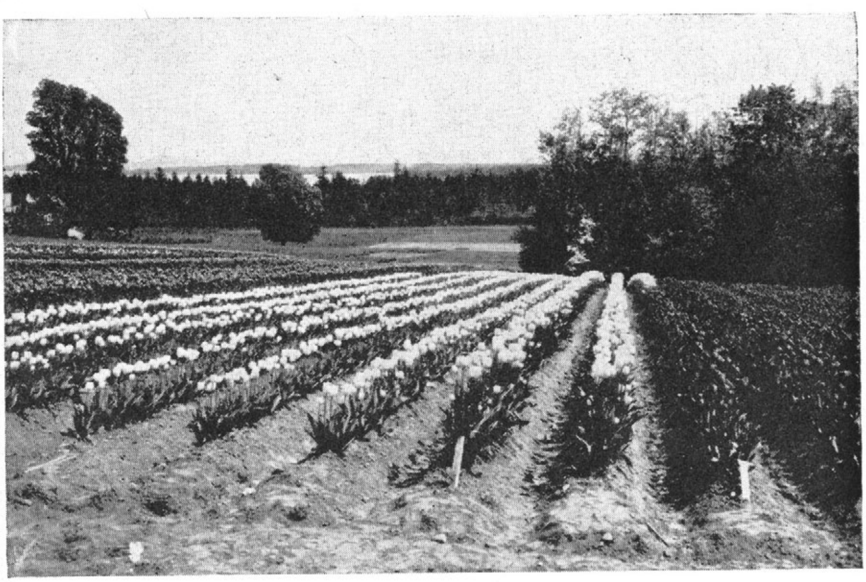


FIG. 15—Tulips on Saanichton clay. The low area in the background is Cowichan clay loam. Courtesy of J. J. Woods.

A very high percentage of the soils belonging to this series is cultivated and cropped intensively. Small fruits, cane fruits, vegetables, bulbs and forage crops are commonly grown.

Poorly Drained

Cowichan Series

Cowichan clay loam covers 24,680 acres located mainly on the Gulf Islands, on the Saanich Peninsula, at Duncan and at Alberni. The soil has developed on fine-textured marine materials and belongs to the Dark Gray Gleysolic soil group. The soil profile is characterized by 6 to 8 inches of dark grayish brown to black granular clay loam (A_1) over 4 to 6 inches of very pale brown slowly permeable subangular blocky clay loam (A_2) which, in turn, is over pale brown mottled, highly plastic and very slowly permeable marine clay (C).

Clay loam is the dominant textural class although there may be many areas where the texture is more nearly clay.

The original forest vegetation consisting of red cedar, hemlock, alder and maple has been logged off. Second growth alder, willows, maple and red cedar now predominate.

The topography is very gently sloping to level. The soil is poorly drained; permeability of the A_1 horizon is intermediate while that of the other horizons is very low. The lower part of the A_1 horizon may be mottled and the subsoil upon drying out becomes very hard.

A typical Cowichan soil has the following characteristics:

Horizon	*Depth in inches*	
A_{00}	2- 1	Moss, leaves, needles, etc., largely undecomposed.
A_0	1- 0	Dark brown well decomposed organic matter. pH 5.0.
A_1	0- 8	Very dark brown (10 YR 2/2 moist, 4/2 dry) clay loam, strong medium subangular blocky and granular structure, friable. pH 5.2. Horizon boundary abrupt.
A_2	8-14	Brown (10 YR 5/3 moist, 7/3 dry) silt loam of massive to blocky structure. Slight mottling, very plastic and very hard. pH 5.2. Horizon boundary clear.
B_g	14-23	Pale brown (10 YR 6/3 moist, 2.5 Y 7/4 dry) silty clay, highly mottled (10 YR 5/6) amorphous, very plastic and very hard. pH 4.9. Roots rarely penetrate this horizon.
C_1	23-28	Pale brown (10 YR 6/3 moist, 7/3 dry) silty clay loam, highly mottled. Amorphous. pH 5.4.
C_2	28+	Pale brown (10 YR 6/3 moist, 7/3 dry) silty clay loam with amorphous to very coarse blocky structure; blackish organic stains and splotches on cleavage faces. Very slowly permeable; no roots. pH 5.8.

A marked variability occurs within this soil series. The A_1 horizon is sometimes mucky when very poorly drained and may be quite thick; the range permitted is from 6 to 25 inches. The A_2 horizon may be very strongly mottled and in some places absent. Occasionally there may be a weak pebble-line in or over the B_g horizon.

Cowichan soils are associated with Saanichton, Fairbridge and Alberni soils.

FIG. 16—Saanichton clay on ridges under Garry oak and grass, and Cowichan clay loam in level depressional area at lower right. Courtesy of B.C. Government Travel Bureau.

Agriculture

Soils belonging to the Cowichan series are used widely in agriculture. They are well supplied with organic matter and nitrogen to an 8-inch depth (A_1) but total phosphorus is slightly low. They are strongly acid and the exchange complex of the A_1 and B_g horizons is highly unsaturated.

The physical character of the A_2 and B_g horizons leaves much to be desired; the permeability is slow and the non-capillary porosity is low. Drainage conditions result in a soil that is slow to warm up in the spring. In spite of the fact that the available soil moisture capacity of the top foot of soil is 2.4 inches, summer irrigation is necessary for high yields.

Without drainage these soils are devoted largely to the production of cereals, grasses and clovers. When drained they are excellent soils for loganberries, vegetable crops, bulbs and seed growing.

Soils Developed on Coarse-textured Glacial-fluvial, Aeolian and Marine Materials

Rapidly Drained

ESQUIMALT SERIES

The Esquimalt series covers 2,590 acres in the Victoria–Colwood area. The soil has developed on coarse-textured materials and belongs to the Black soil group. The soil profile is characterized by 8 to 10 inches of dark grayish brown granular gravelly sandy loam or sandy loam (A_1) over 8 inches of brown to yellowish brown very permeable loamy sand (B) over gray loose gravelly loamy sand (C).

The dominant soil texture is gravelly sandy loam (1,650 acres) but sandy loam also occurs (940 acres).

The vegetation consists of rather open stands of Douglas fir with a few scattered Garry oak. There is a thin ground cover of grass, weeds and bracken.

The topography is gently sloping or level. The soil is rapidly drained and permeability is rapid. The soil has very low drought resistance and most crops suffer from lack of moisture during the dry summer period.

A typical Esquimalt profile has the following characteristics:

Horizon	*Depth in inches*	
A_0	1- 0	Dark grayish brown semi-decomposed organic mat of needles, grass, leaves and twigs. pH 5.6.
A_1	0-10	Very dark brown (10 YR 2/2 moist, 3/2 dry) sandy loam, medium granular structure. Soft consistence. Pebbles are common. pH 5.9. Horizon boundary is clear.
B	10-18	Brown (10 YR 4/3 moist, 5/3 dry) sandy loam. Pebbles are common. Single grained structure. pH 6.1.
C	18+	Grayish brown (2.5 Y 5/3 moist, 6/3 dry) gravelly sandy loam to gravelly sand, slightly compact, single grained structure. Highly permeable and well stratified. pH 5.9.

The thickness of the A_1 horizon ranges from 3 to 12 inches. Soil textural changes are frequent and range from sandy loam to gravelly sand. Cobbles are occasionally observed in the profile.

Where the A_1 horizon is very thin the soil resembles Qualicum series.

Agriculture

Esquimalt soils are ideally suited for certain lines of agricultural production but are, in fact, largely used for urban and rural housing.

The organic matter and nitrogen contents of the A horizon are relatively high. The top foot of soil holds about 1.8 inches of available water due to its relatively high organic matter content but, since these soils are loose and open, the available water is subject to rapid loss through evaporation. The soil is droughty and requires irrigation.

These soils are particularly adapted for the production of crops for an early market such as strawberries. Bulbs, for the production of cut flowers, are extensively grown.

Qualicum Series

Qualicum soils cover about 117,330 acres located throughout the surveyed area, except in the Alberni, San Juan and Sayward Valleys. They are developed on coarse-textured materials and belong to the Brown Podzolic soil group. The soil profile is characterized by 36 to 44 inches of yellowish brown to pale brown loose very permeable loamy sand or gravelly loamy sand (B), which lies over pale brown or gray loose sand or gravel (C). Gravel may occur in the subsoil.

Gravelly loamy sand is the most common soil texture (76,440 acres) followed by loamy sand (40,890 acres).

The vegetation is composed principally of lodgepole pine with Douglas fir, hemlock, red alder and occasionally arbutus. The understory is dominantly salal. The forest density is lower than that on the Shawnigan and Dashwood series. Occasionally large stumps are observed in the second growth.

The topography is gently undulating to gently rolling with occasional steep slopes. The soil is rapidly drained and has rapid permeability.

A typical Qualicum loamy sand profile has the following characteristics:

Horizon	*Depth in inches*	
A_0	2- 0	Dark brown to black loose litter of partially decayed needles, wood, etc. pH 5.0.
A_2	0- ½	Pinkish gray (5 YR 6/2 moist, 10 YR 6/2 dry) loamy sand, soft, single grained. Not continuous but ranges up to 3/4 inch in thickness. pH 4.6.
B_{22}	½-10	Brown (7.5 YR 5/6 moist, 10 YR 5/6 dry) loamy sand, single grained structure. Upper inch weakly cemented orterde. Very permeable; pebbles are iron coated. pH 6.0. Horizon boundary diffuse.
B_{23}	10-19	Yellowish brown (10 YR 5/6 moist, 6/6 dry) loose sand of single grain structure. pH 6.1. Horizon boundary diffuse.
B_3	19-44	Sand as above but somewhat paler in color. Slightly more compact. pH 6.1.
C	44+	Light olive (2.5 Y 5/4 moist, 2.5 Y 7/4 dry) loose structureless sand grading into gravel at considerable depth. Well stratified. pH 6.1.

The A_2 may be absent as may also the weak orterde development in the upper B_{22} horizon. Gravelly substrata often occur and very commonly gravel and cobbles appear throughout the profile.

The Qualicum grades into Esquimalt series in the Victoria area and into Kye series in the vicinity of Courtenay.

Qualicum is associated with Dashwood, Custer (an imperfectly drained Podzol), Shawnigan and Bowser series.

Agriculture

Soils belonging to this series are submarginal for agriculture except where they are used for specialty crops. At present a very small acreage is improved.

The organic matter, nitrogen and phosphorus contents are low. The cation exchange capacity is very low and the complex is strongly unsaturated. This is an infertile soil.

The available moisture-holding capacity of the top foot is 1.1 inches while that of the top 2½ feet is 3.2 inches. The soil is very porous. These soils are not suitable for agricultural purposes unless irrigated.

Cultivated areas are used mainly for the production of crops such as strawberries and vegetables for the early market. A limited acreage is used for pasture but the carrying capacity is much too low.

Heavy applications of stable and green manures supplemented by commercial fertilizers are essential for economic production.

Well Drained

KYE SERIES

Kye soil series covers 8,310 acres in the Courtenay–Sayward Valley area. It is developed on coarse-textured materials and belongs to the Podzol soil group. The soil profile is characterized by 2 to 3 inches of light gray to white loamy sand (A_2), over 13 to 16 inches of yellowish brown highly permeable loamy sand, or gravelly loamy sand, which grades through 12 to 14 inches of weakly iron cemented sand (B). The C horizon consists of mottled loose sand and gravel.

The most common soil texture is loamy sand (5,110 acres) followed by 3,200 acres of gravelly loamy sand.

The vegetation is mainly second growth Douglas fir, lodgepole pine and salal.

The topography ranges from gently sloping to rolling. The soil is well drained and permeability is rapid.

A Kye soil profile has the following characteristics:

Horizon	*Depth in inches*	
A_0	2- 0	Organic litter of needles and leaves, little decomposed. pH 3.9.
A_2	0- 3	Light gray (10 YR 6/1 moist, 7/1 dry) loamy sand to sand, single grain structure, loose and porous. pH 5.2.
B_{21}	3- 6	Yellowish brown (10 YR 5/6 moist, 6/3 dry) loamy sand to sand, weak medium subangular blocky and single grain structure, weakly cemented. Firm and hard consistence. pH 5.6. Horizon boundary gradual.
B_{22}	6-16	Yellowish brown (10 YR 5/4 moist, 6/3 dry) sand, structure as in B_{21}, very weakly cemented. pH 5.9. Horizon boundary clear.
B_3	16-19	Sand as above but with loose consistence and single grain structure. pH 5.9. Horizon boundary abrupt.
B_g	19-35	Light brownish gray to yellowish brown (10 YR 6/2 to 5/8 moist or dry) massive sand, strongly cemented. Prominently mottled. pH 6.0.
C	35+	Light brownish gray to olive yellow (2.5 Y 6/2 to 6/6 dry) sand, loose and porous. Mottled. pH 6.0.

Drainage conditions are somewhat variable. In somewhat better drained positions the B_g horizon is absent but the parent material usually is mottled.

The A_0 ranges from 2 to 4 inches in thickness and the A_2 from 1 to 5 inches. In some places the B_2 is quite reddish in color. Soil texture ranges from loamy sand to gravelly and cobbly sand.

Kye soils are associated with Bowser, Memekay, Qualicum and Custer series.

Agriculture

Soils belonging to this series are non-agricultural for the present at least. Forestry represents their best use. Fertility is low and the soil reaction is strongly acidic. The base exchange capacity is low and the soil is very droughty.

To date no agricultural development has taken place on these soils.

Somass Series

Somass series covers 3,135 acres in the Alberni Basin. It is developed on coarse-textured materials and belongs to the Concretionary Brown soil group. The profile is characterized by 26 to 36 inches of yellowish red to strong brown very permeable loamy sand or gravelly loamy sand (B), lying on gray loose sand or gravel (C). The profile often contains concretions or iron cemented clods.

Of the 3,135 acres mapped, 2,135 acres are loamy sand, and 1,000 acres are gravelly loamy sand.

The vegetation is Douglas fir, hemlock, red cedar with an understory of salal.

The topography is gently rolling. The soil is well drained and permeability is rapid.

A Somass loamy sand soil has the following characteristics:

Horizon	*Depth in inches*	
A_{00}	2- 1	Dark brown partially decomposed remains of mosses, needles, leaves and wood.
A_0	1- 0	Black (5 YR 2/1 moist, 2/2 dry) well decomposed organic layer, resembles greasy mor. pH 4.1.
B_2	¼- 9	Yellowish red (5 YR 5/6 moist, 7.5 YR 4/4 dry) loamy sand, weak coarse subangular blocky structure, weakly cemented at the top of the horizon. There are some small (3 mm.) concretions and the pebbles are iron-coated. Horizon boundary is clear. pH 5.2.
B_3	9-18	Strong brown (7.5 YR 5/6 moist and dry) loamy sand, weak coarse subangular blocky and single grain. Very friable and soft. Horizon boundary is clear. pH 5.6.
C_1	18-30	Yellowish brown (10 YR 5/4 moist, 6/4 dry) loamy sand, single grained structure, friable; contains gravel. pH 5.6.
C_2	30+	Gray stratified gravel and sand. pH 4.6.

An A_2 horizon has been observed overlying a weakly developed orterde layer in the upper part of the B_2 horizon. The condition is not common. Concretions are present though not so plentiful as in finer-textured soils.

Variation in soil texture ranges from sand to loamy sand. Gravel and cobbles commonly appear throughout the profile. The parent material, unlike Qualicum or Esquimalt series, may be underlain by till particularly on knolls and ridges. Rock outcrops are frequently encountered.

The Somass soils occur in close association with the Sproat and Stamp series.

Agriculture

Soils belonging to this series are unsuitable for agriculture and, consequently, their use for forestry should be given precedence in any planned development scheme.

Imperfectly Drained

Custer Series

Custer soil series covers 3,430 acres in the northern portion of the surveyed area. It is developed on coarse-textured material and belongs to the Podzol soil group. The soil profile is characterized by 4 to 7 inches of light gray loamy sand (A_2) over 5 to 6 inches of reddish brown strongly iron cemented very slowly permeable loamy sand or sandy loam (B_2). Parent material (C) consists of gray loose mottled loamy sand.

Loamy sand is the only textural class encountered.

The vegetation consists mainly of red alder, red cedar, white pine and hemlock. Usually the stands of alder are very dense.

The topography is level to gently undulating but in the Sayward Valley these soils may be found on moderately sloping land. The soil is imperfectly drained and permeability in the B_2 horizon is slow. The subsoil is porous but highly mottled and is moist most of the time.

A typical Custer profile has the following characteristics:

Horizon	*Depth in inches*	
A_0	2- 0	Dark brown very fibrous mat of semi-decomposed leaves, needles and wood. pH 4.9.
A_2	0- 5	Light brownish gray to gray (10 YR 6/2 to 5/1 moist, 7/1 dry) loamy sand. Single grain and weak fine subangular blocky structure, friable and soft. Many roots. pH 5.5.
B_2	5-10	Dark reddish brown to yellowish red (5 YR 3/4 to 4/6 moist or dry) loamy sand, strongly cemented, very hard and very firm. pH 5.5. Horizon boundary abrupt.
B_3	10-27	Strong brown (7.5 YR 5/8 moist, 10 YR 6/8 dry) strongly mottled loamy sand. Massive structure and weakly cemented. pH 5.9. Horizon boundary abrupt.
C	27+	Dark gray (10 YR 4/1, 2.5 Y 5/2 dry) loose stratified sand, somewhat mottled. pH 6.3.

The A_0 varies in state of decomposition and ranges from 2 to 6 inches in thickness; the A_2 horizon varies from 4 to 10 inches. The B_2 is hard and strongly cemented but is not always continuous.

Agriculture

Soils belonging to the Custer series are submarginal for agriculture unless adequately drained. They are low in fertility, shallow, poorly drained and cold. The A_2 horizon is low in organic matter and very low in nitrogen while the B horizon is somewhat better supplied. Soil reaction is strongly acid.

The cemented character of the B_2 horizon restricts plant root development and thereby reduces the agricultural value of these soils.

Under natural conditions these soils are saturated throughout much of the year and are perhaps better utilized for the growing of trees.

Soils Developed on Medium-textured Alluvium with Undifferentiated Drainage

Chemainus Complex

The Chemainus complex covers 32,745 acres. It is of scattered occurrence throughout the surveyed area. Chemainus soils have developed on sandy and silty alluvium and belong to the Alluvial soil group. The soil profile is characterized by 3 to 6 inches of dark brown granular permeable fine sandy loam to clay loam (A_1) over greyish brown permeable stratified alluvium (C).

Soil texture ranges from fine sandy loam to clay loam with the most common texture being loam. The mapping units used were fine sandy loam to loam (17,570 acres) and silt loam to clay loam (15,175 acres). Occasionally pebbles may be present.

The vegetation is mixed. Some areas support valuable stands of hemlock and red cedar. Logged-off areas support a second growth of red alder and young conifers with a ground cover of sword fern, thistle, thimbleberries and huckleberries. In other areas, maple, red alder, willows and cottonwood are dominant with a groundcover consisting of grasses and shrubs.

A well-drained Chemainus silt loam soil type has the following characteristics:

Horizon	*Depth in inches*	
A_0	1- 0	Very dark brown well-decomposed leaf litter.
A_1	0- 4	Dark brown to black (10 YR 2/2 to 2/1 moist, 4/2 dry) silt loam, strong medium granular structure. Friable and soft consistence. pH 6.2. Horizon boundary is abrupt.
C	4+	Grayish brown (10 YR 5/2 moist, 6/2 dry) silt loam, amorphous structure, friable consistence. Stratified. pH 5.9. Mottles start at 13 inches and become prominent at depth.

The A_1 horizon varies in thickness from 3 to 8 inches in the well-drained position, but is usually somewhat thicker in the poorly drained position, and may be of a somewhat mucky nature. In the poorly drained soils mottles are common in the lower part of the horizon.

The depth to sand or gravel is variable; the average depth is about 24 inches with a minimum of about 12 inches.

A variant included with the Chemainus catena covers about 500 acres in the Sayward valley. This variant is developed on materials of similar age and origin as those of the Chemainus catena, has little or no A_1 horizon and has a thin, weakly developed A_2 horizon overlying a yellowish red weakly developed B horizon. This soil represents the primary stage of Podzol soil development.

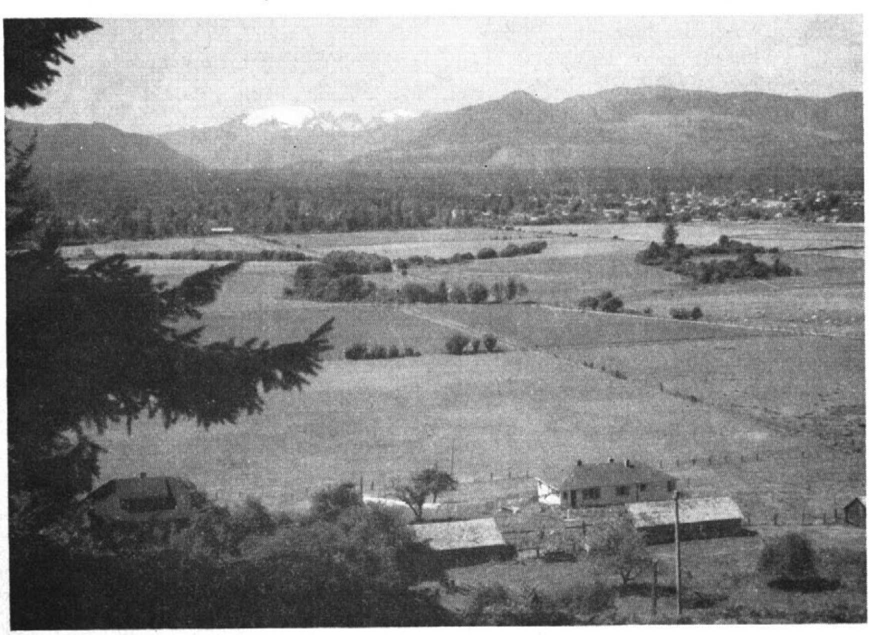


FIG. 17—The alluvial delta of Courtenay River on which Chemainus series occurs. Potato growing and dairying are the main agricultural operations.

Agriculture

Soils belonging to this catena are generally highly fertile and productive. The A_1 horizon is well supplied with organic matter and nitrogen and moderately well supplied with phosphorus. The exchange complex is highly base-saturated and in general this catena is very fertile, yet responses to fertilization may be anticipated. A three-year experiment (12) on Chemainus loam in the vicinity of Nanaimo, demonstrated that an application of nitrogen gave a one-third increase in dry matter with a grass–clover mixture; applications of phosphate and potash gave only very slight increases. On Chemainus silt loam under irrigation marked response may normally be expected from phosphate as well as nitrogen.

The available moisture-holding capacity of the silt loam type is 2.1 inches in the top foot of soil. Soil physical conditions are favorable and irrigation water generally is readily available from shallow dugouts or sand points.

The well-drained Chemainus soils are very desirable for agriculture but the poorly drained phase is questionable unless adequately drained or diked.

These soils are used for mixed and dairy farming and for cash crops such as potatoes, truck crops and vegetable seeds.

Soils Developed on Coarse-textured Alluvium with Undifferentiated Drainage

Cassidy Complex

The Cassidy soils cover 19,100 acres. They are of scattered occurrence throughout the surveyed area. The Cassidy soils are the coarse-textured counterpart of Chemainus soils and occur mainly along swift streams emerging from the mountains. They belong to the Alluvial soil group. The soil profile is characterized by 2 to 4 inches of dark brown granular gravelly loamy sand, loamy sand or sandy loam (A) over brownish gray very permeable gravelly alluvium (C).

Soil texture ranges from sandy loam through coarser-textured classes to stony sand. However, the significant mapping units used were sandy loam (6,150 acres), loamy sand (1,410 acres) and gravelly loamy sand (11,540 acres).

The vegetation consists of maple, red alder and young conifers with a ground cover of shrubs. Stumps are present in the second growth but their frequency and the density of the second growth is lower than on Chemainus soils.

The topography is level to gently sloping with rough micro-relief. Mounds as high as 4 feet result in many short steep slopes. These irregularities are remnants of former stream channels.

Soil drainage for the most part is rapid but there are occasional small poorly drained areas which may amount to 10 per cent of the soil area. Permeability is rapid. Spring and flash floods occasionally deposit or erode materials in the lower lying areas.

A well drained Cassidy sandy loam has the following characteristics:

Horizon	*Depth in inches*	
A_0	2- 0	Dark organic litter, semi-decomposed.
A_1	0- 2	Very dark grayish brown (10 YR 3/2 moist, 4/2 dry) gravelly sandy loam containing a number of small cobbles. Weak fine granular structure. pH 5.5.

C_1	2- 5	Light brownish gray (2.5 Y 6/2 moist, 7/4 dry) gravelly sandy loam; friable. Single grain structure. Well rounded cobbles present. pH 5.7.
	5+	Similar to above; weakly stratified gravelly sandy loam with cobbles. Loose and very porous. pH 6.5.

The thickness of the A_1 ranges from 2 to 6 inches. The gravel and cobble content also is variable. Included in the complex is a variant with little or no A_1 and with weakly developed A_2 and B horizons. Its occurrence is very limited.

Agriculture

No agricultural development has taken place on this soil except for the few areas used for timber grazing purposes. This soil has very low agricultural value and should largely remain in forests to aid in regulating stream flow and thus protect stream channels and cultivated soils nearer the sea.

Soils Developed on Beach Sand, Shells and Organic Debris

NEPTUNE SERIES

Neptune soils cover 1,040 acres and occur as narrow discontinuous deposits along beaches and are developed on sands and gravels containing shells and organic debris. Frequently, Neptune soils occur on ancient Indian camping grounds and are of considerable more interest archeologically than agriculturally. They belong to the Rendzina soil group.

They consist of 12 to 20 inches of black granular or loose gravelly loamy sand or sandy loam with varying quantities of shells, gravel, sand and organic debris.

The soil texture ranges from gravelly loamy sand to sandy loam.

The vegetation consists largely of grasses with a few scattered coniferous or deciduous trees.

The topography is gently sloping. The soil is well drained and permeability is rapid.

A typical soil has the following characteristics:

Horizon	*Depth in inches*	
A_1	0-20	Black (10 YR 2/1 moist and dry) sandy loam containing pebbles and mollusc shells. Moderate fine granular structure, very friable; pebbles are stained black. pH 7.1.
A_3	20-31	Brown (10 YR 4/3 moist, 6/3 dry) gravelly loamy sand containing many shells, single grain structure and loose consistence. pH 6.9.
C	31+	Olive brown (2.5 Y 4/4 wet, 6/4 dry) sand and gravel, mottled, slightly compact. pH 7.0.

The A_1 varies in thickness from 8 inches to 3 or 4 feet. The content of gravel and of shells is quite variable and in some places artifacts may be found.

Agriculture

These soils occur in small patches, are very coarse-textured and so are of no importance agriculturally. Some areas provide pasture and some are devoted to gardening. The surface horizons are very high in organic matter and nitrogen.

Soils Developed on Organic Materials

Poorly Drained

Arrowsmith Peat

Arrowsmith peat covers 20,390 acres in the area north of Malahat and on Denman, Hornby and Quadra Islands. The soil is developed on deep undecomposed organic material and belongs to the Deep Peat soil group. The profile is composed of moss and woody accumulations usually more than 36 inches deep.

The vegetation includes Labrador tea, hardhack, mosses, willow and sometimes blueberries and sedges.

The topography is depressional. Soil drainage is poor; permeability is moderate. A water table lies near the surface throughout most of the year.

The surface few feet of Arrowsmith peat have the following characteristics:

Horizon	*Depth in inches*	
1	0- 3	Very dark brown fibrous peat. pH 3.9.
2	3- 7	Reddish brown fibrous peat, mostly of sphagnum origin. pH 3.4.
3	7-20	Dark reddish brown fibrous peat. pH 3.5.
4	20-27	Dark reddish brown and black peat, somewhat more decomposed than above. pH 3.9.
5	27+	Dark reddish brown and black peat, raw and undecomposed. pH 4.2.

The minimum thickness of organic material is 12 inches and some bogs are known to be 35 feet deep. Occasionally stumps and logs of cedar and yew have been uncovered and in some places old beaver dams are part of the deposit.

The peat varies greatly in respect to state of decomposition and nature of the materials. For the most part the material is of moss and woody origin and is little decomposed; however, in some areas it has been derived from sedge which is well decomposed and varies in depth from 1 to 8 feet.

Agriculture

Some areas of Arrowsmith peat are drained and cultivated and crops such as oats, hay, corn, potatoes and vegetable crops are grown. This soil is difficult to bring into profitable production as clearing and breaking costs are high and drainage is expensive.

The peat ranges in organic content from 94 to 97 per cent and nitrogen from 1.1 to 1.9 per cent.

Soil reaction is extremely acidic and these soils require frequent applications of limestone.

In general these soils are undesirable for agriculture.

Metchosin Muck

Metchosin muck covers 1,645 acres in the area south of Malahat and on some of the Gulf Islands. The soil is developed on shallow well decomposed organic materials and belong to the Shallow Muck soil group. The profile is characterized by 12 to 36 inches of decomposed sedge and woody remains and is usually underlain by strongly mottled clay.

The vegetative cover is mainly willow and alder with an understory of sedges, grasses and shrubs.

The topography is depressional. Soil drainage is poor and permeability is moderate. Upon becoming air dry the cultivated surface resists re-wetting.

A typical Metchosin muck has the following characteristics:

Horizon	*Depth in inches*	
1	0–34	Black well decomposed muck, a few unrecognizable woody fragments in the lower part. Well humified and contains considerable mineral material. Weak granular structure. pH 5.6.
2	34–40	Light brown peat with recognizable plant remains which appear to be sedges. pH 5.1.
3	40+	Gray, mottled silty clay loam.

The depth of organic matter ranges from about 16 inches to 5 feet at the most.

Agriculture

Metchosin mucks, when adequately drained, provide some of the best soils on Vancouver Island.

The mucks contain 60 to 65 per cent organic material and are strongly acid in reaction. Applications of limestone, and phosphorus and potassium fertilizers are required.

These soils are well suited for mixed farming but may also be used for the production of specialty crops such as potatoes, cabbage, and spinach. They are not suited to the production of bulbs and tree fruits.

Miscellaneous Land Types

1. COASTAL BEACH

Coastal beaches cover 2,785 acres in the area. They are composed of sand and gravel, have variable drainage and are gently sloping.

2. ERODED LAND

Eroded land covers 14,850 acres and includes steep river banks, beach bluffs, etc. The soil mantle is variable. Topography is very steeply sloping.

3. MADE (or reclaimed) LAND

Made land includes refuse dumps which have been leveled off, mine tailings, and areas leveled for large structures such as airports and their runways. Only 775 acres of land are involved.

4. ROUGH MOUNTAINOUS LAND

Rough mountainous land covers 31,220 acres within the surveyed area. The soils are very thin and stony and frequently consist of bare rock. Drainage is variable.

5. ROUGH STONY LAND

Rough stony land covers 26,755 acres and includes those areas of thinly mantled bare rock and very stony land within the surveyed area. It is gently to very steeply sloping and has variable soil drainage conditions.

6. TIDAL FLATS

Tidal flats cover 1,260 acres in the area. They are poorly drained coastal beach organic–mineral deposits and subject to saturation with each high tide. They generally are covered by sedges and salt-tolerant grasses and are variable in stoniness.

ANALYTICAL DATA AND THEIR SIGNIFICANCE

Chemical Analyses

Chemical analyses covering a number of representative soils as mapped in the area under review, are presented in Tables 5 to 8 inclusive. These data indicate horizon differences, present a picture of inherent fertility and so serve as a guide to soil management practices.

Table 5 presents data covering soil reaction, organic matter and nitrogen contents, carbon–nitrogen ratio and phosphorus content of mineral soils. Table 6 covers reaction, nitrogen content and loss on ignition of organic soils.

Soil Reaction

Soil acidity itself usually is not directly harmful to plants but indirectly it may interfere with the biological changes taking place in the soil and with the liberation of nutrients for the growing plant. A soil pH ranging from 6.1 to 7.0 is best for most plant species and as the pH drops below 6.0 soil conditions become unfavorable for one group of microorganisms after another, notably for instance, the nitrogen-fixing bacteria. Once the pH drops below 5.0, plant species, as a rule, find it difficult to secure in abundance all nutrients essential for normal growth. When the pH drops to 4.0 and below, chemical and biological activities are such as to suppress plant growth; in fact the soil becomes almost useless for crop production.

A review of the pH data indicates that soils of the Peat group (Table 6) as represented by Arrowsmith series, are extremely acid; in fact the pH lies below 4.0. This degree of acidity must be corrected before such soils can be made productive; it involves drainage to remove excess water and free acids, followed by applications of lime. The Muck soil group as represented by the Metchosin series, indicates only medium acidity and so is not seriously in need of lime. It is just possible that soils belonging to these two groups may vary somewhat in pH throughout the mapped area; the acids in some deposits may be neutralized by surface washings from adjacent limestone deposits.

Rendzina soils, as represented by Neptune series, are neutral (Table 5) in reaction and are well supplied with calcium.

The remaining acidity data in Table 5 suggests a few pH readings below 5.0, however most of them are above pH 5.1; in fact, approximately half the soils have pHs between 5.6 and 6.2 and the rest lie between pH 5.1 and 5.5. Soils belonging to the Black soil group have a pH of 5.8. These soils likely do not need lime except when necessary to maintain the pH at existing levels. The soil series belonging to the Podzol group are somewhat more acid (pH 5.4) and for the production of high quality lime-loving crops some of these podzolic soils may definitely respond to lime.

Soils of the other groups may or may not respond to applications of lime depending on crops being grown, climate and other factors.

Organic Matter

Even though organic matter makes up a distinctly small portion of a soil, either by weight or volume, it nevertheless exercises a very important influence on its chemical and physical properties. Its decomposition results in the liberation of nutrients contained therein, and the by-products of the process act as a solvent for the nutrients contained in the mineral soil fraction. Organic matter also functions as an excellent absorbent for important mineral salts and thereby prevents their loss through leaching.

At the same time organic matter modifies the physical and mechanical properties of a soil. For instance, it plays a very important part in determining the constitution of a soil in respect to moisture-holding capacity, color, structure and consistence; the granular condition so essential for high production on fine-textured soil depends at least partly upon the humus content of a soil.

When brought under cultivation the organic matter in the A_0 as presented in Table 5, might be expected to play a significant role in soil fertility. However, the A_0 must be largely ignored since it is normally, entirely or almost entirely, destroyed during the process of land clearing. These soils, except for Shawnigan gravelly sandy loam, Fairbridge silt loam, Qualicum gravelly loam sand and Kye loamy sand, contain a moderate to a high content of organic matter in the mineral horizons to a 10-inch depth. In many of them the organic matter content carries well down towards the C horizon.

Excellent as some of these soils appear to be in respect to organic matter content, the shift in equilibrium upon being brought under cultivation results in its rapid dissipation. This applies particularly to the light sandy loams and loamy sands. Therefore the frequent incorporation of organic matter becomes a necessity.

Nitrogen

The nitrogen content of the various soils as reported in Tables 5 and 6 indicates a wide variation not only between the soils of different zonal groups but also between the soils within a group. The Organic soils are distinctly high in nitrogen (well over 1 per cent), as might be expected, and the Black soils also contain relatively high amounts though quite variable. All Podzols reported contain less than 0.3 per cent nitrogen and over half of them are below 0.1 per cent. Soils of the remaining great soil groups lie between the Blacks and the Podzols in respect to nitrogen. About one third of all the soils reported have a nitrogen content below 0.1 per cent in the mineral horizons to a 10-inch depth. These should definitely respond to applications of organic manures and nitrogen fertilizers. Approximately one-third have a nitrogen content between 0.1 and 0.3 per cent and many of them, if not all, will ordinarily respond to applications of nitrogen. The nitrogen of the A_0 while important under virgin conditions becomes of little significance once the soils are cleared and brought under cultivation for reasons already outlined.

Carbon–Nitrogen Ratio

The carbon–nitrogen ratio of Black prairie soils approximates 10 to 13 while that of soils developed under forest vegetation in a humid temperate region is usually very much wider, and that in the A_0 is definitely wider than the more humified material in the A and B horizons. It is interesting to observe in Table 5 that the Black soils of the area under review correlate almost perfectly in this regard with corresponding prairie soils. A ratio of less than 13 is desirable for it indicates greater availability of the nitrogen present in the soil and suggests a smaller requirement in fertilizer form. The other soils for which similar data are provided are quite variable and indicate a much wider ratio and probably a greater need for nitrogenous fertilizers.

Phosphorus

The Black and Acid Dark Brown Forest soils are for the most part well supplied with total phosphorus as indicated in Table 5. On the other hand, some of the Podzols, Concretionary Brown and Brown Podzolics are definitely

Table 5 Organic Matter, Nitrogen, Phosphorus and pH Determinations of Representative Profiles

Soil Series	Horizon	Depth in inches	pH	Organic Matter %	N %	C:N	P %
Alberni clay	A_0	2 – 0	5.2	57.27	0.79	42.1	
	B_{21}	0 – 7	5.5	6.76	0.19	20.6	0.11
	B_{22}	7 – 15	5.4	3.86	0.11	20.3	0.11
	B_3	15 – 22	5.0	2.62	0.07	21.7	0.02
	C_1	22 – 24	4.9	1.65	0.03	31.9	0.02
	C_2	24 +	5.4	0.69	0.01	40.0	0.03
Bowser loamy sand	A_1	0 – 2	5.2	11.73	0.54	12.6	0.03
	A_2	2 – 2½	5.2	3.17	0.12	15.3	
	B_2	2½ – 20	5.9	3.59	0.12	17.4	0.03
	B_{2g}	20 – 26	5.9	2.21	0.08	16.0	0.04
	D	26 +	5.8	0.83	0.07	6.9	0.01
Cadboro gravelly sandy loam	A_0	1 – 0	5.3	43.97	1.33	19.2	
	A_1	0 – 9	5.8	11.73	0.61	11.1	0.16
	B_1	9 – 19	5.9	3.17	0.16	11.5	0.08
	B_2	19 – 32	5.9	1.57	0.08	11.4	0.04
	C	32 +	5.7	0.69	0.03	13.3	0.02
Chemainus silt loam	A_1	0 – 4	6.2	18.68	0.75	14.4	0.08
	C	4 +	5.9	2.34	0.09	15.1	0.07
Cowichan clay loam	A_0	2 – 0	5.0	50.37	0.89	32.8	
	A_1	0 – 8	5.2	11.04	0.36	17.8	0.08
	A_2	8 – 14	5.2	0.96	0.05	11.1	0.01
	B	14 – 23	4.9	1.52	0.06	14.7	0.02
	C_2	28 +	5.8	0.69	0.03	13.3	0.02
Custer loamy sand	A_0	1½ – 0	4.9	48.30	1.74	16.1	
	A_2	0 – 5	5.5	2.07	0.06	20.0	
	B_2	5 – 10	5.5	6.90	0.15	26.7	
	B_3	10 – 27	5.9	1.65	0.04	23.9	
	C	27 +	6.3	0.73	0.00		
Esquimalt sandy loam	A_0	1 – 0	5.6	62.79	0.94	38.7	
	A_1	0 – 10	5.9	5.66	0.20	16.4	0.24
	B	10 – 18	6.1	1.20	0.07	9.9	0.01
	C	18 +	5.9	0.96	0.02	27.8	0.04
Fairbridge silt loam	A_0	2 – 0	4.9	9.66			
	AB	0 – 1	5.5	2.05	0.08	14.9	0.08
	B_2	1 – 12	5.7	1.65	0.05	19.1	0.06
	B_3	12 – 19	5.2	1.38	0.04	20.0	0.03
	C_1	19 – 24	5.6	0.55	0.03	10.6	0.05
	C_2	24 +	6.0	0.55	0.02	16.0	0.05
Kye loamy sand	A_0	3 – 0	3.9	44.16	0.45	56.9	
	A_2	0 – 3	5.2	1.14	0.01	66.1	0.01
	B_{21}	3 – 6	5.6	1.66	0.02	48.1	0.07
	B_{22}	6 – 16	5.9	2.35	0.02	68.0	0.04
	B_3	16 – 19	5.9	1.52	0.02	44.1	0.02
	B_g	19 – 35	6.0	0.83	0.01	48.1	
	C	35 +	6.0	0.55	0.00		0.03
Langford loam	A_0	0 – 3	5.9	7.22	0.28	14.7	
	A_{11}	3 – 10	6.1	9.57	0.29	19.1	
	A_{12}	10 – 13	5.4	2.99	0.13	13.3	
	B_2	13 – 20	5.5	1.89	0.10	11.0	
	B_3	20 – 26	5.6	1.71	0.10	17.1	
	D_1	26 – 49	5.5	0.71	0.03	13.7	
Memekay clay loam	A_0	3 – 0	4.9	52.44	1.39	21.9	
	B_2	1 – 7	5.6	6.21	0.17	21.2	0.09
	B_3	7 – 21	5.6	3.17	0.08	23.0	0.07
	C_1	21 – 35	5.7	1.52	0.03	29.4	
	C_2	35 – 72	5.9	0.83	0.02	24.1	0.07
	D	72 +	6.3	0.69	0.01	40.0	0.07
Merville loam	A_1	0 – 8	5.0	17.25	0.82	12.2	0.09
	B	8 – 17	5.6	8.97	0.41	12.7	0.07
	B_g	17 – 34	6.1	1.24	0.06	12.0	0.01
	D	34 +	6.8	0.69	0.01	40.0	0.02

Table 5 Organic Matter, Nitrogen, Phosphorus and pH Determinations of Representative Profiles—*Continued*

Soil Series	Horizon	Depth in inches	pH	Organic Matter %	N %	C:N	P %
Neptune gravelly loamy sand.......	A_1	0 - 20	7.1	44.32	1.28	20.1	
	B	20 - 31	6.9	4.55	0.15	17.6	
	D	31 +	7.0	0.55	0.03	10.6	
Parksville sandy loam.............	A_{11}	0 - 3	5.3	27.65	0.91	17.6	
	A_{12}	3 - 5	5.5	1.88	0.11	9.9	
	B	5 - 9	5.7	0.83	0.03	16.0	
	B_{g1}	9 - 18	6.0	0.42	0.02	12.0	
	B_{g2}	18 - 24	6.2	0.76	0.01	44.0	
	D	24 +	6.3	0.78	0.01	45.0	
Puntledge silt loam................	A_0	2 - 0	4.2	60.10	1.29	27.0	
	A_2	0 - ½	4.6	13.00	0.38	19.8	
	B_2	½ - 9	5.5	7.87	0.25	18.2	0.05
	B_3	9 - 15	5.6	6.07	0.21	16.8	0.06
	D_1	15 - 24	6.1	1.93	0.06	18.7	0.03
	D_2	24 +	5.9	0.83	0.02	24.1	0.02
Qualicum loamy sand..............	A_0	2 - 0	5.0	49.88	1.72	16.8	
	A_2	0 - ½	4.6	3.17	0.06	30.6	
	B_2	½ - 10	6.0	1.93	0.07	16.0	0.03
	B_3	10 - 19	6.1	0.97	0.04	14.1	0.03
	B_1	19 - 44	6.1	1.52	0.05	17.6	0.04
	C_2	44 +	6.1	0.55	0.02	16.0	0.02
Quinsam gravelly sandy loam......	A_0	2 - 0	5.2	73.14	1.00	42.4	
	A_2	0 - 1	4.7	3.17	0.05	36.7	0.01
	B_2	1 - 9	5.4	4.28	0.08	31.0	0.03
	B_3	9 - 20	5.5	2.21	0.05	25.6	0.02
	C_1	20 - 30	5.8	1.10	0.03	21.3	0.01
	C_2	30 +	5.6	0.55	0.01	31.9	0.02
Royston gravelly loam............	A_0	2 - 0	4.8	66.10	1.89	20.3	
	B_{22}	¼ - 9	5.7	2.90	0.07	24.0	0.05
	B_{23}	9 - 20	6.0	1.65	0.06	16.0	0.01
	C_1	20 - 36	5.0	1.10	0.03	21.3	
	C_2	36 +	5.1	0.83	0.02	24.1	0.02
Saanichton clay....................	A_0	1 - 0	6.2				
	A_1	0 - 2	5.9	11.87	0.34	20.2	0.16
	B_1	2 - 6	5.8	4.14	0.14	17.2	0.09
	B_2	6 - 11	5.7	3.04	0.13	13.5	0.14
	B_3	11 - 19	5.3	1.65	0.06	16.0	0.03
	C_1	19 - 30	5.1	0.69	0.03	13.3	0.02
	C_2	30 +	5.3	0.73	0.03	14.1	0.03
Sandwick gravelly loam...........	A_0	1 - 0	4.9	67.53	1.17	33.5	
	A_1	0 - 9	5.2	19.32	0.67	16.7	0.12
	B_1	9 - 16	5.3	9.45	0.37	14.8	0.11
	B_2	16 - 22	5.3	1.79	0.04	26.0	0.03
	C_1	22 - 39	5.4	4.28	0.16	15.5	0.05
	C_2	39 +	5.6	0.83	0.02	24.1	0.03
Sayward loamy sand..............	A_0	2 - 0	5.3	23.46	0.70	19.4	
	A_2	0 - ¼					
	B_{21}	¼ - 3	5.2	9.25	0.18	29.8	
	B_{22}	3 - 15	5.5	4.14	0.10	24.0	
	B_3	15 - 19	5.6	3.17	0.07	26.0	
	C	19 - 50	5.6	1.24	0.03	24.0	
	D	50 +	5.6	0.83	0.02	24.1	
Shawnigan gravelly sandy loam....	A_0	3 - 0	5.1	37.26	0.78	27.7	
	A_2	0 - ¼	5.8	3.59	0.07	29.7	
	B_2	¼ - 9	5.9	1.93	0.05	22.4	0.08
	B_3	9 - 19	5.9	1.52	0.04	22.1	0.03
	C_1	19 - 30	5.7	0.96	0.02	27.9	
	C_2	@ 45	5.7	0.55	0.02	15.9	0.04
		@ 60	5.2	0.69	0.01	40.0	

Table 5 Organic Matter, Nitrogen, Phosphorus and pH Determinations of Representative Profiles—*Concluded*

Soil Series	Horizon	Depth in inches	pH	Organic Matter %	N %	C:N	P %
Somass loamy sand................	A_0	2 – 0	4.1	61.41	1.57	22.7	
	A_2	0 – ¼	4.1	11.59	0.48	14.0	
	B_2	¼ – 9	5.2	3.54	0.20	17.7	
	B_3	9 – 18	5.6	2.28	0.15	8.8	
	C	18 – 30	5.6	0.44	0.03	5.1	
	D	30 +	4.6	1.79	0.03	34.6	
Sproat gravelly sandy loam........	A_0	4 – 0	6.5	48.30	0.73		
	A_2	0 – 1	6.1	2.90	0.06		
	B_2	1 – 9	5.7	4.14	0.08	0.08	
	B_3	9 – 18	6.0	2.62	0.07	0.02	
	C_1	18 – 30	5.9	1.10	0.02	0.03	
	C_2	30 +	6.0	0.06	0.01	0.05	
Stamp gravelly loam..............	A_0	2 – 0	5.2	68.03	1.05	37.6	
	A_2	0 – ¼	5.5	11.45	0.30	22.1	
	B_2	¼ – 12	5.3	3.45	0.09	22.2	0.05
	B_3	12 – 24	5.2	2.48	0.06	24.0	0.03
	C_1	24 – 26	6.1	0.83	0.02	24.1	0.04
Tolmie loam......................	A_0	1 – 0	5.6	19.32	0.71	15.8	
	A_{11}	0 – 4	5.8	13.11	0.66	11.5	0.10
	A_{12}	4 – 8	5.5	4.00	0.16	14.5	0.10
	AB	8 – 16	5.2	1.10	0.06	10.6	0.03
	B_g	16 – 26	4.9	1.10	0.06	10.6	0.02
	D	26 +	5.2	0.69	0.02	20.0	0.02

Table 6 Nitrogen, pH and Loss-on-Ignition Determinations of Organic Soils

Soil Series	Horizon	Depth in inches	pH	N %	Loss on Ignition %
Arrowsmith peat......................	1	0 – 3	3.9	1.76	93.87
	2	3 – 7	3.4	1.14	97.38
	3	7 – 20	3.5	1.55	97.30
	4	20 – 27	3.9	1.69	96.91
	5	27 +	4.2	1.92	96.78
Metchosin muck.......................	1	0 – 34	5.6	1.72	66.00
	2	34 – 40	5.1	0.50	63.30

deficient in this element and require relatively heavy applications of phosphatic fertilizers for even normal production. Series indicating such a deficiency include Quinsam, Bowser, Puntledge, Qualicum and Kye.

Total Calcium and Magnesium

The total calcium and magnesium contents of eight soil types representing five great soil groups are presented in Table 7. The data submitted indicate that all soils with the possible exception of Alberni clay are well supplied with calcium, and even Alberni contains just under 1 per cent. The Podzols, as represented by Memekay clay loam and Kye loamy sand, are marked by a distinctly high calcium content; otherwise, differences between great soil groups appear to be no more marked than are differences between soils within a group.

Table 7 Total Chemical Analyses of Representative Soils Based on Oven-dry Weight Expressed in Per Cent

Horizon	Depth in inches	Si	Fe	Al	Ti	Ca	Mg	Na	K	P
					ALBERNI CLAY					
B_{21}	0 - 7	20.77	9.32	10.92	0.92	0.95	1.81			0.11
B_{22}	7 - 15	22.12	9.36	11.42	0.95	0.94	1.94			0.11
B_3	15 - 22	21.45	9.63	11.26	0.95	0.41	2.55			0.02
C_1	22 - 24	22.01	9.76	11.49	0.91	0.38	2.44			0.02
C_2	24 +	24.82	7.47	10.65	0.46	2.04	2.28			0.03
					COWICHAN CLAY LOAM					
A_1	0 - 8	26.54	4.85	8.32	0.50	1.57	1.01			0.08
A_2	8 - 14	31.06	4.62	7.69	0.46	1.60	1.15			0.01
B	14 - 23	28.02	5.94	9.52	0.65	1.16	1.10			0.02
C_2	28 +	29.19	5.46	9.03	0.61	1.83	1.38			0.02
					ESQUIMALT SANDY LOAM					
A_1	0 - 10	26.19	5.05	8.07	0.50	2.38	2.87	1.40	0.46	0.24
B	10 - 18	29.39	4.99	7.89	0.49	2.44	2.81	1.59	0.57	0.01
C	18 +	30.16	5.01	7.77	0.50	3.32	3.48	2.04	0.65	0.04
					FAIRBRIDGE SILT LOAM					
AB	0 - 1	28.01		8.12	0.64	1.74	1.50			0.08
B_2	1 - 12	28.05	6.24	8.67	0.65	1.60	1.71			0.06
B_3	12 - 19	27.85								0.03
					KYE LOAMY SAND					
A_2	0 - 3	33.54	2.76	7.57	0.31	3.22	1.18			0.01
B_{21}	3 - 6	32.46	3.40	8.08	0.34	3.27	1.40			0.07
B_{22}	6 - 16	31.98	3.99	8.36	0.38	3.40	1.49			0.04
B_3	16 - 19	31.22	4.17	8.60	0.39	3.52	1.74			0.02
C	35 +	29.66	5.61	8.39	0.52	4.08	2.29			0.03
					MEMEKAY CLAY LOAM					
B_2	1 - 7	23.16	8.38	9.01	0.82	3.39	3.45	1.74	0.54	0.09
B_3	7 - 21	23.81	7.60	10.00	0.77	3.54	4.38	1.85	0.54	0.07
C_2	35 - 72	25.37	7.25	9.85	0.67	3.65	4.90	1.84	1.06	0.07
D	72 +	26.51	6.46	9.38	0.65	4.27	4.49	2.19	0.95	0.07
					ROYSTON GRAVELLY LOAM					
C_2	36 +	29.21	5.78	9.02	0.59	1.55	2.01	1.94	0.78	0.02
					SHAWNIGAN GRAVELLY SANDY LOAM					
B_2	½ - 9	30.76	5.42	7.64	0.61	2.57	2.67	1.65	0.59	0.09
B_3	9 - 19	30.96	5.34	7.70	0.62	2.48	2.80	1.71	0.62	0.03
C_2	@ - 45	30.13	5.15	7.91	0.57	2.19	2.82	1.91	0.67	0.04

All soils are high in total magnesium. Memekay clay loam is distinctly higher in magnesium than are the soils in the other great soil groups; Kye loamy sand and Cowichan clay loam are lower than other soils studied. Further analyses are necessary in order to determine the significance of the foregoing data.

There appears to be little or no evidence of downward movement of either iron and aluminum or calcium and magnesium.

Potassium

Limited data are presented in Table 7 covering the potassium content of soils within the surveyed area. Analyses of soils representing each of the soil groups—Black, Brown Podzolic and Podzol—suggest a reasonable level of potassium in each instance. The data suggest, too, that the parent materials are better supplied with total potassium than are the upper horizons.

Cation Exchange Studies

Cation exchange, one of the important mechanisms in soil, provides an explanation for many of the significant phenomena which characterize soils particularly in relation to fertility. It exercises a major influence on physical properties of soil, notably in respect to flocculation and dispersion of clays and heavy clay loams. It plays a significant role in acidity and alkalinity where it serves as a buffer. It functions in fixation of potassium, calcium, ammonium, etc., and thereby reduces losses which would otherwise occur through leaching. It aids, too, among other things, in maintaining a balance between adsorbed plant nutrients and those in the soil solution, and thereby, tends to stabilize the supply of nutrients to the plant throughout the growing season.

Cation exchange is centered in the clay and organic matter fractions of a soil and, since these vary markedly, there is normally a wide variation in the total quantity of cations which can be absorbed by a given quantity of soil. The quantity of these cations absorbed by a soil is a measure of cation exchange capacity.

A review of the data in Table 8 indicates that the A_1 horizons of all soils under study, with the exception of Saanichton clay, have a relatively high cation exchange capacity. The other horizons of all soils, with rare exception, have a low capacity; this is particularly the case with Qualicum loamy sand. Great soil groups in the present instance, are of no significance in respect to cation exchange capacity; soils within a group show as wide a variation as do those cutting across groups.

Base-saturation is an expression of the extent to which the cation exchange is saturated with the bases calcium, magnesium, potassium and sodium, and is expressed as a percentage of the cation exchange capacity. Unsaturation indicates that part of the exchange is occupied by hydrogen. One soil, Chemainus silt loam, an Alluvial soil, is reasonably well saturated (74 per cent) throughout the profile. Nine soils indicate a moderate degree of saturation (35-65 per cent). The others representing about 40 per cent of those studied are highly unsaturated (less than 35 per cent). This suggests the need for periodic liming in order to raise and maintain or just maintain productive capacity. One redeeming feature of many of these soils is the relatively high saturation of the subsoils at depths ranging from about 18 to 30 inches.

Exchangeable potassium is quite variable. Surface horizons of Alberni clay, Chemainus silt loam, Cowichan clay loam and Saanichton clay, each representing a different great soil group, are relatively well supplied with exchangeable potassium. Puntledge silt loam and Qualicum loamy sand are significantly low in this essential element. The other soils are intermediate, and many will, doubtless, become deficient under heavy cropping.

Table 8 Cation Exchange Capacity and Exchangeable Cation of Representative Soils

Horizon	Depth in Inches	Exchangeable Cations (m.e./100 Gms.)						Sum of Cations	Percent Base Saturation
		pH	Ca	Mg	K	Na	H		
ALBERNI CLAY									
B_{21}	0 – 7	5.5	4.50	2.32	1.25	0.14	11.20	19.41	42.3
B_{22}	7 – 15	5.4	1.89	1.38	0.54	0.13	8.30	12.24	32.2
B_3	15 – 22	5.0	4.19	4.08	0.46	0.20	11.00	19.93	44.8
C_1	22 – 24	4.9	6.56	6.44	0.39	0.34	7.50	21.23	64.6
C_2	24 +	5.4	21.82	12.97	0.26	0.38	4.15	39.58	89.5
BOWSER LOAMY SAND									
A_1	0 – 2	5.2	8.09	2.16	0.22	0.22	17.30	27.99	38.2
B_2	2½ – 20	5.9	1.70	0.45	0.08	0.11	4.80	7.14	32.8
B_{2g}	20 – 26	5.9	0.57	0.16	0.02	0.07	4.70	5.52	14.9
D	26 +	5.8	5.80	3.31	0.06	0.35	2.65	12.17	78.3
CADBORO GRAVELLY SANDY LOAM									
A_1	0 – 9	5.8	17.00	3.07	0.25		14.10	34.42	59.0
B_1	9 – 19	5.9	3.24	0.98	0.11		5.73	10.06	43.0
B_2	19 – 32	5.9	3.41	1.40	0.14		2.95	7.90	62.6
C	32 +	5.7	6.20	2.75	0.11		1.70	10.76	84.3
CHEMAINUS SILT LOAM									
A_1	0 – 4	6.2	30.00	8.40	0.66	0.18	10.20	49.44	79.5
C	4 – 12	5.9	7.60	1.40	0.32	0.28	3.77	13.37	71.9
COWICHAN CLAY LOAM									
A_1	0 – 8	5.2	8.06	5.50	0.69	0.42	18.85	33.52	43.7
A_2	8 – 14	5.2	2.00	2.20	0.18	0.22	5.30	9.90	46.4
B	14 – 23	4.9	9.18	7.46	0.27	0.61	6.34	23.86	73.5
C_2	28 +	5.8	13.30	8.19	0.17	0.91	2.18	24.75	91.1
FAIRBRIDGE SILT LOAM									
AB	0 – 1	5.5			0.10	0.96	5.90		
B_2	1 – 12	5.7	2.49	0.94	0.27	0.14	5.43	9.27	41.4
B_3	12 – 19	5.2	2.82	1.79	0.21	0.19	5.03	10.04	49.9
C_1	19 – 24	5.6	6.49	4.72	0.21	0.26	3.93	15.61	74.6
C_2	24 +	6.0	10.35	7.55	0.15	0.30	2.35	20.70	88.6
MERVILLE LOAM									
A_1	0 – 8	5.0	2.17	0.73	0.15	0.18	22.93	26.16	12.4
B	8 – 17	5.6	2.25	0.56	0.12	0.24	15.80	18.97	16.7
B_g	17 – 34	6.1	10.59	5.58	0.06	0.40	2.44	19.07	87.2
D	34 +	6.8	19.44	10.89	0.21	0.50	1.25	32.29	96.1
PUNTLEDGE SILT LOAM									
B_2	½ – 9	5.5	1.39	0.58	0.08	0.23	15.50	17.78	12.8
B_3	9 – 15	5.6	1.70	0.64	0.08		10.10	12.50	19.2
D_1	15 – 24	6.1	2.53	1.30	0.03		5.70	19.56	14.4
D_2	24 +	5.9	14.40	7.90	0.09	0.25	2.43	25.07	90.2
QUALICUM LOAMY SAND									
B_{22}	½ – 10	6.0	0.93	0.03	0.10	0.05	2.34	3.45	32.2
B_{23}	10 – 19	6.1	0.53	0.00	0.08	0.06	1.21	1.88	35.6
B_3	19 – 44	6.1	0.45	0.00	0.04	0.07	1.78	2.34	23.9
C	44 +	6.1	0.50	0.10	0.03	0.09	1.01	1.73	41.6

Table 8 Cation Exchange Capacity and Exchangeable Cations of Representative Soils—*Concluded*

Horizon	Depth in Inches	Exchangeable Cations (m.e./100 Gms.)						Sum of Cations	Percent Base Saturation
		pH	Ca	Mg	K	Na	H		
				Quinsam Gravelly Sandy Loam					
A_2	0 - 1	4.7	2.80	0.56			4.83	8.19	41.0
B_2	1 - 9	5.4	1.56	0.34			7.63	9.53	20.0
B_3	9 - 20	5.5	0.74	0.32			3.80	4.86	27.9
C_1	20 - 30	5.8	0.80	2.32			2.30	5.42	59.7
C_2	30 +	5.6	5.75	1.61			1.55	8.91	82.6
				Royston Gravelly Loam					
B_{22}	¼ - 9	5.7	3.04	0.35	0.23	0.13	5.25	9.00	41.7
B_{23}	9 - 20	6.0	2.73	0.52	0.28	0.11	3.40	7.04	51.7
C_2	36 +	5.1	8.90	4.02	0.15	0.22	3.80	17.09	76.7
				Saanichton Clay					
A_1	0 - 2	5.9	23.92	4.72	0.80		13.33	42.77	68.9
B_1	2 - 6	5.8	5.96	1.83	0.69	0.33	8.10	16.91	52.1
B_2	6 - 11	5.7	3.08	1.99	0.55	0.27	8.23	14.12	41.7
B_3	11 - 19	5.3	3.07	1.95	0.33	0.24	6.15	11.74	47.5
C_1	19 - 30	5.1	4.54	3.81	0.19	0.26	5.13	13.93	63.2
C_2	30 +	5.3	9.42	7.05	0.15	0.57	3.43	20.62	83.1
				Sandwick Gravelly Loam					
A_1	0 - 9	5.2	4.50	1.18	0.18	0.22	27.80	33.88	17.9
B_1	9 - 16	5.3	0.75	1.15	0.07	0.12	16.33	17.42	6.3
B_2	16 - 22	5.3	4.40	1.72	0.05	0.36	7.25	13.78	47.4
C_1	22 - 39	5.4	0.50	0.20	0.04	0.13	10.15	11.02	7.9
C_2	39 +	5.6	20.40	6.90	0.14	0.62	4.38	32.44	86.5
				Shawnigan Gravelly Sandy Loam					
B_2	¼ - 9	5.9	1.68	0.45	0.27		3.60	6.00	40.0
B_3	9 - 19	5.9	1.36	0.14	0.18	0.11	2.51	4.30	41.6
C_1	19 - 30	5.7	0.79	0.08	0.10	0.07	1.70	2.74	38.0
C_2	@ - 45	5.7	2.60	0.59	0.07	0.15	2.18	5.59	61.0
				Sproat Gravelly Sandy Loam					
B_2	1 - 9	5.7	2.66	0.69			4.60	7.95	42.2
B_3	9 - 18	6.0	1.04	0.57			2.60	4.21	38.2
C_1	18 - 30	5.9	0.76	0.44			1.60	2.80	42.9
C_2	30 +	6.0	1.36	0.66			2.76	4.78	42.2
				Stamp Gravelly Loam					
B_2	¼ - 12	5.3	1.69	0.52	0.14	0.11	8.53	10.99	22.4
B_3	12 - 24	5.2	4.92	2.27	0.12	0.19	9.60	17.10	43.9
C_1	24 - 26	6.1	10.06	6.99	0.11	0.27	3.65	27.08	86.5
				Tolmie Loam					
A_{11}	0 - 4	5.8	17.46	3.51	0.53	0.42	13.95	35.87	61.0
A_{12}	4 - 8	5.5	6.90	1.94	0.28	0.35	9.10	18.57	51.0
AB	8 - 16	5.2	3.52	2.10	0.19	0.27	4.98	11.06	55.0
B_x	16 - 26	4.9	6.50	5.74	0.24	0.38	5.60	18.46	69.5
D	26 +	5.2	9.45	8.14	0.18	0.45	2.78	21.00	86.8

Minor Elements

Attention in recent years has been focused on minor elements undoubtedly because of the fact that phenomenal responses have, on occasions, resulted from their use. This has been strikingly illustrated through the use of boron for control of corky core in apples in the Okanagan Valley and cobalt for improving quality of forage for cattle and sheep in New Zealand.

Manganese

Minor element deficiencies have been demonstrated, in a number of instances, throughout British Columbia, and suspected in a number of others, hence this aspect of soil study cannot be entirely overlooked. The exchangeable

Table 9 Exchangeable Manganese Content of Representative Soils

Series and Great Soil Group	Horizon	Depth in Inches	p.p.m.
Alberni Clay (Concretionary Brown)	B_{21}	0 - 7	26.64
	B_{22}	7 - 15	20.96
	B_3	15 - 22	1.34
	C_1	22 - 24	1.29
	C_2	24 +	13.26
Cadboro Gravelly Sandy Loam (Black)	A_1	0 - 9	3.43
	B_1	9 - 19	1.82
	B_2	19 - 32	0.87
	C	32 +	1.13
Cowichan Clay Loam (Dark Gray Gleysolic)	A_1	0 - 8	22.37
	A_2	8 - 14	0.04
	B	14 - 23	0.89
	C_2	28 +	1.06
Fairbridge Silt Loam (Concretionary Brown)	B_2	1 - 12	2.15
	B_3	12 - 19	0.48
	C_1	19 - 24	1.74
	C_2	24 +	2.68
Qualicum Loamy Sand (Brown Podzolic)	B_{22}	½ - 10	0.31
	B_{23}	10 - 19	0.04
	B_3	19 - 44	0.20
Quinsam Gravelly Sandy Loam (Podzol)	A_2	0 - 1	0.89
	B_2	1 - 9	1.42
	B_3	9 - 20	1.92
	C_1	20 - 30	0.45
	C_2	30 +	1.06
Royston Gravelly Loam (Brown Podzolic)	B_{22}	½ - 9	1.16
	B_{23}	9 - 20	0.10
Saanichton Clay (Acid Dark Brown Forest)	A_1	0 - 2	15.19
	B_1	2 - 6	15.56
	B_2	6 - 11	8.85
	B_3	11 - 19	0.16
	C_1	19 - 30	0.10
	C_2	30 +	1.14
Shawnigan Gravelly Sandy Loam (Brown Podzolic)	B_2	½ - 9	0.05
	B_3	9 - 19	0.02
	C_1	19 - 30	0.01
Sproat Gravelly Sandy Loam (Concretionary Brown)	B_2	1 - 9	1.19
	B_3	9 - 18	0.15
	C_1	18 - 30	0.17
	C_2	30 +	0.37
Stamp Gravelly Loam (Concretionary Brown)	B_2	½ - 12	0.07
	B_3	12 - 24	0.14
	C_1	24 - 26	0.21

manganese content of 11 soils representing 6 great soil groups are presented in Table 9. It is clearly apparent from the data that differences between soils within a great soil group are as marked as between soils of different great soil groups; in fact, the horizons within a profile are equally variable in respect to exchangeable manganese and present no consistent evidence of a leaching effect. The data do, however, suggest a positive correlation between texture and manganese content. The clay soils to cultivated depth contain over 15 parts per million manganese; in gravelly sandy loams and loamy sands the content is below 2 parts per million, and in some cases well below ½ part per million. Assuming that 2 to 3 parts per million of available manganese are required for normal plant growth, one may conclude that the fine-textured soils are adequately supplied while the coarse-textured ones may be somewhat deficient. However, field tests on Dashwood gravelly loamy sand at Saanichton (10) have demonstrated that applications of manganese sulphate at 25 lb. per acre supplementing a complete fertilizer when applied to bulbs did not give any increase in yield.

Copper

The total copper content of British Columbia soils varies from about 10 parts per million to almost 100 parts per million, and the variation within a particular area is about as great as when soils of different areas are compared. The data covering a few representative soils on Vancouver Island, as presented in Table 10, are somewhat higher on the average than for other parts of the Province and appear to satify all plant and animal needs. Supporting evidence is noted in field tests conducted at the Canada Agriculture Experimental Farm,

Table 10 Copper Content of Some Vancouver Island Soils(7)

Soil Type	Horizon	Total Copper ppm
Cowichan clay loam	A	50
	B	64
Cassidy loamy sand	A	89
	B	96
Haslam loam	A	54
	B	68
Arrowsmith or Metchosin	A	18
	B	47

Saanichton (10) on Dashwood gravelly loamy sand. In this case the application of 50 lb. of copper sulphate supplementing a complete fertilizer when applied to bulbs, did not produce any beneficial results; in fact on one occasion the application tended to suppress yield. Similarly, when applied to the soil for pears, no beneficial effect was noted.

Zinc

No determinations have been made for zinc but since marked deficiencies have been reported from the Okanagan Valley, the possibility is not being overlooked. Zinc sulphate sprays have been applied to pear and cherry trees in the Saanich Peninsula (10) without apparent benefit.

Boron

In the Fraser Valley, where soils and environmental conditions are not unlike those existing within the surveyed area on Vancouver Island, boron differences have been studied in some detail. Here cultivated soils on fine-textured bottom lands are observed to have a boron content (16) ranging from

0.4 to 2.3 parts per million with an average of 1.25 parts per million. Assuming a minimum requirement of 0.5 to 1 part per million, depending on the crop being grown, one may conclude that many of these soils are deficient in boron at least for certain crops, and this has been amply demonstrated in practice during recent years. Similarly, a large proportion of the upland glacial silt and sandy loams, with an available boron content ranging from 0.3 parts per million, is responding to applications of boron.

Two samples of virgin soil from Vancouver Island were assayed (16) for total boron and the results, 32.5 and 35.0 parts per million, are distinctly higher than the corresponding figures, 15.0 and 17.1 for the Fraser Valley. These differences, however, are probably of little significance for a large proportion of total boron normally occurs as tourmaline (16), a complex alumino-silicate of iron, magnesium or other base, which is extremely resistant to weathering.

In spite of the relatively high total boron content of the two Vancouver Island soil samples, the available boron content averaged only 0.23 parts per million with a range of 0.1 to 0.6 parts per million. From these data one is safe in concluding that many Vancouver Island soils are deficient in available boron. These conclusions are further substantiated by field experiments. Data from the Experimental Station (10) at Saanichton indicate that vegetable crops such as beets, cabbage and cauliflower and legumes such as Ladino clover frequently respond to applications of boron in the form of borax. Woods and Webster (10) suggest that boron deficiencies are quite common on Vancouver Island.

Physical Studies

Mechanical Composition

Mechanical composition of a soil determines to a major degree its porosity, plasticity, temperature relationships and moisture-holding capacity. Since these factors determine not only the suitability of a soil for specific crops but also soil management practices, a close relationship exists between mechanical composition and crop adaptation.

The data, as presented in Table 11, are limited but represent four great soil groups and cover texture ranging from loamy sand to clay. They indicate that the mechanical composition of the horizons within each profile varies widely depending no doubt upon its mode of deposition. Eluviation or removal of clay-like materials from the surface horizons and deposition of same in lower horizons is difficult to recognize. Data for some of the profiles suggest a downward movement of the clay fraction but taking all the data as a whole, combined with supplementary evidence, one is forced to the conclusion that such movement is probably slight or absent.

Soil Moisture and Porosity

Moisture relationships, particularly those relating to storage and release of water for plant growth, are of major importance particularly in regions where precipitation during the growing season is insufficient to provide for optimum growth. A determination of the quantity of available water provided by any one soil involves the use of such data as moisture equivalent, wilting point and bulk density.

Moisture equivalents, representing moisture capacity, and wilting points, as presented in Table 12, are observed to vary with texture. For instance, the clay soils, though showing considerable variation, have a moisture equivalent approximating 34 per cent and a permanent wilting point of about 13 per cent. The corresponding figures for loams appear to be about 25 per cent and 12

Table 11 Mechanical Composition of Representative Soil Profiles Expressed in Per Cent

Horizon	Depth in Inches	Sand 2-0.05 mm.	Silt 0.05-0.002 mm.	Clay 0.002 mm. and less
		ALBERNI CLAY		
B_{21}	0 - 7	3.74	36.89	59.37
Concretions	0 - 7	1.89	66.51	31.60
B_{22}	7 - 15	0.79	37.50	61.71
B_3	15 - 22	1.78	26.90	71.32
C_1	22 - 24	1.38	34.42	64.20
		COWICHAN CLAY LOAM		
A_1	0 - 8	27.94	41.04	31.02
A_2	8 - 14	25.12	49.98	24.90
B	14 - 23	11.09	43.07	45.84
C_2	28 +	13.10	49.86	37.04
		FAIRBRIDGE SILT LOAM		
AB	0 - 1	1.62	73.96	24.42
B_2	1 - 12	0.78	72.60	26.62
Concretions	1 - 12	0.48	69.38	30.14
B_3	12 - 19	3.14	67.51	29.35
C_1	19 - 24	2.00	63.51	34.49
		MERVILLE LOAM		
A_1	0 - 8	39.06	45.65	15.29
B	8 - 16	23.35	51.91	22.74
B_g	17 - 34	23.73	51.23	25.04
D	34 +	3.77	53.57	42.66
		QUALICUM LOAMY SAND		
A_2	0 - ½	83.94	12.41	3.65
B_{22}	½ - 10	90.14	6.10	3.76
B_{23}	10 - 19	94.20	3.27	2.53
B_3	19 - 44	91.82	5.16	3.02
C	44 +	89.43	8.44	2.13
		ROYSTON GRAVELLY LOAM		
B_{22}	¼ - 9	50.05	32.54	17.41
B_{23}	9 - 20	40.61	37.33	22.06
C_1	20 - 36	51.91	30.37	17.72
C_2	36 +	40.42	30.42	29.16
		SHAWNIGAN GRAVELLY SANDY LOAM		
A_2	0 - ¼	51.57	43.22	5.21
B_2	¼ - 9	55.74	35.94	8.32
B_3	9 - 19	55.23	24.60	10.17
C_1	19 - 30	55.99	35.81	8.20

per cent respectively, and those for loamy sands approximately 11 per cent and 6 per cent. These percentages apply roughly to the top 15 inches of soil. Farstad (15) has suggested a moisture equivalent of 12 to 15 per cent and a permanent wilting point of 4 to 5 per cent as representing minimum levels for arable lands. On this basis Kye loamy sand is definitely non-arable and a number of the other soils described barely satisfy minimum requirements.

According to data presented in Table 13 the average available moisture storage capacity in the effective rooting zone is 3.2 inches. This rooting zone is observed to vary from 16 inches in the case of Puntledge silt loam and Tolmie loam to 30 inches with Cadboro gravelly sandy loam, Qualicum loamy sand, Kye loamy sand and Merville loam. The available moisture contents in the top foot of soil are observed to vary from 0.6 inches to 2.5 inches. If 2 inches of available moisture per foot of soil is regarded as the minimum for arable lands, less than half the soils for which data are provided would qualify. Kye loamy sand and Bowser loamy sand hold less than 2 inches of moisture in their effective root zones and therefore appear to be definitely sub-marginal for agriculture. However Bowser is not as bad as it seems since the lower solum is kept moist by seepage water until mid-summer.

Robertson and Holmes (25) point out that the average daily use of water by crops is about 0.15 to 0.20 inches and that during hot sunny weather with low humidity and some wind the requirement is much higher, probably in the vicinity of 0.25 to 0.35 inches per day. This requirement considered in the light of data presented in Tables 2 and 13 emphasize the importance of moisture conservation for most of these soils and particularly those found under a cool Mediterranean climate.

Permeability, determining in large measure the movement of air and water through the soil mass, is a major factor in soil fertility and is governed by the size of pore spaces in a soil rather than by total pore space. An ideal soil should have the pore space about equally divided between large and small pores and, obviously, the horizon showing the lowest per cent of large pores will determine permeability for any particular soil.

The data presented (Table 12) indicate adequate total porosity and indicate at the same time a very wide range in proportion of large pore spaces. For instance, the data covering loamy sands indicate that non-capillary porosity makes up well over 50 per cent of total pore space and thereby contribute to excessive aeration and percolation. At the other extreme, in Chemainus silt loam and Cowichan clay loam the large pores represent distinctly less than 20 per cent of total pore space. While there are some exceptions it is apparent that the soils for the most part indicate a higher non-capillary porosity in the A and upper B horizons than in the lower B and C horizons.

LAND CAPABILITY CLASSES

The foregoing descriptions and discussion of the soils suggest that their productivity and general capabilities vary greatly. On the basis of field observations supplemented by laboratory study four tentative capability groups are proposed.

The criteria for the capability groupings are soil characteristics which affect land quality and land use. These characteristics are soil texture, depth, moisture- holding capacity, natural fertility, drainage, permeability, topography and stoniness. Some non-soil factors which aid in the rating of soils with similar characteristics are inadequacy of precipitation and availability of irrigation water.

The grouping, as presented, may be subject to revision as data permitting the establishment of productivity levels become available. The introduction of new crops, change in cropping and management practices, and the impact on soil resulting from increased population may, too, induce some re-adjustment in the land use groups.

The capability classification groups soils into four classes. Classes I to III may be rated as good, fair and poor crop land. Class IV is essentially forest land but may conceivably have other uses under particular circumstances.

Table 12 Moisture and Porosity Studies of Representative Soils

Horizon	Depth in Inches	Bulk Density	Moisture Equivalent %	Permanent Wilting %	Porosity	
					Total %	Non-cap. %
			ALBERNI CLAY			
B_{21}	0 – 7	0.86	38.8	20.0	72.8	27.3
B_{22}	7 – 15	0.86	39.0	17.7		
B_3	15 – 22	0.91	39.1	20.1	71.9	21.6
C_1	22 – 24	1.07			65.8	7.3
C_2	24 +	1.20			59.2	5.9
			BOWSER LOAMY SAND			
B_2	2½ – 20	1.09	13.8	6.3	61.0	32.4
B_{2g}	20 – 26		10.5	7.1		
			CADBORO GRAVELLY SANDY LOAM			
A_1	0 – 9	1.09	18.3	8.1	54.3	19.8
B_1	9 – 19	1.38	15.4	7.2	51.4	14.0
B_2	19 – 32	1.45	11.6	5.5	46.2	11.1
C	32 +	1.69			34.3	7.7
			CHEMAINUS SILT LOAM			
A_1	0 – 4	0.76	38.8	13.4	63.7	10.1
C	4 – 12	1.02	21.0	5.7	59.0	10.8
			COWICHAN CLAY LOAM			
A_1	0 8	0.84	33.6	10.3	63.8	10.2
A_2	8 – 14	1.59	17.5	4.0	44.3	4.3
B	14 – 23	1.52	31.1	17.1	48.1	3.2
C_2	28 +	1.47			52.4	4.0
			CUSTER LOAMY SAND			
A_2	0 – 5		13.0	**5.4		
B_2	5 – 10		22.6	**16.6		
B_3	10 – 27		10.7	**7.7		
			ESQUIMALT SANDY LOAM			
A_1	0 – 10	*1.09	26.2	9.8		
B	10 – 18	*1.50	7.5	3.6		
			FAIRBRIDGE SILT LOAM			
B_2	1 – 12	1.10	27.6	11.7	62.9	19.4
B_3	12 – 19	1.31	28.6	8.6	55.4	9.1
C_1	19 – 24	1.44			52.1	5.3
C_2	24 +	1.51			49.3	5.8
			KYE LOAMY SAND			
A_2	0 – 3	*1.54	6.6	2.2		
B_{21}	3 – 6	*1.37	6.4	2.0		
B_{22}	6 – 16	*1.30	4.4	2.0		
B_3	16 – 19	*1.37	2.7	1.3		
B_g	19 – 35	*1.37	*2.7	*1.3		
			MERVILLE LOAM			
A_1	0 – 8	0.75	33.3	15.7	65.8	13.8
B	8 – 17	0.97	22.7	13.2	65.9	5.4
B_g	17 – 34	*1.58	29.7	15.4		

Table 12 Moisture and Porosity Studies of Representative Soils—*Concluded*

Horizon	Depth in Inches	Bulk Density	Moisture Equivalent %	Permanent Wilting %	Porosity	
					Total %	Non-cap. %
PUNTLEDGE SILT LOAM						
B_2	½ – 9	0.64	32.5	12.2	74.7	17.1
B_3	9 – 15	0.77	29.1	12.1	75.4	11.2
D_1	15 – 24		26.4	9.9		
QUALICUM LOAMY SAND						
B_{22}	½ – 10	1.37	10.9	3.8	50.1	26.6
B_{23}	10 – 19	1.54	10.9	3.9	45.8	24.6
B_3	19 – 44	1.54	*10.9	*3.9	42.5	26.0
C	44 +	1.70			37.5	26.6
QUINSAM GRAVELLY SANDY LOAM						
A_0	0 – 1	*1.38	16.0	6.2		
B_2	1 – 9	*1.30	16.0	6.4		
B_3	9 – 20	*1.45	15.6	5.2		
ROYSTON GRAVELLY LOAM						
B_{22}	¼ – 9	*1.40	25.4	10.5		
B_{23}	9 – 20	*1.45	22.9	10.1		
SAANICHTON CLAY						
A_1	0 – 2	0.56	41.9	14.1	69.5	22.9
B_1	2 – 6	0.99	29.9	9.5	64.5	15.4
B_2	6 – 11	1.12	27.4	8.9	57.3	14.6
B_3	11 – 19	1.29	24.0	7.5	52.4	12.8
C_1	19 – 30	1.48			47.5	7.3
C_2	30 +	1.51			47.9	4.3
SHAWNIGAN GRAVELLY SANDY LOAM						
B_2	¼ – 9	*1.45	21.6	7.0		
B_3	9 – 19	*1.45	20.1	6.9		
SPROAT GRAVELLY SANDY LOAM						
B_2	1 – 9	*1.30	25.9	7.9		
B_3	9 – 18	*1.40	17.7	6.5		
STAMP GRAVELLY LOAM						
B_2	¼ – 12	*1.35	24.7	12.8		
B_3	12 – 24	*1.40	22.5	11.4		
TOLMIE LOAM						
A_{11}	0 – 4	1.06	*30.0	*15.0	56.1	14.8
A_{12}	4 – 8	*1.25	*20.0	*12.0		
AB	8 – 16	1.58	*29.0	*15.0	40.8	7.6
B_K	16 – 26	*1.58	*29.0	*15.0		

*Estimated value. **Permanent wilting point by sunflower method.

Table 13 Available Soil Moisture Storage Capacity of Vancouver Island Soils

ACCUMULATIVE TOTALS IN INCHES

Series		Depth of soil in inches								
		4	6	8	12	16	18	20	24	30
Alberni	c	0.7	1.0	1.3	2.1	2.8	3.1	3.5		
Bowser	ls	0.4	0.5	0.7	1.0	1.4	1.6	1.7		
Cadboro	gsl	0.4	0.7	0.9	1.3	1.8	2.0	2.2	2.6	3.1
Chemainus	sil	0.8	1.1	1.4	2.1	2.7	3.1	3.4	4.0	
Cowichan	cl	0.8	1.2	1.6	2.4	3.3	3.7	4.2		
Esquimalt	sl	0.7	1.0	1.3	1.8	2.0	2.1			
Fairbridge	sil	0.7	1.1	1.4	2.1	3.2	3.7			
Kye	ls	0.3	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.0
Merville	l	0.5	0.8	1.1	1.4	1.8	2.1	2.6	3.5	4.8
Puntledge	sil	0.5	0.8	1.0	1.6	2.1				
Qualicum	ls	0.4	0.6	0.8	1.1	1.6	1.8	2.1	2.5	3.2
Quinsam	gsl	0.5	0.8	1.0	1.7	2.1	2.4	2.6		
Royston	gl	0.8	1.3	1.7	2.3	3.2	3.6	3.9		
Saanichton	c	0.7	1.1	1.5	2.4	3.2	3.7			
Shawnigan	gsl	0.9	1.3	1.7	2.5	3.3	3.6			
Sproat	gsl	0.8	1.3	1.7	2.3	3.0	3.3			
Stamp	gl	0.6	1.0	1.3	1.9	2.6	2.9	3.2	3.8	
Tolmie	l	0.6	0.8	1.0	1.9	2.8				
Average	....	0.6	0.9	1.2	1.8	2.4	2.7			

Class I

Soils placed in Class I are rated as suitable for general farming. Langford and Saanichton soils are devoted mainly to the production of one or other of the many specialized crops grown on Vancouver Island. The soils of this class are high in organic matter and relatively fertile as disclosed by nutrient level, soil reaction and degree of base-saturation. They are well drained and high in moisture-holding capacity. Factors such as topography and stoniness are such as not to interfere with tillage. Mapped soils placed in this good crop land class and arranged alphabetically include:

Alberni clay	9,705	acres
Chemainus silt loam to clay loam	15,175	
Fairbridge silt loam to silty clay loam	35,000	
Langford loam	3,485	
Lazo loam	315	
Merville loam	3,500	
Saanichton clay	15,355	
	82,535	acres
		(11.6%)

Class II

Soils included in this class are slightly inferior, as farm land, to those in Class I. The inferiority, in some instances, results from lower moisture-holding capacity, in others it is lower fertility resulting from greater acidity and lower per cent base-saturation and in others to less effective drainage conditions. The following soils placed in Class II may be rated as fair crop land.

Cadboro gravelly sandy loam	3,945	acres
Chemainus fine sandy loam to loam	17,570	
Cowichan clay loam	24,680	
Langford sandy loam	3,885	

Lazo sandy loam	245
Merville sandy loam	145
Memekay clay loan	2,975
Puntledge silt loam	11,705
Sandwick gravelly loam	1,690
Tolmie loam	7,745
Tolmie sandy clay loam	11,915
	86,500 acres (12.2%)

Some areas of Cadboro and Sandwick soils may be sufficiently stony to warrant placing them in Class III. Some areas of Cowichan and Tolmie soils are very poorly drained and should be assigned to Class III, but when effectively underdrained most of these soils can be placed in Class I.

Class III

Soils of this group are inferior as farm land. The inferiority is mainly the result of low moisture-holding capacity, low fertility, poor drainage and stoniness. However, a number of them may be quite satisfactory for the production of crops for an early market, providing they are well managed.

Bowser loamy sand	39,085 acres
Cassidy sandy loam	6,150
Custer loamy sand	3,430
Dashwood loamy sand	940
Esquimalt sandy loam	940
Haslam shaly loam	14,725
Langford loamy sand	1,155
Lazo loamy sand	1,210
Metchosin muck	1,645
Parksville sandy loam	5,505
Qualicum loamy sand	40,890
Royston gravelly loam	22,020
Sayward loamy sand	2,895
Shawnigan gravelly sandy loam	79,250
Somass loamy sand	2,135
Sproat gravelly sandy loam	10,660
Stamp gravelly loam	18,290
Tolmie sandy loam	1,225
Tolmie fine sandy loam	1,045
	253,195 acres (35.6%)

Haslam shaly loam, when the underlying shale is deep, may be somewhat better than the average for the class. Poorly drained soils such as Custer loamy sand, Metchosin muck, Parksville sandy loam and Tolmie sandy loam and fine sandy loam may be considerably improved by drainage. Stone-free areas of the till soils, Royston, Shawnigan, Sproat and Stamp, might be included in Class II but the stonier, hilly areas of these soils are non-arable and should be included in Class IV. The other soils in the group are quite drouthy. Thus it can be seen that the application of drainage, stone removal and irrigation water or some combination of these coupled with intelligent tillage and manurial practices can make some of these soils produce quite satisfactory crops.

Class IV

These soils are for the most part non-agricultural and may be classed as forest land. They are characterized by rough topography, excessive stoniness, coarse texture and extremely low moisture-holding capacity. They include:

Arrowsmith peat	20,390	acres
Cassidy loamy sand	1,410	
Cassidy gravelly loamy sand	11,540	
Dashwood gravelly loamy sand	72,970	
Esquimalt gravelly sandy loam	1,650	
Kye loamy sand	5,110	
Kye gravelly loamy sand	3,200	
Neptune gravelly loamy sand	1,040	
Qualicum gravelly loamy sand	76,440	
Quinsam gravelly sandy loam	8,955	
Somass gravelly loamy sand	1,000	
	203,705	acres
		(28.7%)

The following land types also are non-agricultural.

Coastal Beach	2,785	acres
Eroded Land	14,850	
Rock Outcrop	1,365	
Rough Mountainous	31,220	
Rough Stony	26,755	
Tidal Flats	1,260	
Made Land	775	
Water	5,965	
	84,975	acres
		(11.9%)

AGRICULTURAL PROBLEMS

Need for Irrigation

Data presented in Tables 2 and 13 suggest that a deficiency of water for crop production exists throughout the surveyed area. Proof of this deficiency has been abundantly provided through field experiments (9, 11, 13, 14) conducted at the Canada Agriculture Experimental Station at Saanichton and at Illustration Stations throughout the area. Significant responses have invariably been secured year after year upon applying irrigation water to representative crops such as small fruits, potatoes, bulbs, pastures and meadow lands. It has been estimated that milk production in the Cowichan Valley alone may be doubled (23) by irrigating hay and pasture land. This is rather significant, if capable of fulfilment, since in 1951 for instance, $1 million worth of milk from the mainland was consumed on Vancouver Island.

Very little irrigation was practiced on Vancouver Island prior to 1949. By 1952 approximately 1,170 acres were under irrigation, and by 1956 the irrigated acreage had increased to 4,280 acres. Undoubtedly the acreage of irrigated land will continue to increase while water is still available.

Precipitation and soil texture are of major importance, but they alone do not determine irrigation needs. Other factors, such as height of water table and drainage conditions, have a specific effect. For instance, all soils of the Chemainus series regardless of texture have relatively little need of water because of the high water table normally associated with these soils.

The deficiency of moisture in many of the mapped soils during the growing season is already serious but the problem is rapidly becoming more acute as deforestation and land clearing programs evolve. Evidence is rapidly accumulating that these factors supplemented by artificial drainage at higher elevations is depleting the supply of moisture and productivity of soils at lower levels.

The foregoing emphasizes the need for land-use planning if optimum returns are to be realized. Natural water reservoirs at the higher elevations are perhaps more valuable if retained under native vegetation, and thereby providing ground-water storage, rather than used for agricultural production.

Water Supplies

Water is a natural resource and, in spite of its apparent abundance, there is a seasonal scarcity in many localities. In order to ensure an equitable distribution, the right to the use of surface water for all purposes is vested in the Crown. It, through the Water Rights Branch, regulates the distribution of surface waters through the issuance of licences.

Already many of the streams throughout the Saanich Peninsula are fully recorded and where such is the case prospective users must resort to other means in order to secure water for irrigation. This involves storage on streams themselves, by means of dams, and adjacent to streams by means of dugouts. Licences are required and are available for these dugout storages providing the storage is effected before the irrigation season begins.

Prospective users, not being adjacent to a stream and not having an obvious source of water for irrigation, may resort to dugouts which depend on local drainage for storage water; these are not subject to licence.

To date, outside of the Saanich Peninsula little has been done in the surveyed area to provide storage of surplus water for summer use. However, consideration has already been given to the establishment of an Irrigation District in the Cowichan Valley; to this end a preliminary survey (19) has been completed. Three main sources of surface water have been studied and of these "either the Cowichan River or the Chemainus River appear to offer the best source of supply but extensive engineering investigation and study would be required for complete evaluation". In the meantime individual projects can doubtless be developed involving smaller surface supplies and possibly also using ground water.

Ground-water resources may or may not serve as a source of water for irrigation; little is known about the potential of these resources in the area under study. Preliminary investigations (21) throughout the Saanich Peninsula indicate that bedrock wells, while not providing water for irrigation, will furnish an adequate supply of water for domestic use. Most of the wells in the peninsula, all capable of producing large quantities of water, secure their supplies from unconsolidated materials lying on bedrock. In order, however, to have an appreciation of the potential of each well measurements of water levels, over an extended period of time, are necessary. Ground-water resources at a number of points in the vicinity of Duncan and lying between Shawnigan Lake and a point to the north of Maple Bay have been studied by Nasmith (22).

Use of Non-arable Land

Of the 710,900 acres within the surveyed area only 193,300 are in farms (1956) and of these 34 per cent or 65,900 acres are improved and being used for agricultural production. Sixty-six per cent or 2 out of every 3 acres, on the average, are not being used and thus adding to the cost of farm operations. These unused acres must be turned to advantage rather than remain a handicap, if farming is to be the success that it should be on Vancouver Island.

An appreciable proportion of the unused acreage on each farm is usually potentially arable and is being used agriculturally as clearing proceeds, but this is a slow process since costs of clearing are high and farm incomes relatively low. Effective use should be made of this land as it awaits clearing.

Some land possibly is being reserved for water storage as already suggested; if this is the case in all probability it is giving its best return.

A large proportion of the acreage on each farm, as well as that outside of farms, is non-arable for one reason or another and for the purpose at hand, may be classed as forest land.

Wood products, whether in the form of lumber, pulp, posts, Christmas trees, fencing material or fuel, represent a major source of income on Vancouver Island. To realize a share of this income all unused wooded lands on each farm, whether potentially arable or not should be cut on a sustained yield basis. This simply involves the adoption of good forest management practices just as good farming involves the adoption of approved soil and crop management practices.

To facilitate the general adoption of such a practice the Forest Act was amended in 1948 and provides that bona fide farmers living in British Columbia may obtain Crown land which, when combined with a farmer's privately owned forest land, will provide 10,000 cubic feet of wood growth a year. (Forest land is defined as land that will find its most economic use under forest crop and is not suitable for cultivation). This so-called 'forest woodlot' is operated under licence and on a sustained yield basis. For further particulars the reader is referred to publications of the British Columbia Forest Service.

The first license was issued in 1951 and the farm forest woodlot covered was located near Nanaimo. By Nov. 15, 1957, 14 such woodlots were in operation throughout the area under review. These woodlots involve 1,783 acres about one quarter of which represents land owned by the farmers.

Since forest management licences and tree farms operating on a sustained-yield basis are recognized as good practice by the forest industry, the operation of a forest woodlot should be worth careful consideration by every farmer who can qualify for such a lease.

Arable Land for Urban Development

Highly valued agricultural lands including those belonging to the Cadboro, Langford, Tolmie, Saanichton and Esquimalt series located at the southern tip of Vancouver Island and throughout the Saanich Peninsula are being rapidly utilized for urban and suburban industry and housing. This is resulting in the rapid dissipation of already limited areas of agriculturally valuable lands on Vancouver Island. The high proportion of non-arable land should allow municipal planning that would permit best use of both arable and non-arable areas.

Maintenance of Fertility

To guard against soil exhaustion a soil-building program should be instituted immediately upon bringing virgin land into production. To be effective this involves maintaining the content of organic matter at a reasonable level, and returning to the soil nutrients equivalent to those removed annually through cropping and leaching. Maintenance of ground cover through the use of artificial mulches and catch crops is strongly recommended to maintain a desirable structure and to guard against erosion and excessive leaching during the winter months.

Agricultural Land Over-capitalized

The close intertwining of agriculture and industry throughout the surveyed area has led to the capitalizing of land on the basis of possible use for industry and housing rather than for agriculture. This puts an additional load on the farm operator and results in a lower net income.

High Cost of Labor

The close integration of agriculture and industry throughout the surveyed area enables one to live on a farm and work in industry. This means that agriculture must compete with industry for the day-to-day use of high-priced labor.

APPENDIX

Approximate Acreage of Different Soils

Soil Name	Acreage of Soil Type	Acreage of Soil Series	% of Total
Alberni clay		9,705	1.4
Arrowsmith peat		20,390	2.9
Bowser loamy sand		39,085	5.5
Cadboro gravelly sandy loam		3,945	0.6
Cassidy gravelly loamy sand	11,540		
Cassidy loamy sand	1,410		
Cassidy sandy loam	6,150	19,100	2.7
Chemainus fine sandy loam to loam	17,570		
Chemainus silt loam to clay loam	15,175	32,745	4.6
Coastal Beach		2,785	0.4
Cowichan clay loam		24,680	3.5
Custer loamy sand		3,430	0.5
Dashwood loamy sand	940		
Dashwood gravelly loamy sand	72,970	73,910	10.4
Eroded land		14,850	2.1
Esquimalt gravelly sandy loam	1,650		
Esquimalt sandy loam	940	2,590	0.4
Fairbridge silt loam to silty clay loam		35,000	4.9
Haslam shaly loam		14,725	2.1
Kye loamy sand	5,110		
Kye gravelly loamy sand	3,200	8,310	1.2
Langford loamy sand	1,155		
Langford sandy loam	3,885		
Langford loam	3,485	8,525	1.2
Lazo loamy sand	1,210		
Lazo sandy loam	245		
Lazo loam	315	1,770	0.2
Made land		775	0.1
Memekay clay loam		2,975	0.4
Merville loam	3,500		
Merville sandy loam	145	3,645	0.5
Metchosin muck		1,645	0.2
Neptune gravelly loamy sand and sandy loam		1,040	0.1
Parksville sandy loam		5,505	0.8
Puntledge silt loam		11,705	1.6
Qualicum loamy sand	40,890		
Qualicum gravelly loamy sand	76,440	117,330	16.5
Quinsam gravelly sandy loam		8,955	1.2
Rock Outcrop		1,365	0.2
Rough Mountainous land		31,220	4.4
Rough Stony land		26,755	3.8
Royston gravelly loam		22,020	3.1
Saanichton clay		15,355	2.2
Sandwick gravelly loam		1,690	0.2
Sayward loamy sand		2,895	0.4
Shawnigan gravelly sandy loam		79,250	11.1
Somass loamy sand	2,135		
Somass gravelly loamy sand	1,000	3,135	0.4
Sproat gravelly sandy loam		10,660	1.5
Stamp gravelly loam		18,290	2.6
Tidal Flats		1,260	0.2
Tolmie sandy loam	1,225		
Tolmie fine sandy loam	1,045		
Tolmie loam	7,745		
Tolmie sandy clay loam	11,915	21,930	3.1
Water		5,965	0.8
		710,910	100.0

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GLOSSARY

Aeolian material—Material transported and deposited by wind. Those materials that are primarily silty are called loess; those that are primarily sand are called aeolian sands. The sands commonly are in dunes.

Alluvial fan—A fan-shaped outwash deposit formed at the toe of a mountainside gully where it debouches onto flatter ground.

Available nutrients—Plant nutrients in soluble form; readily available for absorption by plant roots.

Boulders—Rock fragments over 2 feet in diameter.

Boulder pavement—A surface essentially paved with stones and boulders that occupy more than 90 percent of the exposed surface.

Calcareous material—Material containing a relatively high percentage of calcium carbonate; it visibly effervesces when treated with hydrochloric acid.

Cation exchange capacity—A measure of the absorptive capacity of the soil for cations or the amount of cations which can be absorbed by a given amount of soil, expressed in terms of milliequivalents per 100 grams of soil. A soil with a fairly high exchange capacity is preferred to one with a low exchange capacity because it will retain more plant nutrients and be less subject to leaching or exhaustion.

Cobbles—Rock fragments from 3 to 10 inches in diameter.

Complex—An area of two or more soil series which are so intimately mixed as to render their separation impractical at the scale of mapping.

Concretions—Hard spheroids developed by the cementation of soil mineral particles.

Consistence (soil)—The relative mutual attraction of the particles in the whole soil mass, or their resistance to separation or deformation. It is described in terms such as loose, soft, friable, firm, hard, sticky, plastic or cemented.

Delta—An alluvial deposit at the mouth of a river emptying into a lake or sea.

Drift—Material of any sort moved from one position to another. The term is most commonly used when referring to glacial drift, or material deposited by glacial action. Glacial drift includes unstratified glacial deposits, or till, and stratified glacial outwash materials.

Effective rooting zone—That portion of the soil in which the growth of roots is uninhibited. Root growth may be inhibited by an impermeable horizon, a free water table or by a coarse-textured drouthy horizon.

Glacial till—An unstratified mixture of stones, sand, silt and clay transported and deposited by glaciers.

Glacio-fluvial material—Material produced by glaciers and carried, sorted, and deposited by water that originated mainly from the melting of glacial ice. These deposits are stratified and may be in the form of outwash plains, deltas, kames, eskers, and kame terraces.

Gravel—Rock fragments from 2 mm. to 3 inches in diameter.

Green manure crop—A crop grown for the purpose of being turned under while green, or soon after maturity, for improving the soil.

Horizon—A layer in the soil profile approximately parallel to the land surface with more or less well-defined characteristics that have been produced through the operation of soil-building processes.

Kame—A more or less conical hill usually of gravel or sand, deposited as a small delta cone or in a depression along the ice front or in a crack or hole within the ice border.

Kettle—A closed depression created by the melting of buried or partly buried blocks of ice after sedimentation has ceased.

Lacustrine materials—Materials deposited by or settled out of lake waters and exposed by lowering of the water levels or elevation of land. They usually are varved.

Moraine—The unstratified till deposited by a glacier.

Mottles—Irregularly marked spots or streaks usually of yellow or orange color, although blues may also occur. Mottling indicates poor aeration and lack of good drainage.

Ortstein—A B horizon which has been irreversibly cemented with iron and humus.

Parent material—The unaltered or essentially unaltered mineral material from which the soil profile develops.

Permeability—The ease with which water and air are transmitted through the soil to all parts of the profile. It is described as rapid, moderate or slow.

pH—The intensity of acidity or alkalinity expressed as the logarithm of the reciprocal of the H-ion concentration. With this notation, pH 7 is neutral; lower values indicate acidity, higher values alkalinity.

Porosity—The percentage of the total soil volume not occupied by soil particles.

Non-capillary pores—Soil pores which do not hold soil moisture by capillarity. In the laboratory non-capillary soil pores are drained by tension of less than 60 cm. of water.

Capillary pores—Soil pores which hold soil moisture by capillarity. In the laboratory capillary soil pores remain undrained by tensions of less than 60 cm. of water.

Potential evapotranspiration—The amount of water that would be transferred from the soil to the atmosphere by evaporation and transpiration if it were constantly available in optimum quantity.

Relief—The elevations or inequalities of the land surface when considered collectively. Minor surface configurations are referred to as micro-relief.

Soil reaction—The acidity or alkalinity of soil. Acidic soil reactions are characterized as follows:

Slightly	pH 6.1 to 6.5
Medium	pH 5.6 to 6.0
Strongly	pH 5.1 to 5.5
Very strongly	pH 4.5 to 5.0
Extremely	pH below 4.5

Solum—The upper part of the soil profile which is above the parent material and in which the processes of soil formation are taking place. It includes the A and B horizons.

Stones—Rock fragments over 10 inches in diameter. The term boulder is sometimes used for fragments over 2 feet in diameter.

Structure—The morphological aggregates in which the individual soil particles are arranged. The following types are mentioned in this report:

Granular—more or less rounded soil aggregates with an absence of smooth faces and edges, relatively non-porous.

Single grained—each grain by itself as in sand.

Blocky—block-like aggregates with sharp angular corners.

Subangular blocky—block-like aggregates with rounded and flattened faces and rounded corners.

Massive or amorphous—large cohesive masses of soil, structureless, with irregular cleavage faces.

Structural aggregates vary in size and are described in terms of very fine, fine, medium, coarse and very coarse. The size classes vary according to the type of structure. The aggregates also differ in grade of development and the grade is characterized as strong, moderate or weak. By convention one describes an aggregate in the order of grade, class and type. Two examples of this convention follows:

strong medium blocky,
moderate coarse granular.

Texture—The relative proportion of the various size groups of individual soil grains. Clays are fine textured, loams are medium textured and sands are coarse textured. Size groups from 2 mm. to 0.05 mm. in diameter are called sand, those from 0.05 to 0.002 mm. are called silt and those less than 0.002 mm. are called clay.

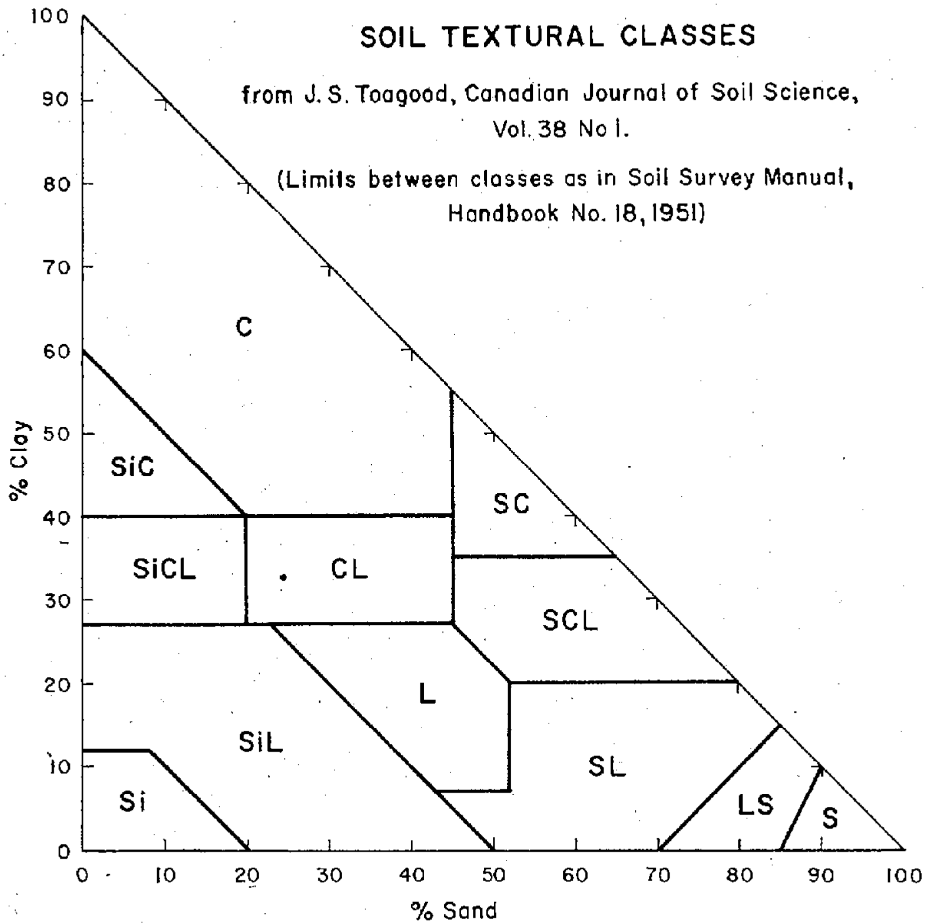

FIG. 18—Soil textural classes.

Topography—In this report topography is used to mean the soil slope. It may be smooth or irregular and the slope classes are defined as follows:

Basin	0	percent
Level	0 - 0.5	"
Very gently sloping	0.5 - 2	"
Gently sloping	2 - 5	"
Moderately sloping	6 - 9	"
Strongly sloping	10 - 15	"
Very strongly sloping	16 - 30	"
Hilly	30+	"

Variant—A soil which differs in one or more respects from a named soil series with which it occurs. It is not of sufficient known extent to warrant separation.

ANALYTICAL METHODS

The physical and chemical analyses were performed in the Soil Survey Laboratory at Vancouver by the following methods.

Physical Analyses

1. Mechanical analysis on the organic-free, iron-free, sample corrected to the oven dry basis by the pipette method of Alexander and Kilmer with modifications by Toogood and Peters.
2. Capillary and non-capillary pore space and bulk density of three-inch soil cores by the method of Leamer and Shaw. (Jour. Am. Soc. Agron. Vol. 33:1003-1008, 1941).
3. Permanent wilting percentage by the dessicator method of Lehane and Staple. (Soil Sci. Vol. 73, 1951).
4. Moisture equivalent by the method of Veihmeyer et al. (First Inter. Congress of Soil Sc., 1927).

Chemical Analyses

A. Total analysis—Standard methods were used except that iron was determined by the Jones reduction method. K_2O and Na_2O were determined on the flame spectrophotometer from a J. Lawrence Smith fusion. P was determined by the $HClO_4$-hydrazine sulfate method of Shelton and Harper. (Iowa State College Jour. of Sc., Vol. 15, 1941).

B. Exchangeable cations—Standard methods were used as outlined by Peech et al (USDA circ. 757, 1947) except that potassium and sodium were determined in HCl on the flame spectrophotometer. Hydrogen was determined by the calcium acetate method of Shaw. (Jour. AOAC, Vol. 35, No. 3, 1952).

C. Reaction (pH) by the glass electrode on a soil paste (Doughty, Sci. Agric. Vol. 22, 1941).

D. Loss on ignition, 850°C. for one-half hour.

E. Hygroscopic water, 105°C. for 24 hours.

F. Total nitrogen, Kjeldahl method using boric acid.

G. Organic matter, modified wet combustion method of Wakely (as used in Peech, USDA Circ. 757, 1947).

The Queen's Printer and Controller of Stationery, Ottawa, 1959

Cat. No. A57-416